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

Thirteenth Meeting
Montreal, 25-27 July 1994

PROJECT PROPOSALS: JORDAN

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

- Phasing-out ODS at National Refrigeration Co.;
- Phasing-out ODS at Middle East Electrical Industries Co. Ltd.;
- Phasing-out ODS at the Household Appliances Manufacturing Co.

PROJECT EVALUATION SHEET

COUNTRY OR REGION:	The Hashemite Kingdom of Jordan
PROJECT TITLE:	Phasing out ODS at the 1) Household Appliances Manufacturing Co. Ltd. (HAMCO) 2) Middle East Electrical Industries Co. Ltd. (MEEI) 3) National Refrigeration Co. (NRC)
BUDGET:	Capital costs HAMCO US $720,830 MEEI US $802,362 NRC US $757,841 Operational costs[1] HAMCO US $54,772 MEEI US $80,791 NRC US $56,046
INCREMENTAL COSTS:	HAMCO US $775,602 MEEI US $883,153 NRC US $813,887
ODS PHASE-OUT:	HAMCO: 16 MT of CFC-11 & 5.2 MT of CFC-12 MEEI: 12 MT of CFC-11 & 4.6 MT of CFC-12 NRC: 11 MT of CFC-11 & 3.3 MT of CFC-12
COST EFFECTIVENESS[2]:	HAMCO: US $36.59 per kg ODP saved MEEI: US $53.20 per kg ODP saved NRC: US $56.92 per kg ODP saved
PROJECT DURATION:	18 months for all the three companies
IMPLEMENTING AGENCY:	UNIDO
NATIONAL COORDINATING AGENCY :	Ministry of Municipal, Rural Affairs and the Environment (MMRAE)
TECHNICAL REVIEW COMPLETED:	YES _X_ NO _

[1] Calculated for six months of operation.

[2] Determined as the ratio of incremental costs to the estimated annual saving of ODP ($/ODP$_{kg}$).

SECRETARIAT'S COMMENTS

1. Three projects are addressed together in these comments (See endnote 1 for a list of the projects).

2. Implementation of the three projects will result in an estimated annual phase-out of 39 MT of CFC-11 and 13.1 MT of CFC-12. It represents the total annual ODS consumption in the domestic refrigerator sector in Jordan.

3. The three projects were submitted for consideration of the Twelfth Meeting of the Executive Committee. The Executive Committee gave UNIDO permission to proceed. UNIDO has analyzed the technology choice and incremental capital and operational costs with the Government of Jordan and individual enterprises in consultation with the Secretariat. The issues raised by the technical reviewer and the Secretariat regarding eligibility of costs of some equipment, possibility of modification of existing equipment, incremental operational costs were properly addressed.

4. The replacement alternatives chosen by the three companies are cyclopentane as foam blowing agent and HFC-134a as refrigerant. Projects include the redesign of all current refrigerator models and the conversion of the plants. The conversion of the production facilities at the three plants will cover the refrigeration system, insulating foam blowing system as well as the refrigeration service carried out by the three companies. Cyclopentane and HFC-134a technologies are ultimate conversion solutions. The three projects will be implemented within 18 months.

5. 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.

6. 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. The companies accepted six month duration of operational costs. The Secretariat submitted a policy paper on the impact on the Fund of various operational cost durations in the domestic refrigeration sector. The operational cost durations will be an issue of discussion at the Thirteenth meeting of the Executive Committee.

7. A new HFC-134a compressor could be made available from other sources of supply at a much lower price. The Secretariat and UNIDO are of the opinion that incremental operating costs are likely to decrease during the coming two years and maybe sooner. The incremental operational costs will be incurred only after the full production of a new product is started, i.e. 18 months from the time funds are received.

8. For the refrigeration service, one-third of the requested evacuation and charging boards and leak detectors for HFC-134a is retained on the assumption that it will take a few years before the HFC-134a refrigerators will be available in sufficient number to warrant the requested number of service units.

SECRETARIAT'S RECOMMENDATIONS

9. The Fund Secretariat recommends approval of the three projects and approval of capital costs as follows:

US $720,830 for the Household Application Manufacturing Co. Ltd.
US $802,362 for the Middle East Electrical Industries Co. Ltd.
US $757,841 for the National Refrigeration Company.

10. The approval of incremental operational costs at US $191,609 for three companies is contingent on a decision from the Executive Committee regarding the duration of operational costs.

11. UNIDO is requested to reassess the incremental operational costs on the basis of market prices prevailing at the time when actual costs are incurred. UNIDO is further requested to report back to the Executive Committee on the costs incurred. Agency overhead costs should be adjusted accordingly.

Endnote

JORDAN

Project	Installed Capacity Units/yr.	Actual Output Units/yr.	ODS Phase Out MT/yr.	Capital Costs (US$)	Operational Costs US $
HAMCO	30,000	11,065	21.2	720,830	54,772
MEEI	50,000	20,000	16.6	802,362	80,791
NRC	30,000	11,824	14.3	757,841	56,046
TOTAL	110,000	42,889	52.1	2,281,033	191,609

PROJECT COVER SHEET

Country:	The Hashemite Kingdom of Jordan
Project Title:	**Phasing out ODS a the National Refrigeration Co., Jordan**
Sectors Covered:	Domestic Refrigeration /Rigid Foam/Refrigerant
ODS Use in Sector (1990):	47 mt of CFC 11 and CFC 12
Project Impact :	Phase out of annual consumption of 11 mt CFC 11; 3 mt CFC 12 in the production and a gradual phase out of currently used 0.3 mt CFC 12 in the service sector (Total ODP = 14.3)
Project Duration:	18 months
Project Economic Life:	10 years
Total Project Cost:	US$ 856,742 (Total of capital cost and incremental operating cost for six month of operation)
Capital Cost:	US$ 792,289
Incremental Operating Cost:	US$ 64,453 (six month of operation)
Implementing Agency's Overheads (13%):	US$ 128,511
Proposed MF Financing:	US$ 985,253
Cost Effectiveness:	See Annex D: Unit Abatement Cost
Counterpart Enterprise:	National Refrigeration Co., Amman
Implementing Agency:	United Nations Industrial Development Organization (UNIDO)
Coordinating Ministry:	Ministry of Municipals, Rural Affairs and the Environment (MMRAE)

PROJECT SUMMARY

This project will phase out 100 percent of the use of CFC 11 and CFC 12 for the production of refrigerators and freezers at National Refrigeration Co., Amman, The Hashemite Kingdom of Jordan. The chosen replacement alternatives are cyclopentane as foam blowing agent and HFC 134a as refrigerant. The project will include the redesign of all current refrigerator models and the conversion of the plant. The redesign of the existing refrigerator models covers activities like prototyping, testing, trial manufacturing and adaptation as well as reliability tests. The conversion of the production facilities covers the refrigeration system, insulating foam blowing system as well as the refrigeration service carried out by the company. The replacement alternatives and the time frame for phasing out the use of ODS will be in line with MMRAE's ODS phase out programme.

I. BACKGROUND

A. Sector Background

The subsector for domestic refrigerators and freezers in The Hashemite Kingdom of Jordan consists of 3 refrigerator factories who are responsible for 100 % of the ODS consumption of CFC 11 and CFC 12 in the subsector.

The Hashemite Kingdom of Jordan does not produce any ODS. All ODS used in the country are directly imported by the users. In 1992 -1993, according to the Country Programme, the total annual consumption of the subsector was estimated to 34 mt CFC 11 and 13 mt CFC 12, totalling to 47 mt for the 42,000 units produced.

The total installed production capacity for refrigerators and freezers is about 100,000 units per year, but the present production is only about 42,000 units per year. The manufacturers expect an increase of about 10 percent per year.

In total about 500,000 refrigerators and freezers are in use in The Hashemite Kingdom of Jordan, of which about 3% will be serviced yearly and a part of them recharged during refrigeration service with CFC 12. Because of lack of environmental awareness, know-how and equipment in the service sector, service staff very often use CFC 12 for washing/flushing of the cooling systems, instead of using vacuum pumps and charging boards. This causes up to 200 percent excess CFC 12 consumption in the service sector reaching 3 mt annually.

Currently no Jordanian company manufactures low energy refrigerators and freezers with an insulation thickness of 40 to 50 mm for refrigerators and 90 mm to 100 mm for freezers.

B. National Refrigeration Co.'s Background

National Refrigeration Co. is a private company 100 % owned by Jordanian citizens. It employs 75 people (120 during summer months) and the installed annual production capacity is about 30,000 units based on the daily production rate of 75 to 120 units. In 1993 the actual production was 11,824 refrigerators and freezers in 10 different models.

In 1993 National Refrigeration Co. used about 7 mt of CFC 11 and 3 mt of CFC 12 in the production process and 0.5 mt of CFC 12 in the refrigeration service.

The Company produces 2 models of refrigerators with one door (8 and 14 cu.ft.), 2 models of two-door two temperature refrigerators (12 and 14 cu.ft.), 2 models of upright freezers (8 and 14 feet), 2 models of no-frost refrigerators (15 and 18 cu.ft.) and two models of chest freezers (6 and 10 cu.ft.).

National Refrigeration Co. (NRC) was the first to start refrigerator production in Jordan and currently it covers a share of about 20 to 25 percent of the local market.

The technologies and know-how currently applied were imported from Westinghouse, Canada based on a former license agreement, which is not valid any more. NRC has developed their own chest freezer models.

NRC is currently running one production line for foaming. The company has limited refrigerator design capabilities and simple refrigeration performance test facilities.

NRC's machinery and equipment for foaming, refrigeration and after sale service is as follows:

1 pc.	Canon Afross model C35 low pressure foaming machine.
1 pc.	mixer for polyol and CFC 11
2 sets	aluminium and wooden foaming moulds for all 10 models
2 pcs.	foaming jigs for freezers (chest models)
2 pcs.	foaming jigs for doors and lids
5 pcs.	foaming jigs for uprights
	Remark: All with electrical heating.
3 pcs.	vacuum pumps for 8 m^3/h
2 pcs.	vacuum pumps for 21 m^3/h
1 pc.	Airserco charging board
1 pc.	General Electric leak tester
	Remark: Plus 1 charging board and 1 leak tester as spare ones.
1 set	test room for 15 thermocouples.
1 pc.	mobile charging station for CFC 12 for after sale service.

National Refrigeration Co. has already recognized the need to be in compliance with the stipulations made in the Montreal Protocol and has agreed to participate in Jordan's ODS phase out programme.

II. PROJECT OBJECTIVE

The objective of this project is to eliminate the use of ODS such as CFC 11 and CFC 12 in the production of domestic refrigerators/freezers and in the refrigeration service at National Refrigeration Co. through conversion to the use of HFC 134a as refrigerant for the cooling system and cyclopentane as blowing agent for the polyurethane insulation foam.

III. PROJECT DESCRIPTION

National Refrigeration Co. is prepared to phase out ODS as soon as the new technologies have been acquired, the necessary machinery and equipment installed and the technical staff trained.

Among the technological options currently available on commercial basis and in line with the established policy of the Ministry of Municipals, Rural Affairs and the Environment to phase out the use of ODS, National Refrigeration Co. has chosen to replace CFC 12 by HFC 134a, because the new type compressors are available, and the technology is mature and commercially applied outside The Hashemite Kingdom of Jordan.

As blowing agent for polyurethane foam National Refrigeration Co. first has decided to use HCFC 141b but after the recommendation from MFMP they have agreed to avoid the use of any transitional substance and to introduce as ultimate solution cyclopentane.

Through the project assistance will be provided in:

a) Procurement of new machinery and equipment;

b) Rebuilding of presently used machinery and equipment wherever technically and economically feasible;

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

d) Installation, commissioning, trial operation, start-up and on-the-job training;

e) Servicing.

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

A. *Refrigeration System*

- The charging equipment and vacuum pumps must only be used for HFC 134a and in meeting the demand for cleaner and dryer cooling systems the existing charging equipment has to be replaced including the vacuum control.

- The charging boards have to be replaced by boards suitable for HFC 134a.

- Because the leak detectors react on Cl molecules, they need to be replaced.

- The currently used vacuum pumps, after being cleaned and connection hoses and gaskets being changed can also be used for HFC 134a.

- To optimize the cooling system for the application of HFC 134a and new specification for components used, performance tests for each model of refrigerator in an air-conditioned test room are needed. Therefore, a minimum specification of refrigeration test equipment needs to be provided (see Annex F: "Preliminary Specification of Refrigeration Test Equipment"). It is understood, that foam testing facilities cannot be financed by MFMP, as stated in the forthcoming para B: Foam System.

- To improve the performance of the cooling system and compensate for a little lower polyurethane insulation value due to the conversion to HFC 134a as the new refrigerant and cyclopentane for the foam, it is necessary to optimize the cooling system as well as the energy consumption to keep an acceptable TEWI value. Therefore, it is necessary to redesign, reconstruct and carry out performance tests for all redesigned models of refrigerators / freezers.

- The technical requirements for components such as tubes, condensers, evaporators, capillary tubes, heat exchangers 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 has to be equipped with 3 AA desiccant molecular sieves.

- The cooling system must not contain any chlorine and max. 1 % non-condensable gases.

- The capillary tube has to be optimized for an increased resistance at low evaporating temperatures.

- It will be necessary to train National Refrigeration Co.'s manufacturing and service technicians at the equipment suppliers' place in new foaming technology as well as in design/calculation and performance testing of cooling systems. During the installation and run-in of the new machinery and equipment the suppliers engineers will have to train National Refrigeration Co.'s technical staff.

B. ***Foam System***

- In order to achieve an acceptable foam quality and insulation value at lowest price, high pressure foaming machines need to be introduced and ex-proofed. The polyol part of the machines have to be made explosion proof and encapsulated. It is also necessary to replace the stirrer in the polyol daily tank as well as the electrical components of the polyol part of the foaming machine.

  Adaptation of the currently used low pressure foaming machines for cyclopentane would require substantial modifications to be carried out at the machine supplier's premises. Apart from the substantial adaptation costs, a further burden would be the several weeks interruption of production for decommissioning, rebuilding, transportation and recommissioning of the machinery. Thus, the only economically viable solution is to replace the low pressure foaming machines with suitable high pressure ones.

  According to our information collected in Jordan, there is no domestic market for the second hand low pressure foaming machines, since not only the refrigerator plants, but also the foam manufacturers are replacing their low pressure foaming machines with

high pressure machines. Thus, similarly to the previously approved by the MFMP foam sector projects the high pressure machines are budgeted at their full cost.

- Since cyclopentane and polyol cannot be delivered premixed in drums or tanks (like CFC 11 and polyol), it will be necessary to provide a mixing station.

- For work safety when using the highly flammable and explosive cyclopentane and in order to meet the relevant requirements of the local authorities, it is recommended to have a gas detector system as well as a fire protection system installed in the foaming department.

- The provision and installation of an exhaust and ventilation system in the foaming department is necessary in order to achieve compliance with established safety rules for the machinery and the plant;

- All machinery and equipment which may come in contact with cyclopentane or the mix of polyol and cyclopentane must be encapsulated and explosion-proof;

- To make the foaming jigs explosion-proof, it is necessary to replace the electric heating elements by copper tubes in which hot water can circulate. (A cheaper option would be to automatically disconnect the existing electrical heating just before foam injection, using the control system of the foaming machine and a timer. For the sake of high operational safety it is, however, recommended to apply the water heater option.). The foaming inner mould plugs have to be partially replaced/rebuilt using aluminium sheets to guarantee a constant temperature at the inner foam plug. The electric valves and microswitches to be used in connection with the foaming jigs need to be explosion-proof.

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

- To reduce the risk from static electricity it is recommended to inject nitrogen just before the injection of polyurethane material in the cabinet.

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

- To keep control over the quality of the foam it is recommended to introduce a minimum specification of test equipment. Since currently no test equipment is being used by National Refrigeration Co. it can, however, not be provided under this project.

C. *Refrigeration Service*

- National Refrigeration Co. has about 200,000 refrigerators/freezers operating in Jordan. They are serviced mainly by the Company's service centre and service car. The amount of CFC 12 used by National Refrigeration Co. for servicing/recharging is about 0.5 mt annually. It is estimated that through better service technologies 2/3 of the latter amount, i.e. about 0.3 mt could gradually be saved in future.

- For National Refrigeration Co.'s refrigeration service a simple mobile recovery unit for CFC 12 (one for the service car currenly used, plus additional units to be exchanged with the Central Collection station) will be provided in order to prevent venting of CFC 12 and to reuse it. (The recovery units consist of a metal or plastic case, filled with activated carbon to absorb the remaining CFC 12 from the system. The CFC 12 will later be recovered from the activated carbon at the Central Collection station and sant for reclamation.)

- 1 new mobile evacuation and charging board for HFC 134a as well as leak detector for service will also be provided (for the service centre).

- National Refrigeration Co.'s service personnel will be trained in using HFC 134a as well as in CFC 12 recovery and recycling.

D. *Justification for Selection of Alternative Technologies*

As new refrigerant for domestic refrigerators and freezers most of the major manufacturers of compressors have chosen HFC 134a as replacement for CFC 12. Thus, for the Jordanian manufacturers of refrigerators and freezers there is for the time being no other option commercially available.

As new blowing agent for the polyurethane foam the situation is quite different. Some manufacturers use:

HCFC 141b with ODP	=	0.11
HCFC 142b with ODP	=	0.065
HCFC 142b + HCFC 22 with ODP	=	0.06
HFC 134a with ODP	=	0
Cyclopentane with ODP	=	0

This means, that the use of HCFC 141b, HCFC 142b and HCFC 142b + HCFC 22 blend could only be accepted as transitional substance for a limited time.

Currently all major European manufacturers are carrying out tests or have already started using cyclopentane. Therefore, MMRAE recommends that the Jordanian manufacturers should introduce an ultimate solution as blowing agent and should not use any transitional substances.

At present HFC 134a is also too expensive, so it is very unlikely that it may become the ultimate blowing agent for polyurethane foam.

IV. INPUTS

1. *Capital Goods Replacement*

The following equipment for National Refrigeration Co. needs to be rebuilt, replaced, as well as new equipment to be provided as specified below:

A. Refrigeration System

a1.	1 pc.	HFC 134a charging boards with vacuum pump, leak check as well as refrigerant supply pump;
a2.	1 pc.	HFC 134a leak detectors;
a3.	1 set	HFC 134a test equipment (minimum specification as for temperature, humidity, voltage regulation systems, as well as for measuring of temperature, pressure, voltage, current, energy consumption and to be added to the existing test equipment);
a4	4 pcs.	existing vacuum pumps cleaned/renovated.

B. Foam System

b1.	1 pc.	High pressure foaming machines with two heads (ex-proofed for use of cyclopentane);
b2.	1 pc.	mixing station for cyclopentane and polyol with daily tank;
b3.	1 set	water heater system for foaming jigs/plugs;
b4.	1 set	gas detector system;
b5.	1 set	exhaust and ventilation system;
b6.	9 sets	foaming jigs (to be rebuilt); *National Refrigeration Co. is willing to share 1/3 of costs of modification*
b7.	20 sets	foaming plugs (to be rebuilt); *National Refrigeration Co. is willing to share 1/3 of costs of modification*
b8.		floor cover (antistatic);
b9.	1 set	pipe installation (ex-proof) from mixers to foaming machines;
b10.	1 set	fire protection system;
b11.	1 set	pumps and pipe-work;
b12	1 set	station for handling of cyclopentane delivered in barrels.

C. Refrigeration Service

c1.	1 pc.	HFC 134a mobile evacuation and charging boards;
c2.	3 pcs.	simple CFC 12 recovery units;
c3.	1 pc.	leak detectors for HFC 134a.

2. ***Conversion/Training***

Within the framework of this project, technicians from National Refrigeration Co. will be trained in (among others) the following areas:

- redesign and reconstruction of refrigerators and freezers;
- 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;
- new technologies for foam and refrigerant;
- specifications for materials;
- safety regulations for flammable/explosive chemicals;
- refrigeration service.

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 model redesign will be carried out by National Refrigeration Co.'s staff under the supervision of the Chief Technical Advisor and specialized international consultants for this project.

As a common practice, modifications of the production lines will be carried out during evenings and off-days and, therefore, it will not cause any costs under this project.

V. PROJECT IMPLEMENTATION

The project implementation will be carried out by UNIDO in close cooperation with National Refrigeration Co.. Necessary local coordination will be done by MMRAE.

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 a Chief Technical Advisor

and specialized consultants will be appointed and fielded by UNIDO. The respective job descriptions will be prepared upon approval of the project.

After competitive bidding, performed according to UNIDO's rules and procedures, a General Contractor will be appointed by UNIDO for the implementation of the major project components (foaming system, refrigeration system, fire protection system, exhausting and ventilation system, etc.). The General Contractor will be responsible for the supply of equipment, installation, commissioning and on-the-job training of National Refrigeration Co.'s staff. The detailed Terms of Reference for the services to be provided by the General Contractor will be elaborated after project approval.

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"[1].

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 National Refrigeration Co.. National Refrigeration Co. will also be responsible for the compliance of the new technologies with established national standards.

Having accepted the conversion of its plants to the use of non-ODS under this project, National Refrigeration Co. 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 relevant construction work will have to be arranged by National Refrigeration Co. under the supervision of the General Contractor and in line with the established milestones for this project. The costs for construction work are, therefore, not reflected in the project budget. The specification for construction work needed will be elaborated by the General Contractor after project approval and necessary site inspection.);
- Technical staff as required by the General Contractor;
- Provision of tools, transportation and lifting equipment as required;

[1] For negotiations to act as General Contractor, UNIDO has already established contacts with Messrs. POLYFA Trading A.S., DK-2650 Copenhagen-Hvidrove, Denmark.

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

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 project's 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.

For the project implementation, milestones are set in Annex E.

VI. PROJECT COSTS

I. INCREMENTAL OPERATING COSTS

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

Modification	Incremental Cost (US$)
HFC 134a compressor	5.00
Capillary tube	0.20
Evaporator/Condenser	1.70
Drier 3 AA	0.03
HFC 134a refrigerant	1.12
Cyclopentane	-0.81
Extra polyurethane foam	2.24
Total	**9.48**

The above mentioned prices are showing the difference between the component prices for CFC 11 and CFC 12 versus component prices for HFC 134a and cyclopentane.

The price increase will be caused by:

- 8 % to 10 % compressor price increase for the new HFC 134a compressor and plus about 10 % 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), totalling to an average of about US$ 5.0 per compressor;

- capillary tube average 1 m longer;

- evaporator/condenser 2 m longer;

- HFC 134a filling average about 10 % less compared with CFC 12 resulting in an incremental cost of US$ 1.12 per unit:

Refrigerant	Filling average/unit, kg	Price, US$/kg	Cost, US$/unit	Incremental cost, US$/unit
CFC 12	0.25	1.88	0.47	
HFC 134a	0.225	7.07	1.59	1.12

- cyclopentane at US$ 1.55/kg will be used in a lower quantity as CFC 11 at US$ 1.80/kg, saving is US$ 0.81/unit:

Blowing agent	Blowing agent average per unit, kg	Price, US$/kg	Cost, US$/unit	Saving, US$/unit
CFC 11	0.91	1.83	1.67	
C-pentane	0.55	1.57	0.86	0.81

- for polyurethane foaming at least 15 % more of the complete mix needs to be charged due to the higher foam density in the initial test period of about 1 year of foam production using cyclopentane (see also Annex G: "Technical Information Sheet of BASF"). The resulting incremental cost is US$ 2.24/unit:

Blowing agent	Foam average/unit, kg	Price, US$/kg	Cost, US$/unit	Incremental cost, US$/unit
CFC 11	6.35	2.35	14.92	
C-pentane	7.30	2.35	17.16	2.24

Remark: *It is recommended to NRC to increase the insulation thickness for refrigerators to min. 40 mm and for freezers to min. 60 mm because all refrigerators and freezers for the Jordanian market need to be a class "T" product for 43 °C ambient temperature*

- The material for the plastic inner liner currently used by NRC is HIPS HP-20F from Klepsch & Co., Piesendorf, Austria. This material can be used in the future as well.

Based on above calculations, the total incremental operating costs for National Refrigeration Co. are calculated for 11,824 units at US$ 9.48 and will be for one year of operation:

US$ 112,092

For six months of operation the total incremental operating cost will be as follows:

US$ 112,092*0.5 = US$ 56,046

Costs for transport and insurance of capital goods are included in the budgeted allocations for the respective items.

Costs for equipment installation, commissioning and on-the-job training of National Refrigeration Co.'s staff are calculated separately.

II. CONTINGENCY FUND

A contingency fund (15 percent of the total project budget) was calculated. The MFMP is proposed to cover unforeseen expenses which might be incurred during the project implementation, e.g. purchase of small testing instruments, which might be required during the conversion process, miscellaneous expenses, price escalation, etc.

III. TOTAL COSTS

- Investment costs will cover capital investment costs (at CIF basis) for modification of manufacturing facilities, materials, new machinery, testing equipment (see Annex A: "Equipment Specification and Cost Breakdown"), training, installation and consultancy services for modifications (see Annex B: "Labour Cost of Subcontractor's Services" and Annex C: "Project Budget").
- The incremental operating costs associated with this project are as above.
- Implementing Agency's overhead costs are 13 percent.
- For the complete costs breakdown see Annex C: "Project Budget".
- For the calculation of the unit abatement cost see Annex D: "Unit Abatement Cost".
- Requested funding by the MFMP: US$ 985,253

Annex A: Equipment Specification and Cost Breakdown

	Quantity	Unit cost, US$	Total cost, US$
Refrigeration system			
Charging boards for production	1	31,300	31,300
Cleaning and renov. of vacuum pumps	4	160	640
HFC 134a leak detectors	1	9,000	9,000
Test equipment	1	50,000	50,000
R12 collection station	1	2,500	2,500
Foaming system			
High pressure foaming machine, 2 heads	1	160,000	160,000
Mixing station	1	60,000	60,000
Water heater system	1	15,000	15,000
Gas detecting system	1	50,000	50,000
Exhaust and ventilation	1	45,000	45,000
Foaming jigs, rebuild.	9	4,500	27,000
Foaming plugs, rebuild.	20	5,000	66,667
Antistatic floor			3,000
Pipe installation	1	15,000	15,000
Fire protection system	1	30,000	30,000
Cyclopentane station, pumps, detectors	1	10,000	10,000
Chiller	1	11,000	11,000
Refrigeration service			
Evacuation and charging board	1	3,000	3,000
CFC 12 recovery unit for service cars	3	30	90
Leak detector for HFC 134a	1	160	160
Total			**589,357**

Annex B: Labour Cost of Subcontractor's Services

Title	Unit	Qty.	Unit cost, US$	Total cost, US$
A. Refrigeration system				
(1 supervisor for 2 weeks)				
Air ticket, Europe - Amman	pc.	1	2,000	2,000
Expert fee	days	14	550	7,700
Daily subsistence allowance	days	14	160	2,240
Subtotal				11,940
B. Foam system				
(1 supervisor for 3 weeks, 1 engineer for 1 week)				
Air ticket, Europe - Amman	pc.	2	2,000	4,000
Expert fee	days	21	550	11,550
Engineer fee	days	7	750	5,250
Daily subsistence allowance	days	28	160	4,480
Local subcontract (piping, installation)				5,000
Subtotal				30,280
C. Refrigeration service				
(1 supervisor for 1 week)				
Air ticket, Europe - Amman	pc.	1	2,000	2,000
Expert fee	days	7	550	3,850
Daily subsistence allowance	days	7	160	1,120
Subtotal				6,970
TOTAL				**49,190**

Annex C: Project Budget

Budget line		Duration, work months	Cost, US$
11-01	Chief technical advisor	1.0	13,000
11-50	International Consultants	1.0	25,000
21-01	Subcontract		638,547
32-01	Study tour on foaming technology, 1 technician	0.5	6,200
32-01	Study tour on refrigeration technology, 1 technician	0.5	6,200
51-00	Miscellaneous:		
	15% contingency fund on capital cost		103,342
	Incremental operating cost		56,046
	15% contingency fund on operating cost		8,407
	Total miscellaneous cost		167,795
99-99	Subtotal		856,742
Implementing Agency Overhead, 13%			128,511
PROJECT TOTAL			985,253

Annex D: Calculation of Unit Abatement Cost

A	*ODS Phase out*	*Unit*	*Total Project*
A1	Average use of CFC 11 per year	mt	11
A2	ODP of CFC 11		1
A3	ODP-weighted CFC 11 phase out (A1*A2)	mt	11
A4	Average use of CFC 12 per year	mt	3.3
A5	ODP of CFC 12		1
A6	ODP-weighted CFC 12 phase out (A4*A5)	mt	3.3
A7	Total ODP weighted phase out (A3+A6)	mt	14.3
B	*Annualized capital cost*	*Unit*	*Total Project*
B1	Total investment cost		
	(model redefinition + production conversion)	US$	792,289
B2	Equipment life	year	10
B3	Discount rate	%	10
B4	Annualized capital cost (B1*0.1627)	US$	128,905
C	*Annual incremental operating cost*	US$	64,453
D	*Unit abatement cost*	*Unit*	*Total Project*
D1	Annualized capital cost per kg ODS phased out (B4/A7/1000)	US$/kg	9.01
D2	Annual incremental operating cost per kg ODS phased out (C/A7/1000)	US$/kg	4.51
D3	Unit abatement cost (D1+D2)	US$/kg	**13.52**

Annex E. Implementation Schedule

MILESTONES / MONTH	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1. Sign the project, receive funding																		
2. Appointment of General Contractor, site inspection																		
3. Elaboration of a detailed project work plan																		
4. Draft of plant layouts																		
FOAM																		
5. Selection of equipment, bidding																		
6. Training ,																		
7. Rebuild jigs + plugs																		
8. Purchase, installation, commissioning																		
9. Prototyping and testing																		
10. Start production with cyclopentane																		
REFRIGERANT																		
11. Redesign of models, training																		
12. Selection of equipment, bidding																		
13. Purchase, installation and commissioning																		
14. Prototyping and testing																		
15. Start production with HFC 134a																		

MILESTONES / MONTH	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
REFRIGERATION SERVICE																		
16. Selection of equipment, bidding																		
17. Purchase and training																		

It is estimated that after 18 months the complete conversion will have been carried out.

Annex F: Preliminary Specification of Refrigeration Test Equipment

A. *To be supplied by the company:*

1 pc. Thermoinsulated test room: W x L x H: 2,500 x 3,000 x 2,800 mm, walls consisting of min. 80 mm thick polyurethane insulated panels covered with 0.6 mm electrogalvanized PVC coated steel plates.

B. *To be financed by MFMP:*

3 pcs. fan motors (ventilators)
2 pcs. heating elements
1 pc. cooling element
1 pc. ice-bank cooling system, complete
1 pc. electronic thermostat
1 pc. voltage stabiliser
1 set fluorescent light and plugs for test room
1 set terminal box for test room for connection of electricity, pressure and temperature
1 pc. terminal box outside test room for regulation equipment
2 pcs. amp. (current) converters
2 pcs. power converters
2 pcs. pressure converters
1 pc. 5 volt DC converter
1 pc. 24 volt DC converter
2 pcs. S-system/thermostat converter
1 pc. current transformer + cables, etc.
2 pcs. input card STBTC for measuring temperatures
1 pc. software Labtech notebook for analyzing signals
1 pc. A/D card RTI 820 for PC
1 pc. Hard disk colour system/PC
1 pc. matrix printer colour system
1 pc. overhead operator control panel
1 pc. Vario transformer
1 pc. frequency meter, digital
1 pc. voltage meter, digital
1 pc. thermometer, digital
1 pc. temperature regulator
1 pc. amperemeter
1 pc. HFI protection relay
1 pc. regulator for fan motors
1 pc. current transformer
1 set relay, cables, clamps etc.

350 kg tylose test packages 200 x 100 x 50 mm
150 kg tylose test packages 100 x 100 x 50 mm
50 kg tylose test packages with thermocouples, 200 x 100 x 50 mm
50 kg tylose test packages with thermocouples 100 x 100 x 50 mm
1,000 m Cu-Constantan thermocouples
2 pcs. Pressure transducers
1 set Software for testing according to ISO 5155.2

Rigid polyurethane foam for refrigeration with cyclopentane as blowing agent

Table 2

Properties of rigid PUR foam with cyclopentane as blowing agent

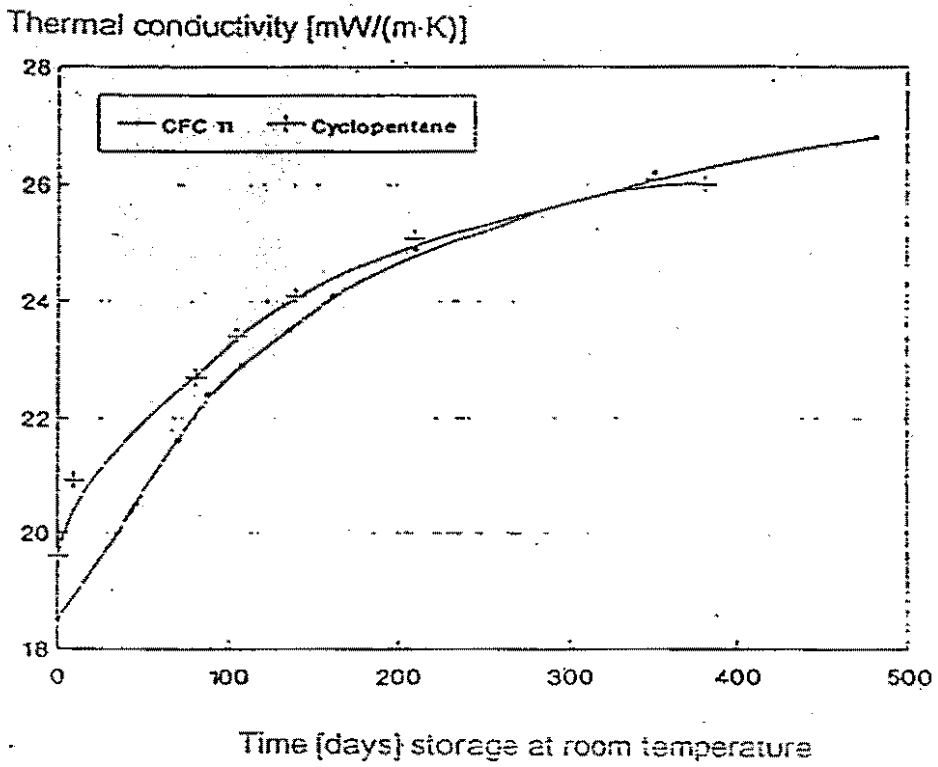
Blowing agent		Cyclo-pentane	n-Pen-tane	CFC 11
Polyol	[parts]	100	100	100
Blowing agent	[parts]	11	11	18
Isocyanate	[parts]	138	138	155
Molding density	[g/l]	39	39	34
Thermal conductivity*	[relative %]	106	121	100
(initial K-value)	[mW/m·K]	(18)	(20.5)	(17)
Compressive strength	[kPa]	140	140	120
Dimensional stability				
-30°C	[%]	<0.5	<0.5	<0.5
+80°C	[%]	<1.0	<1.0	<1.0

* Hesto lambda-control A 50-B single-plate instrument, mean temperature 23°C

Rigid polyurethane foam for refrigeration with cyclopentane as blowing agent

Figure 1

Ageing of diffusion-open rigid PUR foams



Note

The data in this publication are based on our current knowledge and experience. Due to the variety of possible effects during processing and use of our products, they do not free the processor from carrying out his own tests and trials. Our data must not be used to derive a legally binding assurance of certain properties or suitability for a particular application. Any protective rights and existing laws and regulations must be observed by the consignee of our products at his own responsibility.

BASF Aktiengesellschaft
D-6700 Ludwigshafen

Edition 08/93

BASF

Polyurethane

PROJECT COVER SHEET

Country:	The Hashemite Kingdom of Jordan
Project Title:	**Phasing out ODS at the Middle East Electrical Industries Co. Ltd., Jordan**
Sectors Covered:	Domestic Refrigeration /Rigid Foam/Refrigerant
ODS Use in Sector (1990):	47 mt of CFC 11 and CFC 12
Project Impact :	Phase out of annual consumption of 16 mt CFC 11; 5 mt CFC 12 in the production and a gradual phase out of currently used 2 mt CFC 12 in the service sector (Total ODP = 23)
Project Duration:	18 months
Project Economic Life:	10 years
Total Project Cost:	US$ 949,913 (Total of capital cost and incremental operating cost for six month of operation)
Capital Cost:	US$ 857,003
Incremental Operating Cost:	US$ 92,910 (six month of operation)
Implementing Agency's Overheads (13%):	US$ 142,487
Proposed MF Financing:	US$ 1,092,400
Cost Effectiveness:	See Annex D: Unit Abatement Cost
Counterpart Enterprise:	Middle East Electrical Industries Co. Ltd., Amman
Implementing Agency:	United Nations Industrial Development Organization (UNIDO)
Coordinating Ministry:	Ministry of Municipals, Rural Affairs and the Environment (MMRAE)

PROJECT SUMMARY

This project will phase out 100 percent of the use of CFC 11 and CFC 12 for the production of refrigerators and freezers at Middle East Electrical Industries Co. Ltd., Amman, The Hashemite Kingdom of Jordan. The chosen replacement alternatives are cyclopentane as foam blowing agent and HFC 134a as refrigerant. The project will include the redesign of all current refrigerator models and the conversion of the plant. The redesign of the existing refrigerator models covers activities like prototyping, testing, trial manufacturing and adaptation as well as reliability tests. The conversion of the production facilities covers the refrigeration system, insulating foam blowing system as well as the refrigeration service carried out by the company. The replacement alternatives and the time frame for phasing out the use of ODS will be in line with MMRAE's ODS phase out programme.

I. BACKGROUND

A. Sector Background

The subsector for domestic refrigerators and freezers in The Hashemite Kingdom of Jordan consists of three refrigerator factories who are responsible for 100 % of the ODS consumption of CFC 11 and CFC 12 in the subsector.

The Hashemite Kingdom of Jordan does not produce any ODS. All ODS used in the country are directly imported by the users. In 1992 - 1993, according to the Country Programme, the total annual consumption of the subsector was estimated to 34 mt CFC 11 and 13 mt CFC 12, totalling to 47 mt for the 42,000 units produced.

The total installed production capacity for refrigerators and freezers is about 100,000 units per year, but the present production is only about 42,000 units per year. The manufacturers expect an increase of about 10 percent per year.

In total about 500,000 refrigerators and freezers are in use in The Hashemite Kingdom of Jordan, of which about 3% will be serviced yearly and a part of them recharged during refrigeration service with CFC 12. Because of lack of environmental awareness, know-how and equipment in the service sector, service staff very often use CFC 12 for washing/flushing of the cooling systems, instead of using vacuum pumps and charging boards. This causes up to 200 percent excess CFC 12 consumption in the service sector reaching 3 mt annually.

Currently no Jordanian company manufactures low energy refrigerators and freezers with an insulation thickness of 40 to 50 mm for refrigerators and 90 mm to 100 mm for freezers.

B. Middle East Electrical Industries Co. Ltd.'s Background

Middle East Electrical Industries Co. Ltd. (MEE), is a 100% privately owned joint venture between Jordanian citizens and ACMA, Singapore. The Jordanian share is 75%. The company is currently considering to change the ownership structure and continue its operation as a 100% Jordanian public shareholder company. The change of the ownership structure is anticipated to take place shortly (see Annex H).

MEE employs approximately 200 staff.

The currently applied technologies and the know-how were imported from ACMA based on a former license agreement which is not valid any more and from GOLDSTAR (Korea), SILTAL (Italy) and PROFILO (Turkey) for some of the models of the current product range.

In 1993 MEE used about 16 mt of CFC 11 and 5 mt of CFC 12 in the production process and 3 mt of CFC 12 in the refrigeration service.

From November 1992 to November 1993 MEE has manufactured 20,000 refrigerators in 5 to 6 different models and the installed capacity is about 50,000 units per year based on max. 120 units per day production rate.

MEE covers a share of about 40 to 45 percent of the local market.

The company is currently running one production line for foaming. MEE has no refrigerator design capabilities and no refrigeration performance test laboratory facilities.

MEE's machinery and equipment for polyurethane foaming and refrigeration as well as after sale service consist of:

1 pc.	EMB, Elastogran high pressure foaming machine.
1 pc.	preheating oven for cabinets
1 pc.	preheating oven for doors
6 pcs.	steel foaming jigs without heating for cabinets
6 sets	aluminium foaming moulds
4 pcs.	Edwards 12 m^3/h two stage vacuum pumps
4 pcs.	Goldstar vacuum pumps
1 pc.	A'Gramkow charging board
1 pc.	Toshiba leak tester
1 pc.	YOKOGAWA leak tester
1 set	Electrical safety and quality control equipment
7 sets	service equipment for 2 service centres and 5 mobile service cars.

Middle East Electrical Industries Co. Ltd. has already recognized the need to be in compliance with the stipulations of the Montreal Protocol and has agreed to participate in Jordan's ODS phase out programme.

II. PROJECT OBJECTIVE

The objective of this project is to eliminate the use of ODS, such as CFC 11 and CFC 12, in the production of domestic refrigerators/freezers and in the refrigeration service at Middle East Electrical Industries Co. Ltd. through conversion to the use of HFC 134a as refrigerant for the cooling system and cyclopentane as blowing agent for the polyurethane insulation foam.

III. PROJECT DESCRIPTION

Middle East Electrical Industries Co. Ltd. is prepared to phase out ODS as soon as the new technologies have been acquired, the necessary machinery and equipment installed and the technical staff trained.

Among the technological options currently available on commercial basis and in line with the established policy of the Ministry of Municipals, Rural Affairs and the Environment to phase out the use of ODS, Middle East Electrical Industries Co. Ltd. has chosen to replace CFC 12 by HFC 134a, because the new type compressors are available, and the technology is mature and commercially applied outside The Hashemite Kingdom of Jordan.

As blowing agent for polyurethane foam Middle East Electrical Industries Co. Ltd. first has decided to use HCFC 141b but after the recommendation from MFMP they have agreed to avoid the use of any transitional substance and to introduce as ultimate solution cyclopentane.

Through the project assistance will be provided in:

a) Procurement of new machinery and equipment;

b) Rebuilding of presently used machinery and equipment wherever technically and economically feasible;

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

d) Installation, commissioning, trial operation, start-up and on-the-job training;

e) Servicing.

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

A. ***Refrigeration System***

- The charging equipment and vacuum pumps must only be used for HFC 134a and in meeting the demand for cleaner and dryer cooling systems the existing charging equipment has to be replaced including the vacuum control.

- The charging boards have to be replaced by boards suitable for HFC 134a.

- Because the leak detectors react on Cl molecules, they need to be replaced.

- The currently used vacuum pumps, after being cleaned and connection hoses and gaskets being changed can also be used for HFC 134a.

- To optimize the cooling system for the application of HFC 134a and new specification for components used, performance tests for each model of refrigerator in an air-conditioned test room are needed. Therefore, a minimum specification of refrigeration test equipment needs to be provided (see Annex F: "Preliminary Specification of Refrigeration Test Equipment"). It is understood, that foam testing facilities cannot be financed by MFMP, as stated in the forthcoming para B: Foam System.

- To improve the performance of the cooling system and compensate for a little lower polyurethane insulation value due to the conversion to HFC 134a as the new refrigerant and cyclopentane for the foam, it is necessary to optimize the cooling system as well as the energy consumption to keep an acceptable TEWI value. Therefore, it is necessary to redesign, reconstruct and carry out performance tests for all redesigned models of refrigerators / freezers.

- The technical requirements for components such as tubes, condensers, evaporators, capillary tubes, heat exchangers 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 has to be equipped with 3 AA desiccant molecular sieves.

- The cooling system must not contain any chlorine and max. 1 % non-condensable gases.

- The capillary tube has to be optimized for an increased resistance at low evaporating temperatures.

- It will be necessary to train Middle East Electrical Industries Co. Ltd.'s manufacturing and service technicians at the equipment suppliers' place in new foaming technology as well as in design/calculation and performance testing of cooling systems. During the installation and run-in of the new machinery and equipment the suppliers engineers will have to train Middle East Electrical Industries Co. Ltd.'s technical staff.

B. ***Foam System***

- In order to maintain operational safety when using cyclopentane driven foam on the existing high pressure foaming machines they have to be modified and ex-proofed. The polyol part of the machines have to be made explosion proof and encapsulated. It is also necessary to replace the stirrer in the polyol daily tank as well as the electrical components of the polyol part of the foaming machine. Since the existing water chiller is designed for cooling a 250 l polyol tank purchase of a new chiller is not considered.

- Since cyclopentane and polyol cannot be delivered premixed in drums or tanks (like CFC 11 and polyol), it will be necessary to provide a mixing station.

- For work safety when using the highly flammable and explosive cyclopentane and in order to meet the relevant requirements of the local authorities, it is recommended to have a gas detector system as well as a fire protection system installed in the foaming department.

- The provision and installation of an exhaust and ventilation system in the foaming department is necessary in order to achieve compliance with established safety rules for the machinery and the plant;

- All machinery and equipment which may come in contact with cyclopentane or the mix of polyol and cyclopentane must be encapsulated and explosion-proof;

- To make the foaming jigs explosion-proof, it is necessary to replace the electric heating elements by copper tubes in which hot water can circulate. (A cheaper option would be to automatically disconnect the existing electrical heating just before foam injection, using the control system of the foaming machine and a timer. For the sake of high operational safety it is, however, recommended to apply the water heater option.). The foaming inner mould plugs have to be partially replaced/rebuilt using aluminium sheets to guarantee a constant temperature at the inner foam plug. The electric valves and microswitches to be used in connection with the foaming jigs need to be explosion-proof.

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

- To reduce the risk from static electricity it is recommended to inject nitrogen just before the injection of polyurethane material in the cabinet.

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

- To keep control over the quality of the foam it is recommended to introduce a minimum specification of test equipment. Since currently no test equipment is being used by Middle East Electrical Industries Co. Ltd. it can, however, not be provided under this project.

C. *Refrigeration Service*

- Middle East Electrical Industries Co. Ltd. has about 100.000 refrigerators/freezers operating in Jordan as well as a large number of units imported since the 1950s by them. All these are serviced mainly by the Company's 5 service centres and 3 service cars. The amount of CFC 12 used by Middle East Electrical Industries Co. Ltd. for servicing/recharging is about 3 mt annually. It is estimated that through better service technologies 2/3 of the latter amount, i.e. about 2 mt could gradually be saved in future.

- For Middle East Electrical Industries Co. Ltd.'s refrigeration service a simple mobile recovery units for CFC 12 (one for each service car currently used, plus additional units to be exchanged with the Central Collection Station) will be provided in order

to prevent venting of CFC 12 and to reuse it. (The recovery units consist of a metal or plastic case, filled with activated carbon to absorb the remaining CFC 12 from the system. The CFC 12 will later be recovered from the activated carbon at the Central Collection Station and sent for reclamation.)

- 1 new mobile evacuation and charging board for HFC 134a as well as leak detector for service will also be provided (for the service centre).

- Middle East Electrical Industries Co. Ltd.'s service personnel will be trained in using HFC 134a as well as in CFC 12 recovery and recycling.

D. *Justification for Selection of Alternative Technologies*

As new refrigerant for domestic refrigerators and freezers most of the major manufacturers of compressors have chosen HFC 134a as replacement for CFC 12. Thus, for the Jordanian manufacturers of refrigerators and freezers there is for the time being no other option commercially available.

As new blowing agent for the polyurethane foam the situation is quite different. Some manufacturers use:

HCFC 141b with ODP	=	0.11
HCFC 142b with ODP	=	0.065
HCFC 142b + HCFC 22 with ODP	=	0.06
HFC 134a with ODP	=	0
Cyclopentane with ODP	=	0

This means, that the use of HCFC 141b, HCFC 142b and HCFC 142b + HCFC 22 blend could only be accepted as transitional substance for a limited time.

Currently all major European manufacturers are carrying out tests or have already started using cyclopentane. Therefore, MMRAE recommends that the Jordanian manufacturers should introduce an ultimate solution as blowing agent and should not use any transitional substances.

At present HFC 134a is also too expensive, so it is very unlikely that it may become the ultimate blowing agent for polyurethane foam.

IV. INPUTS

1. *Capital Goods Replacement*

The following equipment for Middle East Electrical Industries Co. Ltd. needs to be rebuilt, replaced, as well as new equipment to be provided as specified below:

A. Refrigeration System

a1.	1 pc.	HFC 134a charging boards with vacuum pump, leak check as well as refrigerant supply pump;
a2.	2 pc.	HFC 134a leak detectors;
a3.	1 set	HFC 134a test equipment (minimum specification as for temperature, humidity, voltage regulation systems, as well as for measuring of temperature, pressure, voltage, current, energy consumption and to be added to the existing test equipment);
a4.	8 pcs.	existing vacuum pumps cleaned/renovated.

B. Foam System

b1.	1 pc.	Modification of existing high pressure foaming machines with two heads (ex-proofed for use of cyclopentane);
b2.	1 pc.	mixing station for cyclopentane and polyol with daily tank;
b3.	1 set	water heater system for foaming jigs/plugs;
b4.	1 set	gas detector system;
b5.	1 set	exhaust and ventilation system;
b6.	12 sets	foaming jigs (to be rebuilt);
b7.	20 sets	foaming plugs (to be rebuilt);
b8.		floor cover (antistatic);
b9.	1 set	pipe installation (ex-proof) from mixers to foaming machines;
b10.	1 set	fire protection system;
b11.	1 set	pumps and pipe-work;
b.12	1 pc.	cyclopentane station (for handling of cyclopentane delivered in barrels)

C. Refrigeration Service

c1.	8 pcs.	HFC 134a mobile evacuation and charging boards;
c2.	9 pcs.	simple CFC 12 recovery units;
c3.	8 pcs.	leak detectors for HFC 134a.

2. *Conversion/Training*

Within the framework of this project, technicians from Middle East Electrical Industries Co. Ltd. will be trained in (among others) the following areas:

- redesign and reconstruction of refrigerators and freezers;
- 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;
- new technologies for foam and refrigerant;
- specifications for materials;
- safety regulations for flammable/explosive chemicals;
- refrigeration service.

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 model redesign will be carried out by Middle East Electrical Industries Co. Ltd.'s staff under the supervision of the Chief Technical Advisor and specialized international consultants for this project.

As a common practice, modifications of the production lines will be carried out during evenings and off-days and, therefore, it will not cause any costs under this project.

V. PROJECT IMPLEMENTATION

The project implementation will be carried out by UNIDO in close cooperation with Middle East Electrical Industries Co. Ltd.. Necessary local coordination will be done by MMRAE.

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 a Chief Technical Advisor and specialized consultants will be appointed and fielded by UNIDO. The respective job descriptions will be prepared upon approval of the project.

After competitive bidding, performed according to UNIDO's rules and procedures, a General Contractor will be appointed by UNIDO for the implementation of the major project

components (foaming system, refrigeration system, fire protection system, exhausting and ventilation system, etc.). The General Contractor will be responsible for the supply of equipment, installation, commissioning and on-the-job training of Middle East Electrical Industries Co. Ltd.'s staff. The detailed Terms of Reference for the services to be provided by the General Contractor will be elaborated after project approval.

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"[1].

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 Middle East Electrical Industries Co. Ltd.. Middle East Electrical Industries Co. Ltd. will also be responsible for the compliance of the new technologies with established national standards.

Having accepted the conversion of its plants to the use of non-ODS under this project, Middle East Electrical Industries Co. 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 relevant construction work will have to be arranged by Middle East Electrical Industries Co. Ltd. under the supervision of the General Contractor and in line with the established milestones for this project. The costs for construction work are, therefore, not reflected in the project budget. The specification for construction work needed will be elaborated by the General Contractor after project approval and necessary site inspection.);
- Technical staff as required by the General Contractor;
- Provision of tools, transportation and lifting equipment as required;
- Local transport, communication and secretarial facilities for the General Contractor's and UNIDO's staff involved in the project's implementation.

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

[1] For negotiations to act as General Contractor, UNIDO has already established contacts with Messrs. POLYFA Trading A.S., DK-2650 Copenhagen-Hvidrove, Denmark.

MFMP the project's 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.

For the project implementation, milestones are set in Annex E.

VI. PROJECT COSTS

I. INCREMENTAL OPERATING COSTS

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

Modification	Incremental Cost (US$)
HFC 134a compressor	5.00
Capillary tube	0.20
Evaporator/Condenser	1.70
Drier 3 AA	0.03
HFC 134a refrigerant	1.12
Cyclopentane	-0.73
Extra polyurethane foam	2.02
Total	**9.34**

The above mentioned prices are showing the difference between the component prices for CFC 11 and CFC 12 versus component prices for HFC 134a and cyclopentane.

The price increase will be caused by:

- 8 % to 10 % compressor price increase for the new HFC 134a compressor and plus about 10 % 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), totalling to an average of about US$ 5.00 per compressor;

- capillary tube average 1 m longer;

- evaporator/condenser 2 m longer;

- HFC 134a filling average about 10 % less compared with CFC 12 resulting in an incremental cost of US$ 1.12 per unit:

Refrigerant	Filling average/unit, kg	Price, US$/kg	Cost, US$/unit	Incremental cost, US$/unit
CFC 12	0.25	1.88	0.47	
HFC 134a	0.225	7.07	1.59	1.12

- cyclopentane at US$ 1.55/kg will be used in a lower quantity as CFC 11 at US$ 1.80/kg, saving is US$ 0.73/unit:

Blowing agent	Blowing agent average per unit, kg	Price, US$/kg	Cost, US$/unit	Saving, US$/unit
CFC 11	0.82	1.83	1.50	
C-pentane	0.49	1.57	0.77	0.73

- for polyurethane foaming at least 15 % more of the complete mix needs to be charged due to the higher foam density in the initial test period of about 1 year of foam production using cyclopentane (see also Annex G: "Technical Information Sheet of BASF"). The resulting incremental cost is US$ 2.02/unit:

Blowing agent	Foam average/unit, kg	Price, US$/kg	Cost, US$/unit	Incremental cost, US$/unit
CFC 11	5.70	2.35	13.40	
C-pentane	6.56	2.35	15.42	2.02

Remark: *It is recommended to MEE to increase the insulation thickness for refrigerators to min. 40 mm and for freezers to min. 60 mm because all refrigerators and freezers for the Jordanian market need to be a class "T" product for 43 °C ambient temperature*

- The current material for the plastic inner liner is HIPS which is not expected to be changed. (In case of improper quality of the HIPS plastic material their might be a risk of blistering in connection after conversion to the use of cyclopentane.)

Based on above calculations, the total incremental operating costs for Middle East Electrical Industries Co. Ltd. are calculated for 17,300 units at US$ 7.84/unit and will be for **one year of operation**:

US$ 161,582

For six months of operation the total incremental operating cost will be as follows:

US$ 161,582 x 0.5 = US$ 80.791

Costs for transport and insurance of capital goods are included in the budgeted allocations for the respective items.

Costs for equipment installation, commissioning and on-the-job training of Middle East Electrical Industries Co. Ltd.'s staff are calculated separately.

II. CONTINGENCY FUND

A contingency fund (15 percent of the total project budget) was calculated. The MFMP is proposed to cover unforeseen expenses which might be incurred during the project implementation, e.g. purchase of small testing instruments, which might be required during the conversion process, miscellaneous expenses, price escalation, etc.

III. TOTAL COSTS

- Investment costs will cover capital investment costs (at CIF basis) for modification of manufacturing facilities, materials, new machinery, testing equipment (see Annex A: "Equipment Specification and Cost Breakdown"), training, installation and consultancy services for modifications (see Annex B: "Labour Cost of Subcontractor's Services" and Annex C: "Project Budget").

- The incremental operating costs associated with this project are as above.

- Implementing Agency's overhead costs are 13 percent.

- For the complete costs breakdown see Annex C: "Project Budget".

- For the calculation of the unit abatement cost see Annex D: "Unit Abatement Cost".

- Requested funding by the MFMP is US$ 1,092,400.

The above amount represents the total project cost in view of the statement in ANNEX H. regarding the anticipated 100% Jordanian ownership. If the take over of 100% of the ownership will not materialize before the starting date of the project implementation, MEE will transfer part of the total project cost proportional to the non-jordanian share in the Company, to UNIDO Funds in Trust, account no. 570/337/410, Bank Austria A.G., Vienna International Centre, P.O.Box 400., Vienna, Austria. (Please make sure project number is quoted). To ensure timely and proper project work UNIDO' project implementation activities will start only after having received the required funds from MFMP and from MEE.

Annex A: Equipment Specification and Cost Breakdown

	Quantity	Unit cost, US$	Total cost, US$
Refrigeration system			
Charging boards for production	1	31,300	31,300
Cleaning and renov. of vacuum pumps	8	160	1,280
HFC 134a leak detectors	2	9,000	18,000
Test equipment	1	50,000	50,000
R12 collection station	1	2,500	2,500
Foaming system			
High pressure foaming machine rebuild	1	50,000	50,000
Mixing station	1	60,000	60,000
Water heater system	1	15,000	15,000
Gas detecting system	1	50,000	50,000
Exhaust and ventilation	1	45,000	45,000
Foaming jigs, rebuild.	12	14,000	168,000
Foaming plugs, rebuild.	20	3,000	60,000
Antistatic floor			3,000
Pipe installation	1	15,000	15,000
Fire protection system	1	30,000	30,000
Cyclopentane station	1	10,000	10,000
Water chiller	1	11,000	11,000
Refrigeration service			
Evacuation and charging board	8	3,000	24,000
CFC 12 recovery unit for service cars	9	30	270
Leak detector for HFC 134a	8	160	1,280
Total			**645,630**

Annex B: Labour Cost of Subcontractor's Services

Title	Unit	Qty.	Unit cost, US$	Total cost, US$
A. Refrigeration system				
(1 supervisor for 2 weeks)				
Air ticket, Europe - Amman	pc.	1	2,000	2,000
Expert fee	days	14	550	7,700
Daily subsistence allowance	days	14	160	2,240
Subtotal				11,940
B. Foam system				
(1 supervisor for 3 weeks, 1 engineer for 1 week)				
Air ticket, Europe - Amman	pc.	2	2,000	4,000
Expert fee	days	21	550	11,550
Engineer fee	days	7	750	5,250
Daily subsistence allowance	days	28	160	4,480
Local subcontract (piping, installation)				5,000
Subtotal				30,280
C. Refrigeration service				
(1 supervisor for 1 week)				
Air ticket, Europe - Amman	pc.	1	2,000	2,000
Expert fee	days	7	550	3,850
Daily subsistence allowance	days	7	160	1,120
Subtotal				6,970
TOTAL				**49,190**

Annex C: Project Budget

Budget line		Duration, work months	Cost, US$
11-01	Chief technical advisor	1.0	13,000
11-50	International Consultants	1.0	25,000
21-01	Subcontract		694,820
32-01	Study tour on foaming technology, 1 technician	0.5	6,200
32-01	Study tour on refrigeration technology, 1 technician	0.5	6,200
51-00	Miscellaneous:		
	15% contingency fund on capital cost		111,783
	Incremental operating cost		80,791
	15% contingency fund on operating cost		12,119
	Total miscellaneous cost		204,693
99-99	Subtotal		949,913
Implementing Agency Overhead, 13%			142,487
PROJECT TOTAL			1,092,400

Annex D: Calculation of Unit Abatement Cost

A	*ODS Phase out*	*Unit*	*Total Project*
A1	Average use of CFC 11 per year	mt	16
A2	ODP of CFC 11		1
A3	ODP-weighted CFC 11 phase out (A1*A2)	mt	16
A4	Average use of CFC 12 per year	mt	7
A5	ODP of CFC 12		1
A6	ODP-weighted CFC 12 phase out (A4*A5)	mt	7
A7	Total ODP weighted phase out (A3+A6)	mt	**23**
B	*Annualized capital cost*	*Unit*	*Total Project*
B1	Total investment cost		
	(model redefinition + production conversion)	US$	**857,003**
B2	Equipment life	year	10
B3	Discount rate	%	10
B4	Annualized capital cost (B1*0.1627)	US$	**139,434**
C	*Annual incremental operating cost*	US$	**92,910**
D	*Unit abatement cost*	*Unit*	*Total Project*
D1	Annualized capital cost per kg ODS phased out (B4/A7/1000)	US$/kg	6.06
D2	Annual incremental operating cost per kg ODS phased out (C/A7/1000)	US$/kg	4.04
D3	Unit abatement cost (D1+D2)	US$/kg	**10.10**

Annex E. Implementation Schedule

MILESTONES / MONTH	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1. Sign the project, receive funding																		
2. Appointment of General Contractor, site inspection																		
3. Elaboration of a detailed project work plan																		
4. Draft of plant layouts																		
FOAM																		
5. Selection of equipment, bidding																		
6. Training																		
7. Rebuild jigs + plugs																		
8. Purchase, installation, commissioning																		
9. Prototyping and testing																		
10. Start production with cyclopentane																		
REFRIGERANT																		
11. Redesign of models, training																		
12. Selection of equipment, bidding																		
13. Purchase, installation and commissioning																		
14. Prototyping and testing																		
15. Start production with HFC 134a																		

MILESTONES / MONTH	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
REFRIGERATION SERVICE																		
16. Selection of equipment, bidding																		
17. Purchase and training																		

It is estimated that after 18 months the complete conversion will have been carried out.

ANNEX H

شركة الشرق الأوسط للصناعات الكهربائية
المحدودة المسؤولية
Middle East Electrical Industries Co.Ltd

DATE : 6/6/1994
REF : 328/3/94
TO : UNIDO
ATT : DR/ TAMAS GROF
C.C. : MR/ HUSSEN SHAHIN

DEAR SIR ,

RE : YOUR TODAY TELECON & YESTERDAY MEETING

1- OUR 1993 NET PRODUCTION WAS 17 300 REFRIGERATORS FROM ALL SIZES .

2- WE DO CONFIRM THAT STARTING FROM JULY 15.th,1994 THE COMPANY WILL BE FULLY OWENED BY JORDANIAN SHARE HOLDERS .

3- THE NUMBER OF ELECTRIC REFRIGERATORS JIGS AMOUNG OUR JIGS IS (2) .

KINDLY DON"T HESITATE CONTACTING .

BEST REGARDS

GENERAL MANAGER

DARWISH. M . KHALILI

مدينة عمان الصناعية – تلفون: ٧٢٣٦١٠ – ٧٢٣١٧٧ ٦٢٣٣٩٢

PROJECT COVER SHEET

Country:	The Hashemite Kingdom of Jordan
Project Title:	**Phasing out ODS a the Household Appliances Manufacturing Co. Ltd., Jordan**
Sectors Covered:	Domestic Refrigeration /Rigid Foam/Refrigerant
ODS Use in Sector (1990):	47 mt of CFC 11 and CFC 12
Project Impact :	Phase out of annual consumption of 12 mt CFC 11; 4 mt CFC 12 in the production and a gradual phase out of currently used 0.6 mt CFC 12 in the service sector (Total ODP = 16.6)
Project Duration:	18 months
Project Economic Life:	10 years
Total Project Cost:	US$ 823,851 (Total of capital cost and incremental operating cost for six month of operation)
Capital Cost:	US$ 760,863
Incremental Operating Cost:	US$ 62,988 (six month of operation)
Implementing Agency's Overheads (13%):	US$ 123,578
Proposed MF Financing:	US$ 947,428
Cost Effectiveness:	See Annex D: Unit Abatement Cost
Counterpart Enterprise:	Household Appliances Manufacturing Co. Ltd., Amman
Implementing Agency:	United Nations Industrial Development Organization (UNIDO)
Coordinating Ministry:	Ministry of Municipals, Rural Affairs and the Environment (MMRAE)

PROJECT SUMMARY

This project will phase out 100 percent of the use of CFC 11 and CFC 12 for the production of refrigerators and freezers at Household Appliances Manufacturing Co. Ltd., Amman, The Hashemite Kingdom of Jordan. The chosen replacement alternatives are cyclopentane as foam blowing agent and HFC 134a as refrigerant. The project will include the redesign of all current refrigerator models and the conversion of the plant. The redesign of the existing refrigerator models covers activities like prototyping, testing, trial manufacturing and adaptation as well as reliability tests. The conversion of the production facilities covers the refrigeration system, insulating foam blowing system as well as the refrigeration service carried out by the company. The replacement alternatives and the time frame for phasing out the use of ODS will be in line with MMRAE's ODS phase out programme.

I. BACKGROUND

A. Sector Background

The subsector for domestic refrigerators and freezers in The Hashemite Kingdom of Jordan consists of 3 refrigerator factories who are responsible for 100 % of the ODS consumption of CFC 11 and CFC 12 in the subsector.

The Hashemite Kingdom of Jordan does not produce any ODS. All ODS used in the country are directly imported by the users. In 1992 -1993, according to the Country Programme, the total annual consumption of the subsector was estimated to 34 mt CFC 11 and 13 mt CFC 12, totalling to 47 mt for the 42,000 units produced.

The total installed production capacity for refrigerators and freezers is about 100,000 units per year, but the present production is only about 42,000 units per year. The manufacturers expect an increase of about 10 percent per year.

In total about 500,000 refrigerators and freezers are in use in The Hashemite Kingdom of Jordan, of which about 3 % will be serviced yearly and a part of them recharged during refrigeration service with CFC 12. Because of lack of environmental awareness, know-how and equipment in the service sector, service staff very often use CFC 12 for washing/flushing of the cooling systems, instead of using vacuum pumps and charging boards. This causes up to 200 percent excess CFC 12 consumption in the service sector reaching 3 mt annually.

Currently no Jordanian company manufactures low energy refrigerators and freezers with an insulation thickness of 40 to 50 mm for refrigerators and 90 mm to 100 mm for freezers.

B. Household Appliances Manufacturing Co. Ltd.'s Background

Household Appliances Manufacturing Co. Ltd. (HAMCO) is a private company 100% owned by Jordanian citizens. The Company started production in 1980. It employs 110 people.

The currently applied technologies and the know-how were imported from ZANUSSI, Italy, based on a former license agreement which is not valid any more. HAMCO has recently introduced four new models of which three is with a no-frost system with know-how from IBERNA, Italy.

HAMCO is a full-fledged manufacturer of refrigerators and freezers in Jordan with a market share of about 25 to 30%. They are using the brand name: MISTRAL and are selling mainly on the local and regional market. HAMCO have had orders from Russia and expects to deliver there 2,000 units more.

HAMCO's installed capacity per year is about 30,000 units. In 1993 HAMCO has manufactured 11,065 refrigerators and freezers. 75% of the production is based on a 2 (two) doors fridge/freezer of 320 l model 320/2T.

HAMCO is manufacturing 1 model No-Frost upright display refrigerator (Bottle cooler), 260 l, 1 model one door refrigerator with two stars (-12 degr. C), 160 l, 1 model No-Frost, two-doors fridge / freezer, 4 stars (-18 degr. C.), 330 l, 1 model two-doors, fridge / freezer, 4 stars, 320 l, 1 model No-Frost, upright freezer, 260 l and 1 model upright freezer, 260 l.

The refrigerators have only 32 to 34mm insulation and the freezers 50 to 55mm polyurethane insulation which is at the lower limit with the future expected demands for energy consumption for class "T" products for 43 °C ambient temperature.

In 1993 HAMCO used about 12 mt of CFC 11 and 4 mt of CFC 12 in the production process and 0.8 mt of CFC 12 in the refrigeration service.

HAMCO is currently running one production line for foaming. The company has limited refrigerator design capabilities and simple refrigeration performance test laboratory facilities.

HAMCO's machinery and equipment for foaming, refrigeration and after sale service is as follows:

1 pc.	Canon model C45 low pressure foaming machine;
1 pc.	mixer for polyol and CFC 11 with metering pumps;
2 sets	wooden foaming moulds for all 6 models;
3 pcs.	foaming jigs for cabinets (1 adjustable);
	Remark: All with electrical heating.
1 pcs.	foaming jig for doors;
2 pcs.	vacuum pumps with vacuum meters;
1 pc.	Zanussi charging board with external supply pump;
3 pcs.	leak tester;
1 set	limited test room equipment and computer system;
4 pcs.	charging station for CFC 12 for after sale service.

Household Appliances Manufacturing Co. Ltd. has already recognized the need to be in compliance with the stipulations made in the Montreal Protocol and has agreed to participate in Jordan's ODS phase out programme.

II. PROJECT OBJECTIVE

The objective of this project is to eliminate the use of ODS such as CFC 11 and CFC 12 in the production of domestic refrigerators/freezers and in the refrigeration service at HAMCO through conversion to the use of HFC 134a as refrigerant for the cooling system and cyclopentane as blowing agent for the polyurethane insulation foam.

III. PROJECT DESCRIPTION

Household Appliances Manufacturing Co. Ltd. is prepared to phase out ODS as soon as the new technologies have been acquired, the necessary machinery and equipment installed and the technical staff trained.

Among the technological options currently available on commercial basis and in line with the established policy of the Ministry of Municipals, Rural Affairs and the Environment to phase out the use of ODS, HAMCO has chosen to replace CFC 12 by HFC 134a, because the new type compressors are available, and the technology is mature and commercially applied outside The Hashemite Kingdom of Jordan.

As blowing agent for polyurethane foam HAMCO first has decided to use HCFC 141b but after the recommendation from MFMP they have agreed to avoid the use of any transitional substance and to introduce as ultimate solution cyclopentane.

Through the project assistance will be provided in:

a) Procurement of new machinery and equipment;

b) Rebuilding of presently used machinery and equipment wherever technically and economically feasible;

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

d) Installation, commissioning, trial operation, start-up and on-the-job training;

e) Servicing.

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

A. *Refrigeration System*

- The charging equipment and vacuum pumps must only be used for HFC 134a and in meeting the demand for cleaner and dryer cooling systems the existing charging equipment has to be replaced including the vacuum control.

- The charging boards have to be replaced by boards suitable for HFC 134a.

- Because the leak detectors react on Cl molecules, they need to be replaced.

- The currently used vacuum pumps, after being cleaned and connection hoses and gaskets being changed can also be used for HFC 134a.

- To optimize the cooling system for the application of HFC 134a and new specification for components used, performance tests for each model of refrigerator in an air-conditioned test room are needed. Therefore, a minimum specification of refrigeration test equipment needs to be provided (see Annex F: "Preliminary Specification of Refrigeration Test Equipment"). It is understood, that foam testing facilities cannot be financed by MFMP, as stated in the forthcoming para B: Foam System.

- To improve the performance of the cooling system and compensate for a little lower polyurethane insulation value due to the conversion to HFC 134a as the new refrigerant and cyclopentane for the foam, it is necessary to optimize the cooling system as well as the energy consumption to keep an acceptable TEWI value. Therefore, it is necessary to redesign, reconstruct and carry out performance tests for all redesigned models of refrigerators / freezers.

- The technical requirements for components such as tubes, condensers, evaporators, capillary tubes, heat exchangers 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 has to be equipped with 3 AA desiccant molecular sieves.

- The cooling system must not contain any chlorine and max. 1 % non-condensable gases.

- The capillary tube has to be optimized for an increased resistance at low evaporating temperatures.

- It will be necessary to train HAMCO's manufacturing and service technicians at the equipment suppliers' place in new foaming technology as well as in design/calculation and performance testing of cooling systems. During the installation and run-in of the new machinery and equipment the suppliers engineers will have to train HAMCO's technical staff.

B. ***Foam System***

- In order to achieve an acceptable foam quality and insulation value at lowest price, high pressure foaming machines need to be introduced and ex-proofed. The polyol part of the machines have to be made explosion proof and encapsulated. It is also necessary to replace the stirrer in the polyol daily tank as well as the electrical components of the polyol part of the foaming machine.

  Adaptation of the currently used low pressure foaming machines for cyclopentane would require substantial modifications to be carried out at the machine supplier's premises. Apart from the substantial adaptation costs, a further burden would be the several weeks interruption of production for decommissioning, rebuilding, transportation and recommissioning of the machinery. Thus, the only economically viable solution is to replace the low pressure foaming machines with suitable high pressure ones.

  According to our information collected in Jordan, there is no domestic market for the second hand low pressure foaming machines, since not only the refrigerator plants, but also the foam manufacturers are replacing their low pressure foaming machines with high pressure machines. Thus, similarly to the previously approved by the MFMP foam sector projects the high pressure machines are budgeted at their full cost.

- Since cyclopentane and polyol cannot be delivered premixed in drums or tanks (like CFC 11 and polyol), it will be necessary to provide a mixing station.

- For work safety when using the highly flammable and explosive cyclopentane and in order to meet the relevant requirements of the local authorities, it is recommended to have a gas detector system as well as a fire protection system installed in the foaming department.

- The provision and installation of an exhaust and ventilation system in the foaming department is necessary in order to achieve compliance with established safety rules for the machinery and the plant;

- All machinery and equipment which may come in contact with cyclopentane or the mix of polyol and cyclopentane must be encapsulated and explosion-proof;

- To make the foaming jigs explosion-proof, it is necessary to replace the electric heating elements by copper tubes in which hot water can circulate. (A cheaper option would be to automatically disconnect the existing electrical heating just before foam injection, using the control system of the foaming machine and a timer. For the sake of high operational safety it is, however, recommended to apply the water heater option.). The foaming inner mould plugs have to be partially replaced/rebuilt using aluminium sheets to guarantee a constant temperature at the inner foam plug. The

electric valves and microswitches to be used in connection with the foaming jigs need to be explosion-proof.

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

- To reduce the risk from static electricity it is recommended to inject nitrogen just before the injection of polyurethane material in the cabinet.

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

- To keep control over the quality of the foam it is recommended to introduce a minimum specification of test equipment. Since currently no test equipment is being used by HAMCO it can, however, not be provided under this project.

C. *Refrigeration Service*

- Household Appliances Manufacturing Co. Ltd. has about 180,000 refrigerators/freezers operating in Jordan. They are serviced mainly by the Company's 4 service centres and (3 of them are mobile service cars). The amount of CFC 12 used by HAMCO for servicing/recharging is about 0.8 mt annually. It is estimated that through better service technologies 2/3 of the latter amount, i.e. about 0.6 mt could gradually be saved in future.

- For HAMCO's refrigeration service simple mobile recovery units for CFC 12 (one for each service car currently used, plus additional units to be exchanged with the Central Collection Station) will be provided in order to prevent venting of CFC 12 and to reuse it. (The recovery units consist of a metal or plastic case, filled with activated carbon to absorb the remaining CFC 12 from the system. The CFC 12 will later be recovered from the activated carbon at the Central Collection Station and sent for reclamation.)

- 1 new mobile evacuation and charging board for HFC 134a as well as leak detector for service will also be provided (for the service centre).

- HAMCO's service personnel will be trained in using HFC 134a as well as in CFC 12 recovery and recycling.

D. *Justification for Selection of Alternative Technologies*

As new refrigerant for domestic refrigerators and freezers most of the major manufacturers of compressors have chosen HFC 134a as replacement for CFC 12. Thus, for the Jordanian manufacturers of refrigerators and freezers there is for the time being no other option commercially available.

As new blowing agent for the polyurethane foam the situation is quite different. Some manufacturers use:

HCFC 141b with ODP	=	0.11
HCFC 142b with ODP	=	0.065
HCFC 142b + HCFC 22 with ODP	=	0.06
HFC 134a with ODP	=	0
Cyclopentane with ODP	=	0

This means, that the use of HCFC 141b, HCFC 142b and HCFC 142b + HCFC 22 blend could only be accepted as transitional substance for a limited time.

Currently all major European manufacturers are carrying out tests or have already started using cyclopentane. Therefore, MMRAE recommends that the Jordanian manufacturers should introduce an ultimate solution as blowing agent and should not use any transitional substances.

At present HFC 134a is also too expensive, so it is very unlikely that it may become the ultimate blowing agent for polyurethane foam.

IV. INPUTS

1. *Capital Goods Replacement*

The following equipment for HAMCO needs to be rebuilt, replaced, as well as new equipment to be provided as specified below:

A. Refrigeration System

a1.	1 pc.	HFC 134a charging boards with vacuum pump, leak check as well as refrigerant supply pump;
a2.	2 pc.	HFC 134a leak detectors;
a3.	1 set	HFC 134a test equipment (minimum specification as for temperature, humidity, voltage regulation systems, as well as for measuring of temperature, pressure, voltage, current, energy consumption and to be added to the existing test equipment);

a4.	2 pcs.	existing vacuum pumps cleaned/renovated.

B. Foam System

b1.	1 pc.	High pressure foaming machines (ex-proofed for use of cyclopentane);
b2.	1 pc.	mixing station for cyclopentane and polyol with daily tank;
b3.	1 set	water heater system for foaming jigs/plugs;
b4.	1 set	gas detector system;
b5.	1 set	exhaust and ventilation system;
b6.	4 sets	foaming jigs (to be rebuilt); *HAMCO is willing to share 50% of costs of modification*
b7.	12 sets	foaming plugs (to be rebuilt); *HAMCO is willing to share 50% of costs of modification*
b8.		floor cover (antistatic);
b9.	1 set	pipe installation (ex-proof) from mixers to foaming machines;
b10.	1 set	fire protection system;
b11.	1 set	pumps and pipe-work;
b12.	1 pc.	water chiller
b13.	1 pc.	cyclopentane station (for handling of cyclopentane delivered in barrels)

C. Refrigeration Service

c1.	4 pc.	HFC 134a evacuation and charging boards;
c2.	9 pcs.	simple CFC 12 recovery units;
c3.	4 pc.	leak detectors for HFC 134a.

2. ***Conversion/Training***

Within the framework of this project, technicians from HAMCO will be trained in (among others) the following areas:

- redesign and reconstruction of refrigerators and freezers;
- 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;
- new technologies for foam and refrigerant;
- specifications for materials;
- safety regulations for flammable/explosive chemicals;
- refrigeration service.

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 model redesign will be carried out by HAMCO's staff under the supervision of the Chief Technical Advisor and specialized international consultants for this project.

As a common practice, modifications of the production lines will be carried out during evenings and off-days and, therefore, it will not cause any costs under this project.

V. PROJECT IMPLEMENTATION

The project implementation will be carried out by UNIDO in close cooperation with HAMCO. Necessary local coordination will be done by MMRAE.

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 a Chief Technical Advisor and specialized consultants will be appointed and fielded by UNIDO. The respective job descriptions will be prepared upon approval of the project.

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

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"[1].

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 HAMCO. HAMCO will also be responsible for the compliance of the new technologies with established national standards.

Having accepted the conversion of its plants to the use of non-ODS under this project, HAMCO 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 relevant construction work will have to be arranged by HAMCO under the supervision of the General Contractor and in line with the established milestones for this project. The costs for construction work are, therefore, not reflected in the project budget. The specification for construction work needed will be elaborated by the General Contractor after project approval and necessary site inspection.);
- Technical staff as required by the General Contractor;
- Provision of tools, transportation and lifting equipment as required;
- Local transport, communication and secretarial facilities for the General Contractor's and UNIDO's staff involved in the project's implementation.

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 project's 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.

For the project implementation, milestones are set in Annex E.

[1] For negotiations to act as General Contractor, UNIDO has already established contacts with Messrs. POLYFA Trading A.S., DK-2650 Copenhagen-Hvidrove, Denmark.

VI. PROJECT COSTS

I. INCREMENTAL OPERATING COSTS

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

Modification	Incremental Cost (US$)
HFC 134a compressor	5.00
Capillary tube	0.20
Evaporator/Condenser	1.68
Drier 3 AA	0.03
HFC 134a refrigerant	1.53
Cyclopentane	-0.82
Extra polyurethane foam	2.28
Total	**9.90**

The above mentioned prices are showing the difference between the component prices for CFC 11 and CFC 12 versus component prices for HFC 134a and cyclopentane.

The price increase will be caused by:

- 8 % to 10 % compressor price increase for the new HFC 134a compressor and plus about 10 % 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), totalling to an average of about US$ 5.0 per compressor;

- capillary tube average 1 m longer;

- evaporator/condenser 2 m longer;

- HFC 134a filling average about 10 % less compared with CFC 12 resulting in an incremental cost of US$ 1.53 per unit:

Refrigerant	Filling average/unit, kg	Price, US$/kg	Cost, US$/unit	Incremental cost, US$/unit
CFC 12	0.35	1.88	0.66	
HFC 134a	0.31	7.07	2.19	1.53

- cyclopentane at US$ 1.55/kg will be used in a lower quantity as CFC 11 at US$ 1.80/kg, saving is US$ 0.82/unit:

Blowing agent	Blowing agent average per unit, kg	Price, US$/kg	Cost, US$/unit	Saving, US$/unit
CFC 11	0.93	1.83	1.70	
C-pentane	0.56	1.57	0.88	0.82

- for polyurethane foaming at least 15 % more of the complete mix needs to be charged due to the higher foam density in the initial test period of about 1 year of foam production using cyclopentane (see also Annex G: "Technical Information Sheet of BASF"). The resulting incremental cost is US$ 2.28/unit:

Blowing agent	Foam average/unit, kg	Price, US$/kg	Cost, US$/unit	Incremental cost, US$/unit
CFC 11	6.5	2.35	15.27	
C-pentane	7.47	2.35	17.55	2.28

- The currently used plastic inner liner is HIPS which is not expected to be changed. (In case of improper quality of the HIPS plastic material there might be a risk of blistering caused by the use of cyclopentane.)

Based on the calculation above, the total incremental operating costs for HAMCO are calculated for 11,065 units at US$ 9.90 and will be for **one year of operation**:

US$ 109,543

For six months of operation the total incremental operating cost will be as follows:

US$ 109,543 x 0.5 = **US$ 54,772**

Costs for transport and insurance of capital goods are included in the budgeted allocations for the respective items.

Costs for equipment installation, commissioning and on-the-job training of HAMCO's staff are calculated separately.

II. CONTINGENCY FUND

A contingency fund (15 percent of the total project budget) was calculated. The MFMP is proposed to cover unforeseen expenses which might be incurred during the project

implementation, e.g. purchase of small testing instruments, which might be required during the conversion process, miscellaneous expenses, price escalation, etc.

III TOTAL COSTS

-Investment costs will cover capital investment costs (at CIF basis) for modification of manufacturing facilities, materials, new machinery, testing equipment (see Annex A: "Equipment Specification and Cost Breakdown"), training, installation and consultancy services for modifications (see Annex B: "Labour Cost of Subcontractor's Services" and Annex C: "Project Budget").

-The incremental operating costs associated with this project are as above.

-Implementing Agency's overhead costs are 13 percent.

-For the complete costs breakdown see Annex C: "Project Budget".

-For the calculation of the unit abatement cost see Annex D: "Unit Abatement Cost".

-Requested funding by the MFMP: US$ 947,428

Annex A: Equipment Specification and Cost Breakdown

	Quantity	Unit cost, US$	Total cost, US$
Refrigeration system			
Charging boards for production	1	31,300	31,300
Cleaning and renov. of vacuum pumps	2	160	320
HFC 134a leak detectors	2	9,000	18,000
Test equipment	1	40,000	40,000
R12 collection station	1	2,500	2,500
Foaming system			
High pressure foaming machine, 2 heads	1	160,000	160,000
Mixing station	1	60,000	60,000
Water heater system	1	15,000	15,000
Gas detecting system	1	50,000	50,000
Exhaust and ventilation	1	45,000	45,000
Foaming jigs, rebuild. (50%)	4	14,000	28,000
Foaming plugs, rebuild. (50%)	12	5,000	30,000
Antistatic floor			3,000
Pipe installation	1	15,000	15,000
Fire protection system	1	30,000	30,000
Water chiller	1	11,000	11,000
Cyclopentane station, pump, detectors	1	10,000	10,000
Refrigeration service			
Evacuation and charging board	4	3,000	12,000
CFC 12 recovery unit for service cars	9	30	270
Leak detector for HFC 134a	4	160	640
Total			**562,030**

Annex B: Labour Cost of Subcontractor's Services

Title	Unit	Qty.	Unit cost, US$	Total cost, US$
A. Refrigeration system				
(1 supervisor for 2 weeks)				
Air ticket, Europe - Amman	pc.	1	2,000	2,000
Expert fee	days	14	550	7,700
Daily subsistence allowance	days	14	160	2,240
Subtotal				11,940
B. Foam system				
(1 supervisor for 3 weeks,				
1 engineer for 1 week)				
Air ticket, Europe - Amman	pc.	2	2,000	4,000
Expert fee	days	21	550	11,550
Engineer fee	days	7	750	5,250
Daily subsistence allowance	days	28	160	4,480
Local subcontract (piping, installation)				5,000
Subtotal				30,280
C. Refrigeration service				
(1 supervisor for 1 week)				
Air ticket, Europe - Amman	pc.	1	2,000	2,000
Expert fee	days	7	550	3,850
Daily subsistence allowance	days	7	160	1,120
Subtotal				6,970
TOTAL				**49.190**

Annex C: Project Budget

Budget line		Duration, work months	Cost, US$
11-01	Chief technical advisor	1.0	13,000
11-50	International Consultants	1.0	25,000
21-01	Subcontract		611,220
32-01	Study tour on foaming technology, 1 technician	0.5	6,200
32-01	Study tour on refrigeration technology, 1 technician	0.5	6,200
51-00	Miscellaneous:		
	15% contingency fund on capital cost		99,243
	Incremental operating cost		54,772
	15% contingency fund on operating cost		8,216
	Total miscellaneous cost		162,231
99-99	Subtotal		823,851
Implementing Agency Overhead, 13%			123,578
PROJECT TOTAL			947,428

Annex D: Calculation of Unit Abatement Cost

A	***ODS Phase out***	Unit	Total Project
A1	Average use of CFC 11 per year	mt	12
A2	ODP of CFC 11		1
A3	ODP-weighted CFC 11 phase out (A1*A2)	mt	12
A4	Average use of CFC 12 per year	mt	4.6
A5	ODP of CFC 12		1
A6	ODP-weighted CFC 12 phase out (A4*A5)	mt	4.6
A7	Total ODP weighted phase out (A3+A6)	mt	**16.6**
B	***Annualized capital cost***	Unit	Total Project
B1	Total investment cost		
	(model redefinition + production conversion)	US$	**760,863**
B2	Equipment life	year	10
B3	Discount rate	%	10
B4	Annualized capital cost (B1*0.1627)	US$	123,792
C	***Annual incremental operating cost***	US$	**62,988**
D	***Unit abatement cost***	Unit	Total Project
D1	Annualized capital cost per kg ODS phased out (B4/A7/1000)	US$/kg	7.46
D2	Annual incremental operating cost per kg ODS phased out (C/A7/1000)	US$/kg	3.79
D3	Unit abatement cost (D1+D2)	US$/kg	11.25

Annex E. Implementation Schedule

MILESTONES / MONTH	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1. Sign the project, receive funding																		
2. Appointment of General Contractor, site inspection																		
3. Elaboration of a detailed project work plan																		
4. Draft of plant layouts																		
FOAM																		
5. Selection of equipment, bidding																		
6. Training																		
7. Rebuild jigs + plugs																		
8. Purchase, installation, commissioning																		
9. Prototyping and testing																		
10. Start production with cyclopentane																		
REFRIGERANT																		
11. Redesign of models, training																		
12. Selection of equipment, bidding																		
13. Purchase, installation and commissioning																		
14. Prototyping and testing																		
15. Start production with HFC 134a																		

MILESTONES / MONTH	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
REFRIGERATION SERVICE																		
16. Selection of equipment, bidding																		
17. Purchase and training																		

It is estimated that after 18 months the complete conversion will have been carried out.

Annex F: Preliminary Specification of Refrigeration Test Equipment

3 pcs.fan motors (ventilators)
2 pcs.heating elements
1 pc.cooling element
1 pc.ice-bank cooling system, complete
1 pc.electronic thermostat
1 pc.voltage stabiliser
1 setfluorescent light and plugs for test room
1 set terminal box for test room for connection of electricity, pressure and temperature
1 pc.terminal box outside test room for regulation equipment
2 pcs.amp. (current) converters
2 pcs.power converters
2 pcs.pressure converters
1 pc.5 volt DC converter
1 pc.24 volt DC converter
2 pcs.S-system/thermostat converter
1 pc.current transformer + cables, etc.
2 pcs.input card STBTC for measuring temperatures
1 pc.software Labtech notebook for analyzing signals
1 pc.overhead operator control panel
1 pc.Vario transformer
1 pc.frequency meter, digital
1 pc.voltage meter, digital
1 pc.thermometer, digital
1 pc.temperature regulator
1 pc.amperemeter
1 pc.HFI protection relay
1 pc.regulator for fan motors
1 pc.current transformer
1 setrelay, cables, clamps etc.
350 kg tylose test packages 200 x 100 x 50 mm
150 kg tylose test packages 100 x 100 x 50 mm
50 kg tylose test packages with thermocouples, 200 x 100 x 50 mm
50 kg tylose test packages with thermocouples 100 x 100 x 50 mm
1,000 m Cu-Constantan thermocouples
2 pcs.Pressure transducers
1 setSoftware for testing according to ISO 5155.2