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

Twelfth Meeting
Montreal, 28-30 March 1994

PROJECT PROPOSALS: JORDAN

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

1. Investment Project for Phasing out ODS at Household Appliances Manufacturing Co.

2. Investment Project for Phasing out ODS at Middle East Electrical Industries Co. Ltd.

3. Investment Project for Phasing out ODS at National Refrigeration Co.

PROJECT EVALUATION SHEET

COUNTRY OR REGION:	Jordan
PROJECT TITLE:	Investment Project for Phasing out ODS a) Household Appliances Manufacturing Co. b) Middle East Electrical Industries Co. Ltd. c) National Refrigeration Co.
BUDGET:	(Table attached)
INCREMENTAL COSTS:	a) US $607,674 b) US $521,993[1] c) US $602,917
ODS PHASE-OUT:	a) 16 tonnes of CFC-11 and CFC-12 b) 21 tonnes of CFC-11 and CFC-12 c) 10 tonnes of CFC-11 and CFC-12
COST EFFECTIVENESS[2]:	a) US 38.0$/kg b) US 24.9$/kg c) US 60.3$/kg
PROJECT DURATION:	18 months
IMPLEMENTING AGENCY:	UNIDO
NATIONAL COORDINATING AGENCY:	Ministry of Municipals, Rural Affairs and the Environment
TECHNICAL REVIEW COMPLETED:	YES _X_ NO _

SECRETARIAT'S COMMENTS

1. These projects cover the conversion of domestic refrigerator production and refrigeration service at Household Appliances Manufacturing Co., Middle East Electrical Industries Co. and National Refrigeration Co.in Jordan to alternative technologies based on HFC-134a (refrigerant) and HCFC-141b (blowing agent). The estimate phase-out of ODS is 34 tonnes of CFC-11 and 13 tonnes of CFC-12.

2. These projects will phase out 100 per cent of the use of CFC-11 and CFC-12 for the production of domestic refrigerators.

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1 This amount has been adjusted to reflect the local ownership of 75 per cent.

2 Determined as the ratio of incremental costs to the estimated annual saving of ODP ($\$/ODP_{Kg}$).

3. With regard to the choice of HCFC-141b, the technical reviewer's paper stated that to replace the foam blowing agent CFC-11 the selection of HCFC-141b is a transitional solution for decades due to the remaining ODP. This solution can be recommended to avoid the high expenses necessary for the introduction of the ODP-free blowing agents: cyclopentane and HFC-134a as long term alternatives. Furthermore, the annual figure of produced refrigerators in Jordan is not high enough to justify an environmentally optimal but very expensive solution.

4. The technical reviewer for these projects is the same as that of the Egyptian projects and based on his comments the Secretariat discussed with UNIDO several issues likewise eligibility of equipment and their cost and possibility of modification of existing equipment, cost of Chief Technical Advisers, study tours and high incremental operational costs.

SECRETARIAT'S RECOMMENDATION

1. The Secretariat recommends to give permission to proceed for these projects. UNIDO should revise the costs of the project taking into account comments from the Secretariat and from the technical reviewers.

PROJECT COST

	Household Appliances Manufacturing Co.	Middle East Electrical Industries Co. Ltd.	National Refrigeration Co.
Unit production	12,000	20,000	10,000
Project cost:			
Capital cost	US $385,365	US $355,120	US $418,255
Operational cost*	US $152,400	US $260,800	US $115,300
Total	US $537,765	US $615,920	US $533,555
13% Overhead	US $69,909	US $80,070	US $69,362

* one year operational cost

PROJECT COVER

Country	:	The Hashemite Kingdom of Jordan
Project Title	:	**Investment Project for Phasing Out ODS at Household Appliances Manufacturing Co.**
Sectors Covered	:	Domestic Refrigeration / Rigid Foam / Refrigerant
ODS Use in Sector	:	47 MT of CFC 11 and CFC 12 annually
Project Impact	:	Phase out of annual consumption of 12 MT of CFC 11 and 4 MT of CFC 12 in the production and in the service (Total ODP = 16 MT)
Project Duration	:	18 months
Project Economic Life	:	10 years
Proposed Total Project Cost	:	Total of capital cost and incremental operating cost (first year of operation) US$ 537,765
Project Cost	:	US$ 385,365
Implementing Agency's Overheads (13%)	:	US$ 69,909
Proposed MF Financing	:	US$ 607,674
Cost Effectiveness	:	US$/kg 13,45(see Annex C:Unit Abatement Cost)
Counterpart Enterprise	:	Household Appliances Manufacturing Company (HAMCO), Amman
Implementing Agency	:	UNIDO
Coordinating Ministry	:	Ministry of Municipals, Rural Affairs and the Environment

PROJECT SUMMARY

This project will phase out 100 percent of the use of CFC 11 and CFC 12 for the production of domestic refrigerators at the **Household Appliances Manufacturing Company (HAMCO), Amman, The Hashemite Kingdom of Jordan**. The chosen replacement alternatives are HCFC 141b as foam blowing agent and HFC 134a as refrigerant. The project will be implemented through redefinition of all current refrigerator models and the conversion of the production facilities of the plant. The redefinition of the existing refrigerator models covers activities as prototyping, testing, trial manufacturing and adaptation as well as extensive reliability tests. The conversion of production facilities covers the refrigeration system, insulation foam system as well as the refrigeration service carried out by the company.

Date: 3 February 1994

BACKGROUND

SECTOR BACKGROUND

Refrigeration subsector

The subsector for domestic refrigeration in the Hashemite Kingdom of Jordan consists of 3 manufacturers who are responsible for 100 percent of the consumption of CFC 11 and CFC 12 in the subsector.

Consumption of ODS

The total 1992 to 1993 consumption in the subsector according to the Country Programme was estimated at 34 MT CFC 11 and of 13 MT CFC 12, totalling 47 MT for 42,000 units produced in the subsector.

Jordan does not produce any ODS. All ODS used in the country are directly imported by the users.

Conversion strategy

For phasing out the use of ODS the production facilities of the domestic refrigeration manufacturers Household Appliances Manufacturing Company (HAMCO), Middle East Electrical Company (MEE) and National Refrigeration Company (NRC) will be converted. Their total production from November 1, 1992 to October 31, 1993 was 42,000 units, while their total ODS consumption was 47 MT which represents 100 percent of the domestic refrigeration ODS consumption in Jordan.

Used technologies

The companies are using the same types of ODS, and show a great similarity in their production methodologies, although differences exist in quality assurance, accuracy and product finishing. For insulation foam blowing CFC 11 and for the cooling systems CFC 12 are being used respectively. All specialized components like compressor, dryer, and evaporator are imported.

HAMCO's BACKGROUND

Ownership and licences

Household Appliances Manufacturing Company (HAMCO), is a company founded in 1980 and 100 percent privately owned by Jordanian citizens. The currently applied technologies and the know-how were imported from Italy. A former license agreement with Zanussi (Italy) is not valid any more. The compressors are still being imported from Zanussi.

HAMCO is the second largest refrigerator manufacturer in Jordan, using 12 MT of CFC 11 and 4MT of CFC 12 to produce about 12,000 refrigerators annually. Currently the product range consists of six models, of which two models, with 12 cubic feet and 14 cubic feet capacity respectively, form the biggest share.

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

Outline of enterprise assessment and last year's performance and consumption

(based on production between November 1992 and October 1993)

HAMCO has limited or no knowledge about the HFC 134a and HCFC 141b solutions. Therefore, full technical support for the conversion will be needed; test facilities are available; no conversion activities or tests have been carried out yet; plant layout and operation need to be improved.

Number of employees:	approx. 100
Number of units produced annually:	approx. 12,000
Number of models:	6
CFC 11 consumption (in MT, annually):	12
CFC 12 consumption (in MT, annually):	4
Total ODS consumption (in MT, annually):	16

PROJECT OBJECTIVE

The objective of this project is to eliminate the use of CFC 11 and CFC 12 in the production of domestic refrigerators and freezers and in the refrigeration service at Household Appliances Manufacturing Company (HAMCO), through conversion of the production equipment to the use of HFC 134a as refrigerant and HCFC 141b as insulating foam blowing agent.

PROJECT DESCRIPTION

HAMCO is prepared to phase out ODS as soon as the new technology has been acquired, the necessary machinery and equipment installed and the technical staff trained.

A. Refrigeration System

Among the technological options currently available on commercial basis, HAMCO has chosen to replace CFC 12 by HFC 134a because the new type compressors are available, the technology is mature and commercially applied outside Jordan.

B. Foam System

Instead of the blowing agent CFC 11 for polyurethane foam, HAMCO has decided to introduce HCFC 141b for a transitional period, because HCFC 141b has only one tenth of the ODP of CFC 11. Its plant introduction would not require any bigger change in the basic operations, machinery and equipment. It is expected that HAMCO will still be eligible for financial assistance from MFMP at a later stage when a more developed ODP-free foaming technology will also be available for smaller refrigerator and freezer manufacturers, i.e. at justifiable investment cost.

C. Refrigeration Service

To save CFC 12 in the course of repair and maintenance to be carried our by the refrigerator manufacturer, HAMCO is prepared to introduce simple recovery units for their refrigeration service as well as the necessary equipment for servicing HFC 134a refrigeration systems. This (comparably low investment) will save a considerable amount of CFC 12 over the years to come through recovery and recycling. The HAMCO service personnel will be trained in-house by those engineers who will be trained through the project.

D. Justification For Selection Of Alternative Technologies

Various alternatives for replacement of currently used CFCs have been considered. These are mentioned hereunder, as well as an assessment of their suitability in Jordan.

Foam	Assessment	Consequences
Cyclo Pentane	ODP = 0, flammable and explosive	special infrastructure and equipment needed
HCFC 142b plus HCFC 22 (60/40)	HCFC 142b is flammable and explosive before being mixed with HCFC 22 and Polyol ODP = 0.06	special infrastructure and equipment needed
HCFC 141b	ODP = 0.11	"intermediate solution"; almost drop-in solution; minor adjustments in production process and product design required
CFC 11, 50% reduced	ODP = 0.5	drop-in solution; minor adjustments in production process required
HFC 134a	ODP = 0	too expensive; high pressure foaming machine needed
HCFC 142b	ODP = 0.065 flammable and explosive before being mixed with Polyol	minor adjustments in production process required; high pressure foaming machine needed
Refrigerant		
Propane	explosive,toxic	technology not yet mature and not available (would require special infrastructure, special protection for health, substantial danger when servicing)
HFC 134a	ODP = 0	product design can largely stay the same, adjustments needed; replacement of some production equipment, increased manufacturing process control required

INPUTS

A. Capital Goods Replacement

Refrigeration System

The technology for refrigeration with HFC 134a is well known. Critical elements as compressor, drier, capillary tube, evaporator, etc., will have to be imported.

When applying HFC 134a as refrigerant, the system has to be much cleaner and dryer. The vacuum pumps, after being cleaned can also be used for the new refrigerant.

The refrigerant charging board has to be replaced for reasons of density changes and Cl pollution. Since the leak detectors react on Cl molecules, they are to be replaced as well.

A central recovery and recycling unit for CFC 12 needs to be introduced.

Foam System

The technology for blowing the insulation foam, using HCFC 141b as blowing agent is well known and tested. The same production facilities can be used, with changes of some parts like the blowing nozzles, improved foaming jigs and plugs, a new mixing station and an oven for preheating the cabinets before foaming, etc.

Refrigeration Service

To ensure appropriate refrigeration service, the following equipment needs to be provided:

- mobile evacuation and charging board for HFC 134a;
- simple mobile recovery units for CFC 12.

B. Model Redefinition

The redefinition of the current refrigerator models covers all activities to assure that the new models are on the same level of functionality and reliability. Several stages in this process are essential:

- Design, calculation and drafting;
- Prototyping;
- Functionality and performance testing, including trial runs;
- External problem solving consultancy.

C. Conversion/Training

Within the framework of this project, HAMCO's personnel will be trained in (among others) the following areas:

- management and production control;
- quality assurance in relation to conversion.
- maintenance of the new machinery and equipment;
- refrigeration laboratory tests;
- new technologies for foam and refrigerant;
- specification for materials;
- refrigeration service

As a common practice, modifications to the product lines will be carried out during evenings and weekends and will, consequently, not cause any costs for this project.

PROJECT IMPLEMENTATION

The project will be implemented by UNIDO in close cooperation with HAMCO.

Local coordination will be done by the Department of the Environment of the Ministry of Municipals, Rural Affairs and the Environment.

To substantively assist, coordinate and supervise the project implementation on behalf of UNIDO, a Chief Technical Advisor will be appointed.

For the implementation of major components of the project (foaming system, refrigeration system, etc.) subcontracts will be concluded, based on competitive bidding. The subcontracts will include supply of equipment, installation, commissioning and on-the-job training of HAMCO's staff. The Terms of Reference for the subcontracts will be elaborated after approval of the project.

The final equipment specification and workplan can only be elaborated after approval of the basic approach for the project implementation by the Multilateral Fund for the Implementation of the Montreal Protocol (MFMP).

Having accepted the conversion of its plant to the use of non-ODS under this project, HAMCO will be committed to provide the following inputs:

- Technical staff as required by the subcontractors;

- All activities and costs involved for 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 in line with the established Milestones for this project. (The costs for the construction work are, therefore, not reflected in the project budget.)

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

- Local transport, communication and secretarial facilities for the subcontractors' 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 the enterprise level. Upon the approval 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 hereunder.

MILESTONES	D	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1. Sign the project, receive funding	1	x																	
2. Make a detailed project workplan	1	x																	
3. Initial training of management	1	x																	
4. First redesign of models	4		x	x	x	x													
5. Prototyping and testing	6						x	x	x	x	x	x							
6. Selection of equipment, bidding	3		x	x	x														
7. Purchase, installation and commissioning	6					x	x	x	x	x	x								
8. From start of production to full conversion of prod. facilities.	8											x	x	x	x	x	x	x	x

(month)

The above schedule presents a worst case scenario. It is likely that an earlier completion of all implementation activities can be achieved.

Substantive and financial reporting will be in accordance with the MFMP's requirements.

PROJECT COST

This investment project proposal presents the *incremental cost* as additional cost that the enterprise incurs in taking action to phase out ODS, and is as such defined as the *difference* between the *actual cost* of the phase out activity and the *baseline cost*. The baseline cost is the cost that the company incurs when staying at the same level of operation, without phasing out ODS.

Baseline cost. The cost for maintaining the same level of operation is assumed to be zero. Any extension of presently existing production facilities in order to respond to the increasing demand from the market cannot be accommodated in the grant request. This request is based on the capacity and production level as analyzed during November 1993. No decommissioning of existing production capacities is foreseen.

Discount rate. The discount rate applied for the new equipment to be introduced is 10 percent .

With regard to the costs for conversion of the production facilities, HAMCO is eligible for grant financing from the MFMP for the following elements:

I. Incremental cost related to capital goods replacements, including training, redefinition of products, facility (re)construction, installation, start-up, etc. These are named **investment cost.**

II. **Incremental operating cost** for four years, in proportion to the operations such as labor, maintenance and feedstock.

III. **Contingencies**

I. INVESTMENT COST

- Investment cost for modification of manufacturing facilities, new machinery, materials, testing equipment, (see **Annex A: "Equipment Specification and Cost Breakdown"**); training, installation and consultancy services for modifications, (see **Annex B: "Project Budget for HAMCO"**).

II. INCREMENTAL OPERATING COST

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

Modification	Description	US $
HFC 134a Compressor	All compressors are imported. Various types of compressors are available on the market. It is estimated that the buy in price of the compressor will raise by at least 25 percent . On top of that, increased care has to be taken in handling compressors during fridge assembly.	7.5
Inner- and door liner modification	The more aggressive solvent contained in HCFC 141b will affect the polystyrene innerliner; HIPS or ABS material has to be used.	1.5
Increased length capillary tube/evaporator	Average 1m	0.1
New dryer for HFC 134a	All dryers are imported. A suitable type for HFC 134a will be of 3 AA.	0.03
HFC 134a charge	Replacement of CFC 12 by HFC 134a; price increase per kg is at the moment US$ 5.9	1.62
New foaming agent HCFC 141b	Replacement of CFC 11 by HCFC 141b; price increase per kg foam used is at the moment US$ 0.355	1.95
TOTAL		12.70

The incremental operating cost are partly dependant on the price differences between the ODS to be phased out and their replacements.

Through this project it is proposed to assist HAMCO with the incremental operating cost, based on the current level of production for the duration of one year. Basis for the calculation of the incremental operating cost is one production year, i.e. the number of units produced in one year (between November 1992 and October 1993). The required budgets for the incremental operating cost for the years two to four will be calculated at the end of each preceding year, and applied for as a revision of this project with the MFMP for funding.

No incremental savings are foreseen to be encountered. The manufacturing and assembly process is not likely to change substantially, generating other savings or cost, apart from the cost already accounted to each part in the above table. No additional cost for energy or water, etc. are foreseen.

III. CONTINGENCY FUND

A contingency fund (15 percent of the total project budget) has been calculated. The Multilateral Fund is proposed to cover unforeseen expenses which might be incurred during the project implementation, e.g. purchase of small testing instruments and whose needs will be caused during the conversion process, miscellaneous expenses, etc.

IV. TOTAL COST

- *Investment cost* of US$ 385,365 will include capital investment cost for modification of manufacturing facilities, materials and testing equipment, training and consultancy for modifications.

- *Incremental operating cost* associated with this project are 100 percent caused by increased prices for imported parts for each refrigerator and their handling during further production and assembly. For a one year period these costs are totalling to US$ 152,400, which is based on actual production figures.

- For the amount of eligible grant financing, a local ownership fraction of 100 percent has been considered.

- *Other cost*: A 15 percent contingency was included to ensure adequate funding of project cost following project appraisal.

- Implementing Agency's overheads are 13 percent.

- The total project cost is US$ 537,765

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

- Requested funding by the MFMP: US$ 607,674

Annex A: Equipment Specification and Cost Breakdown

	Explanation	Cost per unit	Total cost USD
Vacuum pump	To maintain production capacity two more pumps are needed than currently installed, since the time required for evacuating the system is longer.	7,300	14,600
Refrigerant/ charging board	One charging board for HFC 134a	31,300	31,300
Service evacuation and charging board for HFC 134a	Seven service evacuation and charging boards are needed	3,000	21,000
Leak detector	The existing leak detectors trigger on Cl molecules and, therefore, they are not usable. Two fairly moderate, standard leak detector have been chosen as replacement.	9,000	18,000
Recovery and recycling unit	One central recovery and recycling unit for CFC 12 needs to be installed at the factory, both, for production and service.	50,000	50,000
Service recovery unit	10 simple mobile recovery units for CFC 12 to be provided for the service centers	500	5,000
Modification of foaming equipment	Modification of high pressure foaming machines, jigs and plugs	35,000	35,000
Mixing station	Mixing station for polyol and HCFC 141b to be provided for the production	50,500	50,500
Preheating oven	Preheating oven to be provided for the production	15,400	15,400
Installation and training	Installation and commissioning of refrigeration equipment, including training	6,500	6,500
	Installation and commissioning of foaming equipment, including training	9,800	9,800
Total US$			257,100

All prices are including transport and insurance, as well as installation and commissioning (where appropriate).

Annex B: Project Budget for HAMCO

		Duration w/m	US$
BL 11-01	Chief Technical Advisor	2.0	30,000
BL 11-51	Consultant in production layout and refrigeration production	0.5	8,000
BL 11-52	Consultant in refrigeration system design	0.5	8,000
BL 11-53	Consultant for monitoring of project implementation, participation in Project Implementation Review meetings (2 missions)	0.5	12,000
BL 21-01	Subcontract for provision of equipment for refrigeration systems, including installation, commissioning and on-the-job training of HAMCO's staff (one weeks, one specialist)		146,400
BL 21-01	Subcontract for provision of equipment for foam systems, including installation, commissioning and on-the-job training of HAMCO's staff (two weeks, one specialist)		110,700
BL 32-01	Study tour for two HAMCO technicians and one staff of the Ozone Office to foaming machine and blender supplier for technical inspection and training purposes	0.5	12,000
BL 32-02	Study tour for one HAMCO technician and one staff of the Ozone Office to refrigeration equipment supplier for technical inspection and training	0.5	8,000
BL 51-00	Miscellaneous (15% Contingency Fund)		50,265
Subtotal I			385,365
Incremental operating cost			152,400
Subtotal II			537,765
Implementing Agency's overheads (13%)			69,909
Total		US$	607,674

Annex C: Unit Abatement Cost

A	ODS Phase out		Total Project
A1	Average use of CFC 11 per year	MT	12
A2	ODP of CFC 11		1
A3	ODP-weighted CFC 11 phase (A1*A2)	MT	12
A4	Average use of CFC 12 per year	MT	4
A5	ODP of CFC 12		1
A6	ODP weighted CFC 12 phase out (A$*A5)	MT	4
A7	Total ODP-weighted phase out	MT	16
B	Annualized capital cost		
B1	Total investment cost (model redefinition + production conversion)	US$	385,365
B2	Equipment life	Year	10
B3	Discount rate	%	10
B4	Annualized capital cost (B1*0.1627)	US$	62,699
C	Annual incremental operating cost	US$	152,400
D	Unit Abatement cost		
D1	Annualized capital cost per kg ODS	$/kg	3.92
D2	Annual incremental operating cost per kg ODP phased out (C/A7*1000)	$/kg	9.53
D3	Unit abatement cost (D1+D2)	$/kg	13.45

REVIEW JORDAN PROJECTS
Household Appliances Manufacturing Co. (HAMCO)

GENERAL REMARKS

In order to assess the project review it is very important to have more details and the condition of the production facilities e.g.:

- type and manufacturer of the foaming stations,
- leak test facilities,
- charging stations,
- vacuum pumps.

If possible, this information should be included in the project review (see also recommendations of the OORG).

PROJECT SUMMARY

The chosen replacement alternatives for the refrigerant CFC12 and the foam blowing agent CFC11 are the refrigerant HFC134a and the HCFC141b as foam blowing agent. This solution can be recommended due to the following aspects:

- Long term solution for the refrigerant (low GWP, zero ODP)
- Compressors for HFC134a are available from all major suppliers world-wide. All other components such as dryers, oil for the compressors etc. are available on the market.
- Due to its low ODP (0.11) and low GWP (HCFC141b : 440 compared to CFC11 : 3500) the foam blowing agent HCFC141b is the industrial solution in the major refrigerator companies in the United States in order to achieve a considerable reduction of ODP with moderate expenses for the changes necessary at the foaming equipment. Equipment for the foaming system can be modified or replaced from the main suppliers (Germany, Italy).
- Refrigerators with HFC134a as refrigerant are in production world-wide, refrigerators with HCFCR141b-blown foam are already in production in Europe and America. **Experience for construction and production using HFC134a as the refrigerant and HCFC141b as the blowing agent is available and the technology is mature.**

BACKGROUND

SECTOR BACKGROUND

The service sector and the amount of ODS used for servicing is not mentioned in the sector background.

HAMCO's BACKGROUND

The impact on energy efficiency should be considered and design modifications with an increased insulation thickness are important. These design modifications require test facilities as well as training of the staff for the optimization of the refrigeration system and the insulation. Without these measures, a replacement of ODS in refrigerators with HCF134a and a new foam blowing agent will not lead to reliable refrigerators.

PROJECT OBJECTIVE

PROJECT DESCRIPTION

A. Refrigeration System

To reduce the consumption of ODS in Jordan in the refrigerator sector, hydrocarbons are also a possible alternative as refrigerant for household applications. Hydrocarbons have the environmental advantage of a low GWP compared with HFC134a, but the incremental costs are higher because new compressors are necessary (e.g. higher swept volume for isobutane) and additional safety equipment in the production line is required. Today compressors for hydrocarbons are not commercially available.

B. Foam System

To replace the foam blowing agent CFC11 the selection of HCFC141b is a transitional solution for decades due to the remaining ODP. This solution can be recommended to avoid the high expenses necessary for the introduction of the ODP-free blowing agents cyclo pentane or HFC134a as long term alternatives. Furthermore, the annual figure of produced refrigerators at HAMCO is not high enough to justify an environmentally optimal but very expensive solution.

An ODP-free solution for the foam blowing agent could be the use of HFC134a or cyclo pentane. But in comparison with HCFC141b they are much more expensive, because for HFC134a high pressure foaming stations are required and for cyclo pentane protection against explosion is necessary. All other technical options are also transitional substances because they are not ODP-free or under investigations and not approved at present (e.g. CO_2).

It is recommended to examine the optimal insulation thickness under the climatic conditions in Jordan and to improve the present refrigerant cycle design for HFC134a in order to reduce the energy consumption of the system (Total Equivalent Warming Impact). For this optimization HAMCO's test facilities should be used, measurement equipment is necessary.

C. Refrigeration Service

For servicing refrigerators in field, a vacuum pump and a small filling station are necessary. Combined vacuum and filling systems are also available on the market which should be used either with HCF134a or CFC12. A recovery and recycling unit for service purpose is not recommended, because the amount of refrigerant inside the system is too small for a proper operation of this equipment and this method is not used in Europe. Instead of a recovery and recycling system another cost effective and simple method is recommended, where a small tube filled with activated carbon is connected to the refrigerator and the refrigerant is absorbed by activated carbon (patent AEG Hausgeräte AG, Germany, licences are available). After recovery, the absorbed refrigerant can be recycled using a central recycling station.

For servicing refrigerators at a service station, a recovery unit is recommended instead of the activated carbon system.

Furthermore leak detectors for the service cars are recommended. Detectors which can detect CFC12 as well as HFC134a are commercially available (about US$ 600).

D. Justification for Selection of Alternative Technologies

See A. Refrigeration System and B. Foam System respectively.

INPUTS

A. Capital Goods Replacement

Refrigeration System

- The installed charging equipment and the vacuum pumps after some modifications can also be used with HFC134a if the status of the existing equipment allows this measure. For the conversion it is necessary to replace all flexible hoses and sealings of the charging stations with HFC134a approved materials. For the vacuum pumps in the production line only backflow valves should be installed in order to prevent a backflow of oil vapour from the pump to the refrigerator. Modern vacuum pumps are equipped with such a backflow valve.
- For leak testing in the production, different methods can be implemented:
  - helium leak detection systems including a mass spectrometer (best solution but very cost intensive)
  - HFC134a leak detectors (require the system to be filled with HFC134a and after approved leak test the refrigerant has to be removed using a recovery / recycling unit).
- The cleaning procedure for the vacuum pumps cannot be recommended and it is not necessary (installing a backflow valve).
- The timeframe for testing and optimization of the refrigerators (capillary tube adaption, establishing new rules for dryness and cleanliness) will take more time.
- Training programs are recommended for the optimization of the refrigerators and during installation of the new equipment.
- In the absence of national standards for the technical requirement of the components, European or American standards should be used.

Foam System

- The insulation thickness should be increased in order to minimize the energy losses. It is recommended to examine the optimal insulation thickness under the specific Jordanian climatic conditions. Modifications at the housing due to a thicker insulation require new production tools which are expensive.
- For checking the new foaming chemicals and the foam quality, tests should be performed in cooperation with the suppliers of the machines and the distributors of the chemicals during installation. Further tests with refrigerators should be performed in order to measure the heat loss as a function of time, the foam distribution inside the

housingHand other measures which are important for a proper quality. Detailed investigations of the foam should be performed by external institutions.

B. Model Redefinition

- Reliability tests over a longer period (at h for each model) are recommended in order to confirm the reliabilty of the new models.

C. Conversion / Training

- The foam and refrigerant technology should be changed stepwise at the parallel production lines in order to solve initial problems during production and to transfer the experience to the other production lines. In this case, failures and problems will not lead to a total breakdown of the production lines.

D. After Sales Service

- One vacuum pump, one charging cylinder and a leak detector (model which can handle CFC12 and HFC134a) are necessary for the evacuation, charging and leak detection of the system for each service car.
- The amount of CFC12 in the failed system is too low and so proper operation of the recovery unit is not possible. For recovery of CFC12 it is recommended to use simple tools which are more cost effective and in use in Germany instead of expensive recovery units (cylinders filled with activated carbon). Therefore a central recycling station (model which can handle CFC12 and HFC134a) is recommended including test equipment for the refrigerant quality.

PROJECT IMPLEMENTATION

MILESTONES

Design changes (e.g. increase of the insulation thickness, heat exchangers etc.) require modifications of the housing and the inner liner. These modifications are not mentioned in the time frame, therefore the timeframe for redesign of the models including equipment changes in the production line should be enlarged.

PROJECT COSTS

The recommended measures in this review effect also the cost statement of the project. Without having any detailed information about the equipment which is suggested in the project proposal for the modification of the production lines and the service sector, it is not possible to value these.

Annex A : Equipment Specification and Cost Breakdown

- recovery systems for service cars (activated carbon systems).
- foam test equipment has to be specified (cooperation with foam / system suppliers)

Annex C : Unit Abatement Cost

For the calculation of the 'Total ODP-weighted phase' and the 'Unit abatement cost' the remaining ODP of the blowing agent HCFC141b is not taken into consideration.

Annex D : Cleaning Technology for Vacuum Pumps

The cleaning procedure for vacuum pumps is not recommended.

PROJECT COVER

Country	:	The Hashemite Kingdom of Jordan
Project Title	:	**Investment Project for Phasing Out ODS at Middle East Electrical Industries Co. Ltd.**
Sectors Covered	:	Domestic Refrigeration / Rigid Foam / Refrigerant
ODS Use in Sector	:	47 MT of CFC 11 and CFC 12 annually
Project Impact	:	Phase out of annual consumption of 15 MT of CFC 11 and 6 MT of CFC 12 in the production and in the service (Total ODP = 21 MT)
Project Duration	:	18 months
Project Economic Life	:	10 years
Proposed Total Project Cost	:	Total of capital cost and incremental operating cost US $ 615.120 (100%)
Project Cost	:	US$ 355.120 (100%)
Implementing Agency's Overheads (13%)	:	US$ 80,070
Incremental Operating Costs/Year	:	US$ 260,800 (100%)
Proposed MF Financing	:	US$ 521.993 (75%)
Cost Effectiveness	:	US$ 15.17
Counterpart Enterprise	:	Middle East Electrical Industries Co. Ltd (MEE)
Implementing Agency	:	UNIDO
Coordinating Ministry	:	Ministry of Municipals, Rural Affairs and the Environment

PROJECT SUMMARY

This project will phase out 100 percent of the use of CFC 11 and CFC 12 for the production of domestic refrigerators in the **Middle East Electrical Industries Co. Ltd, (MEE), Amman, The Hashemite Kingdom of Jordan**. The chosen replacement alternatives are HCFC 141b as foam blowing agent and HFC 134a as refrigerant. The project will be implemented through redefinition of all current refrigerator models and the conversion of the production facilities of the plant. The redefinition of the existing refrigerator models covers activities as prototyping, testing, trial manufacturing and adaptation as well as extensive reliability tests. The conversion of production facilities covers the refrigeration system, the insulation foam blowing system and also the refrigeration service carried out by the company.

Date: 3 February 1994

BACKGROUND

SECTOR BACKGROUND

Refrigeration subsector

The subsector for domestic refrigeration in the Hashemite Kingdom of Jordan consists of 3 manufacturers who are responsible for 100 percent of the consumption of CFC 11 and CFC 12 in the subsector.

Consumption of ODS

The total 1992 to 1993 consumption in the subsector according to the Country Programme was estimated at 34 MT CFC 11 and of 13 MT CFC 12, totalling 47 MT for 42,000 units produced in the subsector.

Jordan does not produce any ODS. All ODS used in the country are directly imported by the users.

Conversion strategy

For phasing out the use of ODS the production facilities at the domestic refrigeration manufacturers Household Appliances Manufacturing Company (HAMCO), Middle East Electrical Company (MEE) and National Refrigeration Company (NRC) will be converted. Their total production from November 1, 1992 to October 31, 1993 was 42,000 units, while their total ODS consumption was 47 MT, which represents 100 percent of the domestic refrigeration ODS consumption in Jordan.

Used technologies

The companies use all the same type of ODS, and show a great similarity in production methodologies, although differences exist in quality assurance, accuracy and product finishing. For foam blowing in the insulation CFC 11 and for the cooling systems CFC 12 are being used respectively. All specialized components like compressor, dryer and evaporator are imported.

MEE's BACKGROUND

Ownership and licences

MEE is a company 100 percent privately owned joint venture between Jordanian citizens and ACMA, Singapore. The Jordanian share is 75 percent. The company is currently considering to take back the ACMA shares in order to continue negotiations for a new joint venture with GOLDSTAR, Republic of Korea. A possible future GOLDSTAR share of 10 to 15 percent was indicated.

The currently applied technologies and the know-how were imported from ACMA based on a former license agreement which is no longer valid and from GOLDSTAR for some of the models of the currently produced range.

MEE is the largest of the three domestic refrigerator manufacturing enterprises in Jordan, using about 15 MT of CFC 11 and 6 MT of CFC 12 to produce about 20,000 refrigerators annually. Currently the product range consists of 6 models.

MEE has already recognized the need to be in compliance with the stipulation made in the Montreal Protocol and to participate in Jordan,s ODS phase out programme.

Outline of enterprise assessment and last year,s performance and consumption

(based on production between November 1992 and October 1993)

MEE has limited or no knowledge of the HFC 134a and HCFC 141b solutions; the company expects limited support from licensor, therefore, the company needs full technical support for the conversion; test facilities are not available; no conversion activities or tests have been carried out yet; change of plant layout and operation started, however, need to be continued.

Number of employees:	125
Number of units produced annually:	20,000
Number of models:	6 (only fridges)
CFC 11 consumption (in MT, annually):	15
CFC 12 consumption (in MT, annually):	6
Total ODS consumption (in MT, annually):	21

PROJECT OBJECTIVE

The objective of this project is to eliminate the use of CFC 11 and CFC 12 in the production of domestic refrigerators and in the refrigeration service at Middle East Electrical Industries Co. Ltd (MEE), through conversion of the production equipment to the use of HFC 134a as refrigerant and HCFC 141b as insulating foam blowing agent.

PROJECT DESCRIPTION

MEE is prepared to phase out ODS as soon as the new technology has been acquired, the necessary machinery and equipment installed and the technical staff trained.

A. Refrigeration System

Among the technological options currently available on commercial basis, MEE has chosen to replace CFC 12 by HFC 134a because the new type compressors are available, the technology is mature and commercially applied outside Jordan.

B. Foam System

Instead of the blowing agent CFC 11 for polyurethane foam, MEE has decided to introduce HCFC 141b for a transitional period, because HCFC 141b has only one tenth of the ODP of CFC 11. Its introduction would not require any bigger change in the basic operations, machinery and equipment. It is expected that NRC will still be eligible for financial assistance from MFMP at a later stage when a more developed ODP-free foaming technology will also be available for smaller refrigerator and freezer manufacturers, i.e. at justifiable investment cost.

C. Refrigeration Service

To save CFC 12 in the course of repair and maintenance to be carried our by the refrigerator manufacturer, NRC is prepared to introduce simple recovery units for their refrigeration service as well as the necessary equipment for servicing HFC 134a refrigeration systems. This (comparably low) investment will save a considerable amount of CFC 12 over the years to come through recovery and recycling. The MEE service personnel will be trained in-house by those engineers who will be trained through the project.

C. Justification For Selection of Alternative Technologies

Various alternatives for replacement of currently used CFCs have been considered. These are mentioned hereunder, as well as an assessment of their suitability in Jordan.

Foam	Assessment	Consequences
Cyclo Pentane	ODP = 0, flammable and explosive	special infrastructure and equipment needed
HCFC 142b plus HCFC 22 (60/40)	HCFC 142b is flammable and explosive before being mixed with HCFC 22 and Polyol ODP = 0.06	special infrastructure and equipment needed
HCFC 141b	ODP = 0.11	"intermediate solution"; almost drop-in solution; minor adjustments in production process and product design required
CFC 11, 50% reduced	ODP = 0.5	drop-in solution; minor adjustments in production process required
HFC 134a	ODP = 0	expensive and high pressure foaming machine needed
HCFC 142b	ODP = 0.065 flammable and explosive before being mixed with Polyol	minor adjustments in production process required; high pressure foaming machine needed
Refrigerant		
Propane	explosive, toxic	technology not yet mature and not available; (would require special infrastructure, special protection for health, substantial danger when servicing)
HFC 134a	ODP = 0	product design can largely stay the same, adjustments needed; replacement of some production equipment, increased manufacturing process control required

INPUTS

1. Capital Goods Replacement

Refrigeration system

The technology for refrigeration with HFC 134a is well known. Critical elements as compressor, drier, capillary tube, evaporator, etc., have to be imported.

When applying HFC 134a as refrigerant, the system has to be much cleaner and dryer. The existing vacuum pumps after being cleaned can also be used for the new refrigerant.

The refrigerant charging board has to be replaced for reasons of density changes and Cl pollution. Since the leak detectors react on Cl molecules, they have to be replaced as well.

A central recovery and recycling unit for CFC 12 needs to be introduced.

Foam System

The technology for blowing the insulating foam, using HCFC 141b as blowing agent is well known and tested. The same production facilities can be used, with changes of some parts, like the blowing nozzles, improved foaming jigs and plugs, a new mixing station and an oven for preheating the cabinets before foaming, etc.

Refrigeration Service

To ensure appropriate refrigeration service, the following equipment needs to be provided:

- mobile evacuation and charging boards for HFC 134a;
- simple mobile recovery units for CFC 12.

B. **Model Redefinition**

The redefinition of the current refrigerator models covers all activities to assure that the new models are on the same level of functionality and reliability. Several stages in this process are essential:

- Design, calculation and drafting;
- Prototyping;
- Functionality and performance testing, including trial runs;
- External problem solving consultancy.

C. **Conversion/Training**

Within the framework of this project, MEE's personnel will be trained in (among others) the following areas:

/

- management and production control;
- quality assurance in relation to conversion;
- maintenance of the new machinery and equipment;
- refrigeration laboratory tests;
- new technologies for foam and refrigerant;
- specification for materials;
- refrigeration service

As a common practice, modifications of the production lines will be carried out during evenings and weekends and will, consequently,not cause any costs for this project.

PROJECT IMPLEMENTATION

The project will be implemented by UNIDO in close cooperation with MEE.

Local coordination will be done by the Department of the Environment of the Ministry of Municipals, Rural Affairs and the Environment.

To substantively assist, coordinate and supervise the project implementation on behalf of UNIDO, a Chief Technical Advisor will be appointed.

For the implementation of major components of the project (foaming system, refrigeration system, etc.) subcontracts will be concluded, based on competitive bidding. The subcontracts will include supply of equipment, installation, commissioning and on-the-job training of MEE's staff. The Terms of Reference for the subcontracts, including the detailed equipment specification will be elaborated after approval of the project.

The final equipment specification and workplan can only be elaborated after approval of the basic approach for the project implementation by the Multilateral Fund for the Implementation of the Montreal Protocol (MFMP).

Having accepted the conversion of its plant to the use of non-ODS under this project, MEE will be committed to provide the following inputs:

- Technical staff as required by the subcontractors;

- All activities and costs involved for construction work needed (including the provision of technical infrastructure) to accomodate the new technologies introduced under this project. The relevant construction work will have to be arranged by MEE in line with the established Milestones for this project. (The costs for the construction work are, therefore, not reflected in the project budget.);

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

- Local transport, communication and secretarial facilities for the subcontractors' 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 the enterprise level. Upon the approval 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 hereunder.

MILESTONES	D	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1. Sign the project, receive funding	1	x																	
2. Make a detailed project workplan	1	x																	
3. Initial training of management	1	x																	
4. First redesign of models	4		x	x	x	x													
5. Prototyping and testing	6						x	x	x	x	x	x							
6. Selection of equipment bidding	3		x	x	x														
7. Purchase, installation and commissioning	6					x	x	x	x	x	x								
8. From start of production to full conversion of prod. facilities.	8										x	x	x	x	x	x	x	x	x

The above schedule presents a worst case scenario. It is likely that earlier completion of implementation activities can be achieved.

Substantive and financial reporting will be in accordance with the MFMP's requirements.

PROJECT COST

This investment project proposal presents the *incremental cost* as additional cost that the enterprise incurs in taking action to phase out ODS, and is as such defined as the *difference* between the *actual cost* of the phase out activity and the *baseline cost*. The baseline cost is the cost that the company incurs when staying at the same level of operation, without phasing out ODS.

Baseline cost. The cost for maintaining the same level of operation is assumed to be zero. Any extension of presently existing production facilities in order to respond to the increasing demand from the market cannot be accommodated in the grant request. This request is based on the capacity and production levels as analyzed during November 1993. No decommissioning of existing production capacities is foreseen.

Discount rate. The discount rate applied for the new equipment to be introduced is 10 percent .

With regard to the costs for the conversion of the production facilities, MEE is eligible for grant financing from the MF for the following elements:

I. Incremental cost related to capital goods replacements, including training, redefinition of products, facility (re)construction, installation, start-up, etc. These are named **investment costs**.

II. **Incremental operating cost** for four years, in proportion to the operations such as labor, maintenance and feedstock.

III. **Contingencies**

I. INVESTMENT COST

- Investment cost for modification of manufacturing facilities, new machinery, materials, testing equipment, (see **Annex A: "Equipment Specification and Cost Breakdown"**); training, installation and consultancy services for modifications, (see **Annex B: "Project Budget for MEE"**).

II. INCREMENTAL OPERATING COST

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

Modification	Description	US $
HFC 134a compressor	All compressors are imported. Various types of compressors are available on the market. At the moment mostly compressors from GOLDSTAR are used. It is estimated that the buy-in price of the compressor will raise by at least 25 percent. On top of that, increased care has to be taken in handling compressors during fridge assembly.	7.5
Inner- and doorliner modification	The more aggressive solvent contained in HCFC 141b will affect the polystyrene innerliner. HIPS or ABS materials have to be used.	1.5
Increased length capillary tube/evaporator	Average 1m	0.
New dryer for HFC 134a	All dryers are imported. A suitable type for HFC 134a will be of 3 AA.	0.03
HFC 134a charge	Replacement of CFC 12 by HFC 134a. Price increase per kg is at the moment US$ 5.9	1.31
New foaming agent HCFC 141b	Replacement of CFC 11 by HCFC 141b. Price increase per kg foam used is at the moment US$ 0.355	2.6
TOTAL		13.04

The incremental operating cost are partly dependant on the price differences between the ODS to be phased out, and their replacements.

Through this project it is proposed to assist MEE with the incremental operating cost based on the current level of production for the duration of one year. Basis for the calculation of the incremental operating cost is one production year, i.e. the number of units produced in one year (between November 1992 and October 1993). The required budgets for the operational incremental cost for the years two to four will be calculated at the end of each preceding year, and applied as a revision of this project with the MFMP for funding.

No incremental savings are foreseen to be encountered. The manufacturing and assembly process is not likely to change substantially, bringing other savings or cost, apart from the cost already accounted to each part in the above table. No additional costs for energy or water, etc. are foreseen.

III. CONTINGENCY FUND

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

IV. TOTAL COST

- *Investment cost* of US$ 355,120 will include all capital investment cost needed for modification of manufacturing facilities, materials and testing equipment, training and consultancy for modifications.

- Cost for transport and insurance of capital equipment is included in the budgeted allocations for the respective items.

- The *incremental operating cost* associated with this project are 100 percent caused by increased prices for imported parts for each refrigerator and their handling during further production and assembly. For the first year of operation these costs are totalling to US$ 260,800, which is based on actual production figures.

- *Other cost*: A 15 percent contingency was included to ensure adequate funding of project costs following project appraisal.

- Implementing Agency's overheads are 13 percent.

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

- The *total project cost* is US$ 695,990 (100%)

- For the amount of eligible grant financing, a local ownership fraction of 75 percent has been considered. The total project cost was thus multiplied by the fraction of local ownership to determine the proposed grant amount, totalling to US$ 521,993.

- Requested funding by the MFMP: <u>US$ 521,993</u>

- In order to ensure a proper project implementation, MEE is requested immediately after project approval by the MFMP to transfer the balance of 25 percent of the project budget, totalling to US$ 173,997 to **UNIDO Funds in Trust, account no. 570/337/410, Bank Austria A.G., Vienna, International Centre, P.O. Box 400**. (make sure project number is quoted). UNIDO's project implementation activities will only start after having received the required funds from MFMP and from MEE.

Annex A: Equipment Specification and Cost Breakdown

	Explanation	Cost per unit	Total cost USD
Vacuum pump	The exisiting eight vacuum pumps need to be cleaned to accommodate HFC 134a refrigerant	600	4.800
Refrigerant/ charging board	One charging board for HFC 134a	31,300	31.300
Service evacuation and charging board for HFC 134a	Seven service evacuation and charging boards are needed	3,000	21.000
Leak detector	The existing leak detectors trigger on Cl molecules and, therefore, they are not usable. Two fairly moderate, standard leak detector have been chosen as replacement.	9,000	18.0600
Revovery units	10 simple mobile recovery units for refrigeration servive	500	5.000
Recovery and recycling unit	One central recovery and recycling unit for CFC 12 needs to be installed at the factory/service center, both, for production and service.	50,000	50.000
Modification of foaming equipment	Modification of high pressure foaming machines, jigs and plugs	25,000	25.000
Mixing station	Mixing station for polyol and HCFC 141b to be provided for the production	50,500	50.500
Preheating oven	Preheating oven to be provided for the production	15,400	15.400
Installation and training	Installation and commissioning of refrigeration equipment, including training	7,000	7.000
	Installation and commissioning of foaming equipment, including training	9,800	9.800
Total USD			237.800

All prices are including transport and insurance, as well as installation and commissioning (where appropriate).

Annex B: Project Budget for MEE

		Duration w/m	US$
BL 11-01	Chief Technical Advisor	2.0	30,000
BL 11-51	Consultant in production layout and refrigeration production	0.5	8,000
BL 11-52	Consultant in refrigeration system design	0.5	8,000
BL 11-53	Consultant for monitoring of project implementation, participation in Project Implementation Review meetings (2 missions)	0.5	12,000
BL 21-01	Subcontract for provision of equipment for refrigeration systems, including installation, commissioning and on-the-job training of MEE's staff (one weeks, one specialist)		137,100
BL 21-01	Subcontract for provision of equipment for foam systems, including installation, commissioning and on-the-job training of MEE's staff (two weeks, one specialist)		100,700
BL 32-01	Study tour for two technicians to foaming machine and blender supplier for technical inspection and training purposes	0.5	8,000
BL 32-02	Study tour for one technician to refrigeration equipment supplier for technical inspection and training	0.5	5,000
BL 51-00	Miscellaneous (15% Contingency Fund)		46,320
Subtotal I			355,120
Incremental operating cost (100%)			260,800
Subtotal II			615,920
Implementing Agency's overheads (13%)			80,070
Subtotal III			695,990
Total (75%)		US$	521,993
MEE cost sharing (25%)		US$	173,997

Annex C: Unit Abatement Cost

A	ODS Phase out		Total Project
A1	Average use of CFC 11 per year	MT	15
A2	ODP of CFC 11		1
A3	ODP-weighted CFC 11 phase (A1*A2)	MT	15
A4	Average use of CFC 12 per year	MT	6
A5	ODP of CFC 12		1
A6	ODP weighted CFC 12 phase out (A$*A5)	MT	6
A7	Total ODP-weighted phase out	MT	21
B	Annualized capital cost		
B1	Total investment cost (model redefinition + production conversion)	US$	475,870
B2	Equipment life	Year	10
B3	Discount rate	%	10
B4	Annualized capital cost (B1*0.1627)	US$	77,424
C	Annual incremental operating cost	US$	275,600
D	Unit Abatement cost		
D1	Annualized capital cost per kg ODS	$/kg	2,75
D2	Annual incremental operating cost per kg ODP phased out (C/A7*1000)	$/kg	12,42
D3	Unit abatement cost (D1+D2)	$/kg	15,17

REVIEW JORDAN PROJECTS
Middle East Electrical Industries Co. Ltd. (MEE)

GENERAL REMARKS

In order to assess the project review it is very important to have more details and the condition of the production facilities e.g.:

- type and manufacturer of the foaming stations,
- leak test facilities,
- charging stations,
- vacuum pumps.

If possible, this information should be included in the project review (see also recommendations of the OORG).

PROJECT SUMMARY

The chosen replacement alternatives for the refrigerant CFC12 and the foam blowing agent CFC11 are the refrigerant HFC134a and the HCFC141b as foam blowing agent. This solution can be recommended due to the following aspects:

- Long term solution for the refrigerant (low GWP, zero ODP)
- Compressors for HFC134a are available from all major suppliers world-wide. All other components such as dryers, oil for the compressors etc. are available on the market.
- Due to its low ODP (0.11) and low GWP (HCFC141b : 440 compared to CFC11 : 3500) the foam blowing agent HCFC141b is the industrial solution in the major refrigerator companies in the United States in order to achieve a considerable reduction of ODP with moderate expenses for the changes necessary at the foaming equipment. Equipment for the foaming system can be modified or replaced from the main suppliers (Germany, Italy).
- Refrigerators with HFC134a as refrigerant are in production world-wide, refrigerators with HCFCR141b-blown foam are already in production in Europe and America. **Experience for construction and production using HFC134a as the refrigerant and HCFC141b as the blowing agent is available and the technology is mature.**

BACKGROUND

SECTOR BACKGROUND

The service sector and the amount of ODS used for servicing is not mentioned in the sector background.

MEE's BACKGROUND

The impact on energy efficiency should be considered and design modifications with an increased insulation thickness are important. These design modifications require test facilities as well as training of the staff for the optimization of the refrigeration system and the insulation. Without these measures, a replacement of ODS in refrigerators with HCF134a and a new foam blowing agent will not lead to reliable refrigerators.

PROJECT OBJECTIVE

PROJECT DESCRIPTION

A. Refrigeration System

To reduce the consumption of ODS in Jordan in the refrigerator sector, hydrocarbons are also a possible alternative as refrigerant for household applications. Hydrocarbons have the environmental advantage of a low GWP compared with HFC134a, but the incremental costs are higher because new compressors are necessary (e.g. higher swept volume for isobutane) and additional safety equipment in the production line is required. Today compressors for hydrocarbons are not commercially available.

B. Foam System

To replace the foam blowing agent CFC11 the selection of HCFC141b is a transitional solution for decades due to the remaining ODP. This solution can be recommended to avoid the high expenses necessary for the introduction of the ODP-free blowing agents cyclo pentane or HFC134a as long term alternatives. Furthermore, the annual figure of produced refrigerators at MEE is not high enough to justify an environmentally optimal but very expensive solution.

An ODP-free solution for the foam blowing agent could be the use of HFC134a or cyclo pentane. But in comparison with HCFC141b they are much more expensive, because for HFC134a high pressure foaming stations are required and for cyclo pentane protection against explosion is necessary. All other technical options are also transitional substances because they are not ODP-free or under investigations and not approved at present (e.g. CO_2).

It is recommended to examine the optimal insulation thickness under the climatic conditions in Jordan and to improve the present refrigerant cycle design for HFC134a in order to reduce the energy consumption of the system (Total Equivalent Warming Impact). This optimization requires test facilities including measurement equipment.

C. Refrigeration Service

For servicing refrigerators in field, a vacuum pump and a small filling station are necessary. Combined vacuum and filling systems are also available on the market which should be used either with HCF134a or CFC12. A recovery and recycling unit for service purpose is not recommended, because the amount of refrigerant inside the system is too small for a proper operation of this equipment and this method is not used in Europe. Instead of a recovery and recycling system another cost effective and simple method is recommended, where a small tube filled with activated carbon is connected to the refrigerator and the refrigerant is absorbed by activated carbon (patent AEG Hausgeräte AG, Germany, licences are available). After recovery, the absorbed refrigerant can be recycled using a central recycling station.

For servicing refrigerators at a service station, a recovery unit is recommended instead of the activated carbon system.

Furthermore leak detectors for the service cars are recommended. Detectors which can detect CFC12 as well as HFC134a are commercially available (about US$ 600).

D. Justification for Selection of Alternative Technologies

See A. Refrigeration System and B. Foam System respectively.

INPUTS

A. Capital Goods Replacement

Refrigeration System

- The installed charging equipment and the vacuum pumps after some modifications can also be used with HFC134a if the status of the existing equipment allows this measure. For the conversion it is necessary to replace all flexible hoses and sealings of the charging stations with HFC134a approved materials. For the vacuum pumps in the production line only backflow valves should be installed in order to prevent a backflow of oil vapour from the pump to the refrigerator. Modern vacuum pumps are equipped with such a backflow valve.
- For leak testing in the production, different methods can be implemented:
  - helium leak detection systems including a mass spectrometer (best solution but very cost intensive)
  - HFC134a leak detectors (require the system to be filled with HFC134a and after approved leak test the refrigerant has to be removed using a recovery / recycling unit).
- The cleaning procedure for the vacuum pumps cannot be recommended and it is not necessary (installing a backflow valve).
- The timeframe for testing and optimization of the refrigerators (capillary tube adaption, establishing new rules for dryness and cleanliness) will take more time.
- Training programs are recommended for the optimization of the refrigerators and during installation of the new equipment.
- In the absence of national standards for the technical requirement of the components, European or American standards should be used.

Foam System

- The insulation thickness should be increased in order to minimize the energy losses. It is recommended to examine the optimal insulation thickness under the specific Jordanian climatic conditions. Modifications at the housing due to a thicker insulation require new production tools which are expensive.
- For checking the new foaming chemicals and the foam quality, tests should be performed in cooperation with the suppliers of the machines and the distributors of the chemicals during installation. Further tests with refrigerators should be performed in order to measure the heat loss as a function of time, the foam distribution inside the

housing etc. and other measures which are important for a proper quality. Detailed investigations of the foam should be performed by external institutions.

B. Model Redefinition

- Reliability tests over a longer period (at least 2000 h for each model) are recommended in order to confirm the reliabilty of the new models.

C. Conversion / Training

- The foam and refrigerant technology should be changed stepwise at the parallel production lines in order to solve initial problems during production and to transfer the experience to the other production lines. In this case, failures and problems will not lead to a total breakdown of the production lines.

D. After Sales Service

- One vacuum pump, one charging cylinder and a leak detector (model which can handle CFC12 and HFC134a) are necessary for the evacuation, charging and leak detection of the system for each service car.
- The amount of CFC12 in the failed system is too low and so proper operation of the recovery unit is not possible. For recovery of CFC12 it is recommended to use simple tools which are more cost effective and in use in Germany instead of expensive recovery units (cylinders filled with activated carbon). Therefore a central recycling station (model which can handle CFC12 and HFC134a) is recommended including test equipment for the refrigerant quality.

PROJECT IMPLEMENTATION

MILESTONES

Design changes (e.g. increase of the insulation thickness, heat exchangers etc.) require modifications of the housing and the inner liner. These modifications are not mentioned in the time frame, therefore the timeframe for redesign of the models including equipment changes in the production line should be enlarged.

PROJECT COSTS

The recommended measures in this review effect also the cost statement of the project. Without having any detailed information about the equipment which is suggested in the project proposal for the modification of the production lines and the service sector, it is not possible to value these.

Annex A : Equipment Specification and Cost Breakdown

- recovery systems for service cars (activated carbon systems).
- foam test equipment has to be specified (cooperation with foam / system suppliers)

Annex C : Unit Abatement Cost

For the calculation of the 'Total ODP-weighted phase' and the 'Unit abatement cost' the remaining ODP of the blowing agent HCFC141b is not taken into consideration.

Annex D : Cleaning Technology for Vacuum Pumps

The cleaning procedure for vacuum pumps is not recommended.

PROJECT COVER

Country	:	The Hashemite Kingdom of Jordan
Project Title	:	**Investment Project for Phasing Out ODS at National Refrigeration Co.**
Sectors Covered	:	Domestic Refrigeration / Rigid Foam / Refrigerant
ODS Use in Sector	:	47 MT of CFC 11 and CFC 12 annually
Project Impact	:	Phase out of annual consumption of 7 MT of CFC 11 and 3 MT of CFC 12 in the production and in the service (Total ODP = 10 MT)
Project Duration	:	18 months
Project Economic Life	:	10 years
Proposed Total Project Cost	:	Total of capital cost and incremental operating cost (first year of operation) US$ 533,555
Project Cost	:	US$ 418,255
Implementing Agency's Overheads (13%)	:	US$ 69,362
Incremental Operating Cost/Year	:	US$ 115,300
Proposed MF Financing	:	US$ 602,917
Cost Effectiveness	:	US$/kg 18.34(see Annex C:Unit Abatement Cost)
Counterpart Enterprise	:	National Refrigeration Co. (NRC), Amman
Implementing Agency	:	UNIDO
Coordinating Ministry	:	Ministry of Municipals, Rural Affairs and the Environment

PROJECT SUMMARY

This project will phase out 100 percent of the use of CFC 11 and CFC 12 for the production of domestic refrigerators at the **National Refrigeration Co. (NRC), Amman, The Hashemite Kingdom of Jordan**. The chosen replacement alternatives are HCFC 141b as foam blowing agent and HFC 134a as refrigerant. The project will be implemented through redefinition of all current refrigerator models and the conversion of the production facilities of the plant. The redefinition of the existing refrigerator models covers activities as prototyping, testing, trial manufacturing and adaptation as well as extensive reliability tests. The conversion of production facilities covers the refrigeration system, the insulation foam blowing system as well as the refrigeration service carried out by the company.

Date: 3 February 1994

BACKGROUND

SECTOR BACKGROUND

Refrigeration subsector

The subsector for domestic refrigeration in the Hashemite Kingdom of Jordan consists of 3 manufacturers who are responsible for 100 percent of the consumption of CFC 11 and CFC 12 in the subsector.

Consumption of ODS

The total 1992 to 1993 consumption in the subsector according to the Country Programme was estimated at 34 MT CFC 11 and of 13 MT CFC 12, totalling 47 MT for 42,000 units produced in the subsector.

Jordan does not produce any ODS. All ODS used in the country are directly imported by the users.

Conversion strategy

For phasing out the use of ODS the production facilities of the domestic refrigeration manufacturers Household Appliances Manufacturing Company (HAMCO), Middle East Electrical Company (MEE) and National Refrigeration Company (NRC) will be converted. Their total production from November 1, 1992 to October 31, 1993 was 42,000 units, while their total ODS consumption was 47 MT, which represents 100 percent of the domestic refrigeration ODS consumption in Jordan.

Used technologies

The companies ARE using the same types of ODS, and show a great similarity in production methodologies, although differences exist in quality assurance, accuracy and product finishing. For insulation foam blowing CFC 11 and for the cooling systems CFC 12 are being used respectively. All specialized components like compressor, dryer and evaporator are imported.

NRC's BACKGROUND

Ownership and licences

National Refrigeration Company (NRC), is a company 100 percent privately owned by Jordanian citizens. The currently applied technologies and the know-how were imported from Westinghouse (Canada), based on a former license agreement which is not valid anymore.

NRC is the smallest domestic refrigerator manufacturer in Jordan, using 7 MT of CFC 11 and 3 MT CFC 12 to produce about 10,000 refrigerators anually. The company is the oldest refrigerator manufacturing company in Jordan (established 45 years ago).

The product range consists of upright freezers and refrigerators and chest freezers, in total 10 models.

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

Outline of enterprise assessment, and last year's performance and consumption.

(based on production between November 1992 and October 1993)

NRC has limited or no knowledge about the HFC 134a and HCFC 141b solutions. The machinery and equipment and equipment currently in use is outdated. Therefore, full technical support for the conversion will be needed; test facilities are not available; no conversion activities or tests have been carried out yet; plant layout and operation need to be improved. The model redefinition has to take care of increase in insulation thickness. The currently produced models of chest freezers, however, have by far a too low insulation thickness. The current and also future energy requirements will, therefore call for an increased insulation. It can, however not be envisaged that the MFMP will cover all expenses for model redefinition and the corresponding investment cost to be incurred in the course of plant conversion, if the current models are found not being adequate for the ambient temperature.

Number of employees:	75 (120 during summer months)
Number of units produced annually:	approx. 10,000
Number of models:	10
CFC 11 consumption (in MT, annually):	7
CFC 12 consumption (in MT, annually):	3
Total ODS consumption (in MT, annually):	10

PROJECT OBJECTIVE

The objective of this project is to eliminate the use of CFC 11 and CFC 12 in the production of domestic refrigerators and freezers and in the rfrigeration service at National Refrigeration Co. (NRC), through conversion of the production equipment to the use of HFC 134a as refrigerant and HCFC 141b as insulating foam blowing agent.

PROJECT DESCRIPTION

NRC is prepared to phase out ODS as soon as the new technology has been acquired, the necessary machinery and equipment installed and the technical staff trained.

A. Refrigeration System

Among the technological options currently available on commercial basis , NRC has chosen to replace CFC 12 by HFC 134a because the new type compressors are available, the technology is mature and commercially applied outside Jordan.

B. Foam System

Instead of the blowing agent CFC 11 for polyurethane foam, NRC has decided to introduce HCFC 141b for a transitional period, because HCFC 141b has only one tenth of the ODP of CFC 11. Its introduction would not require any bigger change in the basic operations, machinery and equipment. It is expected that NRC will still be eligible for financial assistance from MFMP at a later stage when a more developed ODP-free foaming technology will also be available for smaller refrigerator and freezer manufacturers, i.e. at justifiable investment cost.

As already stated above, the current model range was found not being suitable for the ambient temperature with regard to insulation thickness. A proper insulation thickness would have absorbed the slightly smaller k - value, using HCFC 141b without major model redefinition. Therefore, the investment cost involved to achieve the required insulation thickness are expected to be covered by NRC.

C. Refrigeration Service

To save CFC 12 in the course of repair and maintenance to be carried out by the refrigerator manufacturer, NRC is prepared to introduce simple recovery units for their refrigeration service as well as the necessary equipment for servicing HFC 134a refrigeration systems. This (comparably low) investment will save a considerable amount of CFC 12 over the years to come through recovery and recycling. The NRC service personnel will be trained in-house by those engineers who will be trained through the project.

D. Justification For Selection Of Alternative Technologies

Various alternatives for replacement of currently used CFCs have been considered. These are mentioned hereunder, as well as an assessment of their suitability in Jordan.

Foam	Assessment	Consequences
Cyclo Pentane	ODP = 0, flammable and explosive	special infrastructure and equipment needed
HCFC 142b plus HCFC 22 (60/40)	HCFC 142b is flammable and explosive before being mixed with HCFC 22 and Polyol ODP = 0.06	special infrastructure and equipment needed
HCFC 141b	ODP = 0.11	"intermediate solution"; almost drop-in solution; minor adjustments in production process and product design required
CFC 11, 50 percent reduced	ODP = 0.5	drop-in solution, minor adjustments in production process required
HFC 134a	ODP = 0	too expensive and high pressure foaming machine needed
HCFC 142b	ODP = 0.065 flammable and explosive before being mixed with Polyol	minor adjustments in production process required; high pressure foaming machine needed
Refrigerant		
Propane	explosive, toxic	technology not yet mature and not available; (would require special infrastructure, special -protection for health, substantial danger when servicing)
HFC 134a	ODP = 0	product design can largely stay the same, adjustments needed; replacement of some production equipment, increased manufacturing process control required

INPUTS

A. Capital Goods Replacement

Refrigeration system

The technology for refrigeration with HFC 134a is well known. Critical elements as compressor, drier, capillary tube, evaporator, etc., will have to be imported.

When applying HFC 134a as refrigerant, the system has to be much cleaner and dryer. The existing vacuum pumps, after being cleaned can also be used for the new refrigerant.

The refrigerant charging board has to be replaced for reasons of density changes and Cl pollution. Since the leak detectors react on the Cl molecules, they are to be replaced as well.

A recovery and recycling unit for CFC 12 needs to be introduced.

Foam system

The technology for blowing the insulation foam, using HCFC 141b as blowing agent is well known and tested. The same production facilities can be used, with changes of some parts, like the blowing nozzles, improved foaming jigs and plugs, a mixing station and an oven for preheating the cabinets before foaming, etc.

Refrigeration Service

To ensure appropriate refrigeration service, the following equipment needs to be provided:

- mobile evacuation and charging boards for HFC 134a;
- simple mobile recovery units for CFC 12.

B. Model Redefinition

The redefinition of the current refrigerator models covers all activities to assure that the new models are on the same level of functionality and reliability. Several stages in this process are essential:

- Design, calculation and drafting;
- Prototyping;
- Functionality and performance testing, incl. trial runs;
- External problem solving consultancy.

C. Conversion / Training

Within the framework of this project, NRC,s personnel will be trained in (among others) the following topics:

- management and production control;
- quality assurance in relation to conversion;
- maintenance of the new machinery and equipment;

- refrigeration laboratory tests;
- new technologies for foam and refrigerant;
- specification for materials;
- refrigeration service

As a common practice, modifications of the production lines will be carried out during evenings and weekends and will, consequently, not cause any costs for this project.

PROJECT IMPLEMENTATION

The project will be implemented by UNIDO in close cooperation with NRC.

Local coordination will be done by the Department of the Environment of the Ministry of Municipals, Rural Affairs and the Environment.

To substantively assist, coordinate and supervise the project implementation on behalf of UNIDO, a Chief Technical Advisor will be appointed.

For the implementation of major components of the project (foaming system, refrigeration system, etc.) subcontracts will be concluded, based on competitive bidding. The subcontracts will include supply of equipment, installation, commissioning and on-the-job training of NRC's staff. The Terms of Reference for the subcontracts will be elaborated after approval of the project.

The final equipment specification and workplan can only be elaborated after approval of the basic approach for the project implementation by the Multilateral Fund for the Implementation of the Montreal Protocol (MFMP).

Having accepted the conversion of its plant to the use of non-ODS under this project, NRC will be committed to provide the following inputs:

- Technical staff as required by the subcontractors;

- All activities and costs involved for construction work needed (including the provision of technical infrastructure) to accommodate the new technologies under this project. The relevant construction work will have to be arranged by NRC in line with the established Milestones for this project. (The costs for the construction work are, therefore, not reflected in the project budget.)

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

- Local transport, communication and secretarial facilities for the subcontactors 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 the enterprise level. Upon the approval 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 hereunder.

MILESTONES	month D	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1. Sign the project, receive funding	1	x																	
2. Make a detailed project workplan	1	x																	
3. Initial training of management	1	x																	
4. First redesign of models	4		x	x	x	x													
5. Prototypes and testing	6						x	x	x	x	x	x							
6. Selection of equipment, bidding	3		x	x	x														
7. Purchase, installation and commissioning	6					x	x	x	x	x	x								
8. From start of production to full conversion of prod. facilities	8											x	x	x	x	x	x	x	x

The above schedule presents a worst case scenario. It is likely that earlier completion of implementation activities can be achieved.

Substantive and financial reporting will be in accordance with the MFMP's requirements.

PROJECT COST

This investment project proposal presents the *incremental cost* as additional cost that the enterprise incurs in taking the action to phase out ODS, and is as such defined as the *difference* between the *actual cost* of the phase out activity and the *baseline cost*. The baseline cost is the cost that the company incurs when staying at the same level of operation, without phasing out ODS.

Baseline cost. The cost for maintaining the same level of operation is assumed to be zero. Any extension of presently existing production facilities in order to respond to the increasing demand from the market, cannot be accommodated in the grant request. This request is based on the capacity and production level as analyzed during November 1993. No decommissioning of existing production capacities is foreseen.

Discount rate. The discount rate applied for the new equipment to be introduced is 10 percent.

With regard to the costs for the conversion of the production facilities, NRC is eligible for grant financing from the MFMP for the following elements:

I. Incremental cost related to capital goods replacements, including training, redefinition of products, facility (re)construction, installation, start-up, etc. These are named **investment cost**.

II. **Incremental operating cost** for four years, in proportion to the operations such as labor, maintenance and feedstock.

III. **Contingencies**

I. INVESTMENT COST

- Investment cost for modification of manufacturing facilities, new machinery, materials, testing equipment, (see **Annex A: "Equipment Specification and Cost Breakdown"**); training, installation and consultancy services for modifications, (see **Annex B: "Project Budget for NRC"**).

II. INCREMENTAL OPERATING COST

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

Modification	Description	US $
HFC 134a compressor	All compressors are imported. Various types of compressors are available on the market. It is estimated that the buy-in price of the compressor will raise by at least 25 percent. On top of that, increased care has to be taken in handling compressors during fridge assembly.	7.5
Inner- and doorliner modification	The more aggressive solvent contained in HCFC 141b will affect the polystyrene innerliner. HIPS or ABS materials have to be used.	0.75 *
Increased length capillary tube/evaporator	Average 1m	0.1
New dryer for HFC 134a	All dryers are imported. A suitable type for HFC 134a will be of 3 AA.	0.03
HFC 134a charge	Replacement of CFC 12 by HFC 134a. Price increase per kg is at the moment US$ 5.9	1.35
New foaming agent HCFC 141b	Replacement of CFC 11 by HCFC 141b. Price increase per kg foam used is at the moment US$ 0.355	1.8
TOTAL		11.53

* Steel innerliner is being used for about 50 percent of the production.

The incremental operating cost are partly dependant on the price differences between the ODS to be phased out, and their replacements.

Through this project it is proposed to assist NRC with the incremental operating cost based on the current level of production for the duration of one year. Basis for the calculation of the incremental operating cost is one production year, i.e. the number of units produced in one year (between November 1992 and October 1993). The required budgets for the recurrent incremental costs for the years two to four will be calculated at the end of each preceding year and applied as a revision of this project with the MFMP for funding.

No incremental savings are foreseen to be encountered. The manufacturing and assembly process is not likely to change substantially bringing other savings or cost, apart from the cost already accounted to each part in the above table. No additional cost for energy or water etc. are foreseen.

III. CONTINGENCY FUND

A contingency fund (15 percent of the total project budget) has been calculated. The Multilateral Fund is proposed to cover unforeseen expenses which might be incurred during the project implementation, e.g. purchase of small testing instruments whose needs will be caused during the conversion process, miscellaneous expenses, etc.

IV. TOTAL COST

- *Investment cost* of US$ 418,255 will include capital investment cost for modification of manufacturing facilities, materials and testing equipment, training and consultancy for modifications.

- The *incremental operating costs* associated with this project are 100 percent caused by increased prices for imported parts for each refrigerator and their handling during further production and assembly. For the first year of operation these costs are totalling to US$ 115,300, which is based on actual production figures.

- For the amount of eligible grant financing, a local ownership fraction of 100 percent has been considered.

- *Other cost*: A 15 percent contingency was included to ensure adequate funding of project cost following project appraisal.

- Implementing Agency's overheads are 13 percent.

- The *total project cost* is US$ 533,555

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

- Requested funding by the MFMP: <u>US$ 602,917</u>

Annex A: Equipment Specification and cost Breakdown

	Explanation	Cost per Unit	Total cost US$
Vacuum pump	The existing two vacuum pumps need to be cleaned to accommodate HFC 134a refrigerant	600	1,200
Refrigerant/ charging board	One charging board for HFC 134a	31,300	31,300
Service evacuation and charging board for HFC 134a	One service evacuation and charging board is needed	3,000	3,000
Leak detector	The existing leak detector triggers on Cl molecules and, therefore it is not usable. One fairly moderate, standard leak detector has been chosen as replacement.	9,000	9,000
Recovery and recycling unit	One central recovery and recycling unit for CFC 12 needs to be installed at the factory both for production and service.	50,000	50,000
Service recovery unit	10 simple mobile recovery units for CFC 12 to be provided for the service center.	500	5,000
Modification of foaming equipment	Procurement of one high pressure foaming machine, modification of jigs and plugs	109,000	109,000
Mixing station	Mixing station for polyol and HCFC 141b to be provided for the production	50,500	50,500
Preheating oven	Preheating oven to be provided for the production	15,400	15,400
Installation and training	Installation and commissioning of refrigeration equipment, incl. training	6,500	6,500
	Installation and commissioning of foaming equipment, incl. training	11,800	11,800
	Total	US$	292,700

All prices are including transport and insurance, as well as installation and commissioning (where appropriate).

Annex B: Project Budget for NRC

		Duration w/m	US$
BL 11-01	Chief Technical Adviser	2.0	30,000
BL 11-51	Consultant in production layout and refrigeration production	0.5	8,000
BL 11-52	Consultant in refrigeration system design	0.5	8,000
BL 11-53	Consultant for monitoring of project implementation, participation in Project Implementation Review meetings (2 missions)	0.5	12,000
BL 21-01	Subcontract for provision of equipment for refrigeration systems, including equipment installation, commissioning and on-the-job training of NRC's staff (one week, one specialist)		106,000
BL 21-02	Subcontract for provision of equipment for foaming system, including equipment installation, commissioning and on-the-job training of NRC's staff (two weeks, one specialist)		186,700
BL 32-01	Study tour for two technicians to foaming machine and blender supplier for technical inspection and training purposes	0.5	8,000
BL 32-02	Study for one technician to refrigeration equipment supplier for technical inspection and training	0.5	5,000
BL 51-00	Miscellaneous (15 percent Contingency Fund)		54,555
Subtotal I			418,255
Incremental operating cost			115,300
Subtotal II			533,555
Implementing Agency's Overheads (13 percent)			69,362
	TOTAL		US$ 602,917

Annex C: Unit Abatement Cost

A	ODS Phase out		Total Project
A1	Average use of CFC 11 per year	MT	7
A2	ODP of CFC 11		1
A3	ODP-weighted CFC 11 phase (A1*A2)	MT	7
A4	Average use of CFC 12 per year	MT	3
A5	ODP of CFC 12		1
A6	ODP weighted CFC 12 phase out (A$*A5)	MT	3
A7	Total ODP-weighted phase out	MT	10
B	Annualized capital cost		
B1	Total investment cost (model redefinition + production conversion)	US$	418,255
B2	Equipment life	Year	10
B3	Discount rate	%	10
B4	Annualized capital cost (B1*0.1627)	US$	68,050
C	Annual incremental operating cost	US$	115,300
D	Unit Abatement cost		
D1	Annualized capital cost per kg ODS	$/kg	6.81
D2	Annual incremental operating cost per kg ODP phased out (C/A7*1000)	$/kg	11.53
D3	Unit abatement cost (D1+D2)	$/kg	18.34

REVIEW JORDAN PROJECTS
National Refrigeration Co. (NRC)

GENERAL REMARKS

In order to assess the project review it is very important to have more details and the condition of the production facilities e.g.:

- type and manufacturer of the foaming stations,
- leak test facilities,
- charging stations,
- vacuum pumps.

If possible, this information should be included in the project review (see also recommendations of the OORG).

PROJECT SUMMARY

The chosen replacement alternatives for the refrigerant CFC12 and the foam blowing agent CFC11 are the refrigerant HFC134a and the HCFC141b as foam blowing agent. This solution can be recommended due to the following aspects:

- Long term solution for the refrigerant (low GWP, zero ODP)
- Compressors for HFC134a are available from all major suppliers world-wide. All other components such as dryers, oil for the compressors etc. are available on the market.
- Due to its low ODP (0.11) and low GWP (HCFC141b : 440 compared to CFC11 : 3500) the foam blowing agent HCFC141b is the industrial solution in the major refrigerator companies in the United States in order to achieve a considerable reduction of ODP with moderate expenses for the changes necessary at the foaming equipment. Equipment for the foaming system can be modified or replaced from the main suppliers (Germany, Italy).
- Refrigerators with HFC134a as refrigerant are in production world-wide, refrigerators with HCFCR141b-blown foam are already in production in Europe and America. **Experience for construction and production using HFC134a as the refrigerant and HCFC141b as the blowing agent is available and the technology is mature.**

BACKGROUND

SECTOR BACKGROUND

The service sector and the amount of ODS used for servicing is not mentioned in the sector background.

NRC's BACKGROUND

The impact on energy efficiency should be considered and design modifications with an increased insulation thickness are important. These design modifications require test facilities as well as training of the staff for the optimization of the refrigeration system and the insulation. Without these measures, a replacement of ODS in refrigerators with HCF134a and a new foam blowing agent will not lead to reliable refrigerators.

PROJECT OBJECTIVE

PROJECT DESCRIPTION

A. Refrigeration System

To reduce the consumption of ODS in Jordan in the refrigerator sector, hydrocarbons are also a possible alternative as refrigerant for household applications. Hydrocarbons have the environmental advantage of a low GWP compared with HFC134a, but the incremental costs are higher because new compressors are necessary (e.g. higher swept volume for isobutane) and additional safety equipment in the production line is required. Today compressors for hydrocarbons are not commercially available.

B. Foam System

To replace the foam blowing agent CFC11 the selection of HCFC141b is a transitional solution for decades due to the remaining ODP. This solution can be recommended to avoid the high expenses necessary for the introduction of the ODP-free blowing agents cyclo pentane or HFC134a as long term alternatives. Furthermore, the annual figure of produced refrigerators at NRC is not high enough to justify an environmentally optimal but very expensive solution.

An ODP-free solution for the foam blowing agent could be the use of HFC134a or cyclo pentane. But in comparison with HCFC141b they are much more expensive, because for HFC134a high pressure foaming stations are required and for cyclo pentane protection against explosion is necessary. All other technical options are also transitional substances because they are not ODP-free or under investigations and not approved at present (e.g. CO_2).

NRC recognized the necessity of increasing the insulation thickness. It is recommended to examine the optimal insulation thickness under the climatic conditions in Jordan and to improve the present refrigerant cycle design for HFC134a in order to reduce the energy consumption of the system (Total Equivalent Warming Impact). This optimization requires test facilities including measurement equipment.

C. Refrigeration Service

For servicing refrigerators in field, a vacuum pump and a small filling station are necessary. Combined vacuum and filling systems are also available on the market which should be used either with HCF134a or CFC12. A recovery and recycling unit for service purpose is not recommended, because the amount of refrigerant inside the system is too small for a proper operation of this equipment and this method is not used in Europe. Instead of a recovery and recycling system another cost effective and simple method is recommended, where a small tube filled with activated carbon is connected to the refrigerator and the refrigerant is absorbed by activated carbon (patent AEG Hausgeräte AG, Germany, licences are available). After recovery, the absorbed refrigerant can be recycled using a central recycling station.

For servicing refrigerators at a service station, a recovery unit is recommended instead of the activated carbon system.

Furthermore leak detectors for the service cars are recommended. Detectors which can detect CFC12 as well as HFC134a are commercially available (about US$ 600).

D. Justification for Selection of Alternative Technologies

See A. Refrigeration System and B. Foam System respectively.

INPUTS

A. Capital Goods Replacement

Refrigeration System

- The installed charging equipment and the vacuum pumps after some modifications can also be used with HFC134a if the status of the existing equipment allows this measure. For the conversion it is necessary to replace all flexible hoses and sealings of the charging stations with HFC134a approved materials. For the vacuum pumps in the production line only backflow valves should be installed in order to prevent a backflow of oil vapour from the pump to the refrigerator. Modern vacuum pumps are equipped with such a backflow valve.
- For leak testing in the production, different methods can be implemented:
  - helium leak detection systems including a mass spectrometer (best solution but very cost intensive)
  - HFC134a leak detectors (require the system to be filled with HFC134a and after approved leak test the refrigerant has to be removed using a recovery / recycling unit).
- The cleaning procedure for the vacuum pumps cannot be recommended and it is not necessary (installing a backflow valve).
- The timeframe for testing and optimization of the refrigerators (capillary tube adaption, establishing new rules for dryness and cleanliness) will take more time.
- Training programs are recommended for the optimization of the refrigerators and during installation of the new equipment.
- In the absence of national standards for the technical requirement of the components, European or American standards should be used.

Foam System

- The insulation thickness should be increased in order to minimize the energy losses. It is recommended to examine the optimal insulation thickness under the specific Jordanian climatic conditions. Modifications at the housing due to a thicker insulation require new production tools which are expensive.
- For checking the new foaming chemicals and the foam quality, tests should be performed in cooperation with the suppliers of the machines and the distributors of the chemicals during installation. Further tests with refrigerators should be performed in order to measure the heat loss as a function of time, the foam distribution inside the

housing etc. and other measures which are important for a proper quality. Detailed investigations of the foam should be performed by external institutions.

B. Model Redefinition

- Reliability tests over a longer period (at least 2000 h for each model) are recommended in order to confirm the reliabilty of the new models.

C. Conversion / Training

- The foam and refrigerant technology should be changed stepwise at the parallel production lines in order to solve initial problems during production and to transfer the experience to the other production lines. In this case, failures and problems will not lead to a total breakdown of the production lines.

D. After Sales Service

- One vacuum pump, one charging cylinder and a leak detector (model which can handle CFC12 and HFC134a) are necessary for the evacuation, charging and leak detection of the system for each service car.
- The amount of CFC12 in the failed system is too low and so proper operation of the recovery unit is not possible. For recovery of CFC12 it is recommended to use simple tools which are more cost effective and in use in Germany instead of expensive recovery units (cylinders filled with activated carbon). Therefore a central recycling station (model which can handle CFC12 and HFC134a) is recommended including test equipment for the refrigerant quality.

PROJECT IMPLEMENTATION

MILESTONES

Design changes (e.g. increase of the insulation thickness, heat exchangers etc.) require modifications of the housing and the inner liner. These modifications are not mentioned in the time frame, therefore the timeframe for redesign of the models including equipment changes in the production line should be enlarged.

PROJECT COSTS

The recommended measures in this review effect also the cost statement of the project. Without having any detailed information about the equipment which is suggested in the project proposal for the modification of the production lines and the service sector, it is not possible to value these.

Annex A : Equipment Specification and Cost Breakdown

- recovery systems for service cars (activated carbon systems).
- foam test equipment has to be specified (cooperation with foam / system suppliers)

Annex C : Unit Abatement Cost

For the calculation of the 'Total ODP-weighted phase' and the 'Unit abatement cost' the remaining ODP of the blowing agent HCFC141b is not taken into consideration.

Annex D : Cleaning Technology for Vacuum Pumps

The cleaning procedure for vacuum pumps is not recommended.