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Executive Committee of
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Implementation of the Montreal Protocol

Seventeenth Meeting
Montreal, 26-28 July 1995

PROJECT PROPOSAL: SRI LANKA

This document includes the following project proposal:

- Elimination of CFCs 11 and 12 at Three Domestic Refrigerator Manufacturers (AEC Ltd, Glacio Ltd. & Regnis Lanka Ltd.) UNDP

PROJECT COVER SHEET

COUNTRY: SRI LANKA

PROJECT TITLE:	Elimination of CFCs 11 and 12 at THREE Domestic Refrigerator manufacturers.
SECTOR COVERED:	Domestic Refrigeration
ODS USE IN SECTOR:	22.20 tons ODS (Nov 93 - Oct 94)
PROJECT IMPACT (ODP):	20.49 ODP tons
TOTAL PROJECT COST:	US$ 1,198,352
INCREMENTAL CAPITAL COST:	US$ 1,124,500
INCREMENTAL OPERATING COST:	US$ 73,852
PROPOSED MLF GRANT:	US$ 911,438
UNIT ABATEMENT COST:	9.94 US$/Kg
PROJECT COST-EFFECTIVENESS:	44.48 US$/Kg
PROJECT DURATION:	1.5 years.
ECONOMIC LIFE:	10 years.
NATIONAL COORDINATING BODY:	Ministry of Transport, Environment, & Women's Affairs
IMPLEMENTING AGENCY:	UNDP
APPRAISAL DATE:	November 1994, January 1995

PROJECT SUMMARY

This project will phase out the use of CFCs at the only three manufacturers of domestic refrigerators and freezers in Sri Lanka. TWO of the THREE enterprises, Associated Electrical Corporation Ltd and Glacio Ltd, are 100% Sri Lankan-owned. The other enterprise, Regnis (Lanka) Ltd, is 51% owned by Article 5.1 countries. 99.5% of the production is sold in Sri Lanka. All three enterprises currently use CFC 11 as a blowing agent in the production of rigid polyurethane insulation foam for the refrigerator cabinets and doors, and CFC 12 is used as the refrigerant. In this project CFC 11 use will be eliminated by conversion to the use of HCFC 141b (AEC & Glacio) and cyclopentane (Regnis). CFC 12 is replaced by HFC 134a. The project will eliminate 20.49 ODP tons/yr (based on Nov 93 - Oct 94 figures) which includes some CFC 12 used for servicing. Funds requested will be used to change the existing production lines, and for technology transfer, safety matters, technical assistance, re-design, testing, pre-production trials, and training. Incremental operational costs resulting from the conversion to the new technology (6 months only) are also included.

Prepared by:	Stuart Kelly , in collaboration with the Sri Lankan Ministry of Transport, Environment, & Women's Affairs.
Reviewed by:	Dr L.J.M. Kuijpers (Refrigeration) and Dr H. Creyf (Foam). Their comments are attached.

PROJECT OF THE GOVERNMENT OF SRI LANKA

ELIMINATION OF CFCs IN THE MANUFACTURE OF DOMESTIC REFRIGERATORS

1. PROJECT OBJECTIVE.

The objective of this project is to eliminate CFCs used by three manufacturers of domestic refrigerators and freezers. The CFCs which will be eliminated include CFC 11, used as a blowing agent for producing thermal insulating foams, and CFC 12, used as a refrigerant in the production of domestic refrigerators and freezers.

2. SECTOR BACKGROUND.

The Sri Lanka Country Programme (CP) for the Phase-out of Ozone Depleting Substances (ODS) under the Montreal Protocol was approved at the 12th Meeting of the Executive Committee of the Multilateral Fund for the Montreal Protocol in March 1994.

Data on ODS consumption in the CP is provided for the year 1991 when total consumption was estimated as 231 ODP tons, with CFC 12 and CFC 11 accounting for 162.4 ODP tons (70.3%), and 39.1 ODP tons (16.9%) respectively. These figures are based on import statistics. Data for 1992/1993 indicate an increase in imports of the principal ODS of 20% per annum and it is estimated that total consumption in 1994 could be approximately 350 ODP tons.

Consumption of ODS by sector in 1991 indicated that the refrigeration and air-conditioning sector was the largest consumer, accounting for a total of 188 ODP tons (81.4%).

In preparing this project proposal, the following data for the 12 months November 1993 to October 1994, inclusive, was established as the best estimate of current CFC consumption for the manufacture of domestic refrigerators and freezers. ODS elimination project proposals are being presented to the Montreal Protocol Multilateral Fund for all the THREE enterprises indicated, the only manufacturers of domestic refrigerators and freezers in Sri Lanka.

ENTERPRISE	PRODUCTION VOLUME	ODS CONSUMPTION (tes)	
		CFC 11	CFC 12
AEC Ltd	14,029	3.15	2.52
REGNIS (LANKA) Ltd	10,079	5.12	1.22
GLACIO Ltd	4,868	4.19	1.50
TOTALS	28,976	12.46	5.24

This consumption of 17.70 ODP tons in the manufacture of domestic refrigerators and freezers, represents approximately 5% of present day total ODS consumption in Sri Lanka.

Customs data indicates a similar annual level of imports of domestic refrigerators and freezers from Korea, Australia, and ASEAN countries. Exports are minimal, with one enterprise exporting around 120 refrigerators per annum to Papua New Guinea, Vanuatu, and the Maldives.

Sri Lanka has a population of approximately 17 million but only something like 30% of households have electricity. The estimated existing refrigerator/freezer population is around 500,000 units. Expansion in electricity supply, coupled with retirement of existing refrigerators is expected to sustain growth in domestic refrigerator and freezer sales at 5+% per annum for the next several years.

A further 4.5 tons of CFC 12 was consumed by AEC Ltd and GLACIO Ltd in the repair and servicing of domestic refrigerators and freezers. The project proposals for these two enterprises includes for recovery and recycling equipment to substantially reduce this consumption of CFC 12.

There is, as yet unquantified, additional consumption of CFC 12 for servicing domestic refrigerators mostly by private service agencies in the unorganised sector. The Montreal Protocol Unit of the Ministry of Transport, Environment, and Womans Affair's will undertake a study to determine the consumption of ODS for servicing in ALL the refrigeration and air-conditioning sub sectors, and will prepare a strategy for reduction of this ODS consumption.

The **22.2 tons "ODS USE IN SECTOR"** in the Project Summary Sheet, therefore, refers only to presently identified ODS consumption in the Domestic Refrigeration Sector.

Whilst PU foam blown with CFC 11 is exclusively used as the refrigerator insulation material by Regnis and Glacio, AEC uses some glass fibre wool for insulation. This is taken into account in all cost calculations in this project.

The industry imports all raw materials and parts. Compressors are sourced from a variety of suppliers including Aspera, Matsushita, Sanyo, Embraco, Tecumseh, and L'Unite Hermetique.

Uninhibited growth in the manufacture of domestic refrigerators and freezers would lead to an estimated consumption in the year 2000 of 30 tons per year of CFCs 11 and CFC 12.

The Ministry of Transport, Environment, and Women's Affairs, with the assistance of UNDP, has designed a strategy for the elimination of CFC 11 and CFC 12 in this sector beginning in 1995. Approval of this project by the MLF in March 1995 will result in the complete phase-out of the use of CFCs in the manufacture of domestic refrigerators and freezers in Sri Lanka in 1996.

3. PROJECT DESCRIPTION

3.1. REPLACEMENT OF CFC 11 WITH HCFC 141b.

Associated Electrical Corporation and Glacio Ltd will transfer to HCFC 141b as an interim step to an ODS-free system. The injection machines for the rigid insulation foam should be a high pressure machines that will be able to process the higher viscosities and mixing requirements of the low ODS systems, and also any of the developing ODS-free systems.

This will require equipment replacement and training at Associated Electrical Corporation Ltd and Glacio Ltd. Details of the existing foam injection equipment are provided in para 4. f the Annex containing individual enterprise data.

Associated Electrical Corporation Ltd and Glacio Ltd will also require test-runs before being able to start industrial production with the new technology. These activities will include training of staff in worker-safety related to HCFC 141b.

Operational Costs for six months are requested by both enterprises, to be paid following approval of the project.

3.2 REPLACEMENT OF CFC 11 WITH CYCLOPENTANE.

Regnis (Lanka) Ltd will transfer to cyclopentane as a zero-ODP replacement for CFC 11. The foam injection machine should be a suitably flameproofed high pressure machine which can process the higher viscosities and mixing requirments of the cyclopentane systems.

This will require equipment replacement and training at Regnis (Lanka) Ltd, as well as independent safety audits before, and after, installation of the new foam mixing and injection equipment. Details of the existing foam injection equipment are provided in para 4. of the Annexes containing individual enterprise data.

Regnis will also require test-runs before being able to start industrial production with the new technology. These activities will include training of staff in worker-safety related to the highly flammable nature of cyclopentane.

Whilst cyclopentane costs less than CFC 11, incremental operating benefits will be more than offset by higher insurance costs, higher maintenace costs, and the costs of more frequent safety training. Incremental operating benefits are not, therefore, considered.

3.3. REPLACEMENT OF CFC 12 WITH HFC 134a.

All three enterprises will replace CFC 12 with HFC 134a. The conversion to HFC 134a requires the use of HFC 134a compressors and the associated new synthetic lubricants, re-design of the refrigeration systems to cater for the difference in thermodynamic performance of HFC 134a versus CFC 12, prototyping, testing and optimization of each refrigerator model, and pilot scale manufacture and testing before full scale conversion of production to HFC 134a for each model. The conversion will result in changes in manufacturing procedures for which production line supervisor and operator training will be required.

The different properties of HFC 134a, the need to avoid cross-contamination with CFC 12, and the phased nature of the conversion of refrigerator production from CFC 12 to HFC 134a, means that new system evacuation, refrigerant charging, and leak detection equipment will be required. Details of the existing equipment on which the technology change will impact are provided in para 4. of the Annexes containing individual enterprise data.

Operational Costs for six months are requested for all three enterprises, to be paid following approval of the project.

3.4 CFC 12 RECOVERY & RECYCLING DURING SERVICE OPERATIONS

Associated Electrical Corporation Ltd and Glacio Ltd both have refrigerator service centres located at their manufacturing sites. Because of the high cost of a new refrigerator relative to average personal income refrigerators and often "rebuilt" rather than scrapped. Both enterprises consume CFC 12 for re-charge as well as system flushing after compressor failure. Consumption per annum for such servicing and repair operations is 2.5 tons at AEC and 2.0 tons at Glacio. Provision of a single recovery and recycle machine at each enterprise will eliminate an estimated 80% of this CFC 12 consumption.

4. TECHNOLOGY

4.1. REPLACEMENT OF CFC 11.

4.1.1. OVERVIEW

Currently, the three principal technology options for the replacement of CFC 11 in thermoset insulation foams are:

CFC 11 > partial water/HCFC 141b > ?
CFC 11 > partial water/HCFC 22,142b > HFC 134a, HFC 152a
CFC 11 > n-, iso-, and cyclo-, pentane

In addition, compounds such as perfluoroalkanes, HCFC 123, fluorinated ethers and 2-chloropropane have been suggested, but the technology is not mature. Furthermore, the products are either only available in limited quantities, or toxicological testing is not complete and, therefore, safety in use cannot be evaluated.

The first option, <u>the "liquid" solution</u>, is the one which will be applied in this project at **Associated Electrical Corporation Ltd** and **Glacio Ltd**. This employs technology that is closely related to the existing CFC 11 technology. The final step to non-ODS technology in this process is not yet decided. One potential solution is HFC 356, but full water blown foam with improved cell structure remains an option in systems where dimensional changes, although costly, are possible.

The second one, the "gas" solution, utilizes a gaseous mixture of physical blowing agents, and always requires new equipment and extensive adjustments. The final step in this process is seen as the introduction of gaseous HFC's.

The third option, pentane technology, has recently been introduced in Europe. Pentanes are flammable and this means a careful review of manufacturing operations with respect to the safe handling of a flammable foam blowing agent. This is the technology which will be applied at **Regnis (Lanka) Ltd**. Pentane technology is often not a practical or cost effective option in the existing workplace environments at many smaller scale enterprises due to the safety modifications required.

Several companies currently offer pentane technology packages, including equipment. However, UNDP requires an independent safety review prior to, and after, installation.

4.1.2. SELECTION

Based on economic and environmental considerations, cyclopentane appears to be the best choice for domestic refrigerator and freezer applications. It combines an attractive price with zero ODP properties. Regnis Ltd have already conducted their own study of CFC 11 replacements and their preferred option is cyclopentane. The existing production line configurations and the foam chemicals processing and injection arrangements at Regnis can readily be converted to safely accomodate cyclopentane. However, the safety related modifications required for the use of a flammable blowing agent like cyclopentane would be difficult and costly to realise at both Associated Electrical Corporation Ltd and Glacio Ltd. For these reasons, therefore, cycopentane was not considered a cost effective option at the present time for these enterprises.

The use of HCFC 141b is recognised by Associated Electrical Corporation Ltd and Glacio Ltd as a CFC 11 replacement that is:

- proven technology in both processing and product performance
- environmentally acceptable
- available in the Sri Lankan market
- a technology that can be implemented safely and cost effectively by AEC and Glacio within the existing factory configuration

The choice of high pressure foam dispensing equipment will facilitate the subsequent step to a final zero-ODP insulating foam system and Associated Electrical Corporation Ltd and Glacio both accept that any additional capital costs associated with such a change is for their own account.

4.1.3. IMPACT ON THE PRODUCTION PROCESS

The use of both reduced ABA/141b and cyclopentane technology, with the higher related viscosities of the polyol blend will be facilitated through the employment of high pressure foam production equipment.

Required modifications (HCFC-141b):

HCFC 141b is moderately flammable in the gaseous state, but the liquid is not flammable. In the intended application HCFC 141b/polyol blends should not pose any risk, but a monitoring check at commissioning will be performed to ensure safe worker exposure levels. Ventilation is to be installed where needed to ensure exposure levels are maintained below the recommended occupational exposure limit.

In refrigerator and freezer models where HIPS cabinet and door liners are employed, the liner material should be modified to be resistant to HCFC 141b. No change to existing metal liners is required.

Cyclopentane technology:

The use of cyclopentane (CP) will require substantial changes in the production and storage facilities based on the highly flammable/explosive character of the substance. The adherence to the strictest safety standards available, such as EN, NFPA or other internationally recognized standards is required for UNDP implemented projects. These standards classify explosive zones ("EX areas") generally in three categories:

Zone 0 **Where a constant amount of highly flammable/ explosive liquids or gases can be expected. Areas inside CP pipes and tanks are Zone 0 (level, pressure and temperature controls). Materials used have to be explosion proof (EX) and grounded.**

Zone 1 **Where from time to time highly flammable liquids or gases can be expected; Areas in and around molds and fixtures are Zone 1. Materials used have to be EX-e, -d or -ia and grounded. Zone-1 can generally be reclassified to Zone 2 by applying sufficient ventilation.**

Zone 2 **Where only by accident or scheduled maintenance highly flammable/explosive gases can be expected. Tank storage areas, premix stations and foam dispensers are generally Zone 2. Materials required are EX-n or with IP54 sealing. Grounding to avoid spark building triggered by differences in electrical potential, is required.**

Other requirements related to the use of CP are:

- **The installation of containment around CP storage tanks;**
- **Installation of premix equipment--CP cannot purchased pre-blended;**
- **Antistatic clothing and shoes in Zone 0/1 areas;**
- **Installation of CP gas sensors in all EX areas, connected to a central panel and an automatic recorder/ printer;**
- **A portable gas detector to monitor CP concentrations throughout the plant according to an approved monitoring plan;**
- **An approved preventive maintenance system and emergency response plan;**
- **Training for production and maintenance personnel in the safe handling of CP;**
- **Process Safety Audits (PSAs) by a UNDP appointed independent contractor prior, during and after implementation.**

In line with the above-mentioned modifications on equipment and safety requirements, process adjustment are required to cope with the lower insulation value, higher core temperatures and longer aging times related to the use of CP.

THE USE OF CYCLOPENTANE MUST CONFORM TO THE SAFETY REQUIREMENTS OF RELEVANT LOCAL AND STATE AUTHORITIES

4.2. REPLACEMENT OF CFC 12.

4.2.1. OVERVIEW

HFC 134a is universally accepted as a replacement for CFC 12 in the manufacture of domestic refrigerators. HFC 134a is widely available and the technology is mature, having already been introduced commercially in many of the Developed Countries. Replacement of CFC 12 with HFC 134a requires relatively modest changes to existing production facilities.

Whilst Hydrocarbon refrigerants are being used on a limited basis in some Developed Countries, the technology is not considered sufficiently developed for transfer to Sri Lanka at the present time. Safety issues associated with the use of flammable hydrocarbon refrigerants, and the supply of suitable compressors further mitigate against the adoption of this technology.

HFC 152a might be considered as another candidate for CFC 12 replacement in domestic refrigerators. However, HFC 152a is also flammable, the technology has not been developed commercially, and there are some questions around it's stability in refrigerator systems. Furthermore, compressors for use with HFC 152a are not commercially available.

4.2.2. SELECTION

The selected technology is HFC 134a. The CFC 12 based technology used by all the enterprises was largely developed "in-house" and without any formal technology transfer agreements with internationally recognised manufacturers of domestic refrigerators.

The new HFC 134a based technology will be developed by the enterprises with assistance from compressor and refrigerant suppliers. The companies currently have no formal technology transfer agreements. Provision is made within the project budget for formal technology assistance from compressor and refrigerant suppliers, as well as the relevant UNDP consultants, in order to ensure successful implementation of this project.

4.2.3. IMPACT ON THE PRODUCTION PROCESS

HFC 134a, like CFC 12, is non-flammable. HFC 134a has also been the subject of extensive toxicological testing and is considered safe in use in industrial applications provided the suppliers recommended occupational exposure levels are not exceeded. At the present time this means ensuring that exposure levels do not exceed 1000 parts per million on an 8-hour time-weighted average basis. This is the same as the Occupational Exposure Limit (OEL)/Threshold Limit Value (TLV) for CFC 12 and thus no changes from current practices are required.

There will be an approximately 10% reduction in the mass charge of HFC 134a compared with CFC 12 for a refrigerator system of the same capacity. This is taken into account in the calculation of the incremental operational costs. (See para 5. of Annex containing individual enterprise data).

It is well understood that the chemical stability of HFC 134a/synthetic lubricant systems in domestic refrigerators, and hence the long term performance of the appliance, is sensitive to moisture content and certain chlorinated impurities. This requires that CFC 12 and HFC 134a handling equipment be carefully segregated, and it also calls for better evacuation of the system prior to refrigerant charging.

Because system cleanliness and moisture content is paramount to the successful manufacture of HFC 134a refrigerators all three enterprises will need to carefully re-assess production procedures and re-train production personnel as appropriate. Provision for this is made within the project proposal budgets.

The conversion from CFC 12 to HFC 134a will take place on a model by model basis, so that each enterprise will be producing both CFC 12 and HFC 134a refrigerators during the implementation phase of this project. This is feasible given the configuration of each company's production facilities. This means that there is a requirement for new system evacuation equipment and refrigerant charging equipment at all the enterprises.

Leak detection of the refrigeration system is an integral part of the manufacturing process and the use of HFC 134a requires that new leak detection equipment be employed.

5. PROJECT COSTS

5.1. INCREMENTAL CAPITAL COSTS

CAPITAL COST FOR CFC 11 PHASE-OUT	
1 HIGH PRESSURE FOAMING MACHINE WITH 2 MIXING HEADS	150,000
1 HIGH PRESSURE FOAMING MACHINE (80 Kgs/min)	125,000
1 PENTANE FOAM DISPENSER (60 Kg/min)	160,000
1 PENTANE PRE-MIXING UNIT	70,000
1 CYCLOPENTANE TANK/DRUM STORAGE SYSTEM & PIPING	30,000
FIXTURE VENTILATION (1 off)	45,000
GAS DETECTION SYSTEM (1 off)	30,000
MISC. FIRE & SPARK PROTECTION	40,000
PLANT MODIFICATIONS	20,000
TRAINING, TEST TRIALS & TECHNOLOGY TRANSFER	35,000
CONTINGENCIES (10%)	69,000
Subtotal (US$)	**774,000**

CAPITAL COST FOR CFC 12 PHASE-OUT	
REFRIGERANT CHARGING EQUIPMENT (4 off)	105,000
VACUUM PUMPS (5 off)	15,000
RETROFITTING VACUUM PUMPS (7 off)	3,500
LEAK DETECTION EQUIPMENT (5 off)	15,000
R12 RECOVERY & RECYCLE MACHINES (2 off)	10,000
TRAINING	15,000
RE-DESIGN, PROTOTYPING, TESTING, PILOT SCALE PRODUCTION & RELIABILITY TEST TRIALS (8 models)	110,000
TECHNOLOGY TRANSFER/TECHNICAL ASSISTANCE	45,000
CONTINGENCIES (10%)	32,000
Subtotal (US$)	**350,500**
TOTAL INCREMENTAL CAPITAL COST (US$)	**1,124,500**

5.2 INCREMENTAL OPERATING COSTS

The calculation of the incremental operating cost is based on a six month period using 50% of the actual production for the period November 1993 to October 1994 inclusive and ignoring growth. Individual enterprise data is provided in the project Annexes and these contain explanations on how the incremental operational costs were obtained. No incremental costs or benefits are considered in the case where CFC 11 is replaced by cyclopentane. The costs are summarized below:

PHASE-OUT OF CFC 11	
Costs for Materials:	**24,679**
PHASE-OUT OF CFC 12	
Costs for Materials:	**49,173**
TOTAL INCREMENTAL OPERATING COST (US$)	**73,852**

5.3. TOTAL PROJECT INCREMENTAL COSTS

TOTAL COST (Capital + Operational) (US$)	**1,198,352**
FUNDING REQUESTED FROM MLF (US$)	**911,438***

* Taking account of Article 5.1 country capital ownership

5.4 UNIT ABATEMENT COST (US$/Kg)

a. Capital Investment Costs	**1,124,500**
b. Capital Recovery Factor (10% p.a.)	**0.16275**
c. Incremental Operating Costs	**66,238**
d. ODS Reduction (ODP Kgs Nov 93 - Oct 94)	**20,490**
e. Unit Abatement Cost (US$/Kg)	**9.94**

[(a x b) + c] /d

THE PROJECT UNIT ABATEMENT COST IS 9.94 US$/Kg

5.5 PROJECT COST-EFFECTIVENESS

CE= 911,438/20,490= US$ 44.48/Kg.

6. FINANCING PLAN

The three enterprises request reimbursement of the full amount of the project costs of **US$ 911,438** in line with the Article 5.1 country ownership of the enterprises.

7. PROJECT IMPLEMENTATION

7.1 MANAGEMENT

UNDP will oversee the successful implementation of this project, and will provide technical assistance during project execution.

7.2 SCHEDULE

TASK	TIME TO COMPLETION					
	Q1	Q2	Q3	Q4	Q5	Q6
1. Preparation						
MLF Approval	X					
Procurement Preparation	XX	X				
Vendor Selection		XX				
2. Installation						
Arrival of Equipment		XX				
Customs Clearance		X				
Machine Installation		X	X			
3. Start-Up						
Machine Start-up			X			
Trials & Training			XXX	XXX	XX	
Mass Production Change					X	XX
Certification						X

8. PROJECT IMPACT

This project will eliminate the use of 20.49 ODP tons per year. This is based on figures for the 12 months, November 1993 - October 1994.

9. ANNEXES

Annex 1. - Associated Electrical Corporation Ltd (AEC)
Annex 2. - Glacio Ltd
Annex 3. - Regnis (Lanka) Ltd

Annex 1. - AEC Ltd

COUNTRY: SRI LANKA

PROJECT TITLE:	Elimination of CFCs 11 and 12 in the Manufacture of Domestic Refrigerators at ASSOCIATED ELECTRICAL CORPORATION (AEC)
SECTOR COVERED:	Domestic Refrigeration
ODS USE IN SECTOR:	22.20 tons ODS (Nov 93 - Oct 94)
PROJECT IMPACT (ODP):	7.32 ODP tons
TOTAL PROJECT COST:	US$ 345,814
INCREMENTAL CAPITAL COST:	US$ 308,500
INCREMENTAL OPERATING COST:	US$ 37,314
PROPOSED MLF GRANT:	US$ 345,814
UNIT ABATEMENT COST:	11.95 US$/Kg
PROJECT COST-EFFECTIVENESS:	47.24 US$/Kg
PROJECT DURATION:	1.5 years.
ECONOMIC LIFE:	10 years.
NATIONAL COORDINATING BODY:	Ministry of Transport, Environment, & Women's Affairs
IMPLEMENTING AGENCY:	UNDP
APPRAISAL DATE:	November 1994, January 1995

PROJECT SUMMARY

ASSOCIATED ELECTRICAL CORPORATION Ltd (AEC) is a 100% Sri Lankan-owned company manufacturing domestic refrigerators and freezers for sale in Sri Lanka. AEC Ltd currently uses CFC 11 as a blowing agent in the production of rigid polyurethane insulation foam for the refrigerator cabinets and doors, and CFC 12 is used as the refrigerant. Based on Nov 93 - Oct 94 figures, this project will eliminate 7.32 ODP tons/yr of CFCs 11 and 12 by conversion to the use of HCFC 141b as the foam blowing agent and HFC 134a as the refrigerant respectively. Funds requested will be used to change the existing production lines, and for technology transfer, technical assistance, re-design, testing, pre-production trials, and training. Incremental operational costs resulting from the conversion to the new technology (6 months only) are also included.

Prepared by: Stuart Kelly, in collaboration with the Sri Lankan Ministry of Transport, Environment, & Women's Affairs.

Reviewed by: Dr L.J.M. Kuijpers (Refrigeration) and Dr H. Creyf (Foam). Their comments are attached.

PROJECT OF THE GOVERNMENT OF SRI LANKA

ELIMINATION OF CFCs IN THE MANUFACTURE OF DOMESTIC REFRIGERATORS

1. PROJECT OBJECTIVE

This sub-project will phase out 7.32 tons of ODP upon project completion and contribute to the phaseout of CFCs in the domestic refrigeration sub-sector as a whole in Sri Lanka.

2. SECTOR BACKGROUND. }**as described in the main project document**

3. ENTERPRISE BACKGROUND

ASSOCIATED ELECTRICAL CORPORATION Ltd (AEC) is one of only **THREE** enterprises presently manufacturing domestic refrigerators and freezers in Sri Lanka and they account for approximately **48%** of the total local production of such products. AEC is a 100 per cent Sri Lanka owned enterprise. More details on ASSOCIATED ELECTRICAL CORPORATION are given below:

CFC USE IN LAST 12 MONTHS:	3.15 tons CFC 11 2.52 tons CFC 12 for manufacturing 2.50 tons CFC 12 for servicing
FULL NAME:	ASSOCIATED ELECTRICAL CORPORATION Ltd
PLANT LOCATION:	Nagoda, Kalutara, Sri Lanka
% ARTICLE 5 COUNTRY OWNERSHIP:	100% (Sri Lanka)
No. OF MODELS:	8
PRODUCTION IN LAST 12 MONTHS:	14,029 units
No. OF PRODUCTION LINES:	2
COMPRESSOR SUPPLIERS:	Aspera, Italy L'Unite Hermetique, France
CONTACT PERSONS:	A.J. de A. Abraham - Director/Gen Mgr Dinesh A. de Zoysa - Director/Dep GM Tel: (941) 326211/541220 Fax: (941) 447840

OTHER INFORMATION:

Associated Electrical Corporation Ltd was founded in 1961 and is a diversified enterprise engaged in the manufacture and assembly of domestic refrigerators and freezers, as well as the import of Yamaha Power Products, and real estate. It markets it's refrigerator/freezer products under the SISIL brand name. The current product range comprises 3 refrigerators, and four chest freezers. AEC also make a bottle cooler but only in very small numbers.

The original single door CFC refrigerator technology was based on the "Leonard" refrigerator, whilst the double door model was based on a "Tatung" design, both without any formal agreements between the respective enterprises. AEC has never had any formal technical or technology transfer agreements with internationally recognised refrigerator manufacturers and they have developed design improvements "in-house".

All production is sold in Sri Lanka. The company presently employs 257 persons, 250 of whom are engaged in activities related to refrigerator assembly operations. This project encompasses all ODS consumption used in refrigerator manufacturing and servicing operations at AEC.

It should be noted that the company does not use rigid PU insulation foam for all the refrigerator/freezer models. Glass fibre wool is employed for the single door refrigerator cabinets, and the larger freezer models and the bottle cooler employs part PU foam, part glass fibre wool. The larger freezers and the bottle cooler also use metal cabinet liners, whereas HIPS is used for the refrigerators and the small chest freezer. This is taken into account in the average weights of PU foam and liner material used in the calculation of incremental operating costs.

The following tables provide a summary of refrigerator and freezer production by Associated Electrical Corporation Ltd during the 12 month period November 1993 to October 1994 inclusive.

Model No.	Capacity Cu ft	Description	Production Volume	Kgs of Cabinet & Door Liner
R 60	6.0	SD Ref	800	4.642 HIPS
R 80	8.0	SD Ref	11,641	5.704 HIPS
D/D	7.6	DD Ref	950	6.310 HIPS
D 50	4.5	Freezer	109	3.150 HIPS
D 100	10.0	Freezer	199	1.550 HIPS*
D 140	14.0	Freezer	124	1.870 HIPS*
D 160	16.0	Freezer	184	2.380 HIPS*
B/C	12.0	Bottle Cooler	22	2.160 HIPS*
Totals or Weighted Average			14,029	* Doors only 5.523

Model No.	Productio nVolume	R12 Charge Kgs	Kgs R12 Consumptio n	Compressor HP & Prices	Kgs PU Foam per Unit
R 60	800	0.153	122.4	1/8 34.30	1.15*
R 80	11,641	0.170	1,979.0	1/6 34.65	1.35*
D/D	950	0.187	177.7	1/6 34.65	5.25
D 50	109	0.170	18.5	1/6 34.65	6.26
D 100	199	0.323	64.3	1/4 42.91	2.96**
D 140	124	0.477	59.2	1/3 50.70	3.79**
D 160	184	0.477	87.8	1/3 50.70	4.13**
B/C	22	0.289	6.4	3/8 72.30	3.37**
Totals or Weighted Average	14,029	0.179	2,515.3	35.09	* Door Only ** PU/GF Mix 1.725

Key: SD = Single Door DD = Double Door Ref = Refrigerator
Frz = Freezer GF = Glass Fibre

4. PROJECT DESCRIPTION

Associated Electrical Corporation Ltd presently uses CFC 11 for the production of rigid insulating foams needed for the refrigerator and freezer cabinets and doors, and uses CFC 12 as refrigerant for both new equipment manufacture and servicing. The total consumption in the 12 months November 1993 - October 1994, and the ODP tons that will be eliminated by this project are shown in the following table:

Enterprise	CFC 11 (tes)	ODP tons eliminated (see Note*)	CFC 12 (tes)	Total ODP tons eliminated
AEC Ltd	3.15	2.80	4.52**	7.32

Notes: *The second column of figures for CFC 11 takes the ODP of HCFC 141b into account (ODP = 0.11). ** Assumes 80% reduction in servicing consumption of 2.5 tons CFC 12.

4.1. REPLACEMENT OF CFC 11 WITH HCFC 141b.

Associated Electrical Corporation will transfer to HCFC 141b as an interim step to an ODS-free system. The use of cyclopentane is not supported by the UNDP cyclopentane consultant for this enterprise because of physical constraints.

The relevant existing equipment at Associated Electrical Corporation Ltd on which the technology change to HCFC 141b will impact is as follows:

- 1 x 1979 Viking VIK 60 low pressure PU foam injection machine. Max throughput 60 Kg/min. Serial No. 5724/79. Vintage 1979. This machine is used exclusively for foaming the doble door refrigerator cabinets.
- 1 x Viking SP27 low pressure PU foam inject injection machine. Max throughput 20 Kg/min. Serial No. RFCM 2253. Vintage 1972. This machine is used for foaming doors, the small freezer, etc.

For ease of operation and equipment maintenance, the UNDP consultant recommended replacement of the above two foaming units with one high pressure machine with <u>two</u> mixing heads, one for high output such as for the cabinet, and one for low output for the doors.

4.2. REPLACEMENT OF CFC 12 WITH HFC 134a.

HFC 134a is universally accepted as a Zero-ODP replacement for CFC 12 in the manufacture of domestic refrigerators and the technology is mature. The selected technology is HFC 134a.

The relevant existing equipment at Associated Electrical Corporation Ltd on which the technology change to HFC 134a will impact is as follows:

- 1 x in-house modified Danfoss R12 charging machine
- 1 x GE R12 charging machine
- 5 x Genevac GDV 25 dual stage vacuum pumps, 19 M3/hr
- 2 x Genevac GDV 45 dual stage vacuum pumps, 34 M3/hr
- 2 x GE H2 hand-held R12 electronic leak detectors

Note: The 5 Genevac GDV 25 vacuum pumps are installed and in use on the refrigerator assembly line. 1 Genevac GDV 45 vacuum pump is installed on the freezer assembly line, the other GDv 45 is on standby.

5. PROJECT COSTS

5.1. INCREMENTAL CAPITAL COSTS

CAPITAL COST FOR CFC 11 PHASE-OUT

HIGH PRESSURE FOAMING MACHINE with 2 mixing heads	150,000
TRAINING, TEST TRIALS & TECHNOLOGY TRANSFER	10,000
CONTINGENCIES (10%)	16,000
Subtotal (US$)	**176,000**

CAPITAL COST FOR CFC 12 PHASE-OUT

REFRIGERANT CHARGING EQUIPMENT (2 off)	45,000
VACUUM PUMP (2 off)	6,000
RETROFITTING VACUUM PUMPS (5 off)	2,500
LEAK DETECTION EQUIPMENT (2 off)	2,000
R12 RECOVERY & RECYCLE MACHINE	5,000
TRAINING	5,000
RE-DESIGN, PROTOTYPING, TESTING, PILOT SCALE PRODUCTION & RELIABILITY TEST TRIALS (8 models)	40,000
TECHNOLOGY TRANSFER/TECHNICAL ASSISTANCE	15,000
CONTINGENCIES (10%)	12,000
Subtotal (US$)	**132,500**
TOTAL INCREMENTAL CAPITAL COST (US$)	**308,500**

5.2 INCREMENTAL OPERATING COSTS

The calculation of the incremental operating costs is based on a six month period using 50% of the actual production for November 1993 to October 1994 inclusive and ignoring growth. Paragraph 6. provides detailed explanations on how the incremental operational costs were obtained, the costs are summarized below:

PHASE-OUT OF CFC 11

Cost for Materials (see Annex A Part 1.):	**13,539**

PHASE-OUT OF CFC 12

Costs for Materials (see Annex A Part 2.):	**23,775**
TOTAL INCREMENTAL OPERATING COST (US$)	**37,314**

5.3. TOTAL PROJECT INCREMENTAL COSTS

TOTAL COST (Capital + Operational) (US$)	**345,814**
% Article 5.1 Country Ownership	**100%**
FUNDING REQUESTED FROM MLF (US$)	**345,814**

5.4 UNIT ABATEMENT COST (US$/Kg)

a. Capital Investment Costs	**308,500**
b. Capital Recovery Factor (10% p.a.)	**0.16275**
c. Incremental Operating Costs	**37,314**
d. ODS Reduction (ODP Kgs Nov 93 - Oct 94)	**7,320**
e. Unit Abatement Cost (US$/Kg) [(a x b) + c] /d	**11.95**

THE PROJECT UNIT ABATEMENT COST IS 11.95 US$/Kg

5.5 PROJECT COST-EFFECTIVENESS (US$/Kg)

CE = (308,500+37,314)/7,320 = US$47.24/kg

6. INCREMENTAL OPERATIONAL COST CALCULATIONS

6.1. Incremental Costs resulting from replacing the CFC 11 Blowing Agent in the Refrigerator Insulation Foam with HCFC 141b (US$)

AEC Ltd	CFC 11	HCFC 141b	Diff
Use per Kg of Foam produced			
a. Kg Polyol	0.360	0.373	0.013
b. MDI	0.510	0.510	-
c. Kg Blowing Agent	0.130	0.117	(0.013)
Prices in US$/Kg			
d. Polyol	2.52	2.62	0.10
e. MDI	2.45	2.45	-
f. Blowing Agent	2.66	4.20	1.54
g. Liner (Type: HIPS with EVOH Protection)	1.94	2.14	0.20
Cost per Kg of Foam Produced			
h. = a. x d. Polyol	0.907	0.977	0.070
i. = b. x e. MDI	1.250	1.250	-
j. = c. x f. Blowing Agent	0.346	0.491	0.145
k. = h+i+j Total Cost per Kg of Foam	2.503	2.718	0.215
Materials Used per Refrigerator			
l. Kg of Foam per Refrigerator (avg)	1.73	1.90	0.17
m. Kg of Liner material per refrigerator (avg)	5.52	5.52	-
Cost per Refrigerator			
n. = l. x k. for Foam	4.33	5.16	0.83
o. = m. x g. for Liner	10.71	11.81	1.10
p. = n. + o. Total per Refrigerator	15.04	16.97	1.93
q. = No. of Refrigerators (see Note 1.)	7,015		
TOTAL INCREMENTAL OPERATIONAL COST (US$)	**13,539**		

(see Notes 1., and 4. below)

6.2. Incremental Costs resulting from replacing the CFC 12 Refrigerant with HFC 134a (US$)

AEC Ltd	CFC 12	HFC 134a	Diff
1. Refrigerant			
a. Price per Kg of Refrigerant	2.96	9.00	
b. Kg of Refrigerant per Refrigerator (average)	0.179	0.161	
c. No. of Refrigerators Produced (see Note 1.)	7,015	7,015	
1d. Cost for Refrigerant = a x b x c	3,717	10,165	6,448
2. Compressors			
a. Cost per Compressor (see Note 2.)	35.47	37.68	
b. No. of Compressors (see Note 1.)	7,015	7,015	
2c. Cost for Compressors = a x b	248,822	264,325	15,503
3. Condensers			
a. Cost per Condenser	4.37	4.37	
b. No. of Condensers	7,015	7,015	
3c. Cost for Condensers = a x b	30,656	30,656	-
4. Filter/Dryer			
a. Cost per Filter/Dryer (average)	0.38	0.50	
b. No. of Filter/Dryers (see Note 1.)	7,015	7,015	
4c. Cost for Filter/Dryers = a x b	2,666	3,508	842
5. Capillary Tubes			
a. Cost per Capillary Tube (average)	0.78	0.92	
b. No. of Capillary Tubes (see Note 1.)	7,015	7,015	
5c. Cost for Capillary Tubes = a x b	5,472	6,454	982
TOTAL INCREMENTAL OPERATIONAL COST (US$) = 1d + 2c + 3c + 4c + 5c (Diff)	23,775		

Note 1. Figures in the above tables are based on the actual production volume for the 12 month period November 1993 to October 1994 obtained from Associated Electrical Corporation Ltd at the time of project preparation. As Incremental Operational costs are claimed for 6 months only, 50% of this 12 months production volume has been used in the calculation.

Note 2. Refrigerant and compressor prices used in the above tables are weighted average prices for the three refrigerator manufacturers.

Note 3. The calculated incremental costs for the HFC 134a refrigerant are based on a 10% reduction in the mass charge compared with CFC 12.

Note 4. The calculation of incremental operational costs for the CFC 11 replacement takes account of the fact that not all of the refrigerators and freezers manufactured by Asssociated Electrical Corporation Ltd use PU insulation foam and HIPS liner. The necessary adjustment is made within the average weight of foam and liner per refrigerator.

Annex 2. - Glacio Ltd

COUNTRY: SRI LANKA

PROJECT TITLE:	Elimination of CFCs 11 and 12 in the Manufacture of Domestic Refrigerators at GLACIO Ltd.
SECTOR COVERED:	Domestic Refrigeration
ODS USE IN SECTOR:	22.20 tons ODS (Nov 93 - Oct 94)
PROJECT IMPACT (ODP):	6.83 ODP tons
TOTAL PROJECT COST:	US$ 267,000
INCREMENTAL CAPITAL COST:	US$ 246,000
INCREMENTAL OPERATING COST:	US$ 21,000
PROPOSED MLF GRANT:	US$ 267,000
UNIT ABATEMENT COST:	8.93 US$/Kg
PROJECT COST-EFFECTIVENESS:	39.09 US$/Kg
PROJECT DURATION:	1.5 years.
ECONOMIC LIFE:	10 years.
NATIONAL COORDINATING BODY:	Ministry of Transport, Environment, & Women's Affairs
IMPLEMENTING AGENCY:	UNDP
APPRAISAL DATE:	November 1994

PROJECT SUMMARY:

GLACIO Ltd is a 100% Sri Lankan-owned company manufacturing domestic fridges and freezers for sale in Sri Lanka. GLACIO Ltd currently uses CFC 11 as a blowing agent in the production of rigid polyurethane insulation foam for the refrigerator cabinets and doors, and CFC 12 is used as the refrigerant. Based on Nov 93 - Oct 94 figures, this project will eliminate 6.83 ODP tons/year of CFCs 11 and 12 by conversion to the use of HCFC 141b as the foam blowing agent, and HFC 134a as the refrigerant respectively. Funds requested will be used to change the existing production lines, and for technology transfer, technical assistance, re-design, testing, pre-production trials, and training. Incremental operational costs resulting from the conversion to the new technology (6 months only) are also included.

Prepared by:	Stuart Kelly, in collaboration with the Sri Lankan Ministry of Transport, Environment, & Women's Affairs.
Reviewed by:	Dr L.J.M. Kuijpers (Refrigeration) and Dr H. Creyf (Foam). Their comments are attached.

PROJECT OF THE GOVERNMENT OF SRI LANKA

ELIMINATION OF CFCs IN THE MANUFACTURE OF DOMESTIC REFRIGERATORS

1. PROJECT OBJECTIVE.

This sub-project will phase out 6.83 tons of ODP upon project completion and contribute to the phase out of CFCs in the domestic refrigeration sub-sector as a whole in Sri Lankas.

2. SECTOR BACKGROUND. } as described in the main project document

3. ENTERPRISE BACKGROUND

GLACIO Ltd is one of only **THREE** enterprises presently manufacturing domestic refrigerators and freezers in Sri Lanka and they account for approximately 17% of the total local production of such products. GLACIO Ltd is a 100 per cent Sri Lanka owned enterprise. More details on GLACIO Ltd are given below:

CFC USE IN LAST 12 MONTHS:	4.19 tons CFC 11 1.50 tons CFC 12 for manufacturing 2.00 tons CFC 12 for servicing
FULL NAME:	GLACIO Ltd
PLANT LOCATION:	Nawinna, Maharagma, Sri Lanka
% ARTICLE 5 COUNTRY OWNERSHIP:	100% (Sri Lanka)
No. OF MODELS:	5
PRODUCTION IN LAST 12 MONTHS: November 1993 - October 1994	4,868 units
No. OF PRODUCTION LINES:	1
COMPRESSOR SUPPLIERS:	Embraco
CONTACT PERSONS:	Mervyn P. Wijesinha - Chariman/MD D.C. Lelwela - Director - Industries S.P. Thiruarul - Prodn/Planning Mgr Tel: (941) 850292 Fax: (941) 856271

OTHER INFORMATION:

Glacio Ltd was founded in 1967 and is engaged in the manufacture, and service of domestic refrigerators and freezers. Glacio is a company within the Rowlands Group, a long established (1927) Sri Lankan group of companies with interests in metalworking, tyre re-treading, and dried food manufacture. Refrigerator/freezer products are marketed under the "Usha" brand name. The current product range comprises 3 single door refrigerators, a chest freezer, and a bottle cooler. The 8 cu ft refrigerator dominates production. The original CFC refrigerator technology was developed "in-house" and modified with time to meet market requirments. Glacio has never had any formal technical or technology transfer agreements with internationally recognised refrigerator manufacturers.

All production is sold in Sri Lanka. The Rowlands Group employs a total of 450 persons, some 135 of whom work in the Glacio refrigerator assembly and servicing operations. This project encompasses all ODS consumption used in manufacturing and servicing operations at Glacio Ltd.

The enterprise uses PU foam insulation for all of their production, and all but the freezer model utilise HIPS liners for the cabinets and doors. The freezer has a metal cabinet liner and this is taken into account in the calculation of incremental operating costs.

The following tables provide a summary of refrigerator and freezer production by Glacio Ltd during the 12 month period November 1993 to October 1994 inclusive.

Model No.	Capacity Cu ft	Description	Production Volume	Compressor HP	Kgs of Cabinet & Door Liner
REF 6 REF 8 REF 9 BC FRZ	6.0 8.0 9.0 9.0 5.0	SD Ref SD Ref SD Ref SD Bot Cooler Freezer	243 3,407 730 120 368	1/10 1/10 1/8 1/8 1/6	6.62 HIPS 9.92 HIPS 10.12 HIPS 7.80 HIPS 3.63 HIPS*
Totals or Weighted Average			4,868		* Door only 9.258

Model No.	Productio nVolume	R12 Charge Kgs	Kgs R12 Consumptio n	Compressor Prices	Kgs PU Foam per Unit
REF 6 REF 8 REF 9 BC FRZ	243 3,407 730 120 368	0.308 0.308 0.308 0.308 0.308	74.8 1,049.4 224.8 37.0 113.3	34.60 34.60 35.30 35.30 37.60	4.30 4.90 5.20 5.20 4.80
Totals or Weighted Average	4,868	0.308	1,499.3	34.95	4.915

Key: SD = Single Door DD = Double Door Ref = Refrigerator
Frz = Freezer BC = Bottle Cooler

4. PROJECT DESCRIPTION

Glacio Ltd presently uses CFC 11 for the production of rigid insulating foams needed for the refrigerator and freezer cabinets and doors, and uses CFC 12 as refrigerant. The total consumption in the 12 months November 1993 - October 1994, and the ODP tons that will be eliminated by this project are shown in the following table:

Enterprise	CFC 11 (tes)	ODP tons eliminated (see Note*)	CFC 12 (tes)	Total ODP tons eliminated
GLACIO Ltd	4.19	3.73	3.10**	6.83

Notes: *The second column of figures for CFC 11 takes the ODP of HCFC 141b into account (ODP = 0.11). ** Assumes 80% reduction in servicing consumption of 2.0 tons CFC 12.

4.1. REPLACEMENT OF CFC 11 WITH HCFC 141b.

Glacio Ltd will transfer to HCFC 141b as an interim step to an ODS-free system.

The relevant existing equipment at Glacio Ltd on which the technology change to HCFC 141b will impact is as follows:

- 1 x 1967 Viking low pressure Foam Injection Machine. Maximum throughput 5 Kg/min.

4.2. REPLACEMENT OF CFC 12 WITH HFC 134a.

HFC 134a is universally accepted as a zero-ODP replacement for CFC 12 in the manufacture of domestic refrigerators and the technology is mature. The selected technology is HFC 134a.

The relevant existing equipment at Glacio Ltd on which the technology change to HFC 134a will impact is as follows:

- 1 x locally modified Danfoss design dual station R12 charging machine
- 1 x A. Pfeiffer R06S Vacuum Pump, nominal 6 M3/hr capacity
- 1 x Refco hand held R12 electronic leak detector

5. PROJECT COSTS

5.1. INCREMENTAL CAPITAL COSTS

CAPITAL COST FOR CFC 11 PHASE-OUT	
HIGH PRESSURE FOAMING MACHINE	125,000
TRAINING, TEST TRIALS, & TECHNOLOGY TRANSFER	10,000
CONTINGENCIES (10%)	13,000
Subtotal (US$)	**148,000**

CAPITAL COST FOR CFC 12 PHASE-OUT	
REFRIGERANT CHARGING EQUIPMENT (1 off)	25,000
VACUUM PUMP (1 off)	3,000
LEAK DETECTION EQUIPMENT (1 off)	1,000
R12 RECOVERY & RECYCLING MACHINE	5,000
TRAINING	5,000
RE-DESIGN, PROTOTYPING, TESTING, PILOT SCALE PRODUCTION & RELIABILITY TEST TRIALS (5 models)	35,000
TECHNOLOGY TRANSFER/TECHNICAL ASSISTANCE	15,000
CONTINGENCIES (10%)	9,000
Subtotal (US$)	**98,000**
TOTAL INCREMENTAL CAPITAL COST (US$)	**246,000**

5.2 INCREMENTAL OPERATING COSTS

The calculation of the incremental operating costs is based on a six month period using 50% of the actual production for November 1993 to October 1994 inclusive and ignoring growth. Paragraph 6. provides detailed explanations on how the incremental operational costs were obtained, the costs are summarized below:

PHASE-OUT OF CFC 11	
Cost for Materials (see Annex A Part 1.):	**11,140**
PHASE-OUT OF CFC 12	
Costs for Materials (see Annex A Part 2.):	**9,860**
TOTAL INCREMENTAL OPERATING COST (US$)	**21,000**

5.3. TOTAL PROJECT INCREMENTAL COSTS

TOTAL COST (Capital + Operational) (US$)	**267,000**
% Article 5.1 Country Ownership	**100%**
FUNDING REQUESTED FROM MLF (US$)	**267,000**

5.4 UNIT ABATEMENT COST (US$/Kg)

a. Capital Investment Costs	**246,000**
b. Capital Recovery Factor (10% p.a.)	**0.16275**
c. Incremental Operating Costs	**21,000**
d. ODS Reduction (ODP Kgs November 93 - October 94)	**6,830**
e. Unit Abatement Cost (US$/Kg) [(a x b) + c] /d	**8.93**

THE PROJECT UNIT ABATEMENT COST IS 8.93 US$/Kg

5.5 PROJECT COST-EFFECTIVENESS (US$/Kg)

CE = (246,000+21,000) / 6830 = US$ 39.09/Kg

6. INCREMENTAL OPERATIONAL COST CALCULATIONS

6.1. Incremental Costs resulting from replacing the CFC 11 Blowing Agent in the Refrigerator Insulation Foam with HCFC 141b (US$)

GLACIO Ltd	CFC 11	HCFC 141b	Diff
Use per Kg of Foam produced			
a. Kg Polyol	0.325	0.342	0.017
b. MDI	0.500	0.500	-
c. Kg Blowing Agent	0.175	0.158	(0.017)
Prices in US$/Kg			
d. Polyol	2.52	2.62	0.10
e. MDI	2.45	2.45	-
f. Blowing Agent	2.66	4.20	1.54
g. Liner (Type: HIPS with EVOH Protection)	1.94	2.14	0.20
Cost per Kg of Foam Produced			
h. = a. x d. Polyol	0.819	0.896	0.077
i. = b. x e. MDI	1.225	1.225	-
j. = c. x f. Blowing Agent	0.466	0.664	0.198
k. = h+i+j Total Cost per Kg of Foam	2.510	2.785	0.275
Materials Used per Refrigerator			
l. Kg of Foam per Refrigerator (avg)	4.92	5.41	0.49
m. Kg of Liner material per refrigerator (avg)	9.26	9.26	-
Cost per Refrigerator			
n. = l. x k. for Foam	12.35	15.07	2.72
o. = m. x g. for Liner	17.96	19.82	1.86
p. = n. + o. Total per Refrigerator	30.31	34.89	4.58
q. = No. of Refrigerators (see Note 1.)	2,434		
TOTAL INCREMENTAL OPERATIONAL COST (US$)	**11,148**		

(see Notes 1., and 4. below)

6.2. Incremental Costs resulting from replacing the CFC 12 Refrigerant with HFC 134a (US$)

GLACIO Ltd	CFC 12	HFC 134a	Diff
1. Refrigerant			
a. Price per Kg of Refrigerant	2.96	9.00	
b. Kg of Refrigerant per Refrigerator (average)	0.308	0.277	
c. No. of Refrigerators Produced (see Note 1.)	2,434	2,434	
1d. Cost for Refrigerant = a x b x c	2,219	6,068	3,849
2. Compressors			
a. Cost per Compressor (see Note 2.)	35.47	37.68	
b. No. of Compressors (see Note 1.)	2,434	2,434	
2c. Cost for Compressors = a x b	86,334	91,713	5,379
3. Condensers			
a. Cost per Condenser	4.18	4.18	
b. No. of Condensers	2,434	2,434	
3c. Cost for Condensers = a x b	10,174	10,174	-
4. Filter/Dryer			
a. Cost per Filter/Dryer (average)	0.70	0.82	
b. No. of Filter/Dryers (see Note 1.)	2,434	2,434	
4c. Cost for Filter/Dryers = a x b	1,704	1,996	292
5. Capillary Tubes			
a. Cost per Capillary Tube (average)	0.72	0.86	
b. No. of Capillary Tubes (see Note 1.)	2,434	2,434	
5c. Cost for Capillary Tubes = a x b	1,753	2,093	340
TOTAL INCREMENTAL OPERATIONAL COST (US$) = 1d + 2c + 3c + 4c + 5c (Diff)		**9,860**	

Note 1. Figures in the above tables are based on the actual production volume for the 12 month period November 1993 to October 1994 obtained from Glacio Ltd at the time of project preparation. As Incremental Operational costs are claimed for 6 months only, 50% of this 12 months production volume has been used in the calculation.

Note 2. Refrigerant and compressor prices used in the above tables are weighted average prices for the three refrigerator manufacturers.

Note 3. The calculated incremental costs for the HFC 134a refrigerant are based on a 10% reduction in the mass charge compared with CFC 12.

Note 4. The calculation of incr. operational costs for the CFC 11 replacement takes account of the fact that the freezer manufactured by Glacio Ltd uses a metal cabinet liner rather than HIPS. Adjustment is made within the average weight of liner per refr.

Annex 3. - Regnis (Lanka) Ltd

COUNTRY:	**SRI LANKA**
PROJECT TITLE:	Elimination of CFCs 11 and 12 in the Manufacture of Domestic Refrigerators at REGNIS (LANKA) Ltd
SECTOR COVERED:	Domestic Refrigeration
ODS USE IN SECTOR:	22.20 tons ODS (Nov 93 - Oct 94)
PROJECT IMPACT (ODP):	6.34 ODP tons
TOTAL PROJECT COST:	US$ 585,538
INCREMENTAL CAPITAL COST:	US$ 570,000
INCREMENTAL OPERATING COST:	US$ 15,538
PROPOSED MLF GRANT: (51% local ownership)	US$ 298,624
UNIT ABATEMENT COST:	8.71 US$/Kg
PROJECT COST-EFFECTIVENESS:	28.96 US$/Kg
PROJECT DURATION:	1.5 years.
ECONOMIC LIFE:	10 years.
NATIONAL COORDINATING BODY:	Ministry of Transport, Environment, & Women's Affairs
IMPLEMENTING AGENCY:	UNDP
APPRAISAL DATE:	November 1994, April 1995

PROJECT SUMMARY

REGNIS (LANKA) Ltd is a 51% Sri Lankan-owned company manufacturing domestic refrigerators and freezers principally for sale in Sri Lanka. REGNIS (LANKA) Ltd currently uses CFC 11 as a blowing agent in the production of rigid polyurethane insulation foam for the refrigerator cabinets and doors, and CFC 12 is used as the refrigerant. Based on Nove 93 - Oct 94 figures, this project will eliminate 6.34 ODP tons/year of CFCs 11 and 12 by conversion to the use of cyclopentane as the foam blowing agent and HFC 134a as the refrigerant respectively. Funds requested will be used to change the existing production lines, and for technology transfer, safety matters, technical assistance, re-design, testing, pre-production trials, and training. Incremental operational costs relating to conversion to the HFC 134a technology (6 months only) are included.

Prepared by:	Stuart Kelly, in collaboration with the Sri Lankan Ministry of Transport, Environment, & Women's Affairs.
Reviewed by:	Dr L.J.M. Kuijpers (Refrigeration) and Dr H. Creyf (Foam). Their comments are attached.

PROJECT OF THE GOVERNMENT OF SRI LANKA

ELIMINATION OF CFCs IN THE MANUFACTURE OF DOMESTIC REFRIGERATORS

1. PROJECT OBJECTIVE.

This sub-project will phase out 6.34 tons of ODP upon project completion and contribute to the phase out of CFCs in the domestic refrigeration sub-sector as a whole in Sri Lanka.

2. SECTOR BACKGROUND.)as described in the main project document

3. ENTERPRISE BACKGROUND

REGNIS (LANKA) Ltd is one of only **THREE** enterprises presently manufacturing domestic refrigerators and freezers in Sri Lanka and they account for approximately **35%** of the total local production of such products. REGNIS is a 51 per cent Sri Lanka owned, enterprise, the balance of capital being held by SINGER Company NV, Netherlands. More details on REGNIS are given below:

CFC USE IN LAST 12 MONTHS:	5.12 tons CFC 11 1.22 tons CFC 12
FULL NAME:	REGNIS (LANKA) Ltd
PLANT LOCATION:	Off Borupana Road, Ratmalana, Sri Lanka
% ARTICLE 5 COUNTRY OWNERSHIP:	51% (Sri Lanka)
No. OF MODELS:	5
PRODUCTION IN LAST 12 MONTHS: November 1993 - October 1994	8,300 units
No. OF PRODUCTION LINES:	2
COMPRESSOR SUPPLIERS:	Matsushita, Sanyo, Tecumseh
CONTACT PERSONS:	V.G.K. Vidyaratne - Factory Director Bertie Fernando - Commercial Director Tel: (941) 622641/635408 Fax: (941) 622032

OTHER INFORMATION:

Regnis (Lanka) Ltd was founded in 1987 and is engaged in the manufacture and assembly of domestic refrigerators and freezers as well as table top gas cookers and ceiling fans. It markets it's refrigerator/freezer products under the SINGER brand name. The current product range comprises 3 refrigerators, a chest freezer, and a bottle cooler.

The original CFC refrigerator technology was supplied by Sanyo Universal Electric Co. who were manufacturing Singer designed refrigerators. Regnis began by importing SKD units and progressively moved to complete local assembly. It has subsequently developed it's own models "in-house" to meet local market needs. There are currently no formal technical assistance or technology transfer agreements with Singer, or any other internationally recognised refrigerator manufacturers. Singer does not play an active role in the local company management and operations.

98.8% of refrigerator production is sold in Sri Lanka with the balance exported in small lots to Paua New Guinea, Vanuatu, and the Maldives. The company presently employs 169 persons, 160 of whom are engaged in activities related to refrigerator assembly operations. This project encompasses all ODS consumption used in manufacturing operations at Regnis (Lanka) Ltd. The enterprise does not have it's own servicing centres and no provision is made within this project for ODS recovery and recycling.

The enterprise uses PU foam for insulation for all their production, and all except the freezer model utilise HIPS liners for the cabinets. The freezer has a metal liner. HIPS are also used for the door insulation with the exception of the bottle cooler which has a glass door.

The following tables provide a summary of refrigerator and freezer production by Regnis (Lanka) Ltd during the 12 month period November 1993 to October 1994 inclusive.

Model No.	Capacity Cu ft	Description	Production Volume	Compresso r HP	Kgs of Cabinet & Door Liner
ALS 5	5.0	SD Ref	644	1/10	2.53 HIPS
ALS 7	7.0	SD Ref	3,784	1/8	3.41 HIPS
PLS 7	7.0	DD Ref	4,988	1/6	3.16 HIPS
BC	4.5	GD Bot Cooler	402	1/4	2.78 HIPS
FRZ	225 litre	Freezer	261	1/4	1.00 HIPS*
Totals or Weighted Average			10,079		* Door only 3.143

Model No.	Productio nVolume	R12 Charge Kgs	Kgs R12 Consumptio n	Compressor Prices	Kgs PU Foam per Unit
ALS 5	644	0.095	61.2	33.00	3.08
ALS 7	3,784	0.105	397.3	35.00	4.13
PLS 7	4,988	0.126	628.5	37.00	4.13
BC	402	0.175	70.4	41.00	3.75
FRZ	261	0.220	57.4	41.00	6.02
Totals or Weighted Average	10,079	0.121	1,214.8	36.26	4.097

Key: SD = Single Door DD = Double Door Ref = Refrigerator
GD = Glass Door Frz = Freezer BC = Bottle Cooler

4. PROJECT DESCRIPTION

Regnis presently uses CFC 11 for the production of rigid insulating foams needed for the refrigerator and freezer cabinets and doors, and uses CFC 12 as refrigerant. The total consumption in the 12 months November 1993 - October 1994, and the ODP tons that will be eliminated by this project are shown in the following table:

Enterprise	CFC 11 (tes)	ODP tons eliminated	CFC 12 (tes)	Total ODP tons eliminated
REGNIS	5.12	5.12	1.22	6.34

4.1. REPLACEMENT OF CFC 11 WITH CYCLOPENTANE.

Regnis will transfer to cyclopentane as a zero-ODP replacement for CFC 11 used as the foam blowing agent.

The relevant existing equipment at Regnis (Lanka) Ltd on which the technology change to cyclopentane will impact is as follows:

- 1 x 1987 Cannon C60 RF2 low pressure Foam Injection Machine. Max throughput 60 Kg/min. Serial No. 120413.

4.2. REPLACEMENT OF CFC 12 WITH HFC 134a.

HFC 134a is universally accepted as a Zero-ODP replacement for CFC 12 in the manufacture of domestic refrigerators and the technology is mature. The selected technology is HFC 134a.
The relevant existing equipment at Regnis (Lanka) Ltd on which the technology change to HFC 134a will impact is as follows:

- 1 x Danfoss model 118 x 2150 automatic R12 charging station complete with refrigerant feed pump and vaccum pump (1989 vintage)
- 1 x Refco "Dial a Charge" R12 charging unit. Refco Model No. 10760. (1987 vintage)
- 1 x Edwards EM28 dual stage high vacuum Pump, nominal 8 M3/hr capacity (1989 vintage)
- 3 x Kinney KC8C dual stage vacuum pumps, 8 CFM capacity
- 2 x GE Ferret H25 R12 electronic leak detectors

Note: Three of the vacuum pumps are in service with one on standby.

5. PROJECT COSTS

5.1. INCREMENTAL CAPITAL COSTS

CAPITAL COST FOR CFC 11 PHASE-OUT	
ONE PENTANE FOAM DISPENSER (60 KG/MIN OUTPUT)	160,000
ONE PENTANE PRE MIXING UNIT	70,000
SMALL TANK/DRUM STORAGE SYSTEM & PIPING	30,000
FIXTURE VENTILATION	45,000
GAS DETECTION SYSTEM	30,000
MISC. FIRE & SPARK PROTECTION	40,000
(FLAMEPROOF MOTORS & SWITCHES	
SEALING ELECTRICAL CONTROL CABINETS	
FIRE PROTECTION SYSTEM & EXTINGUISHERS	
EARTHING & STATIC DISCHARGE DISSIPATION)	
PLANT MODIFICATION	20,000
TRAINING, TEST TRIALS, & TECHNOLOGY TRANSFER	15,000
CONTINGENCIES (10%)	40,000
Subtotal (US$)	**450,000**
CAPITAL COST FOR CFC 12 PHASE-OUT	
REFRIGERANT CHARGING EQUIPMENT (1 off)	35,000
VACUUM PUMPS (2 off)	6,000
RETROFITTING VACUUM PUMPS (2 off)	1,000
LEAK DETECTION EQUIPMENT (2 off)	12,000
TRAINING	5,000
RE-DESIGN, PROTOTYPING, TESTING, PILOT SCALE PRODUCTION & RELIABILITY TEST TRIALS (5 models)	35,000
TECHNOLOGY TRANSFER/TECHNICAL ASSISTANCE	15,000
CONTINGENCIES (10%)	11,000
Subtotal (US$)	**120,000**
TOTAL INCREMENTAL CAPITAL COST (US$)	**570,000**

5.2 INCREMENTAL OPERATING COSTS FOR CFC 12 REPLACEMENT

The calculation of the incremental operating cost for CFC 12 replacement by HFC 134a is based on a six month period using 50% of the actual production for the period November 1993 to October 1994 inclusive. Annex A provides detailed explanations on the calculation, the total costs are summarized below:

PHASE-OUT OF CFC 12 (TOTAL INCREMENTAL OPERATING COST)	
Cost for Materials (see Annex A. Part 2.)	**15,538**

5.3. TOTAL PROJECT INCREMENTAL COSTS

TOTAL COST (Capital + Operational) (US$)	**585,538**
% Article 5.1 Country Ownership	**51.00%**
FUNDING REQUESTED FROM MLF (US$)	**298,624**

5.4 UNIT ABATEMENT COST (US$/Kg)

a. Capital Investment Costs (51%)	**290,700**
b. Capital Recovery Factor (10% p.a.)	**0.16275**
c. Incremental Operating Costs (51%)	**7,924**
d. ODS Reduction (ODP Kgs Nov 93 - Oct 94)	**6,340**
e. Unit Abatement Cost (US$/Kg) [(a x b) + c] /d	**8.71**

THE PROJECT UNIT ABATEMENT COST IS 8.71 US$/Kg

5.5 PROJECT COST-EFFECTIVENESS

ISC 1 = 30,000+45,000+30,000+40,000+20,000 = 165,000
ISC 2 = 35,000+10,000 = 45,000
Total ISC = (165,000+45,000) x 51% = 107,100
CE = (290,700-107,100) / 6340 = US$ 28.96/Kg

6. INCREMENTAL OPERATIONAL COST CALCULATIONS

6.1. Incremental Costs resulting from replacing the CFC 12 Refrigerant with HFC 134a (US$)

REGNIS (LANKA) Ltd	CFC 12	HFC 134a	Diff
1. Refrigerant			
a. Price per Kg of Refrigerant	2.96	9.00	
b. Kg of Refrigerant per Refrigerator (average)	0.121	0.109	
c. No. of Refrigerators Produced (see Note 1.)	5,040	5,040	
1d. Cost for Refrigerant = a x b x c	1,805	4,944	3,139
2. Compressors			
a. Cost per Compressor (see Note 2.)	35.47	37.68	
b. No. of Compressors (see Note 1.)	5,040	5,040	
2c. Cost for Compressors = a x b	178,769	189,907	11,138
3. Condensers			
a. Cost per Condenser	5.61	5.61	
b. No. of Condensers	5,040	5,040	
3c. Cost for Condensers = a x b	28,274	28,274	-
4. Filter/Dryer			
a. Cost per Filter/Dryer (average)	0.63	0.75	
b. No. of Filter/Dryers (see Note 1.)	5,040	5,040	
4c. Cost for Filter/Dryers = a x b	3,175	3,780	605
5. Capillary Tubes			
a. Cost per Capillary Tube (average)	0.66	0.79	
b. No. of Capillary Tubes (see Note 1.)	5,040	5,040	
5c. Cost for Capillary Tubes = a x b	3,326	3,982	656
TOTAL INCREMENTAL OPERATIONAL COST (US$) = 1d + 2c + 3c + 4c + 5c (Diff)	15,538		

Note 1. Figures in the above tables are based on the actual production volume for the 12 month period November 1993 to October 1994 obtained from Regnis (Lanka) Ltd at the time of project preparation. Incremental Operational costs are claimed for 6 months only and 50% of this 12 months production volume has been considered.

Note 2. Refrigerant and compressor prices used in the above tables are weighted average prices for the three refrigerator manufacturers in Sri Lanka.

Note 3. The calculated incremental costs for the HFC 134a refrigerant are based on a 10% reduction in the mass charge compared with CFC 12.

Note 4. Incremental operational costs/benefits for CFC 11 replacement by cyclopentane are not considered. Cyclopentane is cheaper than CFC 11 but the increased costs for insurance, more frequent maintenance, and safety training due to the flammable nature of cyclopentane, more than offsets any incremental cost benefits.

Country of origin: SRI LANKA

Project title: Elimination of CFCs 11 and 12 at three Domestic Refrigerator Manufacturers (AEC Ltd, Glacio Ltd and Regnis (Lanka) Ltd)

Sector/sub-sector Domestic refrigeration
Relationship to country program UNDP

Note *This review addresses only the refrigerant conversion part of the project, it does not address the part related to the foam blowing agent conversion.*

Technology

- In domestic refrigeration, HFC-134a technology is a proven and acceptable (nontransitional) technology to reduce CFC-12 consumption.
- None of the three companies in this project (AEC, Glacio and Regnis) do have a formal technology transfer agreement. However, all companies plan to develop the HFC-134a technology with assistance from compressor and refrigerant suppliers. Furthermore provisions for external assistance are present. Due to these facts, a successful project implementation can be expected.
- Other technologies than HFC-134a were considered (hydrocarbons, HFC-152a) but were not selected because of the state of development, safety issues and the lack of commercially available compressors. From the zero ODP technologies HFC-134a is one of the most cost effective solutions.

Environmental impact

HFC-134a has an ODP of zero and a GWP of 0.27. For domestic refrigeration a GWP of this magnitude is negligible.

Project costs

- The equipment requested by all three manufacturers is essential for the conversion process. Costs of equipment, training and testing are reasonable as well as costs for servicing equipment.
- Incremental operational costs are reasonable and correctly applied (for six months).
- If the UAC values are calculated for the refrigerant conversion part of the projects then the following values are obtained : AEC 19.20 , Glacio 17.88 and Regnis 15.80 USD/kg/year. These values are reasonable compared to other, similar projects (although the UAC value of the Glacio company is based on a CFC-12 usage of 1.5 MT which must be too high for the size of the company).
- The UAC values above exclude the effect of the refrigerant reduction in the servicing parts of the projects. Investments in the servicing parts (recovery and recycling equipment) are reasonable although the possible refrigerant reduction is somewhat overestimated.
- The foreign ownership of the Regnis company is correctly taken into account.

Implementation timeframe Reasonable.
Relevance and adequacy of information provided Sufficient
Recommendations Approval as proposed

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