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Implementation of the Montreal Protocol

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Montreal, 13-16 December 1994

PROJECT PROPOSAL: ALGERIA

This document includes the following project proposal and the Fund Secretariat's Comments and Recommendations:

Investment Project for Phasing out CFCs at Entreprise Nationale des Industries de l'Electromenager (ENIEM) (UNIDO)

PROJECT EVALUATION SHEET

COUNTRY OR REGION:	Algeria	
PROJECT TITLE:	Investment Project for Phasing out CFCs at Entreprise Nationale des Industries de l'Electromenager (ENIEM)	
BUDGET:	Capital Costs: Operating Costs:	US $5,005,550 US $1,669,500
INCREMENTAL COSTS:	US $6,675,050	
ODS PHASE-OUT:	425 MT CFCs 11 and 12 per year	
COST EFFECTIVENESS:	US $15.71 per kg ODP saved	
PROJECT DURATION:	18 months	
IMPLEMENTING AGENCY:	UNIDO	
NATIONAL COORDINATING AGENCY:	National Commission for Ozone, Ministry of Interior and Environment	
TECHNICAL REVIEW COMPLETED:	YES _X_ NO _	

SECRETARIAT'S COMMENTS

1. This project will phase out the use of CFCs 11 and 12 in the entire domestic refrigeration production sub-sector in Algeria.

2. ENIEM is a state owned enterprise which consists of three refrigerator factories and one freezer factory. The four factories have installed capacity of 500,000 units per year of which the current production is about 320,000 units per year.

3. The refrigeration and foam systems in each factory will be converted to HFC-134a and cyclopentane, respectively.

4. Conversion to HFC-134a entails replacement of the current refrigerant evacuation and charging boards, leak detectors, refitting existing vacuuming system, model redesign and testing. Refrigeration services will be equipped to handle the recovery of both CFC-12 and HFC-134a.

5. Conversion to cyclopentane necessitates replacement of existing low pressure foam machines with high pressure machines, retrofitting of existing high pressure machines, modification of fixtures, acquisition of cyclopentane storage and delivery system, replacement of premixing stations as well as implementing a very stringent safety programme to ensure personnel and plant safety owing to the flammable nature of cyclopentane.

6. Refrigerator model redesign and the technical aspects of the conversion, including safety measures associated with cyclopentane application, will be supervised by a Chief Technical Advisor and specialized consultants appointed and fielded by UNIDO. A General Contractor will also be appointed by UNIDO for the implementation of the major project components (foaming system, refrigeration system, fire protection system, exhausting and ventilation system, on-the-job training, etc.). These arrangements would ensure a proper technology transfer and safe operations.

7. Incremental operational costs are associated with new HFC-134a compressor, refrigeration system optimization, higher cost of the refrigerant and extra polyurethane foam due to increased density. Incremental operational costs are calculated on the basis of average European price level for six months of operation. ENIEM accepted six month duration of operational costs. US $85,500 in salaries for new experienced personnel to be hired by the enterprise is included in the operating costs. In light of the facts presented in paragraph 6 above, this cost is not eligible for funding.

8. The cost-effectiveness of the project is similar to that in other projects.

SECRETARIAT'S RECOMMENDATION

9. The Secretariat recommends final approval of the project and of the project incremental costs in the amount of US $6,589,550.

PROJECT COVER

Country/Region:	ALGERIA
Project title:	Investment Project for Phasing out CFCs at Entreprise Nationale des Industries de l'Electromenager (ENIEM)
Sector Covered:	Domestic refrigeration (Rigid foams and Refrigerant) without commercial and industrial refrigeration
ODS Consumption in this Sector:	In 1991 ODS consumption in this sector was 353 MT CFC 11 and 69 MT of CFC12 in Algeria. The total consumption of ODS in the domestic refrigeration sector was 802 MT ODS.
Project impact:	Phase out of annual consumption of 353 MT of CFC 11, 69 MT of CFC 12 for production of refrigerators and freezers and 3,4 MT for service (Total ODP=425,4 MT)
Project duration:	18 months
Project economic lifetime:	10 years
Total proposed project cost:	US $7,542,810
Project investment cost:	US $5,005,550
Implementing Agency's overheads:	US $ 867,760
Incremental Operating Cost: (half year operation costs)	US $1.669,500
Proposed MF financing:	US $7,542,810
Cost effectiveness:	See Annex C: Unit Abatement cost
Counterpart enterprise:	ENIEM - Entreprise Nationale des Industries de l'Electromenager, Tizi Ouzou/Algeria
Implementing Agency:	UNIDO
Coordinating Ministry:	National Commission for Ozone, Ministry of Interior and Environment

PROJECT SUMMARY

This project will phase out 100% of the use of CFC 11 as blowing agent and of CFC 12 as cooling agent for the production of domestic refrigerators and freezers of ENIEM in their factories in Algeria.

The chosen replacement alternatives are cyclopentane as foam blowing agent and HFC 134a as refrigerant in refrigerators and freezers. The project will include 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 and the refrigeration service sector of the company.

One of the 3 refrigerator factories of ENIEM is fully automated from steel coils, plastic sheet to finished products. All lines are automatic and interconnected. The conversion will cause 2 months production interruption which will result in losses of DINAR 482,374,000 (US $12,719,715) in production costs and loss of profit in this factory (R2). The losses in the other 2 factories are smaller: DINAR 77,000,000 (US $1,898,567. These losses are the contribution of ENIEM to the project execution, but ENIEM can not really bear more than these high amounts. The total amounts for the conversion to be covered by ENIEM exceed the amounts covered by the Multilateral Fund.

Date: 31 August 1994.

BACKGROUND

Sector Background

The subsector for domestic refrigerators and freezers in Algeria consists of only one public manufacturer: ENIEM - Entreprise Nationale des Industries de l'Electromenager. In 1991 the total ODP consumption in Algeria in the domestic refrigerator and freezer branch was, excluding industrial and commercial refrigeration, about 802 MT, of which ENIEM consumed 424,4 MT for the production of refrigerators and freezers. The rest of the CFCs consumed in this branch are used for serving about 3,2 Mio. domestic refrigerators and freezers in Algeria. Algeria does not produce the CFCs. The total consumption of CFCs for the production of different polyurethane foams was about 650 MT and the total consumption of CFC's and HCFC's in the refrigeration sector was about 762 MT ODS in 1991. The demand for ODS at the moment is stagnant, but it is estimated that it will increase in the future if the conversion is not made.

ENIEM has in their 3 refrigerator and freezer factories a total installed capacity of 500,000 units per year in 1 shift with 79% capacity efficiency.

ENIEM is state owned. ENIEM shares nearly 100% of the refrigerator and freezer market in Algeria, the rest is imported and service about 1% with own service centers and 80% by ENIEM licensed service shops of the refrigerators in Algeria. The current overall number of refrigerators and freezers in operation in Algeria is estimated at 3,2 Mio. units. Service, maintenance and repair operations in this sector are carried out through a large network of refrigerator workshops that are often licensed by ENIEM. In addition, workshops of ENAPAT, ENAPEM, ENITEC, ENIFROID and EDIED provide servicing for refrigerators and freezers.

Currently, ENIEM does not produce low energy consumption refrigerators but does produce low energy consumption chest freezers. The insulation thickness reaches the standards of today's refrigerator technology with 35mm insulation of refrigerators, 50mm insulation of vertical freezer and 75mm of chest freezers, but does not yet follow the dimensions used from some advanced manufacturers for the Northern Europe market.

ENIEM's Background

ENIEM is a 100% state owned company operating in the manufacture and sale of domestic appliances (refrigerators, freezers, gas cookers, air conditioners, heaters and lamps) since 1973.

Their first refrigerator factory and their first models were designed in cooperation with Bosch/Germany in 1973. The second refrigerator factory and their models were designed in cooperation with Toshiba/Japan in 1985 and their third factory and freezer models were designed in cooperation with Lematic. A new 2 door refrigerator-freezer combination was introduced in 1994 in cooperation with Lematic. 10% of the production is exported. ENIEM employs 3,665 staff.

ENIEM has 3 refrigerator factories in Tizi-Ouzou with the following annual capacities:

		capacity nominal	capacity with 79 % capacity efficiency
1)	Factory RI Model 160l, 200l and 240l refrigerators	150.000	120.000 units/year in 1 shift
2)	Factory RII Model 300D, 350S, 290C, 220F	410.000	320.000 units/year in 1 shift
3)	Chest freezer factory Model CF 1301, CF 1686	75.000	60.000 units/year in 1 shift
	Total Refrigerator and freezer production	635.000	500.000 units/year in 1 shift

Furthermore ENIEM has 2 gas cooker factories, one air conditioner factory, and one factory for heaters and one for lamps.

Because of a crisis in Algeria the production of refrigerators and freezers went down to 318,068 units in 1993. An increase of 5% per year is expected for the next four years.

ENIEM produces following refrigerators and freezers in their factories:

Factory RI:

- 1 door refrigerator model 160l with freezer compartment**, 160l gross, 105l net volume.

- 1 door refrigerator model 200l with freezer compartment**, 200l gross, 144l net volume.

- 1 door refrigerator, model 240l with freezer compartment**, 240l gross, 174l net volume.

Factory RII:

- 1 door refrigerator model 350S with freezer compartment **, 362l gross, 297l net refrigerator and 34l net freezer volumes.

- 2 door refrigerator-freezer*** model 300D, 325l gross, 229l net refrigerator and 83l net freezer volumes.

- 2 door refrigerator-freezer*** model 290C, 316l gross, 167l net refrigerator and 131l net freezer volumes.

- 1 door freezer model, 256l gross and 244l net volume

- A new 2 door refrigerator-freezer model 520l, 520l gross, 380l net refrigerator and 129l net freezer volume.

Chest freezer factory:

- 1 chest freezer**** model CF 1301 with 360l gross and 350l net volume.

- 1 chest freezer**** model CF 1686 with 480l gross and 468l net volume.

ENIEM has in their plants the following equipment relevant to the CFC free conversion of the refrigerator and freezer production (other lines which do not need to be converted are not mentioned):

1. R I factory:

1.1 Polyurethane wet part

1 pc. 500l tank on balance for premixing of polyol and CFC 11;
1 pc. 500l tank for premixed polyol and CFC 11;
1 pc. 500l tank for Isocyanate;
1 pc. Hennecke PUR machine HK 165 (20-245) without recycling with 2 mixing heads.

1.2 Polyurethane dry part

8 pcs Stations in 2 rows with bell position jigs;
24 pcs Plugs.

1.3 Evacuation, charging and testing lines:

10 pcs Vacuum pumps (Leybold);
2 pcs Evacuating and CFC 12 charging station of A'Gramkow;
3 pcs Leak detectors for CFC 12 - Leybold Inficon.

2. R II factory:

2.1 Polyurethane central tank storage system:

1 pc. CFC 11 storage tank, 3.000 l;
1 pc. Polyol compound storage tank, 6.000 l;
1 pc. Polyol compound storage tank for premixing with CFC 11 on balance 3.000 l;
1 pc. Polyol/CFC 11 storage tank, 6.000 l;
1 pc. Bank of nitrogen bottles;
1 pc. Isocyanate storage tank 6.000 l.

2.2 Polyurethane wet part for the cabinet line:

1 pc. Isocyanate compound tank 350 l;
1 pc. Polyol/CFC 11 compound tank 350 l;
3 pcs High pressure foaming machines from Mitsui Toatsu (Elastogran license); one for each mixhead.

The foaming is made with 3 parallel shooting mix heads in one cabinet on bell position. Therefore, 3 foaming machines (one for each head) are absolutely needed.

2.3 Polyurethane wet part for the door line:

1 pc. Isocyanate compound tank 350 l;
1 pc. Polyol/CFC 11 compound tank 350 l;
2 pcs High pressure foaming machines from Mitsui Toatsu (Elastogran license); one for each mixhead.

The foaming is made with 2 parallel shooting mix heads in one door. Therefore, 2 high pressure machines are needed.

2.4 Polyurethane cabinet line (dry part):

1 pc. Fully automatic cabinet PUR foaming line (carousel type) with up to 30 moving jig positions in bell position, full automatic loading and unloading, fully automatic opening and closing of the jigs, full automatic foam injection on robot with 3 parallel shooting mixheads;
63 pcs Foaming jigs;
112 pcs Plugs (30 pcs for model 350l, 28 pcs for 227F, 27 pcs for 290C, 27 pcs for 300D).

2.5 Polyurethane door line (dry part):

1 pc. Fully automatic door PUR foaming line (carousel type) with 20 moving jig positions, fully automatic loading/unloading, fully automatic opening and closing of the moulds, fully automatic foam injection on robot with 2 parallel shooting mixheads;
25 pcs Door foaming jigs;
80 pcs Mould profiles (20 pcs of each of the 4 produced models).

2.6 Evacuation charging and testing lines

1 pc. Evacuation charging line with 23 pcs moving pumps;
2 pcs 1000 kg CFC 12 containers;
2 pcs Feeding pumps for CFC12 gas production;
1 pc. Switch over CFC 12 feeding station;

2 pcs Production evacuation and charging stations;
8 pcs Production leak detectors from Toshiba.

3. Chest freezer factory

3.1 Polyurethane wet part

1 pc. Hennecke PUR foaming machine HK 650 with 2 mixheads;
2 pcs 500l tanks for polyol/R11 and for Isocyanate compound;
1 pc. Premixing station;
2 pcs Mixheads and spare heads.

3.2 Polyurethane chest freezer line:

5 pcs Chest freezer jig stations in bath position;
10 pcs Chest freezer plugs expandable.

3.3 Polyurethane chest freezer door line:

5 pcs Door jig stations;
10 pcs Door mould profiles.

3.4 Evacuation, charging and testing lines:

20 pcs Vacuum pumps from Kinney;
2 pcs Production evacuation and charging stations for R12 from Danfoss;
2 pcs Production electronic leak detector for R12 from GE.

ENIEM's equipment for foaming and refrigerator charging and testing is mainly from 1985 (R 2), some from 1992 (chest freezer lines and charging and testing line of R 1), some from 1982 and 1988 (R1 dry part) and 1 pc. PUR machine of R1 from 1977, but still in good condition.

ENIEM has a well equipped performance test laboratory in which they can simulate climate conditions up to 43°C. To optimize the R134a cooling system and to improve the quality, they still need some new equipment for it, because their existing equipment is needed to control the running production according to the international standards and additional test capacities have to be built up to shorten the conversion time to 2 years.

ENIEM's Refrigeration Service

ENIEM has its own network of service shops in Algeria with 11 main service centers and 21 sets of service equipment including 10 vacuum pumps. In addition their refrigerators are serviced by 300 service shops all over Algeria licensed by ENIEM. All the service centers are equipped with normal refrigeration service equipment. To date, there exist no CFC 12 recovery equipment in the domestic refrigeration sector in Algeria.

ENIEM services about 1% of all serviced refrigerators in its own service centers and 80% of all serviced refrigerators are in shops licensed by ENIEM. During the last 15 years serviced (equal to the average life time for refrigerators and freezers), ENIEM have manufactured about 3,2 Mio. units of refrigerators and freezers of which 5 to 10% are expected to require refrigeration service each year.

With an average CFC12 refrigerant charge of refrigerators and freezers of 0,16 kg weighted by the quantity of models serviced on the market plus 30% for the loss totalling 208g per unit. ENIEM's service uses about 3,4 MT of CFC12 (per year in their own service centers). Only a part of the service needs recharge of freon.
*

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 ENIEM 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

ENIEM is prepared to phase out ODS in the refrigeration section as soon as the new technology has been acquired, the necessary machinery and equipment installed, the refrigerator and freezer models are converted and the technical staff is trained. Among the technological options currently available on a commercial basis, ENIEM has chosen to replace CFC 12 with HFC 134a, because the new type of compressors are available, the technology is matured and commercially applied. For a hydrocarbon solution (isobutane or propane), the service problem in North Africa is not yet solved and not completely controllable by the producer, so there is still a risk of accidents if hydrocarbons are used as a cooling agent. For the blowing agent (CFC 11) for polyurethane foam, ENIEM has decided to avoid the application of any transitional substance and to introduce cyclopentane as an ultimate solution.

The refrigeration systems need to be optimized as part of the change to the new components for the HFC 134a refrigeration system in order to reduce the refrigerators' and freezers' energy consumption.

Assistance, through the project, is sought for:

(a) Procurement of new machinery and equipment;

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

(c) Redesign, reconstruction, prototype manufacturing and testing of refrigerators and freezers;

(d) Installation, commissioning, training in Europe and on-the-job training, trial operation and start-up etc.

During the period of 2-2½ years additional testing equipment is needed to reach in this department the testing capacity needed for the conversion of all 10 different models in their different version.

For the 11 refrigeration service centres of ENIEM, each center needs 1 recovery unit and 10 mobile recovery bags for CFC 12 as well as 2 sets of equipment which will be used for servicing HFC 134a refrigeration systems.

The following machinery and equipment need to be rebuilt, replaced or new equipment has to be added in the 3 refrigerator and freezer factories of ENIEM:

A. Refrigeration System

A.1 The 6 automatic production evacuation and charging boards of the 3 refrigerator and freezer factories - 2 in each of 3 of the factories - have to be replaced by boards suitable for use with HFC 134a. The 2 of the 121 and the 2 of the chest freezer factory have to have feeding pumps integrated, the 2 in the R2 factory have separate feeding pumps.

A.2 The feeding pumps for CFC12 and the switch-over charger of the 2 refrigerant agent tanks have to be replaced with units suitable for HFC 134a, because the existing pumps for CFC12 had the switch over unit, switching between the 2 CFC12 tanks in case of finishing on tank cannot be on uses any more.

A.3 There exist, in all 3 factories, 63 vacuum pumps including 10 pumps at the servicing center. After having applied a special cleaning technology (described in Annex D) they can be reused.

A.4 The existing 10 evacuation pumps with a capacity of $8m^3/h$ from Leybold in the R1 factory are just sufficient to evacuate the systems at the needed speed to keep the same capacity of 150,000 units per year and to eliminate condensed humidity before charging with HFC 134a.

The existing 20 evacuation pumps in the chest freezer factory are over sized (8,2m^3/h), so, after cleaning, they can easily be used for the HFC 134a without reducing the capacity of 75,000 units per year.

But the 23 evacuation pumps on carriages for the R2 factory are not sufficient to keep the same production capacity of 410,000 units per year after conversion to HFC 134a. The evacuation time for HFC 134a has to be increased by 20-30% to remove condensed liquids. This can be achieved only by adding 3 new pumps on carriage. Otherwise, the total production of R2 will be diminished by the same percentage which is not acceptable for ENIEM.

A.5 Because the 12 existing production leak detectors of the 3 factories react on Chlorine molecules, they need to be replaced with special leak detectors for R134a. For cost and cycle time reasons, 8 leak detectors can be replaced with electronic models like Inficons HLD 4000A but

A.6 the 4 leak detectors of the R2 factory need to be replaced with 2 electronic detectors to HFC 134a and 2 larger units like ECOTEC 500. Replacement of the existing CFC12 leak detectors by electronic leak detectors for HFC 134a only cannot be accepted for the large installation with full automatization and high integration. Only very reliable and HFC 134a specifies mass spectrometer leak detectors (such as those used in similar large installations in Europe, the USA and Japan) are technically and economically acceptable, as a stoppage caused by wrong signals (Chloratoms) and the necessary adjustments of the electronic leak detectors will cause such damage and loss in production.

A.7 New performance tests for each model have to be completed to ensure optimization of the cooling system for the application of HFC 134a in connection with the use of the new components for HFC 134a. The existing test equipment is used to help the standards for the running production. Therefore, some new test equipment and material need to be provided. In this model conversion program, ENIEM, with the help of foreign experts, have to find ways to compensate for a lower polyurethane insulation value due to the conversion to cyclopentane for the foam in comparison to CFC12 foam and HFC 134a as the new refrigerant, to keep the energy consumption as well as the GWP at a lower acceptable value.

A.8 Control manifolds or pressure switches with green/red lights are also needed for the 63 pumps used for the evacuation of the system for the change of R134a. These can be made locally, and only materials have to be imported.

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

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

- The capillary tube has to be optimized for increased resistance at low evaporating temperatures because the volume flow with HFC 134a is about 80% of the volume flow with CFC12.

B. Foam system

The solutions for the foam system in each of the 3 factories are different and have to be considered separately.

1. R1 factory:

B.1-3 For the existing HK 165 Hennecke foam machine without recirculation of foam material, no retrofitting unit exists, and therefore it needs to be completely replaced with a new high pressure foaming machine specially designed for cyclopentane driven foaming. This includes the 2 mixheads, spare mixheads and the polyol/R11 compound work tank of 500 l because the existing mixheads without recirculation cannot be retrofilled.

B.25 The existing 8 fixtures can be modifed to exhaust the cyclopentane and to automatically disconnect the fixture's electronic heater during foaming. The electrical components will be replaced with ex-proof components, and the foaming area will be separated from the other areas. Inside the 8 jigs, special venting profiles will be introduced by suction out the cyclopentane.

B.26 The 8 plugs of the R 1 PUR cabinet line have to be slightly adjusted to be able to remove the cyclopentane from the mould.

2. R2 factory

The central PUR component storage system of the R2 factory with 3 6,000 l and 2 3,000 l tanks will not be changed but that the tank on the balance and the CFC 11 tank become obsolete. These tanks cannot be used for cyclopentane.

B.4-7 The existing high pressure machines must be retrofitted in a way that all equipment of the polyol sections of the 2 existing double tank systems (one system for the cabinet line and one system for the door line) and the 5 existing high pressure foaming machines (3 for the 3 parallel shooting mixheads for the cabinet line and 2 for the 2 parallel shooting mixheads for the door line) need to be replaced and other parts of this equipment like the 5 mixheads need to be refitted, injectors for nitrogen have to be added and connected to nitrogen network.

B.14 An exhaust with gas feelers and 2 ventilation air-locks has to be built around the first 4 stations.

- The 3 cabinets holes on the backside of the cabinets (through which the 3 mixheads inject the foam) have to be closed by valves or pieces of laminated paper to avoid a worker's having to enter the ex-proof zone during venting of cyclopentane after foam injection.

B.23-24 The 63 cabinet jigs and 112 plugs have to be modified to ensure that cyclopentane is removed before the jig enters the heater.

B.16 The first 4 positions of the R2 door line starting from foam injection will be encapsulated and connected to the exhaust system. The heater has to be modified for this reason. The electrical switches inside the ex-zone have to be made ex-proof, the line has to be connected to earth and 10 gas feelers and 2 ventilation air-locks have to be added.

B.24-25 All 25 door jigs and the 80 profiles have to be modified to ensure that no cyclopentane is left when the jigs enter the heater. Especially the door profile has to be modified in a way that no paper has to be manually placed by workers directly after injection of foam as it is not allowed for the workers to work inside the enclosed foaming area. The profiles should be able to close the system in a way that only gas and cyclopentane can escape but no foam and that no paper is needed to protect the mould to become dirty.

- We have to take into consideration that retrofitting in such a fully automatic line with high processing integration can cause a production interruption of about 2 months resulting in high losses for ENIEM.

3. <u>Chest freezer factory:</u>

B.9-10 The existing PUR wet part (Hennecke PUR machine HK 650 with 2 tanks and 2 mixheads) can be modified by a retrofitting unit, and the 4 mixheads (2 on the line and 2 spare) can be rebuilt to enter nitrogen injectors and to connect it to the nitrogen network.

B.26 The 5 cabinet foaming jig stations can be modified by adding defined venting channels, exhaust systems and gas detectors and by modifying the electrical components and heaters to ex-proof.

B.27 The 10 expandable plugs need to be modified to install cyclopentane venting channels and to avoid that cyclopentane remains in the plug.

B.28 The 5 door jig stations have to be modified by adding defined venting channels, exhaust system and gas detectors and replacing the electrical components and the heaters to ex-proof or by switching off the heaters during the first 70 sec. of foaming.

4. For all 3 factories:

B.10 Since cyclopentane and polyol cannot be delivered premixed in drums or tanks (as CFC 11) and the existing premixing equipment can not be used for cyclopentane, it is necessary to provide a premixing station per factory. Transportation of premixed polyol/Cyclopentane between the factories is not very useful because of demixing of the components and, therefore, a strong reduction in quality and, last but not least, safety problems. For safety reasons, the premixing should be done outside the production area or even the building so that only premixed polyol, and not pure c-pentane, will be transported into the working areas. The transport pipes should be made as short as possible.

- The final specification of the cyclopentane to be used (purity and mix) will be defined after conducting a market review in Algeria to assess its availability.

For the time being, there are no Algerian manufacturers of cyclopentane in the requested purity (Benzine, n-Hexane).

B.11 For work safety using the highly flammable and explosive cyclopentane, it is necessary to have 3 gas detector systems in the following foaming departments:

- R1 cyclopentane filling place, premixing, PUR foaming machine and cabinet foaming line,
- R2 PUR cabinet foaming machine group and cabinet foaming line, and
- chest freezer cyclopentane tank, filling station, premixing, PUR foaming machine and door and cabinet foaming lines.

B.12 Following gas feelers are needed for the factories and their working areas:

Working areas	R1 factory	R2 factory	Chest freezer factory
- Gas tank filling places	1	1	1
- Premixing	1	1	1
- Polyurethane machine groups	1	4	1
- Polyol/c-pentane tanks	1	2	1
- Cabinet lines	8	6	5
- Door lines	3	6	6
Total	15	20	15

All together for all the 3 factores 50 gas sensors are needed.

To avoid zero point shifting which often cause alarm even if no gas is escaped, no combustable sensors can be taken, but only infra-red sensors are acceptable.

B.34 All work areas in contact with cyclopentane must also be equipped with fire protection systems, i.e. 15 of fire protection systems are required for the following work areas:

- R1 cyclopentane tank filling station,
- R2 cyclopentane tank filling station,
- Chest freezer cyclopentane tank filling station,
- R1 PUR premixing station,
- R2 PUR premixing station,
- Chest freezer PUR premixing station,
- R1 PUR machine,
- R2 cabinet PUR machines group,
- R2 door PUR machines group,
- Chest freezer PUR machine,
- R1 cabinet foaming line,
- R2 cabinet foaming line,
- Chest freezer cabinet foaming line,
- R2 door foaming line, and
- Chest freezer door foaming line.

B.35 It is necessary to provide 3 tanks for cyclopentane, one in each of the 3 factories, in order to be able to automatically deliver the components to the premixing stations. A centralized c-pentane storage system with long distance double wall tubes, pressure controlled, self closing valves etc. seems more expensive than 3 separate ones and much more risky under the local conditions (earthquake).

To operate c-pentane PUR lines in Algeria, only the following conditions can only be accepted given the safety operation aspects:

1. The c-pentane tank has to be made 5-10m away from the factory building and under-ground,

2. The pure c-pentane should not enter any work area, so the premixing should also be done outside the work area and, if possible, the factory building to avoid heating of tubes because of the very high viscosity of polyol compound for cyclopentane blown polyurethane at low temperatures (limit + 5°C).

3. Only well trained operators should enter the foaming area or manipulate any jig inside the foaming area, and only specially trained maintenance technicians are allowed to enter the foaming area, the PUR machine rooms and premixing rooms after stoppage and switching off of the PUR lines and machines.

   - All pipes and feeding pumps which contain any cyclopentane have to be newly made and ex-proof, with double wall, pressure controlled and self- closing valves. Equipment between the pipes and feeding pumps has to be installed in a way that distances are small and that the work areas are not crossed by the pipes. Any closed channels underneath the pipes in which cyclopentane can accumulate should be avoided, and the pipes and pumps should be well ventilated. The following pipes and pump connections are needed:

B.29 - 3 sets of feeding pumps and recirculation pipes between the 3 filling stations and 3 cyclopentane tanks;

- 3 sets of pipe and ex-proof pumps for emptying the tanks;

B.30 - 3 sets of cyclopentane feeding pipes, low pressure ex-proof feeding pumps between the cyclopentane tank and the 3 premixing stations;

B.31 - 4 sets of polyol/cyclopentane compound feeding pipes between the 3 premixing stations and 4 working tanks of polyol and cyclopentane compound mixtures;

B.32 - 9 sets of polyol/cyclopentane compound feeding pipes and recirculation pipes between the 7 polyol/cyclopentane compound dosing pumps and the 9 mixheads (two on R1 PUR cabinet line, one on the chest freezer cabinet line, one on the chest freezer door line, three on R2 PUR cabinet line, two on R2 PUR door line).

B.13 To keep control on the new foaming chemicals as well as the foam (because of its higher density and lower insulation value) 1 set of test equipment (specified in Annex A: "Specification for Equipment") is necessary for each factory.

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

B.14-20 The provision and installation of 12 exhaust and ventilation systems in the foaming departments of all 3 factories is necessary in order to achieve compliance with established safety rules for the machinery and the plant. Separate exhaust systems are needed for the following groups:

- R1 premixing station,
- R1 PUR foaming machine,
- R1 cabinet foaming line,
- R2 premixing station,
- R2 PUR foaming machines group for cabinets,
- R2 PUR foaming machines group for doors,
- R2 cabinet foaming line,
- R2 door foaming line,
- Chest freezer premixing station,
- Chest freezer PUR foaming machine,
- Chest freezer cabinet foaming line, and
- Chest freezer door foaming line.

- Because of the flammable and explosive cyclopentane, all machinery and equipment which will come in contact with the cyclopentane or the mix of polyol and cyclopentane have to be explosion proof. For cost reasons, the construction should be made as much as possible in a way that all electrical components are positioned outside the foaming area or switched off during the time of foaming.

- All foaming jigs and plugs must be equipped with a good earth connection to avoid the appearance of static electricity.

- Storage tanks which contain cyclopentane will be pressurized by nitrogen, and cabinets or door jigs for foaming which will come into contact with c-pentane will be cleaned of air by nitrogen.

C. Refrigeration Service

To cover the requested service in the future, each of the 11 refrigerator service centers of ENIEM should receive 2 sets of R134a mobile evacuation and charging boards, 3 sets of electronic leak detectors for R134a and 10 sets of recovery bags for R12 and 1 stationary recovery unit for R12. Each center should collect the R12 from the recovery bags and return the R12 to centralized reclaim stations in Algeria to be reused in the service. This will reduce the imports and cost of R12 in Algeria.

This equipment will only cover ENIEM's own service centers but not the service shops licensed by ENIEM but not owned by them.

D. Justification for Selection of Alternative Technologies

All major manufacturers of compressors have agreed to replacement for CFC 12 with HFC 134a as the new refrigerant for domestic refrigerators and freezers.

The alternative to use hydrocarbons like isobutane or propane, or mixtures of it, as a refrigerant is already available on the market and is used by some major producers in Germany and Italy, but their application in a North African country at this stage of development still seems risky. Even if ENIEM would change the cooling system construction in a way that the refrigerators would be supplied from the factory completely hermetically closed and all systems were behind the innerliners, there is a risk that after the first unauthorized service, the system would not be correctly fitted again and would cause an accident. In addition, the filling requires very exact quantities with max. +/-1g, and stronger deviation will cause higher GWP than the R134a. Besides the risks, this exactness in filling needs cartrige systems or very expensive charging equipment so that the price advantage of hydrocarbons in comparison to R134a is more than lost. In case such hydrocarbons really gain a large part of the market and the service men are aware of these new risks and the service conditions in these countries can be strongly improved, we will think again about switching to these new refrigerants or others cheaper than the HFC 134a; but for the time being, HFC 134a should be used in Algeria.

For the new blowing agent of the polyurethane foam, the situation is as follows:

Upon recommendation of the HCFC blowing agent manufacturers (HCFC 141b with ODP=0,1 HCFC 142b with ODP=0,065 and HCFC 122/22 with ODP=0,06), many European, American and Far East manufacturers tried to use these blowing agents, but could not yet solve the technical problems of these HCFC in a satisfactory way, which in addition would only be a temporary solution.

The problems were:

1. Blistering of the cheap polystyrene innerliner material normally used for the refrigerators which could be partially solved by new developed materials with higher prices.

2. Lower stability and shrinking of the foams because of higher water content, which obliges the manufacturer to increase the density of the foam and which does not allow in medium terms strong reduction of the density by new developed polyol density. The switching to TDI instead of MDI used in the USA to avoid this problem also increases the costs.

3. Strong diffusion of the blowing agent from the foam and replacement by air, which in only a few months strongly, increases the thermal conductivity, and after a few years, such foam reaches values as if it were blown with CO_2. A proposed solution with multilayer inner liner material also strongly increases the cost of the refrigerator.

4. Meanwhile, directly after foaming the cyclo-pentane driven foam reached thermal conductivity values similar to the ones for R11 reduced foam.

5. ENIEM is aiming at the European market and an HCFC solution is already boycotted in some countries and, sooner or later, will be in the whole European market.

Nearly, all refrigerator producers in Europe and many in the Far East have already switched, or will switch in the near future, to cyclopentane as a blowing agent because of its good insulation values and the cheaper cost of materials (innerliner, PUR quantities). The manufacturing technology with highly flammable and explosive c-pentane is meanwhile so mature and the control systems are so perfect and safe that it can be applied even in developing countries if some strict processing regulations are followed and regularly controlled and the staff in this section are well selected and trained. But the technical solutions for c-pentane PUR foaming in developing countries have to be made as safe, or even safer, than the ones in Europe. We have to take into consideration that the workers in developing countries often do not have the high degree of professional education and theoretical knowledge of such complicated machines as workers in developed countries. This will increase the cost.

As far as possible, workers should not enter the closed PUR premixing room, the PUR machine room and the foaming area. Only very good trained operators and maintenance technicians wearing antistatic clothes and shoes should enter this section. Maintenance should only be made after all machines are switched off and strong ventilation systems, backed up by an emergency power supply are switched on.

The cyclopentane tanks as well as the premixing stations for mixing the c-pentane with the polyol compound should be placed outside the production areas or even the building and closed so that no unauthorized person can enter this section. Inside the work building, only premixed c-pentane should be pumped, and the double tube pipes should be placed in a way that, in the worse case, no ignition and no accumulation of c-pentane up to the LEL-level in a closed unventilated room, trunk channel, etc. is possible.

The design of the machines, the layout of the building and piping of polyol compound including c-pentane and every detail must be made in a way that it will fulfil the most strict safety and operation regulations in developed countries.

INPUTS

1. Capital Goods Replacement

A. Refrigeration System

In the 3 factories the following equipment needs to be changed as well as new equipment is to be provided as specified below:

A.1 6 pcs. HFC 134a production refrigerant charging boards with vacuum pump, 4 pcs with refrigerant supply pump and all with vacuum check;

A.2 2 pcs. HFC 134a feeding pumps and the 1 pc. switch over charger for the R2 factory;

A.3 The existing 63 pcs. vacuum pumps have to be cleaned and refilled;

A.4 3 pcs. new 2 stages evacuation stations on carriage;

A.5 10 pcs. production HFC 134a leak detectors of type Inficon HD 4000A;

A.6 2 pcs. production leak detectors of ECOTEC 500;

A.7 1 set of refrigerant test equipment and material for laboratory;

A.8 63 pcs. vacuum control for existing 63 pcs. vacuum pumps, which can be cleaned to be used for R134a, to increase the vacuum control on the more delicate R134a charging process;

B. Foam System

In the 3 factories the following equipment needs to be changed or new equipment has to be provided as specified below:

B.1-3 The existing old Hennecke foam machine HK 165 without recirculation of foam materials cannot be retrofitted and needs to be replaced completely with 2 tanks, filling pumps, foaming machine with 2 pumps, hydraulic unit, chiller, heat exchangers 1 set of tank filling pumps, tube system, 2 pcs mixheads and 1 pc. control board by a new complete foaming machine with all above-mentioned accessories suitable for cyclopentane.

The major part of the remaining 6 pcs high pressure foaming machine, tanks, tubes and pipes, electrical components, etc. have to be replaced by cyclopentane suitable equipment and parts, the mixheads have to be retrofitted and nitrogen injectors in the mixheads and pressure switches in all sections of the lines have to be added. The retrofitted groups are the following:

B.4-5 3 pcs PUR machine on R 2 factory cabinet line with 1 pc. tank group, 3 pcs mixheads, 3 pcs spare mixhead, 1 set of pipes and tubes, 1 pc. hydraulic group, 1 pc. heat exchanger, 1 pc. chiller and 1 pc. control board;

B.6-7 2 pcs PUR machines on R 2 factory door line with 1 pc. tank group, 2 pcs mixheads, 2 pcs spare mixhead, 1 set of pipes and tubes, 1 pc. hydraulic group, 1 pc. chiller, 1 pc. heat exchanger and 1 pc. control board;

B.8-9 1 pc. PUR machine with 1 pc. tank group, 1 set of tank filling pumps, 2 pcs mixheads in different sizes, 2 spare heads, 1 set of pipes and tubes, 1 pc. hydraulic group, 1 pc. chiller, 1 pc. heat exchanger and 1 pc. control board in the chest freezer factory.

B.10 3 pcs. premixing stations for cyclopentane and polyol, one for each factory, from which two have to be made with polyol tanks; the third one is connected to a central storage system;

B.11 3 pcs. gas detector system with control boards;

- 1 pc. gas detector system with control board for the cabinet line including PUR machine group in the R2 factory;

- 1 pc. gas detector system with control board to control premixing and cyclopentane tank, feeding pump and filling station;

- 1 pc. gas detector system with control board for the door line including PUR machine group in the R2 factory;

- 1 pc. gas detector system with control board for the cabinet line of the R1 factory including control on premixing and cyclopentane tank, feeding pump and filling station;

- 1 pc. gas detector system with control board for the chest freezer cabinet and door lines of the chest freezer factory including premixing station, cyclo-pentane tank, feeding pump and filling station;

Because of the distances between these production halls and areas a combination of the gas feeler systems is not possible. The controllers of the area have to act immediately after alarm and cannot walk 10-15 min. to intervel.

B.12 50 pcs. gas feelers totally on all the 5 pcs gas detector systems;

B.13 3 sets foam test equipment;
12 pcs of different exhausting and ventilation systems:

B.14 8 pcs exhaust and ventilation systems for the 8 jig stations of the cabinet line of the R1 factory;

B.15 1 pc. exhaust and ventilation system for the cabinet line of the R2 factory consisting of 1 pc. large encapsulation, exhaust and ventilation system around the first 5 carousel positions of the jigs starting from the PUR foam injection position, plus 2 air-lock fans;

B.16 1 pc. exhaust and ventilation system for the door line of the R2 factory consisting of 1 pc. large encapsulation, exhaust and ventilation system around the first 5 carousel positions of the jigs starting from the PUR foam injection, plus 2 air-lock fans;

B.17 5 pcs exhaust and ventilation systems for the 5 jig stations of the chest freezer cabinet line of the chest freezer factory;

B.18 5 pcs exhaust and ventilation systems for the 5 door jigs of the chest freezer door line of the chest freezer factory;

B.19 4 pcs exhaust and ventilation system for the 4 pcs PUR machine groups with working tanks of the R1 factory (1 pc.), of the R2 factory (2 pcs), and the chest freezer factory (1 pc.)

B.20 3 pcs exhaust and ventilation system for the 3 premixing stations of the R1 factory, the R2 factory and the chest freezer factory;

Modifications of the cabinet and door foaming jigs, plugs and mould profiles to get defined venting channels for cyclopentane to avoid that cyclopentane not removed by the exhaust will explode during the heating; consisting of

B.21 8 pcs modification of cabinet foaming jigs in the R1 factory;

B.22 8 pcs modification of the cabinet foaming plugs in the R1 factory;

B.23 63 pcs modification of the cabinet foaming jigs of the R2 factory;

B.24 112 pcs modification of the cabinet foaming plugs of the R2 factory;

B.25 25 pcs modification of door foaming jigs of the R2 factory;

B.26 5 pcs modification of cabinet foaming jigs of the chest freezer factory;

B.27 10 pcs modification of expandable cabinet foaming plugs of the chest freezer factory;

B.28 5 pcs modification of the door foaming jigs of the chest freezer factory;

Cyclopentane pipes and pump installations with double tubes, pressure control leak detectors, ex-proof and self closing valves:

B.29 3 pcs feeding pipe, recirculation pipe, and low pressure pump systems between filling places and cyclo-pentane tanks is needed to enter gas into the empty tanks of the truck;

B.30 3 pcs pipe and low pressure pump systems between cyclo-pentane tanks and premixing stations;

B.31 4 pcs pipe systems between the 3 pcs premixing stations and 4 pcs PUR foaming machine work tanks of polyol/cyclopentane mixture;

B.32 9 pcs pipe systems, feeding and recirculation pipes between the 7 pcs polyurethane foam machines and 9 pcs mixheads:

- 3 pcs on cabinet line in R2 factory,
- 2 pcs on door line in R2 factory,
- 2 pcs on cabinet line in R1 factory,
- 1 pc. on cabinet line of the chest freezer factory, and
- 1 pc. on door line of chest freezer factory.

We propose a layout so that special heating of the pipes for high viscose polyol compound can be avoided and that the pipes which contain cyclopentane can be reduced to the minimum distances.

B.32 11 areas of antistatic floor cover, one for each foaming line, in each foaming machine room and premixing room totally 1735 sq.m.

B.34 15 sets fire protection systems, one set for each foaming line, foaming machine, premixing room and tank filling station;

B.35 3 pcs. tank for cyclopentane with all necessary safety devices pressurized by nitrogen loading and feeding pump groups, one for each factory;

B.36 3 pcs. chillers, one for each PUR foaming machine group;

C. Refrigeration Service

C.1 22 pcs. HFC 134a service evacuation and charging boards for refrigeration service;

C.2 110 pcs. recovery bags for CFC 12;

C.3 11 pcs. stationary recovery units for CFC 12;

C.4 33 pcs. electronic leak detectors for HCF 134a;

C.5 Incremental spare part set.

2. Conversion/ Training

Within the framework of the project, personnel from ENIEM will be trained locally by the consultants and the machinery suppliers in (among others) the following areas:

- management and production control;
- quality control in relation to the conversion;
- operation of the new machinery and equipment;
- maintenance of the new machinery and equipment;
- refrigeration laboratory tests and performance optimization;
- new technologies for foam and refrigerant;
- specifications for material;
- safety regulations for flammable/explosive chemicals.

3. Model Redesign

It is foreseen that for all models redesign and reconstruction are required, followed by the manufacture of some prototypes and refrigeration performance tests. The major cost of this model redesigning has to be covered by ENIEM and only a small portion of the costs for these activities are included in the training component for technical staff, as well as in the international expert component.

PROJECT IMPLEMENTATION

The project will be implemented by UNIDO in close cooperation with The National Commission For Ozone. Local coordination will be carried out by ENIEM.

The project will include supply of equipment, installation, commissioning, training abroad and on-the-job training of ENIEM's staff. In order to guarantee a proper transfer in particular of the new foaming technology using the highly flammable and explosive cyclopentane, the selected contractor is requested to issue an "Operational Safety Statement".

For the operation of such technology using highly inflammable and explosive materials, a local authorization for the operation is needed and such lines have to be regularly controlled by the responsible local authority. The local authorities should be already involved in the stage of engineering of the plant to avoid that an installed expensive plant is not allowed to be started.

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

Any construction work needed to accommodate the equipment for the new foaming technology using cyclopentane will have to be carried out by ENIEM and is not reflected in the project budget. The specification for construction work will be elaborated by the selected contractor after project approval and as an outcome of his necessary site inspection.

As a common practice, modifications of the production lines will be carried out during evenings and off days, especially the yearly holiday period, and it should be tried as much as possible to reduce the losses in the regular production which can not be avoided because of the dimensions of the lines and their degree of automatization.

The proposed tentative work plan of the project implementation is as follows:

TIME SCHEDULE

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

1.  Sign the project, receive funding       X
2.  Make a detailed project work plan       X
3.  Initial training  of management           X

FOAM:

4.  Selection of equipment                   XXXXXXX
5.  Authorization by  local authorities        X         X          XXX
6.  Training                                               XX     XXX
7.  Manufacturing of equipment,                     XXXXXXXXXXXXXXXXXXXX
    installation, commissioning
8.  Start production                                                     X

REFRIGERANT:

9.  Redesign of models                       XXXXXXXXXXXXXXXXXXXXXXXXXX
10. Training                                   X
11. Selection of equipment                   X
12. Purchase, installation                     XX             XXXX
    and commissioning
13. Prototypes and testing                       XXXXXXXXXXXXXXXXXXXXXX
14. Start production with HFC 134a                          XXXXXXXXXXXX

Refrigeration Service:

15. Selection of equipment                     X
16. Purchase, installation commissioning       XXX              XX
    and training
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It is estimated that after 18 months the complete conversion of the factory will have been carried out. But the redesign of all the refrigerator and freezer models, the testing, optimization and prototyping can take up to 24 months, so that one of the 3 factories probably has to continue to produce CFC 12 refrigerators after the 18 months and will be converted when the last refrigerator model redesign and prototypes are optimized which should take place inside of 2 years only, if possible, within the 18 months.

PROJECT COSTS

I. INVESTMENT COSTS

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

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	0,13
- Condenser modification	0,50
- Evaporator modification	1,00
- 3AA drier	0,15
- HFC 134a refrigerant	0,60
- Extra polyurethane foam because of higher density minus lower refrigerant price	2,52
Total	9,90

The above prices show the difference between the component prices for CFC 11 and CFC 12 and component prices for HFC 134a and cyclopentane.

ENIEM has requested higher price differences, especially for the compressor, which can be reduced to the above-mentioned prices if the cooling system is optimized by high efficiency evaporators and condensers which is cheaper than to only increase the power of the compressor. This will also reduce the energy consumption of the refrigerators and freezers.

All prices are without customs duty and tax.

The price increase will be caused by:

- Compressor for the new HFC 134a compressor and for a one size bigger compressor (to cope with the lower capacity at low evaporating temperature, but no heavy duty compressor, coping with significant voltage fluctuations), averaging to +10%;

- Capillary tube prolongation and changes (average plus US $0,13);

- Evaporator and condensers in the average 1-2 coils or 1-2 serpentines larger reduction of pitches, increase of condenser files to increase the total surface by about 10%, averaging cost increase of US $1,00 for the evaporator respective US $0,50 for the condenser in comparison to the ones used for CFC 12;

- HFC 134a charge (because of 16% less charging of R134a per volume in comparison to R12 plus increase of cooling system volume because of increase of condensers and evaporators) = about 9% less than with CFC 12 based on an average charge weighted by the produced quantities of 0,185 kg CFC 12 at US $2,00/kg as a current price and a current price for HFC 134a at US$ 5,75/kg, excluding any customs tax):
  Present use: 0,185 kg x 0,91 x US $2,00 = US $0,37
  Future use: 0,185 kg x 0,91 x US $5,75 = US $0,97
  The difference is US $0,60.

Comparative cost analysis of foam system:

R11 system				Cyclopentane system			
Chemicals	Weight %	Price $/kg	Cost US$	Chemicals	Weight %	Price $/kg	Cost US$
Polyol+ MDI	86	1,819	1,564	Polyol + MDI	94	2,01	1,889
R11	14	1,70	0,238	c-pentane	6	1,73	0,104
		Average:	1,802			Average	1,993

PUR cost US$/kg	1,802	PUR costs US$/kg:	1,993
Kg per unit:	7,500	Kg per unit:	8,050
Total costs US$/unit:	13,515	Total costs US$/unit:	16,044

Incremental cost difference: US $2,52.

The price of CFC 11 at US $1,70 per kg is surprising. ENIEM has recently purchased CFC11 has this price from India and the expert of UNIDO checked this prices and found that the South Eastern producers entered in the North African and Middle East market after the strong increase of such products in Europe and the USA.

The operation cost of the enterprise after the conversion is not expected to change much: 8 more experienced men with higher wages (8 persons at US $25,000 each per year) minus 3 persons with lower wages (US $13,000 per person) because more complicated machines and safety precautions will increase the annual costs for the 3 factories by US $161,000 per year.

So the total incremental operating cost increase for the production annual of 320,000 refrigerators and freezers in the first year will be (320,000xUS $9.90)+(US $161,000) for a total of US $3,329,000. For a half years coverage, according to the decisions of the Multilateral Fund, incremental operating cost of US $1,669,500 are included in the project.

Costs for transport and insurance of capital equipment are included in the budget allocations for the respective items.

III. CONTINGENCY FUND

A contingency fund (10% of the total budget) is included in the funding requested from the Multilateral Fund.

Because of the high automatization of the lines in the R2 factory, such a contingency fund is requested to cover unforeseen expenses caused by complicated high integrated and high speed processing of the production.

IV. TOTAL COSTS

- Investment cost, (Annex A: "Equipment Specification and Cost Breakdown").
- The net incremental operating cost as above.
- Executing agency's overhead cost are (13%).
- For the complete cost breakdown (Annex B: "Project Budget").
- For the calculation of the unit abatement cost (Annex C: "Unit Abatement Cost").
- Requested funding by the MFMP:

US $7,542,810

Annex A: Investment with Equipment Specification and cost Breakdown

	Description	Qty.	Unit cost US$	Total cost US$
A. Refrigeration System:				
A.1	Charging board for HFC 134a	6	21,000	126,000
A.2	Refrigerant supply pumps	2	7,800	15,600
A.3	Vacuum pump (63 renovations)	63	100	6,300
A.4	Pump stations on carriage	3	7,000	21,000
A.5	Production leak detector for HFC 134a Inficon HLD 4000A	10	4,500	45,000
A.6	Production leak detector for HFC 134a ECOTEC 500	2	28,000	56,000
A.7	Test equipment for prototypes	1 set	50,000	50,000
A.8	Vacuum control (for existing pumps)	63	70	4,410
A.9	Prototype Material	10 sets	1,000	10,000
	Sub-total			**334,310**
B. Foam System:				
B.1	New high pressure foaming machine for R1 cabinet line (excluding mixhead)	1	160,000	160,000
B.2	Mixhead for R1 cabinet line	2	25,000	50,000
B.3	PUR filling system for R1	1	15,000	15,000
B.4	High pressure foaming machine for R2 cabinet line (excluding mixhead)	3	160,000	480,000
B.5	Modification of mixhead for R2 cabinet line and nitrogen handling and electricals	6	5,000	30,000
B.6	High pressure foaming machine for R2 door line (excluding mixhead)	2	160,000	320,000
B.7	Modification of mixheads for R2 door line and nitrogen handling and electricals	4	5,000	20,000
B.8	High pressure foaming machine for chest freezer factory (excluding mixhead)	1	160,000	160,000
B.9	Modification of mixheads for chest freezer factory and nitrogen handling	4	5,000	20,000
B.10	Premixing	3	60,000	180,000
B.11	Gas detector system	3	70,000	210,000
B.12	Infra-red gas sensors	50	1,500	75,000
B.13	Foam test equipment	3 sets	1,000	3,000
B.14	Exhaust and ventilation system for R1 cabinet line	8	5,000	40,000
B.15	Exhaust and ventilation system for R2 cabinet line	1 set	45,000	45,000
B.16	Exhaust and ventilation system for R2 door line	1 set	45,000	45,000

B.17	Exhaust and ventilation system for chest freezer cabinet line	5	5,000	25,000
B.18	Exhaust and ventilation system (chest freezer door line)	5	5,000	25,000
B.19	Exhaust and ventilation system for 4 foaming machines	4	5,000	20,000
B.20	Exhaust and ventilation system for 3 premixing stations	3	5,000	30,000
B.21	Modification of the R1 cabinet foaming jigs	8	9,000	72,000
B.22	Modification of the R1 cabinet foaming plugs	8	3,000	24,000
B.23	Modification of R2 cabinet foaming jigs	63	9,000	567,000
B.24	Modification of R2 cabinet foaming plugs	112	3,000	336,000
B.25	Modification of R2 door foaming jigs	25	9,000	225,000
B.26	Modification of chest freezer cabinet foaming jigs	5	3,000	15,000
B.27	Modification of chest freezer cabinet foaming plugs	10	3,000	30,000
B.28	Modification of chest freezer door foaming jigs	5	12,000	60,000
B.29	Pumps, pipe work for filling of tanks	3	11,000	33,000
B.30	Pumps, pipe work from tanks to premix	3	9,000	27,000
B.31	Pumps, pipe work from premix to foaming machines	4	8,000	32,000
B.32	Pumps, pipe work from PUR machine to mixheads	9	12,000	108,000
B.33	Antistatic floor	$1735m^2$		15,000
B.34	Fire protection system	15 sets	9,000	135,000
B.35	Tank for cyclopentane			
	- in R1 and chest freezers factory	2	30,000	60,000
	- in R2 factory	1	30,000	30,000
B.36	Chiller	3	11,000	33,000
B.37	Materials for starting up (10 sets of 10 models each of US $300)	10x10	300	30,000
	Sub-total			**3,785,000**
C. Refrigeration Service:				
C.1	Charging board for service	22	1,100	24,200
C.2	Recovery bags for CFC 12	110	18	1,980
C.3	Recovery unit for CFC12	11	1,500	16,500
C.4	Electronic leak detector for R 134a	33	250	8,250
C.5	Incremental spare parts	1 set	1,500	1,500
	Sub-total			**52,430**
	Subtotal (groups A+B+C)*			**4,171,740**

* The following equipment and installation work are not included in the budget:

(a) Pre-heating ovens for foaming (existing);

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

(c) Tank and installation for pipe lines for HFC 134a to the charging boards.

(d) Any building work (inside and outside) for the installation of the tank and the premixing station for cyclopentane.

(e) Any special place for the truck for cyclopentane tank.

(f) Any change of lay-out in factory which requires to changing the position of the machinery and equipment as well as new installation of the old equipment.

(g) Steel construction for floor for new foaming equipment.

Tax & Custom Duty are not included in the prices for the machinery and will not be covered by this project.

Specification for Machinery

A. Refrigeration System:

A.1 - Evacuation and charging board for HFC 134a for production.
Fully automatic board with vacuum check
2 stage vacuum pumps $8m^3/h$
4 charging channels - built-in supply pump
Refrigerant: HFC 134a
Charges: Min 50g - Max 2,200g +/- 1% or 1g

A.2 HFC 134a feeding pump

A.3 - Vacuum pump renovation
Min capacity $8m^3/h$
Time for evacuation to vacuum level for the appliances
Max 15 minutes
Maximum limit of non-condensable gases 1% (vol) after evacuation

A.4 - Evacuation station on carriage

A.5 - Leak detector for production for HFC 134a
Type HLD 4000 A
Sensitivity range: 0.5 to 150g/year.
Microprocessor controlled.
Calibration gas: HFC 134a
Calibration: Automatic by the incorporated leak standard

A.6 - Leak detector for higher speed production for HFC 134a
Type ECOTEC 500
Speed: < 1 sec.
Sensitivity range: 0,1g to 10000g/year
Microprocessor controlled;
Calibration: Automatic

A.7 - Test equipment for Performance Test for HFC 134a
The test equipment is completed by:
(a) Pressure transducers for HFC 134a for suction and discharge pressure range +/- 0.005 bar
(b) Materials for prototypes
(c) Computerized refrigerator test recorder with PC, registration program, temperature interface and 2 feelers, humidity interface and feeler, printer
(d) Performance test materials according to ISO 7371
(e) Service charging board for HFC 134a
(f) Service leak detector for HFC 134a

B. Foam System:

B.1 - B.4, B.6, B.8 - The existing 7 high pressure foaming machines have to be replaced (1 machine) or rebuilt (6 machines) for cyclopentane and the polyol sections have to be completely replaced. Some safety devices (pressure control) even in the isocyanate section have to be added so that at the end each machine comprises the following assemblies:

- 1 pc. Special metering pump for polyol-pentane, in corrosion-proofed design, suited for a pre-pressure of 10 bars, nominal output 40 l/min., special shaft sealing and leakage monitoring device.
- 1 pc. Metering pump nominal output 40 l/min. for isocyanate.
- 1 pc. Pump motor (s) for polyol and Isocyanate pump.
- 1 pc. Hydraulic unit with 2 accumulators, valves, accessories and cooling.
- 2 pcs Leakage-free special filter systems.
- 1 set Contact pressure gauges with min./max. contacts.
- 1 set Safety valves and throttles valves.
- 2 pcs Removable, large-sized leakage basin inside the machine frame.
- 1 set Tubes and flexible lines to mixheads.

Throttle-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 (with 2-component)
1 Device for checking the switching function of the Isocynate-mixhead nozzle (a Polyol-pentane mixing as single component is not possible)
1 Flow sensor for nitrogen-gas for inertizing

PUR tank stations consisting of:

- Work tank, special design suitable for pentane, size 500 l, operating pressure up to 10 bar for polyol/pentane mixture, double-walled for temperature control with unpressurized water, inner shell made of stainless steel with stirrer driven via coupling and motor (no stirrer shaft seal), filling level sensor for continuous measurement, filling level sensor for preventing overfilling, 1 set of fittings and accessories for connecting nitrogen supply, 2 pneumatically driven self-closing safety ball valves with solenoid valves, non-return valve 10 bar, firmly set, safety valve, adjustable, for limiting the rise of tank pressure during refilling.

  Tank design in compliance with the regulations valid in one of the developed countries with the highest safety standards, delivered with a test certificate like TUV.

  - In the case of the R1 factory a second standard double wall tank for Isocyanate is requested.

  - **Temperature control device of special design for polyol/pentane** for raw material temperature control via the double jacket of the work tank; with electr. heating of 5kW and 1 cooling system for direct cooling by means of cold water of about 14°C produced by a chiller, as cold water is not available in this country at all times of the year.

  - **System for automatic transfer from the premixing station polyol/blowing agent mixture.** The filling level is measured and displayed by a sensor (component of tank). When the set min. filling level has been reached, the premixing machine is started and the filling valve of the work tank is opened.When the set max. filling level has been reached, the replenishing procedure is finished. The filling process is monitored. When the overfilling sensor is reached/responds, the replenishing procedure is also interrupted and a signal is given. This filling control has interfaces for a superior safety control and corresponds to the valid regulations of developed countries.

Refrigerating machine for re-cooling the water for the temperature control devices. Designed as air-cooled compressor unit with a cooling capacity of about 17 MJ/h (= about 4000 kcal/h) - at an ambient temperature of about 30°C (43°C max.)

B.10 - **Premixing station** for automatic metering and mixing of polyol with pentane. The pre-mixing station is a metering device for the production of polyol/pentane mixture with a constant mixing ratio which can be preselected. The premixing station operates according to the principle of difference metering.

The pentane throughput is precisely recorded and documented by means of a mass flow meter; the polyol throughput by means of a gear-type flow meter. The mixing of the component streams meeting each other takes places by static mixing elements. The tightness of the system towards the outside is obtained by the design and the use of suitable construction elements; in order to avoid corrosion by hydrous polyols, all component-contacting parts are corrosion-resistant. Only sealing materials with proven resistance to polyol, pentane and nitrogen can be used.

All connecting pipelines made of special steel; with special screw connections. As secondary safety equipment, the Premixing station has to include an overall casing with an exhaust socket (DN 100) - in the lower third of the back wall - for connecting a run-controlled fan to be provided separately (below); design, for example, in accordance with VDMA regulation 24169, part 1;

- **Electric control system for the PUR machine**

By means of this electric control, given rated values are automatically monitored and kept constant in a closed control circuit within given limit values.

Control, data entry and display of relevant parameters are effected via PC compatible control computer with LCD display.

Control:

- On and off switching motors and valves on and off as well as corresponding monitoring functions
- Pressure monitoring (contact pressure gauges),
- Switching the machine off in case limit values are exceeded
- Error message: optical and acoustical fault indication, message in plain language on the LCD display

Operation modes:

(a) Automatic operation
(b) Manual operation
(c) Test operation

In general:

- Adjustable blowing agent portion	4-25 vol %
- Necessary polyol entry pressure	min. 4 bar, max. 10 bar
- Necessary pentane entry pressure	min. 3 bar, max. 10 bar
- Exit pressure of mixture	max. 15 bar
- Compressed air supply	min. 5 bar
- Polyol viscosity	max. 10,000m Pas

The connecting line from Premixing station to work tank (polyol-pentane-mixture) has to be designed for an operating pressure of 60 bar.

Output of basic polyol min.	9,2 l/min.
Drive	N = 1,1, kW
Output of blowing agent:	
- continuously adjustable -	0,36 to 2,3l/min.
Drive of tandem pump	N= 1,1, kW

B.11 - Gas detector system with control board for gas sensors and air flow controls (pressure switches) of fan motors
Number of infrared gas sensors: 25 pcs
(Combustible gas sensors are not sufficient because of frequent alarm failures).
Number of pressure switches: 35 pcs
Flammable limits: In air 1.4-8%

B.13 - 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
Freezers to measure dimension stability are existing

B.14-
B.20 - Exhausting and ventilation in different dimensions
Capacity: 2 steps a min. 4000 m^3/h and min 8000 m^3/h
Air change: 53 times per hour
Total capacity: Min 16000 m^3/h
Ex-proof or placed outside O-Zone.
For the 2 carousel exhausts and ventilations in the R2 factory air-lock fans are needed.

B.21 - Foaming cabinet jigs modification
Electrical heating elements and all electric components have to be replaced with ex-proof ones or automatically disconnected in time of foaming.
Earth connection of jigs.
Gas venting profiles with connectors to exhaust system.

B.23 - Foaming door jigs modification
Electrical heating elements and all electric components have to be replaced with ex-proof ones or automatically disconnected in time of foaming.
Earth connection of jigs.
Gas venting profiles with connectors to exhaust system.

B.29-
B-32 - Different pipe and pump installations for cyclopentane and polyol/cyclopentane mixtures with double wall tubes, leak control, built-in SD valves for separation into sectors, ex-proof pumps between:
- filling place and tanks (3 sets)
- tank and premix (3 sets)
- premix and PUR machine (4 sets)
- PUR machines and mixheads (9 sets).

Single wall tubes between nitrogen tanks and 9 mixheads, 3 cyclopentane tanks, 4 polyol/cyclopentane tanks (16 sets).

B.33 - Antistatic floor
Painting of floor in foaming area with antistatic paint

B.34 - Fire protection systems
Foam spray system for polyurethane chemicals and cyclopentane according to local regulation

B.35 - Tank for cyclopentane
40 m^3 capacity, made of double wall stainless steel
Pressure: 7 bar
Insulation of tank
Valves and fittings for connection
Connection for nitrogen pre-pressure
Pumps and Pipe work for cyclopentane tank
2 pcs. double pumps ex-proof of which one is only used during repair works of the other
Level control for tank with shut-down valve,

The 2 pcs gas are detectors connected to the gas detector system of the PUR machine respective premixing (R2)
Pump for tank for loading at tank
Level control at leak container for cyclopentane

B.36 - Chiller
Cooling range: 0-15°C
Pump capacity: about 6000 ltr/h
Circulation medium: water
Cooling capacity: 15 kW

C. Refrigeration Service:

C.1 - Service evacuation and charging board for HFC 134a manually operated
2-stage vacuum pump
Refrigerant: HFC 134a
Charge: 50g to 500g +/- 5g
Hose connection with quick connectors

C.2 - Recovery bags for CFC 12 with valve to be connected to the existing service evacuation and charging boards of CFC 12.

C.3 - Recovery unit for CFC 12 to empty the recovery bags
Type: Refco Fest

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

Annex B: Project Budget

Budget line	Description	Duration w/m	Budget US$
	General consultancy		
	Chief technical advice with experience in production layout, refrigeration production and refrigeration system design as well as the changes in construction because of changing the foaming position	20.0	**60,000**
	Checking/Ex-proofing of PUR machine, tanks, pre-mixing and foaming places	6.0	**20,000**
	- Antistatic floor, safety training of ENIEM's staff (two weeks, two specialists)	4.0	
	Local subcontract for provision of:		**305,000**
	- 3 tanks for cyclopentane	90,000	
	- 19 sets of pumps, pipe work for cyclopentane/ polyol,	200,000	
	- 1735 m^2 of antistatic floors including installation and commissioning of the system (two weeks, two specialists)	15,000	
	Local subcontract for provision of:		**135,000**
	- 14 sets of fire protection system including equipment installation, training and commissioning of the system (2 weeks, two specialists)	4.0	
	Subcontract for provision of:		**230,000**
	- 27 sets of exhausting and ventilation including equipment installation and commissioning of the system (one week, two specialists)		

A. Refrigeration System:

- **Machinery:**		**356,310**
- 6 pcs Charging board for HFC 134a	126,000	
- 2 pcs Refrigerant supply pumps	15,600	
- Vacuum pump (63 renovations)	6,300	
- 3 pcs Pump station on carriage	40,000	
- 10 Production leak detector for HFC 134a Inficon HLD 4000A	45,000	
- 2 Production leak detector for HFC 134a ECOTEC 500	56,000	
- Vacuum control (for existing pumps)	4,410	
- 10 sets Prototype Material	10,000	
Equipment installation, commissioning and local training (4 weeks, 1 specialist)	22,000	
Test and monitoring equipment	50,000	

B. Foaming System:

- **Machinery; service and starting up**		**3,385,000**
- 1 High pressure foaming machine for R1 cabinet line	160,000	
- 2 Mixheads for R1 cabinet line	50,000	
- 1 PUR filling system for R1	15,000	
- 3 High pressure foaming machine for R2 cabinet line	480,000	
- Modification of 6 Mixheads for R2 cabinet line and nitrogen handling	30,000	
- 2 High pressure foaming machines for R2 door line	320,000	
- Modification of 4 Mixheads for R2 door line and nitrogen handling	20,000	
- 1 High pressure foaming machine for chest freezer factory	160,000	
- Modification of 4 Mixheads for chest freezer factory and nitrogen handling factory	20,000	
- 3 Premixing stations	180,000	
- 5 Gas detector system	210,000	
- 50 Infrared gas sensors	75,000	
- 3 sets Foam test equipment	3,000	
- Modification of the 8 R1 cabinet foaming jigs	72,000	
- Modification of the 8 R1 cabinet foaming plugs	24,000	
- Modification of the 63 R2 cabinet foaming jigs	567,000	
- Modification of the 112 R2 cabinet foaming plugs	336,000	

- Modification of the 25 R2 door foaming jigs	225,000	
- Modification of the 5 chest freezer cabinet foaming jigs	15,000	
- Modification of the 10 chest freezer cabinet foaming plugs	30,000	
- Modification of the 5 chest freezer door foaming jigs	60,000	
- 3 pcs Chiller	33,000	
- 40 sets Materials for starting up (10 sets of 10 models each at US $300)	30,000	
- Project sites preparation, engineering and civil works related to equipment installation, start-up, commissioning and training of local personnel	270,000	

C. Refrigeration Service

- **Machinery**		**59,190**
- 22 pcs Charging board for service	24,200	
- 110 pcs Recovery bags for CFC 12	1,980	
- 11 pcs Recovery unit for CFC12	16,500	
- 33 pcs Electronic leak detector for R134a	8,250	
- 1 set incremental spare parts	1,500	
including equipment installation, commissioning and training (1 week, 1 specialist)	6,760	
Subtotal		**4,550,500**

Miscellaneous:

Contingency Fund (10% of the costs of all equipment, services and operating incremental costs calculated)		**455,050**
Subtotal I		**5,005,550**
Incremental operating cost (half year of operation)		**1,669,500**
Subtotal II		**6,675,050**
Agency's Overheads (13% of all)		**867,760**
TOTAL	US$	**7,542,810**

Refrigeration Service

By investment in recovery units, it will be possible to reclaim about 50% of the used CFC 12 from the refrigerators and freezers servicing, if a central reclaiming station is established in Algeria.

ENIEM's service organization is expected to service about 1% of all refrigerators serviced in Algeria in its service centers and 80% of all refrigerators serviced will be serviced in shops licensed by ENIEM with an average CFC 12 refrigerant charge of 0,208kg CFC 12; but not all need recharging.

Annex C: Calculation of Unit Abatement Cost:

A	ODS Phase out		Total Project
A1	Average use of CFC 11 per year MT	MT	353
A2	ODP of CFC 11		1
A3	ODP-weighted CFC 11 phased out (A1*A2)	MT	353
A4	Average use of CFC 12 per year plus service	MT	69 +3,4
A5	ODP of CFC 12		1
A6	ODP weighted CFC 12 phased out (A4xA5)	MT MT	69 +3,4
A7	Total ODP-weighted phased out	MT	425,4
B	Annualized capital cost		
B1	Total investment cost (model redefinition + production conversion)	US $	6,675,050
	Equipment life	Year	10
B3	Discount rate	%	10
B4	Annualized capital cost (B1x0.1627)	US $	1,086,031
C	Annual incremental recurrent cost (1/2)	US $	1,669,500
D	Unit Abatement cost		
D1	Annualized capital cost per kg ODS phased out (B4/(A7x1000)	$/kg	2.55
D2	Annual 1/2 incremental recurrent cost per ODP phased out (C/A7x1000)	$/kg	3.92
D3	Unit abatement cost (D1+D2)	$/kg	6.47

Annex D: Cleaning Technology for Vacuum Pumps

If vacuum pumps which have been used for evacuating of CFC 12 systems have to be used for HFC 134a refrigeration systems, it is possible to clean the pumps and use them, if:

(a) the vacuum pump is in good condition; and
(b) the vacuum pump has a minimum capacity of $8m^3$/hour.

Cleaning process

1. Replace the hose from the vacuum pump to the connector (Hansen coupling) for the service tube of the compressor (or filter) with a new one;

2. The connector (Hansen coupling) can still be used for HFC 134a refrigerator system;

3. Load the vacuum pump with about 50 cm^3 Ester oil via the hose and start the vacuum pump. Let it run for 30 minutes;

4. Empty the vacuum pump of the used Ester oil and charge it again with 50 cm3 Ester oil;

5. Start the vacuum pump and let it run for another 30 minutes;

6. Empty the vacuum pump for the second time and recharge it with 50 cm^3 of Ester oil;

7. Start the vacuum pump for the third time and let it run for 30 minutes;

8. Empty the vacuum pump and now it is ready for use in HFC 134a refrigeration systems;

9. Connect the vacuum pump to an HFC 134a refrigeration system and evacuate the system down to the specified vacuum level;

10. Connect the refrigeration system to the HFC 134a charging board and re-evacuate. Charge again with the specified amount of HFC 134a;

11. Start the compressor and let the system run for about one hour.

    If some mineral oil or chloride is still left in the vacuum-pump on the suction side, it will be transferred to the HFC 134a refrigeration system and the capillary tube will be blocked after few minutes.

Note: After the vacuum pump has been washed with Ester oil, it should only be used for HFC 134a refrigeration systems.

WS Atkins Consultants Ltd.
Technical Review - Refrigerator Project

1. Country of Origin — Algeria

2. Project Title — Investment Project for Phasing out CFC's at l'Entreprise Nationale des Industries de l'Electromenager (ENIEM)

3. Sector/sub-sector — Domestic Refrigeration/Rigid Foam

4. Relationship to Country Programme

The project is the only domestic refrigerator project mentioned in the Country Programme

5. Technology

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

This combination is becoming standard for W.European and Japanese refrigerator manufacturers.

b) The technology is not transitional; ODP of both substances is zero.

No foreign company is identified as a source of technical expertise either for the foam or refrigeration part. Henneke will supply the foam equipment; refrigerator circuit modification will be carried out with specialised consultant help.

6. Environmental Impact

a) Both Cyclopentane and HFC-134a have zero ODP

b) The proposal contains adequate description of safety training but makes no reference to Algerian safety or environmental regulations. The local regulations regarding VOC's (Volatile Organic Compounds) should be given. The project needs to show that these regulations are being met.

c) Safety equipment is described in detail. However other safety issues such as local regulations governing hydrocarbon use and safety management after project implementation are not.

The OORG Foams committee have made the following conditions for acceptance of Cyclopentane projects:

i) 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 entity concerned confirming their willingness to advise on safety issues and provide ongoing support in this area following project implementation.

ii) That a clear safety management plan be devised. This involves identifying a safety team who have the right to carry out surprise safety checks and close down production without reference to management. This should be headed by an executive at director level whose normal duties do not involve production.

7. Project Costs

a) Costs are not supported by suppliers' quotations. Three are normally required for each major equipment piece. In general costs seem reasonable and are carefully presented (though duplicated for some reason) and correlated with a description of the equipment concerned. However the following seems high and require further justification:

i) Foaming machines.

It is not clear what machines are being replaced and which are being retrofitted. In one part the text states that only one is being replaced (R-1) and six are being retrofitted, yet costs for several foaming machines appear in the list of costs ($160,000). If these are retrofitting costs, they are thought to be high.

ii) The description of the ECOTEC leak detector reads as if production facilities are being upgraded for no good reason. This should be justified more carefully.

iii) The test equipment should be described

iv) The condenser cleaning station should be described. The operations described would not on the face of things justify equipment costing $100,000.

v) Modification of the R-2 factory production lines should be supported by contractors' quotes.

vi) The largest single costs element is modification of foaming jigs and plugs. The description should state exactly what is involved and support this with a suppliers' quotation. The unit price discrepancy between these items for factory R-1 and R-2 should be explained.

b) Incremental Operating Costs

i) The incremental compressor price is (at 20% of CFC-12 compressor) slightly high. The need for a larger capacity compressor needs explanation.

ii) Unit costs given for modification of evaporator and condenser seem high. Optimising a refrigerator circuit is a complicated business. Are the proposers sure that these costs are realistic? Note that OORG Refrigeration Chairman Dr. L. Kuipjers makes no allowance for heat exchanger modifications in his 6th. June paper "Development Status and Cost Aspects of Alternative Refrigerants for Domestic Refrigeration".

c) Consultancy Costs

These are reasonable given the absence of a refrigeration technical partner.

d) Scrap Value of Existing Equipment

This issue has not been addressed. This should be estimated and subtracted from the project costs.

8. Cost Effectiveness

The UAC using 6 months Incremental Operating Costs are $10.27/kg. Calculated using 4 years (the standard method), the UAC is about $31/kg, but still of the right order for a medium sized Article 5 country producer ($35.4/kg given in L. Kuipjer's paper mentioned above).

Thus the project can be considered environmentally cost effective.

9. Implementation Time

The proposed time frame is reasonable

10. Recommendation

Approval providing the equipment cost issues are addressed..