UNITED
NATIONS

EP

United Nations
Environment
Programme

Distr.
LIMITED

UNEP/OzL.Pro/ExCom/17/32
30 June 1995

ORIGINAL: ENGLISH

Executive Committee of
the Multilateral Fund for the
Implementation of the Montreal Protocol

Seventeenth Meeting
Montreal, 26-28 July 1995

PROJECT PROPOSALS: CHINA

This document includes the following project proposals which have been grouped by sector. The agency responsible for the implementation of the project is also indicated. The project proposals are presented in the order indicated below.

Foam

• Conversion to CFC-free Technology in the Manufacture of Flexible Polyurethane Foam (Slabstock) at Yifeng Polyurethane Plastic Plant	World Bank
• Conversion to CFC-free technology in the manufacture of Flexible (Slabstock) Polyurethane foam at Liangzhu	World Bank
• Conversion to CFC-free Technology in the Manufacture of flexible Polyurethane Foam (Slabstock) at Penglai	World Bank
• Conversion to CFC-free technology in the manufacture of Flexible (Slabstock) Polyurethane foam at Zhenjiang	World Bank
• Conversion to CFC-free technology in the manufacture of flexible PUF products at Daimei	UNDP
• Elimination of CFCs in the Manufacture of EPS/PE Sheets/Nettings at 4 Companies (Tianjin Gangda, J.I.P. Buotou, Cangzhou, Handan No.7)	UNDP
• Elimination of CFC-11 in the manufacture of rigid polyurethane foam products at Tianjin Polyurethane Plastic Plant	UNDP

Refrigeration

• Elimination of CFCs in the Manufacture of Domestic Refrigerators at Guagdong Kelon	UNDP
• Elimination of CFCs in the Manufacture of Domestic Refrigerators at Changsha Zhongyi Group	UNDP
• Conversion of domestic-refrigerator and freezer factories to phase out CFC-12 and CFC-11 by hydrocarbons isobutane and cyclo-pentane at Hangzhou Xiling Holdings Company	UNIDO
• MAC Compressor Factory Production Conversion from CFC-12 to HFC-134a MAC Compressor at Shanghai Ek Chor General Machinery Co. Ltd.	World Bank
• MAC Factory Production Conversion from CFC-12 to HFC-134a MAC System at Yueyang Hengli Air Conditioning Equipment Co. Ltd.	World Bank
• MAC Compressor Factory Production conversion from CFC-12 to HFC-134a MAC Compressor at Guangzhou Haohua Automobile Parts Co.Ltd.	World Bank
• MAC Co. Production Conversion from CFC-12 to HFC-134a MAC System at Shanghai Automobile Air Conditioner Co. (SAAC)	World Bank

MONTREAL PROTOCOL ON
SUBSTANCES THAT DEPLETE THE OZONE LAYER

PROJECT COVER SHEET

COUNTRY:	People's Republic of China
PROJECT TITLE:	YIFENG Conversion to CFC-free Technology in the Manufacture of Flexible Polyurethane Foam (Slabstock)
SECTOR COVERED:	Foamed Plastics
ODS USE IN SECTOR:	17,773t CFCs (=ODP) 1991
PROJECT IMPACT:	Phaseout of 60t CFC11 per year
PROJECT DURATION:	One year
PROJECT ECONOMIC LIFE:	10 years

TOTAL PROJECT COST:

Investment Costs	US$ 271,500
10% contingency	27,150
Incremental Operating cost	45,000
Total Incremental Investmt. Cost	343,650
33% foreign ownership	(113,400)
OTF amount @ 67% ownership	US$ 230,250
3% Financial Agency Fee	6,900
Proposed OTF Grant	US$ 237,100

PROPOSED OTF FINANCING:	US$ 237,100
COST EFFECTIVENESS:	Unit Abatement Cost: US$1.50/kg./year Grant Effectiveness: US$3.84/kg
IMPLEMENTING ENTERPRISE:	Yifeng Polyurethane Plastic Plant
COORDINATING NATIONAL BODY:	National Environmental Protection Agency
IMPLEMENTING AGENCY:	The World Bank

PROJECT SUMMARY

Yifeng Polyurethane Plastic Plant is a joint venture which produces polyurethane flexibel foam slabstock, using CFC-11 as a blowing agent. The prupose of this project is to phaseout the CFC-11 usage through a combination of methylene chloride and fast cure. The project includes equipment to support this conversion, provisions for technology transfer as well as process and safety training.

TECHNICAL ASSESSMENT: This project has been reviewed and is supported by Dr. Mike Jeffs, OORG Expert for the foam sector. His comments have been incorporated in this summary.

PROJECT OF THE GOVERNMENT OF CHINA

YIFENG CONVERSION TO CFC-FREE TECHNOLOGY
IN THE MANUFACTURE OF FLEXIBLE POLYURETHANE FOAM (SLABSTOCK)

1. PROJECT OBJECTIVE

The objective of this project is to phaseout the use of CFCs in the manufacturer of flexible-PUF at Yifeng.

2. SECTOR BACKGROUND

The Chinese foam industry consumed in 1991 17,773 tons CFCs (China Country Program). CFC-11 was the dominant substance (15,600 t PUF), followed by CFC-12 (2,173 t XPS/PE). Production is divided between larger state owned enterprises and smaller township or private enterprises. Production and process information from state enterprises is well documented. However information on the rest of the industry is less reliable. More detailed information about the sector is provided in the following table:

Categories Subcategories	ODS (t)	Production (t)	Plants (range)
Extruded PS/PE	2,173	13,000	30-50
Flexible Polyurethane	2,000	50,000	50-100
Pipe Insulation	600	4,000	10-20
Sprayed PUF	600	4,000	50-200
Appliance Foams	5,000	40,000	40-70
PUF Panels	7,400	52,000	20-50
Total Rigid PUF	13,600	100,000	120-340
TOTAL	17,773	163,000	200-490

The Chinese Foam Industry
Selected Industry Data (1991)

Government and industry are committed to sharply reduce, and ultimately eliminate CFC utilization. NCLI is responsible for the phaseout coordination in all foam categories. Ministerial responsibility is divided into two areas:

- Refrigerating foams
- Non-refrigerating foams

Other ministries are involved in the refrigeration foams, i.e.:

- Ministry of Chemical Industry (MCI),
- Ministry of Internal Trade (MIT),
- China Aerospace Industry Cooperation (CAIC),
- Ministry of Machinery Industry (MMI),

Complete phaseout for non-refrigeration foams is targeted for the year 2000. Refrigerating foams are expected to be CFC free from the year 2005. Uninhibited use of CFCs in foams for domestic refrigeration is expected to lead to an increase during 1991-1995 by 8% per year, and after 1995 by 3% per year. For other foams, a growth rate of 6% per year is forecasted.

3. ENTERPRISE BACKGROUND

Yifeng Polyurethane Plastic Plant was established in 1989 by Beijing Fenghuang Fashion Company (52%), Beijing Planning Committee Investment Company (15%) and Hongkong-based Wanfeng LTD. (33%). The company employs 110 workers. Sales in 1993 were 37 million RMB. The company produces flexible PUF slabstock and products thereof mainly for the textile industry (shoulder pads, laminates). In addition raw blocks are sold.

For its flexible-PUF slabstock production the plant operates a Vertifoam production line (Cannon Viking, round/square convertible, 1989). Capability of production is 3,000 t. Production in 1993 was 2,500 tons, for which 60 t CFC-11 was used. For 1994 a production of 3,000 t and a consumption of 110 t CFCs is expected.

4. PROJECT DESCRIPTION

Under this project Yifeng will phaseout the use of CFC through a combination of methylene chloride (MC) and accelerated curing. The project includes equipment needed for the MC retrofit and two vacuum tables (for round blocks and for square blocks) for the accelerated cooling technology. An external expert will provide the design for local production, supervise the installation, start-up and production trials and will provide training on how to operate the installation without undue fire and exposure risks.

5. TECHNOLOGY

5.1 OVERVIEW AND SELECTION

There are numerous options to replace CFCs in the manufacture of flexible PUF slabstock. These are described and reviewed in UNEP's "Technical Options Handbook" for foamed plastics. Yifeng management attended a seminar organized by NCLI, NEPA and the World Bank. Subsequently MC was selected as the preferred option, based on technical as well as economic considerations. However, the local available MC causes severe scorching in low density/high water formulations. An accelerated cooling system to mitigate this effect is therefore selected as complementary technology.

5.2 IMPACT ON PRODUCTION PROCESS

The use of methylene chloride (MC) requires the installation of a non-corrosive, chemical resistant storage and metering system as well as sufficient ventilation in production and curing area to limit workers exposure to an acceptable level.

The installation of an accelerated cooling (AC) system will reduce the need for curing space. The available space is sufficient and suitable in location to house the required twin-system (the plant produces square and round blocks, for which different vacuum tables are needed). A backup generator has to be installed to avoid fire risk in case of a power outing.

Safety and production training is required following installation, prior and during start-up. The plant intends to have most of the equipment locally manufactured. Drawings and specifications will be provided by an external process expert who also will supervise installation, start-up, production trials and process/safety training.

6. PROJECT COSTS

The incremental investment costs of $298,650 include capital investment of the forced cooling system, MC storage/metering system, trial production, safety and training, and 10% contingency (Annex 1).

The incremental operating costs of US$45,000 represent net present value of IOC for four years discounted at 10%. Details are provided in Annex 2.

Total OTF grant request of US$237,100 includes the incremental investment costs, incremental operating cost, excluding 33% of incremental investment cost representing foreign ownership, 10% contingency and a 3% financial agency fee.

7. FINANCING PLAN

The company requests a grant for the part of the project costs that reflect the Chinese shareholdership of 67% at US$230,250. Including 3% financial agency fee, the total grant request amounted to US$237,100. The enterprise is responsible to provide counterpart funding of US$113,400 ($343,650- $230,250), representing the difference between total incremental investment costs and the requested OTF grant.

8. COST EFFECTIVENESS

The unit abatement cost calculated over a 10 year life span of the project is US$1.5 per ODP weighted kg of CFC11 phased out. This has been derived from the incremental annualized capital costs of US$271,500 and net annualized recurrent operating costs of US$45,600 (first year), for the phaseout of about 60 ODP weighted MT of CFC11. The grant effectiveness is $3.84/kg.

9. PROJECT IMPACT

This project will result in the elimination of the use of annually a minimum of 60t CFC-11. It applies economically feasible and environmentally acceptable technology. No regulatory permit is required for its use.

10. PROJECT IMPLEMENTATION

Following date of approval, the schedule below will apply:

TASK	TIME FOR COMPLETION					
	Q1	Q2	Q3	Q4	Q5	Q6
Fastcure/MC						
Specifications	x					
Preparation of tenders	x					
Purchase Order	x					
Installation, Start-up		x				
Training			x			
Trials				xx	xx	
Commissioning					x	

ANNEXES

Annex 1: Incremental Investment Costs
Annex 2: Incremental Operating Costs
Annex 3: Cost Effectiveness Calculation
Annex 4: OORG Technical Review

ANNEX 1

INCREMENTAL CAPITAL COSTS

Forced Cooling System (two units, for round and square blocks, including feed conveyors, installation		US$ 160,000
MC Storage/metering system		US$ 30,000
Trials (6 foam types, 3 trials/type @ 5 minutes @ US$ 100.00/ minute chemicals, 1/2 recovered through usable foam)		US$ 4,500
Safety: Electrical Generator	US$ 20,000	
Airflow Meter	US$ 5,000	
MC Monitor	US$ 2,000	US$ 27,000
Training, Technology Transfer (includes provision of FC construction drawings and construction Supervision)		US$ 50,000
Subtotal		**US$271,500**
10% Contingencies		27,150
Incremental Capital Costs		US$ 298,650

REMARKS:

1. The forced cooling system has been costed by a US civil engineer. It includes two cooling converyors, one for round blocks and one for square blocks, US$ 70,000 each, and a selective feed converyor system, US$ 20,000. It is intended to have this equipment locally made, under technical supervision. The same installation from a reputable international equipment supplier, such as Cannon-Viking will cost about US$ 200,000, excl. feed conveyors.

2. The electrical generator is needed because breakdown of power would casue fire dager in the production.

3. The foam needs to have a minimum airflow of about 5 m/sec (ASTM test) to be successfully cooled. An airflow meter is therefore included in the budget. The need has been established during the implementation of the Tianjing demonstration project.

ANNEX 2

INCREMENTAL OPERATING COSTS

ASSUMPTIONS

ITEM	PRICE (US$/T	CONSUMPTION (T/Y) BEFORE	AFTER	INFORMATION SOURCE
CFC-11	1,400	90	-	ICI
MC	950	-	83	Recipient
TIN	8,000	10	11.25	Goldschmidt
ENERGY (/KWH)	0.07		60,000	Power Cy.
PRODUCTION	2,000	2,300	2,300	Recipient

INVESTMENT IN EQUIPMENT : US$190,000
CFC/MC RATIO : 1.00/0.90
YIELD LOSS : 3/2/1/0%/y on 50% of production[1/]
MAINTENANCE : 5% of equipment investment

The recipient may use softner or 100% water in certain formualtions. While softener will not substantially change operating costs, the use of water will but is to the benefit of the receipient and therefore not incremental.

INCREMENTAL OPERATING COSTS (SAVINGS) CALCULATION (000 US$)

COST ITEM	1995	1996	1997	1998	TOTAL
BASELINE					
CFC-11	126	126	126	126	
TIN	80	80	80	80	
TOTAL	206	206	206	206	
POST-PROJECT					
MC	78.9	78.9	78.9	78.9	
TIN	90	90	90	90	
INCR. YIELD LOSS	69	46	23	0	
INCR. ENERGY	4.2	4.2	4.2	4.2	
INCR. MAINTENANCE	9.5	9.5	9.5	9.5	
TOTAL	**251.6**	**228.6**	**205.6**	**182.6**	
IOC (SAVINGS)	45.6	22.6	(0.4)	(23.4)	
DISCOUNT FACTOR	0.91	0.83	0.75	0.68	
NPV of IOC	**42.4**	**18.8**	**(0.3)**	**(15.9)**	**45.0**

[1/] 50% of the production will use MC

ANNEX 3

COST EFFECTIVENESS CALCULATION

1. Unit Abatement Cost

a.	Incremental Capital Costs	: US$ 271,500
b.	Incremental Operating Costs (first year)	: US$ 45,600
c.	Project Useful Life	: 10 years
d.	ODS reduction per year	: 60,000 kg
e.	Capital Recovery Factor	: 0.16275
	Unit Abatement Cost [(a * e)+b]/d	: US$1.50/kg/year

2. Grant Effectiveness

a.	OTF Grant requested	: US$ 230,250
b.	ODS phaseout per year	: 60,000kg
	Grant effectiveness	: US$ 3.84/kg

ANNEX 4

CHINA - YIFENG

TECHNOLOGY

The enterprise is proposing to convert its production of flexible slabstock foam from a technology based on CFC 11 to methylene chloride.

Methylene chloride technology is widely used in the industry to replace CFC 11. It generally provides an economic solution to meet the technical needs of the product. Other technologies are considered. The enterprise has concerns regarding the quality of the locally available methylene chloride and consequently an accelerated cooling system is proposed. In addition, a softening agent will be required to produce low density foams of the required softness.

The enterprise will use external experts (not identified) to oversee the conversion.

ENVIRONMENTAL ISSUES

Methylene chloride has a very low ODP and is not a controlled substance.

The main issue relates to the provision of a safe working environment. The enterprise proposes a range of equipment and training and necessary training to manage this issue.

PROJECT COSTS

There are discrepancies in the project documents between the cover sheet and item 6.1. Total Project Costs and item 7 Financing Plan which need clarification. However, the project cost effectiveness falls within the limit proposed by the EC.

The proposed capital and other one-off items are justified. The operating cost calculation indicates a near neutral cost / saving position.

IMPLEMENTATION TIMEFRAME

Acceptable.

RECOMMENDATION

Approval provided the discrepancies mentioned under project costs are resolved to the satisfaction of the Task Manager.

GMF/kd/23/5/95

MONTREAL PROTOCOL ON SUBSTANCES THAT DEPLETE THE OZONE LAYER

PROJECT COVER SHEET

COUNTRY	:	People's Republic of China
PROJECT TITLE	:	Conversion to CFC-free technology in the manufacture of Flexible (Slabstock) Polyurethane foam at Liangzhu.
SECTOR COVERED	:	Foamed Plastics
ODS USE IN SECTOR	:	17,773 MT CFCs (=ODP), 1991
PROJECT IMPACT	:	120 MT CFC-11 (base 1994)
PROJECT DURATION	:	1.5 years
PROJECT ECONOMIC LIFE	:	10 years
TOTAL PROJECT COST	:	Incremental Capital Costs : US$ 170,000 10% contingency : 17,000 Incremental Operating Savings : (21,700) Net Incremental Investment Costs: 165,300 Financial Agent Fee : 5,000 Proposed OTF grant : US$ 170,300
PROPOSED OTF FINANCING	:	US$ 170,300
COST EFFECTIVENESS	:	Unit Abatement Costs: US$ 0.36/kg/year Grant Effectiveness: US$ 1.38/kg
IMPLEMENTING ENTERPRISE	:	Liangzhu Foam Plastic Plant, Hangzhou, China
CO-ORDINATING NATIONAL BODY	:	National Environment Protection Agency
IMPLEMENTING AGENCY	:	The World Bank

PROJECT SUMMARY

This project will phase out 120 MT of CFC-11 in the production of flexible slabstock polyurethane foam at Liangzhu Foam Plastic Plant, Hangzhou, by converting from CFC-11 to Methylene Chloride as an auxilliary blowing agent. The project requires storage and metering system for methylene chloride, improved ventilation and safety systems, technical support for converting the formulations and process and safety training.

TECHNICAL ASSESSMENT: This project has been reviewed and is supported by Dr. Mike Jeffs, OORG Expert for the foam sector.

1. PROJECT OBJECTIVE

The objective of this project is to phase out the use of CFC-11 in the manufacture of flexible polyurethane slabstock foam at Liangzhu Foam Plastic Plant at Hangzhou, China.

2. SECTOR BACKGROUND

The Chinese Foam Industry consumed about 17,773 MT CFCs in 1991 (Ref. China Country Program). CFC-11 was the dominant substance (15,600 MT) followed by CFC-12 (2173 MT, in EPS EPE foams). No other ODS was used in statistically significant amounts, although some MCF may have been used in adhesive applications. Furthermore, some MCF and CFC-113 may have been used as mold release agents. Production is divided between generally larger state-owned enterprises and mostly smaller township or private enterprises. The table below provides more detailed information.

The Chinese Foam Industry- Selected Data (1991)			
Categories/Subcategories	ODS (MT)	Production (MT)	No. of Plants
Extruded PS/PE Foam	2,173	13,000	30 - 50
Flexible Polyurethane Foam	2,000	50,000	50 - 100
Rigid Polyurethane Foam			
Pipe Insulation	600	4,000	10 - 20
Sprayed PUF	600	4,000	50 - 200
Appliance Foam	5,000	40,000	40 - 70
PUF Panels	7,400	52,000	20 - 50
Total	13,600	100,000	120 - 340
TOTAL	**17,773**	**163,000**	**200 - 490**

The National Council of Light Industry (NCLI) is responsible for the phaseout co-ordination in all the foam categories. The other ministries/agencies involved are as under :

- Ministry of Chemical Industry (MCI)
- Ministry of Internal Trade (MIT)
- Ministry of Machinery Industry (MMI)

The Ministerial responsibility is divided into two areas :

- Refrigerating Foams
- Non-Refrigerating Foams

Complete phase-out of CFCs for non refrigerating foams is targeted for the year 2000. Rfrigerating foams are expected to be CFC-free by the year 2005.

3. ENTERPRISE BACKGROUND

Liangzhu Foam Plastic Plant is located at Hangzhou. The enterprise produced about 1100 MT of flexible slabstock PU foam in 1994, consuming about 120 MT of CFC-11. The enterprise is state-owned. The production facility includes a Beamech Vertifoam plant. The enterprise used eight formulations, four for round buns and four for square blocks. They also produced both adhesive and flame laminated foams with high molecular weight polyethylene film. The 1994 sales were RMB 19 million (US$ 2.25 million).

4. PROJECT DESCRIPTION

In this project Liangzhu will phase out the use of CFC-11 in its production of flexible slabstock PU foam, by converting to Methylene Chloride as the auxilliary blowing agent.

Methylene Chloride alone, however is not a sufficient replacement for CFC-11 at present, for low density flexible foams. Use of Methylene Chloride alone results in higher exotherm, thereby adversely affecting the foam quality and also constitutes a fire hazard, exposing the workers to fire risk. The modifications required to implement the use of Methylene Chloride are as under :

a) Increased/improved process ventilation.
b) Installation of fire safety equipment.
c) Reformulation.

The project budget includes cost of an international foams process expert assist Liangzhu in making the necessary formulation adjustments and provide adequate safety training.

5. JUSTIFICATION FOR SELECTION OF ALTERNATIVE TECHNOLOGY

There are numerous options of replacing CFCs in the production of flexible slabstock polyurethane foams. They can be categorized as under :

- **Conservation**
  CFC reduction through better housekeeping/management, reformulation, recovery/recycling.

- **Alternative blowing agents**
  Methylene Chloride, HCFCs, Acetone, AB technology.

- **Alternative Chemistry**
  Extended Range Polyols, Softening additives.

- **Alternative Manufacturing Technologies**
  EnviroCure, E-Max, Rapid Cure, Waterlily, Vacuum Foam etc.

The enterprise has opted for alternative blowing agent pathway and to an extent alternative chemistry (introduction of softening additives). Methylene Chloride constitutes the most economical solution. With the implementation of adequate safeguards, methylene chloride can also result in an environmentally acceptable solution. Methylene Chloride alone however, is not appropriate for manufacturing foams with very low densities (below 20 kg/m^3).

Trial runs with methylene chloride with increased water levels are found to give satisfactory results, in a cost effective manner without unacceptable losses in performance and processing. However, a precondition is a well planned reformulation program to implement adjustments in the amounts of blowing agent and catalyst.

Further, workplace concentrations of methylene chloride have to be limited to acceptable industrial hygenic standards. Methylene Chloride is a highly volatile chlorinated substance with a relatively low acute toxicity. The volitility can trigger high concentrations in the air. The substance is classified by the USEPA and the International Agency for Research on Cancer (IARC) as a probable human carcinogen. The U.S. Occupational Safety and Health Administration has set a time weighted average (TWA) 8-hour level of 500 ppm. In several other industrialized countries the level is even more strict (upto 50 ppm). Careful handling is therefore required to avoid exposure. Examples of safety measures include proper encapsulation of the production units, ventilation of production/storage areas, safety training of personnel and industrial hygiene monitoring.

6. PROJECT COSTS

The investment costs of US$ 187,000 include capital investment in metering/storage system for methylene chloride/softener, ventilation and safety equipment, trials, technical assistance and training, and 10% contingency. The breakdown of these is provided in Annexure 1.

The incremental operating savings of US$ 21,700 represent net present value of incremental operating costs/savings for four years of operation and do not reflect growth. Details are provided in Annexure 2.

The total OTF financing requested is US$ 170,300 representing the above costs, and inclusive of 3% financial agency fee.

7. COST EFFECTIVENESS

7.1 Unit Abatement Cost

The unit abatement cost calculated over a 10 year life span of the project is US$ 0.36 per ODP weighted kg of CFC-11 phased out. This has been derived from the incremental annualized capital costs of US$ 170,000 and net annualized recurrent operating costs of US$ 15,900(first year), for the phase-out of about 120 ODP weighted MT of CFC-11. The cost effectiveness of this project is in line with or better than other similar projects.

7.2 Grant Effectiveness

The grant effectiveness (ratio of the total OTF grant requested and the minimum ODS phased out in the first year of operation post-project) works out to **US$ 1.38/kg**, which is well within the threshold values stipulated by the Fund Secretariat.

8. REQUIRED REGULATORY ACTION

This project utilises environmentally acceptable and economically feasible technology and does not require any specific regulatory permits or action.

9. RESULTS

This project will eliminate the use of 120 MT of CFC-11 in the first year of implementation.

10. SCHEDULE

TASK	Q1	Q2	Q3	Q4	Q5	Q6
1. a) MLF Approval	X					
b) ProcurementPreparation		X				
c) Vendor Selection		X				
2. a) Transportation, arrival and customs clearance				X		
b) Installation and plant modifications.			X	X		
3. a) Machine Start-up					X	
b) Trials/Training					X	X
c) Certification						X

ANNEXURES

Annexure 1 : Capital Costs
Annexure 2 : Incremental Operating Costs
Annexure 3 : Cost Effectiveness Calculation
Annexure 4 : OORG Technical Review

ANNEXURE 1

Capital Costs

1. Metering and storage system for Methylene Chloride	: US$ 30,000
2. Metering and storage system for softener	: US$ 15,000
3. Ventilation System	: US$ 30,000
4. Fire safety equipment (Water lances, sprinklers, pumps, piping)	: US$ 40,000
5. Trials	: US$ 20,000
6. Technical assistance for formulations and safety	: US$ 20,000
7. Process and safety training	: US$ 15,000
Subtotal	: US$ 170,000
Contingencies, @ 10%	: US$ 17,000
Incremental Capital Costs	**: US$ 187,000**

ANNEXURE 2

Incremental Operating Costs

Assumptions

1. CFC-11 Price	: US$ 1.30/kg
2. Methylene Chloride Price	: US$ 0.80/kg
3. Price of Softening Additive	: US$ 3.00/kg (Required 5 MT/y post-project)
4. Price of Amine Catalyst	: US$ 3.75/kg (Required 2 MT/y post project)
5. Cost of non-CFC formulation	: US$ 2.00/kg
6. CFC : MC Ratio	: 1 : 0.9
7. Total production	: 1100 MT
8. Yield loss (post-project)	: 1st year 3%, 2nd year 2%, 3rd year 1%, 4th year 0%
9. Production affected by yield loss	: 75 %
10. Increased Energy Consumption	: 50,000 Kwh
11. Energy Costs	: US$ 0.1/Kwh
12. Maintenance Costs	: 5% of equipment costs
13. Net investment on equipment	: US$ 170,000 (Ref. Annexure 1)
14. No growth considered.	

Baseline		1995	1996	1997	1998
Cost of 120 MT CFC-11(US$)	:	156,000	156,000	156,000	156,000
Total (US$)	:	156,000	156,000	156,000	156,000

Post-Project					
Cost of 108 MT MC (US$)	:	86,400	86,400	86,400	86,400
Cost of Yield Loss	:	49,500	33,000	16,500	0
Cost of Increased Energy	:	5,000	5,000	5,000	5,000
Cost of Increased Maintenance	:	8,500	8,500	8,500	8,500
Cost of Softening Additive	:	15,000	15,000	15,000	15,000
Cost of Amine Catalyst	:	7,500	7,500	7,500	7,500
Total (US$)	:	171,900	155,400	138,900	22,400
Net Incremental Costs (US$)	:	15,900	(600)	(17,100)	(33,600)
Discount Factor	:	0.91	0.83	0.75	0.68
NPV @ 10% (US$)	:	**14,469**	**(498)**	**(12,825)**	**(22,848)**
For 4 years (US$), rounded :	:	**(21,700)**			

ANNEXURE 3

Cost Effectiveness Calculation

1. Unit Abatement Cost

A. Incremental Capital Costs	: US$ 170,000
B. Incremental Operating Costs (First year)	: US$ 15,900
C. Project Useful Life	: 10 years
D. ODS reduction per year	: 120,000 kg
E. Capital Recovery Factor	: 0.16275
UNIT ABATEMENT COST [(A X E) + B] / D	: **US$ 0.36/kg/y**

2. Grant Effectiveness

A. OTF grant requested	: US$ 165,300
B. ODS phased per year	: 120,000 kg
GRANT EFFECTIVENESS [A /B]	: **US$ 1.38/kg**

CHINA - LIANGZHU FOAM PLASTIC PLANT

TECHNOLOGY

The enterprise is proposing to convert its flexible polyurethane slabstock production from the use of CFC 11 to methylene chloride as the auxiliary blowing agent.

Methylene chloride is widely used in the industry to replace CFC 11. It generally provides an economic solution to meet the technical needs of the product. Other technologies were also considered.

The enterprise will use external experts (not identified) to oversee the conversion.

ENVIRONMENTAL ISSUES

Methylene chloride has a very low ODP and is not a controlled substance.

The main issue relates to the provision of a safe working environment. The enterprise proposes a range of equipment and training and necessary training to manage this issue.

PROJECT COSTS

The project cost effectiveness is well within the EC's proposed limit for this category.

The capital and other one-off items are justified. The operating cost calculation indicates a net saving over four years.

IMPLEMENTATION TIMEFRAME

Acceptable.

RECOMMENDATION

Approved.

GMPJ/kd/23/5/95

MONTREAL PROTOCOL ON SUBSTANCES THAT DEPLETE THE OZONE LAYER

PROJECT COVER SHEET

COUNTRY	People's Republic of China
PROJECT TITLE:	Conversion to CFC-free Technology in the Manufacture of flexible Polyurethane Foam (Slabstock)
SECTOR COVERED:	Foamed Plastics
ODS USE IN SECTOR:	17,773t CFCs (=ODP), 1991
PROJECT IMPACT:	Phase-out 70t CFC-11 per year (base 1993)
PROJECT DURATION:	One year
PROJECT ECONOMIC LIFE:	10 years
TOTAL PROJECT COST:	Incremental Investment Cost: US$ 291,500 10% contingency 29,100 Incremental operating costs 19,600 Net incremental investmt. cost 340,200 Financial Agent Fee: 10,200 Proposed OTF grant US$ 350,400
PROPOSED OTF FINANCING:	US$ 350,400
COST EFFECTIVENESS:	Unit Abatement Cost: US$ 1.04/kg/year Grant Effectiveness: US$ 4.86/kg
IMPLEMENTING ENTERPRISE:	Penglai Polyurethane Plastic Factory
COORDINATING NATIONAL BODY:	National Environmental protection Agency
IMPLEMENTING AGENCY:	The World Bank

PROJECT SUMMARY

The project will phaseout 70MT (base 1993) CFC-11 used to produce polyurethane flexible foams through the use of water/methylene chloride blowing agent and an accelerated cooling system at the Penglai Plastic Plant, a 100% state owned enterprise. The project request is only for incremental capital costs and covers an accelerated curing system, a metering and storage system for methylene chloride, improved ventilation, safety and safety training. The project will be completed within one year of authorization.

TECHNICAL ASSESSMENT: The project has been reviewed and supported by the OORG technical reviewer, Dr. Mike Jeffs. His comments are attached Project costs have been adjusted to below cost effectiveness guidelines (funding for incremental operating costs are included).

1. PROJECT OBJECTIVES

The objective of this project is to phaseout the use of CFCs in the manufacture of F-PUF at Penglai Polyurethane Plastics Plant.

2. SECTOR BACKGROUND

The Chinese foam industry consumed in 1991 17,773 tons CFCs (China Country Program). CFC-11 was the dominant substance (15,600 t, PUF), followed by CFC-12 (2,173 t, XPS/PE). Production is divided between larger state owned enterprises and smaller township or private enterprises. production and process information from state enterprises is well documented. however information on the rest of the industry is less reliable. More detailed information about the sector is provided in the following table:

Categories Subcategories	ODS (t)	Production (t)	Plants (range)
Extruded PS/PE	2,173	13,000	30-50
Flexible Polyurethane	2,000	50,000	50-100
Pipe Insulation	600	4,000	10-20
Sprayed PUF	600	4,000	50-200
Appliance Foams	5,000	40,000	40-70
PUF Panels	7,400	52,000	20-50
Total Rigid PUF	13,600	100,000	120-340
TOTAL	**17,773**	**163,000**	**200-490**

The Chinese Foam Industry
Selected Industry Data (1991)

Government and industry are committed to sharply reduce, and ultimately eliminate CFC utilization. NCLI is responsible for the phaseout coordination in all foam categories. Ministerial responsibility is divided into two areas:

- Refrigerating foams
- Non-refrigerating foams

Other ministries are involved in the refrigeration foams, i.c.:

- Ministry of Chemical Industry (MCI)
- Ministry of Internal Trade (MIT),
- China Aerospace Industry Cooperation (CAIC),
- Ministry of Machinery Industry (MMI),

Complete phaseout for non-refrigeration foams is targeted for the year 2000. Refrigerating foams are expected to be CFC free from the year 2005. Uninhibited use of CFCs in foams for domestic refrigeration is expected to lead to an increase during 1991-1995 by 8%/y, and after 1995 by 3% per year. For other foams, a growth rate of 6% per year is forecasted.

3. ENTERPRISE BACKGROUND

Penglai Polyurethane Plastic Plant ("Penglai") was established in 1984. The company produces and converts flexible PUF slabstock and produces flexible PUF molded parts for the matrass, furniture and transportation sectors.

For its F-PUF slabstock production the plant operates a vertifoam production line (Cannon-Viking, round/square convertible, 1991). Capability of production is about 3,000t. Production in 1993 was 1,000 tons, for which 70 tons CFC-11 was used. For 1994 a production of 2,000t and a consumption of 140t CFCs is expected.

In the F-PUF molded production, where 2 high pressure Cannon foam dispensers are employed for a production of 500t, no CFCs are used anymore.

4. PROJECT DESCRIPTION

Under this project Penglai will phaseout the use of CFC through a combination of methylene chloride (MC) and accelerated curing. The project includes equipment needed for the MC retrofit and two vacuum tables (for round blocks and for square blocks) for the accelerated cooling technology. An external expert will provide the design for local production, supervise the installation, start-up and production trials and will provide training on how to operate the installation without undue fire and exposure risks.

5. JUSTIFICATION FOR ALTERNATIVE TECHNOLOGY SELECTION

There are numerous options to replace CFCs in the manufacture of FPUF slabstock. These are described and reviewed in UNEP's "Technical Options Handbook" for foamed plastics.

Penglai management attended a seminar organized by NCLI, NEPA and the World Bank under a grant of the MLF. Subsequently MC was selected as the preferred option, based on technical as well as economic considerations. However, unstable quality of the local made chemicals sometimes causes scorching in low density/high water formulations. An accelerated cooling system to mitigate this effect is therefore selected as complementary technology. In low density/supersoft foams MC extracts too much heat energy from the system, causing processing problems. This will be mitigated through the use of a softening agent which will reduce the MC content in these formulations while maintaining the softness.

6. PROJECT COSTS

Investment costs of US$340,200 include capital investment of forced cooling system, MC storage and metering system, ventilation system, trial production, safety and training, and 10% contingency. See breakdown in Annex 1.

Incremental operating costs of $19,600 represent net present value of IOC for four years discounted at 10%. Details are in Annex 2.

Requested Funding: The proposed OTF grant for Penglai is US$350,400 and was calculated as follows: sum of investment costs, 10% contingency, incremental operating costs and 3% financial agency fee.

7. FINANCING PLAN

100% of project cost is to be covered by the grant.

8. COST EFFECTIVENESS

The unit abatement cost calculated over a 10 year life span of the project is US$1.04 per ODP weighted kg of CFC11 phased out. This has been derived from the incremental annualized capital costs of US$291,500 and net annualized recurrent operating costs of US$25,600 (first year), for the phaseout of about 70 ODP weighted MT of CFC11. The grant effectiveness is $4.86/kg.

9. PROJECT IMPACT

This project will result in the elimination of the use of annually a minimum of 60 tons of CFC11, based on 1993 consumption. It applies economically feasible and environmentally acceptable technology. No regulatory permit is required for is use.

The use of methylene chloride (MC) has an insignificant impact on the environment. The average atmospheric lifetime is about 6 months but can be as low as 2 months in industrial areas. Because of this relatively short lifetime MC has a negligible ozone depletion potential (0.007). Also, methylene chloride does not significantly contribute to acid rain, smog (POCP: 0.9) and global warming.

Water borne concentrations of methylene chloride will, based on the high volatility, quickly be reduced (90-95 % reduction within 0.5-1.5 hours (1)). Both aerobic and anaerobic biodegradation have been demonstrated (1,2). As a consequence, very low concentrations of MC are present in the hydrosphere, and indeed often cannot be detected.

Sufficient ventilation is required in production and curing area to limit workers exposure to an acceptable level (50ppm is recommended). The accelerated cure unit needs back-up power to avoid situations that could lead to self ignition of the foam.

Safety, production and emergency response training is required following installation, prior and during start-up as well as on a recurrent base. The project should be closed with a post-audit, assuring compliance with the recommended safety features.

Indirect Project Impact: The project will not influence quality and price of the products.

10. PROJECT IMPLEMENTATION

Management: The National Environmental Protection Agency will oversee the successful implementation of this project. The project will be carried out at the Penglai Plastic Factory.

Schedule

TASK	TIME FOR COMPLETION					
	Q1	Q2	Q3	Q4	Q5	Q6
Fastcure						
Purchase order	x					
Arrival, Customs clearing			xx			
Installation, Start-up			x			
Vertifoam						
Preparation of Tenders	x					
Purchase Orders	x					
Arrival of Equipment		xx				
Installation, Start-up			xxx			
Training			x			
Trials			x	xx		
Commissioning				x		

ANNEXES

Annex 1: Incremental Capital Costs
Annex 2: Incremental Operating Costs
Annex 3: Cost Effectiveness Calculation
Annex 4: OORG Technical Review

ANNEX 1

BREAKDOWN OF CAPITAL COSTS

Forced Cooling System (two units, for round and square blocks, including feed conveyors, installation		US$ 160,000
MC Storage/metering system		US$ 30,000
Ventilation improvements		US$ 20,000
Trials (6 foam types, 3 trials/type @ 5 minutes @ US$ 100.00/ minute chemicals, 1/2 recovered through usable foam)		US$ 4,500
Safety: Electrical Generator	US$ 20,000	
Airflow Meter	US$ 5,000	
MC Monitor	US$ 2,000	US$ 27,000
Training, Technology Transfer (includes provision of FC construction drawings and construction Supervision)		US$ 50,000
Subtotal		**US$291,500**
10% Contingencies		29,100
Inctremental Capital Costs		**US$ 320,600**

REMARKS:

1. The forced cooling system has been costed by a US civil engineer. It includes two cooling converyors, one for round blocks and one for square blocks, US$ 70,000 each, and a selective feed converyor system, US$ 20,000. It is intended to have this equipment locally made, under technical supervision. The same installation from a reputable international equipment supplier, such as Cannon-Viking will cost about US$ 200,000, excl. feed conveyors.

2. The electrical generator is needed because breakdown of power would casue fire dager in the production.

3. The foam needs to have a minimum airflow of about 5 m/sec (ASTM test) to be successfully cooled. An airflow meter is therefore included in the budget. The need has been established during the implementation of the Tianjing demonstration project.

ANNEX 2

INCREMENTAL OPERATING COSTS

ASSUMPTIONS

ITEM	PRICE (US$/T	CONSUMPTION (T/Y) BEFORE	AFTER	INFORMATION SOURCE
CFC-11	1,400	70	-	ICI
MC	950	-	63	Recipient
TIN	8,000	8	9	Goldschmidt
ENERGY (/KWH)	0.07		60,000	Power Cy.
PRODUCTION	2,000	1,000	1,000	Recipient

INVESTMENT IN EQUIPMENT : US$ 190,000
CFC/MC RATIO : 1.00/0.90
YIELD LOSS : 3/2/1/0%/y on 50% of production[1/]
MAINTENANCE : 5% of equipment investment

The recipient may use softner or 100% water in certain formualtions. While softener will not substantially change operating costs, the use of water will but is to the benefit of the receipient and therefore not incremental.

INCREMENTAL OPERATING COSTS (SAVINGS) CALCULATION (000 US$)

COST ITEM	1995	1996	1997	1998	TOTAL
BASELINE					
CFC-11	98	98	98	98	
TIN	64	64	64	64	
TOTAL	162	162	162	162	
POST-PROJECT					
MC	59.9	59.9	59.9	59.9	
TIN	72	72	72	72	
INCR. YIELD LOSS	42	28	14	0	
INCR. ENERGY	9.5	9.5	9.5	9.5	
INCR. MAINTENANCE	9.5	9.5	9.5	9.5	
TOTAL	**187.6**	**173.6**	**159.6**	**145.6**	
IOC (SAVINGS)	25.6	11.6	(2.4)	(16.4)	
DISCOUNT FACTOR	0.91	0.83	0.75	0.68	
NPV of IOC	**23.0**	**9.6**	**(1.8)**	**(11.2)**	**19.6**

[1/] 50% of the production will use MC

ANNEX 3

COST EFFECTIVENESS CALCULATION

1. Unit Abatement Cost

1. Unit Abatement Cost

a. Incremental Capital Costs	: US$291,500
b. Incremental Operating Costs (first year)	: US$25,600
c. Project Useful Life	: 10 years
d. ODS reduction per year	: 70,000 kg
e. Capital Recovery Factor	: 0.16275
Unit Abatement Cost [(a * e) + b]/d	: US$1.04/kg/year

2. Grant Effectiveness

a. OTF Grant requested	: US$340,200
b. ODS phaseout per year	: 70,000 kg
Grant effectiveness	: $4.86/kg

M:\Projects\ODS3\PS\Plai-FM.doc

ANNEX 4

CHINA - PENGLAI POLYURETHANE PLASTIC PLANT

TECHNOLOGY

The enterprise is proposing to convert its production of flexible slabstock foam from a technology based on CFC 11 to methylene chloride.

Methylene chloride technology is widely used in the industry to replace CFC 11. It generally provides an economic solution to meet the technical needs of the product. Other technologies are considered. The enterprise has concerns regarding the quality of the locally available methylene chloride and consequently an accelerated cooling system is proposed. In addition, a softening agent will be required to produce low density foams of the required softness.

The enterprise will use external experts (not identified) to oversee the conversion.

ENVIRONMENTAL ISSUES

Methylene chloride has a very low ODP and is not a controlled substance.

The main issue relates to the provision of a safe working environment. The enterprise proposes a range of equipment and training and necessary training to manage this issue.

PROJECT COSTS

The cost effectiveness at $ 6.4/kg ODS is just above the EC limit of $ 6.2/kg unless safety related items are separated out. The equipment and other one-off costs are justified.

The operating cost calculation indicates very low incremental costs which will not be claimed.

IMPLEMENTATION TIMEFRAME

Acceptable.

RECOMMENDATION

Approved.

GMFJ/kd/23/5/95

MONTREAL PROTOCOL ON SUBSTANCES THAT DEPLETE THE OZONE LAYER

PROJECT COVER SHEET

COUNTRY	:	People's Republic of China
PROJECT TITLE	:	Conversion to CFC-free technology in the manufacture of Flexible (Slabstock) Polyurethane foam at Zhenjiang.
SECTOR COVERED	:	Foamed Plastics
ODS USE IN SECTOR	:	17,773 MT CFCs (=ODP) 1991
PROJECT IMPACT	:	150 MT CFC-11 (base 1994)
PROJECT DURATION	:	1.5 years
PROJECT ECONOMIC LIFE	:	10 years
TOTAL PROJECT COST	:	Incremental Capital Costs : US$ 250,000 10% contingency : 25,000 Incremental Operating Savings : (3,900) Net Incremental investment cost : 271,100 Financial Agent fee, 3% : 8,100 Proposed OTF grant : US$ 279,200
PROPOSED OTF FINANCING	:	US$ 279,200
COST EFFECTIVENESS	:	Unit Abatement Costs : US$ 0.46/kg ODP per year Grant Effectiveness : US$ 1.81/kg
IMPLEMENTING ENTERPRISE	:	Zhenjiang # 5 Plastic Factory, Zhenjiang Jiangsu
CO-ORDINATING NATIONAL BODY	:	National Environment Protection Agency
IMPLEMENTING AGENCY	:	The World Bank

PROJECT SUMMARY

This project will phase out 120 MT of CFC-11 in the production of flexible slabstock polyurethane foam at Zhenjiang # 5 Plastic Factory, by converting from CFC-11 to Methylene Chloride as an auxilliary blowing agent. The project requires storage and metering system for methylene chloride, improved ventilation and safety systems, technical support for converting the formulations and process and safety training.

TECHNICAL ASSESSMENT: This project has been reviewed and is supported by Dr. Mike Jeffs, OORG Expert in the foam sector.

1. PROJECT OBJECTIVE

The objective of this project is to phase out the use of CFC-11 in the manufacture of flexible polyurethane slabstock foam at Zhenjiang # 5 Plastic Factory, at Zhenjiang Jiangsu, China.

2. SECTOR BACKGROUND

The Chinese Foam Industry consumed about 17,773 MT CFCs in 1991 (Ref. China Country Program). CFC-11 was the dominant substance (15,600 MT) followed by CFC-12 (2173 MT, in EPS/EPE foams). No other ODS was used in statistically significant amounts, although some MCF may have been used in adhesive applications. Furthermore, some MCF and CFC-113 may have been used as mold release agents. Production is divided between generally larger state-owned enterprises and mostly smaller township or private enterprises. The table below provides more detailed information.

The Chinese Foam Industry- Selected Data (1991)			
Categories/Subcategories	ODS (MT)	Production (MT)	No. of Plants
Extruded PS/PE Foam	2,173	13,000	30 - 50
Flexible Polyurethane Foam	2,000	50,000	50 - 100
Rigid Polyurethane Foam			
Pipe Insulation	600	4,000	10 - 20
Sprayed PUF	600	4,000	50 - 200
Appliance Foam	5,000	40,000	40 - 70
PUF Panels	7,400	52,000	20 - 50
Total	13,600	100,000	120 - 340
TOTAL	**17,773**	**163,000**	**200 - 490**

The National Council of Light Industry (NCLI) is responsible for the phaseout co-ordination in all the foam categories. The other ministries/agencies involved are as under :

- Ministry of Chemical Industry (MCI)
- Ministry of Internal Trade (MIT)
- Ministry of Machinery Industry (MMI)

The Ministerial responsibility is divided into two areas :

- Refrigerating Foams
- Non-Refrigerating Foams

Complete phase-out of CFCs for non refrigerating foams is targeted for the year 2000. Rfrigerating foams are expected to be CFC-free by the year 2005.

3. ENTERPRISE BACKGROUND

Zhenjiang # 5 Plastic Factory is located at Zhenjiang Jiangsu. The enterprise produced about 2700 MT of flexible slabstock PU foam in 1994, consuming about 150 MT of CFC-11. The enterprise is state-owned. The production facility comprises of separate buildings. One building houses a Laaderberg Maxfoam plant producing square blocks and another has a Viking Vertifoam plant producing round buns. Curing area is common to both plants and is in another building.

4. PROJECT DESCRIPTION

In this project Zhenjiang will phase out the use of CFC-11 in its production of flexible slabstock PU foam, by converting to Methylene Chloride as the auxilliary blowing agent.

Methylene Chloride alone, however is not a sufficient replacement for CFC-11 at present, for low density flexible foams. Use of Methylene Chloride alone results in higher exotherm, thereby adversely affecting the foam quality and also constitutes a fire hazard, exposing the workers to fire risk. The modifications required to implement the use of Methylene Chloride are as under :

a) Increased/improved process ventilation.
b) Installation of fire safety equipment.
c) Reformulation.

The project budget includes cost of an international foams process expert assist Zhenjiang in making the necessary formulation adjustments and provide adequate safety training.

5. JUSTIFICATION FOR SELECTION OF ALTERNATIVE TECHNOLOGY

There are numerous options of replacing CFCs in the production of flexible slabstock polyurethane foams. They can be categorized as under :

- **Conservation**
  CFC reduction through better housekeeping/management, reformulation, recovery/recycling.

- **Alternative blowing agents**
  Methylene Chloride, HCFCs, Acetone, AB technology.

- **Alternative Chemistry**
  Extended Range Polyols, Softening additives.

- **Alternative Manufacturing Technologies**
  EnviroCure, E-Max, Rapid Cure, Waterlily, Vacuum Foam etc.

The enterprise has opted for alternative blowing agent pathway and to an extent alternative chemistry (introduction of softening additives). Methylene Chloride constitutes the most economical solution. With the implementation of adequate safeguards, methylene chloride can also result in an environmentally acceptable solution. Methylene Chloride alone however, is not appropriate for manufacturing foams with very low densities (below 20 kg/m^3).

Trial runs with methylene chloride with increased water levels are found to give satisfactory results, in a cost effective manner without unacceptable losses in performance and processing. However, a precondition is a well planned reformulation program to implement adjustments in the amounts of blowing agent and catalyst.

Further, workplace concentrations of methylene chloride have to be limited to acceptable industrial hygenic standards. Methylene Chloride is a highly volatile chlorinated substance with a relatively low acute toxicity. The volitility can trigger high concentrations in the air. The substance is classified by the USEPA and the International Agency for Research on Cancer (IARC) as a probable human carcinogen. The U.S. Occupational Safety and Health Administration has set a time weighted average (TWA) 8-hour level of 500 ppm. In several other industrialized countries the level is even more strict (upto 50 ppm). Careful handling is therefore required to avoid exposure. Examples of safety measures include proper encapsulation of the production units, ventilation of production/storage areas, safety training of personnel and industrial hygiene monitoring.

6. PROJECT COSTS

The investment costs of US$ 275,000 include capital investment in metering/storage system for methylene chloride/softener, ventilation and safety equipment, trials, technical assistance and training, and 10% contingency. The breakdown of these is provided in Annexure 1.

The incremental operating savings of US$ 3,900 represent net present value of incremental operating savings for four years of operation and do not reflect growth. Details are provided in Annexure 2.

The total OTF financing requested is US$ 279,200 representing the above costs, inclusive of 3% financial agent fee.

7. COST EFFFECTIVENESS

7.1 Unit Abatement Cost

The unit abatement cost calculated over a 10 year life span of the project is US$ 0.46 per ODP weighted kg of CFC-11 phased out. This has been derived from the incremental annualized capital costs of US$ 250,000 and net annualized recurrent operating costs of US$ 28,550 (first year), for the phase-out of about 150 ODP weighted MT of CFC-11. The cost effectiveness of this project is in line with or better than other similar projects.

7.2 Grant Effectiveness

The grant effectiveness (ratio of the MLF grant requested and the minimum ODS phased out in the first year of operation post-project) works out to **US$ 1.81/year** which is well within the threshold values stipulated by the Fund Secretariat.

8. REQUIRED REGULATORY ACTION

This project utilises environmentally acceptable and economically feasible technology and does not require any specific regulatory permits or action.

9. RESULTS

This project will eliminate the use of 150 MT of CFC-11 in the first year of implementation.

10. SCHEDULE

TASK	Q1	Q2	Q3	Q4	Q5	Q6
1. a) MLF Approval	X					
b) ProcurementPreparation		X				
c) Vendor Selection		X				
2. a) Transportation, arrival and customs clearance				X		
b) Installation and plant modifications.			X	X		
3. a) Machine Start-up					X	
b) Trials/Training					X	X
c) Certification						X

ANNEXURES

Annexure 1 : Capital Costs
Annexure 2 : Incremental Operating Costs
Annexure 3 : Cost Effectiveness Calculation
Annexure 4 : OORG Technical Review

ANNEXURE 1

Capital Costs

1. Laaderberg Machine

a. Metering and storage system for Methylene Chloride	: US$ 30,000
b. Metering and storage system for softener	: US$ 15,000
c. Ventilation System	: US$ 30,000
d. Fall Plate modifications	: US$ 5,000

2. Viking Machine

a. Metering and storage system for Methylene Chloride	: US$ 30,000
b. Metering and storage system for softener	: US$ 15,000
c. Ventilation System	: US$ 30,000

3. Fire safety equipment (Water lances, sprinklers, pumps, piping)	: US$ 40,000
4. Trials	: US$ 20,000
5. Technical assistance for formulations and safety	: US$ 20,000
6. Process and safety training	: US$ 15,000
Subtotal	: US$ 250,000
Contingencies, @ 10%	: US$ 25,000
Incremental Capital Costs	: **US$ 275,000**

ANNEXURE 2

Incremental Operating Costs

Assumptions

1. CFC-11 Price	: US$ 1.30/kg
2. Methylene Chloride Price	: US$ 0.80/kg
3. Price of Softening Additive	: US$ 3.00/kg (Required 7 MT/y post-project)
4. Price of Amine Catalyst	: US$ 3.75/kg (Required 3 MT/y post project)
5. Cost of non-CFC formulation	: US$ 2.00/kg
6. CFC : MC Ratio	: 1 : 0.9
7. Total production	: 2700 MT
8. Yield loss (post-project)	: 1st year 3%, 2nd year 2%, 3rd year 1%, 4th year 0%
9. Production affected by yield loss	: 50 %
10. Increased Energy Consumption	: 60,000 Kwh
11. Energy Costs	: US$ 0.1/Kwh
12. Maintenance Costs	: 5% of equipment costs
13. Net investment on equipment	: US$ 250,000 (Ref. Annexure 1)
14. No growth considered.	

Baseline		1995	1996	1997	1998
Cost of 150 MT CFC-11(US$)	:	195,000	195,000	195,000	195,000
Total (US$)	:	195,000	195,000	195,000	195,000
Post-Project					
Cost of 135 MT MC (US$)	:	108,000	108,000	108,000	108,000
Cost of Yield Loss	:	64,800	43,200	21,600	0
Cost of Increased Energy	:	6,000	6,000	6,000	6,000
Cost of Increased Maintenance	:	12,500	12,500	12,500	12,500
Cost of Softening Additive	:	21,000	21,000	21,000	21,000
Cost of Amine Catalyst	:	11,250	11,250	11,250	11,250
Total (US$)	:	223,550	201,950	180,350	158,750
Net Incremental Costs (US$)	:	28,550	6,950	(14,650)	(36,250)
Discount Factor	:	0.91	0.83	0.75	0.68
NPV @ 10% (US$)	**:**	**25,980**	**5,768**	**(10,988)**	**(24,650)**
For 4 years (US$), rounded	**:**	**(3,900)**			

ANNEXURE 3

Cost Effectiveness Calculation

1. Unit Abatement Costs

A. Incremental Capital Costs	: US$ 250,000
B. Annualized Incremental Operating Costs	: US$ 28,550
C. Project Useful Life	: 10 years
D. ODS reduction per year	: 150,000 kg
E. Capital Recovery Factor	: 0.16275
UNIT ABATEMENT COST [(A X E) + B] / D	: **US$ 0.46/kg/y**

2. Grant Effectiveness

A. OTF Grant Requested	: US$ 271,100
B. ODS phased out per year	: 150,000 kg
GRANT EFFECTIVENESS [A / B]	: **US$ 1.81/year**

CHINA - ZHEJIANG NO 5 PLASTIC FACTORY

TECHNOLOGY

The enterprise is proposing to convert its two production lines for flexible polyurethane slabstock foam from CFC 11 to methylene chloride as an auxiliary blowing agent.

Methylene chloride is widely used in the industry to replace CFC 11. It generally provides an economic solution to meet the technical needs of the product. Other technologies were also considered.

The enterprise will use external experts (not identified) to oversee the conversion.

ENVIRONMENTAL ISSUES

Methylene chloride has a very low ODP and is not a controlled substance.

The main issue relates to the provision of a safe working environment. The enterprise proposes a range of equipment and training and necessary training to manage this issue.

PROJECT COSTS

The project cost effectiveness is well within the EC's proposed limit for this category.

The capital and other one-off items are justified. The operating cost calculation indicates a net saving over four years.

IMPLEMENTATION TIMEFRAME

Acceptable.

RECOMMENDATION

Approved.

GMFW/kd/23/5/95

PROJECT COVER SHEET

COUNTRY	:	CHINA
PROJECT TITLE	:	DAIMEI-Conversion to CFC-free technology in the manufacture of flexible PUF products
SECTOR COVERED	:	Foamed Plastics
ODS USED IN SECTOR	:	17,773 MT CFCs (=ODP) in 1991
PROJECT IMPACT	:	77 t of CFC-11 (1994 consumption)
PROJECT DURATION	:	18 months
PROJECT ECONOMIC LIFE	:	10 years
TOTAL PROJECT COST	:	USD 490,000 Capital Costs USD 126,000 Operating Costs
PROPOSED MLF GRANT	:	USD 370,000 (60% local ownership)
COST EFFECTIVENESS	:	Unit Abatement Cost : USD 1.98/kg/y Grant Effectiveness : USD 5.57/kg/y
NATIONAL EXECUTING AGENCY	:	Ministry of Machinery Industry (MMI)
NATIONAL COORDINATING BODY	:	National Environmental Protection Agency (NEPA)
IMPLEMENTING AGENCY	:	UNDP
APPRAISAL DATE	:	December 1994

PROJECT SUMMARY

This project will eliminate the use of about 77 t of CFC-11 in the production of flexible box foam, cold & hot cured molded PUF and integral skin moldings, at DAIMEI POLYURETHANE CO. LTD., by converting to Methylene Chloride (Flexible Slabstock), Water/Additive (Cold and hot cured moldings) and n-Pentane (integral skin moldings). The proposed costs will provide for equipment, trials, technical assistance for formulations and process/safety training. This project replaces Yanfeng as a demonstration project for CFC-free automotive foams. While applying for this project, the Chinese Government will withdraw the Yanfeng project, that, after the firm entered a JV with Ford, will phaseout the use of CFCs by its own financial and technical means.

PREPARED BY: Bert Veenendaal
REVIEWED BY: Dr. Hubert Creyf

PROJECT OF THE GOVERNMENT OF CHINA

DAIMEI - CONVERSION TO CFC-FREE TECHNOLOGY IN THE MANUFACTURE OF FLEXIBLE PUF PRODUCTS

1. PROJECT OBJECTIVE

The objective of this project is (i) to phase out the use of CFC-11 in the manufacture of flexible and semi-rigid polyurethane foam at Daimei Polyurethane Co. Ltd. and (ii) to function as a demonstration project for the implementation of non-ODS technology in the Chinese automotive trim industry.

2. SECTOR BACKGROUND

The Chinese Foam Industry consumed about 17,773 MT CFCs in 1991 (Ref. China Country Program). CFC-11 was the dominant substance (15,600 MT) followed by CFC-12 (2173 MT, in EPS EPE foams). The table below provides more detailed information.

The Chinese Foam Industry- Selected Data (1991)			
Categories/Subcategories	ODS (MT)	Production (MT)	No. of Plants
Extruded PS/PE Foam	2,173	13,000	30 - 50
Flexible Polyurethane Foam	2,000	50,000	50 - 100
Rigid Polyurethane Foam			
Pipe Insulation	600	4,000	10 - 20
Sprayed PUF	600	4,000	50 - 200
Appliance Foam	5,000	40,000	40 - 70
PUF Panels	7,400	52,000	20 - 50
Total	13,600	100,000	120 - 340
TOTAL	**17,773**	**163,000**	**200 - 490**

The National Council of Light Industry (NCLI) is responsible for the phaseout co-ordination in all the foam categories. The other ministries/agencies involved are as under :

* Ministry of Chemical Industry (MCI)
* Ministry of Internal Trade (MIT)
* Ministry of Machinery Industry (MMI)

The Ministerial responsibility is divided into two areas :

* Refrigerating Foams
* Non-Refrigerating Foams

Complete phase-out of CFCs for non refrigerating foams is targeted for the year 2000 and for refrigerating foams by the year 2005.

3. ENTERPRISE BACKGROUND

The Daimei Polyurethane CO. Ltd. is located in Nizi town in Daishan County, in the Zhejiang province, in coastal East China. The company was set up in 1982. The company has about 400 employees of which 30 are engineers. The manufacturing facilities are located in an area of about 35,000 sqm, of which 15,000 sqm is covered by buildings. The company has an operating joint venture with a Hongkong based company (who has 40% holding). The company manufactures flexible slabstock PUF, hot cure molded seats, cold cured automotive seats and integral skin products such as steering wheels, seats, knobs, headrests etc. The company consumed about 77 t of CFCs in all the above operations and about 2,300 t of foam in 1994.

4. PROJECT DESCRIPTION

Under this project, Damei will phaseout the use of ozone depleting substances in its various foam manufacturing operations. The scope of the project as a demonstration project is to apply where possible permanent technologies with minimum implications on the operating costs.

The chosen technologies and related activities are as follows:

a) Flexible Slabstock Foam : Daimei operates a locally procured box foam machine. It will phase out the use of CFC-11 in its production of flexible slabstock PU foam, by converting to Methylene Chloride as the auxiliary blowing agent. This would involve costs for provision of ventilation, a methylene chloride pump, trials, technical assistance for formulation and for safety/process training.

b) Hot Cured Moldings : The CFC-11 will be replaced by water based system in conjunction with additives. The increased viscosities will require the use of high pressure foam dispenser in place of the present low pressure unit. The current high pressure unit for integral skin foams will be used for this purpose. Provision for cost of trials, technical assistance for formulation and process training will be required.

c) Cold Cured Moldings : The CFC-11 will be replaced by water based system with modified polyol. The company already has a high pressure machine, hence only costs of trials, training and technical assistance would be involved.

d) Integral Skin Moldings : CFC-11 will be replaced by n-pentane. The company already has a high pressure machine for this production line and will relocate this unit in the hot cured foam production. A new high pressure foam dispenser suitable for the use of flammable liquids is foreseen in conjunction with auxiliaries, such as a premixer, buffer and storage tanks, and safety related investments such as ventilation, grounding and a hydrocarbon sensing system. In addition, trials, technical assistance and training will be required.

The project will function as a demonstration project for CFC-free manufacturing technologies in automotive foams. Originally, Yanfeng in Shanghai was selected for this purpose and a grant of USD 670,000 was approved (14th ExCom). However, this company entered a joint venture with Ford and has retracted from its agreement to act as a demonstration project, with includes the willingness to share the experience acquired under this project with other companies. The Government will therefore withdraw the Yanfeng project and submit the Damei proposal as a substitute.

5. TECHNOLOGY

There are numerous technologies to replace the use of CFCs in **flexible PUF boxfoams**. Available replacements fall into the following categories:

- o Alternative blowing agents
- o Alternative chemistry
- o Alternative manufacturing technologies

Methylene chloride has been chosen as the most economic alternative. The relatively high densities do not require any supporting technologies.

ODS phaseout technologies for **flexible PU molded foams** are for all practical purposes restricted to water based technologies, sometimes complemented with (premixed) additives, specifically in the case of hot cured foams.

ODS phaseout technologies for **integral skin foams** are:

Low ODS Technologies ("Interim")	> HCFC-22
	> HCFC-141b
ODS free technologies ("Permanent")	> Pentane
	> HFC-134a
	> Water Based

The company has selected n-pentane as replacement in this application. Water based technology has not yet been introduced by chemical suppliers in China and HFC-134a would increase the operating costs to an unacceptable level.

6. PROJECT COSTS

6.1. CAPITAL COSTS

Description	Cost(USD) Item	Group	Safety
a) Slabstock PUF		30,000	
Methylene Chloride Pump/Hoses	5,000		
Ventilation	10,000		
Fire Safety provisions	5,000		
Trials	5,000		
Training/Technical Assistance	5,000		
b) Hot Cured Moldings		35,000	
Relocation Foam Dispenser	20,000		
Trials	5,000		
Technical assistance/training	10,000		
c) Cold Cured Moldings		15,000	
Trials	5,000		
Technical assistance/training	10,000		
d) Integral skin Moldings		365,000	
Pentane Foam Dispenser	155,000		45,000
Pre-blender with Buffer Tank	85,000		25,000
Pentane Tank	30,000		30,000
Ventilation	20,000		20,000
HC Sensing System	35,000		35,000
Grounding	5,000		5,000
Trials	5,000		5,000
Technical assistance/training	20,000		
Safety Audit	10,000		10,000
Contingencies (10%)		45,000	17,000
TOTAL INCREMENTAL CAPITAL COST		**490,000**	**187,000**

Prices for equipment are taken from similar projects, where possible from the results of recent competitive bidding.

6.2. OPERATING COSTS/BENEFITS

The details of operating costs/benefits for all the above mentioned production lines is described hereunder :

a) Flexible Slabstock Foam

Before	: 20 t CFC-11 (USD 1.4/kg)	: USD 28,000
After	: 18 t MeCl (USD 0.95/kg)	: USD 17,100
Net Incremental Operating Savings (A)		: USD (10,900)

b) Hot Cured Moldings

Before	: 44 t CFC-11 (USD 1.4/kg)	: USD 61,600
	150 t TDI (USD 2.50/kg)	: USD 375,000
After	: 194 t TDI (USD 2.50/kg)	: USD 485,000
	4 t Additive (USD 7.5/kg)	: USD 30,000
Net Incremental Operating Costs (B)		: USD 78,400

c) Cold Cured Moldings

Before	: 5 t CFC-11 (USD 1.4/kg)	: USD 7,000
	18 t MDI (USD 2.50/kg)	: USD 45,000
After	: 25 t MDI (USD 2.50/kg)	: USD 62,500
Net Incremental Operating Costs (C)		: USD 10,500

d) Integral Skin Moldings

Before	: 8 t CFC-11 (USD 1.4/kg)	: USD 10,400
After	: 6 t n-pentane (USD 0.8/kg)	: USD 4,800
Net Incremental Operating Savings (D)		: USD (5,600)

Incremental Operating Costs (A+B+C+D): USD 72,400

Net present Value (2y; 10%) (x 1.74)) USD 126,000

Chemical prices are obtained from several companies and chemical suppliers and standardized for UNDP and World Bank projects in the foam industry that are prepared for the 17th ExCom

6.3. COST EFFECTIVENESS

5.3.1 Unit Abatement Costs

a.	ODS Reduction Capital Costs	: US$ 490,000
b.	Annual incremental costs	: US$ 72,400
c.	Capital Recovery Factor(10y/10%)	: 0.16275
d.	ODS Reduction/year	: 77,000 kg
Unit Abatement Costs [{(a(c) + b})/d]		**:US$ 1.98/kg/y**

6.3.2 Grant Effectiveness

According to a decision taken at the 16th ExCom, the cost effectiveness of projects submitted to the 17th ExCom should not exceed certain established thresholds. The cost effectiveness has been defined as the complete costs (before substraction of foreign owned shares) minus safety related items (in case of the use of pentane), divided by the ODP/y saved.

a.	Project Costs	: US$	616,000
b.	Safety related Costs	: US$	187,000
c.	ODS phased out	: kg	77,000
Grant Effectiveness [(a-b)/c]		**: US$**	**5.57/kg/y**

The applicable thresholds are:	GENERAL FOAMS	9.53
	FLEXIBLE POLYURETHANE	6.23
	INTEGRAL SKIN	16.86

The project thus qualifies from a view of grant effectiveness.

7. FINANCIAL PLAN

The enterprise requests a grant covering 60% of the total incremental cost as calculated under 5.1 and 5.2, which represents the local share :

US$ 370,000
===========

8. PROJECT IMPACT

This project will eliminate the use of 77 t of CFC-11 in the first year after implementation. The project employs commercially viable and environmentally acceptable technology.

9. SCHEDULE

TASK	Q1	Q2	Q3	Q4	Q5	Q6
1.a) MLF Approval	X					
b) Procurement Preparation		X				
c) Vendor Selection		X				
2.a) Transportation, arrival and customs clearance				X		
b) Installation and plant modification.			X	X		
3.a) Machine Start-up					X	
b) Trials/Training					X	X
c) Certification						X

Annex: Technical Review

...\UNDP\CHINA\DAIMEI.WPD
950619/CC/BV/004

PROJECT COVER SHEET

COUNTRY:	CHINA
PROJECT TITLE:	Elimination of CFCs in the Manufacture of EPS/PE Sheets/Nettings at 4 companies
SECTORS COVERED:	Foamed Plastics
ODS USE IN SECTOR:	7,773 tons CFCs (=ODP) in 1991
PROJECT IMPACT:	270 t/y CFCs (=ODP; base 1993)
PROJECT DURATION:	18 months
PROJECT ECONOMIC LIFE:	10 years
TOTAL PROJECT COST:	Incremental Capital Cost: USD 2,189,000
PROPOSED MLF GRANT:	USD 2,189,000
COST EFFECTIVENESS:	USD 8.1/kg (Grant Effectiveness) USD 1.32/kg/y (Unit Abatement Cost)
NATIONAL EXECUTING AGENCY:	National Council of Light Industry (NCLI)
NATIONAL COORDINATING AGENCY:	National Environmental Protection Agency (NEPA)
IMPLEMENTING AGENCY:	UNDP
APPRAISAL DATES:	December 1994

PROJECT SUMMARY

In China, about 100 enterprises manufacturing extruded PS/PE foam sheet have been identified. Currently, predominantly CFC-12 is used as blowing agent. Under this project, 4 enterprises will switch to the use of butane as alternative blowing agent. Butane is highly flammable and its usage requires extensive safety measures. The process conversion to butane will include retrofitting of existing extruders, installation of butane storage tanks, building modifications, exhaust and ventilation systems and gas detection systems. Technology transfer and trials are also essential elements of the conversion.

Prepared by: Mr. Ko Swee Hee
Reviewed by: Mr. Denis Knaus

PROJECT OF THE GOVERNMENT OF CHINA

ELIMINATION OF CFCs IN THE MANUFACTURE OF EXTRUDED POLYSTYRENE/POLYETHYLENE FOAM SHEETS AT 4 ENTERPRISES

1. PROJECT OBJECTIVE

The objective of this project is to phaseout the use of CFCs in the manufacture of extruded polystyrene foam sheet at 4 enterprises across China.

2. SECTOR BACKGROUND

The Chinese foam industry consumed in 1991 17,773 tons CFCs (China Country Programme). CFC-11 was the dominant substance (15,600 t, PUF), followed by CFC-12 (2,173 t, XPS/XPE). Production is divided between larger state-owned enterprises and smaller township or private enterprises. More detailed information about the sector is provided in the following table:

Categories Sub-categories	ODS (t)	Production (t)	Plants (range)
Extruded PS/PE	2,173	13,000	30- 50
Flexible Polyurethane	2,000	50,000	50-100
Pipe Insulation	600	4,000	10- 20
Sprayed PUF	600	4,000	50-200
Appliance Foams	5,000	40,000	40- 70
PUF Panels	7,400	52,000	20- 50
Total Rigid PUF	13,600	100,000	120-340
TOTAL	**17,773**	**163,000**	**200-490**

The Chinese Foam Industry
Selected Industry Data (1991)

Government and industry are committed to sharply reduce and ultimately eliminate CFC utilization. The National Council of

Light Industry (NCLI) is responsible for the phaseout coordination in all foam categories and has, as part of the Country Programme preparation, worked out a detailed phaseout strategy. This strategy has just been updated.

The proposed sub-projects in this proposal have been developed as part of a MLF funded instructional workshop program, implemented through The World Bank. The stated goal of this program is to develop a minimum of five ODS phaseout projects after each workshop. So far, 30 project requests have been logged after just two workshops. The next and last workshop will be held in February 1995.

3. ENTERPRISE BACKGROUND

The following 4 enterprises are covered by this project:

ENTERPRISE	CFC TONNES	LOCAL SHARE
TIANJIN GANGDA	55	100%
J.I.P. BUOTOU	90	100%
CANGZHOU	75	100%
HANDAN NO.7	50	100%
TOTAL:	270	

More information on the individual enterprise is provided under the respective sub-project in the annexes.

4. PROJECT DESCRIPTION

The total CFC consumption of the four enterprises amounted to 270 tonnes in 1994. In line with China's plan to eliminate ODS consumption, the enterprises have selected, after technical and economic evaluation of the various available options, butane as the replacement of choice. Under the project, existing extruders will be retrofitted and the production areas will be adapted to meet the butane usage requirements. Butane storage tanks and the required safety systems to mitigate fire and exposure hazards from the use of butane will be installed, as well as improved exhaust and ventilation systems. Extensive safety and production training will also be provided by an external process expert.

5. TECHNOLOGY

5.1 OVERVIEW

There are several options to replace CFCs in the production of XPS/XPE foam sheet, such as:

- o Atmospheric gases (Nitrogen; Carbon Dioxide);
- o Hydrocarbons (LPG; butanes; pentanes);
- o HCFCs (-22; -142b);
- o HFCs (-134a; -152a).

5.1.1 ATMOSPHERIC GASES

NITROGEN GAS is inert, nontoxic and noncombustible, but asphyxiant. The use is burdened by a low solubility in the resin and a relatively high density of the end product. New resin developments may make the use of nitrogen a more viable in the future.
BERSTORFF TECHNOLOGY is based on a mixture of nitrogen and alcohol. This technology exhibits undefined risks in toxicity and fire. The resulting product has also a higher density.
CARBON DIOXIDE GAS is an asphyxiant, high energy consuming and moderately toxic gas. Carbon dioxide as a co-agent is proven technology. The use of only CO_2 in EPS sheet is patented and requires licensing.

5.1.2 HYDROCARBONS

N-PENTANE, BUTANE, ISOPENTANE AND ISOBUTANE are proven replacements. The technology is cost effective and results in product of acceptable quality. However, the flammability of hydrocarbons requires stringent safety precautions in the manufacturing process, resulting in the need for retrofitting. In addition, hydrocarbons are petrochemically reactive and contribute to the formation of atmospheric zone.
LIQUIFIED PETROLEUM GASES (LPG) has also been proposed as replacement for CFC-12 in PE/PP and PS foam industry. LPG is however toxic, flammable and not generally accepted for food packaging. If used, molecular sieves as purifier/deodorizer and a buffer agent for boiling point stabilization will be required.

5.1.3 HYDROCHLOROFLUOROCARBONS

HCFC-22 is non-flammable, low in toxicity, thermal and chemical active, has been proven effective. The compound has however an ODP, and only qualifies as an interim replacement. **HCFC-142b** can be used alone or in combination with HCFC-22 to reduce the flammability. The price penalty is however considerable and equipment has to be modified to cope with the moderate flammability and the modified diffusivity of the compound.

5.1.4 HYDROFLUOROCARBONS

HFC-134a is non-flammable, low in toxicity and with no ODP, is just recently introduced in the market. The current pricing will prevent utilization in the very cost sensitive food serving and packaging applications. The utilization of HFC-134a in foam competes with the utilization as a refrigerant in appliances and automotive air conditioners. **HFC-152a** is low in toxicity, moderate flammable and possesses no ODP. It appears to be a long term alternative. The compound's flammability will required modification of production equipment.

5.2 SELECTION

The use of butane has been selected to replace CFCs in the conversion because it is

- a proven technology in processing and product performance,
- environmentally acceptable,
- low in toxicity,
- adaptable to the existing equipment,
- cost effective

A draw back is its high flammability, requiring stringent safety precautions. Also, butane is currently only available with a maximum purity of ranging from 60 to 80% which will affect the quality slightly. The enterprises are all aware of this and will address both issues during project implementation.

5.3. REQUIRED MODIFICATIONS

The use of LPG/butane will require substantial changes in the production and storage facilities. The possible changes or modification may include :

- **Plant Exhaust System**
  - The plant/warehouse air must be moving at all times.
  - Exhaust ducts or fans mounted at floor level and parallel to the foam extruder line.
  - Exhaust ducts or fans to draw fresh air across the plant floor area in the foam storage area.
  - The plant and warehouse air should be changed hourly.
  - The exhaust fans do not need explosion proof motors.

- **Ceiling Fans/Blow-down Fans**
  - Production area and the warehouse should have ceiling fans spaced 10-13 meter apart.

* Fans should run continuously and will keep the air circulating to prevent pockets of butane build up in the building.

o **Foam Storage Area**

* Air must be moving at all times by using fans and wall mounted exhaust fans at floor area.
* Fans spaced 10 -13 meter apart with louvered openings located on the wall opposite the exhaust fans.
* Exhaust ducts to draw fresh air across the plant floor in the foam storage area.
* Polyethylene bags used to wrap rolls should be perforated to allow butane to flow out of and fresh air to flow in. Diameter of holes is about 10 to 15 mm and spaced about 150 to 200 mm apart. Furthermore, polyethylene bags should be anti-static.
* Stack rolls on pallets to circulate air around the roll more easily.

o **Butane Sensing Equipment**

* Permanent monitoring device to be installed at the following locations to detect possible presence of butane:
  - bulk storage tank
  - high pressure pump
  - die-head of extruder
  - reclaim grinder/recycling machine
  - foam storage area.
* Portable gas detecting system to monitor the butane throughout the plant.

o **Bulk Storage Tank**

* Installation and location of bulk storage tank are subject to compliance with the local rules and regulations. The recommended design pressure for a hydrocarbon tank is 250 psi, this will allow storage of propane which exerts the maximum vapor pressure.
* Low pressure pump, high pressure pump and deodorizer to be included in this area.
* Standard safety features pertaining to the use of hydrocarbons, such as piping system, pressure relief and return system, pressure gauge and switch, water sprinkler system, fire fighting equipment etc to be considered while design for the bulk storage tank area.

o The whole plant must have sufficient fire extinguishers, of which some are trolley mounted and most are handheld. Both CO_2 or powder type of fire extinguishers are acceptable. Static eliminators should be installed at winding section to arrest static current from the roll.

- o In line with the above-mentioned modifications on equipment and safety requirement, the following process adjustment are required:
  * addition of anti-shrinkage and buffer agent to improve cell size and to control diffusion,
  * Readjustment of heaters and extrusion pressure to achieve the correct density and to reduce fire hazard,
  * addition of anti-static agent to further reduce fire hazards from spark generation.

Users of hydrocarbons are subject to stringent fire regulations. The appointment and training of a company safety expert is strongly recommended. The emission of hydrocarbons is currently not regulated in China, nor are restrictions expected in the foreseeable future.

ALL SAFETY PRECAUTIONS MUST CONFORM TO THE REQUIREMENTS OF RELEVANT LOCAL, PROVINCIAL AND STATE AUTHORITIES

6. PROJECT COSTS

6.1 INCREMENTAL CAPITAL COSTS

For the conversion of the manufacturing process to use of butane, the following cost elements may be involved:

Equipment retrofitting:
- motors & accessories
- mechanical adjustments
- Engineering/labor fees

Building modification:
- Fire deflecting walls
- Separation walls
- Separation of the Control Room

Relocation costs:
- Dismantling and re-assembling of extruder(s) or thermoforming equipment from current location to another within the same plant or to a new location (cost of the new location are not included)
- loading and unloading (requiring the use of crane-lift) of extruders
- Transportation cost

Trials and production training:

Technology transfer and safety training

The consolidated project cost of these 4 sub-projects is

USD 1,881,100
=============

A summary of the incremental capital costs for the 4 sub-projects is presented in Table 1 below.

TABLE 1: SUMMARY OF INCREMENTAL CAPITAL COSTS(USD)

TABLE 1: SUMMARY OF INCREMENTAL CAPITAL COSTS(USD)

Enterprise	Tank	Retrofit	HP Pump/ Metering	Sprinkler	Miscellaneous Equipment	Safety	TT	Cont.	Total
Tianjin Gangda	60,000(1)	70,000	75,000	30,000	8,500	139,000	20,000	40,000	443,000
Cangzhou	80,000(2)	80,000	100,000	30,000	52,500	143,500	20,000	50,000	556
J.I.P. Buotou	85,000(2)	120,000(5)	175,000	30,000	52,500	158,500	20,000	64,000	705,000
Handan No. 7	50,000	80,000	75,000	30,000	68,500	117,500	20,000	44,000	485,000
Total	275,00	350,000	425,000	120,000	182,000	559,000	80,000	1998,000	2,189,000

6.2 INCREMENTAL OPERATING COSTS

The costs and availability of CFCs in China varies from place to place and can be very high in remote areas. On the other side, facilities in such areas have no problems to include such costs in their prices as the very location provides also a real sales protection. The calculation of incremental costs/benefits (IRC/IRB) with standardized chemical prices would change competitive positions dramatically. Although butane is cheaper than CFC-12, additional recurring costs on account of additives, extra maintenance, safety training and monitoring, higher insurance etc., are expected. These additional costs in the case of these four enterprises are negligible and no incremental operating cost is requested.

6.3 COST EFFECTIVENESS

6.3.1 Grant Effectiveness

a)	MLF Grant:	US$ 2,189,000
b)	ODS phased out:	270,000 kg
	Grant Effectiveness [a/b]:	**USD8.1/kg**

6.3.2 Unit Abatement Costs

a)	Project Costs:	USD 2,189,000
b)	Annual Incremental Costs/Benefits:	USD 0
c)	Capital Recovery Factor (10%):	0.16275
d)	ODS Reduction/yr:	kg 270,000
	Unit Abatement Costs [(a*c + b)/d]:	USD 1.32/kg/y

7. FINANCING PLAN

The total incremental costs being requested for the 4 sub-projects amounts to **USD 2,189,000**.

8. PROJECT IMPLEMENTATION

8.1 Management

UNDP will oversee the successful implementation of the sub-projects and will provide technical assistance during project execution.

8.2 SCHEDULE

The following implementation schedule is applicable to all the 4 enterprises.

TASK	Q1	Q2	Q3	Q4	Q5	Q6
Project Preparation						
Specifications	X					
Tenders, Selection	XX		X			
Purchase Orders	X		X			
Site preparation		X				
Building Adaptations		XX				
Civil Works			XXX			
Tanks Installation				X	XX	
Equipment Changes				XXX		
Start-up, Trials, Training					XX	X
Commissioning						X

9. REQUIRED REGULATORY ACTION

The enterprises will check with local authorities on fire regulations and will comply fully with national and local safety regulations and standards.

10. PROJECT IMPACT

These projects will eliminate the use of a total of **270 tons** of CFCs upon project completion. The projects employ commercially viable and environmentally acceptable technology.

11. ANNEXES

Annex 1: Sub-project No. 1: TIANJIN GANGDA
Annex 2: Sub-project No. 2: CANGZHOU
Annex 3: Sub-project No. 3: BUOTOU
Annex 4: Sub-project No. 4: HANDAN # 7

Annex 1

PROJECT COVER SHEET

COUNTRY:	CHINA
PROJECT TITLE:	TIANJIN GANGDA PLASTICS CO. - Elimination of CFC-12 in the Manufacture of EPS Foam Sheet
SECTOR COVERED:	Foamed Plastics
ODS USED IN SECTOR:	17,773 t CFCs (=ODP) in 1991
PROJECT IMPACT:	55 t CFC-12/y (1993 consumption)
PROJECT DURATION:	18 months
PROJECT ECONOMIC LIFE:	10 years
TOTAL PROJECT COST:	Capital cost: USD 443,000 (incremental capital cost)
PROPOSED MLF GRANT:	USD 443,000
COST EFFECTIVENESS:	USD 8.0/kg (Grant Effectiveness) USD 1.31/kg/y (Unit Abatement Cost)
NATIONAL EXECUTING AGENCY:	China National Council of Light Industry (NCLI)
NATIONAL COORDINATING BODY:	National Environmental Protection Agency (NEPA)
IMPLEMENTING AGENCY:	UNDP
APPRAISAL DATE:	December 1994

==

PROJECT SUMMARY

TIANJIAN GANGDA PLASTIC CO. Ltd. is a state-owned enterprise which is directly under the supervision of Tianjin State-operated Farm Management Bureau. Under this project, Kangda will eliminate the use of 70 t of CFC-12 by using butane as a substitute. The project includes the costs of retrofitting the existing extruder, other butane equipment and safety equipment, technology transfer and trials.

Prepared by: Ko Swee Hee
Reviewed by: Dr. , UNDP Technical Reviewer

PROJECT OF THE GOVERNMENT OF CHINA

TIANJIN GANGDA - CONVERSION TO CFC-FREE TECHNOLOGY IN THE MANUFACTURE OF EXTRUDED POLYSTYRENE FOAM SHEETS

1. PROJECT OBJECTIVE

The project will eliminate the use of 70 t/yr of CFC-11 in the manufacturing of extruded polystyrene foams at Tianjin Gangda.

2. ENTERPRISE BACKGROUND

TIANJIN GANGDA was established in 1992 as a state-owned enterprise under the supervision of the Tianjin State-operated Farm management Bureau. The enterprise is located about 12 km to the southwest of Tianjin. The existing extruder together with the vacuum forming and recycling machines is located in a single storied building which is suitable to implement the conversion to butane. The factory employs about 100 workers. Raw materials and CFCs usage were as follows:

1992: 300 t of resin, 30 t CFC-12;
1993: 500 t of resin, 55 t CFC-12;
1994: 650 t of resin, 70 t CFC-12.

3. PROJECT DESCRIPTION

Under this project, TIANJIN GANGDA will phase out the use of CFC-12 in its XPS foam sheet production through substitution by butane as replacement. Butane is available in China with purity degree ranging from 60-80% which is still acceptable as blowing agent in this industry. "MERCAPTAN" is added into butane to ease detection of butane presence. This requires deodorizing as well as strict control on variation in volatiles by adding buffering agent. The project includes modification of existing extruder, fire safety and alarm system in the production area and warehouse to mitigate fire and exposure hazard from the use of butane. Extensive production and safety training and technology transfer to the plant operators will be provided through an external process specialist.

4. PROJECT COSTS

4.1. CAPITAL COSTS

Description		Cost (USD)
o 1 butane bulk tank		60,000
o Extruder retrofitting (1 set)		70,000
o High pressure pump/metering system		75,000
o Cast heaters with EX terminal box		8,500
o Sprinkler system		30,000
o Fire safety & Alarm systems		135,500
Exhaust Fans (38 pcs)	45,000	
Exhaust hood	5,500	
Industrial blowdown fans (38)	21,000	
Gas sensing/detection system (6)	25,000	
Portable gas detector (1)	4,000	
Fire extinguishers	15,000	
Trolley mounted (6)	12,000	
Handheld (15)	3,000	
Antistatic blowers and bars (2)	6,000	
Emergency spot light (6)	4,000	
Relocation of Electrical Wiring	3,000	
Explosion-proof lights (48 pc)	4,000	
Fire doors 2-sided open (8 pc)	3,000	
o Clothing		4,000
o Technology transfer/training		20,000
o Contingency/rounding		40,000
TOTAL INCREMENTAL CAPITAL COST		**443,000**

4.2. OPERATING COSTS/BENEFITS

Before (CFC-12):	55 t @ US$ 1,550/t =	US$ 85,250
After (Butane):	55 t @ US$ 1,100/t =	US$ 60,500
Additives:	275 kg @ US$ 30/kg =	8,250
Maintenance/Training & monitoring:	5% of project cost =	22,040
Sub-total:		US$ 90,790
Net Incremental Operating Cost:		US$ 5,540/yr

The net cost is negligible and it is not being requested.

4.3. COST EFFECTIVENESS

4.3.1 Grant Effectiveness

a.	MLF Grant	US$ 443,000
b.	ODS phased out	55,000 kg

Grant Effectiveness [a/b]:US$ 8.0/kg

4.3.2 Unit Abatement Cost

a.	ODS Reduction Capital Costs	US$443,000
b.	Annual incremental costs	-
c.	Capital Recovery Factor(10y/10%)	0.16275
d.	ODS Reduction/year	kg 55,000
Unit Abatement Costs [{(a(c) + b})/d]:		**US$/kg/y 1.31**

5. FINANCIAL PLAN

The enterprise requests a grant covering the total incremental cost of **US$ 443,000** as calculated under 3.1

6. PROJECT IMPACT

This project will eliminate the use of at least 55 t of CFC-12 in the first year of implementation. The project employs commercially viable and environmentally acceptable technology.

7. ANNEXES

Annex 1A: Technical Review

TECHNICAL REVIEW

1. Country:
China

2. Project Title:
Elimination of CFC-12 in the manufacture of polystyrene foam sheet at TIANJIN GANGDA PLASTICS CO.

3. (Sub) Sector:
Foamed Plastics.

4. CP-Relationship:
The CP of China targets for a total CFC phase out by the year 2000. The responsible body is the National Council of Light Industry (NCLI) with the involvement of the National Environmental Protection Agency (NEPA).

5. Technology:

5.1 HYDROCARBON
N-BUTANE is proven replacements for CFC-12 in the manufacturing of polystyrene foam sheet. The technology is cost effective and results in product of acceptable quality. However, the flammability of hydrocarbons requires stringent safety precautions in the plant, manufacturing process, and post extrusion conversion resulting in the need for retrofitting. The lack of good management and maintenance at the typical Chinese plant makes using 100% hydrocarbon, as a foam blowing agent, a potentially dangerous situation.

5.2 CARBON DIOXIDE GAS BLENDED WITH N-BUTANE
Blending **CARBON DIOXIDE GAS** with **N-BUTANE** is a proven replacements for CFC-12 in the manufacturing of polystyrene foam sheet. The technology is cost effective and results in product of acceptable quality. The blend reduces significantly, the fire hazard associated with using a 100% hydrocarbon as a polystyrene foam blowing agent and is the most sensible and safest choice for China. The process is patented and requires licensing.

6. ENVIRONMENTAL IMPACT:
N-BUTANE emissions contribute to the formation of smog which can be reduced by utilizing carbon dioxide as a partial replacement for these gases.

7. PROJECT COSTS:
The incremental costs as presented are acceptable, as are the incremental operating savings and is based on other field visits where the scope of the safety modifications required to retrofit the plant and process equipment was significant.

The cost to the MLF elimination of 1 kg. of ODS is USD8.00 /kg

8. IMPLEMENTATION:

The time frame of the project is feasible.

9. RECOMMENDATIONS:

The project should be accepted as written, however, if possible the carbon dioxide/n-butane should be used to reduce the safety risks encountered when using 100% n-butane.

Prepared by Dennis A. Knaus, UNDP Foam Sector Consultant

PROJECT COVER SHEET

COUNTRY:	CHINA
PROJECT TITLE:	CANGZHOU FOREIGN TRADE PACKAGING CO. Elimination of CFC-12 in the Manufacture of EPS Foam Sheets.
SECTOR COVERED:	Foamed Plastics
ODS USED IN SECTOR:	17,773 t CFCs (=ODP) in 1991
PROJECT IMPACT:	75 t of CFC-12 (1994)
PROJECT DURATION:	18 months
PROJECT ECONOMIC LIFE:	10 years
TOTAL PROJECT COST:	US$ 556,000 Incr. Capital Cost
PROPOSED MLF GRANT:	USD 556,000
COST EFFECTIVENESS:	Unit Abatement Cost - US$ 1.2/kg Grant Effectiveness - US$ 7.4/kg
NATIONAL IMPLEMENTING AGENCY:	China National Council of Light Industry (NCLI)
NATIONAL COORDINATING BODY:	National Environmental Protection Agency (NEPA)
IMPLEMENTING AGENCY:	UNDP
APPRAISAL DATE:	December 1994

===

PROJECT SUMMARY

Cangzhou Foreign Trade Packaging Co. ("Cangzhou") is a state-owned enterprise directly under the supervision of Foreign Trade Economic Relations Bureau of Cangzhou city. Under this project, Cangzhou will phase out 75 t of CFC-12 by converting to butane. The project includes retrofitting of existing extruder, installation of butane tank, safety equipment and training, technology transfer and trials.

PREPARED BY: Ko Swee Hee
REVIEWED BY: Dr.

PROJECT OF THE GOVERNMENT OF CHINA

CANGZHOU - CONVERSION TO CFC-FREE TECHNOLOGY IN THE MANUFACTURE OF EPS FOAM SHEETS

1. PROJECT OBJECTIVE

The project will eliminate the use of 75 t/yr of CFC-12 in the manufacture of EPS foam sheets at CANGZHOU Company.

2. ENTERPRISE BACKGROUND

CANGZHOU was established in 1991 as a state-owned enterprise under the direct supervision of the Foreign Trade Economic Relations Bureau. It is situated in the Cangzhou City in Hebei Province. The existing production area including the extruder, the vacuum forming machine and the recycling machine is in a building that adjoins the worker's hostel, which will not be safe when the changeover to butane is implemented. The company has therefore decided to relocate its production area to another building within the same premises, where this project will be implemented. The company employs about 80 workers in a three shift operation. The raw material and CFCs usage was as follows:

1992: 480 mt of resin, 50 t CFC-12
1993: 600 mt of resin, 75 t CFC-12
1994: 600 mt of resin, 75 t CFC-12

3. PROJECT DESCRIPTION

Under this project, CANGZHOU will phase out the use of CFC-12 in its EPS foam sheets production through replacement by butane. Butane is available in China with purity ranging from 60-80% which is still acceptable as blowing agent in this industry. "MERCAPTAN" is added into butane to ease detection of butane presence, thus requiring deodorizing as well as strict control on variation in volatiles by adding buffering agent. The project includes modification of existing extruder, fire safety and alarm system in the production area and warehouse to mitigate fire and explosion hazard from the use of butane. Extensive production and safety training and technology transfer to the plant operators will also be provided through an external process specialist.

4. PROJECT COSTS

4.1. CAPITAL COSTS

Description		Cost (USD)
o 2 butane bulk tank (5 t)		80,000
o Sprinkler system		30,000
o Extruder retrofitting (2 sets)		80,000
o High pressure pump/metering systems (2)		100,000
o Cast heaters with EX terminal box		8,500
o Fire deflection wall (10m)		4,000
o Equipment Relocation		40,000
o Fire safety & Alarm systems		139,500
Exhaust fans (14 pcs)	45,000	
Ventilation ducting (32m)	15,000	
Industrial blow down fans (22 pc)	22,000	
Gas sensing/detection system (7 pt)	35,000	
Portable gas detector	4,000	
Fire extinguishers		
* Trolley mounted (5)	6,500	
* Handheld (20)	2,000	
Antistatic blowers and bars (2)	6,000	
Emergency spot light (6)	4,000	
o Clothing		4,000
o Technology transfer/training		20,000
o Contingency/rounding		50,000
TOTAL INCREMENTAL CAPITAL COST		**556,000**

4.2. OPERATING COSTS

Before (CFC-12):	75 t @ US$ 1,550/t =	US$ 116,250
After (Butane):	75 t @ US$ 1,100/t =	US$ 82,500
Additives:	375 kg @ US$ 30/kg =	11,250
Maintenance/Training & monitoring:	5% of project cost =	23,400
Sub-total:		US$117,150
Net Incremental Operating Cost:		US$ 900/yr

The net cost is negligible and it is not being requested.

4.3. COST EFFECTIVENESS

4.3.1 Grant Effectiveness

a. MLF Grant	US$ 556,000
b. ODS phased out	75,000 kg
Grant Effectiveness [a/b]	**US$ 7.4/kg**

4.3.2 Unit Abatement Costs

a. ODS Reduction Capital Costs	US$ 556,000
b. Annual incremental costs	-
c. Capital Recovery Factor(10y/10%)	0.16275
d. ODS Reduction/year	kg 75,000
Unit Abatement Costs [{(a(c) + b})/d]	**US$ 1.2/kg**

5. FINANCING PLAN

The enterprise requests a grant covering the total incremental costs of **USD 468,000.**

6. PROJECT IMPACT

This project will eliminate the use of 75 t of CFC-12 in the first year after implementation. The project employs commercially viable and environmentally acceptable technology.

7. ANNEXES

Annex-2A: Technical Review

TECHNICAL REVIEW

1. Country:
China

2. Project Title:
Elimination of CFC-12 in the manufacture of polystyrene foam sheet at CANGZHOU FOREIGN TRADE PACKAGING CO.

3. (Sub) Sector:
Foamed Plastics.

4. CP-Relationship:
The CP of China targets for a total CFC phase out by the year 2000. The responsible body is the National Council of Light Industry (NCLI) with the involvement of the National Environmental Protection Agency (NEPA).

5. Technology:

5.1 HYDROCARBON
N-BUTANE is proven replacements for CFC-12 in the manufacturing of polystyrene foam sheet. The technology is cost effective and results in product of acceptable quality. However, the flammability of hydrocarbons requires stringent safety precautions in the plant, manufacturing process, and post extrusion conversion resulting in the need for retrofitting. The lack of good management and maintenance at the typical Chinese plant makes using 100% hydrocarbon, as a foam blowing agent, a potentially dangerous situation.

5.2 CARBON DIOXIDE GAS BLENDED WITH N-BUTANE
Blending **CARBON DIOXIDE GAS** with **N-BUTANE** is a proven replacements for CFC-12 in the manufacturing of polystyrene foam sheet. The technology is cost effective and results in product of acceptable quality. The blend reduces significantly, the fire hazard associated with using a 100% hydrocarbon as a polystyrene foam blowing agent and is the most sensible and safest choice for China. The process is patented and requires licensing.

6. ENVIRONMENTAL IMPACT:
N-BUTANE emissions contribute to the formation of smog which can be reduced by utilizing carbon dioxide as a partial replacement for these gases.

7. PROJECT COSTS:
The incremental costs as presented are acceptable, as are the incremental operating savings and is based on other field visits where the scope of the safety modifications required to retrofit the plant and process equipment was significant.

The cost to the MLF elimination of 1 kg. of ODS is USD7.40 /kg

8. IMPLEMENTATION:
The time frame of the project is feasible.

9. RECOMMENDATIONS:
The project should be accepted as written, however, if possible the carbon dioxide/n-butane should be used to reduce the safety risks encountered when using 100% n-butane.

Prepared by Dennis A. Knaus, UNDP Foam Sector Consultant

Annex 3

PROJECT COVER SHEET

COUNTRY:	CHINA
PROJECT TITLE:	JOINT INDUSTRIAL PLASTIC PRODUCTS CORPORATION, BUOTOU - Elimination of CFC-12 in the Manufacture of XPE Foam Netting
SECTOR COVERED:	Foamed Plastics
ODS USED IN SECTOR:	17,773 MT CFCs (=ODP) in 1991
PROJECT IMPACT:	90 t CFC-12/y (1994)
PROJECT DURATION:	18 months
PROJECT ECONOMIC LIFE:	10 years
TOTAL PROJECT COST:	Incr. Capital Cost USD 705,000
PROPOSED MLF GRANT:	USD 705,000
UNIT ABATEMENT COST:	US$1.27/kg/yr
GRANT EFFECTIVENESS:	USD 7.8/kg (Grant Effectiveness)
NATIONAL IMPLEMENTING AGENCY:	China National Council of Light Industry (NCLI)
NATIONAL COORDINATING BODY:	National Environmental Protection Agency (NEPA)
IMPLEMENTING AGENCY:	UNDP
APPRAISAL DATE:	December, 1994

PROJECT SUMMARY

The Joint Industrial Plastic Products Corporation (J.I.P BOUTOU), Botou City, is a state-owned enterprise directly under the supervision of the Light Industry (Textile) Bureau of Botou city. It produces PE foam netting, using CFC-12 as a blowing agent. The purpose of this project is to phase out the CFC-12 usage through butane. The project provides incremental capital and operating costs for conversion, safety and training, and will result in eliminating the use of 90 t of CFC-12.

PREPARED BY: Ko Swee Hee
REVIEWED BY: Dr. UNDP Technical Reviewer

PROJECT OF THE GOVERNMENT OF CHINA

JIPPC, BUOTOU - CONVERSION TO CFC-FREE TECHNOLOGY IN THE MANUFACTURE OF EXTRUDED POLYETHYLENE FOAM NETTING

1. PROJECT OBJECTIVE

The project will eliminate the use of 90 t/yr of CFC-12 in the manufacture of extruded polyethylene foam netting at Joint Industrial Plastic Products Corporation, Buotou.

2. ENTERPRISE BACKGROUND

The Joint Industrial Plastic Products Corporation (JIP BUOTOU) was established in 1991 as a state enterprise under the direct supervision of the Light Industry (Textile) Bureau of Botou City. The enterprise is situated in Botou City in Hebei province. The existing five extruders are housed in the same building as the other plastic blow molding/film extruders. It will not be safe to implement the conversion in these premises. Hence the company will relocate the extruders to another building in the plant where the conversion to CFC free technology will take place. The company currently employs 40 workers in three shifts. Its raw materials and CFCs usage is as follows:

1992 : 300 t of resin, 90 t CFC-12
1993 : 300 t of resin, 90 t CFC-12
1994 : 300 t of resin, 90 t CFC-12

3. PROJECT DESCRIPTION

Under this project, JIP BUOTOU will phase out the use of CFC-12 in its PE foam netting production through replacement by butane. Butane is available in China with purity ranging from 60-80% which is still acceptable as blowing agent in this industry. "MERCAPTAN" is added into butane to ease detection of butane presence, thus requiring deodorizing as well as strict control on variation in volatiles by adding buffering agent. The project includes modification of existing extruders, fire safety and alarm system in the production area and warehouse to mitigate fire and explosion hazards from the use of butane. Extensive production and safety training and technology transfer to the plant operators will also be provided through an external process specialist.

4. PROJECT COSTS

4.1. CAPITAL COSTS

Description		Cost(USD)
o 2 butane bulk tanks		85,000
o High pressure pump/metering systems (5)		175,000
o Cast heaters with EX terminal box		8,500
o Extruder retrofitting (5)		120,000
o Fire deflection wall (10 m)		4,000
o Equipment relocation		40,000
o Fire safety & Alarm systems		154,500
Exhaust fans (18 pcs)	22,000	
Exhaust hood	25,000	
Industrial blow down fans (18)	18,000	
Gas sensing/detection system (5)	35,000	
Portable gas detector (1)	4,000	
Fire extinguishers		
* Trolley mounted (4)	6,000	
* Handheld (12)	2,000	
Antistatic blowers and bars (2)	40,000	
Emergency spot light (5)	2,500	
o Sprinkler System		30,000
o Clothing		4,000
o Technology transfer/training		20,000
o Contingency/rounding		64,000
TOTAL INCREMENTAL CAPITAL COST		**USD 705,000**

4.2 OPERATING COSTS

Before (CFC-12):	90 t @ US$ 1,550/t =	US$ 139,500
After (Butane):	90 t @ US$ 1,100/t =	US$ 99,000
Additives:	450 kg @ US$ 30/kg =	13,500
Maintenance:	5% of project cost =	22,765
Add'l Safety Training & monitoring:	2% of project cost =	9,106
Sub-total:		US$144,371
Net Incremental Operating Cost:		US$ 4,871/yr

The net cost is negligible and it is not being requested.

4.3 COST EFFECTIVENESS

4.3.1. Unit Abatement Costs

a.	ODS Reduction Capital Costs	US$ 705,000
b.	Annual incremental costs	
c.	Capital Recovery Factor(10y/10%)	0.16275
d.	ODS Reduction/year	90,000 kg
	Unit Abatement Costs [{(a(c) + b})/d]	**US$/kg/y 1.27**

4.3.2 Grant Effectiveness

a. MLF Grant	US$ 705,000
b. ODS phased out	90,000 kg
Grant Effectiveness [a/b]	**US$ 7.8/kg**

5. FINANCING PLAN

The enterprise requests a grant of US$ 705,000 covering the total incremental costs as calculated under 3.1 above.

6. PROJECT IMPACT

This project will eliminate the use of 90 t of CFC-12 in the first year after implementation. The project employs commercially viable and environmentally acceptable technology.

7. ANNEXES

Annex-3A: Technical Review

TECHNICAL REVIEW

1. Country:
China

2. Project Title:
Elimination of CFC-12 in the manufacture of polyethylene foam netting at JOINT INDUSTRIAL PLASTIC PRODUCTS CORPORATION, BUOTOU.

3. (Sub) Sector:
Foamed Plastics.

4. CP-Relationship:
The CP of China targets for a total CFC phase out by the year 2000. The responsible body is the National Council of Light Industry (NCLI) with the involvement of the National Environmental Protection Agency (NEPA).

5. Technology:

5.1 HYDROCARBON
N-BUTANE is proven replacements for CFC-12 in the manufacturing of polyethylene foam netting. The technology is cost effective and results in product of acceptable quality. However, the flammability of hydrocarbons requires stringent safety precautions in the plant, manufacturing process, and post extrusion conversion resulting in the need for retrofitting. The lack of good management and maintenance at the typical Chinese plant makes using 100% hydrocarbon, as a foam blowing agent, a potentially dangerous situation.

5.2 CARBON DIOXIDE GAS BLENDED WITH N-BUTANE
Blending **CARBON DIOXIDE GAS** with **N-BUTANE** is a proven replacements for CFC-12 in the manufacturing of polyethylene foam netting. The technology is cost effective and results in product of acceptable quality. The blend reduces significantly, the fire hazard associated with using a 100% hydrocarbon as a polyethylene foam blowing agent and is the most sensible and safest choice for China. The process is patented and requires licensing.

6. ENVIRONMENTAL IMPACT:
N-BUTANE emissions contribute to the formation of smog which can be reduced by utilizing carbon dioxide as a partial replacement for these gases.

7. PROJECT COSTS:
The incremental costs as presented are acceptable, as are the incremental operating savings and is based on other field visits where the scope of the safety modifications required to retrofit the plant and process equipment was significant.

The cost to the MLF elimination of 1 kg. of ODS is USD7.80 /kg

8. IMPLEMENTATION:

The time frame of the project is feasible.

9. RECOMMENDATIONS:

The project should be accepted as written, however, if possible the carbon dioxide/n-butane should be used to reduce the safety risks encountered when using 100% n-butane.

Prepared by Dennis A. Knaus, UNDP Foam Sector Consultant

Annex 4

PROJECT COVER SHEET

COUNTRY:	CHINA
PROJECT TITLE:	HANDAN NO.7 - Elimination of CFC-12 in the Manufacture of EPS Foam sheet
SECTOR COVERED:	Foamed Plastics
ODS USED IN SECTOR:	17,773 t CFCs (=ODP) in 1991
PROJECT IMPACT:	60 t of CFC-12 (1994)
PROJECT DURATION:	One year
PROJECT ECONOMIC LIFE:	10 years
TOTAL PROJECT COST:	Incremental Capital Cost USD 485,000
PROPOSED MLF GRANT:	USD 485,000
COST EFFECTIVENESS:	USD 8.1/kg (Grant Effectiveness) USD 1.31/kg/y (Unit Abatement Cost)
NATIONAL EXECUTING AGENCY:	China National Council of Light Industry (NCLI)
NATIONAL COORDINATING BODY:	National Environmental Protection Agency (NEPA)
IMPLEMENTING AGENCY:	UNDP
APPRAISAL DATE:	December, 1994

===

PROJECT SUMMARY

HANDAN NO.7 is a state-owned enterprise which produces EPS Foam Sheets, using CFC-12 as a blowing agent. The purpose of this project is to phaseout the CFC-12 usage through a conversion to butane. The project contains capital cost for conversion, safety and training.

Prepared BY: Ko Swee Hee
Reviewed BY: Dr.

PROJECT OF THE GOVERNMENT OF CHINA

HANDAN NO.7 - CONVERSION TO CFC-FREE TECHNOLOGY IN THE MANUFACTURE OF EXTRUDED POLYSTYRENE FOAM SHEET

1. PROJECT OBJECTIVE

The project will eliminate the use of 60 t/yr of CFC-12 in the manufacture of extruded polystyrene foam sheet at Handan No. 7.

2. ENTERPRISE BACKGROUND

HANDAN-7 was established in 1988 as a state enterprise under the supervision of the Handan Plastics Industry Corporation of Hebei Province. The factory is located in the city of Handan. The existing extruder and the recycling machine are located in a building that adjoins other buildings. This would be unsafe once the conversion to butane is implemented. The company has therefore decided to shift its production to a new location within the same premises, where conversion can take place safely.

HANDAN-7 employs about 21 workers for its production.CFC consumption since 1991 is as follows:

1992: 90 t of resin, 45 t CFC-12
1993: 120 t of resin, 50 t CFC-12
1994: 130 t of resin, 60 t CFC-12

3. PROJECT DESCRIPTION

Under this project, HANDAN-7 will phase out the use of CFC-12 in its XPE/XPS Foam Sheet through substitution by butane technology as replacement. Butane is available in China with purity degree ranging from 60-80% which is still acceptable as blowing agent in this industry. "MERCAPTAN" is added into butane to ease detection of butane presence. This requires deodorizing as well as strict control on variation in volatiles by adding buffering agent. The project includes modification of existing extruder, fire safety and alarm system in the production area and warehouse to mitigate fire and explosion hazard from the use of butane. Extensive production and safety training and technology transfer to the plant operators will be provided through an external process specialist.

4. PROJECT COSTS

4.1. CAPITAL COSTS

Description		Cost (USD)
o Butane bulk tank		50,000
o High pressure pump/metering system		75,000
o Extruder retrofitting		80,000
o Cast heaters with EX terminal box		8,500
o Construct fire-proof pump room		20,000
o Relocation of equipment		40,000
o Sprinkler system		30,000
o Fire safety & Alarm systems		113,500
Exhaust Fans (14)	17,000	
Exhaust hood	5,000	
Industrial blow down fans (16)	16,000	
Gas sensing/detection system (4)	35,000	
Portable gas detector (1)	4,000	
Fire extinguishers		
* Trolley mounted (4)	8,000	
* Handheld (8)	1,000	
5 Antistatic blowers	25,000	
Emergency Spotlight (5)	2,500	
o Technology transfer/training		20,000
o Clothing		4,000
o Contingency/rounding		44,000
		=======
TOTAL INCREMENTAL CAPITAL COSTS		**485,000**
		=======

4.2. OPERATING COSTS/BENEFITS

Before	(CFC-12): 60 t @ US$ 1,550/t =	US$ 93,000
After (Butane):	60 t @ US$ 1,100/t =	US$ 66,000
Additives:	300 kg @ US$ 30/kg =	9,000
Maintenance:	5% of project cost =	21,700
Add'l Safety Training & monitoring		
Sub-total:		US$ 96,700
Net Incremental Operating Cost:		US$ 3,700/yr

The net cost is negligible and it is not being requested.

4.3. COST EFFECTIVENESS

4.3.1 Grant Effectiveness

a. MLF Grant	US$ 485,000
b. ODS phased out	Kg 60,000
Grant Effectiveness [a/b]	**US$ 8.1/kg**

4.3.2 Unit Abatement Costs

a.	ODS Reduction Capital Costs	US$485,000
b.	Annual incremental benefits	-
c.	Capital Recovery Factor(10y/10%)	0.16275
d.	ODS Reduction/year	60,000 kg
Unit	**Abatement Costs [{(a(c) + b})/d]**	**US$/kg/y 1.31**

5. FINANCING PLAN

The enterprise requests a grant of **US$ 485,000** covering the total incremental cost as calculated under 3.1.

6. PROJECT IMPACT

This project will eliminate the use of 60 tons of CFC-12 in the first year after implementation. The project employs commercially viable and environmentally acceptable technology.

7. ANNEXES

Annex-4A: Technical Review

TECHNICAL REVIEW

1. Country:
China

2. Project Title:
Elimination of CFC-12 in the manufacture of polystyrene foam sheet at HANDAN NO. 7.

3. (Sub) Sector:
Foamed Plastics.

4. CP-Relationship:
The CP of China targets for a total CFC phase out by the year 2000. The responsible body is the National Council of Light Industry (NCLI) with the involvement of the National Environmental Protection Agency (NEPA).

5. Technology:

5.1 HYDROCARBON
N-BUTANE is proven replacements for CFC-12 in the manufacturing of polystyrene foam sheet. The technology is cost effective and results in product of acceptable quality. However, the flammability of hydrocarbons requires stringent safety precautions in the plant, manufacturing process, and post extrusion conversion resulting in the need for retrofitting. The lack of good management and maintenance at the typical Chinese plant makes using 100% hydrocarbon, as a foam blowing agent, a potentially dangerous situation.

5.2 CARBON DIOXIDE GAS BLENDED WITH N-BUTANE
Blending **CARBON DIOXIDE GAS** with **N-BUTANE** is a proven replacements for CFC-12 in the manufacturing of polystyrene foam sheet. The technology is cost effective and results in product of acceptable quality. The blend reduces significantly, the fire hazard associated with using a 100% hydrocarbon as a polystyrene foam blowing agent and is the most sensible and safest choice for China. The process is patented and requires licensing.

6. ENVIRONMENTAL IMPACT:
N-BUTANE emissions contribute to the formation of smog which can be reduced by utilizing carbon dioxide as a partial replacement for these gases.

7. PROJECT COSTS:
The incremental costs as presented are acceptable, as are the incremental operating savings and is based on other field visits where the scope of the safety modifications required to retrofit the plant and process equipment was significant.

The cost to the MLF elimination of 1 kg. of ODS is USD8.10 /kg

8. IMPLEMENTATION:

The time frame of the project is feasible.

9. RECOMMENDATIONS:

The project should be accepted as written, however, if possible the carbon dioxide/n-butane should be used to reduce the safety risks encountered when using 100% n-butane.

Prepared by Dennis A. Knaus, UNDP Foam Sector Consultant

PROJECT COVER SHEET

COUNTRY:	China
PROJECT TITLE:	Eliminate CFC-11 in the manufacture of rigid polyurethane foam products at Tianjin Polyurethane Plastic Plant
SECTOR COVERED:	Foamed Plastics
ODS USE IN SECTOR:	17,773 tonnes CFCs (=ODP) in 1991
PROJECT IMPACT:	130 tonnes/yr CFC-11 (1993 consumption)
PROJECT DURATION:	18 months
TOTAL PROJECT COST:	US \$ 965,000 incremental capital cost US \$125,000 incremental recurrent cost US \$1,090,000 total incremental cost
FORMER COMBINED MLF GRANT:	US \$1,150,000 reflecting national ownership (UNDP US 690,000 + World Bank US \$460,000)
REVISED COMBINED MLF GRANT:	US \$914,500 reflecting national ownership
PROJECT COST REDUCTION:	US \$235,500
COST EFFECTIVENESS:	US \$1.77/kg/yr (unit abatement cost) US \$7.03/kg/yr (grant effectiveness)
NATIONAL IMPLEMENTING AGENCY:	National Council of Light Industry
COORDINATING NATIONAL BODY:	National Environmental Protection Agency (NEPA)
IMPLEMENTING AGENCY:	UNDP
APPRAISAL DATE:	3 June 1994/10 June 1995

PROJECT SUMMARY

This combined project will phaseout CFC-11 use in rigid PU foam production using pentane. At the 10th ExCom Meeting (June 1993), the World Bank received approval for a 50% CFC-free project budgeted at US $460,000 to eliminate 31 ODS tonnes in polyol blending (CPR/FOA/10/INV/46). At the 13th ExCom Meeting (July 1994), UNDP received approval for a 100% CFC-free project at the same plant budgeted at US $690,000 to eliminate an additional 100 ODS tonnes in rigid PUF using pentane (CPR/FOA/13/INV/74). Subsequently, the company decided to adopt the 100% CFC-free technology for a combined operation costing US $914,500 that will eliminate 130 tonnes of CFC-11 at a savings of US $235,000. This reflects the 100% local ownership of the pipe and box insulation and laboratory and blending facility and 75% local ownership of panel production. The combined project will be implemented by UNDP. The World Bank will transfer US $253,685 ($224,500 + support costs) to UNDP and will return the remaining US $206,315 to the Multilateral Fund.

PROJECT COVER SHEET

COUNTRY:	CHINA
PROJECT TITLE:	Elimination of CFCs in the Manufacture of Domestic Refrigerators at GUANGDONG KELON
SECTOR COVERED:	Domestic Refrigeration
ODS USE IN SECTOR:	8,490 tons of CFC-11/12 (1993)
PROJECT IMPACT:	767.2 t/y CFCs (1994) : 656.6 t/y CFC-11 110.6 t/y CFC-12
PROJECT DURATION:	1.5 years
PROJECT ECONOMIC LIFE:	10 Years
TOTAL PROJECT COST:	USD 9,160,100 (USD 6,740,100 Incremental Capital Cost USD 980,000 Incremental Recurrent Cost USD 1,440,000 Costs by Kelon)
PROPOSED MLF GRANT:	USD 7,720,100
COST EFFECTIVENESS:	USD 5.87/kg/y (Grant effectiveness) USD 4.19/kg/y (Unit abatement cost)
NATIONAL IMPLEMENTING AGENCY:	National Council of Light Industry (NCLI/Household Electrical Appliances)
NATIONAL COORDINATING BODY:	National Environmental Protection Agency (NEPA)
IMPLEMENTING AGENCY:	UNDP
APPRAISAL DATES:	July/October 1994, April 1995

PROJECT SUMMARY

Guangdong Kelon Electrical Holding Company LTD ("KELON") is one of China's largest manufacturers of domestic refrigerators. It is a fully Chinese-owned enterprise manufacturing domestic refrigerators and air-conditioners. Under this project, Kelon will phaseout the use of 760 tons of CFCs in the production of refrigerators by switching to the use of cyclopentane as the replacement blowing agent for cabinet and door insulation, and to iso-butane as refrigerant. Funds requested will be used to retrofit the three existing production lines in a way that will satisfy international safety standards, to cover the cost of technology transfer, testing, pre-production trials and training, as well as 6-month incremental operational costs resulting from the conversion to the new technology.

PREPARED BY: Mr. Tommy Lauridsen/Bert Veenendaal (Foam)
Mr. Roger Hodson (Refrigerant)

REVIEWED BY: Dr. Mike Jeff (Foam)
Dr. L.J.M. Kuijpers/J.M.P. Jhanssen (Refrigerant)

PROJECT OF THE GOVERNMENT OF CHINA

ELIMINATION OF CFCs IN THE MANUFACTURE OF DOMESTIC REFRIGERATORS AT GUANGDONG KELON

1. PROJECT OBJECTIVE

The objective of this project is to phase out the use of 760 tons of CFCs in the manufacture of domestic refrigerators at the Guangdong Kelon Electrical Holding Company.

2. SECTOR BACKGROUND

China's Country Programme (CP) for the Phase-out of Ozone Depleting Substances (ODS) under the Montreal Protocol was approved at the 9th meeting of the Executive Committee of the Multilateral Fund (MLF) in March 1993.

"OZONE PROTECTION IN CHINA - a Strategic Study on the phase-out of CFCs in the Domestic Refrigeration Sector in the People's Republic of China", prepared by The Office of Household Electrical Appliances Industry of National Council of Light Industry, in cooperation with the China Household Electrical Appliances Association (December 1994), provides data on ODS consumption. In 1993 it is estimated that 6,740 tons of CFC 11, and 1,580 tons of CFC 12 were consumed in the manufacture of new domestic refrigerators and freezers. A further 170 tons of CFC 12 were consumed in recharging refrigerators and freezers following repairs and service operations. This consumption of ODS in the domestic refrigeration sector is estimated to represent some 12% of total ODS consumption in China in 1993.

China has 240 million households but the total existing refrigerator population is estimated at only 43 million. Annual production of domestic refrigerators and freezers is growing at an average rate of 16% per annum, and it reached 8.1 million units in 1993. Export increases even faster. In 1993, China exported 450,000 refrigerators, which is double compared to 1991.

There are an estimated 100 domestic refrigerator and freezer production lines with a production capacity of 15 million units per annum. Most of the refrigerator production lines were imported from Italy, Germany and Japan in 1908's. Much of the demand for compressors is satisfied by 16 local compressor production lines with an annual capacity of 13 million units. Production of refrigerators and freezers was as follows:

1990:	5.16	million	units
1991:	5.49	"	"
1992:	6.23	"	"
1993:	8.1	"	"

The high production growth rates and the low level of refrigerator ownership, coupled with the relatively high existing level of ODS consumption, means that the domestic refrigeration sector has a high priority in China's ODS phase-out strategy. Uninhibited growth would result in an estimated consumption in the year 2000 of 11,000 tons per year of CFC 11 and 2,600 tons per year of CFC 12 for the manufacture of domestic refrigerators and freezers in China.

CFC-11 consumption has been increased proportionally and reached 6,740t in 1993. With the high market potential of refrigerators and freezers, the consumption increase will remain strong if no mitigating measures are applied.

Complete phaseout for the domestic refrigeration sub-sector is targeted for the year 2005. Approval of this project by the MLF in 1995 should result in the elimination of the CFCs used in the manufacture of domestic refrigerators at Guandong Kelon by early 1997 and will make a significant contribution to China's overall ODS elimination programme.

3. ENTERPRISE INFORMATION

3.1 General Background

Guandong KELON was formed in 1983 as a Township Enterprise and is presently one of the largest manufacturers of domestic refrigerators in China with a market share of about 12%. In 1994 the company produced over 900,000 units of refrigerators and in 1995 a production figure of 1-1.2 million units is expected. The company employs about 4,500 workers, has over 950 million RMB in assets and belongs to the 500 largest companies in China. Its production program includes direct cooling refrigerators, no frost refrigerators, window type air conditioners and split type air conditioners. Models are supplied with both 110V/60Hz and 220V/50Hz. About 10% of the production is targeted for export.

Factory #1 has one door insulation station, one cabinet insulation station with 10 fixtures and one premix/compounding station. All foaming units are from Cannon. All fixtures and molds are electrically heated.

Factory #2 has three door insulation stations, five cabinet insulation stations with a total of 30 fixtures, two premix stations and compounding stations. All fixtures and molds are electrically heated.

The refrigeration equipment includes Leybold vacuum pumps 160+ units) and three charging units, Agramkow accumulator, halogen testing units. Annex-1 provides the present layout of the two production lines.

3.2 Company Data

FULL NAME:	Guandong Kelon Electrical Holding Co. Ltd.
NAME OF CONTACT	Ms. Huang Xiao Chi Vice Chief Engineer
ADDRESS:	No. 8 Ronggang Road Rongqi, Shunde Guangdong, China
TEL/FAX:	86-765-6621876 86-765-6621260
% ARTICLE 5 OWNERSHIP:	100% China owned
CONSUMPTION (1994):	649 t/y CFC-11 (for 111 t/y CFC-12 (manufacturing)
NUMBER OF MODELS:	8
PRODUCTION FOR 1994:	909,605
NO. OF PRODUCTION LINES:	3
COMPRESSOR SUPPLIERS:	Matsushita (Japan) 60% Embraco (Brazil) 20% Unidad (Spain) 20%

3.3 Information on Ownership

According to the Enterprise and confirmed by NEPA, the company is 100% China owned.

3.4 Description of the Kelon refrigerator models

The following tables provide a summary of the refrigerator production and CFCs consumption by KELON during the 12 month period from 1 January to 31 December 1994.

Table 1: CFC-11 Consumption

Model No.	Production Volume	Wt of PUF	Total of PUF
BCD103	124,613	3.553	442,750
BCD165	273,507	4.91	1,342,919
BCD193	92,321	5.81	536,385
BCD203	194,089	6.11	1,185,884
BCD216	60,017	6.32	379,307
BCD190W	145,087	5.68	824,094
BCD210W	10,040	5.90	59,236
BCD190B	10,051	5.68	57,090
	909,605 units		4,827,665

CFC-11 used: 4,827,665 x 0.136 = 656,562 kgs

Table 2: CFC-12 Consumption

Model No. use	Description	Capacity Litres	Production Volume	R12 charge kgs	kgs
BCD103	DD	103	124,613	0.100	12,461
BCD165	DD	165	273,507	0.110	30,086
BCD193	DD	193	92,321	0.120	11,078
BCD203	DD	203	194,089	0.140	27,173
BCD216	DD	216	60,017	0.140	8,402
BCD190W	DD NF	190	145,087	0.130	18,861
BCD210W	DD NF	210	10,040	0.135	1,355
BCD190B	DD	190	10,051	0.120	1,206
Total or Weighted Average			909,605	0.122	110,622

Key: SD=Single door, DD=Double Door, Frz=Freezer, NF-No Frost

4. PROJECT DESCRIPTION

Under this project KELON will phase out the use of CFCs in the production of domestic refrigerators. The replacement technology of choice for production of insulation foams for its refrigerator cabinets and doors will be cyclopentane, and for refrigerant is iso-butane. The project has been selected by NCLI's Household Electrical Appliances Office (HEA) as one of three demonstration projects for the application of these technologies on domestic refrigerators in China.

4.1 Replacement of CFC-11 by Cyclo-pentane

KELON's two foam production lines will be retrofitted to allow the use of a flammable substance as a blowing agent. This includes replacement of the dispensers, installation of water heating for the fixtures and emission control for the fixture/door-mold stations. A third line has been eliminated. The two premix stations will be modified through installation of static premixers and buffer tanks for the polyol/cyclopentane blend and connected to outside storage tanks for cyclopentane. All critical areas will be connected to two gas sensing and alarm systems--one for each plant and connected to a recorder/printer, allowing for retroactive fault-analyses.

The conversion will be implemented on a turn-key basis by the equipment supplier, with the necessary civil works (including ventilation and piping systems) and fire protection systems being done by KELON under the guidance of the equipment supplier. In addition, under a Technology Agreement with Liebherr covering the conversion to iso-butane refrigerating system, Liebherr will also assure overall project responsibility to ensure that appropriate safety measures are adopted for the cyclopentane conversion as well. A UNDP-appointed cyclopentane specialist will also provide continuous backstoppping to KELON in carrying out its responsibilities and will oversee the overall project implementation. Process and safety training for staff and personnel will be provided by the equipment suppliers. Additional training, if required, will be provided by the cyclopentane specialist and by the UNDP safety expert. Incremental recurrent cost for six months is also included.

4.2 Replacement of CFC-12 by Iso-butane (R600a)

KELON currently uses CFC-12 as refrigerant for its refrigerators. Successful completion of the project will see KELON using isobutane as the refrigerant for the majority of its refrigerators. For certain export markets, KELON is required to switch to HFC-134a; this conversion will be financed by KELON from its own resources and is not included under this project.

KELON has 3 refrigerator production lines. Since the refrigerator models are not interchangeable, all 3 lines will need to be changed to the use of isobutane.

The conversion to isobutane requires the use of isobutane compressors which are able to use conventional mineral oils. Re-design of the refrigeration system is required to cater for the difference in the thermodynamic performance of isobutane versus CFC 12, prototyping, testing and optimization of each refrigerator model, followed by pilot scale manufacture and further testing before full scale conversion of production facilities to allow the use of isobutane as refrigerant. The conversion will result in changes in manufacturing procedures, including different safety needs for which production line supervisor and operator training will be required.

The different properties of isobutane, in particular the flammable nature of the refrigerant and the need to avoid cross contamination with CFC 12 and the phased nature of the conversion of refrigerator production from CFC-12 to isobutane, means that new refrigerant charging and leak detection equipment will be required. Additional ventilation will be needed to allow for the flammable nature of isobutane. There will also be a need for the installation of appropriate gas leak detectors and safety alarm systems which will shut down the production if an escape of gas occurs. The technology change of which this project will impact on is given later. Operational costs for six months are requested.

The two system conversions (foam and refrigerant) to using hydrocarbons (cyclopentane and isobutane) will be supervised by Liebherr under a Technical Agreement with KELON. Liebherr will supply the isobutane refrigerant technology, and will collaborate closely with Leybold/Agramkow for the necessary charging equipment and safety measures. This Agreement also includes safety certification (by TUV/Germany).

The impact of the tecnology change in the existing production process is described in 5.2.3.

5. TECHNOLOGY

5.1 CFC-11 Replacement

5.1.1 Overview

There are currently two main directions in the development of CFC-free foam systems for domestic refrigerators :

CFC 11 > partial water/HCFC 141b > ?
CFC 11 > cyclopentane

In addition vacuum panels ~~are~~ have been introduced on a limited scale but the technology is currently still in commercial development, expensive and limited available. The first option employs technology that is closely related to the existing one. The final step to non-ODS technology in this process is not yet decided. One potential solution is the use of liquid HFCs such as HFC-356 or HFC-245 derivatives, but full water blown foam with improved cell structure remains an option. The second option has recently been introduced commercially in Europe. Cyclopentane is flammable and this means a careful review of manufacturing operations with respect to the safe handling of a highly flammable/explosive foam blowing agent. Its use may not be a practical option in the existing work environments of some enterprises. In addition, cyclopentane is not everywhere available.

5.1.2 REQUIRED MODIFICATIONS

The use of cyclopentane (CP) will require substantial changes in the production and storage facilities based on the highly flammable/explosive character of the substance. The adherence to the strictest safety standards available, such as EN, NFPA or other internationally recognized standards is required for UNDP implemented projects. These standards classify explosive zones ("EX areas") generally in three categories:

Zone 0 Where a constant amount of highly flammable/ explosive liquids or gases can be expected. Areas inside CP pipes and tanks are Zone 0 (level, pressure and temperature controls). Materials used have to be explosion proof (EX) and grounded.

Zone 1 Where from time to time highly flammable liquids or gases can be expected; Areas in and around molds and fixtures are Zone 1. Materials used have to be EX-e, -d or -ia and grounded. Zone-1 can generally be reclassified to Zone 2 by applying sufficient ventilation.

Zone 2 Where only by accident or scheduled maintenance highly flammable/explosive gases can be expected. Tank storage areas, premix stations and foam dispensers are generally Zone 2. Materials required are EX-n or with IP54 sealing. Grounding to avoid spark building triggered by differences in electrical potential, is required.

Other requirements related to the use of CP are:

- The installation of containment around CP storage tanks;
- Installation of premix equipment--CP cannot purchased pre-blended;
- Antistatic clothing and shoes in Zone 0/1 areas;
- Installation of CP gas sensors in all EX areas, connected to a central panel and an automatic recorder/ printer;
- A portable gas detector to monitor CP concentrations throughout the plant according to an approved monitoring plan;
- An approved preventive maintenance system and emergency response plan;
- Training for production and maintenance personnel in the safe handling of CP;
- Process Safety Audits (PSAs) by a UNDP appointed independent contractor prior, during and after implementation.

In line with the above-mentioned modifications on equipment and safety, process adjustments are required to cope with the lower insulation value, higher core temperatures and longer aging times related to the use of CP.

THE USE OF CYCLOPENTANE MUST CONFORM TO THE SAFETY REQUIREMENTS OF RELEVANT LOCAL AND STATE AUTHORITIES

5.1.3 SELECTION

Kelon has considered all main options to replace CFC-11. The company has produced at its own expenses a pilot series with reduced CFC. The technology interfered with the production line productivity because of longer curing times. Adjustments would have been possible but costly. The company stopped the evaluation after it decided not to pursue an interim solution.

The HCFC-22/-142b has not been pursued because (i) this option is seldom used anywhere and technology transfer may be problematic, (ii) HCFC-142b will not be produced in China, making pricing and supply uncertain and (iii) the technology constitutes an interim solution.

HCFC-141b has not been pursued because of (i) potential liner problems and (ii) its interim character.

Cyclopentane has been investigated extensively through in house-production and laboratory-trials as well in a seminar with ICI-Singapore and discussions with Cannon, the supplier of most of the current equipment and partner in the project development. despite some challenges in energy efficiency and process safety, KELON has selected this technology as being currently the most suitable non-ODS option for domestic refrigerators.

5.2 CFC-12 Replacement

5.2.1 Overview

Both HFC-134a and hydrocarbon are now accepted as CFC replacements for the manufacturing of domestic refrigerators. Iso-butane is the selected technology in this project proposal for the reasons given under 4.2 above. Iso-butane technology in the enterprises in the article 5 countries is dependent on a formal Technology Agreement with a technology partner who is already manufacturing domestic refrigerators using iso-butane on a commercial scale. The selected technology partner in this project is Liebharr in Germany who are already using iso-butane for most of their production of domestic refrigerators in Euirope, except for no frost models. Safety issues associated with the use of iso-butane refrigerant will be addressed under this Technology Agreement. Suitable compressors are available from a number of other suppliers.

Presently, pure isobutane is not available in china in commercial quantities. Therefore, in the initial stages it will be necessary to import iso-butane of the appropriate quality and several suppliers have been identified. The question of local manufacture is being addressed locally.

HFC 152a might be considered as another candidate for CFC 12 replacement in domestic refrigerators. However, HFC 152a is also flammable, the technology has not been developed commercially and there are some questions about its stability in refrigerator systems. Furthermore, compressors for use with HFC 152a are not commercially available.

5.2.2 Selection

KELON plans to convert all 3 refrigeration production lines to use isobutane; since they plan limited exports to USA and to Japan which will not accept refrigerators containing flammable refrigerants, they will at their own expense modify a small production facility to enable HFC 134a to be used. The selection of isobutane has been achieved with the help of their technology partner, Liebherr, who has assisted with prototyping several of the Kelon refrigerator models, and the supplier of iso-butane compressor and raw materials, and the charging and leak detection equipment A'Gramkow in Denmark. This company has supplied most of the isobutane equipment in Europe and has trained local representation in China. This should ensure successful completion of the project. The two companies will oversee the safe installation of the new facility and ensure that the enterprise management are able to operate the factory safely.

The reasons for KELON to choose isobutane are:

a) Available technology and help from their technology partner;
b) Availability of suitable compressors which are potentially cheaper than HFC 134a compressors;
c) Ability to use existing lubricants which are cheaper than those needed for use in a 134a compressor;
d) Lower greenhouse warming potential than HFC 134a;
e) Isobutane will be easier to produce in China than 134a;
f) Initial tests with optimised isobutane refrigerators show that they are more energy efficient than the equivalent models operating on 134a.

5.2.3 Impact on Production Processes

Isobutane is flammable. It has also been the subject of toxicological testing and is considered safe in industrial applications provided the suppliers recommended exposure levels are not exceeded. At the present time, this means ensuring that exposure levels do not exceed 500 parts per million on an 8 hour time weighted average basis. This is 50% of the Occupational Exposure Limit (OEL). Threshold limit value for CFC 12. The additional ventilation requirements for the use of a flammable refrigerant will ensure that OEL figures are met.

There will be an approximately 66% reduction in the mass charge of isobutane compared with CFC 12 for a refrigerator system of the same capacity. This is taken into account in the calculation of the incremental operational cost under 6.2.2.

Isobutane can be used with existing mineral oil lubricants although there is a need to increase the viscosity compared to R12. The chemical stability of isobutane is well understood. The reduced charge compared to that of R12 means that more sensitive charging and leak testing equipment is needed. This requires that CFC 12 and isobutane handling equipment be carefully segregated.

Because careful use of flammable refrigerants is needed and system cleanliness is paramount to the successful manufacture of isobutane refrigerants, the enterprise will carefully need to re-assess production procedures and re-train production personnel.

The relevant existing equipment at Kelon on which the technology change to R600a will impact is as follows:

- 2 R-12 Charging Machines Leybold FDI/4 (1990)
- 1 R-12 automatic charging machine from To-Oli Kogyo Japan
- 2 leak detectors Inficon HLD 3000
- 2 leak detectors Inficon HLD 4000A
- 4 leak detectors Toshiba HAL 8F

6. PROJECT COSTS

6.1 INCREMENTAL CAPITAL COSTS

6.1.1 CFC-11 Replacement

DESCRIPTION	SUB-TOTAL	TOTAL
Storage Tank (35 M3)	USD 25,000	
Underground Installation, complete..	USD 112,000	
Premix Station with Buffer Tank.....	USD 210,000	
CP Foam Dispensers (2)..............	USD 220,000	
Modifications Fixtures..............	USD 265,000	
Modifications Door Line.............	USD 135,000	
Safety Control Measures.............	USD 105,000	
SUB-TOTAL FACTORY-1...............		**USD 1,072,000**
Storage Tanks (35 M3)...............	USD 25,000	
Underground Installation,complete...	USD 112,000	
Premix Station with Buffer Tank.....	USD 210,000	
CP Foam Dispensers (6)..............	USD 705,000	
Modifications Fixtures..............	USD 1,205,000	
Modifications Door Line.............	USD 205,000	
Safety Control Measures.............	USD 225,000	
SUB-TOTAL FACTORY-2...............		**USD 2,687,000**
Installation, both Plants...........	USD 100,000	
Laboratory EX-Proofing..............	USD 10,000	
Technology transfer/training........	USD 30,000	
Trials..............................	USD 25,000	
Contingency.........................	USD 375,000	
TOTAL GENERAL COSTS...............		**USD 540,000**
TOTAL INCREMENTAL CAPITAL COST....		**USD 4,299,000**

Annex-2 provides more details.

6.1.2 CFC-12 Replacement

3 refrigerant Charging Machines	USD	688,000
Spares for charging machines	USD	19,500
3 sets 600a atmospheric monitors	USD	163,000
2 sets of spares (1 for each factory)	USD	10,000
3 helium recovery units	USD	107,000
9 mass spectrometer leak detectors	USD	310,000
2 standard leak kits	USD	7,000
Spare parts for detectors	USD	5,000
9 explosion proof vacuum pumps (rectification area)	USD	63,000
Installation costs	USD	34,000
Explosion-proof gas storage room, ventilation system and gas piping to production area	USD	86,300
11 EX-proof anti-static centrifugal style fans	USD	25,300
Liebherr agreement for prototyping	USD	260,000
Liebherr agreement for technology transfer	USD	290,000
Ultrasonic welding equipment	USD	103,000
Training trainers in Germany (1 M/M)	USD	15,000
Pilot service station maintenance kits (5)	USD	11,000
Production trials/technology transfer	USD	25,000
Contingencies (10% of capital cost)	USD	219,000
Sub-total Capital Cost for CFC 12	**USD**	**2,441,100**
TOTAL INCREMENTAL CAPITAL COSTS:	**USD**	**6,740,100**

In addition to the above-mentioned incremental capital costs, KELON is expected to finance from its own resources additional works and services related to this technology conversion. These amount to US$1,440,000 (Annex 2B refers).

6.2 INCREMENTAL RECURRENT COSTS

6.2.1 Phaseout of CFC-11

KELON will incur incremental recurrent costs related to higher densities needed to compensate for lower inherent insulation value of cyclopentane compared to CFC-11 as well as for higher material costs. Total cost increase for a production level as that of 1994 is USD 1,955,760. These costs are specified in Annex 3. KELON is requesting payment of incremental recurrent cost for six months amounting to **US$ 980,000.**

6.2.2 Phaseout of CFC-12

The change from CFC 12 to iso-butane refrigerant will necessitate a change to a compressor with a larger capacity due to the different thermodynamic properties. For small capacity compressors (Kelon uses only 1/6 and 1/5 HP compressors), these changes can usually be readily accommodated by the compressor supplier without any incremental cost. The same mineral oil lubricant will be used with iso-butane. While there are no actual compressor costings in the Chinese market to support this conclusion, it is confirmed by experience in Europe where iso-butane refrigerators are in commercial production. Given that no changes are envisaged to the filter dryer and capillary tube, then there are no incremental operating costs associated with the technology change from CFC 12 to iso-butane.

There will be higher ongoing insurance, maintenance and training costs which will more than offset any incremental operating benefits that might accrue from a lower mass charge of iso-butane and a lower unit cost.

6.3 TOTAL PROJECT INCREMENTAL COST

Capital cost for replacement of CFC-11	USD 4,299,000
Capital Cost for Replacement of CFC-12	USD 2,441,100
Incremental operating cost of cyclopentane	USD 980,000
TOTAL INCREMENTAL COST	**USD 7,720,100**

6.4 PROJECT SAFETY RELATED COSTS (US$)

Cyclo-pentane storage tanks	50,000
Installations	224,000
Premix stations with buffer tanks	126,000
Modification to fixtures	1,470,000
Modification to door line	340,000
Safety control measures	330,000
EX labotary	10,000
Gas detection system for R600a	163,000
EX R600a storage room	86,300
EX fans	25,300
Technology transfer	290,000
EX Welding machine	103,000
TOTAL:	**3,217,600**

6.5 COST EFFECTIVENESS

a) MLF grant	USD 7,720,100
b) Safety related costs	USD 3,217,600
c) ODP	Kgs 767,200
Grant effectiveness (a-b)/c	**USD 5.87/kg/yr**

6.6 UNIT ABATEMENT COSTS

a) ODS Reduction Project Costs.............**USD** 7,720,100
b) Annual Incremental Costs...............**USD 1,955,760**
c) Capital Recovery Factor.......................**0.16275**
d) ODS Reduction/Y.........................**kg 767,200**
Unit Abatement Costs [{a(c) + b}/d].....USD 4.19/kg/yr

7. FINANCING PLAN

The company requests disbursement of the full project incremental costs amounting to **US$ 7,720,100** which represents the full incremental capital cost and six months of incremental recurrent cost based on 1994 production volume.

8. PROJECT IMPLEMENTATION

8.1 MANAGEMENT

UNDP will oversee the successful implementation of this project and will provide technical assistance during project execution.

8.2 IMPLEMENTATION SCHEDULE

TASK	TIME FOR COMPLETION					
	Q1	Q2	Q3	Q4	Q5	Q6
Preparation						
Implementation Documents	xx					
Equipment Specifications	xx					
Procurement						
Contracting	x	x				
Site preparation						
Civil Works		xx	xxx	xxx	xxx	
Installation						
Equipment Arrival/clearance				x		
Installation				x	x	
Dry/wet testing				x	xxx	
Reliability test						
Start-up						
Semi-Industrial Trials					x	x
Safety inspection					x	
Safety/Production Training					x	
Mass Production Trials						xx
Verification Testing						x
Commissioning						
Certification of Completion						x
Handover Protocol						x

9. PROJECT IMPACT

This project will result in the elimination of the use of annually 767.2 tons CFCs, based on 1994 consumption figures. The project applies environmentally acceptable technology while providing adequate process safety and protection against worker's exposure.

10. ANNEXES

Annex-1: Plant Layouts
Annex-2: Detailed cost information
Annex-3: Incremental recurrent cost
Annex-4 Technology Agreement
Annex-5: Technical Review

ANNEX-2

EQUIPMENT SPECIFICATIONS
KELON PROJECT

A: FACTORY #1

1. Cyclopentane Storage..............................USD 165,500

Storage Tank 35 m/3...............USD 25,000
Containment.......................USD 25,000
Tank Assessories..................USD 15,500
Pump Group (3 pumps)..............USD 63,000
Installation (pipe, cables).......USD 23,000
Connection to Premix Station..... USD 14,000

2. Cyclopentane Premix Station......................USD 210,000

Premixer..........................USD 200,000
(incl 4 sensors, buffer tank)
Ventilation, piping...............USD 10,000

3. Cyclopentane Foam Dispensers (retrofitting)......USD 220,000

One 401 pentane dispenser.........USD 115,000
(with one MH; incl. 2 sensors;
no need for stainless tanks)
One 161 pentane dispenser.........USD 105,000
(with one MH; incl 2 sensors;
no need for SS tanks)

4. Water Heating, Fixtures..........................USD 265,000

10 Sets of Aluminum Plates
incl. 2 temperature controls.....USD 80,000
Ventilation.......................USD 9,000
Electrical Modifications..........USD 35,000
Ventilation Enclosure (10 units)..USD 141,000
incl. ventilators

5. Water Heating, Door Molds.......................USD 135,000

Incl. mixing head enclosure, mold
enclosure, water heating,
ventilation, installation

6. Safety Related Equipment.........................USD 105,000

Vapor Control Cabinet Production..USD 30,000
incl. 2 ventilators @ 12,000 m^3
2 flow sensors
13 gas sensors
master control
Vapor Control Door production.....USD 25,000

incl. 2 ventilators @ 5,000 m^3
1 flow sensor
4 gas sensors
master control

Cables, Installation..............	USD	8,000
One portable gas monitor..........	USD	5,000
Alarm system, recorder/printer...	USD	12,000
Electrical Grounding	USD	25,000

TOTAL CONVERSION COSTS FOR FACTORY #1 ......USD 1,100,500

B: FACTORY #2

1. Cyclopentane Storage.............................USD 137,000

Storage Tank 2 x 35 m/3...........	USD	25,000
Containment.......................	USD	20,000
Tank Assessories..................	USD	13,000
Pump Group (3 pumps)..............	USD	50,000
Installation (pipe, cables).......	USD	15,000
Connection to Premix Station.....	USD	14,000

2. Cyclopentane Premix Station.......................USD 210,000

Premixer......................... (incl 4 sensors, buffer tank)	USD	200,000
Ventilation, piping..............	USD	10,000

3. Cyclopentane Foam Dispensers (retrofitting)......USD 705,000

3 401 pentane dispensers.......... (with 2MH; incl. 2 sensors; no need for SS tanks)	USD	360,000
1 401 pentane dispenser........... (with 1MH; incl. 2 sensors; no need for SS tanks)	USD	115,000
2 161 pentane dispensers.......... (with 3MH; incl 2 sensors, no need for SS tanks)	USD	230,000

4. Water Heating, Fixtures........................USD 1,205,000

30 Sets of Aluminum Plates........	USD	475,000
5 Sets of Aluminum Plates incl. 5 temperature controls.....	USD	80,000
Ventilation......................	USD	130,000
Electrical Modifications.........	USD	115,000
Ventilation Enclosure (35 units).. (incl. ventilators)	USD	380,000

Water Installation...............USD 25,000

5. **Water Heating, Door Molds......................USD 205,000**

Incl. mixing head enclosure, mold
enclosure, water heating,
ventilation, installation

6. **Total Safety Related Equipment..................USD 225,000**

Vapor Control Cabinet Production..USD 110,000
incl. 2 ventilators @ 12,000 m^3
2 flow sensors
13 gas sensors
master control
Vapor Control Door production.....USD 30,000
incl. 2 ventilators @ 5,000 m^3
1 flow sensor
4 gas sensors
master control
Cables, Installation.............USD 40,000
One portable gas monitor..........USD 5,000
Alarm system, recorder/printer....USD 15,000
Electrical grounding.............USD 25,000

TOTAL CONVERSION COSTS FOR FACTORY #2 ......USD 2,687,000

ANNEX-3

INCREMENTAL RECURRENT COSTS KELON PROJECT

Kelon blends currently all the individual components of its polyurethane formulations, using domestic materials to the extend feasible. It intends to do so in the future, but has to co-blend several imported polyols to achieve satisfactory processing when using cyclopentane (CP). Also, catalysts and surfactant have to be changed. The current (CFC) formulation and the future (CP) formulation are attached and show a price increase for the resulting foam of USD 0.22/kg.

In addition the foam density will have to be increased to achieve acceptable insulation performance. For costing purposes it has been agreed to use a 10% density increase although ,according to ICI recommendations, an increase of about 20% is needed. The lower amount is based on the expectation that Kelon will be able to optimize its formulations as it has done before for CFC-11.

The following table shows the effect of the changes as mentioned on the annual costs for foam insulation.

	Before (CFC-11)	**After (cyclopentane)**
Price of Foam (USD/kg)	1.40	1.62
Average Foam Use per Unit (kg)	5.80	6.40
Production 1994	870,000	870,000
Cost of Foam per year (USD)	7,064,400	9,020,160
Difference After/Before (USD)	1,955,760	
For Six Months Only (USD)	977,880	
Rounded (USD)	**980,000**	

The company will opt for the disbursement of half a year operating cost, which amounts to **USD 980,000**

ICI Polyurethanes

TELEFAX

Dr. Mike Jeffs
International Environmental
Affairs Manager
Everslaan 45
B-3078 Everberg

CHINA - KELON

TECHNOLOGY

The enterprise is proposing to convert the polyurethane rigid foam insulation used in the manufacture of refrigerators to a technology based on cyclopentane. The project is concerned with the enterprise's two existing production lines at Factories 1 and 2.

Cyclopentane technology is now well proven in several countries. It is widely used in the European Union and in Australia, New Zealand and in several developing countries.

The enterprise has considered other technologies, notably HCFC 141b but also liquid HFCs and full CO_2 / water blowing. The latter technology is not yet in use in this sector and the liquid HFCs are still under development. Compared to HCFC 141b, cyclopentane offers a zero ODP solution which can be used in the long term.

ENVIRONMENTAL ISSUES

The main issue concerns safe operation with highly flammable cyclopentane. The project proposal includes a full range of equipment to enable the enterprise to operate safely with this technology. Safety training will be carried out by the equipment supplier. The enterprise has also engaged Liebherr of Germany to assure the safety of the conversion and its operation. Liebherr are the most experienced enterprise using cyclopentane, having converted to its use early in 1993. In addition there will be assistance provided by a UNDP-appointed expert.

Cyclopentane has a zero ODP and a low GWP.

The only other issue is for the enterprise to ensure that it satisfies local regulations on VOC emissions.

PROJECT COSTS

The overall grant cost effectiveness, including the refrigerant elements, is within the EC's limits.

The capital items proposed are all justified and appropriate to a project of this magnitude.

The enterprise is requesting funding to cover incremental operating costs for six months. This includes a foam density increase of 10% compared to CFC 11-based foam (Annexe 3) which is now being experienced to obtain foam of sufficient dimensional stability (and not to compensate for insulation value as stated on P 12). The incremental cost calculation is transparent.

IMPLEMENTATION TIMEFRAME

This is generally acceptable. However, the six month period for equipment delivery for a project of this magnitude may be optimistic against current delivery times which are running at about 9-10 months.

RECOMMENDATION

Approval.

GMFJ/kd/12/6/95

Country of origin: CHINA

Project title: Elimination of CFCs in the Manufacture of Domestic Refrigerators at GUANGDONG KELON

Sector/sub-sector Domestic refrigeration

Relationship to country program (UNDP)

Note *This review addresses only the refrigerant conversion part of the project, it does not address the part related to the foam blowing agent conversion.*

Technology

1. In this project, isobutane is selected as the alternative refrigerant for the replacement of CFC-12. In domestic refrigeration, isobutane is an acceptable (nontransitional) technology to reduce CFC-12 consumption.
2. KELON does have a technology transfer agreement with Liebherr, Germany. A copy of the agreement was included in the project documentation. Liebherr will deliver the know how regarding the modifications to the production facilities and will assist in the necessary product development. Furthermore Liebherr will address all relevant safety issues associated with the application of isobutane. Next to the Liebherr participation, support will be given by the equipment supplier, A'Gramkow. Due to these aspects, a successful project implementation can be expected.
3. Due to the fact that KELON has a (small) export part to countries which do not accept flammable refrigerants in domestic appliances, a part of the future production will apply HFC-134a. Costs associated with this conversion are incurred by the company.
4. Part of the product range is of the No-Frost type (155000 units/y). At present, no commercial production of No-Frost appliances with isobutane takes place in the developed countries. From additional information supplied, it is concluded that these appliances will be produced using HFC-134a (Part of these appliances are also necessary for the export market discussed under item 3).
5. The availability of isobutane compressors is essential. The present compressor suppliers (Matsushita, Embraco and Undidad) will be able to deliver the compressors requested. Furthermore negotiations with other suppliers are currently going on.
6. A supplier of isobutane, of the correct quality, has already been identified.
7. The use of isobutane was preferred over HFC-134a due to the advantage in GWP and due to the fact that the company expects to have lower manufacturing costs in future with isobutane (which is questionable). HFC-152a was considered but not selected due to the non-availability of compressors and possible stability issues.

Environmental impact

Isobutane has no ODP and a negligible GWP. Safety and health impacts during production are addressed properly with the proposed production line modifications. Redesign of the appliances related to safety is covered within the prototyping agreement with Liebherr.

Project costs

1. The 3 refrigerant charging units claimed are expensive (230,000 USD each). However, this price is based on demonstrated quotations.
2. The number of mass spectrometer leak detectors claimed is quite high (9). Additional information supplied reveals that this is related to the production logistics where currently 3 leak detection mechanisms are in operation on each production line which equates to 9 systems. Changing the production logistics would probably be more costly.
3. Other equipment requested is essential and the costs are reasonable.

4. The technology transfer fee for Liebherr amounts to 75,000 DM (app. 50,000 USD) for the refrigerant part separately. Next to this, an agreement for prototyping exists of 260,000 USD. The total of both (310,000) can be considered as technical assistance. This total amount is relatively high but acceptable.
5. The costs of training, testing and trials are reasonable.
6. No incremental operational costs are claimed.
7. When the UAC value is calculated for the refrigerant conversion part separately, a value of 3.6 USD/kg/year is obtained, which is low compared to other, domestic refrigeration, projects. This is mainly due to the fact that no incremental operational costs are claimed. The total of the incremental investments is relatively high.
8. For the calculation of the cost effectiveness of the project, the safety costs are deduced from the incremental investment costs. It is not clear which items from the incremental investments are brought under "safety costs". However, even if no safety costs are deduced, the cost effectiveness threshold will not be exceeded for the total of the project (foam plus refrigerant).

Implementation timeframe Reasonable

Relevance and adequacy of information provided
The project description together with information supplied by UNDP consultants constituted sufficient information for a judgement.

Recommendations Approval as proposed

Janssen M.J.P.,
Eindhoven, The Netherlands, 9-June-1995

Kuijpers L.J.M.,
Technical University Eindhoven, NL

PROJECT COVER SHEET

COUNTRY:	CHINA
PROJECT TITLE:	Elimination of CFCs in the Manufacture of Domestic Refrigerators at Changsha ZHONGYI Group
SUB-SECTOR COVERED:	Domestic Refrigeration
ODS USE IN SECTOR:	8,490 tons of CFC-11/12 (1993)
PROJECT IMPACT:	360.23 t/y: 306t/y CFC-11 (1994) 54.23t/y CFC-12 (1994)
PROJECT DURATION:	1.5 year
PROJECT ECONOMIC LIFE:	10 Years
TOTAL PROJECT COST:	USD 4,404,900 USD 2,967,800 Incremental Capital Cost USD 1,437,100 Incremental Recurrent Cost
PROPOSED MLF GRANT:	USD 4,404,900
COST EFFECTIVENESS:	Grant effectiveness - USD 8.97/kg/yr Unit abatement cost - USD 5.3/kg/yr
NATIONAL COORDINATING BODY:	National Environmental Protection Agency (NEPA)
IMPLEMENTING AGENCY:	UNDP
APPRAISAL DATES:	July/October 1994, April 1995

------------------------**PROJECT SUMMARY**-------------------------

Changsha Zhongyi Group Corp. Ltd., "ZHONGYI", is a fully Chinese-owned enterprise manufacturing domestic refrigerators, freezers and air-conditioners. The 1994 production of refrigerators was 416,000. Under this project, ZHONGYI will eliminate the use of over 360 tons of CFCs in the production of refrigerators by switching to the use of cyclopentane as alternative blowing agent for cabinet and door insulation, and to HFC-134a as refrigerant. Funds requested will be used to retrofit the two existing production lines as well as to compensate for associated incremental operational costs (6 months only).

PREPARED BY: Mr. Tommy Lauridsen/Bert Veenendaal (Foam)
Mr. Roger Hodson (Refrigerant)

REVIEWED BY: Dr. Mike Jeff, UNDP Technical Reviewer (Foam)
Dr. L.J.M. Kuijpers/J.M.P. Janssen (Refrigerant)

PROJECT OF THE GOVERNMENT OF CHINA

ELIMINATION OF CFCs IN THE MANUFACTURE OF DOMESTIC REFRIGERATORS AT CHANGSHA ZHONGYI GROUP

1. PROJECT OBJECTIVE

The objective of this project is to phaseout the use of over 360 tons of CFC-11/12 in the manufacture of domestic refrigerators at the Changsha Zhongyi Group Co. Ltd.

2. SECTOR BACKGROUND

China's Country Programme (CP) for the Phase-out of Ozone Depleting Substances (ODS) under the Montreal Protocol was approved at the 9th meeting of the Executive Committee of the Multilateral Fund (MLF) in March 1993.

"OZONE PROTECTION IN CHINA - a Strategic Study on the phase-out of CFCs in the Domestic Refrigeration Sector in the People's Republic of China", prepared by The Office of Household Electrical Appliances Industry of National Council of Light Industry, in cooperation with the China Household Electrical Appliances Association (December 1994), provides data on ODS consumption. In 1993 it is estimated that 6,740 tons of CFC 11, and 1,580 tons of CFC 12 were consumed in the manufacture of new domestic refrigerators and freezers. A further 170 tons of CFC 12 were consumed in recharging refrigerators and freezers following repairs and service operations. This consumption of ODS in the domestic refrigeration sector is estimated to represent some 12% of total ODS consumption in China in 1993.

China has 240 million households but the total existing refrigerator population is estimated at only 43 million. Annual production of domestic refrigerators and freezers is growing at an average rate of 16% per annum, and it reached 8.1 million units in 1993. Export increases even faster. In 1993, China exported 450,000 refrigerators, which is double compared to 1991.

There are an estimated 100 domestic refrigerator and freezer production lines with a production capacity of 15 million units per annum. Most of the refrigerator production lines were imported from Italy, Germany and Japan in 1908's. Much of the demand for compressors is satisfied by 16 local compressor production lines with an annual capacity of 13 million units. Production of refrigerators and freezers was as follows:

1990:	5.16	million	units
1991:	5.49	"	"
1992:	6.23	"	"
1993:	8.1	"	"

The high production growth rates and the low level of refrigerator ownership, coupled with the relatively high existing level of ODS consumption, means that the domestic refrigeration sector has a high priority in China's ODS phase-out strategy. Uninhibited growth would result in an estimated consumption in the year 2000 of 11,000 tons per year of CFC 11 and 2,600 tons per year of CFC 12 for the manufacture of domestic refrigerators and freezers in China.

CFC-11 consumption has been increased proportionally and reached 6,740t in 1993. With the high market potential of refrigerators and freezers, the consumption increase will remain strong if no mitigating measures are applied.

Complete phaseout for the domestic refrigeration sub-sector is targeted for the year 2005. Approval of this project by the MLF in 1995 should result in the elimination of the CFCs used in the manufacture of domestic refrigerators at Changsha Zhongyi by early 1997 and will make a significant contribution to China's overall ODS elimination programme.

3. ENTERPRISE INFORMATION

3.1 General Background

Changsha Zhongyi Group was founded in 1980 when they imported two refrigerator production lines from Merloni in Italy to become one of the largest manufacturers of domestic refrigerators in China. In 1990, the Zhonygi group was formed. Production is steadily growing, from 380,000 refrigerators in 1993 and 416,000 in 1994. There are plans to import a third production line. The company also manufactures at an associate company other products such as freezers, air conditioners, drinking water fountains which use HCFC- 22, and sterilizers for towels. The company employs 2,100 workers, 460 of them are engineers. It has more than 220 million RMB in assets. Annex-1 provides a layout of the two production lines.

3.2 Company Data

FULL NAME:	ZHONGYI Electrical Appliance Corporation
LOCAL OWNERSHIP:	100%
PLANT LOCATION:	Changsha, Hunan Province
NAME OF CONTACT:	Mr. He Jian Zhong, Sr. Engineer Mr. Li Pei, Engineer
ADDRESS:	381 LaoDong Road Changsha, Hunan Province, China
TEL/FAX:	731-555-8123 Fax: 731-555-3188
NUMBER OF MODELS:	6 refrigerators
# PRODUCTION LINES:	2
PRODUCTION FOR 1994:	416,000 refrigerators
CONSUMPTION (1/1 - 31/12/94):	306 tons CFC-11 54.23 tons CFC-12

COMPRESSOR SUPPLIERS:	Beijing Compressor	60%
	Wongsha	20%
	Aspera (Italy)	20%

3.3 Description of the 6 models

The following tables provide a summary of the refrigerator production and CFC consumption by Zhongyi during the 12 month period from 1 January to 31 December 1994.

Table 1: CFC-11 Consumption

Model No.	Production Volume	Wt of PUF	Total PUF
BCD182	160,000	4.73	756,800
BCD218	160,000	6.1	976,000
BCD240	45,000	8.27	372,150
BCD200	32,000	6.5	208,000
BCD183W	2,000	4.85	9,700
BCD203W	17,000	6.2	105,400
	416,000	Avg 5.84 kg	2,428,050

CFC-11 = 2,428,250 x 0.126 = 305,934 kgs

Table 2: CFC-12 Consumption

Model No. use	Description	Capacity Litres	Production Volume	R12 Charge	R12 (kgs)
BCD182	DD Ref	182	160,000	0.115	18,400
BCD218	DD Ref	218	160,000	0.135	21,600
BCD240	DD Ref	240	45,000	0.150	6,750
BCD200	DD Ref	200	32,000	0.145	4,640
BCD183W	DD Ref NF	183	2,000	0.145	290
BCD203W	DD Ref NF	203	17,000	0.150	2,550
Total or Weighted Average			416,000	0.130	54,230

Key: SD=Single Door, DD=Double Door, Frz=Freezer

Table 3: Compressors

Model No.	Compressor Capacity in HP	
	R12	R134a
BCD182	1/6	1/6
BCD218	1/5	1/5
BCD240	1/4	1/4
BCD200	1/5	1/5
BCD183W	1/5	1/5
BCD203W	1/4	1/4

Weighted Average Price	$ 45.20	$ 49.20

4. PROJECT DESCRIPTION

Under this project ZHONGYI will phaseout the use of CFCs in the production of domestic refrigerators. The replacement technology of choice will be cyclopentane as blowing agent and HCFC-134a as refrigerant. The project is selected by NCLI's Household Electrical Appliances Office (HEA) as one of three demonstration projects for test application of this technology in China.

4.1 Replacement of CFC-11 by Cyclopentane

ZHONGYI's two operational production lines, consisting of two Perros foaming units, one with seven and the other with ten jigheads, will be retrofitted to allow the use of a flammable substance as a blowing agent for production of insulation foams for refrigerator cabinets and doors. The third one, which is under construction, will be installed directly for the use of pentane and will be financed by the company. The retrofit includes replacement of the existing foam dispensers, installation of water heating for the fixtures and emission control for the fixture/door-mold stations. The two premix stations will be modified through installation of static premixers and buffer tanks for the polyol/cyclopentane blend and connected to an outside storage tank for cyclopentane. All critical areas will be connected to a central gas sensing, ventilation control and alarm system and connected to a recorder/printer, allowing for retroactive fault-analyses.

The implementation of this component will be carried out on a turn-key basis by the equipment supplier. Process & safety training will be provided by the equipment supplier. The necessary civil works on the ventilation and piping systems and fire protection systems will be done by ZHONGYI, under the guidance of the equipment supplier. In addition, a UNDP-appointed cyclopentane specialist will provide continuous back-stopping to ZHONGYI in carrying out its responsibilities and assist in overall project implementation. Incremental recurrent cost for six months is also included.

4.2 Replacement of CFC-12 by HFC-134a

The conversion from CFC-12 to HFC 134a requires the use of 134a compressors and associated new synthetic lubricants, re-design of the refrigeration system to cater for the difference in the thermodynamic performance of HFC 134a versus CFC 12, prototyping, testing and optimization of each model, and pilot-scale manufacture and testing before full-scale conversion of production to HFC 134a.

The conversion will result in changes in manufacturing procedures for which production lines supervisor and operator training will be required.

The different properties of HFC 134a, the need to avoid cross contamination with CFC 12 and the phased nature of the conversion of refrigerator production from CFC 12 to HFC 134a, means that new system evacuation, refrigerant charging and leak detection equipment will be required. The technology change on which this project will impact is given under section 5.

5. TECHNOLOGY

5.1 OVERVIEW

5.1.1 CFC-11 Replacements

There are currently two main directions in the development of CFC-free foam systems for domestic refrigerators :

CFC 11 > partial water/HCFC 141b > ?

CFC 11 > cyclopentane

In addition vacuum panels are have been introduced on a limited scale but the technology is currently still in commercial development, expensive and limited available. The first option employs technology that is closely related to the existing one. The final step to non-ODS technology in this process is not yet decided. One potential solution is the use of liquid HFCs such as HFC-356 or HFC-245 derivatives, but full water blown foam with improved cell structure remains an option. The second option has recently been introduced commercially in Europe. Cyclopentane is flammable and this means a careful review of manufacturing operations with respect to the safe handling of a highly flammable/explosive foam blowing agent. Its use may not be a practical option in the existing work environments of some enterprises. In addition, cyclopentane is not everywhere available.

5.1.2 SELECTION

ZHONGYI has considered the two main options to replace CFC-11 in a feasibility study prepared early 1994. After discussions with chemical suppliers, equipment suppliers, the attendance of a seminar organized by HEA and advice of an external expert, ZHONGYI selected cyclopentane technology, the main reason being that ZHONGYI wanted a permanent replacement.

5.1.3. REQUIRED MODIFICATIONS

The use of cyclopentane (CP) will require substantial changes in the production and storage facilities based on the highly flammable/explosive character of the substance. The adherence to the strictest safety standards available, such as EN, NFPA or other internationally recognized standards is required for UNDP implemented projects. These standards classify explosive zones ("EX areas") generally in three categories:

Zone 0 Where a constant amount of highly flammable/ explosive liquids or gases can be expected. Areas inside CP pipes and tanks are Zone 0 (level, pressure and temperature controls). Materials used have to be explosion proof (EX) and grounded.

Zone 1 Where from time to time highly flammable liquids or gases can be expected; Areas in and around molds and fixtures are Zone 1. Materials used have to be EX-e, -d or -ia and grounded. Zone-1 can generally be reclassified to Zone 2 by applying sufficient ventilation.

Zone 2 Where only by accident or scheduled maintenance highly flammable/explosive gases can be expected. Tank storage areas, premix stations and foam dispensers are generally Zone 2. Materials required are EX-n or with IP54 sealing. Grounding to avoid spark building triggered by differences in electrical potential, is required.

Other requirements related to the use of CP are:

- o The installation of containment around CP storage tanks;
- o Installation of premix equipment--CP cannot purchased pre-blended;
- o Antistatic clothing and shoes in Zone 0/1 areas;
- o Installation of CP gas sensors in all EX areas, connected to a central panel and an automatic recorder/ printer;
- o A portable gas detector to monitor CP concentrations throughout the plant according to an approved monitoring plan;
- o An approved preventive maintenance system and emergency response plan;
- o Training for production and maintenance personnel in the safe handling of CP;
- o Safety Audits by a UNDP appointed independent expert prior, during and after implementation.

In line with the above-mentioned modifications on equipment and safety, process adjustments are required to cope with the lower insulation value, higher core temperatures and longer aging times related to the use of CP.

THE USE OF CYCLOPENTANE MUST CONFORM TO THE SAFETY REQUIREMENTS OF RELEVANT LOCAL AND STATE AUTHORITIES

5.2 REPLACEMENT OF CFC-12

5.2.1 Overview

HFC 134a is universally accepted as a replacement for CFC 12 in the manufacture of domestic refrigerators. HFC 134a is widely available and the technology is mature, having already been introduced commercially in many developed countries.

Hydrocarbon refrigerants are being used on a limited basis in at least one developed country. Safety issues associated with the use of flammable hydrocarbon refrigerants and the absence of suitable compressors on a commercial scale are major factors that need to be taken in full consideration when adopting this technology.

China is also conducting experiments with other technologies such as **HFC-152a** which might be considered as another candidate for CFC-12 replacement in domestic refrigerators. However, HFC-152a is also flammable, the technology has not been developed commercially and there are some questions about its stability in refrigerator systems. Furthermore, compressors for use with HFC-152a are not commercially available.

5.2.2 Selection

The selected technology is HFC 134a and has been developed with the help of compressor and refrigerant suppliers and the Beijing Household Electric Appliance Research Institute. This should ensure satisfactory completion of the project.

5.2.3 Impact on Production Processes

HFC 134a like CFC 12 is non-flammable. HFC 134a has also been the subject of extensive toxicological testing and is considered safe in industrial applications provided the suppliers' recommended exposure levels are not exceeded. At the present time this means ensuring that exposure levels do not exceed 1000 parts per million on an 8 hour time weighted average basis. This is the same as the Occupational Exposure Limit (OEL). Threshold limit value for CFC 12 and thus no changes from current practices are required.

There will be an approximately 10% reduction in the mass charge of HFC 134a compared with CFC 12 for a refrigerator system of the same capacity. This is taken into account in the calculation of the incremental operational cost (see Annex 3).

It is well understood that the chemical stability of HFC 134a/synthetic lubricant systems in domestic refrigerators and hence the long term performance of the appliance is sensitive to moisture content and certain chlorinated impurities. This requires that CFC 12 and HFC 134a handling equipment be carefully segregated and it also calls for better evacuation of the system prior to refrigerant charging.

Because system cleanliness and moisture content is paramount to the successful manufacture of HFC 134a refrigerators, the enterprise will carefully need to re-assess production procedures and re-train production personnel as appropriate. Provision is made for this within the proposal.

The relevant existing equipment at Zhongyi on which the technology change to 134a will impact is as follows:

- 1 R-12 Charging Machine Gallileo Vacutec
- 1 R-12 Merloni Progetti 5001187B automatic charging machine (1988)
- 1 R-12 Liebherr CFC 12 automatic charging machine
- 43 Gallileo 2x5 Vacsound vacuum pumps
- 2 2x5 Gallileo pumps on rectification line
- 2 Liebherr automatic pre-vacuum stations
- 2 Leybold HLD 3000 Leak Detectors

6. PROJECT COSTS

6.1 INCREMENTAL CAPITAL COSTS

6.1.1 Incremental Costs related to CFC-11 Conversion

TANK STORAGE, COMPLETE..............................USD		132,000
CENTRAL SAFETY CONTROL SYSTEM........................USD		**150,000**
PRODUCTION LINE #1.................................USD		**951,000**
Premix Station with Buffer Tank...USD	123,000	
2 CP Foam Dispensers (40+116).....USD	473,000	
Modifications Fixtures (7)........USD	255,000	
Modifications Door Line...........USD	100,000	
PRODUCTION LINE #2.................................USD		**951,000**
Premix Station with Buffer Tank...USD	123,000	
2 CP Foam Dispensers (40+116).....USD	398,000	
Modifications Fixtures............USD	330,000	
Modifications Door Line. ....USD	100,000	
GENERAL COSTS......................................USD		**548,400**
Installation, both Lines.......... USD	100,000	
Training..........................USD	50,000	
Process Safety Audits.............USD	25,000	
External Process Specialist.......USD	25,000	
Production Trials.................USD	100,000	
Contingency, Rounding.............USD	248,400	

INCREMENTAL CAPITAL COST FOR CFC-11:...........USD 2,732,400

(Annex-2 provides more details)

6.1.2 Incremental Capital Costs related to CFC-12 conversion

	US$
2 Refrigerant Charging Machines	100,000
4 new vacuum pumps with fittings	15,000
Retrofitting of 39 vacuum pumps	20,000
2 R-134a electronic HLD4000c leak detectors	14,000
Training	10,000
Prototyping/pilot trials, reliability trial etc.	40,000
Technology transfer/technical assistance	15,000
Contingencies (10% of capital cost)	21,400
Sub-total Capital Cost for CFC 12	235,400
TOTAL INCREMENTAL CAPITAL COSTS	**US$ 2,967,800**

6.2 INCREMENTAL RECURRENT COSTS/SAVINGS

Incremental recurrent costs are requested for a period of six months based on 1994 production volume. Details are provided in Annex 3. The calculation is based on a six month period using production data based on January to December 1994 figures. This was done further to a decision at the 13th Executive Committee Meeting held in Montreal in July 1994.

6.2.1 Phaseout of CFC-11

ZHONGYI will incur incremental recurrent costs related to higher densities needed to compensate for lower inherent insulation value of cyclopentane compared to CFC-11 as well as for higher material costs. The incremental operating cost for six months based on 1994 production volume amounts to **US$ 415,000.** These costs are calculated in Annex-3.

6.2.2 Phaseout of CFC-12

Costs for materials (see Annex 3): US$1,022,100

6.2.3 TOTAL INCREMENTAL OPERATING COST US$1,437,100

6.3 TOTAL INCREMENTAL COST

Capital cost for CFC-11 phaseout	US$	2,732,400
Capital cost for CFC-12 phaseout		235,400
Incremental operating cost for CFC-11 phaseout		415,000
Incremental operating cost for CFC-12 phaseout		1,022,100
TOTAL		4,404,900

6.4 PROJECT COST EFFECTIVENESS

6.4.1 COST EFFECTIVENESS

Incremental costs		US$ 4,404,900
Incremental capital costs		2,967,800
Incremental safety costs		1,173,000
Central safety control systems	150,000	
Foam dispensers	173,000	
Fixtures modifications	255,000	
	330,000	
Door-line modifications	100,000	
	100,000	
Safety audits	25,000	
Training	40,000	

CE = (4,404,900-1,173,000)/360,230 = **US$ 8.97/kg**

6.4.2 UNIT ABATEMENT COST

a.	Capital Investment Costs	2,967,800
b.	Incremental Operational Costs	1,437,100
c.	Capital Recovery Factor (10% p.a.)	0.16275
d.	ODS Reduction (ODP kgs)	360,230

Unit Abatement Costs [{a(c) + b}/d].....USD/kg/y 5.3

7. FINANCING PLAN

The company requests disbursement of the full incremental costs of **USD 4,404,900**.

8. PROJECT IMPLEMENTATION

8.1 PROJECT MANAGEMENT

UNDP will oversee the successful implementation of this project, and will provide technical assistance during project execution.

8.2 IMPLEMENTATION SCHEDULE

TASK	TIME FOR COMPLETION					
	Q1	Q2	Q3	Q4	Q5	Q6
Preparation						
Implementation Documents	xx					
Equipment Specifications	xx					
Procurement						
Contracting	x	x				
Site preparation						
Civil Works		xx	xxx	xxx	xxx	
Installation						
Equipment Arrival/clearance				x		
Installation				x	x	
Dry/wet testing				x	xxx	
Reliability test						
Start-up						
Semi-Industrial Trials					x	x
Safety inspection					x	
Safety/Production Training					x	
Mass Production Trials						xx
Verification Testing						x
Commissioning						
Certification of Completion						x
Handover Protocol						x

9. PROJECT IMPACT

This project will result in the elimination of the use of annually 360 tons CFCs based on 1994 consumption. The project applies environmentally acceptable technology while providing adequate process safety and protection against worker's exposure.

10. ANNEXES

Annex-1: Plant Layout
Annex-2: Detailed incremental capital costs information
Annex-3: Incremental recurrent costs
Annex-4: Technical Review

ANNEX 2

EQUIPMENT SPECIFICATIONS (FOAM) ZHONGYI PROJECT

A: GENERAL EQUIPMENT

1. Cyclopentane Storage...............................USD 137,000

Storage Tank 35 m/3...............USD 25,000
Containment.......................USD 20,000
Tank Assessories..................USD 13,000
Pump Room (3 pumps)...............USD 50,000
Pipe installation Tank/Pumps......USD 8,000
Electrical Installation...........USD 7,000
Connection to Premix Stations.....USD 14,000

2. Safety Control System.............................USD 150,000

One Gas Alarm & Ventilation
Control System with:
11 Sensors Cabinet station-1
6 Sensors Door Station -1
15 Sensors Cabinet Station-2
6 Sensors Door Station-2
6 Sensors Premix/Storage....USD 106,000
Ventilation flow switches.........USD 14,000
Installation..........................30,000

B: PRODUCTION LINE #1

1. Cyclopentane Premix Station......................USD 123,000

1 Pentane Premixer 15 l/min.......USD 80,000
1 Buffer Tank, 2001 with pump.....USD 20,000
Pipe Connections..................USD 10,000
Ventilation.......................USD 8,000
Electrical Panel, Installation....USD 5,000

2. **Cabinet Station.................................USD 535,000**

One 801 CP Foam Dispenser........ (2 MH; normal tank; transfer wagon & rail system)	USD 285,000
House for 7 Cabinets..............	USD 50,000
Fixture Enclosures (7)............	USD 28,000
Ventilation.......................	USD 50,000
Water heating panels, including temperature control..............	USD 80,000
Electrical Modifications..........	USD 25,000
Electrical Grounding..............	USD 17,000

3. **Door Station....................................USD 288,000**

One Pentane Foam Dispenser 321, Standard Tank, incl piping......	USD 188,000
Housing for heating Zone..........	USD 6,000
Water heating, incl Housing.......	USD 15,000
Water installation................	USD 9,000
Electrical Modifications..........	USD 12,000
Electrical grounding..............	USD 7,000
Enclosure of Foam Area............	USD 11,000
Automatic Mixhead moving System...	USD 15,000
Ventilation,incl. Installation....	USD 25,000

B: PRODUCTION LINE #2

1. **Cyclopentane Premix Station.....................USD 123,000**

1 Pentane Premixer 15 l/min.......	USD 80,000
1 Buffer Tank, 200l with pump.....	USD 20,000
Pipe Connections..................	USD 10,000
Ventilation.......................	USD 8,000
Electrical Panel, Installation....	USD 5,000

2. **Cabinet Station.................................USD 540,000**

One Pentane Foam Dispenser 401 Standard Tank, incl. piping.....	USD 210,000
Housing for 10 Cabinets...........	USD 65,000
Enclosure for fixtures............	USD 40,000
Ventilation.......................	USD 65,000
Water Panels/temperature control..	USD 100,000
Electrical Modifications..........	USD 30,000
Electrical Grounding..............	USD 30,000

4. **Door Station....................................USD 288,000**

One Pentane Foam Dispenser 32l, Standard Tank, incl piping......	USD	188,000
Housing for heating Zone..........	USD	6,000
Water heating, incl Housing.......	USD	15,000
Water installation................	USD	9,000
Electrical Modifications..........	USD	12,000
Electrical grounding..............	USD	7,000
Enclosure of Foam Area............	USD	11,000
Automatic Door handling System....	USD	15,000
Ventilation,incl. Installation....	USD	25,000

TOTAL CONVERSION COSTS FOR LINE 1 & 2.......USD 2,184,000

ANNEX-3

INCREMENTAL RECURRENT COSTS

ZHONGYI PROJECT

1. Conversion from CFC-11 to Cyclopentane

Zhongyi buys polyol with all components blended in it except CFC-11. It intends to do so in the future. The new foam formulation will show a slight increase in unit price.

In addition, the foam density will have to be increased to achieve acceptable insulation performance. For costing purposes it has been agreed to use a 10% density increase.

The following table shows the effect of the changes as mentioned on the annual costs for foam insulation.

	Before (CFC-11)	**After (cyclopentane)**
Price of Foam (USD/kg)	2.18	2.22
Average Foam Use per Unit (kg)	6.75	7.42
Production Oct. 93 through Sep. 94	470,000	n.a
Cost of Foam per year (USD)	6,916,050	7,742,028
Difference Before/After (USD)		825,978
For Six Months Only (USD)		412,989
Rounded (USD)		415,000

The company will opt for the disbursement of half a year operating cost, which amounts to: **USD 415,000**
==========

2. **Conversion from CFC-12 to HFC-134a**

		CFC 12	HFC 134a	Diff.
1.	Refrigerant a. Price/kg of refrigerant (see note below) b. Kg of refrigerant/refrigerator average c. No. of refrigerators produced	2.4 0.130 416,000	8.0 0.117 416,000	5.6 0.013 416,000
	Cost of refrigerant =	129,792	389,376	259, 584
2.	Compressors a. Cost of compressor b. No. of compressors	45.2 416,000	49.2 416,000	4.0 416,000
	Cost for compressors =	18,803,200	20,467,200	1,664,000
3.	Condensers a. Cost per condenser b. No. of condensers	No change	No change	0
	Cost for condensers =			0
4.	Filter Dryer a. Cost per filter dryer (average) b. No. of filter dryers	0.64 416,000	0.76 416,000	0.12
	Cost for filter dryers =	266,240	316,160	49,920
5.	Capillary tubes a. Cost per capillary tube (average) b. No. of capillary tubes	0.70 416,000	0.87 416,000	0.17
	Cost for capillary tubes =	291,200	361,920	70,720

INCREMENTAL OPERATIONAL COST FOR 1 YR (1+2+3+4+5): US$ 2,440,224
INCREMENTAL OPERATIONAL COST OF SIX MONTHS: US$ 1,022,112

ICI Polyurethanes

TELEFAX

Dr. Mike Jeffs
International Environmental
Affairs Manager
Everslaan 45
B – 3078 Everberg

CHINA - ZHONGYI

TECHNOLOGY

The enterprise is proposing to convert the polyurethane rigid foam insulation used in the manufacture of refrigerators to a technology based on cyclopentane. The project is concerned with the enterprise's two existing production lines each of which has cabinet and door manufacturing capability. The enterprise is installing a third production line to operate with cyclopentane at its own expense.

Cyclopentane technology is now well proven in several countries. It is widely used in the European Union and in Australia, New Zealand and in several developing countries.

The enterprise has considered other technologies, notably HCFC 141b but also liquid HFCs and full CO_2 / water blowing. The latter technology is not yet in use in this sector and the liquid HFCs are still under development. Compared to HCFC 141b, cyclopentane offers a zero ODP solution which can be used in the long term.

ENVIRONMENTAL ISSUES

The main issue concerns safe operation with highly flammable cyclopentane. The project proposal includes a full range of equipment and measures, such as safety audits, to enable the enterprise to operate safely with this technology. This includes the necessary detection and ventilation equipment. The training will be carried out by the equipment supplier backed up by a UNDP-appointed expert experienced in such technology.

Cyclopentane has a zero ODP and a low GWP.

The only other issue is for the enterprise to ensure that it satisfies local regulations on VOC emissions.

PROJECT COSTS

The overall grant cost effectiveness, including the refrigerant elements, is within the EC's limits.

The capital items proposed are all justified and appropriate to a project of this magnitude.

The enterprise is requesting funding to cover incremental operating costs for six months. This includes a foam density increase of 10% compared to CFC 11-based foam (Annexe 3) which is now being experienced to obtain foam of sufficient dimensional stability (and not to compensate for insulation value as stated on P 10). The incremental cost calculation is transparent.

IMPLEMENTATION TIMEFRAME

This is generally acceptable. However, the six month period for equipment delivery for a project of this magnitude may be optimistic against current delivery times which are running at about 9-10 months.

RECOMMENDATION

Approval.

GMFJ/kd/12/6/95

Country of origin:	CHINA
Project title:	Elimination of CFCs in the Manufacture of Domestic Refrigerators at CHANGSHA ZHONGYI GROUP
Sector/sub-sector	Domestic refrigeration
Note	*This review addresses only the refrigerant conversion part of the project, it does not address the part related to the foam blowing agent conversion.*

Technology

- In this project, HFC-134a is selected as the alternative refrigerant for the replacement of CFC-12. In domestic refrigeration, HFC-134a technology is a proven and acceptable (nontransitional) technology to reduce CFC-12 consumption.
- ZHONGYI does not have a formal technology transfer agreement. However, the technology will be developed (and has been developed) with assistance from the compressor suppliers and the refrigerant supplier. Furthermore, assistance is given by the Beijing Household Electric Appliance Research Institute. Next to this, provisions for external support are present. Altogether, a successful project implementation can be expected.
- Other technologies than HFC-134a were considered (hydrocarbons, HFC-152a) but were not selected because of the state of development, safety issues and the lack of commercially available compressors. From the zero ODP technologies HFC-134a is one of the most cost effective solutions.

Environmental impact

HFC-134a has an ODP of zero and a GWP of 1300 compared to carbon dioxide (100 year time horizon). For domestic refrigeration a GWP of this magnitude is acceptable.

Project costs

- The equipment requested is essential for the conversion process and the associated costs are reasonable.
- The costs of training, testing, trials and technical assistance are reasonable.
- Incremental operational costs are claimed for half a year.
- The different items claimed in the incremental operational costs calculation are reasonable. The total incremental operational costs per unit amounts to 4.9 USD which is reasonable.
- When the UAC value is calculated for the refrigerant conversion part separately, a value of 19.5 USD/kg/year is obtained, which is in line compared to other, similar, projects.

Implementation timeframe	Reasonable
Relevance and adequacy of information provided	Reasonable
Recommendations	Approval as proposed

Janssen M.J.P.,
Eindhoven, The Netherlands, 9-June-1995

Kuijpers L.J.M.,
Technical University Eindhoven, NL

Project Proposal for the Multilateral Fund for the Implementation of the Montreal Protocol Financing

COUNTRY	People's Republic of China		
PROJECT TITLE	Conversion of domestic refrigerator and freezer factories to phase out CFC-12 and CFC-11 by hydrocarbons isobutane and cyclo-pentane at Hangzhou Xiling Holdings Company		
SECTORS COVERED	Domestic Refrigeration: refrigerators and freezers		
ODS USE IN SECTOR	1706 MT of CFC-12 as refrigerant and 6740 MT of CFC-11 as foam blowing agent annually		
PROJECT IMPACT	Phase out of an annual consumption of 60 MT of CFC-12 (ODP = 60 MT) and of 300 MT of CFC-11 (ODP = 300 MT), total 360 MT of ODS/ODP		
PROJECT DURATION	36 months		
PROJECT ECONOMIC LIFE	10 years		
TOTAL PROJECT COST	100 per cent incremental investment cost and 6 months of incremental operating cost		
PROPOSED MF FINANCING	Incremental investment (capital) cost	US$	3,999,000
	10 per cent contingency	US$	399,900
	Incremental operating cost for 6 months	US$	951,210
	13 per cent agency overhead	US$	695,514
	Total cost of project	**US$**	**6,045,624**
OWNERSHIP STRUCTURE	100 per cent Chinese		
UNIT ABATEMENT COST	(Please see Annexes 3 and 7.b)		
COST-EFFECTIVENESS **WITH** SAFETY SYSTEMS	14,86 US$/kg of ODS phased out (5,350,110/360,000=14,86)		
COST-EFFECTIVENESS **WITHOUT** SAFETY SYSTEMS	6.52 US$/kg of ODS phased out (Please see Annex 7.a, 2,348,110/360,000=6.52)		
COUNTERPART ENTERPRISE	Hangzhou Xiling Holdings Company		
IMPLEMENTING AGENCY	UNIDO		
COORDINATING MINISTRY	China National Council of Light Industry through China Household Electrical Appliances Association		
NATIONAL COORDINATING AGENCY	National Environmental Protection Agency (NEPA) of China		

PROJECT SUMMARY

Following the request of the Government of the PR China and based on the strategy study of elimination of ODS in the refrigeration sector, a project has been developed to replace CFC-12 by isobutane as refrigerant and CFC-11 by cyclo-pentane as foam blowing agent at three refrigerator and freezer manufacturing factories of the Hangzhou Xiling Holding Co.

Isobutane as refrigerant and cyclo-pentane as foam blowing agent have been selected on the basis of environmental and technological reasons such as zero ODP, near zero GWP, its increasing international acceptance, availability of well-developed technological safety standards, etc.

This project covers the conversion of the refrigerant and the foam blowing agent. The upgrading of repair and maintenance services is expected to be the subject of an another project.

The project will phase out 360 MT of ODS (CFC-12 as refrigerant and CFC-11 as foam blowing agent) annually used for the production of domestic refrigerators and freezers in the three factories of the Hangzhou Xiling Holdings Company. The project is considered to be one of the pilot projects for the application of hydrocarbons as refrigerant and foam blowing agent in the household refrigerator and freezer manufacturing factories in China.

1. Background

1.1 Refrigeration sub-sector

The sub-sector for domestic refrigeration in China covers today approximately 70 refrigerator and 30 freezer manufacturing companies having a total consumption of 8,446 MT of CFC's in 1993. The total annual production capacity is approximately 15 million units. The Hangzhou Xiling Holdings Company is the fifth largest firm in the Chinese refrigerator and freezer market. It has a market share of about 7 per cent.

1.2 Company background

Hangzhou Xiling Holdings Company comprises of three factories which are all located in Hangzhou. The company started to manufacture home appliances, e.g. refrigerators, in 1973. Up to now, approximately 1,200,000 refrigerators and freezers have been manufactured. The three factories are specialized and contribute to the total output as follows (see also **Exhibit** 1):

Factory I:
This factory is the largest within the company and is manufacturing the models: BC106, BC122, BCD175, and BCD192. The annual output in 1994 is 220,000 units.

Factory II (physically located adjacent to Factory I):
This factory is the second largest having an output of 150,000 units in 1994. It manufactures exclusively the models BC158 and BD188.

Factory III (located at 5 km from Factories I and II):
The 1994 production of this factory will reach 110,000 units, mainly the models BD106, BC122, and BCD258.

Exhibit 1. Total production of refrigerators and freezers, and total consumption of CFC's in 1993 at Hangzhou Xiling Holding Co.

No.	Model name	Factory	Total output, units	Consumption of CFC-11		Consumption of CFC-12	
				kg/unit	Total, MT	kg/unit	Total, MT
1	BC122	I, III	103,507	0.61	63.139	0.14	14.491
2	BD106	I, III	103,507	0.92	95.226	0.15	15.526
3	BC158	II	31,502	0.94	29.612	0.14	4.410
4	BCD175	I	18,619	0.58	10.799	0.14	2.607
5	BCD192	I	10,794	0.61	6.584	0.14	1.511
6	BD188	II	19,976	1.45	28.965	0.14	2.797
7	BD130	II	16,779	1.02	17.115	0.15	2.517
8	BC130	III	7,977	0.62	4.946	0.14	1.117
9	BD128	III	7,977	0.93	7.419	0.15	1.197
10	Others	I, III	30,532	0.72	21.983	0.14	4.274
Total			351,170		285.788		50.446
Total amount of CFC's consumed (*)					300.000		60.000

(*) The difference in consumption figures results from losses during the production processes, and from use of refrigerant for repair work.

Based on a licence agreement signed in 1985 with the German company Liebherr-Hausgeraete GmbH, comprehensive investments were made to modernize and to enlarge the production capacity. Most of the production facilities were installed between the years 1988 and 1992. The total capital value of the Hangzhou Xiling Holdings Company is RMB 240 million which corresponds to US$ 28.2 million. The total production capacity is approximately 500,000 refrigerators and freezers annually. The market value of annual production is RMB 650 million (US$76.5 million). The target for the year 2000 is to reach an annual sales figure of RMB 2 billion (US$235.3 million).

Actually, 50 different models of refrigerators and freezers are manufactured on four assembly lines. Referring to **Exhibit 1**, seven models accounted for about 305,000 units (87 per cent) in 1993). The Company mainly manufactures for the domestic market. The exports were less than 10,000 units in 1993. The CFC-12 consumption in 1993 was 60 MT. It is expected that about 90 MT of CFC-12 will be needed in 1994.

As already mentioned, the average age of the production equipment is six years, and the expected lifetime will be 15 years. Four high pressure foaming machines delivered by Hennecke, Germany in 1989, and Cannon, Italy in 1992 are operated using CFC-11 to produce the insulation foam. Plugs, jigs, and fixtures for cabinet and door foaming were designed by Liebherr, Hennecke and, partly, by the Company itself. Vacuum pumps (partly Liebherr patented design) may be used for the non-CFC production after retrofitting (however, some new vacuum pumps will additionally be needed). Leak detectors designed by Liebherr and by Chinese institutes will have to be completely replaced. New charging equipment will be needed for the hydrocarbon technology.

The company has its own research and development department. Special test facilities have to be provided to help the company to respond to new demands resulting from the use of the hydrocarbon technology.

The company is manufacturing refrigerators and freezers of high quality. A three-year warrantee is provided. So far, during the warrantee period, and on the average, about 2,600 units had been repaired. This number corresponds to less than 1 per cent of the total number of units that were sold over the same period.

1.3 Consumption of ODS

According to the Country Programme, the total ODS consumption in the sub-sector in 1993 is 6,740 MT of CFC-11 and 1,706 MT of CFC-12 which adds up to a total of 8,446 MT of ODS. The quantity of CFC's consumed at the manufacturing processes at the Company can be seen from **Exhibit 1**. The total consumption of CFC-11 was 300 MT in 1993. In the same year, 60 MT of CFC-12 was used.

1.4 Conversion strategy

As explained in **Exhibit 1**, the total output of refrigerators and freezers in 1993 was approximately 350,000 units. While the total capacity is 500,000 units/year, it is expected that the production will reach 480,000 units in 1994. Therefore, the consumption of CFC-11 and CFC-12 will reach around 400 MT/year and 90 MT/year, respectively. However, 1993 production figures were used in the design of the project.

The refrigeration sector strategy prepared by the China Household Electrical Appliances Association (CHEAA) and the China National Council for Light Industry (CNCLI) has been presented to the Executive Committee of the Multilateral Fund at its Sixteenth Meeting. According to that study, it was decided to use isobutane in order to replace CFC-12 as refrigerant at the Hangzhou Xiling Holdings Company. The foam blowing agent CFC-11 will be replaced by cyclo-pentane.

The company Liebherr-International AG, Switzerland, visited the Hangzhou Xiling factories to discuss the required changes in the design of products and in the manufacturing process. The ideas developed by Liebherr-International have been taken into consideration in this project document. Liebherr- International A.G. presented a written declaration to transfer know-how to the Hangzhou Xiling Holdings Company during all phases of the conversion process from using CFC's to the alternatives isobutane as refrigerant and cyclo-pentane as foam blowing agent.

The three factories show great similarity in product design and production methods. The specialization of each of the three factories has already been outlined in Section 1.2 "Company background".

Due to the fact that a great number of different models of refrigerators and freezers have to be analyzed with respect to the redesign of the electric equipment and the size of the compressor and evaporator (larger outer dimension of the compressor and smaller quantity of refrigerant charged into the refrigeration cycle), a time period of 4 years will be taken into account to implement the project and to convert all models step by step from the application of CFC-12 to the use of isobutane, and from the application of CFC-11 to the use of cyclo-pentane. Comprehensive field tests are considered to be necessary to prepare the customers to accept the new refrigerant.

1.5 Used technologies

As already mentioned isobutane as refrigerant and cyclo-pentane as foam blowing agent will be used. All components needed for the refrigeration cycle like compressor (specific models are imported in small quantities), evaporator, condenser, dryer which are compatible with isobutane and mineral oil (already used together with CFC-12) are available on the Chinese domestic market if the Jiaxipera Compressor Co. will start to manufacture hermetic compressor designed for the application of isobutane.

Chemicals like refrigerant and foam blowing agent will most probably be manufactured domestically, while materials like plastic for inner liner (ABS, HIPS) and foam components (polyuretane and isocyanate) are imported. For the project, HFC-134a and R-600a (isobutane) were considered as possible refrigerant alternatives (see **Exhibit** 2).

Exhibit 3 explains that by using R600a as refrigerant the COP may become higher compared with CFC-12 and HFC-134 a. Precondition is that the refrigerator cabinet and the refrigeration cycle as a whole will be optimized. This is a time and money consuming procedure. **Exhibit 4** shows that a larger compressor is necessary having approximately twice the theoretical displacement compared with a compressor used for CFC-12. This may result in larger outside dimensions of the compressor case.

As concerns CFC-11 the only acceptable alternative to replace it is the use of cyclo-pentane. Cyclo-pentane has a zero ODP and a zero GWP. The overall heat transfer coefficient is nearly the same compared with CFC-11 which means that no changes in the cabinet design and insulation thickness are necessary.

1.6 Ownership and licences

The Hangzhou Xiling Holdings Company is a completely state owned factory.

Licences for some of the refrigerator and freezer models have already been contracted in 1985. The original models were later on adapted to the market demands and customer habits.

It is a part of this project that the specific know-how for the application of isobutane and cyclo-pentane will be provided by the Liebherr Hausgeraete Company, Germany, or other experienced international companies which already use the isobutane and cyclo-pentane technology.

Exhibit 2. Alternative refrigerants to replace CFC-12

Refrigerant	Assessment	Consequences
Isobutane	• Inflammable and explosive in certain limits of mixture with air. • ODP = 0. • High Coefficient of Performance (COP) which means lower energy consumption (see Exhibit 1). • GWP near zero.	Special infrastructure needed. Technology and specific know-how available which guarantees safe conditions during manufacture, repair and service. Special service technology must be applied. Relatively easy to implement. Changes in product design and manufacturing technology are necessary (larger compressor).
HFC-134a	• ODP = 0. • Lower Coefficient of Performance compared to CFC-12 and isobutane expressed by a higher consumption of energy (see Fig. 1).	Product design except the cooling circuit can stay the same. Increased manufacturing process control required. Specially high cleanliness necessary. Components affected by the refrigerant must be free of mineral oil.

Exhibit 3. Coefficient of Performance (COP)

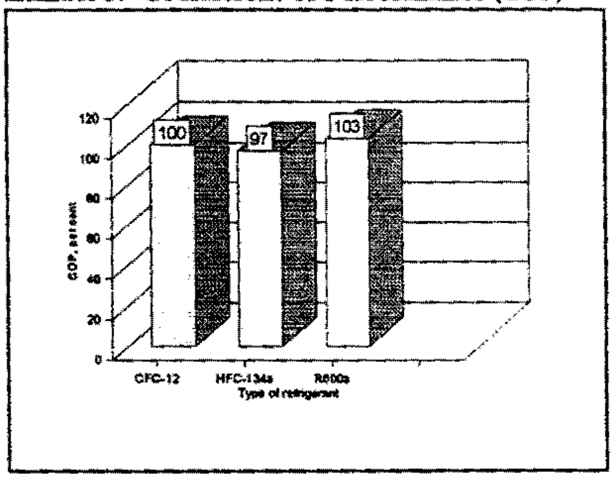
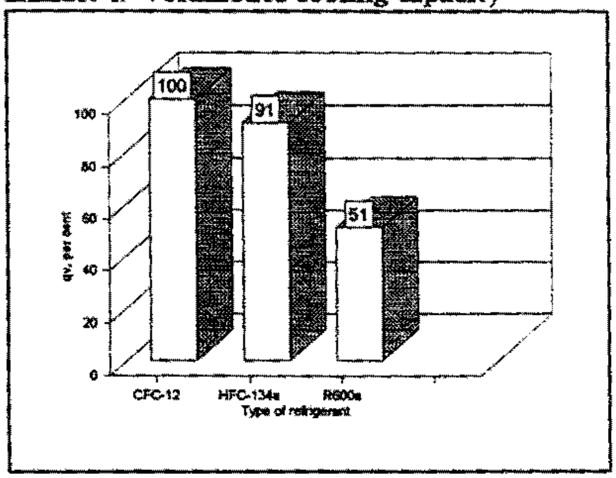


Exhibit 4. Volumetric cooling capacity



1.7 Future developments

Due to the fact that the company has nearly reached their production limits of the facilities available no production increase is planned for the next two years. Following the conversion to isobutane the production will again be increased up to 800,000 units annually in the year 2000. For this reason new production facilities will be built, the finances of which do not form a part of the present project in any way.

It has to be mentioned as well that servicing and repair of refrigerators and freezers charged with isobutane as refrigerant is not considered in this project. It is, however, strongly recommended to develop a solution for a servicing and repair technology in the frame of a separate project. This could be done by UNIDO upon request of the government of the PR China.

2. Project objectives

Four main objectives for the project were outlined:

(I) Complete elimination of the use of CFC-12 as refrigerant for all models of refrigerators and freezers by the utilization of the refrigerant isobutane. By this step 60 MT of CFC-12 consumed in 1993 or 90 MT of CFC-12 consumed in 1994 and in the following years will be phased out annually.

(ii) Complete elimination of the use of CFC-11 as foam blowing agent for all models of refrigerators and freezers by the utilization of cyclo-pentane. By this step, 300 MT of CFC-11 consumed in 1993 will following the conversion be phased out.

(iii) The same production costs and the same high quality level must be guaranteed following the implementation of the project.

(iv) The Hangzhou Xiling project is considered to have the character of a pilot project in the PR China. Following this project further Chinese refrigerator and freezer manufacturers will based on the experiences with the project be converted to the use of hydrocarbons as refrigerant.

3. Project description

The three factories of the Hangzhou Xiling Holdings Company have decided to replace refrigerant CFC-12 with the hydrocarbon isobutane and foam blowing agent CFC-11 with the hydrocarbon cyclo-pentane.

Through the project assistance will be provided to enable:

a) Transferring the know-how.

b) Redesigning, prototype manufacturing and testing of refrigerators and freezers in the laboratory as well as in the field.

c) Modifying and/or reconstructing the production facilities according to safety requirements (storage tank for larger quantities of hydrocarbons, because it is expected that delivery of hydrocarbons upon short notice cannot not be guaranteed in the near future).

d) Redesigning and adapting the present production machinery and equipment wherever technically and economically feasible.

e) Procuring new machinery and equipment.

f) Installing, commissioning and starting-up of the new machinery and equipment.

g) On-the-job-training of the operators and maintenance crews.

The guarantee for the safe operation of the production facilities will be ensured by certificates provided by nationally and internationally authorized authorities (such as TUV certificate provided by the German authorities), by the transfer of know-how, and training of the management, technical staff and workers.

4. Inputs

The incremental investment costs resulting from the redesign of the different models of refrigerators and freezers, equipment to be replaced as well as new equipment are listed in **Annex 1.**

4.1 Refrigeration system and cabinet redesign

The application of isobutane and cyclo-pentane at the Hangzhou Xiling factories has been decided upon in the Refrigeration Sector Strategic Study mentioned before. This study was presented to the Sixteenth Meeting of the Executive Committee of the Multilateral Fund.

As already mentioned, the three factories of the Hangzhou Xiling Holdings Company utilize the technology transferred from the Liebherr Company, Germany. The new hydrocarbon technologies are available from the same source, as well as from a number of other technology suppliers. The hydrocarbon technologies and the possible risks involved are well known and appropriate measures will be taken against accidents. The technology is approved by many European refrigerator and freezer manufacturers. Special experience is available with respect to safety aspects in connection with the use of isobutane as refrigerant and cyclo-pentane as foam blowing agent.

Advantages of the use of isobutane are:

- Mineral oil may be used comparable with the quality of the oil used with the CFC-12 technology.
- The quantity of refrigerant charged into the refrigeration cycle is one third only compared with the CFC-12 technology.
- Lower energy consumption compared with the HFC-134a technology which means a higher value of the coefficient of performance, COP (COP = refrigeration capacity/energy input).

Disadvantages of the isobutane technology are:

- A compressor with a higher theoretical displacement is needed resulting from the lower density of the refrigerant. This may result in larger outside dimensions of the compressor and resulting in possible changes of the cabinet design especially the place where the compressor is regularly situated.
- Resulting from the inflammability and the small charge of refrigerant, the refrigeration cycle must guarantee a very small leak rate (< 0.3 gr/year) in order to ensure a lifetime of the appliance of about 15 years. Therefore, ultra -high-frequency welding equipment is needed to close the charging tube on the compressor following refrigerant charging. Further, it is desirable to use the helium leak test technology to detect small leaks.
- Hydrocarbons need special storage facilities and special protected areas for the charging equipment together with a ventilation system including isobutane sensors which start the ventilation system when the concentration of isobutane in the air reaches the lower set limit, but stops operation of the whole assembly line in case that an upper limit is exceeded.
- The refrigerator and freezer cabinets have to be redesigned in order to install electric switches outside the cabinet and to omit the electric heating systems used to avoid the formation of frost at the door frame, as usually employed in freezers.

- Handling and storing of hydrocarbons (cyclo-pentane and isobutane) requires a special safety philosophy. Safety philosophy in this respect does not only cover a series of individual measures, but must be a concept which includes the technology, product and equipment design, safety precautions, and training of the staff. Only a few experienced companies in Europe have the know-how and are willing to transfer the know-how based on a mutual agreement. Without a full responsibility of an experienced partner for the conversion process, the application of isobutane cannot be recommended.

Therefore the following changes and measures have to be taken into account:

- Transfer of know-how by an experienced refrigerator and freezer manufacturer which has already converted its own production to isobutane and cyclo-pentane technologies.

- Redesign of the refrigeration cycle and the cabinet.

- Utilization of hermetic compressors developed for the use of isobutane.

A project in parallel is being prepared and will be implemented to convert the production of hermetic compressors from the application of CFC-12 to isobutane. The project is connected with Jiaxipera Compressor Manufacturing Company in China. In case that the above project will be delayed the compressors needed by Xiling Holdings Company have to be imported from abroad.

4.1.1 Model evaluation and field test

As already mentioned the utilization of isobutane as refrigerant requires the redesign of each individual refrigerator model, field tests and model evaluation. The redesign of a model available consists of an analysis regarding thermodynamics and as a second step an analysis with respect to safety measures. The following steps have to be considered:

I) Theoretical analysis of all components of the refrigeration cycle with respect to changes resulting from the use of isobutane instead of CFC-12 (compressor, evaporator, condenser, capillary tube, filter/dryer, piping).

ii) Redimensioning of the components where necessary. Especially the evaporator and the capillary tube have to be redesigned taking into account the lower density of isobutane. With respect to safety the inner volume of the evaporator has to be minimized to ensure that the quantity of the isobutane charged into the refrigeration cycle will be as small as possible.

iii) Redesign of the refrigerator cabinet especially the place where the compressor is regularly situated resulting from larger outside dimensions of the isobutane refrigeration compressor.

iv) Redesign of the refrigerator cabinet and the refrigeration cycle taking safety measures into consideration:
   - installation of all electric switches (thermostats, switch for inner lighting, electric frame heating system to omit the formation of frost) outside the cabinet.
   - redesign of the piping system to reduce the number of joints to be welded.
   - redesign of the piping system to ensure that pipes and joints are always outside of the thermal insulation of the cabinet.

   In order to facilitate efficient redesign work of the Company, some test equipment will be provided to complement the present testing capabilities.

v) Building of prototypes

vi) Testing of prototypes (measuring the inside temperature of the cabinet, the energy consumption during 24 h, the relative running time).

vii) Evaluation of prototypes.

viii) Redesign the models in those cases where the test results evaluated are unsatisfactory.

ix) Field test of new refrigerators.

x) Preparation of the redesigned and tested model for mass production.

The steps mentioned above are considered within the project regarding the funds and appropriate time needed for implementation.

4.2 Equipment changes or modifications

Considering the present lay out of production lines in the Hangzhou Xiling factories, the following points should be taken into account:

a) **Assembly of the refrigeration circuit**

The list of required equipment is given in **Annex 5**.

- retrofitting and/or adaptation of present vacuum pumps
- installation of helium leak test equipment including helium recovery system and storage
- installation of new charging equipment including storage facilities (underground container, equipment to decant isobutane from the large container to small movable cylinders used at the charging machine)
- installation of safety control system including isobutane detectors, a ventilation system, and protective walls to avoid that isobutane leaks may flow away into uncontrolled areas
- installation of ultra-high frequency welding equipment to close the charging pipe following refrigerant charging
- installation of high voltage testing facility to test insulation in order to avoid sparks

b) **Foaming of the refrigerator cabinet and of the door**

The technology is well established to manufacture PUR insulation foam by using cyclo-pentane as the foam blowing agent. However, following should be considered:

- high pressure foaming machines have to be used in order to achieve an acceptable foam quality and insulation effectiveness (already available but must be adapted to the use of cyclo-pentane)
- premixing stations have to be installed to ensure the mixing of cyclo-pentane with polyol
- storage tanks for cyclo-pentane have to be added to the installation
- cyclo-pentane sensors have to be installed on critical parts of the equipment in order to avoid that in case of leaks explosive mixtures of air and cyclo-pentane will be formed
- exhaust and ventilation systems have to be installed which starts operation in case that critical mixtures of air and cyclo-pentane will be formed

- all parts of the equipment specially the foaming jigs and fixtures have to be grounded to avoid the appearance of static electricity
- the whole pipe system including storage tanks and mixing units have to be pressurized with nitrogen gas in order to avoid the formation of explosive mixtures inside the system
- it is recommended to fill the gap between inner liner and refrigerator cabinet before the injection of the liquid foam material with nitrogen to avoid the formation of an explosive air-cyclo-pentane-mixture
- the control panel has to be redesigned taking into consideration the changes and modifications in the foam blowing procedure as described above.

4.3 Preparation for the mass production

The conversion process of the current refrigerator and freezer models to the utilization of isobutane as refrigerant covers all activities to make sure that the new models are on the same level of functionality, quality and reliability as the original. Several stages in this process have to be considered:

- design, calculation and drafting (the company already uses CAD technology)
- prototype production
- functionality and performance testing
- production simulation and trial runs
- field tests for functionality, safety and reliability
- conversion of the trial production to mass production
- safety training and training on-the-job of the staff
- external problem solving consultancy

The individual steps and the expected time frame are outlined in the work plan given in **Annex** 2.

4.4 Conversion

Exhibit 5 provides an overview concerning the facilities available to manufacture the expected variety and quantity of appliances as analyzed for the year 1993.

Exhibit 5. Overview of production facilities available at the Xiling Company

	Total	Factory I	Factory II	Factory III
Number of models of refrigerators and freezers manufactured	14(*)	5	5	6
Number of assembly lines	4	1	2	1
Number of sets of plugs, jigs, and fixtures	48	12	16	16
Number of foaming machines (high pressure)	4	2	1	1
Number of vacuum pumps	49	5 (**)	24	20
Number of leak detectors	7	3	2	2
Number of charging machines	5	2	2	1
Capacity of units to be manufactured	480,000	220,000	150,000	110,000

(*) the total number of 14 models results from the fact that the same models are manufactured in different factories (see **Exhibit 1**).

(**) special types

5. Project implementation

The project will be coordinated by the China National Council of Light Industry through China Household Electrical Appliances Association. The project will be implemented by UNIDO. UNIDO as the implementing agency has the appropriate experience and capabilities for the successful implementation of projects on the enterprise level. Upon the approval by the Executive Committee of the Multilateral Fund for the Implementation of the Montreal Protocol, the project's fund will be transferred to UNIDO. A respective project allotment document will then be issued by UNIDO financial section. Any substantive alterations of the project will be subject to approval by the Chinese Government and the ExCom of the Multilateral Fund.

Annex 2 shows a draft work plan, as already mentioned.

The following companies amongst others are able to transfer specific know-how:

1. AFROS CANNON SpA
   Via Galileo Perroris 65
   I-21042 Caronno Pertusella (VA)
   Italy

2. dkk Gesellschaft fuer Entwicklung und Projektmanagement mbH
   August-Bebel-Strasse 24
   D-09435 Scharfenstein
   Germany

3. FORON Haushaltsgeraete GmbH
   Arnsfelder Strasse 4
   D-09518 Niederschmiedeberg
   Germany

4. Liebherr-Hausgeraete GmbH
   Postfach 1161
   D-88411 Ochsenhausen
   Germany

5. Maschinenfabrik Hennecke GmbH
   Polyurethan-Anlagentechnik
   Birlinghovener Strasse 30
   D-53754 Sankt Augustin-Birlinghoven
   Germany

6. Project cost

The grant requested presents the incremental costs as additional cost that the factories incur in taking the action to phase out ODS, and such defined as the difference between the actual cost of the phase out activity and the baseline cost. The baseline cost is the cost that companies incur when staying at the same level of operation, without phasing out ODS.

Costs of conversion of the production facilities eligible for grant financing comprise the following elements:

a) Incremental investment cost (capital cost)
b) Incremental operating cost (recurrent cost)
c) Contingency.

Cost for transport and insurance of capital equipment is included in the budgeted allocations. In the prices the estimated labour cost for increased handling and quality control are included, taxes and duties are excluded. A discount rate of 10 per cent is used throughout the project.

6.1 Baseline cost

These cost are assumed to be zero. Although the Hangzhou Xiling Holdings Company is planning to extend their production facilities in order to respond to the increasing demand from the market, these extended capacities are not involved in the grant requested. This request is based on the capacities and production levels as analyzed during January 1993 and December 1993. No decommissioning of existing production capacities is foreseen because the foaming machines will be adapted to the application of cyclo-pentane. The charging machines used for CFC-12 are not up-to-date and will be scrapped.

6.2 Incremental investment costs

Incremental investment cost will cover capital investment cost for the modification of the refrigerator and freezer models, for the modification of the manufacturing facilities, materials, new machinery, installation, commissioning, training, and consultancy (see **Annex 1**).

6.3 Incremental operating costs

Recurrent incremental costs are partly dependent on the price difference between the refrigerant and foam blowing agent to be phased out, other new and/or additional components and inputs of the production. In this project document it is proposed to provide the Hangzhou Xiling Holdings Company recurrent costs for a period of six months.

Exhibits 6 and 7 show the incremental operating cost per unit resulting from the modifications:

Exhibit 6. Incremental operating cost resulting from the substitution of CFC-12 by isobutane

Modification	Description	Incremental cost/unit, US$
Isobutane compressor	Compressors are manufactured domestically. Smaller quantities of compressors for special conditions are imported from Matsushita, Japan. It is estimated that the purchase price will be higher compared with the price of a CFC-12 compressor of the same capacity (350 RMB = 44 US$ for the model Y6P mostly used at company)	3.00
Isobutane refrigerant(*)	Charge reduced by 66 per cent due to lower density (**)	-0.03
Incremental refrigeration circuit cost difference, US$		2.97

*) The average charge of the refrigerant CFC-12 is 0.12 kg per unit.

**)

Refrigerant	Charge/unit, kg	Price/kg, US$	Cost/unit, US$
CFC-12	0.12	2.6	0.312
Isobutane	0.04	7.0	0.280

Exhibit 7. Incremental operating cost resulting from the substitution of CFC-11 by cyclo-pentane

	R-11			C-pentane		
	wt by %	Price $/kg	Cost, $	wt by %	Price $/kg	Cost, $
Polyol+MDI	86	2.50	2.15	94	2.50	2.35
Blowing agent	14	3.00	0.42	6	4.00	0.24
Cost of the mixture, $/kg			2.57			2.59
Mixture consumption per unit refrigerator, kg			6.00			6.90
Total foam cost per unit, $			15.42			17.87
Incremental foam cost difference, $/unit						2.45

The total per unit incremental operating costs are given in **Exhibit 8** below.

Exhibit 8. Per unit incremental operating costs

Type of incremental operating cost	Cost/unit, US$
Cost resulting from the conversion of the refrigerant	2.97
Cost resulting from the conversion of the foam blowing agent	2.45
Total	5.42

The incremental operating costs are shown in **Exhibit 9**. The calculation of Exhibit 9 are based on the production level of 1993.

Exhibit 9. Incremental operating cost

Refrigerator and freezer units manufactured annually		351,000
Per unit incremental operating cost	US$	5.42
Total annual incremental operating cost	US$	1,902,420
The amount for six months of operation (to be paid to the Factory)	US$	951,210

6.4 Contingency

Ten per cent contingency fund is included in the total project budget. This fund is proposed to cover unforeseen expenses which might be incurred during project implementation, purchase of small testing instruments, miscellaneous expenses, etc.

6.5 Total cost of project

Total cost of the project is given in **Exhibit 10** below.

Exhibit 10. Total cost of the project

Incremental investment cost	US$	3,999,000
Contingency (10 per cent)	US$	399,900
Subtotal	US$	4,398,900
Incremental operating cost for 6 months	US$	951,210
Agency overhead (13 per cent)	US$	695,514
Total cost of the project	US$	6,045,624

Unit Abatement Cost of the project is calculated in Annex 3.

Annex 1

Investment cost

Item	Description of activity		Qty	Unit Price, US$	Total, US$
STEP 1:MODIFICATION OF THE REFRIGERATOR CABINET AND REFRIGERATION CYCLE TO THE UTILIZATION OF ISOBUTANE					
1.1	Analysis and redesign of one model under the supervision of an international company (cost breakdown for one model is given below)		1	200,000	200,000
	Know-how transfer and training of Chinese staff in model redesign	50,000			
	Supervisor mission; including fees, subsistence allowance, air ticket	20,000			
	Preparation of model for testing (5 units)	20,000			
	Experimental analyses, functional testing, measuring energy consumption	30,000			
	Field test and feedback	20,000			
	Final evaluation and redesign of the model	30,000			
	Preparation of the final model for mass production including safety certification by international and national authorities	30,000			
	Total redesign costs for one model	200,000			
1.2	Redesign of the remaining 5 models by Hangzhou Xiling Co.		5	30,000	150,000
1.3	Testing equipment		1	15,000	15,000
	Total of STEP 1				**365,000**
STEP 2: MODIFICATION OF THE REFRIGERANT ASSEMBLY LINE; ADDITIONAL EQUIPMENT FOR THE APPLICATION OF ISOBUTANE (DETAILS OF THE APPROPRIATE EQUIPMENT NEEDED ARE OUTLINED IN ANNEX 5)					
2.1	Preparation of the mass production on Assembly line I				
2.1.1	Replacement of the old vacuum pumping unit (Liebherr design) by one special high-speed vacuum system		1	65,000	65,000
2.1.2	Isobutane charging station including refrigerant supply pump		1	115,000	115,000
2.1.3	Isobutane quadruple leak detector		1	33,000	33,000
2.1.4	Safety system, including ventilation system		1	60,000	60,000
2.1.5	Ultrasonic welding equipment		1	40,000	40,000
2.1.6	Helium leak detection system including He charging, detection and recovery		1	97,000	97,000
2.1.7	Safety training of the staff		1	10,000	10,000
	Total for Assembly Line I				420,000
2.2	Preparation of the mass production on Assembly line II, including the safety training of the staff (Same conditions as Assembly Line II)				420,000
2.3	Preparation of the mass production on Assembly line III, including the safety training of the staff (the available vacuum pumps may be used without modifications, therefore the amount is reduced by US$ 65,000)				355,000
2.4	Preparation of the mass production on Assembly line IV, including the safety training of the staff (Same conditions as Assembly Line III)				355,000

Item	Description of activity	Qty	Unit Price, US$	Total, US$
2.5	Storage tank for isobutane, one tank to serve all factories (10 m^3 tank including safety package and transport equipment, barrels, for distribution inside factory to chargers at the assembly lines)	1	50,000	50,000
	Total STEP 2			**1,600,000**
	Total STEP 1 and STEP 2			**1,965,000**
STEP 3: MODIFICATION OF THE FOAMING EQUIPMENT FOR THE FOAM INSULATION USING CYCLO-PENTANE AS FOAM BLOWING AGENT INSTEAD OF CFC-11				
3.1	Foaming installation designed and constructed by Hennecke, Germany (Schematic flow diagramme of the installation is given in **Annex 4.b**)			
3.1.1	Modification of the foaming installation for cabinets: a) retrofit unit HK 650 b) day tank 250 l for cyclo-pentane and polyol mixture c) control unit for cyclo-pentane d) additional heat exchanger for cyclo-pentane e) Pentamat premixing unit for cabinet and doors f) PPT-control unit for the cabinet plant	1	200,000	200,000
3.1.2	Modification of the foaming installation for doors a) retrofit unit HK 650 b) day tank 250 l for cyclo-pentane and polyol mixture c) control unit for cyclo-pentane d) additional heat exchanger for cyclo-pentane e) PPT-control unit for the door plant	1	100,000	100,000
3.1.3	Cyclo-pentane detection system (2 sets, one each for cabinet and door plant)	2	50,000	100,000
3.1.4	Exhaust system for cyclo-pentane a) exhaust system for fixtures (plugs and jigs) b) exhaust system for the wet part of the door plant c) exhaust system for the wet part of the cabinet plant	2	50,000	100,000
3.1.5	Fire protection system	2	30,000	60,000
3.1.6	Engineering, commissioning and start-up	1	100,000	100,000
3.1.7	Certification of the plant reliability and safety (such as TUV certificate)	1	50,000	50,000
3.1.8	Training of the staff	1	20,000	20,000
	Sub-total for Hennecke foaming equipment			**730,000**

Item	Description of activity	Qty	Unit Price, US$	Total, US$
3.2	Foaming installation designed and constructed by Afros CANNON, Italy (The schematic drawing of the machine is given in Annex 4b)			
3.2.1	Premixing unit "Multi-Easy Froth" (2 unit for 2 foaming machines located in different factories)	2	100,000	200,000
3.2.2	Retrofitting unit: PENTA MODULE 100 (2 units for the 2 foaming machines)	2	82,000	164,000
3.2.3	Safety package including exhaust system, cyclo-pentane sensors, fire protection system and the safety certificate (such as TUV)	2	155,000	310,000
3.2.4	Engineering, construction and start-up	2	30,000	60,000
	Sub-total for Afros Cannon foaming equipment			**734,000**
3.3	Storage facility for cyclo-pentane			
3.3.1	Centralized storage facility for cyclo-pentane for Factories I and II (tank, 30 m^3 capacity, including all piping and nitrogen pressurization)	1	70,000	70,000
3.3.2	Pumping system to load and unload the tanker truck and storage tank, including transport cylinders (for Factories I and II)	1	10,000	10,000
3.3.3	Cyclo-pentane tank for Factory III (10 m^3 capacity, including piping, nitrogen pressurization and pumping set-ups)	1	50,000	50,000
	Total for c-pentane storage facility			**130,000**
3.4	Jigs and fixtures for trial production (one set of cabinet and door jigs and fixtures for one model)	1	120,000	120,000
3.5	Redesign of jigs and fixtures for doors and cabinets (48 sets, at US$ 5,000/set)	48	5,000	240,000
3.6	Training of the staff of the three plants (3 technicians for 15 days, air ticket, etc.)	3	10,000	30,000
	Total of STEP 3			**1,984,000**
	International consulting services			50,000
	GRAND TOTAL			**3,999,000**

Annex 2

Work plan for the conversion of the refrigerant CFC-12 TO Isobutane and of the foam blowing agent CFC-11 to Cyclo-pentane

#	Activity	First year				Second year				Third year			
		Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
1	Preparation of detailed work plan												
2	Initial training of the management												
3	Redesign of the first models												
4	Prototype testing												
5	Selection of equipment												
6	Purchase, installation and commissioning												
7	Trial production												
8	Reliability test												
9	Final redefinition of models												
10	Full conversion of production facilities and start of mass manufacture of all models												

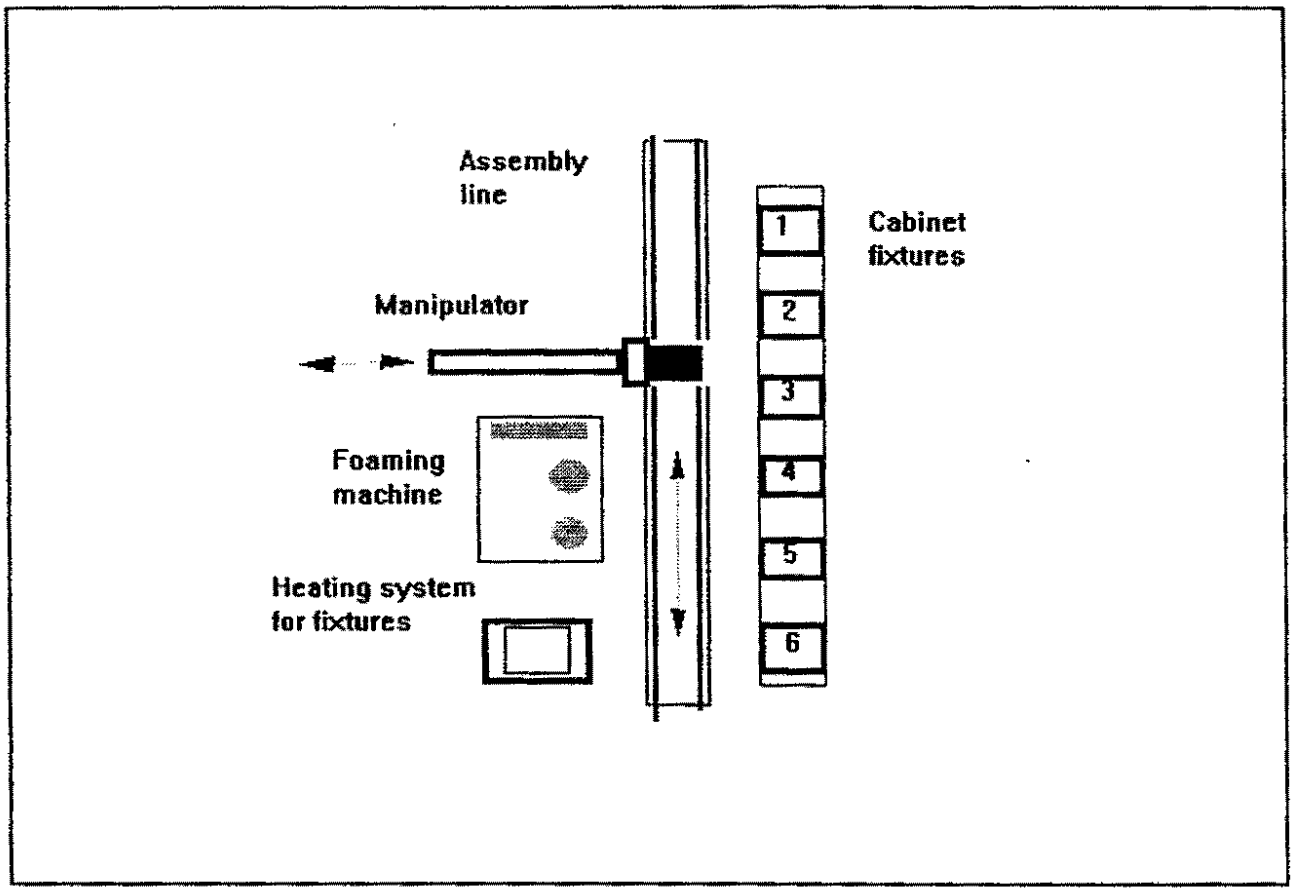
Annex 3

Calculation of unit abatement cost

		Unit	Total amount	Share of MF
A	ODS phase out			
A1	Average use of CFC-11 and CFC-12 per year	MT	360.0	
A2	ODP of CFC-11 and CFC-12		1.0	
A3	ODP weighted CFC-11 and CFC-12 phase out (A1xA2)	MT	360.0	
A4	**Total ODP weighted phase out**	**MT**	**360.0**	
B	Annualized capital cost			
B1	Total investment cost including 10% contingency	US$	4,398,900	4,398,900
B2	Equipment life	years	10	10
B3	Discount rate	%	10	10
B4	**Annualized capital cost (B1x0.1627)**	**US$**	**715,701**	**715,701**
C	**Annual incremental cost**	**US$**	**1,902,420**	**951,210**
D	Unit Abatement cost			
D1	Annualized capital cost per kg of ODS eliminated (B4/(A4x1000))	US$/kg	1.99	1.99
D2	Annual incremental recurrent cost per kg of ODS eliminated (C/(A4x 1000))	US$/kg	5.28	2.64
D3	**Unit abatement cost (D1+D2)**	**US$/kg**	**7.27**	**4.63**

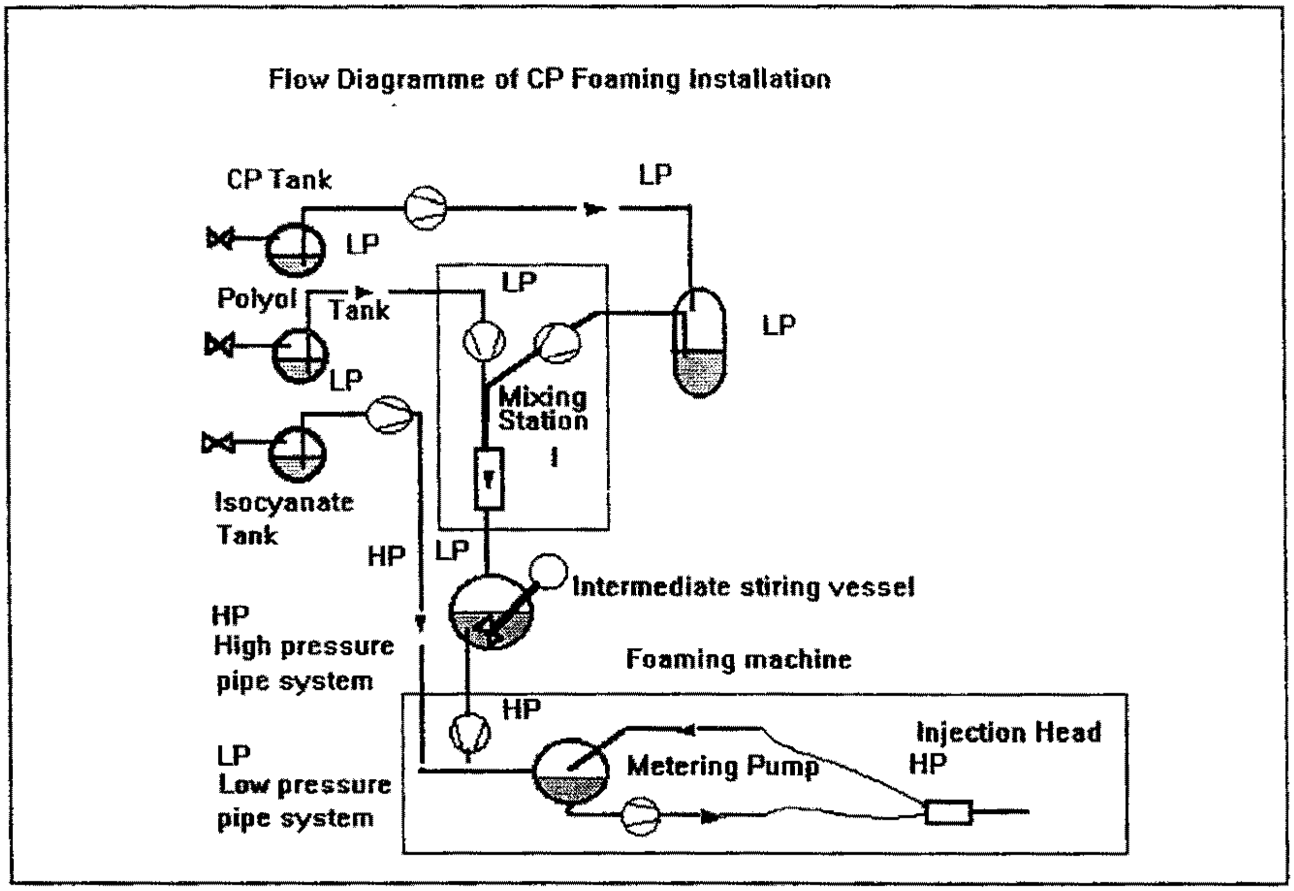
Annex 4.a

Schematic flow diagramme of the foam blowing equipment designed by Liebherr, Germany



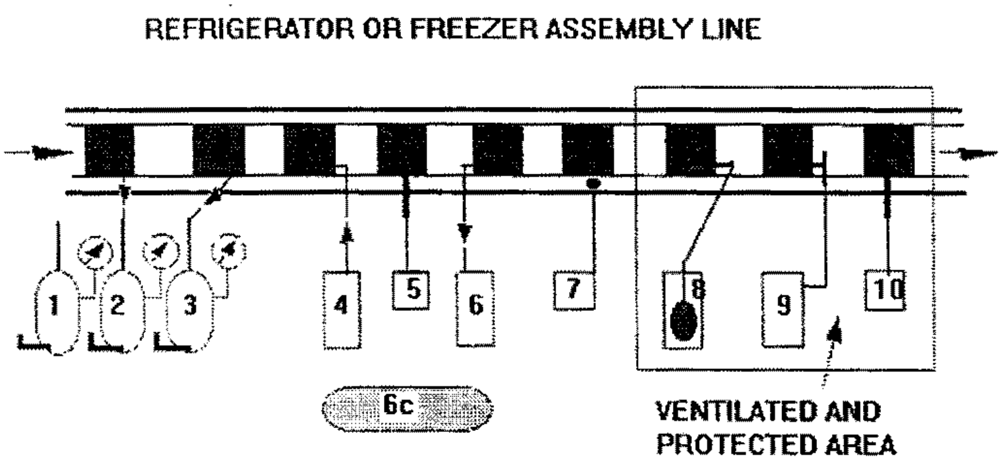
Annex 4.b

Schematic flow diagramme of the foaming machine delivered by Afros Cannon, Italy



Annex 5

Flow diagramme showing the specific equipment needed to charge refrigerators and freezers with isobutane on the assembly line



Legend:

1,2,3 Vacuum pumps and vacuum testing units, 4 Helium charging unit,
5 Helium leak detector, 6 Helium recovery unit, 6a Helium tank,
7 High tension testing equipment, 8 Combined vacuum pump and isobutane charging unit, 9 Ultra-high frequency welding unit,
10 Isobutane leak testing unit

Annex 6

Information package on Hangzhou Xiling Holding Co.

The following selected data were collected from a questionnaire prepared by UNIDO and mailed to the Hangzhou company before the formulation mission. The answers were discussed and verified during the formulation mission.

	Question	Answer
1	Which type of products are manufactured?	Household refrigeration and commercial refrigeration
2	How many people are employed?	850 in manufacturing, 50 in service shops
3	What is the installed capacity?	500,000 units annually
4	Actual production	1993 360,000 units; 1994 480,000 units
5	Company's market share?	approximately 7 %
6	Percentage of the total production manufactured for the export?	10,000 units
7	Production target for the year 2000?	800,000 units
8	Quantity of refrigerant used annually?	1994: 400 MT R11, 90 MT R12
9	Is the production under licence?	Liebherr Hausgeraete GmbH, Germany
10	For how many years has the company been on the market?	more then 20 years
11	Has any other refrigerant than R12 been used?	R500 two years ago
12	How many alliances have been made since 1980?	approximately 1,000,000 units
13	How many production lines are in operation?	4
14	Average age of the production lines?	6 years
15	How many different models are made?	6 refrigerator models, 3 freezer models, 1 no-frost freezer model
16	Has there been any significant charge reduction of refrigerant?	no
17	Are compressors manufactured locally or imported?	30 % locally, 65 % domestically, 5 % imported (Matsushita/Japan)
18	Component cleanliness requirements?	Blowing nitrogen through pipes, closed pipe ends
19	How great is the percentage of appliances which do not pass the final functionality test?	2 %
20	Which test facilities are available?	Climatic chamber, capacity measuring equipment, energy consumption measuring equipment
21	Extreme design temperatures?	-18 oC/ 38 oC ambient temperature
22	Which type of standards are applied for performance testing?	ISO and national standards
23	How is service performed?	One service shop in the company, 300 service shops outside
24	Life expectancy of the appliances?	10 years
25	How much refrigerant is used for servicing	180 kg per year
26	Which types of systems are serviced by the shops?	Everything
27	Are appliances brought to the shops by the customers?	yes, mostly
28	Qualification of service shop man?	Experience and training once every year
29	Is legal requirements necessary to run a repair shop?	Not yet, but will become necessary
30	How many vacuum pumps are operated?	42 vacuum pumps, and 2 machines designed by Liebherr
31	Degree of dryness inside the refrigeration cycle?	130 mg water
32	Vacuum pressure achieved within the cycle?	1.3 Pa
33	What is the time the vacuum is hold within the cycle?	25 min with vacuum pumps, 1.5 min with Liebherr equipment
34	How many leak detectors are available	6
35	Type of leak test equipment?	5 Liebherr made units, 1 China made units (1993/ CD-1000)
36	Number of charging stations	5 + 1, two from Liebherr, one Japanese model

Annex 7.a

Calculation of cost of safety system

Item	Item no according to Annex 1	Description of activity	Total, US$
1	1.1; 1.2	Analysis and redesign of 6 refrigerator models (difference to HCFC-134a refrigerator design)	350,000
2	2.1.2	Isobutane charging station (difference to HCFC-134a charging station)	115,000
3	2.1.4	Safety system, including ventilation system	60,000
4	2.1.5	Ultrasonic welding equipment	40,000
5	2.1.6	Helium leak detection and recovery	97,000
6	2.1.7	Safety training of the staff	10,000
7	2.2	Appropriate cost for assembly line II	322,000
8	2.3	Appropriate cost for assembly line III	257,000
9	2.4	Appropriate cost for assembly line IV	257,000
10	2.5	Storage tank for isobutane	50,000
11	3.1.1	Modification of the foaming installation for cabinets	200,000
12	3.1.2	Modification of the foaming installation for doors	100,000
13	3.1.3	C-pentane detection system	100,000
14	3.1.4	Exhaust system for cyclo-pentane	100,000
15	3.1.5	Fire protection system	60,000
16	3.1.6	Certification of the plant reliability	50,000
17	3.2.1	Premixing installations "Multi-Easy Froth"	200,000
18	3.2.2	Retrofitting units: PENTA MODULE 100	164,000
19	3.2.3	Safety packages	310,000
20	3.3	Storage facility for cyclo-pentane	130,000
21	3.6	Training of the staff	30,000
TOTAL EXPENDITURE FOR SAFETY			**3,002,000**

Annex 7.b

Calculation of unit abatement cost excluding safety systems

	-	Unit	Total amount	Share of MF
A	ODS phase out			
A1	Average use of CFC-11 and CFC-12 per year	MT	360.0	
A2	ODP of CFC-11 and CFC-12		1.0	
A3	ODP weighted CFC-11 and CFC-12 phase out (A1xA2)	MT	360.0	
A4	**Total ODP weighted phase out**	**MT**	**360.0**	
B	Annualized capital cost			
B1	Total investment cost Cost of safety system (re: Annex 7.a)	US$	4,398,900 -3,002,000	1,396,900
	Investment cost without safety system		**1,396,900**	
B2	Equipment life	years	10	10
B3	Discount rate	%	10	10
B4	**Annualized capital cost (B1x0.1627)**	**US$**	**227,276**	**227,276**
C	**Annual incremental cost**	**US$**	**1,902,420**	**951,210**
D	Unit Abatement cost			
D1	Annualized capital cost per kg of ODS eliminated (B4/(A4x1000))	US$/kg	0.63	0.63
D2	Annual incremental recurrent cost per kg of ODS eliminated (C/(A4x 1000))	US$/kg	5.28	2.64
D3	**Unit abatement cost (D1+D2)**	**US$/kg**	**4.43**	**2.50**

THE MONTREAL PROTOCOL ON SUBSTANCES THAT DEPLETE THE OZONE LAYER CHINA ODS PHASE OUT PROJECT

PROJECT COVER SHEET

COUNTRY:	The People's Republic of China
PROJECT TITLE:	Automobile Air Conditioner (MAC) Compressor Factory Production Conversion from CFC-12 to HFC-134a MAC Compressor
SECTOR COVERED:	Automobile Air Conditioning (MAC)
ODS USE IN SECTOR (1994):	1,278 MT ODP (1,278 MT CFC-12)
PROJECT IMPACT:	Phase out 361 MT ODP per year from 1996 to 1999 (including complementary SAAC project)
PROJECT DURATION:	18 months

PROJECT COST:

Incremental Investment Cost:	US$ 858,600
15% Contingency:	US$ 128,800
Incremental Operating Cost:	0
Less: scrap value	(54,000)
Net incremental investmt cost	US$ 933,000
3% Financial Agency	28,000
Proposed OTF grant	US$ 961,000

PROPOSED OTF GRANT:	US$ 961,000
COST EFFECTIVENESS (CE):	Unit Abatement Cost: US$5.29/kg/Year Grant Effectiveness: US$7.13/kg
IMPLEMENTING ENTERPRISE:	Shanghai Ek Chor General Machinery Co. Ltd. (Ek Chor)
COORDINATING AGENCY:	National Environmental Protection Agency (NEPA)
IMPLEMENTING AGENCY:	The World Bank

PROJECT SUMMARY

This project will, together with Shanghai Automobile Air Conditioning Factory's heat exchanger production conversion project, eliminate 361 MT ODP per year (361 MT CFC-12) in China. The existing CFC-12 MAC compressor production line will be replaced by HFC-134a MAC compressors production. This requires compressor redesign and additional production equipment for the factory. This project, part of China's MAC sector's strategy to cease CFC-12 use in new equipment by 2,005, may act as a demonstration project for other MACS producers in China.

Technical Assessment: The project has been reviewed and supported by the OORG technical reviewer, Mr. Bob Proctor. His comments are attached. A review of the technical competence of the enterprise will be carried out during appraisal of the project.

PROJECT OBJECTIVE

The objective of this project is to convert the factory's production of CFC-12 automobile air conditioner compressor to HFC-134a MAC compressor, and thereby, together with Shanghai Automobile Air Conditioner Factory, phase out 361 MT of CFC-12 consumption per year as part of the overall country ODS phase out strategy.

SECTOR BACKGROUND

The development of China's MACS industry started in the late 80's, rather later than elsewhere. China's current production is less than 1% of MACS production worldwide. Since China is the World's most populous country with over 1.1 billion inhabitants and living standards are rising fast, the potential MACS market is huge. Recent expansion of MACS production has reflected this. 1992 MACS production was only 180,000 units, but rose to 265,000 units by 1994. The total national ownership of MACS systems by end 1994 was estimated at 1.49 million and the total annual CFC-12 use (for service and new system charge) was about 1,278 tones. 1995 production of MACS equipped vehicles is estimated at 265,000 . CFC-12 usage associated with this is 1,510 tones.

China plans to cease production of CFC-12 based MACS and completely phaseout use of CFC-12 in the sector by 2005. This strategy is described in the China Country Program. Table 1 below gives the statistics and prediction of China's CFCs consumption associated with MACs ownership and production from 1991 to 2005.

In 1994, 392 tones of CFC-12 were used for the initial charge of MACS and 886 tones for service. 140,000 of the 265,000 total MACS made in 1994 were manufactured by Ek Chor. Annual amount of CFC-12 used as for charging new MACS using Ek Chor's compressors was 168 tones.

Table 1: Statistics and Prediction of China's MAC Production, Ownership and CFCs Consumption From 1991 - 2005

(1,000 Vehicle)

	Automobile				MAC		CFCs Consumption (MT)		
Year	Ownership	Production	Import	Retired	Ownership	Production	New MAC	Service	Total
1991	8,000	710	98		500	100	180	320	500
1992	6,920	1,060	211		760	180	296	477	773
1993	8,120	1,300	314		1,110	230	356	676	1,032
1994	9,540	1,340	283	250	1,490	270	392	886	1,278
1995	11,150	1,610	300	300	1,920	265	342	1,168	1,510
1996	12,940	1,840	350	400	2,410	320	413	1,479	1,892
1997	14,900	2,110	400	600	3,110	480	634	1,857	2,491
1998	17,150	2,400	450	800	3,820	650	858	2,276	3,134
1999	19,000	2,700	500	1,000	4,850	820	1,102	2,862	3,964
2000	20,000	3,000	500	2,000	5,950	1,110	1,497	3,506	5,003
2005					9,500	1,680	2,288	5,584	7,872

INTEGRATED SECTOR APPROACH TO PHASEOUT

Four projects are being submitted that will between them phaseout 70 percent of the CF-12 used in new MACS in China. All these are based on the adoption of HFC-134a to replace CFC-12. They are EK Chor (MACS compressor), Shanghai Auto Air Conditioner Corporation (condenser), Guangzhou Haohua (compressor) and Yueyang Hengli (bus MACS and auto MACS condensers). These are two fundamentally different approaches involved in the Chinese approach to conversion of the automotive MACS industry. Both are based on the need to produce HFC-134a MACS with an equivalent performance in terms of capacity and efficiency as the CFC-12 MACS currently produced. They are not the result of customer demands, but the minimum essential features to convert to HFC-134a MACS system.

(a) The performance and efficiency should be equivalent to the current CFC-12 systems

(b) The external dimensions of automotive MACS condensers should be no greater than those currently supplied. This is because of the limited space available for installation in a car's engine compartment. Use of a larger condenser would involve re-design by the vehicle manufacturer who would probably source his condensers elsewhere if his existing supplier could not meet this requirement. This involves the practicalities of installing a MACS in a given vehicle. It is not a customer requirement for an enhanced product.

EK Chor make compressors that are used exclusively by Shanghai Santana on VW and Audi cars. Santana source their condensers from SAAC and Yueyang. Some are of the serpentine type (from SAAC) and some are still of the finned copper tube variety (from Yueyang). Haohua supplies a number of different customers in Southern China who buy their condensers from a variety of sources.

Both Haohua and EK Chor are licensees of the Sanden Corporation of Japan and currently produce the same 5 cylinder CFC-12 compressors. EK Chor have not been able to conclude a deal to purchase new HFC-134a compressor technology from Sanden, despite trying. Haohua has been in production only since 1993 (and who retain close links with Sanden) have been able to conclude a technology transfer deal. This technology is for Sanden's new 7 cylinder HFC-134a designs developed from their CFC-12 compressor which Sanden considers obsolete. Haohua's project is thus based on the purchase of manufacturing rights for Sanden's new compressor range.

EK Chor have been in the MACS business since 1991, and unlike Haohua are well equipped with world class test facilities and excellent development engineers. Their approach is to modify the existing Sanden 5 cylinder CFC-12 compressor for use with HFC-134a. Because the compressor swept volume remains the same, systems using this compressor must be equipped with larger capacity condensers to offset the loss of system performance experienced when a CFC-12 system is directly retrofitted with HFC-134a. EK Chor compressors are supplied exclusively to Shanghai Volkswagen who source their condensers from SAAC. Thus, the SAAC project involves production of increased capacity condensers to match EK Chor's compressors. These two components are necessary in order to produce a MACS with equivalent capacity and efficiency to their present CFC-12 MACS.

All projects are being optimized in regard to technology source and costs, use of local technology and equipment where appropriate and reuse of existing equipment wherever technically feasible. Components that (might) relate to product upgrade and/or capacity expansion are being funded by the enterprises. This overall approach to the MAC sector will result in the lowest cost of transforming China's MAC sector to use of HFC 134a and represents the lowest possible request for assistance from the Multilateral Fund.

ENTERPRISE BACKGROUND

ENTERPRISE BACKGROUND

Shanghai Ek Chor General Machinery Co. Ltd. (Ek Chor) is belongs to the Shanghai Municipal Automobile Industry Corporation. Ek Chor introduced Sanden MAC compressor technology and equipment in 1991 with a production capacity of 200,000 units per year. Actual production of MAC compressor in 1993 was 140,000 units which accounts 61% of the national total MAC production. Ek Chor's products are mainly supplied to Shanghai Santana Automobile Factory, Beijing Cherokee, Changchun Audi 100, Jetta and other small and medium sized vehicle producers.

There are 310 staff at Ek Chor, including 16 senior engineers and graduate 34 engineers. Total factory area of Ek Chor production workshop and office building is 25,000 m^2 which accommodate the following 5 separate production lines: MAC Compressor machining line, Clutch Machining line, MAC Compressor Assembly line, Clutch Assembly and General Assembly. There are several administrative departments at Ek Chor: Product R & D Dept., Manufacturing Dept., Production Planning Dept., Quality Control Dept., Chief Engineer's Office, Accounting Dept., Marketing Dept., etc. Currently, the factory produces MAC compressor, together with Shanghai Automobile Air Conditioner Co. Ltd. (SAAC) has charged 168 tons of CFC-12 in 1994, or 42.9 % of sector's total consumption for new MAC CFC-12 use in China.

Existing compressors are produced according to international standards as prescribed by the Sanden Corporation.. Quality control is carried out by the Shanghai Municipal Auto Industry Corporation. Ek Chor produces only for the domestic Chinese market. Local ownership fraction is 50 percent, with the remaining 50% being owned by Thai partners. The enterprise is thus 100% owned by parties from Article 5 countries and should be eligible for 100% funding from the Multilateral Fund.

PROJECT DESCRIPTION

The project involves:

1) Modification of existing Sanden designed compressor for use with HFC-134a.

2) Import key HFC-134a MAC compressor manufacturing equipment and instrument, retooling the present facilities and equipment and convert SD-5 CFC-12 MAC compressor production line with the annual capacity of 200,000 Units (double shift) to production of the modified HFC-134a compressor. Production capacity will be unchanged.

3) The complete elimination of 16.5 MT of ODS cleaning agent of trichloroethane by employing aqueous based component cleaning technology

4) <u>Training</u>

   Two types of training is involved, namely:

   i) Instruction in operation and maintenance of new machinery - 45 mandays of foreign engineers on site (US$50,000)

   ii) Overseas training. - 75 mandays of Ek Chor staff.

   The former (i) is required to ensure that introduction of the new machinery is as trouble-free as possible. This item covers installation and commissioning of new equipment in addition to instruction of SEGM's operatives.

The allowance made for (ii) recognizes the fact that Ek Chor are re-designing the compressor themselves and will need to be able to seek information and engineering support from overseas sources. MACS compressor technology has been imported into China and mastered to some degree by Chinese companies like EK Chor. However the real centres of expertise are abroad. This project is thought to be within the technical competence of EK Chor. The opportunity to consult with overseas experts will be an important factor in successful implementation.

During the first year of project implementation, Ek Chor will reduce the present CFC-12 SD-5 MAC compressor production and associated CFC-12 consumption by 50%. Complete elimination of CFC based production will be achieved 18 months later on project completion.

Note: Compressors will be produced according to relevant SAE/ISO standards. They will be equipped with couplings compatible with HFC-134a charging hoses to prevent use of CFC-12 in the MACS on which they are used.

JUSTIFICATION FOR ALTERNATIVE TECHNOLOGY SELECTION

HFC-134a based technology has been selected for the following reasons:

1) Because of its good thermodynamic properties, zero ODP and non-flammability, HFC-134a has been recognized worldwide as the most appropriate replacement for CFC-12 in Automobile Air Conditioning systems.

2) The production technology for HFC-134a MACS is already well developed in industrial countries.

3) Supplies of domestically produced HFC-134a should be available in China from 1998.

TECHNOLOGY SOURCES AND AVAILABILITY

The existing Sanden MAC compressor production line was purchased from Sanden (Japan) in 1990. SEGM have not succeeded in reaching an agreement with Sanden for a license to produce Sanden's new HFC-134a compressor design for a reasonable cost. Thus the enterprise has decided to modify Sanden's CFC-12 design for HFC-134a use. The tools and equipment which constitute the bulk of the investment cost of this project are concerned with production of this modified design.

The design modifications involved are considered to be within the technical competence of EK Chor.

Since the new compressor will have the same swept volume as the old CFC-12 compressor, it must be used in conjunction with a larger capacity condenser in order that the final system has the same capacity as the existing CFC-12 MACS. These will be provide by the Shanghai Air Conditioner Corporation (SAAC) and Yuuyang who are presenting associated projects to produce higher capacity Multiflow condensers. EK Chor sell all their compressors to customers who source all their condensers from SAAC. EK Chor's customers have pronounced themselves satisfied with this approach to producing HFC-134a MACS.

PROJECT COSTS

The total project cost of US$5,166,700 equals the ODS reduction portion of the overall project (investment cost plus net incremental operating cost less salvage value of redundant equipment). This project will not provide Ek Chor with any incremental revenues, but will result in incremental operating costs. (However, a portion of investment cost, plus incremental operating costs will be funded by the enterprise).

Incremental investment cost of US$987,400 (including 15% contingency) is for purchase of additional equipment needed for the conversion of production to replace the present standard Sanden CFC-12 SD-5 MAC compressor with the version modified for HFC-134a use. A considerable amount of existing equipment will be re-used for the new production. Ek Chor is a Sino-Thai joint venture and thus should be eligible for 100% funding from the Multilateral Fund.

A significant amount of existing production equipment will be re-used on the new production. The original purchase cost of this equipment detailed in Annex 6 was US$ 36,784,500.

Net incremental Operating Cost of US$952,000 p.a. at full output comprises increased component and material costs associated with production of the new design. The compressor body is of special alloy; HFC-134a compatible seal material and lubricant are mor expensive and higher system pressure differences mean that re-enforced bearings have to be employed. These costs are partly offset by a saving made by the use of an improved casting technique. Annex 3, Table 1 gives details of these costs. The Incremental Operating Costs for the project based on a 4 year project life are US$2,843,500. However funding for Incremental Operating Costs is *not* being requested.

Salvage value of the replaced existing equipment is $54,400

Requested Funding The proposed grant for Ek Chor is US$961,000 and was calculated as follows: 15% contingency was added to the incremental investment cost and the salvage value deducted from that. A financial agent fee of 3% was added to the resulting figure to give the grant amount requested from the Multilateral Fund.

PROJECT IMPLEMENTATION:

	Schedule (months)																	
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Negotiate Order	X	X	X															
Order Equip.			X	X														
Initial Design			X	X	X													
Inst. Design				X	X	X	X											
Order Domestic Equip.			X	X	X													
Install. & Training								X	X	X	X	X	X	X	X	X	X	
Trial Run																	X	X

Management: Auto Industry Dept. of Ministry of Machine Industry will oversee the successful implementation of the project. The project will be implemented at Shanghai Ek Chor General Machinery Co. Ltd. (Ek Chor).

Project Director: Mr. Dong Rongyong, General Manager of Ek Chor.
Project Manager: Mr. Qin Kecheng, Deputy Chief Engineer of Ek Chor.

ENVIRONMENTAL CONSIDERATIONS

An environmental assessment is carried out by Shanghai Municipal Environmental Protection Bureau (EPB). The project will meet standards and regulations stipulated by the Shanghai EPB. No new pollutants will be generated from the production.

PROCUREMENT:

Imported and domestic equipment needed are shown in Table 1 of Annex 1. Contracts will be awarded after evaluation and comparison of quotations solicited from at least 3 qualified suppliers. The choice of procurement agency will be discussed and selected after appraisal.

REQUIRED REGULATORY ACTIONS

A preferential duty making HFC-134a at least as cheap as CFC-12 is required for as long as CFC-12 is available, since CFC-12 can be used in HFC-134a MACS actually with a slightly improved performance.

PROJECT RESULTS

Direct Project Impact: After completion in 1996, this project will over 4 years from 1996 - 1999, eliminate an average of 361 Tones of CFC-12 p.a.(361 Tones ODP).

Indirect Project Impact: Since IOC's are not being requested, the effect on product price is unpredictable. Implementation of this project is not expected to create any workforce redundancies. This may serve as a demonstration project to other enterprises.

ANNEX 1

Table 1: Cost Breakdown of Equipment required for Production of the Modified HFC-134a Compressor (US$)

Components	Description	Qty	Total cost	Remarks
Compressor Assembly	Piston ring inserter	1	29,200	Imported
	Piston lapping machine	1	99,600	Imported
	HFC-134a charging machine	1	75,000	Imported
	HFC-134a leak sniffer		1,000	Imported
	PAG oil charging machine	1	93,200	Imported
Clutch assembly	Press for rotor bearing	1	22,500	Imported
Clutch Machining	Drawing die for ring		11,000	China
	Blanking die		2,000	China
	Jig for rotor		2,700	China
Swash Plate & shaft	Jig for press assembling		700	China
	Die casting die		3,000	China
Front Housing	Jig for forming oil ways		800	China
	Front housing jig		1,500	China
	Casting die		3,100	China
ODS free cleaning solution	Replace trichloroethane by using aqueous based system		200,000	
Receiver Dryer Equipment & Housing	Welding furnace for aluminum body		160,000	
	Dies for aluminum body: Blanking die		25,000	
	Dies for aluminum body Drawing die		42,000	
	Jig for aluminum body		15,000	
Technical Training	Instln & debug from foreign eqmt.supplier: 4 men x 25 day/man x $500/man.day		50,000	
	Overseas training: 5men x 15man/day x $150/man.day		11,250	
	International travel fare for Ek Chor staff: 5 men x $2,000		10,000	
	Subtotal: (rounded)		858,600	
	Contingency (15%) (rounded)		128,800	
	Total (rounded)		**987,400**	

ANNEX 1

Table 2: Cost Breakdown of Equipment required for Production of the Modified HFC-134a Compressor (US$)

Self Financed by Ek Chor

Components	Description	Qty	Total cost	Remarks
Cylinder block Die casting Equipment	Casting dies (3 set)	1	435,000	Imported
	Pressure casting machine (700 MT)	1	635,900	Imported
	Honing stone	20	76,300	Imported
	Jig & tool for cylinder block & housing		2,000	China
	HFC-134a Recovery/recycling Machine	1	59,000	
	Subtotal: (rounded)		1,208,800	
	Contingency (15%) (rounded)		181,400	
	Total:		1,390,200	

ANNEX 2

Table 1: Scrap Value of the Equipment to be Replaced

Equipment Description	Qty	Purchase Date	Buying Price (JY)	NPV ($)	Dismantle Cost ($)	Scrap Value ($)
Piston ring inserter	1 set	12/21/1988	2,140,000	5,136	500	1,200
Piston Lapping Machine	1 set	12/21/1988	7,300,000	17,520	800	3,500
CFC-12 charge machine	1 set	12/21/1988	6,823,000	16,375	800	3,300
CFC-12 recovery unit	1 set	12/21/1988	4,376,000	10,500	500	2,500
Oil charge machine	1 set	12/21/1988	6,823,000	17,520	500	3,500
Press for Rotor Bearing	1 set	12/21/1988	1,645,000	3,969	300	800
Die casting machine	1 set	12/21/1988	43,423,000	104,215	1,500	18,000
Casting dies	3 set	12/21/1988	31,884,000	76,521	1,500	15,000
Honing stone No.230	5 set	12/21/1988	280,000	672	200	200
Honing stone No.500	5 set	12/21/1988	280,000	672	200	200
Drawing die for ring/EC-130	1 set	12/21/1988	3,228,000	7,747	1,000	3,500
Drawing die for ring/EC-132	1 set	12/21/1988	3,228,000	7,747	1,000	3,500
Component washing machine	1 set	12/21/1988	13,394,000	32,145	1,000	6,000
Degreaser	1 set	12/21/1988	4,980,000	11,925	1,000	4,000
Sub total:				312,664	10,800	65,200
Total scrap value of redundant equipment: Scrap value minus dismantle cost:					65,200 - 10,800 = 54,400	

Note: The present value of the equipment has been depreciated for 7 years.
The scrap value of redundant equipment is deducted from funding request of the enterprise.
The original equipment cost was calculated at a US Dollar/Yen rate of 125 Y = $US1

ANNEX 3

Table 1: Incremental Operating Cost After Conversion (US$)

	When Using CFC-12		When Using HFC-134a		Incremental Production Cost After Conversion
Description	Material used	Unit Price	Material Used	Unit Price	
Lubricant	Mineral oil	0.03	Synthetic oil	0.28	0.25
Sealant	NBR	0.77	HNBR	1.60	0.85
Bearings	Standard	10.35	Reinforced	13.75	3.4
Compressor material	Cast Iron liner	2.6	All Alloy	7.5	4.9
Production Cost (body)	Making liner	2.6	Integral	0	-2.6
Net Incremental Operating Cost					6.8

Incremental Operating Costs (based on 50% production in 1996) are shown below:

1996 $476,000
1997 $952,000
1998 $952,000
1999 $952,000

$US 2,843,500 Discounted at 10%

ANNEX 4

BREAKDOWN OF PROJECT COST AND FINANCING

Investment Cost	Investment Cost	Contingency	Total
Imported MAC compressor equip. (Annex 1: Table 1)	858,600	128,800	987,400
Ek Chor Self Financed (Annex 1: Table 2)	1,208,800	181,400	1,390,200
Subtotal:	2,187,600	329,200	2,377,600
Incremental Investment Funding Requested from Multilateral Fund	858,600	128,800	987,400
Incremental Operating Costs Requested from Fund			0
Less: Scrap value of redundant equip. (Annex 2: Table 1)			(54,400)
Subtotal			933,000
Financial Agent Fee (3 %) (rounded)			28,000
Total (proposed ODS Grant) (rounded)			961,000

Note: MP funding is 40.16 % of incremental capital cost minus the salvage value of the redundant equipment. No incremental operating costs are being claimed.

Total Project Costs

Total Investment Costs	US$ 2,377,600
4 yr. Incremental Operation Costs	US$ 2,843,500
Salvage Value Redundant Equip.	(US$ 54,400)
Total	**US$ 5,166,700**

ANNEX 5

Calculation of Unit Abatement Costs and Grant Effectiveness

UAC = {C(F) + (OC- OS)}/ODP

Where:

A = Unit Abatement Cost, $kg /ODP.year

C = ODS reduction investment cost, including all initial one time costs such as technology and training the annualized capital cost charges

F = Capital recovery factor, the annualized capital cost charges, discounted at a standard rate of 10% per year over the economic life of the investment (F = 0.1627 for 10 years)

OC = The annual incremental operating costs in the first year of full operation

OS = The annual incremental operating savings of revenue in the first year of full operation.

ODP = The annual ODS reduction at the first year of full operation expressed in ODP units.

The incremental operating cost in the first year of full operation of this project, together with SAAC's MAC condenser production conversion project, is $952,000 + 126,000 = $1,078,000

The investment cost of this project, together with SAAC's MAC condenser production conversion project, is (including 15% contingency):

US$ 2,377,600 (Ek Chor) + US$2,733,400 (SAAC) == $5,111,000

and the economic life is 15 years. Then:

C(F) =$5,111,000 * 0.1627 = 831,560

$$\textbf{UAC} = \frac{\text{US\$831,560 + (US\$1,078,000 - 0)}}{\text{361,000 kg ODP}} = \textbf{US\$5.29/ kgODP.year}$$

Note:This calculation is based on total project costs. If the self financed portions are removed, the UAC falls to about US$3.06/ODP.Year.

$$\textbf{Grant Effectiveness} = \frac{\text{US\$933,000 (Ek Chor) + US\$1,642,300 (SAAC)}}{\text{361,000 kg.ODP}} = \textbf{US\$ 7.13/ kg ODP}$$

ANNEX 6

Justification of Equipment

Piston Ring Inserter

The piston ring on the new compressor will be of a different type to accommodate the higher pressure differences in the HFC-134a compressor.

Piston Lapping Machine

The assembled pistons have to be lapped to the cylinder surface. The fact that piston and ring design is different makes a new piece of equipment necessary.

HFC-134a Charging Machine

The existing charging machine is used for product quality control and is not capable of economic modification.

Oil Charging Machine

Poly Alkyl Glycol (PAG) lubricant is used in place of mineral oil in MACS. This is acutely hygroscopic. Contamination with minute quantities of residual oil can have disastrous consequences. PAG oil is incompatible with some gasket and sealing material used on mineral oil charging machines. These are generally not capable of economic modification.

A new PAG oil charging machine is therefore required.

Casting Dies and Jigs and Tooling for Compressor Body

These are required in connection with production of the modified body design.

Honing Stone

New stones for honing the cylinder bores are required because of the change in material of the compressor bodies

Press for Rotor Bearing

The use of a reinforced bearing of different design to the original requires the use of a new machine to press fit the bearing into the rotor.

Clutch Machining Tools

New jigs and dies are required because of the re-design of the clutch components.

Swash Plate Tools

These are required because of design modifications to the compressor.

Front Housing Tools

These are required because of design modifications to the compressor.

Receiver Drier Tools

The new drier body must be constructed from Aluminum in place of steel because of the corrosion problems associated with HFC-134a systems using PAG lubricant.

Brazing Furnace

The aluminum construction of the new receiver drier requires the use of a brazing furnace in its manufacture.

Aqueous based Component Cleaning Equipment

Existing equipment uses trichloroethane, an ODS. Component washing equipment must be completely replaced with an environmentally friendly aqueous based system

ANNEX 7

Table 1: List of Equipment to be Re-used by Ek Chor after Conversion

S/No	Equipment Name	Original Value (JY)	Present Value (JY)	Years Used
1	Piston swaging machine, C-1-0206	11,704,000	3,611,200	7 years
2	Parts washing machine, C-1-0239, 1 set	13,394,000	4,018,200	7 years
3	Planet plate swaging machine, C-1-0289 1 set	12,461,000	3,738.300	7 years
4	Valve plate assembly machine, C-1-0292 1 set	8,700,000	2,010,000	7 years
5	Torque and dead centre measure machine C-1-0346 1 set	10,216,000	3,084,800	7 years
6	Cylinder head bolt tighten machine, C-1-0352 1 set	2,920,000	876,000	7 years
7	U-nut tighten machine C-1-0471, 1 set	3,924,000	1,177.200	7 years
8	Air gap checking machine, C-1-0478 1 set	5,729,000	1,718,700	7 years
9	Single purpose machine, C-2-0597 2 sets	10,580,000	3,174,000	7 years
10	4-spindle drilling machine, C-2-0640 1 set	11,179,000	3,353,700	7 years
11	6-spindle drilling machine, C-2-0669 1 set	6,168,000	1,850,400	7 years
12	Multi-spindle driller, C-2-0684 1 set	6,212,000	1,863,600	7 years
13	2-spindle horning machine, C-2-0743 1 set	20,456,000	6,136,800	7 years
14	Impregnation equipment, C-2-0750 1 set	23,845,000	7,159,600	7 years
15	Preheat & heat oven C-4-1904, 1 set	7,653,000	2,295,900	7 years
16	NC Lathe (LC-20), C-5-0903, 1 set	23,089,000	6,926,700	7 years
17	NC Lathe (LC-15), C-5-09038, 1 set	24,000,000	7,200,000	7 years
18	Crank press 150 ton, C-1-0471, C-5-0952, 1 set	15,320,000	4,596,000	7 years
19	NC Lathe (LC-10), C-5-0965, 1 set	16,830,000	5,049,000	7 years
20	Knuckle joint press 400 ton, C-6-1014, 1 set	29,609,000	8,882,700	7 years
21	Calorie Meter, C-8-2258, I set	38,380,000	11,484,000	7 years
	Total	**302,369,000** **US$ 36,784,500**		

COUNTRY OF ORIGIN: THE PEOPLE'S REPUBLIC OF CHINA

PROJECT TITLE: AUTOMOBILE AIR CONDITIONER (MAC) COMPRESSOR FACTORY PRODUCTION CONVERSION FROM CFC-12 TO HFC-134a MAC COMPRESSOR.

IMPLEMENTING ORGANIZATION: SHANGHAI EK CHOR GENERAL MACHINERY CO. LTD. (EK CHOR)

SECTOR: AUTOMOBILE AIRCONDITIONING (MAC)

RELATIONSHIP TO THE COUNTRY PROGRAM:

This project proposal appears to be compatible with a total program focused at the elimination of the use of CFC-12 as a MAC refrigerant.

TECHNOLOGY:

The technology uses HFC-134-a as a refrigerant, which is considered the lowest technical risk and the most environmentally sound replacement available. The standards and specifications have been established and published by recognized international technical associations.

The redesign of the compressor is a relatively high risk undertaking, but feasible. The general technology required when converting a compressor from CFC-12 to HFC-134a refrigerant is known but the task of implementing it is significant.

ENVIRONMENTAL IMPACT:

The reduction in CFC emissions projected in the proposal are reasonably attainable.

Trychloroethane cleaning is replaced with an aqueous wash.

PROJECT COSTS:

The technical training costs are not within the OORG guide lines however they appear reasonable considering the undertaking and are less than typical license agreements.

The other projected costs appear reasonable.

Recommendations:

The reviewer recommends approval of this proposal with the acknowledgement that some costs do not meet the guide lines and the risk is higher than it would be if a licensing arrangement was used.

The reviewer recommends verification of the technical competence of the enterprise prior to launch of the project.

OORG REVIEWER------------------------------R. H. PROCTOR

REVIEW DATE--------------------------------June 8, 1995

Ozone Operations Resources Group
(OORG)

TECHNICAL REVIEW

1. **Country of origin:**	Peoples Republic of China.
2. **Project title:**	Phase out of TCA in each of four plants used for the manufacture of refrigerator parts.
3. **Sector Covered:**	Solvent uses in metal parts manufacture.
3a **ODS use in sector:**	Data not available.
4. **Relationship to country programme**	Phase out of 37 tonnes of 1,1,1,TCA in four separate plants.

5. **Technology:**

a) The use of aqueous washing in place of trichloroethane vapour degreasing is becoming the most popular technology change in this sector. It is environmentally sound and very safe.

b) The technology is not transitional, as it does not depend upon a solvent or chemicals which might face future bans.

c) Feasibility of transfer to the country concerned

i) There is no formal technology transfer as the project is basically the delivery and installation of four aqueous parts cleaning lines. The supplier does propose assistance with installation and Start up supervision which must, by definition, include some training

ii) There is no licensing agreement.

iii) Consideration of other technologies is not described. The choice of technology, however, is logical for the type of production.

iv) Complete data is not provided for this proposal, only the cost of the plant for each manufacturing centre. (Incremental operating costs and operating savings are not available.) Thus only an estimate of UAC can be given. Assuming that there would be a saving on solvent costs but an increase in energy costs including drying the parts gives an approximate UAC of about $3.7 per ODP Kg.

6. Environmental Impact:

(a) The ODP of the substitute aqueous system is zero. There will however an increase in indirect GWP owing to the increase in energy consumption in all of the main process areas.

(b) There is no specific Health and Safety risk associated with aqueous cleaning systems. Normal factory safety should be applied.

7. Project costs:

(a) All the cost components identified in the project are essential to the conversion; it is not possible, with the information available, to determine whether the current production rate will be maintained.

(b) None of the cost components would be expected to be present in the existing facility. The substitution of an aqueous cleaning system for a TCA vapour degreaser is a fundamental change requiring complete re-equipment.

(c) Cost of equipment.

(i) The base line costs are addressed properly.

(ii) The decision to replace all of the existing equipment is consistent with the complete change in technology..

(iii) All the requests for equipment are consistent with the project plan.

(iv) There is little opportunity for re-use of existing equipment.

(v) The fate of any scrapped equipment is not described.

(vi) NA.

(vii) No information is provided concerning changes in production capacity, the proposal is confined to a description and specification for the aqueous cleaning systems alone.

(d) Appropriateness of training and related costs, if any.

There is a proposal from the supplier to provide start up training and operator instruction.

e) Operating costs

(i) Operating costs arc not included in the proposal.

(ii) No information is provided concerning operating savings or energy savings. The project proposal is confined to the specification of the cleaning units alone.

8. Implementation timeframe.

The timeframe proposed is feasible.

9. Recommendations

(a) Approval as proposed.

OORG Technical reviewer:.....B.H.Baxter....BHBaxter

Date Review completed: ...6.6.95.......................

THE MONTREAL PROTOCOL ON
SUBSTANCES THAT DEPLETE THE OZONE LAYER
CHINA ODS PHASE OUT PROJECT

PROJECT COVER SHEET

COUNTRY:	The People's Republic of China
PROJECT TITLE:	Automobile Air Conditioner (MAC) Factory Production Conversion from CFC-12 to HFC-134a MAC System
SECTOR COVERED:	Automobile Air Conditioning (MAC)
ODS USE IN SECTOR (1994):	1,278 MT ODP (1,278 MT CFC-12)
PROJECT IMPACT:	Phase out 434 MT ODP per year from 1996 to 1999 (Of which 274 MT ODP depends on complementary Haohua Project)
PROJECT DURATION:	Two Years

PROJECT COST:

Incremental Investment Cost:	US$1,607,800
Contingency:	US$ 241,200
Incremental Operating Cost:	0
Less: Salvage value	(81,000)
Net Incremental Investment Cost:	US$1,768,000
3% Financial Agency Fee	53,000
Proposed OTF grant:	US$1,821,000

PROPOSED OTF GRANT:	US$1,821,000
COST EFFECTIVENESS (CE):	Unit Abatement Cost: US$3.38/Kg ODP/Year Grant Effectiveness: US$9.17/Kg ODP
IMPLEMENTING ENTERPRISE:	Yueyang Hengli Air Conditioning Equipment Co. Ltd., Hunan
COORDINATING AGENCY:	National Environmental Protection Agency (NEPA)
IMPLEMENTING AGENCY:	The World Bank

PROJECT SUMMARY

This project will eliminate 434 MT ODP per year (218 MT CFC-12) in China. The CFC-12 MAC condenser and bus condenser & evaporator production line will be replaced by HFC-134a MAC condenser and bus condenser lines. Modification of compressor and condenser & evaporator as well as additional imported equipment for the factory is required. After new production lines are completed,434 MT of CFC-12 use can be eliminated annually. The project will be part of China's MAC industry sector's CFC-12 phase out trategy to cease CFC-12 use in new equipment by 2005.

Technical Assessment: The project has been reviewed and supported by the OORG technical reviewer, Mr. Bob Proctor. His comments are attached. Training costs have been reduced in accordance with OORG guidelines.

PROJECT OBJECTIVE:

The objective of this project is to convert the factory's production of CFC-12 bus Mobile Air Conditioning Systems (MACS) production (i.e. comprising compressor, condenser and evaporator) and MAC condenser to HFC-134a MACS, and thereby phase out 434 MT of CFC-12 consumption per year from 1996 - 2000 as part of the country's overall ODS phase out strategy.

SECTOR BACKGROUND

The development of China's MACS industry started in the late 80's, rather later than elsewhere. China's current production is less than 1% of MACS production worldwide. Since China is the World's most populous country with over 1.1 billion inhabitants and living standards are rising fast, the potential MACS market is huge. Recent expansion of MACS production has reflected this. 1992 MACS production was only 180,000 units, but rose to 270,000 units by 1994. The total national inventory of MACS systems by end 1994 was estimated at 1.49 million and the total annual CFC-12 use (for service and new system charge) was about 1,278 tonnes. 1995 production of MACS equipped vehicles is estimated at 265,000. CFC-12 usage associated with the MACS sector in 1995 is estimated at 1,510 tonnes.

China plans to cease production of CFC-12 based MACS and completely phaseout use of CFC-12 in the sector by 2005. This strategy is described in the China Country Program.

In 1994, 392 tones of CFC-12 were used for the initial charge of MACS and 886 tonnes for service.

About 2,000 bus MACS and 50,000 automobile MACS were manufactured by Yueyang Hengli and current consumption is 139 tonnes. Auto MACS were assembled using compressors produced by Hao Hua of Guangzhou. Table 1 below gives estimated of China's MAC production, ownership, actual and estimated future unconstrained CFC-12 consumption:

Table : Statistics and Prediction of China's MAC Production and CFC-12 Consumption 1991 - 2005

	Automobile				MAC		CFCs Consumption (MT)		
Year	Ownership	Production	Import	Retired	Ownership	Production	New MAC	Service	Total
1991	8,000	710	98		500	100	180	320	500
1992	6,920	1,060	211		760	180	296	477	773
1993	8,120	1,300	314		1,110	230	356	676	1,032
1994	9,540	1,340	283	250	1,490	270	392	886	1,278
1995	11,150	1,610	300	300	1,920	265	342	1,168	1,510
1996	12,940	1,840	350	400	2,410	320	413	1,479	1,892
1997	14,900	2,110	400	600	3,110	480	634	1,857	2,491
1998	17,150	2,400	450	800	3,820	650	858	2,276	3,134
1999	19,000	2,700	500	1,000	4,850	820	1,102	2,862	3,964
2000	20,000	3,000	500	2,000	5,950	1,110	1,497	3,506	5,003
2005					9,500	1,680	2,288	5,584	7,872

INTEGRATED SECTOR APPROACH TO PHASEOUT

Four projects are being submitted that will between them phaseout 70 percent of the CF-12 used in new MACS in China. All these are based on the adoption of HFC-134a to replace CFC-12. They are EK Chor (MACS compressor), Shanghai Auto Air Conditioner Corporation (condenser), Guangzhou Haohua (compressor) and Yueyang Hengli (bus MACS and auto MACS condensers). These are two fundamentally different approaches involved in the Chinese approach to conversion of the automotive MACS industry. Both are based on the need to produce HFC-134a MACS with an equivalent performance in terms of capacity and efficiency as the CFC-12 MACS currently produced. They are not the result of customer demands, but the minimum essential features to convert to HFC-134a MACS system.

(a) The performance and efficiency should be equivalent to the current CFC-12 systems

(b) The external dimensions of automotive MACS condensers should be no greater than those currently supplied. This is because of the limited space available for installation in a car's engine compartment. Use of a larger condenser would involve re-design by the vehicle manufacturer who would probably source his condensers elsewhere if his existing supplier could not meet this requirement. This involves the practicalities of installing a MACS in a given vehicle. It is not a customer requirement for an enhanced product.

EK Chor make compressors that are used exclusively by Shanghai Santana on VW and Audi cars. Santana source their condensers from SAAC and Yueyang. Some are of the serpentine type (from SAAC) and some are still of the finned copper tube variety (from Yueyang). Haohua supplies a number of different customers in Southern China who buy their condensers from a variety of sources.

Both Haohua and EK Chor are licensees of the Sanden Corporation of Japan and currently produce the same 5 cylinder CFC-12 compressors. EK Chor have not been able to conclude a deal to purchase new HFC-134a compressor technology from Sanden, despite trying. Haohua has been in production only since 1993 (and who retain close links with Sanden) have been able to conclude a technology transfer deal. This technology is for Sanden's new 7 cylinder HFC-134a designs developed from their CFC-12 compressor which Sanden considers obsolete. Haohua's project is thus based on the purchase of manufacturing rights for Sanden's new compressor range.

EK Chor have been in the MACS business since 1991, and unlike Haohua are well equipped with world class test facilities and excellent development engineers. Their approach is to modify the existing Sanden 5 cylinder CFC-12 compressor for use with HFC-134a. Because the compressor swept volume remains the same, systems using this compressor must be equipped with larger capacity condensers to offset the loss of system performance experienced when a CFC-12 system is directly retrofitted with HFC-134a. EK Chor compressors are supplied exclusively to Shanghai Volkswagen who source their condensers from SAAC. Thus, the SAAC project involves production of increased capacity condensers to match EK Chor's compressors. These two components are necessary in order to produce a MACS with equivalent capacity and efficiency to their present CFC-12 MACS.

All projects are being optimized in regard to technology source and costs, use of local technology and equipment where appropriate and reuse of existing equipment wherever technically feasible. Components that (might) relate to product upgrade and/or capacity expansion are being funded by the enterprises. This overall approach to the MAC sector will result in the lowest cost of transforming China's MAC sector to use of HFC 134a and represents the lowest possible request for assistance from the Multilateral Fund.

ENTERPRISE BACKGROUND

Yueyang Hengli Refrigeration Equipment Co. Ltd. (Yueyang) is belongs to Yueyang Municipal Industry Bureau, and comes under the control of the China National Automobile Industry Corporation (CNAIC). The enterprise is the only factory to manufacture the large bus MAC compressor and bus MACS in China and accounts for 95% of the nation's total. It is also one of the largest MACS manufacturers in China and was listed as one of 500 largest industrial enterprises of China in 1993. The factory has a MACS and Refrigeration Research Institute, and a Central Laboratory for developing and testing all components used in MACs.

Yueyang Hengli introduced Konvekta (Germ) and Bock (Germ) heat exchanger and compressor technology in 1986. Production facilities were installed with a total design capacity of 250,000 units p.a. (5,000 Bus MACS, 40,000 medium sized and special purpose vehicle MACS, 225,000 automobile MACS). 1993 production was 2,000 bus MACS, and 50,000 auto MACS. Total factory 1994 CFC consumption was 139 tonnes.

In 1994, Bus MACS production climbed to 40,000 units and auto MACS production reached 60,000 units.

Yueyang Hengli's products are mainly supplied to North Vehicle Manufacturing Co., China No. 2 Automobile Industry Corporation, No. 1 Automobile Industry Corporation and other small, medium and large sized vehicles producers.

There are 2,000 staff and workers at Yueyang Hengli Co. Ltd., of whom 400 are technicians including 33 senior engineers and 128 graduate engineers in various technical disciplines.

Components are manufactured according to Konvekta and Bock standards and quality is monitored by the China National Automobile Industry Corporation (CNAIC). Yueyang's products are sold only in the domestic market. The enterprise is 100% Chinese owned.

PROJECT DESCRIPTION

The project consists of the following components:

i) Improvement of Casting Facilities

Because system pressures may be higher in an HFC-134a system, elements of the compressor body need to be strengthened. These are the cylinder heads and end plate currently produced in cast iron on site rather than in aluminium as stipulated in the Bock design. This is due to the limitations of Yueyang's contractor's casting facilities.

The cast iron components have not been entirely successful and Yueyang will take this opportunity to modify their production process to conform to the Bock design requirement. Since this arguably constitutes a product upgrade, Yueyang have opted to finance this from enterprise sources.

ii) Modification of Bus MACS Condenser and Production

Owing to the phenomenon of copper plating that has been observed on HFC-134a MACS systems employing copper tube condensers, condensers for HFC-134a bus MACS will be made from Aluminium tube. Special Aluminium brazing equipment is required (see Annex 6).

iii) Increase of Condenser Capacity

When HFC-134a is used in an unmodified CFC-12 MACS, the system suffers a loss in capacity of about 5%. This is due to the different thermodynamic characteristics of HFC-134a which give rise to a higher system pressure ratio which reduces the volumetric efficiency of the compressor and thus the flow rate of refrigerant around the system.

This can be compensated by increasing the heat exchanger capacities in order to reduce the pressure ratio to those found in CFC-12 systems. Increase in condenser capacity is most effective in doing this. This approach has the added advantage of reducing pressure levels in the system to those associated with CFC-12 and thus preventing exposure of system components such as the compressor to higher pressures

iv) Conversion of Automobile MACS Condenser Production

Some condensers are supplied to clients using EK Chor auto MAC compressors. These require condensers of increased capacity to restore system capacity (as described above for Bus MACS) but unchanged physical dimensions because of the space constraints in automobile MAC installations. This is achieved by replacing the present copper tube designs with new multiflow condenser technology.

Multiflow condensers are made from aluminium and therefore the problem of copper plating in HFC-134a MACS using copper condensers described earlier is also avoided.

This project component requires:

a) The purchase of Multiflow Condenser technology

b) Re-equipping the present auto MAC condenser production to produce the Multiflow type condensers.

v) Technical Training

Staff training is required to successfully implement production of Multiflow condensers. This consists of two types:

i) Training on service and installation of bus MACS. $130 per operative has been allowed for this which will provide over 1 month's training and is considered ample.

ii) Overseas training. Optimising the bus MACS for HFC-134a use is considered within the technical competence of Yueyang. The opportunity to consult with foreign experts will be an important element in successful project implementation, and a far more cost effective option than purchase of foreign technology.

vi) Replacement of Existing Trichloroethane Component Cleaning

Trichloroethane is an ODP. The existing system will be replaced with an environmentally friendly aqueous based system. This will eliminate 7 tonnes of Trichloroethane use per year.

vii) SAE/ISO standards will be employed throughout manufacture and service. This will reduce leakage by improving system reliability. Interchangeability with foreign produced components will also be a benefit of this. Use of couplings compatible with HFC-134a charging hoses will prevent system from being charged with CFC-12.

JUSTIFICATION FOR ALTERNATIVE TECHNOLOGY SELECTION

HFC-134a based technology has been selected for the following reasons:

1) Because of its good thermodynamic properties, zero ODP and non-flammability, HFC-134a has been recognized worldwide as the most appropriate replacement for CFC-12 in Automobile Air Conditioning systems.

2) The production technology for HFC-134a MACS is already well developed in industrial countries.

3) Supplies of domestically produced HFC-134a should be available in China from 1998.

TECHNOLOGY SOURCES AND AVAILABILITY

The present Yueyang Hengli MAC compressor and MACS manufacturing technology and key production equipment were imported from Konvekta and Bock in 1986. Well known MAC Multi-Flow Condenser manufacturers, such as TCI, McKenica, Emerson & Renwick USA, Inc. (E&R USA, Inc.), and Fin Machine Inc. have expressed their willingness to transfer their HFC-134a MACS manufacturing technology and to convert Yueyang Hengli's present CFC-12 Auto MAC condenser production line to HFC-134a compatible Multiflow condenser production.

The deal for production equipment and technology transfer offered by Fin Machine has been provisionally selected and has been used in cost compilation for this project (Annex 1).

PROJECT COSTS

Total project cost of US$3,765,400 equals the ODS reduction portion of the overall project (investment cost plus net incremental operating cost minus scrap value of abandoned equipment and excluding financial agent fee). This project will not provide Yueyang with any incremental revenues, but will result in incremental operating costs (Annex 3).

Incremental investment cost of US$1,849,000 (including 15% contingency) is for purchase of additional equipment needed for the conversion of production line to replace: 1). Present CFC-12 bus MAC compressors by HFC-134a MAC compressors, and 2). Present CFC-12 MAC fin & tube condenser by Fin Machine Inc. (Annex 1: Tables 1 & 2). Most equipment for production of present CFC-12 compressors and MAC can also be used for production of HFC-134a bus MAC compressors and automobile MACS.

The present value of this equipment detailed in Annex 6 is US$1,875,600.

Net incremental Operating Cost of US$516,400 are due to the conversion of production line to replace CFC-12 bus MAC compressors, bus and car MAC system. As HFC-134a bus MAC compressors and MAC system require different some materials and components to those used in CFC-12 MACS, the unit cost of production will be increased by approximately US$80/unit and car MAC system will be US$0.40/unit (Annex 2: Table 1), thus the production cost of the HFC-134a MAC compressors and systems are increased about US$172,900 year. This gives Incremental Operating Costs of $516,400 for a 4 year period. However, funding for incremental operating costs is *not* being requested.

Salvage value of replaced equipment of $81,000 is deducted from the incremental investment cost.

Requested Funding The proposed OTF grant for Yueyang Hengli is US$1,821,000 and was calculated as follows: incremental investment costs, net of salvage value of redundant equipment after conversion, add 15% contingency and a 3% financial agency fee.

PROJECT IMPLEMENTATION:

	Schedule (months)																	
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Negotiate Order	X	X																
Order Equip.			X															
Initial Design	X	X	X															
Inst. Design				X	X	X												
Order China Eqp.					X	X	X	X	X	X								
Install. & Training											X	X	X	X	X	X		
Trial Run																	X	X

Management: The Dept. of Auto Industry of Ministry of Machine Industry (MMI) will oversee the successful implementation of the project. The project will be carried out at Yueyang Hengli Refrigeration Equipment Co. Ltd..

Project Director: Mr. Peng Heyi, General Manager of Yueyang Hengli Refrigeration Equipment Co. Ltd.

Project Engineer: Mr. Yi Shuqing, Chief Engineer of Yueyang Hengli Refrigeration Equipment. Co. Ltd.

ENVIRONMENTAL CONSIDERATIONS

Environmental Assessment (EA) is carried out by Hunan Provincial Environmental Protection Bureau (EPB). The project will meet standards and regulations stipulated by the Hunan Provincial EPB. No new pollutants will be generated from the production.

HFC-134a is a powerful greenhouse gas, though with a lower GWP than the CFC-12 which it replaces. Improved product design and installation and service practices will educe emissions as far as possible.

PROCUREMENT

Imported and domestic equipment needed are shown in Table 1 and Table 2. (Annex 1) Contracts will be awarded after evaluation and comparison of quotations solicited from at least 3 qualified suppliers. The choice of procurement agency will be discussed at appraisal..

REQUIRED REGULATORY ACTIONS

A preferential duty making HFC-134a at least as cheap as CFC-12 is required for as long as CFC-12 is available. CFC-12 can be used in MACS designed for HFC-134a and actually gives a slightly improved performance. Such a duty is presently being studied by MMBI and NEPA

In addition, anticipated legislation will make use of CFC-12 in new MACS illegal from end 2005. Use of CFC-12 as a refrigerant will be completely phased out from start 2005.

PROJECT RESULTS

Direct Project Impact: Annual use of 434 tonnes of CFC-12 will be eliminated, along with 7.1 tonnes of Trichloroethane.

Indirect Project Impact Since IOC's are not being requested, the effect on product price is unpredictable. Implementation of this project is not expected to create any workforce redundancies. It is not anticipated that this technology will be replicated to other enterprises.

ANNEX 1

Table 1: Cost Breakdown of Factory Conversion for HFC-134a MFC Condenser Production (US$)

Components	Description	Qty	Total Cost	Remark
Multi Flow	Medium volume fin machine		195,000	Fin Machine
	One set of Multi-Flow fin tooling		9,000	"
	Fully Automatic Matrix Core Builder		250,000	"
	One set of tooling for Core Builder		25,000	"
	Extruded Uncoil and cut off Machine	1	200,000	"
Condenser	Technology transfer package	1	50,000	"
	Complete set of press tooling for MFC header plate	1	40,000	"
	Installation, commissioning and acceptance		10,000	"
	Packaging, freight, Shipping & Insurance for equipment		10,000	"
Technical	Foreign Experts Supervise the installation in sito: 4 men x 12 days x $500/man.day		24,000	
	Publicize/outreach program: Train servicemen/user: 4 workshop x 30 men/workshop x $130/workshop.man		15,600	
Training	Subtotal:		828,600	
	Contingency (15%)		124,300	
	TOTAL (rounded)		952,900	

Table 2: Cost Breakdown of The Factory Conversion for HFC-134a Bus MAC Compressor, Condenser & Evaporator Production (US$)

Components	Description	Qty	Total cost	Remark
Bus MAC Compressor	HFC - 134a charging and evacuating machine	1	10,000	
	HFC - 134a leak sniffer		1,000	
	PAG oil charging machine	1	90,850	
Bus MAC Condenser and Evaporator	Inert Gas Welding Machine	1	12,000	China
	Tubing brazing (Sealing) machine for HFC - 134a bus MAC	1	432,600	Camlaw
	Expansion head for Tube expander	2	2,100	
	Tube bending moulds for tube bending machine	3	15,000	
Non ODS washing	Phase out 7 T of trichloroethane use by using aqueous wash process	1	200,000	import
Training	Publicize/outreach program/Train service: 4 wkshp x 30 men/wkshp x $130/wkshp.man		15,600	
	Subtotal:		779,150	
	Contingency (15%)		116,870	
	TOTAL (rounded)		896,000	

Table 3: Cost Breakdown of The Additional Equipment for HFC-134a MAC Production (US$)

FINANCED BY YUEYANG

Components	Description	Qty	Type	Total cost	Remark
Bus MAC Compressor	MAC testing stand, (2,000 - 30,000 Kcal/H)	1	Vista92	420,000	US Vista Co.
	Mazak machining centre (Horizontal)	1		150,000	
Foundry Workshop Renovation	Pressure casting machine (90 MT)	1		500,650	
	Compressor block dies	2		177,750	
	Rear housing die	2		39,350	
	Subtotal			1,287,750	
	Contingency (15%)			193,250	
	TOTAL			1,481,000	

Table 4: Salvage Value of the Redundant Equipment ($)

Component	Remarks	Equipment Description	Original price	Present value	Salvage value
Compressor part	Obsolete	Jigs, fixtures and dies	$24,000	$15,000	$1,000
	Obsolete	Compressor cylinder machining equip	$300,000	$18,000	$3,000
Machining equipment	Convert to R-22 use	Grinder	$25,000	$12,000	$12,000
	Obsolete	Low pressure casting machine	$35,000	$20,000	$10,000
	Obsolete	Cylinder head casting die (2 set)	$150,000	$100,000	$2,000
	Obsolete	End plate casting die (2)	$35,000	$25,000	$1,000
Compressor Assembly Equipment	Convert to R-22 use	CFC-12 charging machine	$40,000	$18,000	$11,000
	Convert to R-22 use	Oil charging machine	$45,000	$20,000	$13,000
	Partially convert to other use	CFC-12 compressor testing stand	$150,000	$60,000	$10,000
MAC system production equipment	Partially convert to other use	CFC-12 MAC soft pipe sealing machine	$250,000	$120,000	$15,000
		Trichloroethane cleaning machine	$150,000	$100,000	$3,000
Grand total:				$910,000	$81,000

ANNEX 2

Table 1: Incremental Operating Cost After Conversion (US$)

		When Using CFC-12		When Using HFC-134a		Incremental Production cost after conversion
	Description	Material used	U. rate	Material Used	U.rate	
Bus MAC Compressor	Lubricant	Mineral oil	1.49	PAG lubricant	4.24	2.75 x 2,000 = 5,500
	Sealant	NBR	4.60	HNBR	7.30	2.70 x 2,000 = 5,400
	Bearings	Standard	19.00	Reinforced	29.00	10.00 x 2,000 = 20,000
Bus MAC condenser & evaporator	Exp. valve		56.00		62.00	6.00 x 2,000 = 12,000
	Tube: H.pressure	12 M	100.00	12 M	125.00	25.00 x 2,000 = 50,000
	Tube: L.pressure	12 M	110.00	12 M	140.00	30.00 x 2,000 = 60,000
		Net Unit IOC for Bus System				82.45
Subtotal of bus MAC unit:						82.45 x 2,000 = 152,900
Car MAC condenser	Exp. valve		13.24		13.33	0.09 x 50,000 = 4,500
	Materials		62.78		63.09	0.31 x 50,000 = 15,500
		Net Unit IOC for Auto MACS				0.40
Subtotal of car MAC system:						0.40 x 50,000 = 20,000
	Total incremental operating cost:					**172,900**

Incremental Operating Costs (based on 50% production in 1996) are shown below:

1996 $86,450
1997 $172,900
1998 $172,900
1999 $172,900

$US516,400 Discounted at 10%

ANNEX 3

BREAKDOWN OF PROJECT COST AND FINANCING

	Investment Cost	Investment	Contingency	Total
	Imported MAC condenser production equipment (Annex 1: Table 1)	828,600	124,300	952900
	Imported bus MAC compressor/condenser/evaporator equip. (Annex 1: Table 2)	779,150	116,870	896,000
	Sub-total of imported production equipment (Annex 1: Table 1 & Table 2)	1,607,800	241,200	1,849,000
	Self financed accessory equipment (Annex 1: Table 2)	1,287,750	193,250	1,481,000
	Subtotal:	2,895,500	434,400	3,330,000
	Less: Enterprise funding (Additional accessary equipment Annex 1: Table 2)	(1,287,750)	(193,250)	(1,481,000)
	Less: Salvage value of Redundant equipment after conversion (Annex 1: Table 4)			(81,000)
	Incremental investment cost proposed for OTF financing			1,768,000
II.	Incremental operating cost proposed for OTF financing			0
III.	Financial Agent Fee (3%)			53,000
	Total (proposed ODS Grant)			1,821,000

Note: OTF proposed funding equals: 57.2 % of incremental capital cost minus the salvage value of redundant equipment & 0% of incremental operating costs.

Total Project Costs

Total Investment Costs	US$ 3,330,000
4 yr. Incremental Operation Costs	US$ 516,400
Salvage Value Redundant Equip.	(81,000)
Total	**US$ 3,765,400**

ANNEX 4

Calculation of Unit Abatement Cost and Grant Effectiveness

UAC = {C(F) + (OC--OS/R)}/ODP

Where: A = Unit Abatement Cost, $/kg ODP/year

C = ODS reduction investment cost, including all initial one time costs such as technology and training the annualized capital cost charges

F = Capital recovery factor, the annualized capital cost charges, discounted at a standard rate of 10% per year over the economic life of the investment

OC = The annual incremental operating costs in the first year of full operation.

OS/R = The annual incremental operating savings of revenue in the first year of full operation.

ODP = The annual ODS reduction at the first year of full operation expressed in ODP units.

The investment cost of the Yueyang project is (incl. 15% contingency):

$1,018,300 (MAC) + $1,009,000 (bus MAC) + $1,481,000 (self funded for bus MAC) == $3,508,300

The annual incremental operating cost is also divided into two parts: 1) MAC condenser - $152,900
2) bus MAC- $20,000

The economic life is 10 years.

The ODS elimination of Yueyang is divided into two part: 1) will be contingent upon Haohua's project implementation, and 2) Bus MAC production conversion will be realized by Yueyang factory alone. Then

C(F) = {($2,969,600/Haohua + $3,329,900/Yueyang) x 0.1627 = $1,024,930

$$\text{UAC} = \frac{1{,}024{,}930 + \{[\$270{,}000/\text{HH} + \$152{,}900/\text{YY bus MAC} + \$20{,}000/\text{YY MAC}] - 0\}}{[274{,}000\ (\text{Haohua + Yueyang MAC}) + 160{,}000\ (\text{Yueyang bus MAC})]\ \text{kg ODP}} = \text{US\$3.38/kg ODP/year}$$

Grant Effectiveness = [US$1,768,000 (Yueyang) + US$2,212.000 (Haohua)]/434,000 kg ODP
= **US$9.17/ kgODP/Year**

ANNEX 5

Equipment Justification

Auto MACS Condenser Production

The equipment detailed in Table 1 (Annex 1) the minimum inventory required production of the new condenser design according to the technology suppliers, Fin Machine Inc.

Bus MACS System Production

HFC-134a Charging & Evacuating Machine

HFC-134a is not compatible with some materials used in such equipment designed for CFC-12, and charge levels are different to CFC-12 systems. The existing machine is not capable of economic modification. A new piece of equipment is required.

HFC-134a Leak Detector

CFC-12 leak detectors are not capable of detecting HFC-134a. The existing leak detector used in production must therefore be replaced by HFC-134a specific detectors.

PAG Oil Charging Machine

Poly Alkyl Glycol (PAG) lubricating oil is used in place of mineral oil on MACS. This is acutely hygroscopic and requires special charging equipment. The existing mineral oil charging machine is not capable of economic modification.

Inert Gas Welding Machine

This is required to form the aluminium condenser outlet tube to the drier inlet. This was not required previously when the condenser was made of copper tube and brazing in atmospheric air was sufficient.

Aluminium Tube Brazing Equipment

A brazing furnace is required to join aluminium fins to aluminium heat exchange tubing.

Aqueous based Component Cleaning Equipment

The existing equipment uses Trichloroethane, an ODS. Component washing equipment must be completely replaced by an environmentally friendly system.

ANNEX 6

List of the equipment that will be re used by Yueyang:

	Equipment	Original Value	Current Value	Age	Remarks
Bus MAC	Vertical Machining Centre	2 x $500,000	2 x $485,000	1 year	MEZAK
	Tool & dies for VMC	$100,000	$95,000	"	"
Compressor	#1 Jig boring machine	$58,000	$40,000	3 year	Chinese
	#2 jig boring machine	$64,000	$44,000	"	"
Machines	Sub total:	$1,222,000	$1,149,000		
MAC	Fin press	$521,000	$235,000	5 year	U.S.
	Single end tube expander	$129,300	$58,000	"	U.S.
Condenser	Tube bender	$59,000	$29,400	"	U.S.
	U shape tube bender	$57,500	$29,000	"	U.S.
Equipment	Dimension Calibrator	$42,000	$23,500	"	U.S.
	Fin press with dies	$551,000	$223,500	"	German
	Tube expander/Dia 10& 12	$105,000	$47,000	"	German
	Tube end former	$51,000	$23,500	"	German
	Fin centre dies	$80,000	$37,000	"	
	Cleaning machine	$38,200	$17,600	"	German
	Sub total:	$1,635,100	$726,600		
Total		US$2,857,100	US$1,857,600		

COUNTRY OF ORIGIN: THE PEOPLE'S REPUBLIC OF CHINA (page 1 of 1)

PROJECT TITLE: AUTOMOBILE AIR CONDITIONER (MAC) FACTORY PRODUCTION CONVERSION FROM CFC-12 TO HFC-134A

IMPLEMENTING ORGANIZATION:
YUEYANG HENGLI AIR CONDITIONING EQUIPMENT CO. LTD., HUNAN

SECTOR: AUTOMOBILE AIRCONDITIONING (MAC)

RELATIONSHIP TO THE COUNTRY PROGRAM:

This project proposal appears to be compatible with a total program focused at the elimination of the use of CFC-12 as a MAC refrigerant.

TECHNOLOGY:

The technology uses HFC-134a as a refrigerant, which is considered the lowest technical risk and the most environmentally sound replacement available. Standards and specifications have been established and published by recognized international technical associations. This proposal incorporates Konvekta and Bock standards, as well as SAE standards.

This proposal proceeds from copper tube condensers to aluminum tube, multi flow condensers as recommended by the OORG guide lines.

ENVIRONMENTAL IMPACT:

The reduction in CFC emissions projected in the proposal are reasonably attainable. The proposal includes replacing trichloroethane vapor degreasing with an aqueous based system.

PROJECT COSTS:

The technical training costs do not meet the OORG guide lines, (Report 11 January 1995).

RECOMMENDATIONS:

This reviewer recommends approval of this proposal provided the training costs are made compatible to the OORG guidelines.

The reviewer suggests reconsideration of the proposed training costs.

REVIEWER-------------------R. H. PROCTOR

REVIEW DATE------------------------June 8, 1995

THE MONTREAL PROTOCOL ON
SUBSTANCES THAT DEPLETE THE OZONE LAYER
CHINA ODS PHASE OUT PROJECT

PROJECT COVER SHEET

COUNTRY:	The People's Republic of China
PROJECT TITLE :	Automobile Air Conditioner (MAC) Compressor Factory Production conversion from CFC-12 to HFC-134a MAC Compressor
SECTOR COVERED:	Automobile Air Conditioning (MAC)
ODS USE IN SECTOR (1994):	1,278 MT ODP (1,278 MT CFC-12)
PROJECT IMPACT:	Phase out 274 MT ODP per year (including complementary Yueyang Project)
PROJECT DURATION:	18 Months

PROJECT COST:

Incremental Investment Cost:	US$1,961,700
15% Contingency:	294,300
Incremental Operating Cost:	0
Less: Salvage value	(44,000)
Net Incremental Investment Cost	US$2,212,000
3% Financial Agency Fee	66,400
Proposed OTF Grant	US$2,278,400

PROPOSED OTF GRANT:	US$ 2,278,400
COST EFFECTIVENESS (EC):	Unit Abatement Cost: US$2.98/kg/Year Grant Effectiveness: US$8.07/kg
IMPLEMENTING ENTERPRISE:	Guangzhou Haohua Automobile Parts. Co. Ltd. (Haohua)
COORDINATING AGENCY:	National Environmental Protection Agency (NEPA)
IMPLEMENTING AGENCY:	The World Bank

PROJECT SUMMARY

This project will eliminate 274 MT ODP per year (274 MT CFC-12) in China. CFC-12 MAC compressor production line will be replaced by HFC-134a MAC compressor production. A license to produce a new HFC-134a compressor and additional imported production equipment is required. After the new production line is completed, 274 MT of CFC-12 use will be eliminated annually. The project will be part of China's MAC industry sector's CFC-12 phase out strategy to cease CFC-12 use in new equipment by 2005

Technical Assessment: The project has been reviewed and supported by the OORG technical reviewer, Mr. Bob Proctor. His comments are attached. The project costs have been reduced in accordance with OORG guidelines.

PROJECT OBJECTIVE:

To convert current CFC-12 MACS compressor production to HFC-134a compressor production.

SECTOR BACKGROUND

The development of China's MACS industry started in the late 80's, rather later than elsewhere. China's current production is less than 1% of MACS production worldwide. Since China is the World's most populous country with over 1.1 billion inhabitants and living standards are rising fast, the potential MACS market is huge. Recent expansion of MACS production has reflected this. 1992 MACS production was only 180,000 units, but rose to 270,000 units by 1994. The total national ownership of MACS systems by end 1994 was estimated at 1.49 million and the total annual CFC-12 use (for service and new system charge) was about 1,278 tones. 1995 production of MACS equipped cars is estimated at 265,000. CFC-12 usage associated with this is 1,510 tones.

China plans to cease production of CFC-12 based MACS and use of CFC-12 in the sector by 2005. This strategy is described in the China Country Program.

In 1994, 392 tones of CFC-12 were used for the initial charge of MACS and 886 tones for service. 60,000 of the 270,000 total MACS made in 1994 were manufactured by Guangzhou Haohua Auto. Parts Co. Ltd. Haohua's 1994 consumption of CFC-12 (both new MAC and service change) was 79 tones.

Table 1: Statistics & Prediction of China's MAC Production and CFC-12 Consumption 1991 - 2005

(1,000 Vehicle)

	Automobile				MAC		CFCs Consumption (MT)		
Year	Ownership	Production	Import	Retired	Ownership	Production	New MAC	Service	Total
1991	8,000	710	98		500	100	180	320	500
1992	6,920	1,060	211		760	180	296	477	773
1993	8,120	1,300	314		1,110	230	356	676	1,032
1994	9,540	1,340	283	250	1,490	270	392	886	1,278
1995	11,150	1,610	300	300	1,920	265	342	1,168	1,510
1996	12,940	1,840	350	400	2,410	320	413	1,479	1,892
1997	14,900	2,110	400	600	3,110	480	634	1,857	2,491
1998	17,150	2,400	450	800	3,820	650	858	2,276	3,134
1999	19,000	2,700	500	1,000	4,850	820	1,102	2,862	3,964
2000	20,000	3,000	500	2,000	5,950	1,110	1,497	3,506	5,003
2005					9,500	1,680	2,288	5,584	7,872

INTEGRATED SECTOR APPROACH TO PHASEOUT

Four projects are being submitted that will between them phaseout 70 percent of the CF-12 used in new MACS in China. All these are based on the adoption of HFC-134a to replace CFC-12. They are EK Chor (MACS compressor), Shanghai Auto Air Conditioner Corporation (condenser), Guangzhou Haohua (compressor) and Yueyang Hengli (bus MACS and auto MACS condensers). These are two fundamentally different approaches involved in the Chinese approach to conversion of the automotive MACS industry. Both are based on the need to produce HFC-134a MACS with an equivalent performance in terms of capacity and efficiency as the CFC-12 MACS currently produced. They are not the result of customer demands, but the minimum essential features to convert to HFC-134a MACS system.

(a) The performance and efficiency should be equivalent to the current CFC-12 systems

(b) The external dimensions of automotive MACS condensers should be no greater than those currently supplied. This is because of the limited space available for installation in a car's engine compartment. Use of a larger condenser would involve re-design by the vehicle manufacturer who would probably source his condensers elsewhere if his existing supplier could not meet this requirement. This involves the practicalities of installing a MACS in a given vehicle. It is not a customer requirement for an enhanced product.

EK Chor make compressors that are used exclusively by Shanghai Santana on VW and Audi cars. Santana source their condensers from SAAC and Yueyang. Some are of the serpentine type (from SAAC) and some are still of the finned copper tube variety (from Yueyang). Haohua supplies a number of different customers in Southern China who buy their condensers from a variety of sources.

Both Haohua and EK Chor are licensees of the Sanden Corporation of Japan and currently produce the same 5 cylinder CFC-12 compressors. EK Chor have not been able to conclude a deal to purchase new HFC-134a compressor technology from Sanden, despite trying. Haohua has been in production only since 1993 (and who retain close links with Sanden) have been able to conclude a technology transfer deal. This technology is for Sanden's new 7 cylinder HFC-134a designs developed from their CFC-12 compressor which Sanden considers obsolete. Haohua's project is thus based on the purchase of manufacturing rights for Sanden's new compressor range.

EK Chor have been in the MACS business since 1991, and unlike Haohua are well equipped with world class test facilities and excellent development engineers. Their approach is to modify the existing Sanden 5 cylinder CFC-12 compressor for use with HFC-134a. Because the compressor swept volume remains the same, systems using this compressor must be equipped with larger capacity condensers to offset the loss of system performance experienced when a CFC-12 system is directly retrofitted with HFC-134a. EK Chor compressors are supplied exclusively to Shanghai Volkswagen who source their condensers from SAAC. Thus, the SAAC project involves production of increased capacity condensers to match EK Chor's compressors. These two components are necessary in order to produce a MACS with equivalent capacity and efficiency to their present CFC-12 MACS.

All projects are being optimized in regard to technology source and costs, use of local technology and equipment where appropriate and reuse of existing equipment wherever technically feasible. Components that (might) relate to product upgrade and/or capacity expansion are being funded by the enterprises. This overall approach to the MAC sector will result in the lowest cost of transforming China's MAC sector to use of HFC 134a and represents the lowest possible request for assistance from the Multilateral Fund.

ENTERPRISE BACKGROUND

Guangzhou Hao Hua Automobile Parts Co. Ltd. (Hao Hua) belongs to the Industry Bureau of Panyu City, Guangdong Province and comes under the control of the China National Automobile Industry Corporation. Haohua introduced a Sanden MAC compressor production facility in 1991 with an annual production capacity of 100,000 units.. Hao Hua's products are mainly supplied to Guangzhou Peugeot Automobile Factory, China No. 2 Automobile Corp., Dongfeng Automobile Corp. and other small and medium sized vehicle producers.

There are 320 staff at Hao Hua, including, 6 senior engineers and 32 graduate engineers. The total factory area of Hao Hua is 25,000 M^2 which accommodates 5 separate production lines for the following operations: MAC Compressor machining line, Clutch Machining line, MAC Compressor Assembly line, Clutch Assembly and General Assembly. MACS using Hao Hua compressors used 79 tones of CFC-12 in 1994, or 10% of the sector total.

The Products are produced according to international standards stipulated by the Sanden Corporation. Quality control is carried out by the China National Automobile Industry Corporation. Haohua produces only for the domestic Chinese market and is 100% Chinese owned.

PROJECT DESCRIPTION

The project involves:

1) The transfer of HFC-134a MAC compressor technology from Sanden, Japan; (This is the only option open to Haohua);

2) The import of key HFC-134a MAC compressor manufacturing equipment, retooling of some existing equipment, conversion of SD-5 CFC-12 MAC compressor production line with the annual capacity of 100,000 Units (single shift) to SD-7H15 HFC-134a MAC compressor production line of the same capacity;

3) The complete elimination of 6.5 tones of trichloroethane (an ODS) by adopting aqueous based component cleaning technology.

4) Training of production technicians by Sanden, and training of service network staff in techniques of servicing HFC-134a MACS.

During the second year of project implementation, Hao Hua will reduce the present CFC-12 SD-5 MAC compressor production and CFC-12 consumption by 50%. Complete elimination of CFC based production will be achieved 18 months later on project completion.

JUSTIFICATION FOR ALTERNATIVE TECHNOLOGY SELECTION

HFC-134a based technology has been selected for the following reasons:

1) HFC-134a has been recognized worldwide as the most appropriate replacement for CFC-12 in Automobile Air Conditioning systems. It possesses good thermodynamic properties, zero ODP and is non-flammable.

2) The production technology for HFC-134a MACS is already well developed in industrial countries.
3) Supplies of domestically produced HFC-134a should be available in China from 1998.

TECHNOLOGY SOURCES, AVAILABILITY AND JUSTIFICATION FOR SD-7 COMPRESSOR SELECTION:

1) Technology availability: Since the Sanden SD-5 series production line was imported in 1992, transition to the new 7 cylinder SD-7H series is the most cost effective route for conversion to non-CFC technology. An agreement has been reached in principle with the Sanden Corporation to supply this technology for a reasonable sum. Sanden is only offering the 7 cylinder SD-7H compressor. The 5 cylinder model is considered obsolete by Sanden. Haohua lacks the facilities and expertise to convert the existing 5 cylinder design for HFC-134a use.

   The existing production line is highly automated and specific to the Sanden compressor. Adoption of any other proprietary compressor technology would involve the purchase of an entire new production facility. Investment would be of the order of that made in 1992 for purchase of the original line (about USD 4.4m).

A significant amount of existing equipment can be used for the new production. Equipment is being re-used wherever possible by the use of e.g. new dies (seeTable 1 of Annex 6).

2) Substitution of CFC-12 by HFC-134a in an unmodified CFC-12 MACS results in a loss of capacity of about 5%. This loss of capacity can be restored by either by employing a larger capacity compressor, or increasing the capacity of the system condenser.

Not possessing the expertise and test facilities of EK Chor, Haohua will produce the 7 cylinder compressor. This will involve some circuit re-design, e.g., using larger condensers to reduce the excessive high side pressures that would result if the larger compressors were used directly on circuits design for CFC-12. This design will be the responsibility of the vehicle manufacturers supplied by Haohua. These have all declared themselves satisfied with this approach.

Hao Hua have opted for the first course because their compressors are used with condensers supplied by a variety of suppliers. Not all of these will be able to supply condensers of sufficiently increased capacity and unchanged external dimensions -the essential requirement of all automobile producers.

3) Improvement in Production Technology The current compressor consists of an aluminum body and cast iron cylinder liner. The new design involves integral casting of the compressor body in wear resistant alloy. This will be carried out on new vacuum casting equipment. This is considered an improvement in production technology and is therefore being financed from enterprise's own sources.

Note: Compressors will be produced according to SAE/ISO standards. They will be equipped with couplings compatible with HFC 134a charging hoses to prevent use of CFC-12 in the MACS on which they are used.

PROJECT COSTS

Total project cost of US$3,620,200 equals the ODS reduction portion of the overall project (investment cost plus net incremental operating cost and minus equipment scrap value but excluding the financial agent fee). This project will not provide Hao Hua with any incremental revenues, but will result in incremental operating costs.

Incremental investment cost of US$2,799,000 including 15 % contingency to purchase additional equipment needed for the conversion of production line to replace present SD-5 CFC-12 MAC compressors with CD-7H15 HFC-134a MAC compressors (Annex 1: Tables 1 & 2). Some equipment for production of SD-7 CFC-12 compressors can also be used for production of SD-7H15 HFC-134a MAC compressors (Table 1 Annex 6).

Salvage value of the replaced existing equipment of $44,000 will be deducted from the project cost, although these equip. can not be used for HFC-134a MAC compressor production, but some items can still be used elsewhere (Annex 1: Table 3). MMI will ensure during implementation that this equipment is not used for the production of CFC-12 MACS compressors.

Net incremental Operating Costs of US$270,000 p.a. comprise increased material costs associated with the production of the new design. The compressor body material is of special alloy; HFC-134a compatible seal material and lubricant are more expensive and higher system pressure differences mean that re-enforced bearings have to be employed. These costs are detailed in Table Annex 3 and amount to a unit incremental production cost of US$4.50 giving an annual Incremental Operating Cost of $270,000. This gives a Incremental Operating Cost for a 4 year project life of US$ 865,200. However, funding for incremental operating costs is *not* being requested.

Requested Funding The proposed OTF grant for Hao Hua is US$2,278,400 and was calculated as follows: eligible part of total investment cost of $1,961,700, 15% contingency of $294,300, minus the salvage value of $44,000 of the existing equipment which will no longer be used for the HFC-134a MAC production, and zero portion of incremental operating cost of $945,000. The resulting OTF request of $2,212,000 was then increased by 3% to account for financial agent fee to arrive at total proposed OTF grant of US$2,278,400.

PROJECT IMPLEMENTATION:

	Progressive Schedule (Months)																	
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
CD CH Die casting	X	X	X	X	X	X	X	X	X	X	X	X	X	X				
Cylinder block MFG	X	X	X	X	X	X	X	X	X	X	X	X	X	X				
Clutch rotor MFG	X	X	X	X	X	X	X	X	X	X	X	X						
Cylinder head MFG	X	X	X	X	X	X	X	X	X	X	X	X						
Front house MFG	X	X	X	X	X	X	X	X	X	X	X	X						
Planet plate MFG	X	X	X	X	X	X	X	X	X	X	X	X						
Compressor assembly					X	X	X	X	X	X	X	X	X	X	X	X		
Clutch assembly					X	X	X	X	X	X	X	X	X	X	X	X		
QC equip					X	X	X	X	X	X	X	X	X	X	X	X		
Training							X	X	X	X	X	X						
Trial run																X	X	X

Management: The Dept. of Auto Industry of Ministry Machine Industry (MMI) will oversee the successful implementation of the project. The project will be implemented at Guangzhou Hao Hua Automobile Parts Co. Ltd. (Hao Hua).

Project Director: Mr. Wang Kuntang, General Manager of Hao Hua.

Project Manager: Mr. Sheng Li, Chief Engineer of Hao Hua.

ENVIRONMENTAL CONSIDERATIONS

Environmental Assessment (EA) is be carried out by Guangzhou Municipal Environmental Protection Bureau (EPB). The project will meet standards and regulations stipulated by the Guangzhou EPB. No new pollutants will be generated from the production.

PROCUREMENT:

Imported and domestic equipment needed are shown in Table 1 and Table 2. Contracts will be awarded after evaluation and comparison of quotations solicited from at least 3 suitable suppliers. The choice of procurement agency will be discussed and selected after appraisal.

REQUIRED REGULATORY ACTIONS

A preferential duty making HFC-134a at least as cheap as CFC-12 is required for as long as CFC-12 is available, since CFC-12 can be used in HFC-134a systems and gives a slightly improved performance.

PROJECT RESULTS

Direct Project Impact:

274 tones of CFC-12 will be eliminated (274 ODP tones) per year along with 6 tones of trichloroethane from 1996 to the year of 2000. CFC-12 savings will rise to 300 tones p.a. after 2000.

Indirect Project Impact:

Since IOC's are not being requested, the effect on product price is unpredictable. Implementation of this project is not expected to create any workforce redundancies. It is not anticipated that this technology will be replicated to other enterprises.

ANNEX 1

Table 1: Cost Breakdown of Equipment and Instrument for SD-7H15 HFC-134a MAC Compressors Production (US$)

Components	Description	Total cost	Remarks
Techn. Transfer	HFC-134a MAC compressor prod. tech.	400,000	Int'l bid
Compressor Assembly Equipment	Double piston ring inserter	33,000	
	PAG oil charging machine	78,500	
	Leak detector (sniffer) (8 set)	1,000	
	Modify conrod swash plate clinch machine	84,200	
	retooling, jig, and other necessary fixtures	82,000	Domestic made
Non-ODS cleaning equip.	Install aqueous based cleaning equipment	200,000	competitive bid
Compressor component Machining	MC330 cylinder boring machine	449,200	Domestic made
	P200-45 honing machine	193,400	Domestic made
	Compressor block die (2 sets)	138,400	
	Front housing die (6 sets)	252,000	
Technical Training	Foreign experts supervise the installation in sito: 4 men x 12 days x $500/man.day	24,000	
	Train service center staff & major users and publicizing CFC-free technology: 4 wkshp x 50 men/wkshp x $130/men.wkshp == $26,000	26,000	
	Subtotal: (rounded)	1,961,700	
	Contingency (15%)	294,300	
	Total	**2,256,000**	

ANNEX 1

Table - 2: Cost Breakdown of The Additional Equipment and Instrument for SD-7H15 HFC-134a MAC Compressors Production (US$)
(Funded by Enterprise)

Components	Description	Total cost	Remarks
Compressor Component Manufacture Equipment	Front housing pressure casting die (4 set)	168,000	Domestic made
	Swash plate casting die	35,000	Domestic made
	Drive shaft casting die	39,000	Domestic made
	Modify swash plate gear cutting machine	25,000	domestic made
Auxiliary Equipment	Aluminum anodizing equipment	110,200	surface treatment
	Electrophoresis painting equipment	95,000	reinforcing anti-corrosion
	Subtotal: (rounded)	472,200	
	Contingency (15%)	70,800	
	Total	**543,000**	

Table - 3 Salvage Value of the Replaced Existing Equipment and Instrument for SD-7H15 HFC-134a MAC Compressors Production (US$)

Description	Purchase Date	Original Price	Present Value ($)	Salvage Value ($)
Halogen leak detector	July 28, 1989	950,000 JY	4,700	0
Piston ring inserter	July 28, 1989	2,030,000 JY	10,500	10,500
Compressor body dies	August, 1991	$42,000	29,000	1,000
Front housing cast die	August, 1991	$41,000	28,000	1,000
Oil charging machine	July 28, 1989	6,757,000 JY	33,800	$31,000
Sundry fittings, dies, and fixtures	July 28, 1989	850,000 JY	3,800	500
		Total: (rounded)	109,300	$44,000

ANNEX 2

Table 1: Annual Incremental Operating Cost After Conversion (US$)

	When Using CFC-12		When Using HFC-134a		Incremental Production Cost After Conversion
Description	Material Used	Unit Price	Material Used	Unit Price	
Lubricant	Mineral oil	0.03	PAG Lubricant	0.28	0.25
Sealant	NBR	0.77	HNBR	1.60	0.85
Bearings	Standard	10.35	Reinforced	13.75	3.40
Total annual incremental operating cost per unit:					**4.50**

NOTE: Include increased cost of body material

Incremental Operating Costs (based on 30,000 units or 50% production level in 1996) and 60,000 units in 1997, 1998 and 1999 is shown below:

1996	-$135,000
1997	-$270,000
1998	-$270,000
1999	-$270,000
	$945,000

$865,200 Discounted at 10%.

ANNEX 3

BREAKDOWN OF PROJECT COST AND FINANCING

I	Investment Cost	Investment Cost	Contingency	Total
	MAC compressor equipment (Annex 1: Table 1)	1,961,700	294,300	2,256,000
	Self financed accessory equipment (Annex 1: Table 2)	472,200	70,800	543,000
	Subtotal:	2,433,900	365,100	2,799,000
	Less: Self financing by enterprise (Annex 1: Table 2)	472,200	70,800	543,000
II	Less: The salvage value of the Replaced Equipment (Annex 1: Table 3)			44,000
	Incremental investment cost proposed for OTF financing			2,212,000
III	Incremental Operating Cost for OTF financing			0
	Subtotal:			
IV	Financial Agent Fee (3%)			66,400
	Total (proposed ODS Grant)			**2,278,400**

Note: MP funding is 80% of incremental capital cost minus the salvage value of the redundant equuipment. No incremental operating costs are being claimed.

Total Project Costs:

Total Investment Costs	US$2,799,000
4 years Incremental Operating Costs	865,200
Salvage value of redundant equipment	(44,000)
Total	**US$3,620,200**

ANNEX 4

Calculation of Unit Abatement Costs and Grant Effectiveness

UAC = {C(F) + (OC–OS)}/ODP

Where: A = Unit Abatement Cost, $/kg ODP.year

C = ODS reduction investment cost, including all initial one time costs such as technology and training the annualized capital cost charges

F = Capital recovery factor, the annualized capital cost charges, discounted at a standard rate of 10% per year over the economic life of the investment

OC = The annual incremental operating costs in the first year of full operation.

OS = The annual incremental operating savings of revenue in the first year of full operation.

ODP = The annual ODS reduction at the first year of full operation expressed in ODP units.

The investment cost of the project is US$2,212,000 (incl. 15% contingency and minus salvage value of the replaced equipment) and the economic life is 15 years.

Since the elimination of 274 MT of ODP is contingent upon Yueyang MAC condenser project implementation, so the total investment of the elimination of 274 MT of ODP should be:

$2,212,000 (Haohua) + $1,018,300 (Yueyang MAC condenser) == $3,230,300

Then:

C(F) == $3,230,300 x 0.1627= $525,570

The incremental operating cost of the 79 MT's ODP elimination should also include Yueyang's condenser production conversion project, thus:

$270,000 (Haohua) + $20,000 (Yueyang MAC condenser) =$290,000

$$\text{UAC} == \frac{\text{US\$525,570} + (\text{US\$290,000} - 0)}{\text{274,000 kg ODP}} = \text{US\$2.98/kg ODP/Year}$$

$$\text{Grant Effectiveness} = \frac{\text{US\$2,212,000}}{\text{274,000 kg ODP}} = \text{US\$8.07/kg}$$

(See also complementary Yueyang Project).

ANNEX 5

Equipment Justification

Double Piston Ring Inserter

Piston diameter is smaller on the new 7 cylinder compressor than on the old 5 cylinder model. A new device is required for the automatic assembly of piston rings onto the piston.

Oil Charging Machine

Poly Alkyl Glycol (PAG) lubricant is used in place of mineral oil on MACS. This is acutely hygroscopic and incompatible with some gasket and sealing materials used on mineral oil charging machines. These are generally not capable of economic modification.

A PAG oil charging machine is therefore required

Leak Detectors

CFC-12 leak detectors are not capable of detecting HFC-134a.

The existing 8 CFC-12 leak detectors used in production must therefore be replaced by HFC-134a specific detectors.

Swash Plate Piston Rod Clinch Machine

Dimensions of both conrod and swash plate are changed in the new design. The existing equipment is not capable of being modified according to the suppliers, Sanden Corporation.

A new machine is therefore required

Retooling Jigs and Fixtures

In order that existing equipment may be re-used to produce the new design, jigs must be re-made and equipment retooled.

Cylinder Boring Machine

Because the cylinder bore diameter is changed on the new compressor, a new boring machine is required. The existing machine is not capable of being modified according to the suppliers, Sanden Corporation.

Honing Machine

A new cylinder honing machine is required for the same reasons as the cylinder boring machine above.

Compressor Die Block

The compressor body components are completely re-designed in the new HFC-134a compressor. The acquisition of new dies are necessary to produce these and enable the existing die casting equipment to be used to produce the new design.

Front Housing Die Set

Justification for this is the same as that for the compressor die block.

Aqueous based Component Cleaning Equipment

Existing equipment uses trichloroethane, an ODS. Component washing equipment must be completely replaced with an environmentally friendly aqueous based system.

ANNEX 6

List of Equipment to be Re-used by Haohua after Conversion

EQUIPMENT	Quantity	Original Price	Remarks
MC Machining Center	4 set	DM2,750.347	
402 CNC Lathe	3 set	DM1,117,500	
W206 CNC Lathe	7 set	SF1,105,240	
M130	1 set	AS2,549,000	
M0300 High Frequency Quenching Machine	1 set	FRF1,064,050	
TND CNC 360 Lathe	3 set	RMB2,200,000	China
TH5640 MC	4	RMB2,750.000	
1,315 Broaching Machine	1 set	RMB250,000	China
Piston Swaging Machine	1 set	JY11,576,000	Sanden
Planet Plate Swaging Machine	1 set	JY12,294,000	Sanden
Mainline Conveyor with shelf for part of manual assembly	1 set	JY13,771,400	Sanden
Torque and dead center measuring machine	1 set	JY10,165,000	Sanden
Pumping test machine	1 set	JY 5,053,000	Sanden
Finish line conveyor	1 set	JY10,529,000	Sanden
Salt spray tester	1 set	JY 1,621,000	Sanden
Endurance test bench for compressor	3 set	JY 9,366,000	Sanden
Noise test bench for compressor	1 set	JY 4,726,500	Japan
Resin clogging machine	1 set	JY 4,324,000	Japan
CNC machine	3 set	JY70,500,000	Japan
Die for slitting	1 set	JY 6,276,000	Japan
Preheat and Heat Oven	1 set	JY1,171,600	Japan
Armature caulking machine	1 set	JY5,503,000	Japan

COUNTRY OF ORIGIN: THE PEOPLE'S REPUBLIC OF CHINA (page 1 of 2)

PROJECT TITLE : AUTOMOBILE AIR CONDITIONER (MAC) COMPRESSOR FACTORY PRODUCTION CONVERSION FROM CFC-12 TO HFC-134A MAC COMPRESSOR AUTOMOBILE AIR CONDITIONING (MAC)

IMPLEMENTING ORGANIZATION: GUANGZHOU HAOHUA AUTOMOBILE PARTS CO. LTD. (HAOHUA)

SECTOR: AUTOMOBILE AIRCONDITIONING (MAC)

RELATIONSHIP TO THE COUNTRY PROGRAM:

This project proposal appears to be compatible with a total program focused at the elimination of the use of CFC-12 as a MAC refrigerant.

TECHNOLOGY:

The technology uses HFC-134a as a refrigerant, which is considered the lowest technical risk and the most environmentally sound replacement available. Standards and specifications have been established and published by recognized international technical associations.

This proposal is to replace the current five cylinder CFC-12 Sanden designed compressor automated manufacturing facility with a new HFC-134a Sanden designed seven cylinder compressor manufacturing facility. The proposal states, the technical support or competence needed to modify the current compressor is not available at the enterprise or from Sanden.

ENVIRONMENTAL IMPACT:

The reduction in CFC emissions projected in the proposal are reasonably attainable.

The proposal includes elimination of trichloroethane vapor degreasing and installation of an aqueous based cleaning process.

PROJECT COSTS:

Technology transfer costs and technical training costs exceed the OORG guidelines, (Report 11 January 1995)

IMPLEMENTATION TIME FRAME:

The proposed implementation time frame is reasonable.

Page 2 of 2 for Guangzhou Haohua automobile parts Co. LTD. (Haohua) proposal review.

RECOMMENDATIONS:

The reviewer recommends approval of this project proposal provided the costs can be revised to the OORG recommended guidelines.

OORG REVIEWER-----------------------R. H. PROCTOR.

DATE OF REVIEW-----------------------JUNE 8, 1995

THE MONTREAL PROTOCOL ON SUBSTANCES THAT DEPLETE THE OZONE LAYER CHINA ODS PHASE OUT PROJECT

PROJECT COVER SHEET

COUNTRY:	The People's Republic of China
PROJECT TITLE:	Automobile Air Conditioner (MAC) Co. Production Conversion from CFC-12 to HFC-134a MAC System
SECTOR COVERED:	Automobile Air Conditioning (MAC)
ODS USE IN SECTOR (1994):	1,278 MT ODP (1,278 MT CFC-12)
PROJECT IMPACT:	Phase out 361 MT ODP per year from 1996 to 1999 (including complementary SEGM Project)
PROJECT DURATION:	Two Years

PROJECT COST:

Incremental Investment Cost:	US$1,476,800
15% Contingency:	US$ 221,500
Incremental Operating Cost:	0
Less: Salvage value	(56,000)
Net Incremental Investment Cost	US$1,642,300
3% Financial Agency Fee	49,300
Proposed OTF Grant	US$ 1,691,600

PROPOSED OTF GRANT: US$ 1,691,600

COST EFFECTIVENESS (CE):

Unit Abatement Cost:	US$5.29/ Kg/Year
Grant Effectiveness:	US$ 7.13/kg

IMPLEMENTING ENTERPRISE:	Shanghai Automobile Air Conditioner Co. (SAAC)
COORDINATING AGENCY:	National Environmental Protection Agency (NEPA)
IMPLEMENTING AGENCY:	The World Bank

PROJECT SUMMARY

This project, together with Shanghai Ek Chor General Machinery Co. Ltd. (SEGM) compressor conversion project, will eliminate 361 MT ODP per year (361 MT CFC-12) in China. This project concerns the production of a higher capacity condenser to complement the HFC-134a compressors produced by SEGM. Redesign of MAC condensers and the acquisition of some new production equipment is involved . After the new production facilities are complete, an average of 361 MT of CFC-12 use will be eliminated annually from 1996 to 1999. The project may act as a demonstration project for other MACS producers in China.

Technical Assessment: The project has been reviewed and supported by the OORG technical reviewer, Mr. Bob Proctor. His comments are attached. Project costs have been revised in accordance with the OORG recommended guidelines.

PROJECT OBJECTIVE:

The objective of this project is to convert SAAC's production of CFC-12 automobile air conditioner system to HFC-134a systems, and thereby phase out 361 MT of CFC-12 consumption per year from 1996 to 1999 as part of the overall country ODS phase out strategy.

SECTOR BACKGROUND

The development of China's MACS industry started in the late 80's, rather later than elsewhere. China's current production is less than 1% of MACS production worldwide. Since China is the World's most populous country with over 1.1 billion inhabitants and living standards are rising fast, the potential MACS market is huge. Recent expansion of MACS production has reflected this. 1992 MACS production was only 180,000 units, but rose to 270,000 units by 1994. The total national inventory of MACS systems by end 1994 was estimated at 1.49 million and the total annual CFC-12 use (for service and new system charge) was about 1,278 tones. 1995 production of MACS equipped cars is estimated at 265,000 . CFC-12 usage associated with this is 1,510 tones.

China plans to cease production of CFC-12 based MACS and completely phaseout use of CFC-12 in the sector by 2005. This strategy is described in the China Country Program.

In 1994, 392 tones of CFC-12 were used for the initial charge of MACS and 886 tonnes for service. 140,000 of the 270,000 total MACS made in 1994 were manufactured by SAAC. Annual amount of CFC-12 used as for charging new MACS using these MACs, together with Ek Chor compressors, was 168 tonnes.

Table 1: Statistics and Prediction of China's MAC Production and CFC-12 Comsumption 1991 - 2005

(1,000 Vehicle)

	Automobile				MAC		CFCs Consumption (MT)		
Year	Ownership	Production	Import	Retired	Ownership	Production	New MAC	Service	Total
1991	8,000	710	98		500	100	180	320	500
1992	6,920	1,060	211		760	180	296	477	773
1993	8,120	1,300	314		1,110	230	356	676	1,032
1994	9,540	1,340	283	250	1,490	270	392	886	1,278
1995	11,150	1,610	300	300	1,920	265	342	1,168	1,510
1996	12,940	1,840	350	400	2,410	320	413	1,479	1,892
1997	14,900	2,110	400	600	3,110	480	634	1,857	2,491
1998	17,150	2,400	450	800	3,820	650	858	2,276	3,134
1999	19,000	2,700	500	1,000	4,850	820	1,102	2,862	3,964
2000	20,000	3,000	500	2,000	5,950	1,110	1,497	3,506	5,003
2005					9,500	1,680	2,288	5,584	7,872

INTEGRATED SECTOR APPROACH TO PHASEOUT

Four projects are being submitted that will between them phaseout 70 percent of the CF-12 used in new MACS in China. All these are based on the adoption of HFC-134a to replace CFC-12. They are EK Chor (MACS compressor), Shanghai Auto Air Conditioner Corporation (condenser), Guangzhou Haohua (compressor) and Yueyang Hengli (bus MACS and auto MACS condensers). These are two fundamentally different approaches involved in the Chinese approach to conversion of the automotive MACS industry. Both are based on the need to produce HFC-134a MACS with an equivalent performance in terms of capacity and efficiency as the CFC-12

MACS currently produced. They are not the result of customer demands, but the minimum essential features to convert to HFC-134a MACS system.

(a) The performance and efficiency should be equivalent to the current CFC-12 systems

(b) The external dimensions of automotive MACS condensers should be no greater than those currently supplied. This is because of the limited space available for installation in a car's engine compartment. Use of a larger condenser would involve re-design by the vehicle manufacturer who would probably source his condensers elsewhere if his existing supplier could not meet this requirement. This involves the practicalities of installing a MACS in a given vehicle. It is not a customer requirement for an enhanced product.

EK Chor make compressors that are used exclusively by Shanghai Santana on VW and Audi cars. Santana source their condensers from SAAC and Yueyang. Some are of the serpentine type (from SAAC) and some are still of the finned copper tube variety (from Yueyang). Haohua supplies a number of different customers in Southern China who buy their condensers from a variety of sources.

Both Haohua and EK Chor are licensees of the Sanden Corporation of Japan and currently produce the same 5 cylinder CFC-12 compressors. EK Chor have not been able to conclude a deal to purchase new HFC-134a compressor technology from Sanden, despite trying. Haohua has been in production only since 1993 (and who retain close links with Sanden) have been able to conclude a technology transfer deal. This technology is for Sanden's new 7 cylinder HFC-134a designs developed from their CFC-12 compressor which Sanden considers obsolete. Haohua's project is thus based on the purchase of manufacturing rights for Sanden's new compressor range.

EK Chor have been in the MACS business since 1991, and unlike Haohua are well equipped with world class test facilities and excellent development engineers. Their approach is to modify the existing Sanden 5 cylinder CFC-12 compressor for use with HFC-134a. Because the compressor swept volume remains the same, systems using this compressor must be equipped with larger capacity condensers to offset the loss of system performance experienced when a CFC-12 system is directly retrofitted with HFC-134a. EK Chor compressors are supplied exclusively to Shanghai Volkswagen who source their condensers from SAAC. Thus, the SAAC project involves production of increased capacity condensers to match EK Chor's compressors. These two components are necessary in order to produce a MACS with equivalent capacity and efficiency to their present CFC-12 MACS.

All projects are being optimized in regard to technology source and costs, use of local technology and equipment where appropriate and reuse of existing equipment wherever technically feasible. Components that (might) relate to product upgrade and/or capacity expansion are being funded by the enterprises. This overall approach to the MAC sector will result in the lowest cost of transforming China's MAC sector to use of HFC 134a and represents the lowest possible request for assistance from the Multilateral Fund.

ENTERPRISE BACKGROUND

Shanghai Automobile Air Conditioner Co. (SAAC) is belongs to China National Aviation and Aeronautics Industry Corporation. SAAC introduced a Sanden MAC technology production facility in 1991 with a production capacity of 200,000 units per year Actual production of MAC unit in 1994 was 140,000 units accounting for 61% of the national total MAC production. SAAC's products are mainly supplied to Shanghai Santana Automobile Factory, Beijing Cherokee, Changchun Audi 100, Jetta and other small and medium sized vehicles producers.

Products aremanufacturd according to international standards as prescribed by the Sanden Corporation. Quality is monitored by the Shanghai Municipal Automobile Industry Corporation. SAAC's MACC system is sold only on the domestic Chinese market. The local ownership fraction is 100 percent.

PROJECT DESCRIPTION

The project involves:

1) Design of a new Multiflow type condenser to replace the existing serpentine design, such that the capacity of a given condenser capacity is increased whilst external dimensions are unchanged. SAAC existing designs are optimized for existing heat transfer requirements, therefore improved multiflow technology is required.

2) Acquisition of appropriate heat exchanger production equipment to enable Multiflow type condensers to be produced. Production capcity of the modified condenser production facility will be unchanged at 200,000 units p.a. Much existing production equipment will be re-used. The purchase value of this equipment detailed in Table 1 Annex 7 was US$ 5,208,400.

3) Eliminate 7 MT of ODS cleaning agent of trichloroethane by using an acqueous based system.

4) Training technical staff at Sanden for implementation of these conversion project and subsequent production of CFC-free MAC units.

   The generous allowance of $177,500 comprises two categories of training:

   i) Foreign expert help

   ii) Overseas training of Chinese operatives

   The former (i) is required to provide expert help in design modifications to the condenser. (ii) enables SAAC to seek information and engineering support abroad. Both these recognise the fact that (as with SEGM) the product is being re-designed by the enterprise itself and help should be given to ensure that this is successfully carried out.

   This approach is thought to be far more cost effective than the purchase of a manufacturing licence.

JUSTIFICATION FOR ALTERNATIVE TECHNOLOGY SELECTION

HFC-134a based technology has been selected for the following reasons:

1) Because of its good thermodynamic properties, zero ODP and non-flammability, HFC-134a has been recognized worldwide as the most appropriate replacement for CFC-12 in Automobile Air Conditioning systems.

2) The production technology for HFC-134a MACS is already well developed in industrial countries.

3) Supplies of domestically produced HFC-134a should be available in China from 1998.

4) SAAC has carried out testing to investigate whether increasing fin density of their existing serpentine design can increase the capacity of their condensers. Their conclusion is that it can not and that the

existing fin density is optimum. Increasing width of serpentine tube will increase overall depth of condenser which is unacceptable.

TECHNOLOGY SOURCES AND AVAILABILITY

SAAC used to supply complete MACS systems to local auto manufacturers using compressors produced by Shanghai EK Chor (see next). This company will produce compressors compatible for HFC-134a use, but with the same swept volume as the old CFC-12 models. Due to the higher pressure ratio of HFC-134a compared to CFC-12, the system capacity and efficiency will be reduced because of the reduction in compressor volumetric efficiency. This loss is most effectively compensated by increasing the system condenser capacity. Owing to space constraints in the engine compartment of the small cars produced by their clients, SAAC are obliged to produced a condenser of higher capacity but of the same physical size as their present one.

Multi Flow condenser technology is widely acknowledged to be the most effective form of condenser for MACS. Its use in the context is justified and does not constitute a product upgrade.
The special heat exchange tubing required for Multi Flow condenser can be bought on the open market in China. A suitable condenser design will be developed using this tubing and without the need to buy a production licence from a foreign supplier. SAAC possess world class test facilities and first rate design technicians. The principle of Multi Flow condensers is in the public domain. A design that does not infringe patent rights can easily be developed.

PROJECT COSTS

The total project cost of US$3,053,600 equals the ODS reduction portion of the overall project (investment cost plus net incremental operating cost and excluding financial agent fee). This project will not provide SAAC with any incremental revenues, but will result in incremental operating costs.

Investment cost of US$2,733,300 including purchase of additional equipments needed for the conversion of production line to replace present CFC-12 MAC system with HFC-134a parallel flow condenser and 15% contingency (Annex 1: Tables 1 and 2). Some equipment for production of CFC-12 system can also be used for production of HFC-134a MAC system.

Net incremental Operating Cost for 3½ years of US$376,300 (discounted at 10%) are due to the conversion of production line to replace CFC-12 MAC condenser. The HFC-134a MAC condenser uses different materials giving rise to an increase of approximately US$0.90/unit (Annex 3: Table 1).

Annual IOC is $126,000 for production of 140,000 units.

Requested Funding The proposed grant for SEGM is US$1,691,600 and was calculated as follows: 15% contingency was added to the incremental investment cost and the salvage value deducted. A financial agent fee of 3% was added to the resulting figure to give the grant amount requested from the Multilateral Fund.

PROJECT IMPLEMENTATION

	Schedule (months)																	
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Negotiate Order	X	X																
Order Equip.			X	X														
Initial Design			X	X	X													
Inst. Design			X	X	X	X	X											
Order Domestic Equip.			X	X	X													
Install. & Training								X	X	X	X	X	X	X	X	X	X	
Trial Run																	X	X

Project Supervision:	The Dept. of Auto Industry of Ministry of Machine Industry (MMI) oversee implementation of the project. at Shanghai Automobile Air Conditioning Co. Ltd. (SAAC).
Project Director:	Mr. Zhang Zhenhuan, Deputy Director of SAAC.
Project Manager:	Mr. Shao Hemin, Chief Engineer of SAAC.

ENVIRONMENTAL CONSIDERATIONS

An Environmental Assessement is be carried out by Shanghai Municipal Environmental Protection Bureau (EPB). The project will meet standards and regulations stipulated by the Shanghai EPB. No new pollutants will be generated from the production.

PROCUREMENT

Imported and domestic equipment needed are shown in Table 1 and Table 2. Contracts will be awarded after evaluation and comparison of quotations solicited from at least 3 qualified supplier The choiuce of procurement agency will be discussed and selected after appraisal.

REQUIRED REGULATORY ACTIONS

A preferential duty making HFC-134a at least as cheap as CFC-12 is required for as long as CFC-12 is available, since CFC-12 can be used in HFC-134a MACS actually with a slightly improved performance.

PROJECT RESULTS

Direct Project Impact:	On completion in 1996, this project will, within 4 years from 1996 - 1999, eliminate an average of 361 Tonnes of CFC-12 per year (361 Tonnes ODP).
Indirect Project Impact:	Since IOC's are not being requested, the effect on product price is unpredictable. Implementation of this proejct is not expected to create any workforce redundancies. This may serve as a demonstration project to other enterprises.

ANNEX 1

Table - 1: Cost Breakdown of Equipment and Instrument for HFC-134a MAC Condensor Production Conversion (US$)

Items	Description	SAAC Estimation
Multi Flow Condenser	Fin center roll die	120,000
	150 MT precise press machine	100,300
	Tank hole press die	54,000
	Inlet and outlet die	70,000
	Tank seperator plate slot die	56,000
	Core assembly machine	554,000
	End polisher	120,000
	HFC-134a leak detector	25,000
ODS free cleaning solution	Replace Trichlorethane equipment with Acqueous based process	200,000
Technical Training	Foreign expert: 100 man.day x $500/man.day	50,000
	Chinese staff overseas training: 30 man x 15 day/man x $150/man.day	67,500
	International travel fare for Chinese staff: 30 man x $2,000/man	60,000
	Subtotal	1,476,800
	Contingency (15%)	221,500
	Total:(rounded)	**1,698,300**

Table - 2: Cost Breakdown of Equipment and Instrument for HFC-134a MAC Condensor Production Conversion (US$)
(Enterprise Self Financed)

	Description	SAAC Estimation
Parallel Flow Condenser	Flux painting equipment	400,000
	Assembly line jig, fixtures and die	100,000
	Argon welding equipment	400,000
	Subtotal	900,000
	Contingency (15%)	135,000
	Total:(rounded)	**1,035,000**

ANNEX 2

Table 1: Salvage Value of Redundant Equipment ($)

Component	Equipment Description	Original price	Present value	Salvage value
MAC Condenser production equipment	Fin former roll dies			$5,000
	Flat pipe bender			$30,000
	Equipment for condenser assembly			$3,000
	Brazing equipment			$15,000
	Trichloroethane cleaning equipment	$150,000	$100,000	$3,000
Grand total:				$56,000

Table 2: Incremental Operating Cost After Conversion (US$)

	When Using CFC-12		When Using HFC-134a		Incremental Production
Description	Material Used	Unit Price	Material Used	Unit Price	Cost After Conversion
Metal materials		90.05		90.95	0.90
Total incremental operating cost					0.90

Incremental Operating Costs (Based on 70,000 units or 50% present production level in 1994, and 140,000 units in 1997, 1998, and 1999) is shown below (without discounting):

1996	- $63,000
1997	-$126,000
1998	-$126,000
1999	-$126,000
Total	$441,000

US$376,300 (Discounted at 10%)

Note: Production increases are forecast as follows:

1996	180,000
1997	200,000
1998	200,000
1999	200,000

The current production level of 140,000 units p.a. has been used as the basis for the calculation of annual Incremental Operating Cost.

ANNEX 4

BREAKDOWN OF PROJECT COST AND FINANCING

I	Investment Cost	Investment Cost	Contingency	Total
	Imported Production equipment (Annex 1: Table 1)	1,476,800	221,500	1,698,300
	Domestically purchased accessory equipment (Annex 1: Table 2)	900,000	135,000	1,035,000
	Subtotal:	2,376,800	356,500	2,733,300
	Less: Self financing by enterprise (Domestically purchased Accessary equipment (Annex 1: Table 2)	(900,000)	(135,000)	(1,035,000)
	Less: Salvage value of the replaced existing equipment (Annex 2: Table 1)			(-56,000)
	Incremental investment cost requested from MP funds	1,476,800	221,500	1,642,300
II	Incremental Operating Cost requested from MP funds			0
III	Financial Agent Fee (3%)			49,300
	Total (proposed ODS Grant)			**1,691,600**

Note: Funding requested from Multilateral Fund:60% of incremental capital costs minus salvage value of the redundant equipment. *No* incremental operating costs are requested.

Project Costs

Incremental Investment Costs	$US 2,733,300
Incremental Operating Costs	$US 376,300
Scrap Value Redundant Equip.	$US (56,000)
Total	$US 3,053,600

ANNEX 5

Cost Effectiveness Calculation

UAC = {C(F) + (OC- OS)}/ODP

Where:

A = Unit Abatement Cost, $kg /ODP.year

C = ODS reduction investment cost, including all initial one time costs such as technology and training the
annualized capital cost charges

F = Capital recovery factor, the annualized capital cost charges, discounted at a standard rate of 10% per year
over the economic life of the investment (F = 0.1627 for 10 years)

OC = The annual incremental operating costs in the first year of full operation

OS = The annual incremental operating savings of revenue in the first year of full operation.

ODP = The annual ODS reduction at the first year of full operation expressed in ODP units.

The incremental operating cost in the first year of full operation of this project, together with SAAC's MAC condenser production conversion project, is $952,000 + 126,000 = $1,078,000

The investment cost of this project, together with SAAC's MAC condenser production conversion project, is (including 15% contingency):

US$ 2,377,600 (Ek Chor) + US$2,733,400 (SAAC) = $5,111,000

and the economic life is 10 years. Then:

C(F) =$5,111,000 * 0.1627 = 831,560

$$\text{UAC} = \frac{\text{US\$831,560} + (\text{US\$1,078,000} - 0)}{\text{361,000 kg ODP}} = \text{US\$5.29 kg/ODP.year}$$

Note: This calculation is based on total project costs. If the self financed portions are removed, the UAC falls to about US$3.06/ODP.Year.

$$\text{Grant Effectiveness} = \frac{\text{US\$933,000 (Ek Chor)} + \text{US\$1,642,300 (SAAC)}}{\text{361,000 kg ODP}} = \text{7.13kg ODP}$$

ANNEX 6

Justification of Equipment

Fin Center Roll Die

The new Multiflow condenser has a completely different design to the former serpentine type. The extended heat transfer surface is provided by aluminium strips folded in concertina fashion and inserted between the crossflow tubes.

This die enables existing equipment to form this infill.

150 Tonne Press

This is required for the simultaneous froming of multiple opernings in the header and collector vessels on the multiflow condenser to accomodate the heat exchanger tubes. High positional and dimensional accuracy is needed in order that the clearances at the tube/tank joins be tight enough for brazing to be carried out. This powerful press is consequently required.

Tank hole, Inlet/outlet, Slot die

These are all used for forming holes in the tank and header of the new design. The old design was of a completely different type and did not require forming of these holes.

Core Assembly Machine

This is required for assembly of the heat exchange matrix.

Tube End Polisher

The Header and Tank are formed from tubing. This is required to prepare the tubing ends for brazing endcaps.

ANNEX 7

Table 1. Equipment to be Re-Used by SAAC

	Equipment	Current Value	Age	Remarks
AC	Side panel & head press (60 T)	$63,000	3 Years	Imported
	Condenser Frame Press	$82,000	" "	"
Condenser	Digital Controlled Tube Bender	$374,000	" "	"
	Digital Controlled Machine	$200,000	" "	"
	Milling Machine	$230,000	" "	"
Equipment	Tube End Former	$177,000	" "	"
	Lockrock Furnae	$3,200,000	" "	"
	Spot Welder	$72,000	" "	"
	Fin Centre Assembly Machine	$5,208,400	" "	"
	Painting Line	$54,000	" "	"
	Total:	$5,208,400	" "	"

COUNTRY OF ORIGIN: THE PEOPLE'S REPUBLIC OF CHINA

PROJECT TITLE: AUTOMOBILE AIR CONDITIONER (MAC) CO. PRODUCTION CONVERSION FROM CFC-12 TO HFC-134A SYSTEM

IMPLEMENTING ORGANIZATION: SHANGHAI AUTOMOBILE AIR CONDITIONER CO. (SAAC)

SECTOR: AUTOMOBILE AIRCONDITIONING (MAC)

RELATIONSHIP TO THE COUNTRY PROGRAM:

This project proposal appears to be compatible with a total program focused at the elimination of the use of CFC-12 as a MAC refrigerant.

TECHNOLOGY:

The technology uses HFC-134a as a refrigerant, which is considered the lowest technical risk and the most environmentally sound replacement available. Standards and specifications have been established and published by recognized international technical associations.

A need for the addition of multiflow condenser production capability to the existing aluminum serpentine production capability has been studied by the enterprise and they have determined this is the only way available to them to recover the performance lost when the refrigerant is changed from CFC-12 to HFC-134a.

The OORG guide lines cover conversion from copper tube condensers to aluminum, but do not require multiflow where aluminum serpentine capability exists.

ENVIRONMENTAL IMPACT:

The reduction in CFC emissions projected in the proposal are reasonably attainable.

Trichlorethane cleaning is replaced by an aqueous based process.

PROJECT COSTS:

The projected technical training costs significantly exceed the guide lines published in the OORG report 11, January 1995.

page 2 of 2, Shanghai Automobile Air Conditioner Co. (SAAC) proposal review.

RECOMMENDATIONS:

Based on the analysis of their data by the enterprise the reviewer recommends approval of the proposal providing the projected costs are brought within the OORG recommended guidelines.

OORG REVIEWER---------------------------R. H. PROCTOR

REVIEW DATE-----------------------------June 8, 1995

Ozone Operations Resources Group
(OORG)

TECHNICAL REVIEW

1. Country of origin:	Peoples Republic of China.
2. Project title:	Phase out of TCA in each of four plants used for the manufacture of refrigerator parts.
3. Sector Covered:	Solvent uses in metal parts manufacture.
3a ODS use in sector:	Data not available.
4. Relationship to country programme	Phase out of 37 tonnes of 1,1,1,TCA in four separate plants.

5. Technology:

a) The use of aqueous washing in place of trichloroethane vapour degreasing is becoming the most popular technology change in this sector. It is environmentally sound and very safe.

b) The technology is not transitional, as it does not depend upon a solvent or chemicals which might face future bans.

c) Feasibility of transfer to the country concerned

i) There is no formal technology transfer as the project is basically the delivery and installation of four aqueous parts cleaning lines. The supplier does propose assistance with installation and Start up supervision which must, by definition, include some training

ii) There is no licensing agreement.

iii) Consideration of other technologies is not described. The choice of technology, however, is logical for the type of production.

iv) Complete data is not provided for this proposal, only the cost of the plant for each manufacturing centre. (Incremental operating costs and operating savings are not available.) Thus only an estimate of UAC can be given. Assuming that there would be a saving on solvent costs but an increase in energy costs including drying the parts gives an approximate UAC of about $3.7 per ODP Kg.

6. Environmental Impact:

(a) The ODP of the substitute aqueous system is zero. There will however an increase in indirect GWP owing to the increase in energy consumption in all of the main process areas.

(b) There is no specific Health and Safety risk associated with aqueous cleaning systems. Normal factory safety should be applied.

7. Project costs:

(a) All the cost components identified in the project are essential to the conversion; it is not possible, with the information available, to determine whether the current production rate will be maintained.

(b) None of the cost components would be expected to be present in the existing facility. The substitution of an aqueous cleaning system for a TCA vapour degreaser is a fundamental change requiring complete re-equipment.

(c) Cost of equipment.

(i) The base line costs are addressed properly.

(ii) The decision to replace all of the existing equipment is consistent with the complete change in technology..

(iii) All the requests for equipment are consistent with the project plan.

(iv) There is little opportunity for re-use of existing equipment.

(v) The fate of any scrapped equipment is not described.

(vi) NA.

(vii) No information is provided concerning changes in production capacity, the proposal is confined to a description and specification for the aqueous cleaning systems alone.

(d) Appropriateness of training and related costs, if any.

There is a proposal from the supplier to provide start up training and operator instruction.

e) Operating costs

(i) Operating costs arc not included in the proposal.

(ii) No information is provided concerning operating savings or energy savings. The project proposal is confined to the specification of the cleaning units alone.

8. Implementation timeframe.

The timeframe proposed is feasible.

9. Recommendations

(a) Approval as proposed.

OORG Technical reviewer:.....B.H.Baxter.....BHBaxter

Date Review completed: ...6.6.95......................