UNITED
NATIONS

EP

United Nations
Environment
Programme

Distr.
LIMITED

UNEP/OzL.Pro/ExCom/17/31
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 PROPOSAL: CAMEROON

This document includes the following project proposal:

- Investment project for Phasing out of CFCs at Union Camerounaise d'Entreprise — UNIDO

PROJECT COVER

Country/Region:	**CAMEROON**
Project title:	Investment Project for Phasing out of CFCs at **Union Camerounaise d'Etreprise, Cameroon**
Sector covered:	**Domestic refrigeration** (Rigid foams and Refrigerant) In Cameroon the total ODS consumption of 216,6 MT of CFC 11 and CFC 12.
Project impact:	Phase out of annual consumption of **79,6 MT of CFC 11, 35,5 MT of CFC 12** for production and for service (Total ODP = 115,1 MT).
Project duration:	18 months
Project economic lifetime:	10 years
Total proposed project cost:	**US $ 3,190,125**
Project investment cost:	**US $ 2,419,120**
Implementing Agency's overheads:	**US $ 367,005**
Incremental Operating Cost:	**US $ 404,000** (six months operational costs)
Proposed MF financing:	**US $ 3,190,125**
Cost effectiveness:	See Annex C Threshold 11.69 US $/kg
Counterpart enterprise:	Union Camerounaise d'Entreprise, Cameroon
Implementing Agency:	**UNIDO**
Coordinating Ministry:	**Ministry of Environment and Forest**

PROJECT SUMMARY

This project has been designed to phase out 100% of the use of CFC 11 as blowing agent and CFC 12 as refrigerent agent from the production programme of refrigerators and freezers at the factory of **Union Camerounaise d'Entreprise (U.C.E.) in Douala, Cameroon**.

The chosen replacements are cyclopentane as foam blowing agent and HFC 134a as refrigerant. Apart from the replacement of some of the production equipment and related services, the project includes the redesign of the refrigeration system for all currently produced models and the conversion of the plant.

The redesign of the models covers activities like prototyping, performance testing, trial manufacturing and adaptation, as well as reliability tests.

The conversion of the production facilities covers the refrigeration system, insulation foam blowing system for refrigerators and the refrigeration service sector of the company, but will not yet phase out the HCFC 22 refrigerant (ODP=0.05) of the production of air conditioners.

BACKGROUND

Sector Background

The subsector for domestic refrigerators and freezers in the Cameroons consists of two large manufacturers FAEM and U.C.E. who both share the major part of the total ODP consumed in Cameroon (103MT).

Cameroon does not produce CFCs. According to the country programme the total consumption of CFCs in the production of polyurethane foam was about 21,3 MT in 1991. This figure reflects most probably only the import of pure CFC 11 and does not consider that the majority of CFC 11 was imported to Cameroon already premixed inside the polyol compound of the polyurethane foam material; the actual CFC 11 consumption in Cameroon is much higher than the figures reflected in the country programme. The total consumption of CFC 12 in 1991 was 43,8MT out of which 42,8MT was used in the subsector. The demand of ODP at moment is stagnant, but it is estimated that it will increase in the future again if the conversion will not be made.

Cameroon plays an important role inside the Central African Customs and Economic Union (UDEAC) countries: Cameroon, Gabon, Congo, Central African Republic, Chad, Equat. Guinea; Cameroon exports a significant part of its production to these countries.

Based on a 15 years life expectancy for refrigerators and freezers, a total of 500,000 refrigerators and 400,000 freezers are in use in Cameroon and the sub-region (UDEAC); half of them are in Cameroon. Approximately, 7% will be annually re-charged with about 8 MT of new CFC 12 during refrigeration service in the sub-region UDEAC and 5 MT of new CFC 12 in Cameroon. Due to lack of equipment for the service sector, service staff often use CFC 12 for washing/flushing cooling systems, instead of using vacuum pumps and charging boards. This caused in some cases up to 50% higher CFC 12 consumption in the service sector.

Counterpart's Background

U.C.E. was established in 1979; it is a 100% private stock company operating in the manufactureing and sales of domestic appliances like domestic refrigeration, gas cookers and air conditioners. They have received technical assistance for their production of chest freezers from Derby (Denmark), and of refrigerators from Superser (Spain), and Borghi (Italy).

U.C.E. employs in their factory 282 staff in the production of appliances and 24 staff in the service with the actual annual capacity of 30,000 household refrigerators and of 50,000 freezer units in 1994. The total installed refrigerator production capacity at U.C.E. is 80,000 household refrigerator and freezer units per year.

U.C.E. exports 20% of its production. Less than 10% is exported to UDEAC countries.

U.C.E. produces following refrigerators and freezers:

ONE DOOR REFRIGERATORS:

3 models 225 l, 265 l and 300 l (SUPERSER)
1 model 120l (BORGHI)

TWO DOOR REFRIGERATORS:

3 models: one with 305 l refrigerator and 50 l freezer and the other with 340 l and 70 l freezer (SUPERSER) and 355 l refrigerato/freezer.

CHEST FREEZERS:

11 different models from 140 l to 610 l (DERBY)

Currently, U.C.E. produces no low energy consumption refrigerator.

In addition, U.C.E. produces :

- Air conditioners (Window version and split units) under the license of ELECTRA and
- Gas cookers.

EXISTING PRODUCTION LINES:

The U.C.E. factory consists of the following production lines, separated in production lines for chest freezers, refrigerators, air conditioners and cookers:

- Steel sheet processing lines for refrigerator cabinets, chests and doors,
- Plastic sheet thermoforming line for refrigerator cabinets, chest lids and refrigerator doors,
- Painting lines,
- Pre-assembly lines for cabinets, chests, doors and small items,
- Foaming lines for chest freezer chests, chest lids, refrigerator cabinets and doors,
- Assembly lines,
- Evacuation, charging and testing lines for chest freezers and refrigerators,
- Repair lines,
- Testing lines,
- Packing lines.

U.C.E. uses standard polyurethane foam without CFC reduction with a density of 32 kg/m^3). Its equipment for foaming and refrigerator charging is 7 to 13 years old.

The foaming lines in the factory are divided in chest freezer lines and in refrigerator lines and consist of the following:

Chest freezer lines:

- 2 pcs. low pressure Cannon foaming machine;
- 1 pc. pre-mixing unit from Cannon;
- 8 pcs. fixtures in bell position for chests, not heated, with wooden plugs for 11 models;
- 1 Multi-layer door press, pneumatic, not heated, with wooden profiles for 11 models;
- Evacuation, charging and testing section with
  - 2 pcs. vacuum pumps from Teslar;
  - 2 pcs. automatic evacuation and charging board from A'Gramkow;
  - 2 production electronic leak detector from Leybold Inficon;

Refrigerator lines:

- 2 pcs. low pressure Cannon foaming machine ;
- 4 pcs. cabinet fixtures, semi-automatic in bell position, with 8 aluminium plugs, heated;
- 4 pcs. door moulds with 8 profiles;
- Evacuation, charging and testing section with
  - 2 pcs. vacuum pumps from Teslar;
  - 2 pcs. automatic evacuation and charging boards;
  - 2 production electronic leak detector from Leybold Inficon;

U.C.E. has no performance test laboratory.

U.C.E.'S Refrigeration Service

U.C.E. has 6 service shops equipped with a standard set of refrigeration service equipment (altogether 15 evacuation and charging boards and 15 leak detectors). Presently, there is no CFC 12 recovery and reclaiming equipment or relevant expertise available in Cameroon. UCE manages 22 other service stations around the country.

PROJECT OBJECTIVE

The objective of this project is to eliminate the use of ODS as CFC-11 and CFC-12 in the production of domestic refrigerators and freezers at U.C.E. through conversion to the use of HFC-134a as refrigerant for the refrigerators and freezers and cyclopentane as blowing agent for the polyurethane insulation foam.

PROJECT DESCRIPTION

U.C.E. is prepared to phase-out ODS in their refrigeration section as soon as the new technology has been acquired, the necessary machinery and equipment installed and the technical staff trained.

Among the technological options presently available, U.C.E. has chosen to replace CFC-12 by HFC-134a, since new compressors are available, the technology is matured and commercially applied.

As for the replacement of CFC-11 as blowing agent for polyurethane foam, the company has decided to avoid the application of any transitional substance and to introduce cyclopentane as an ultimate solution.

Assistance, through the project, is sought for:

(a) Procurement of new machinery and equipment;

(b) Re-building and partially replacing presently used equipment, such as vacuum pumps, PUR machines, fixtures, etc.

(c) Re-design, reconstruction, prototypes manufacturing and testing of refrigerators and freezers;

(d) Installation, commissioning, training of national personnel abroad and on-the-job training, trial operation and start-up, etc.

The following machinery and equipment need to be rebuilt, replaced or have to be added:

A. Refrigeration System

- 4 evacuation and charging boards suitable for HFC 134a to replace the 4 production evacuation and charging boards, 2 on the chest freezer line and 2 on the refrigerator line.

- 4 leak detectors suitable for R134a to replace the 4 existing production leak detectors.

- 4 existing vacuum pumps cannot be re-used after application of a special cleaning technology because of their age and need to be replaced by new 3 evacuation stations suitable for HFC 134a.

- To optimize the cooling system for the use of HFC 134a as refrigerant in connection with the use of new HFC 134a compatible components and to compensate for lower efficiency of the system and higher thermal conductivity of the c-pentane blown foam, performance tests have to be carried out for each model. Therefore, some new testing equipment and materials need to be provided.

- Technical requirements for components such as tubes, condensers, evaporators, capillary tubes, heat exchangers, compressors and suction accumulators have to be in line with the established standards such as DIN 8964, i.e. new rules for dryness and cleanliness need to be applied.

- Drier for HFC 134a has to use a desiccant with 3AA pores or desiccant XH7 (Union Carbide).

- The cooling system must not contain any chlorine and max. 1% non-condensable gases. Therefore, a new cleaning liquid has to be used.

- The capillary tube has to be optimized for an increased resistance at low evaporating temperatures because the volume flow with HFC 134a is about 80% of the volume flow with CFC 12.

B. Foam system

- 4 low pressure PUR foaming machines, 2 on the freezer and 2 on the refrigerator line, should be replaced with 4 high pressure machines; related equipment and systems necessary for c-pentane based foaming technology should also be provided;

- The rebuilding of 12 chest and cabinet fixtures, adding exhausts, gas sensors etc. are too expensive for the needed capacity in comparison with 4 new jigs. Furthermore new universal fixtures are safer and do not reduce the foam quality after changing to high viscose cyclopentane driven foam as such the re-builded bell position jigs.

  The reduction to 4 fixtures is possible because of the switching from low to high pressure foam and because of the heating.

- To reach the capacity the 8 wooden chest freezer plugs can be replaced by 8 universal and expandable plugs, adjustable for each chest model of the same widths (U.C.E. has 11 different chest freezers with 3 different widths, but the same size of the compressor compartment;

- The 8 aluminium cabinet plugs can be adjusted and a frame can be added to fix them on the new fixtures;

- The universal multi-layer door press capable to foam doors with or without foodliner profiles needs to be modified to replace electrical components by ex-proof versions;

- The final specification of the cyclopentane to be used (purity and mix) will be defined after carrying out a market review in the country to assess its availability. The current price level is about US $2.10/kg plus packaging and transportation. For the time being, there are no manufacturers of cyclopentane in Cameroon;

- Since cyclopentane and polyol cannot be delivered pre-mixed in drums or tanks (as CFC 11), it is necessary to provide 2 pre-mixing stations, one for each factory building;

- For safety at the plant operation using the highly inflammable and explosive cyclopentane, it is necessary to have 2 gas detectors system as well as to establish a fire protection system;

- It is necessary to provide one storage tank for cyclopentane for the factory in the size sufficient for a standard tank container; the tank should be equipped with necessary piping and safety systems;

- Since the cyclopentane tank should be pressurized by nitrogen, which is also needed during the foaming process, the factory should also be provided with a nitrogen generator and a network;

To operate c-pentane based PUR lines, the following safety conditions have to be fulfilled:

1. The c-pentane tank have to be placed underground and not less than 5 m away from the factory building.
2. Only well-trained operators and maintenance technicians are allowed to enter the foaming area.

3. The workers' clothes and shoes have to be made of antistatic materials, and the floor needs to be covered with an antistatic paint.

4. In order to achieve compliance with established safety rules for the machinery and the plant, it is necessary to provide and install exhaust and ventilation systems in the foaming department.

5. Since cyclopentane is flammable and explosive, all machinery and equipment which will come in contact with cyclopentane or polyol/cyclopentane mixture have to be explosion proof. All electrical components are positioned outside the foaming area or switched off during the time of foaming.

6. All foaming jigs and plugs must be equipped with an earth connection to avoid the accumulation and discharge of static electricity.

7. U.C.E.'s technicians have to be carefully selected and trained at the equipment suppliers' place in the new foaming technology as well as in design/calculation and performance test and calculation/design of cooling systems. During the installation and start up of the new machinery and equipment, the supplier's engineers will have to train U.C.E.'s technical staff in all aspects of the converted plant operation.

C. Refrigeration Service

To cover the requested service in the future, each of the 6 refrigerator service centers of U.C.E. should get 2 sets of R134a mobile charging boards, electronic leak detectors for R134a and 10 recovery bags for R12. Furthermore, each center should collect R12 from the recovery bags and send it back for reclamation.

D. Justification for Selection of Alternative Technologies

All major manufacturers of compressors have accepted the use of HFC 134a as replacement for CFC 12 for domestic refrigerators and freezers.

Relevant expertise and equipment for manufacturing and servicing of refrigerators and freezers based on HFC 134a is also available on the market.

Nearly all producers of refrigerators in Europe, and some in the Far East, have already switched or will switch in the near future to c-pentane as blowing agent due to good insulation values and cheaper cost of material. The manufacturing technology with highly flammable and explosive c-pentane is so matured and the control systems are reliable and safe so that it can be applied in developing countries if some strict processing regulations are followed and regularly controlled and the staff in this section are well selected and trained.

INPUTS

1. Capital Goods Replacement

A. Refrigeration System

The following equipment of the 2 factory lines, the chest freezer line and the refrigerator line, needs to be changed and new equipment should be provided as specified below:

A.1. 4 pcs. Production evacuation and refrigerant HFC 134a charging boards with vacuum pump, refrigerant supply pump and vacuum check;

A.2. 4 pcs. New evacuation stations, because the existing pumps cannot be cleaned and refilled any more for the R134a charging process;

A.3. 4 pcs. Production HFC 134a leak detectors;

A.4. 1 set Refrigerant test equipment and material for laboratory;

B. Foam System

The following equipment needs to be changed or new equipment has to be provided as specified below:

B.1. 4 pcs. High pressure foaming machines for c-pentane will replace the 4 low pressure foaming machines of the chest freezer line and the refrigerator line;

B.2. 1 pc. A second foaming place has to be installed for the production of doors and lids to enable using one foaming machine for filling of cabinet and door jigs; foam doors can easily transported inside the factory;

B.3 4 pcs. Self cleaning mixheads; the 4 machines have to be provided with altogether 3 self-cleaning mixing heads with 2 different sizes for foaming of cabinets and doors. Furthermore 2 different spare heads are needed in the factory to avoid interruptions in production and are to be provided by the counterpart (U.C.E.).

B.4. 2 pcs. Pre-mixing stations for cyclopentane and polyol;

B.5. 2 pcs. Gas detector system with control boards;

B.6. 15 pcs Infrared gas sensors instead of 21 combustible gas sensors;

B.7. 8 pcs. Ventilation sensors for safety reasons;

B.8.	1 pc.	Uninterrupted power supply as integral part of the gas sensor system;
B.9.	4 sets	Exhaust and ventilation system;
B.10.	4 pcs.	Universal cabinet and chest fixtures to replace the 12 existing cabinet and chest fixtures and to avoid their expensive rebuilding;
B.11	1 pc.	Modification of the multi-layer press, replacing electrical components by ex-proof, etc.;
B.12.	8 pcs.	Universal chest plugs to replace 8 jig plugs;
B.13.	8 pcs.	Modification of cabinet plugs, adding frames to fit them on the new fixtures;
B.14.	1 set	Ex-proof piping systems from filling place to cyclopentane tank;
B.15.	2 sets	Ex-proof piping systems from cyclopentane tank to pre-mixers;
B.16.	2 sets	Ex-proof piping systems from premixer to polyol tanks;
B.17.	1 set	Antistatic floor cover;
B.18.	1 set	Fire protection system;
B.19.	1 pc.	Storage tank for cyclopentane with all necessary safety devices;
B.20.	1 pc.	Nitrogen generator for the nitrogen network needed for the cyclopentane foaming machines, premixing, foaming jigs and tanks;
B.21.	1 set	Nitrogen net work;
B.22.	1 pc.	Back-up power supply systems for ventilators;
B.24.	2 pcs.	Water chillers as an integral part of the foaming lines;
B.23.	2 pcs.	Water heaters as an integral part of the foaming fixtures; the cost will be borne by the counterpart;

The layout of the production equipment should be organized in such a way that long piping and SD valves can be avoided.

C. Refrigeration Service

C.1.	12 pcs.	HFC 134a charging boards for refrigeration service, two for each of U.C.E.'s centers;
C.2.	60 pcs.	Recovery bags for CFC 12, 10 in each center;
C.3.	6 pcs.	Stationary recovery units for CFC 12, one in each center;
C.4.	12 pcs.	Electronic leak detectors for HFC 134a, two for each service centre.

2. Conversion/Training

Within the framework of the project, personnel from the counterpart will be trained in (among others) the following areas:

- Management and production control;
- Quality control in relation to conversion;
- Operation of the new machinery and equipment;
- Maintenance of the new machinery and equipment;
- Refrigeration laboratory tests;
- Safety regulations for flammable/explosive chemicals.

3. Model Redesign

It is foreseen that all current household models plus some standard commercial refrigerators and freezers will be redesigned due to replacement of CFC 12 by HFC 134a and followed by the manufacture of some prototypes and refrigeration performance tests. The costs for these activities are partially included in the training component for technical staff, as well as in the international expert service component. The mayor part have to be covered by the counterpart.

As a common practice, necessary modifications of the production lines will be carried out during evenings and off-days and will, therefore, not cause too much losses in the regular production. In addition the installed capacity is not fully used, so that losses can be compensated in other periods of production.

PROJECT IMPLEMENTATION

The project will be implemented in close cooperation with the 'Ministry of Environment and Forest in Cameroon. Local coordination will be carried out by U.C.E., the counterpart.

According to the experience of implementation of such projects in developing countries, the overall responsibility for the conversion should be with one general contractor to make sure that all activities of supplies of equipment and services are well coordinated.

The scope of supply, related services and responsibilities of the counterpart, potential contractors or suppliers as well as of UNIDO, will be specified in the Terms of Reference to be prepared at a later stage as an integrated part of the project document.

For operation of an industrial plant using highly inflammable and explosive materials, a local authorization for the operation is needed and such plants have to be regularly controlled by the responsible local authority.

Any construction work needed to accommodate the equipment for the new foaming technology using cyclopentane will have to be carried out by U.C.E. and are not reflected in the project budget. The specification for construction work will be elaborated by the selected contractor after project approval and site inspection.

TENTATIVE PLAN

Months: **1 2 3 4 5 6 7 8 9 10 11 12 14 16 18**

General:

1. Sign the project document, receive funding X
2. Elaboration of detailed work plan X
   and terms of reference
3. Initial training of management X

FOAM:

4. Final selection of equipment X
5. Purchase and subcontracting of equipment X
   and services
6. Training X XX
7. Delivery of equipment, installation, commissioning XXXXX
8. Start of production X

REFRIGERATION:

9. Redesign of models, training XXXXXXXX
10. Selection of equipment X
11. Purchase, installation and commissioning X XXX
12. Prototypes and testing XXXXXXXXXX
13. Start production with HFC 134a X

REFRIGERATION SERVICE:

14. Selection of equipment X
15. Purchase, installation, training, commissioning X X

PROJECT COSTS

I. INCREMENTAL CAPITAL COSTS

The incremental investment cost will cover cost for modification of manufacturing facilities, new machinery, materials, testing equipment, training, installation and consultancy services for modifications. This cost is shown in Annex A: "Equipment Specification and Cost Breakdown".

The cost of transportation and insurance of equipment (but not installation) is included in the cost of equipment.

II. INCREMENTAL OPERATING COSTS

The currently produced models will require the following modifications based on an average price level:

Modification Incremental cost		(US$)
- HFC 134a compressor		5,00
- Capillary tube modification		0,10
- Condenser modification		1,00
- Evaporator modification		1,00
- 3 AA drier		0,20
- HFC 134a refrigerant		0,41
- Extra polyurethane foam because of higher density (+15%)		2,39
Total	US$	10,10

The above figures reflect the difference between the relevant component price for CFC 11 and CFC 12 versus the component price for HFC 134a and cyclopentane.

All prices are without customs duty and tax.

The increase in price is due to the following:

- Purchase of new one size bigger HFC 134a compressor to cope with the lower capacity at low evaporating temperature, (but no heavy duty compressor, designed to cope with significant voltage fluctuations);

- Capillary tube prolongation and changes (average plus US $0,10);
- Evaporator and condenser on the average 1-2 coils or 1-2 serpentines or few fins larger, average US $ 1,00 (the major production are chest freezers with cheap tube evaporators);
- HFC 134a charge is about 10% less than with CFC 12; based on an average charge of 0,250 kg CFC 12 at US $3,00/kg as a current price and a current price for HFC 134a at US $5,75/kg, excluding customs/tax: (0,250kg x 0,90 x US$5,75) - (0,250 x 3) = 0,414 US $/kg;

Refrigerators in tropical version have larger condensers and contain much more liquid. CFC12.

Comparative cost analysis of foam system:

R11 system C-pentane system

Chemicals	Weight %	Price $/kg	Cost US$	Chemicals	Weight %	Price $/kg	Cost US$
Polyol + MDI	86	2.40	2.06	Polyol + MDI	94	2.50	2.35
R11	14	3.30	0.46	C-pentane	6	2.10	0.12
		Average	2.52			Average	2.47

PU cost US$/kg	2,52	PU costs US$/kg:	2,47
Kg per unit:	7,50	Kg per unit:	8,62
Total costs US$/ unit:	18,90	Total costs US$/ unit:	21,29

Incremental cost difference: US $2,39.

The operation cost of the enterprise after the conversion is not expected to increase very much as a result of higher wages of several highly qualified operators, maintenance and services of modern machines, safety related systems and instrumentation etc. This cost to be absorbed by the company.

Therefore, the total incremental operating cost increase for one year will be US$ 808,000 (Based on production of 80,000 units per year in the first year: 80,000xUS $10.10 = US $808,000).

It was agreed that the counterpart will apply for the incremental operating cost for 6 months = US $404,000.

III. CONTINGENCY FUND

A contingency fund (10% of the total budget) was calculated to cover unforeseen expenses which might incur during the project implementation.

IV. TOTAL COSTS

- Incremental investment cost, (Annex A: "Equipment, Specification and Cost Breakdown").
- The net incremental operating cost (as above).
- Executing agency's overhead cost (13%).
- Complete project cost breakdown (Annex B "Project Budget")
- Calculation of the unit abatement cost (Annex C: "Unit Abatement Cost").
- Requested funding by the MFMP: **US $ 3,190,125**

Annex A: Equipment Specification and Cost Breakdown

Description	Qty.	Unit cost US$	Total cost US$
A. Refrigeration System:			
- Charging board for HFC134a	4	25,000	100,000
- Vacuum pumps	4	4,000	16,000
- Production leak detector for HFC 134a	4	10,000	40,000
- Test equipment for prototypes	1 set	25,000	25,000
	Sub-total for group (A)		181,000
B. Foaming System:			
- High pressure foaming machine excluding mixheads	4	140,000	560,000
- Self cleaning mixheads	4	15,000	60,000
- Premixing stations	2	100,000	200,000
- Gas detector system	2	50,000	100,000
- Exhaust and ventilation	4 sets	32,000	128,000
- Encapsulation cabins in foaming areas	4	35,000	140,000
- Cabinet and chest freezer fixtures	4	75,000	300,000**
- Universal chest plugs expandable	8	10,000	80,000
- Modification of cabinet plugs	8	4,000	32,000
- Pipe installation from filling place to tank	1	10,000	10,000
- Pipe installation from tank to premixing station	2	12,000	24,000
- Pipe installation from premixing to PUR machines	4	5,000	20,000
- Antistatic floor	300 m^2	38	11,400
- Fire protection system	1 set	20,000	20,000
- Tank for cyclopentane	1	70,000	70,000
- Nitrogen bank	1	25,000	25,000
- Nitrogen network and accessories	1	20,000	20,000
- Chiller	2	15,000	30,000
- Power backup generator	1	30,000	30,000
	Sub-total group (B)		1,710,400

**) cost will be borne by the counterpart

C. Refrigeration Service:

- Charging board for service	12	2,000	24,000
- Recovery unit for CFC 12	6	2,500	15,000
- Recovery bag for CFC12	60	30	1,800
- Electronic leak detector for R 134a	12	250	3,000
	Sub-total group (C)		43,800
TOTAL		US$	2,059,200

Due to the cost effectiveness of the project, the cost of the following equipment and installation work is not included in the budget and is to be absorbed by U.C.E.:

(a) Pre-heating ovens for foaming;

(b) Electrical power back-up systems for the foaming areas as required by the safety regulation.

(c) Roller or conveyors for transport of cabinets in and out of pre-heating oven and foaming jigs;

(d) Tank installations and pipelines for delivery of HFC 134a to the charging boards;

(e) Any inside and outside construction, nitrogen network and civil work for the installation of the cyclopentane tank and the premixing station;

(f) Any special work related to the site preparation to receive ISO tank or truck with cyclopentane to be discharged in the storage tank;

(g) Any construction works like encapsulation cabins for the foam section;

(h) Any change of lay-out of the factory which requires changing the position of the machinery and equipment as well as re-allocation of the old equipment.

The scope of U.C.E. supply, services and their responsibilities related to the plant conversion will also be specified in the terms of reference(s) for provision of equipment and services by UNIDO and in the work plan of the project execution.

TECHNICAL SPECIFICATIONS OF EQUIPMENT

A. Refrigeration System:

A.1 Evacuation and charging board for HFC 134a for production

Fully automatic board with vacuum check
2 stages vacuum pumps $12m^3/h$
4 charging channels - built-in supply pump
Refrigerant: HFC 134a
Charges: Min 100g - Max 2200g +/- 1% or 1g

A.2 Vacuum pump

Min. capacity $12m^3/h$
Time for evacuation to vacuum level for the appliances
Max. 15 minutes (in tropical zone: max: 30 mn)
Maximum limit of non-condensable gases 1% (vol) after evacuation

A.3 Leak detector for production for HFC 134a

Type HLD 4000A or similar
Sensitivity range: 0.5 to 150g/year
Microprocessor controlled
Calibration gas: HFC 134a
Calibration: Automatic by the incorporated leak standard

A.4 Test equipment for Performance Test for HFC 134a

The test equipment is completed by:
(a) Materials for prototypes
(b) Refrigerator test recorder, temperature controlling interface unit and feelers, humidity controlling interface unit and feeler, etc.
(c) Performance test according to ISO 7371.

For evacuation, charging and testing the service charging board for HFC 134a and the service leak detector for HFC 134a, as foreseen in group C. will be used.

B. Foam System:

B.1 High pressure foaming machine for cyclopentane complete including the accessories and tie-ins. This will inlcude and not limited to

Special metering pump for Polyol-Pentane.
Metering pump.
AC motors for polyol and isocyanate pumps in IP 54.
Safety valve.
Throttle valves.
Connection pipes between machine and mixhead
Tank station.
Temperature control devices.

Heat exchangers.
Circulation pumps with a capacity of abt. 20 l/min, with double shaft sealing and leakage monitoring device on the Polyol side
Complete piping system etc.

B.2 **Self cleaning hydraulic-controlled mixhead** with:
2 hydraulically controlled recirculation injectors for polyol and isocyanate, polyol injector equipped with leakage monitoring device,
1 hydraulically controlled injector for inertizing the to be foam filled cavity
1 hydraulically switched, adjustable mixture throttle
1 cleaning piston
1 removable outlet pipe

B.3 **Pre-mixing station**
Independent unit for automatic metering and mixing of polyol with pentane
The Premixing station consists in addition of the following construction elements:

A set of safety pressure gauge and valves, filters.
Dropping basin.
Housing with exhaust, if not part of the metering unit. All electrical components inside the box are an intrinsically safe version(Ex-1). All metals have to be connected with earth.

All connecting pipe lines made of special steel; with special screw connections.
Electronic control system
The connecting line from Premixing station to work tank (polyol-pentane-mixture) has to be designed for an operating pressure of 60 bar.

B.4 **Gas detector system**
With control board for gas sensors and air flow controls of fan motors for
Gas sensors and for ventilator air flow controls.
Flammable limits: In air 1.4-8%
Remote alarm on a dedicated line to the guard room

B.5 **Infrared gas sensors**

B.6 **Air flow controls** for the exhaust ventilators connected to gas sensor system

B.7 **Exhaust and ventilation**
Capacity: 2 steps a min 4,000 m^3/h and min 8000 m^3/h
Air change: 53 times per hour
Ex-proof or placed outside O-Zone

B.8 Universal cabinet and chest foaming fixtures
Water heater,
universal,
bath position,
suitable for all sizes up 1700x800x670mm and for cyclopentane,
automation in and out and opening;

B.9 Modification of multilayer press
All electrical installations have to be modified in ex-proof, the line has to be encapsulated, the foaming place has to be modified, the jig and all metals have to be connected to earth, etc.;

B.10 Universal chest freezer foam plugs
3 different widths,
only one size of the compressor compartment,
expandable,
adjustable to different lengths per aluminium blocks;

B.11 Modification of cabinet plugs
Frames have to be added to connect existing plugs to new fixtures.

B.12 Pipe installation from filling place to tank

B.13 Pipe installation from tank for cyclopentane to mixing station
Inside building and outside exhausts with double wall tubes and leak control.

B.14 Pipe installation from premixer to foaming machine
Inside building and outside exhausts with double wall tubes and leak control.

B.15 Antistatic floor
Painting of floor in foaming area with antistatic paint

B.16 Fire protection system
Foam spray system for polyurethane chemicals and cyclopentane according to local regulation

B.17 Tank for cyclopentane
$30m^3$ capacity, made of double wall stainless steel
Pressure: 7 bar
Insulation of tank
Valves and fittings for connection
with pump
Level control for tank with shut-down valve

B.18 Nitrogen generator
Membrane type
for 8 m^3/h dry Nitrogen sufficient for the 2 lines in 2 factory buildings
plus compressor for 13 bar
fittings, pressure controls

B.19 Nitrogen network
To connect nitrogen generator with foaming places and polyol-cyclopentane tanks

B.20 Backup power supply system for ventilators and gas detector systems
With switch over units on a dedicated line

B.21 Chiller
Cooling range: 0-15°C
Pump capacity: about 6,000 ltr/h
Circulation medium: water
Cooling capacity: 15 kW

B.22 Water heater
For heating the foaming fixtures

C. Refrigeration Service:

C.1 Service charging board for HFC134a
Manually operated
2-stages vacuum pump
Refrigerant: HFC 134a
Charge: 50g to 500g +/- 5g
Hoses connection with quick connectors

C.2 Recovery unit for CFC 12
Capacity: 1100g CFC 12
part of reclaiming system

C.3 Recovery bag for CFC 12
Part of reclaiming system

C.4 Electronic leak detectors for HFC 134a for service

Annex B: Project Budget

Budget line	Description	Budget	US$
	General consultancy Engineering design services related to: modification of production layout, conversion of manufacturing processes and equipment, re-designing of refrigeration systems, civil and construction works, utility systems modification		20,000
	Checking/Ex-proofing of PUR machine, tanks, Premixing and foaming places. Safety training of counterpart's staff (two weeks, two specialists)		30,000
	If available **local subcontract** for provision of:		283,400
	1 tank for cyclopentane	70,000	
	1 set of pump, pipe work for tank,	10,000	
	2 set of pipe installation from tank to pre-mixings	24,000	
	2 sets of pipe installation from premixing to PUR machines	20,000	
	1 set of antistatic floors including installation and commissioning of the system (three weeks, two specialists)	11,400	
	1 set if fire protection system including equipment installation, training and commissioning of the system (one week, two specialists)	20,000	
	4 sets of exhausting and ventilation including equipment installation and commissioning of the system (one week, two specialists)	128,000	
	A. Refrigeration System:		
	- Machinery:		240,000
	4 pcs Charging boards for HFC134a	124,000	
	4 pcs Vacuum pumps and vacuum controls	16,000	
	4 pcs Production leak detectors	40,000	
	1 set Test equipment	50,000	
	Equipment installation, commissioning & local training (2 weeks, 1 specialist)	10,000	

B.	**Foaming System:**		
	- Machinery: service and starting up		1,582,000
	4 pcs. High pressure foaming machine	560,000	
	4 pcs Mixheads in 2 different sizes	60,000	
	2 pcs. Premixing stations	200,000	
	2 pcs. Gas detector system	100,000	
	4 pcs. Cabinet and chest freezer fixtures	300,000	
	8 pcs. Universal chest freezer plugs expandable	80,000	
	8 pcs. Modification of cabinet plugs	32,000	
	1 pc. Nitrogen generator	20,000	
	1 pcs. Generator	30,000	
	4 Encapsulation cabine	140,000	
	Equipment installation, commissioning & local training (9 weeks, two supervisors and 2 engineers 2 weeks)	60,000	
C.	**Refrigeration Service**		
	- Machinery:		43,800
	12 pcs Charging board for service	24,000	
	6 pcs Recovery units for CFC12	15,000	
	60 pcs Recovery bags for CFC12	1,800	
	12 pcs Electronic leak detectors	3,000	
		Subtotal	2,199,200
	Miscellaneous:		
	Contingency Fund (10% of the incremental cost of all equipment, services and operating incremental costs calculated)		219,920
Subtotal I			2,419,120
Incremental operating cost (half year of operation)			404,000
Subtotal II (sub-total I + incr. op. cost)			2,780,800
Agency's Overheads (13% of all)			367,005
TOTAL			US $ 3,190,125

Refrigeration Service

By investment in recovery units, it will be possible to reclaim about 50% of the used CFC12 from the refrigerators and freezers for service, if the suppliers of the cooling agent will take back the used materials for recycling.

U.C.E.'s service organization is expected to service about 9600 refrigerators and freezers per year with an average CFC12 refrigerant charge 0,5 kg CFC 12; but not all need recharging.

The above mentioned is based on delivery of recovery units to all U.C.E.'s main service centres, but not to the service shops of their distributors.

Annex C: Cost-effectiveness:

The following formula are applied for calculation of cost-effectiveness:

$$CE=(PICC-(ISC+ISC^2)+PIOC-PIOS)/ODP$$

where CE = cost-effectiveness;
PICC = project incremental capital costs;
ISC = incremental safety cost, Category 1;
ISC^2 = incremental safety cost, Category 2;
PIOC-PIOS = project incremental operating costs - savings;
ODP = ODP-kg saved.

Item	**Cost, US$**
A. Category I. ISC^1	
Tank for cyclopentane	70,000
Pre-mixing stations designed for use with cyclopentane	200,000
Gas detecting system for the foaming area	100,000
Safety exhaust and ventilation for the foaming area	128,000
Nitrogen supply system	25,000
Antistatic floor	11,400
Fire protection system	20,000
Encapsulation cabins of foaming areas	140,000
Power supply for ventilation	30,000
TOTAL	724,400
Plus 10% contingency	72,440
SUBTOTAL CATEGORY I	**796,840**
B. Category II. ISC^2	
High pressure foaming machines	320,000
Mix heads	40,000
Modification of cabinet and chest fixtures	150,000

Pipe installation from tank to premixing station and to PUR machine	27,000
Modificaiton of chest and cabinet plugs	32,000
Consultancy in checking/exproofing of PUR machine, tank, premixing and foaming places, preparation of safety rules and safety training	50,000
TOTAL	619,000
10% contingency	61,900
SUBTOTAL CATEGORY II	**680,900**
TOTAL CATEGORIES I+II ($ISC^1 + ISC^2$)	**1,477,740**
PIOC-PIOS (Incremental operating cost of half year of operation)	404,000
Subtotal PICC-($ISC+ISC^2$)+PIOC-PIOS **Divided by 115.100 US$/kgODP saved**	11,69
COST-EFFECTIVENESS	11.69

1) The quantity and cost of items correspond to the same in Annex A.

WS Atkins Consultants Ltd.
Montreal Protocol

Project Review

1. Country of Origin Cameroun

2. Title Investment Project for Phasing out of CFC's at l'Union Camerounaise d'Entreprise, Cameroun

3. Sector: Domestic Refrigeration/ Rigid Foam

4. Relationship to Country Programme This has not been seen by the reviewer

5. Technology

a) The proposed substitutes, namely HFC-134a to replace CFC-12 as refrigerant and Cyclopentane to replace CFC-11 as a foam blowing agent in the manufacture of domestic refrigerators is considered a suitable choice. This combination is probably the most widely adopted non-ODS solution to refrigerator manufacture at the present time. The use of Isobutane or other hydrocarbon as refrigerant would have been marginally better from an environmental standpoint as HFC-134a is a greeenhouse gas, whereas Isobutane has zero GWP. The increased investment in safety and complications regarding refrigeration circuit re-design are thought to offset this small environmental benefit of Isobutane and the combination chosen offers the best phaseout solution in a developing country such as Cameroun.

b) The technology being adopted is not transitional .Both substances have zero ODP.

c) No technology transfer agreement is involved. The company has produced chest freezers and refrigerators in collaboration with Derby (Den), Superser (Spain) and Borghi (Italy) but technical help from these companies is not specified. UCE engineers will receive training on refrigeration circuit re-design and be provided with test equipment to carry out this work themselves. A contractor will be responsible for installation of the cyclopentane foaming equipment.

The proposed combination is the cheapest non-transitional phaseout solution. Other cheaper technologies such as HCFC-141b for foam blowing would provide only a transitional solution. The direct move to Cyclopentane and HFC-134a is thought to be in principle within the scope of a company like UCE provided ongoing safety and quality assurance support is given.

6. Environmental Impact

a) Cyclopentane and HFC-134a both have an ODP of zero. GWP of Cyclopentane is zero; GWP of HFC-134a is 0.34.

Cyclopentane is a Volatile Organic Compound that contributes to ground level smog formation.

b) The project includes safety measures normally associated with foaming plants using cyclopentane such as ventilated foaming booths with standby electrical supply, infrared sensors, and a foam extinguisher system.

Further definition of how safety will actually be implemented at the plant is thought necessary. Since traditional refrigerator manufacture does not involve the use of flammable substances on a large scale, it is felt that UCE will need careful guidance on the implementation and ongoing management of safety. The formal support of an outside body such as specialised independent consultants, chemical suppliers or equipment suppliers is advised. A formal commitment should be obtained to providing this support.

The project should include a description of how safety will be managed on a day-to-day basis. A high level manager not involved in production should be appointed as safety manager and a safety team nominated. These will have the right to stop production when safety infringements are noticed without reference to management. Safety management, the operation of automatic safety systems and the correct observance of safe working practices in the converted plant should be described in an Operational Safety Statement which should be produced in conjunction with the outside body described above that provides support in safety matters.

Any local safety and environmental regulations governing the use of a VOC such as Cyclopentane should be quoted and the project shown to meet these requirements. The anticipated emissions of Cyclopentane from the plant should be estimated and shown to be minimal.

7. Project Costs

a) all cost components are thought essential to the successful implementation of the project. No increase in production capacity will result. Equipment is being converted where possible (e.g. some vacuum pumps) and significant counterpart contributions are being made (civil engineering works, 50% costs of jig modification, spare foaming heads, nitrogen lines, re-design costs etc.). All Investment costs seem reasonable. Test equipment ($50,000) is not defined. The equipment listed in para. B7 is clearly incomplete. The test equipment should be described in full.

The Cost Effectiveness of $10.64 is well below the MP guideline figure of $13.74. However the validity of the CFC consumption figures used in this calculation is not demonstrated. They appear to be based on about 0.890 kg of CFC-11 and 0.250 kg CFC-12 per refrigerator The latter is a high figure. This calculation should be made more transparent with the charge and foaming agent amounts for each current model given, along with justification of any further amounts wasted in production.

The issue of scrapped equipment (e.g. LP foaming machines) is not addressed. Whilst it is accepted that such equipment probably does not have a secondhand value in Cameroun, it will have a scrap value. Monies obtained from the sale of scrapped equipment should be used to cover project costs. A statement should be made to the effect that redundant production equipment will in fact be scrapped. As an article 5 country Cameroun will still be able to import CFC's until 2006 under present regulations, and such equipment could conceivably again be used to produce refrigerators.

UCE exports 20% of its production. The destination of this export production should be stated. If over 10% is exported to non-article 5 countries, the MP grant should be pro-rated accordingly as per the latest MP guidelines.

Training is not well defined. UCE technicians are said to be responsible for circuit re-design yet the absence of test equipment in the factory suggests that they have currently no experience of refrigerator design. The responsibility for safety training should be clearly stated (see remarks above).

c) Incremental operating costs appear high. The allowance of $5 US per compressor is thought excessive, as is the allowance for evaporator and condenser which do not normally need to be changed. The compressor (unless this increase can be supported by documentation) would normally cost about $3 more (10% of a $30 compressor). The allowances for evaporator and condenser should be removed. The HFC-134a refrigerant component is based on current refrigerant charge of 0.250 kg which seems high.

8. Implementation

The proposed timeframe is reasonable.

9. Recommendations

This is a worthwhile project. Approval is recommended provided the following points are addressed:

i) Proposals for safety implementation are reviewed and described as suggested in para (b) above.

ii) A statement that redundant equipment is scrapped is obtained from UCE.

iii) A fuller description of the nature and implementation of training is given, particularly with regard to the training provided to technicians for refrigerator circuit re-design.

iv) IOC's are reduced as indicated or support for these cost claims provided.

v) A transparent calculation for CFC consumption figures given along with a justification for the 250 g charge used for the IOC calculation.

10. Other Points

There appears to be some confusion over vacuum pumps. On p.6 it is stated that 3 new vacuum pumps will be required because the existing ones are not capable of being modified, whereas on p.24 a cost is given for "renovation" of said pumps.

The High Pressure foaming machine referred to on p.7 (B) is not listed as equipment currently installed on p.5

It is recommended that these inconsistencies be resolved. If new pumps are indeed required it should be ascertained that the amount requested is sufficient.