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PROJECT PROPOSAL: NIGERIA

This document includes the following project proposal:

- Investment Project for Phasing out of CFCs at DEBO Industries Ltd. UNIDO

PROJECT COVER

Country/Region:	**NIGERIA**
Project title:	Investment Project for Phasing out of CFCs at **DEBO Industries Ltd., Nigeria**
Sector covered:	**Refrigeration** (Rigid foams and Refrigerant) **and air conditioning.** In Nigeria the total ODS consumption is 208 MT of CFC-11 and 330 MT of CFC 12 in this sector.
Project impact:	Phase out of annual consumption of **36 MT of CFC 11, 12 MT of CFC 12** for production and **4 MT of CFC 12** for service (Total ODP = 52 MT).
Project duration:	18 months
Project economic lifetime:	10 years
Total proposed project cost:	**US $ 2,113,800**
Project investment cost:	**US $ 1,737,120**
Implementing Agency's overheads:	**US $ 243,180**
Incremental Operating Cost:	**US $ 133,500** (six months operational costs)
Proposed MF financing:	**US $ 2,113,800**
Cost effectiveness:	See Annex C: Threshold: 13.22 US$/kg
Counterpart enterprise:	**DEBO Industries Ltd., Nigeria**
Implementing Agency:	**UNIDO**
Coordinating Ministry:	**Nigerian Federal Environmental Protection Agency (FEPA)**

PROJECT SUMMARY

This project has been designed to phase out 100% of the use of CFC 11 as blowing agent and CFC 12 as refrigerant agent from the production programme of refrigerators and freezers at the factory of **DEBO Industries Ltd. in Lagos/Nigeria.**

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 Nigeria consists of one large manufacturer Thermocool Engineering Co. and a medium size manufacturer Debo Industries Ltd. which both share the major part of the total ODP consumed in this sector in Nigeria. The rest of the market is shared by several other companies, such as Associated Electronics (Philips), Leventis, Gacol, Kolinton.

Nigeria do not produce the CFCs. According to Nigerian import data the total consumption of CFC-11 in the production of polyurethane foam in the refrigeration section was about 208 MT in 1994. In 1994 the total consumption of CFC 12 in 1994 in this sector was 330 MT out of which less than half was used to produce new appliances and the major part was used for recharging existing appliances. 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.

In 1994 about 70,000 domestic refrigerators and freezers were produced in Nigeria and further 16,000 new refrigerators were imported. In addition it is estimated that around 15,000 used refrigerators were imported to Nigeria in the same period. There is practically no Nigerian export of refrigerators to other countries at moment.

Based on a 15 years life expectancy for refrigerators and freezers, a total of about 2 Mio. refrigerators and freezers are in use in Nigeria and approximate 15% will be annually re-charged with about 160 MT of new CFC 12 during refrigeration service. Due to partly 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 causes in such cases an up to 100% higher CFC 12 consumption in the service sector. Another part is loss by evacuation.

Counterpart's Background

DEBO was established in 1978. It is a 100% private company operating in the manufacture and sale of domestic and commercial refrigerators, freezers, gas cookers and air conditioners. they have received technical assistance for their production of refrigerators and freezers of Zanussi, Italy, and for their air conditioners from Gibson, USA.

DEBO employs in their factory 250 staff in the production of appliances and 90 in the service. The annual production for the last 3 years was in the range of 25,000 refrigerators and freezers units per year, with a slight decrease in 1994. The total installed refrigerator production capacity at DEBO is 120,000 household refrigerator and freezer units per year in three shifts.

DEBO covers about 30 % of the Nigerian household refrigerator production and shares more that 21% of the market including imports of new and used refrigerators.

DEBO produces following refrigerators and freezers:

ONE DOOR REFRIGERATORS:

Model 160 with 160 l refrigerator including freezer compartment
Model 200 with 200 l refrigerator including freezer compartment
Model 240 with 240 l refrigerator including freezer compartment

TWO DOOR REFRIGERATORS:

Model 340 with 3401 l refrigerator and freezer

CHEST FREEZERS:

Model 175 with 175 l
Model 280 with 280 l
Model 440 with 440 l

COMMERCIAL REFRIGERATORS:

DEBO Bottle coolers
Antares refrigerated display units
Andromeda cold display units

In addition, DEBO produces:

- Air conditioners (window and split version)
- cold room storage
- gas cookers
- electrical fans

EXISTING PRODUCTION LINES IN THE REFRIGERATOR AND FREEZER SECTION:

The DEBO factories consists of following production lines in the refrigerator section and in the freezer section (the equipment of the lines for air conditioners and cold room storages are not mentioned in the following because the conversion of HCFC 22 filled air conditioners and cold room storage cooling units are not subject of the conversion):

Refrigerator factory:

- Steel sheet processing lines for refrigerator cabinets and doors,
- Painting line,
- Plastic injection machines,

- Plastic sheet thermoforming line for refrigerator cabinets and doors,
- Door gasket extrusion line,
- Pre-assembly lines for cabinets, doors and small items,
- Foaming lines for refrigerator cabinets and doors,
- Assembly lines,
- Evacuation, charging and testing lines for refrigerators,
- Repair line,
- Testing line,
- Packing line.

Freezer factory:

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

DEBO uses standard polyurethane foam without CFC reduction with a density of 32 kg/m^3). Its equipment for foaming and refrigerator charging is 12 to 18 years old.

The foaming lines in the factories - separated in refrigerator and freezer factory - consist of the following:

- 3 pcs. low pressure Cannon foaming machines (model C60RF2 and C35RF2) for refrigerator cabinets, doors, chest freezers and chest lids foaming;

- 1 pc. pre-mixing unit, discontinuous (storage on scale) from Cannon;

- 6 pcs. refrigerator cabinet foaming fixtures, manual, with moulds in bell position;

- 2 pcs. chest freezer chest foaming fixtures, manual, with moulds in bell position;

- 1 pc. universal door foaming jig, automatic, from Perros;

- 3 stationary door fixtures (1 for chest lids, 3 for refrigerator doors);

- 12 pcs. chest plugs in bell position;

- 16 pcs. cabinet plugs in bell position;

- 12 pcs. door moulds;

The evacuation, charging and testing sections of refrigerator lines and of the chest freezer lines consist together of following equipment:

- 12 pcs. vacuum pumps from Galileo;
- 3 pc. automatic evacuation and charging board from Galileo, Air Serco and Ticino;
- 8 pcs. production electronic leak detectors from GE;

DEBO has a performance test laboratory, which is not sufficient equipped to make the performance tests for the converted models. To optimize the R134a cooling system and to improve the quality, test equipment for such test laboratory is needed.

DEBO's Refrigeration Service

DEBO has 6 service shops equipped with a standard set of refrigeration service equipment (altogether 13 evacuation and charging boards and few leak detectors). Presently, there is no CFC 12 recovery and reclaiming equipment or relevant expertise available in Nigeria.

DEBO services about 3000 refrigerators and freezers per year.

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 DEBO 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

DEBO 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, DEBO 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.

Each of the 6 refrigerator service centers of DEBO needs 1 recovery unit and 10 recovery bags for CFC 12 as well as 1 set of equipment (service evacuation and charging board and service leak detector) which will be used for servicing HFC 134a refrigeration systems.

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

A. Refrigeration System

- 3 production evacuation and charging boards on the 2 refrigerator and freezer lines have to be replaced by 2 new boards suitable for HFC 134a.

- 8 existing production leak detectors need to be replaced by 3 special leak detectors for R134a.

- 12 existing vacuum pumps cannot be re-used after application of a special cleaning technology according to pump producers and need to be replaced by new pumps or renovated.

- 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. 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

- 2 new high pressure foaming machines to replace the 3 low pressure PUR foaming machines (2 on the refrigerator cabinet and door lines and 1 on the chest freezer chest and lid lines far away from each other);

- Combining 2 foaming areas to replace 3 machines with 2 ones and combining the refrigerator door and chest freezer production on one place;

- 3 new mixheads for 3 different foaming places in 2 different sizes (one for refrigerator cabinet factory and one for the chest freezer factory and the third one doors and lids) are needed; low pressure mixheads with high consumption of ODS for cleaning cannot be modified to high pressure mixheads; the costs for the necessary 2 spare mixheads will be borne by the counterpart's side;

- Retrofitting the 6 pcs. refrigerator cabinet foaming fixtures and the 2 pcs. chest freezer chest foaming fixtures, all manual, with moulds in bell position will come nearly in the range of 4 new universal fixtures;

- The universal door foaming jig should be modified in a way that cyclopentane driven foam can be used by changing electrical components to ex-proof, adding exhausts, etc.;

- The 3 stationary door fixtures should be modified in a way that cyclopentane driven foam can be used by changing electrical components to ex-proof, adding exhausts, etc.;

- The 16 pcs. cabinet wooden plugs cannot be used for cyclopentane and need to be replaced by aluminium plugs; DEBO produce 4 different refrigerator models on this line; to avoid preassembly and assembly mistakes they need to foam only one model at the same time on the line, that means 8 plugs; to reach a comparable cost effectiveness per phased out ODS only 4 plugs will be granted and the cost of the second set (furhter 4 plugs) will be borne by the counterpart;

- The 12 pcs. chest freezer wooden plugs cannot be used for cyclopentane and need to be replaced by aluminium plugs; DEBO produce at moment only 3 different freezer models and the cool box on this line; to avoid preassembly and assembly mistakes they need to foam only one model at the same time on the line, to reach a comparable cost effectiveness per phased out ODS only 1universal and expandable plug will be granted and the cost of the second one will be borne by the counterpart;

- The 12 door moulds should be modified to be used for cyclopentane; to reach a comparable cost effectiveness per phased out ODS the cost for this modification should be shared by the counterpart;

- 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;

- 2 pre-mixing stations since cyclopentane and polyol cannot be delivered pre-mixed in drums or tanks (as CFC 11);

- For safety at the plant operation using the highly inflammable and explosive cyclopentane, it is necessary to have gas detector systems 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 one standard tank container; the tank should be equipped with necessary piping and safety systems;

- Since the cyclopentane/polyol tanks should be pressurized by nitrogen and the cabinet and door cavities should be flashed with nitrogen during the foaming process, the factory should also be provided with a nitrogen generator and a network; the network cost should be born by the counterpart;

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.

C. Refrigeration Service

To cover the requested service in the future, one-third of the 6 refrigerator service centers of DEBO should get 1 set of R134a mobile charging boards, electronic leak detectors for R134a and recovery bags for R12. Furthermore, each center should collect R12 from the recovery bags and send it back for reclamation.

This equipment will cover the basic needs of DEBO service centers only.

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 in this section needs to be changed and new equipment should be provided as specified below:

A.1. 2 pcs. Production evacuation and refrigerant HFC 134a charging boards with vacuum pump, refrigerant supply pump and vacuum check;

A.2. 4 pcs. Vacuum pumps cannot be cleaned properly and refilled according to pump producers and have to be replaced for the R134a charging process;

A.3. 2 pcs. Production HFC 134a leak detectors;

A.4. 1 set Test equipment for model redesign.

B. Foam System

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

B.1. 2 pcs. New high pressure foaming machines for c-pentane, one on the cabinet and one on the chest freezer line has to replace the 3 existing low pressure foaming machines;

B.2. 1 pcs. Additional foam place with all connections and controls has to be added to the single high pressure machine to be able to replace 3 foaming machines by 2 new one; The foaming of chest freezer lids can be made at the refrigerator line and the lids can be transported to the refrigerator factory;

B.3 2 pcs. PUR filling places to fill the foaming machines from drums;

B.4. 3 pcs. New high pressure mixheads (2 different sizes) because the low pressure mixheads cannot be converted to high pressure mixheads;

The cost for the additional nedded 2 spare heads will be born on the counterpart;

B.5. 2 pcs. Pre-mixing stations for cyclopentane and polyol;

B.6. 2 pcs. Gas detector systems with control boards;

B.7. 1 set Foam testing equipment;

B.8. 5 sets Exhaust and ventilation system;

B.9. Encapsulation cabins to be provided by the counterpart;

B.10. 1 pc. New universal cabinet and chest fixtures in bath position suitable for cyclopentane;

B.11. 1 pc. Rebuilding of universal door fixture, replacing all the electrical components by ex-proof components, earthing etc.;

B.12. 2 pcs. Rebuilding of door fixtures, replacing all the electrical components by ex-proof components, earthing etc.;

B.13. 1 set Ex-proof pipe installation from filling place to tank;

B.14. 2 sets Ex-proof piping system from cyclopentane tank to pre-mixers;

B.15. 2 sets Ex-proof piping system from pre-mixer to the 2 polyol tanks of PUR machines;

B.16. Antistatic floor cover;

B.17. 1 set Fire protection system;

B.18. 1 pce. Storage tank for cyclopentane with all necessary safety devices;

B.19. 1 pc. Nitrogen generator for the nitrogen network needed for the cyclopentane foaming machines, pre-mixing, foaming jigs and tanks;

B.20. 1 set Nitrogen net work to be provided by the counterpart.

B.21. 1 pc. Fixed plugs for refrigerator cabinet to be used for cyclopentane;

To reach a comparable cost effectiveness per phased out ODS the costs for the necessary further 4 refrigerator cabinet plugs will be borne by the counterpart;

B.22. 1 pc. Universal and expandable chest freezer plugs to be used for cyclopentane;

To reach a comparable cost effectiveness per phased out ODS the costs for the necessary further chest freezer plugs will be borne by the counterpart;

B.23. 12 pcs Modification of door moulds to be used for cyclopentane; to reach a comparable cost effectiveness per phased out ODS the cost for this modification should be taken over by the counterpart;

B.24. 1 pc. Back-up power supply systems for ventilators,;

The layout of the production equipment should be organized in such a way that the piping are short and SD valves for separation in sectors can be avoided.

C. Refrigeration Service

C.1. 6 pcs. HFC 134a charging boards for refrigeration service, one for each of DEBO's centers;

C.2. 25 pcs. Recovery bags for CFC 12;

C.3. 3 pcs. Vacuum pumps for CFC 12;

C.4. 6 pcs. Electronic leak detectors for HFC 134a, one 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 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 implementation will be carried out according to the rules and procedures of UNIDO, under the management of the backstopping officer of UNIDO, in close cooperation with with the Nigerian Federal Environmental Protection Agency (FEPA). Local coordination will be carried out by DEBO Industries Ltd., the counterpart.

Purchase of know-how is not considered in the project budget. However, to substantively assist and supervise the technical aspects of the conversion process, to perform troubleshooting and to provide assistance in product redesign work specialized consultants will be appointed and fielded by UNIDO. The respective job descriptions will be prepared upon approval of the project.

The detailed Terms of Reference for the supplies and services to be provided under the project will be elaborated after project approval and sent to FEPA and DEBO Industries Ltd. After competitive bidding, performed according to UNIDO's financial rules and procedures, a General Contractor will be appointed by UNIDO for the implementation of the major project components (foaming system, refrigeration system, etc.). The General Contractor will be responsible for the supply of equipment, installation, commissioning and on-the-job training of DEBO Industries Ltd.'s staff.

In order to guarantee a proper technology transfer and safe operation - in particular of the new foaming technology, using the highly flammable and explosive cyclopentane - the proposed General Contractor will issue an "Operational Safety Statement"

The final equipment specification, the work plan and, consequently the Operational Safety Statement can only be elaborated after approval of the basic approach for project implementation by the MFMP.

The permission from the local authorities for the introduction of the new technologies under this project will have to be obtained by DEBO Industries Ltd. DEBO Industries Ltd. will also be responsible for the compliance of the new technologies with the established national standards.

Having accepted the conversion of its plants to the use of non-ODS under this project, DEBO Industries Ltd. will be committed to provide the following inputs:

- All activities and costs related to the construction work needed (including the provision of technical infrastructure) to accommodate the new technologies introduced under this project. The specification of these work will be elaborated by the General Contractor after project approval and necessary site inspection. Thus, the costs of construction work can be specified only after appointment of the General Contractor and finalization of the equipment list. The relevant construction work will have to be arranged by DEBO Industries Ltd. under the supervision of the General Contractor and in line with the established milestones for this project;

- Technical staff as required by the General Contractor;

- Provision of tools, transportation and lifting equipment as required;

- Provision of materials, utilities, services, manpower, etc. related to commissioning, start-up, trial runs, prototyping and testing;

- Local transport, communication and secretarial facilities for the General Contractor's and UNIDO's staff involved in the project's implementation;

- All other expenses not included in this Project Document and not covered by the budget approved by the Multilateral Fund for the Implementation of the Montreal Protocol.

UNIDO as Implementing Agency has the necessary experience and capabilities for the successful implementation of projects at enterprise level. Upon approval of the project by the MFMP the whole budget will be transferred to UNIDO. The respective project allotment document will then be issued by UNIDO's Finance Section. Any substantive or financial deviation from the approved project is subject to approval by the MFMP and UNIDO.

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 and terms of reference	X														
3. Initial training of management		X													
FOAM:															
4. Final selection of equipment		X													
5. Purchase and subcontracting of equipment and services	X														
6. Training								X			XXX				
7. Delivery of equipment, installation, commissioning								XXXXXX							
8. Start of production													X		
REFRIGERATION:															
9. Redesign of models, training					XXXXXXXXX										
10. Selection of equipment			X												
11. Purchase, installation and commissioning				X				XXXXX							
12. Prototypes and testing							XXXXXXX				XXX				
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$)
- HFC 134a compressor	5,00
- Capillary tube modification	0,10
- Condenser modification	1,00
- Evaporator modification	1,50
- 3 AA drier	0,20
- HFC 134a refrigerant	0,49
- Extra polyurethane foam because of higher density (+15%)	2,39
Total	US$ 10,68

"In recent months, prices of components and raw material raised by 20% to 30% in comparison to last year due to strong demand and low production capacity, compressor, condensors and evaporators are for Central Africa in tropical version which is more expensive."

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 $ 1,50 and US $ 1,00 more respectively;

- 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 CFC-12.

Comparative cost analysis of foam system:

R11 system

Chemicals	Weight %	Price $/kg	Cost US$
Polyol + MDI	86	2.40	2.06
R11	14	3.30	0.46
		Average	2.52

PU cost US$/kg 2.52
Kg per unit: 7,50
Total costs US$/ unit: 18.90

C-pentane system

Chemicals	Weight %	Price $/kg	Cost US$
Polyol + MDI	94	2.50	2.35
C-pentane	6	2.10	0.12
		Average	2.47

PU costs US$/kg: 2.45
Kg per unit: 8.62
Total costs US$/ 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$ 267,000 (based on production of 25,000 units per year in the first year: 25,000xUS $10,68 = US $267,000).

It was agreed that the counterpart will apply for the incremental operating cost for 6 months = US $ 133,500.

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 $2,113,800**

Annex A: Equipment Specification and Cost Breakdown

Description	Qty.	Unit cost US$	Total cost US$
A. Refrigeration System:			
- Charging board for HFC134a	2	25,000	50,000
- Vacuum pumps	4	5000	20,000
- Production leak detector for HFC 134a	2	10,000	20,000
- Test equipment for model redesign	1 set	25,000	25,000
Sub-total for group (A)			**115,000**
B. Foaming System:			
- High pressure foaming machines for refrigerator factory and chest freezer factory	2	150,000	300,000
- PUR filling system pumps	2	15,000	30,000
- Self cleaning mixheads	3	15,000	45,000
- Premixing stations	2	60,000	120,000
- Gas detector system	2	50,000	100,000
- Exhaust and ventilation	5 sets	45,000	225,000
- New universal cabinet fixtures	1	120,000	120,000
- Modification of universal door fixtures	1	10,000	10,000
- Modifications of door fixtures	2	8,000	16,000
- Pipe installation from filling place to tank	1	10,000	10,000
- Pipe installation from tank to premixing stations	2	12,000	24,000
- Pipe installation from premixing to PUR machines	2	10,000	20,000
- Antistatic floor	400 m²	38	15,200
- Fire protection system	1 set	20,000	20,000
- Tank for cyclopentane	1	70,000	70,000
- Nitrogen bottle bank	1	25,000	25,000
- Nitrogen network	1	20,000	20,000
- Cabinet plugs	1	70,000	70,000
- Cabinet plugs	4	23,000	0**
- Universal chest freezer plugs	1	35,000	35,000
- Universal chest freezer plugs	1	35,000	0**
- Modification of door moulds	12	3,000	36,000
- Power backup Generator	1	30,000	30,000
Sub-total group (B)			**1,341,200**

C. Refrigeration Service:

- Charging board for service	6	2,000	12,000
- Vacuum pumps	3	2,500	7,500
- Electronic leak detector for R 134a	6	250	1,500
Sub-total group (C)			**21,000**
TOTAL		**US$**	**1,477,200**

**) 100 % born by DEBO

The cost of the following equipment and installation work is not included in the budget and is to be absorbed by DEBO:

(a) Pre-heating ovens for foaming;

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

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

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

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

(f) 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 DEBO 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 8m^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: maxi. 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. Pumps for PUR filling place

Pumps to fill the Isocyanate compound (MDI) tank of the PUR machine and the pure Polyol compound tank in the pre-mixing station from the drums.

B.3. Self cleaning hydraulic-controlled mixhead with:

Nitrogen inertising, nitrogen flow meter
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 (with 2-component)

1pc. Device for checking the switching function of the isocyanate-mixhead nozzle (a polyol-pentane mixing as single component is not possible)

1 pc. Flow sensor for Nitrogen-gas for inertizing

B.4. 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.5. 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.6. Infrared gas sensors
To avoid false alarms and poisoning of standard combustible sensors and to reduce the needed quantities of sensors infrared sensors are much safer and last longer.

B.7. Air flow controls for the exhaust ventilators connected to a.m. gas sensor system to make sure that the ventilators are really running.

B.8. Foam Test Equipment
Scale 0-1000gr +/- 0.01g
Measuring glass 0-1000 cm^3 +/- 1 deviation
Shearing box for foam
Foam knife
Stirrer
Laboratory cup for foam

B.9. 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
Total capacity: Min 16,000 m^3/h
Point exhausting: Min 30 pcs
Ex-proof or placed outside O-Zone

B.10. Encapsulation cabins
To close the wet part (PUR machine and premixing unit) and to close the dry part (foaming stations) of the foaming sectors.

B.11. New universal cabinet foaming fixtures
Automatic in and out,
Automatic closing,
Suitable for cyclopentane (all electrical installations have to be ex-proof, the fixture have to be encapsulated, the fixture and all metals have to be connected to earth, etc.);

B.12. Rebuilding of universal door fixture
All electrical installations have to be modified in ex-proof, the fixture has to be encapsulated, the foaming place has to be modified, the fixture and all metals have to be connected to earth, etc.;

B.13. Rebuilding of foaming door fixtures
All electrical installations have to be modified in ex-proof, the line has to be encapsulated, the jigs and all metals have to be connected to earth, etc.;

B.14. Pipe installation from filling place to tank

B.15. Pipe installation from tank for cyclopentane to pre-mixing station
Inside building with double wall tubes and leak control. (Built-in S valves for separation into sectors in case proposed layout will not be followed).

B.16. Pipe installation from pre-mixer to foaming machines
Either underneath exhausts or with double wall tubes or hoses without any assembly, with leak control for pall. (Built-in S valves separation into sectors in the pall line in case proposed layout will not be followed).

B.17. Antistatic floor
Painting of floor in foaming area with antistatic paint

B.18. Fire protection system
Foam spray system for polyurethane chemicals and cyclopentane according to local regulation

B.19. Tank for cyclopentane
30 m^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.20. Nitrogen generator
Working with membrane
for 8 m^3/h dry Nitrogen sufficient for the factory
plus compressor for 13 bar,
fittings, pressure controls;

B.21. Nitrogen network
All foaming places and mixheads as well as Pall-cyclopentane mixture tanks and machine encapsulations have to be connected to the nitrogen network, single tubes 1/4 inch;

B.22. Cabinet plugs
Fixed aluminium plugs suitable for cyclopentane;

B.23. Universal and expandable chest freezer plugs
Expandable aluminium plugs
with aluminium blocks adjustable for all models
suitable for cyclopentane;

B.24. Modification of door moulds
To be used for cyclopentane;

B.25. Power backup generator

For the exhaust systems a power backup generator with an automatic switch over unit is needed to ensure the supply of power in cause of power supply interruptions. The generator is installed between main board and the exhausts and gas detector system on a dedicated line. The size depends on the proposed and finally selected exhaust and ventilation systems and their needed electrical motor powers and subject of later technical control.

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 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
	Provision of:		384,200
1	Tank for cyclopentane	70,000	
1 set	Pump, pipe work for tank,	10,000	
2 sets	Pipe installation from tank to premixing	24,000	
2 sets	Pipe installation from pre-mixing to PUR machines including installation and commissioning of the systems (three weeks, two specialists)	20,000	
400m²	Antistatic floors	15,200	
1 set	Fire protection system including equipment, installation, training of the system (one week, two specialists)	20,000	
5 sets	Exhaust and ventilation including equipment installation and commissioning of the system (one week, two specialists)	225,000	
	A. Refrigeration System:		
	- Machinery:		127,000
2 pcs	Charging boards for HFC134a	50,000	
4 pcs	Vacuum pumps	20,000	
2 pcs	Production leak detectors	20,000	
1 set	Test and monitoring equipment	25,000	
	Equipment installation, commissioning & local training (2 weeks, 1 specialist)	12,000	
	B. Foaming System:		
	- Machinery: service and starting up		997,000
2 pcs.	High pressure foaming machine for cabinets, chest and doors	300,000	
2 sets	PUR filling system	30,000	
3 pcs.	Mixheads	45,000	

2 pcs.	Spare mixheads	0**	
2 pcs.	Premixing station	120,000	
2 pcs.	Gas detector system	100,000	
1 pcs.	New universal cabinet fixtures	120,000	
1 pc.	Modification of universal door fixture	10,000	
2 pcs.	Modification of door fixtures	16,000	
1 pc.	Nitrogen bank	25,000	
1 set	Nitrogen network	20,000	
1 pcs.	Cabinet plugs	70,000	
4 pcs.	Cabinet plugs	0**	
1 pc.	Universal/expandable chest freezer plug	35,000	
1 pc.	Universal/expandable chest freezer plug	0**	
12 pcs.	Modification of door moulds	36,000	
1 pc.	Power backup generator	30,000	
	Equipment installation, commissioning & local training (6 weeks two supervisors and 1 engineer 1 week)	40,000	
C.	**Refrigeration Service**		
	- Machinery:		21,000
6 pcs	Charging board for service	12,000	
3 pcs	Recovery units for CFC12 (vacuum pums)	7,500	
6 pcs	Electronic leak detectors	1,500	
	Subtotal		1,579,200
	Miscellaneous: Contingency Fund (10% of the incremental cost of all equipment, services and operating incremental costs calculated)		157,920
Subtotal I			1,737,120
Incremental operating cost (half year of operation)			133,500
Subtotal II (sub-total I + incr. op. cost)			1,870,620
Agency's Overheads (13% of all)			243,180
TOTAL		US $	2,113,800

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.

DEBO's service organization is expected to service about 5000 refrigerators and freezers per year with an average CFC12 refrigerant charge 0,3 kg CFC 12; but not all need recharging.

The above mentioned is based on delivery of recovery units to all DEBO'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+ISC²)+PIOC-PIOS)/ODP

where CE = cost-effectiveness;
PICC = project incremental capital costs;
ISC¹ = incremental safety cost, Category 1;
ISC² = incremental safety cost, Category 2;
PIOC-PIOS = project incremental operating costs - savings;
ODP = ODP-kg saved.

Item	Cost, US$
A. Category I. ISC¹	
Tank for cyclopentane	70,000
Pre-mixing stations designed for use with cyclopentane	120,000
Gas detecting system for the foaming area	100,000
Safety exhaust and ventilation for the foaming area	225,000
Nitrogen supply system	45,000
Antistatic floor	15,200
Fire protection system	20,000
Power supply for ventilation	30,000
TOTAL	625,200
Plus 10% contingency	62,520
SUBTOTAL CATEGORY I	**687,720**

B. Category II. ISC[2]	
Modification of High pressure foaming machines	120,000
Mix heads	45,000
Modification of cabinet and chest fixtures	146,000
Pipe installation from tank to premixing station andto PUR machine	54,000
Modification of chest and cabinet plugs	35,000
Consultancy in checking/exproofing of PUR machine, tank, premixing and foaming places, preparation of safety rules and safety training	50,000
TOTAL	450,000
10% Contingency	45,000
SUBTOTAL CATEGORY II	**495,000**
TOTAL CATEGORIES I+II (ISC[1] + ISC[2])	**1,182,720**
PIOC-PIOS (Incremental operating cost of half year of operation)	**133,500**
Subtotal PICC-(ISC+ISC[2])+PIOC-PIOS Divided by 52,000 US$/kg ODP saved	**687,900**
COST-EFFECTIVENESS	**13,22**

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

Roger Hodson- Independent Consultant to Refrigeration Industry
Technical Review- Domestic Refrigeration Project.

31 May 1995.

1 Country of Origin Nigeria

2 Project Title Investment Project for Phasing out the use of CFC at Debo Industries Ltd.

3 Sector/subsector. Domestic Refrigeration/Rigid foam.

4 Relationship to Country Programme

There are 2 main manufacturers of refrigerators and freezers mentioned in the country programme and both are covered by projects from UNIDO to be submitted at the same time.

5 Technology

(a) The technologies which have been chosen are HFC 134a for the refrigeration circuit and Cyclopentane for the foam insulation these are both technologies which are approved by the Montreal Protocol Technical Options Committee for domestic refrigerator conversion.

This combination is widely used by European and also now by Japanese manufacturers.

(b) The technology is not transitional because the ODP of HFC 134a and cyclopentane is zero.

NO foreign company has been identified as a source of technical expertise either for the foam or the refrigeration part. This is an area of concern and the reviewer has some concerns about the success of the venture unless these issues are fully addressed, particularly in a country where the relevant expertise is some distance away . It is likely that the technology partner will be found during the the tender process.

HFC134a.
A letter is needed from the Enterprise stating how it plans to achieve successful production of a prototype of the 134a refrigerators and freezers. The letter should show who it plans to purchase expert help from. One option might have been Zanussi who supplied some of the original production equipment .Evidence will be needed in the future that the General contractor chosen is able to deliver a satisfactory project.

Cyclopentane.
A statement is needed to clarify who will supply the technology for the new foam system, is it the machine supplier, the supplier of foam chemicals or a company already producing refrigerators using cylopentane. Experience with other similar projects shows that there is a need for such a partner.

The OORG foams committee has made the following conditions for acceptance of Cyclopentane projects;

(a) That a technology partner be identified. This can be either a chemical supplier, equipment supplier or independent consultant. A letter must be obtained from the chosen partner confirming their willingness to advise on safety issues and to provide continuing support in this area up to and after project implementation.

(b) A detailed safety plan must be devised. This involves locating a safety team who have the right to carry out surprise safety checks and have the authority to close down production without reference to management. This team has to be headed by an executive at Director level whose normal duties do NOT include production matters.

6 Environmental Impact.

(a) Both cyclopentane and HCFC 134a have zero ODP.
(b) The project contains adequate information on safety training, but does not refer to Nigerian safety or environmental regulations. The local regulations regarding the use of VOC's (Volatile Organic compounds) should be given . The project needs to show that these regulations are being met. In the absence of local regulations then there is a need to show that another regulation from an international source is being met.
Reference is made to the Operational Safety plan being assembled after approval of the project, UNIDO need to have a mechanism to ensure that this is done since ultimate safety of the project depends on this being carried out.

7 Project Costs.

HFC 134a.
The number of vacuum pumps used by the factory is relatively small and there would appear to be insufficient to allow for some to be taken out of service for retrofit. Replacement of 12 pumps therefore seems to be reasonable, because there will also be need for a limited number of pumps to be used for prototyping work
Other costs icluding those for 134a service installations are satisfactory.

Cyclopentane.
The costs are comparable with other similar projects and there is provision for safety equipment. Without having contractors quotes and a drawing of the scheme it is not possible to make any more comments.

(b) Incremental Operating Costs.

HFC134a.
There is a need for some of these costs to be justified because in other similar projects there has been no need to modify the condenser, or evaporator. The costs for the capillary tube and drier are acceptable.
The differential cost of the compressor seems to be on the high side unless this is the norm for Africa, projects in other continents have shown differentials of the order of 3 to 4 US$.

Cyclopentane.
The increased cost is reasonable in view of the increased density of the foam.

General.
There is no mention of scrap value of the equipment which is to be replaced.

8 Cost Effectiveness.

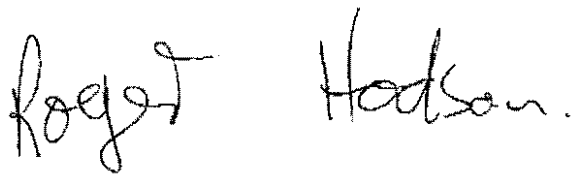
The project is cost effective based on the current guidelines.

9 Implementation Time

The provisional times given in the table are reasonable and reflect the long time which will be needed to get satisfactory prototypes working.

10 Recommendation.
Approval, providing that the issues referred to in this review are addressed.

Roger Hodson



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