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

Eleventh Meeting
Bangkok, 10-12 November 1993

PROJECT PROPOSALS: INDIA

This document includes:

a) Comments and Recommendations from the Fund Secretariat for the first and last project proposals listed below (Comments and Recommendations from the Fund Secretariat for the remaining project proposals listed below will be subsequently submitted); and

b) The following project proposals:

- Modification of CFC-12 Mobile Air Conditioning Manufacturing for HFC-134a (Subros Limited)

- Application Development for the conversion of CFC-11/Polyol Systems to low/non-ODS formulations (Manali Petrochemical Ltd.)

- Applications Development for the conversion of CFC-11/Polyol Systems to low/non-ODS formulations (UB Petroproducts Ltd.)

- Replacement of CFC-11 blowing agent in polyurethane (PU) systems with low and non-ODS materials (Expanded Incorporation)

- IICT, Hyderabad, Basic Data Development - HFC-134a Process.

PROJECT EVALUATION SHEET

COUNTRY OR REGION:	India
PROJECT TITLE:	Modification of CFC-12 Mobile Air Conditioning Manufacturing for HFC-134a
BUDGET:	US $1,710,000
INCREMENTAL COSTS:	US $1,710,000
ODS PHASE-OUT:	84 MT CFC-12
COST EFFECTIVENESS[1]:	US $20.36 per Kg. ODP saved
PROJECT DURATION:	2 years
IMPLEMENTING AGENCY:	The World Bank
NATIONAL COORDINATING AGENCY:	Ministry of Environment and Forests (MOEF)
TECHNICAL REVIEW COMPLETED:	YES _X_ NO _

SECRETARIAT'S COMMENTS

1. This project involves the modification of mobile air conditioner production facilities for the development and production of HFC-134a MACs for the company's export market. This project includes changes in both production equipment and compressor design modifications. The conversion of the production line will benefit the second phase of the project which will concern the phase-out of all compressors for the domestic market.

2. The total project cost is US $2,313,600 which includes US $302,860 of operational costs. Since Nippodenso Company Ltd. of Japan owns 26 per cent of the company, the incremental cost request has been modified according to the Committee's guidelines on transnational corporation ownership.

3. Since the implementation schedule indicates that equipment ordering and technology transfer began in the second quarter of 1993 and was completed in the third quarter, it is assumed that part of this request is for retroactive financing.

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1 **Determined as the ratio of incremental costs to the estimated annual saving of ODP ($\$/ODP_{Kg}$). For CFC-11, ODS=ODP**

SECRETARIAT'S RECOMMENDATION

4. The Secretariat recommends final approval of this project for the amount requested, US $1,710,000 with the understanding that cost estimates included herein will be reassessed during the final appraisal and the Executive Committee is so informed.

PROJECT EVALUATION SHEET

COUNTRY OR REGION:	India
PROJECT TITLE:	IICT, Hyderabad, Basic Data Development - HFC-134a Process
BUDGET:	US $1,400,000
INCREMENTAL COSTS:	US $1,400,000
ODS PHASE-OUT:	n/a
COST EFFECTIVENESS:	n/a
PROJECT DURATION:	2 years
IMPLEMENTING AGENCY:	The World Bank/IDBI
NATIONAL COORDINATING AGENCY:	Ministry of Environment and Forests
TECHNICAL REVIEW COMPLETED:	YES X NO ___

SECRETARIAT'S COMMENTS

1. India Institute of Chemical Technology (IICT), Hyderabad, has developed a chromia-based catalyst and a two-stage process for HFC-134a production. This project would design and construct a pilot facility for the development and testing of the production of HFC-134a based on indigenous technology. The plant would have the capacity of producing 30 tonnes of HFC-134a per year. The intent of the project is to test HFC-134a production process to enable IICT to transfer the basic design, technology, and engineering process to other companies in the country at no charge, and to other developing countries on most favourable and non-commercial terms.

2. Three local major manufacturers of CFCs have agreed to adopt IICT technology for the production, on a commercial scale, of HFC-134a.

3. The proposal was submitted to the World Bank. An OORG production sector expert reviewed the proposal, and raised several technical issues. IICT responded to most of the reviewer's comments. However, the reviewer stated that technology could be transferred at a lower cost than the proposed project. He pointed out that it was likely to be more cost-effective to adapt existing technology to local conditions than to start from the developmental stage as proposed in this project.

SECRETARIAT'S RECOMMENDATIONS

4. The project is not eligible for funding because it seeks to establish a new production facility, albeit on a pilot scale, and not to replace an existing plant.

5. However, if the Government of India makes a commitment not to request funding for licensing of technology to the existing four producers of CFCs, the project might prove cost-effective.

6. The Secretariat therefore recommends that the project be disapproved on eligibility grounds, or deferred pending clarification from the Government of India regarding 2 above.

7. The Secretariat further recommends that a strategy paper on all issues relating to production of substitutes should be developed.

THE MONTREAL PROTOCOL ON SUBSTANCES THAT DEPLETE THE OZONE LAYER PROJECT COVER SHEET

COUNTRY	India
SECTORS COVERED	Refrigeration and Air Conditioning (Automotive Air Conditioning)
ODS CONSUMPTION IN AFFECTED SECTOR	282 MT in 1992
PROJECT TITLE	Modification of CFC-12 Mobile Air Conditioning Manufacturing for HFC-134a
PROJECT DURATION	2 years
PROJECT IMPACT	84 MT ODS
Unit Abatement Cost (UAC)	$4.3 per ODP weighted kg. of CFC-12
PROPOSED BUDGET	Incremental Capital Cost $2,010,740 Incremental Operating Cost $ 302,860 Total Project Cost $2,313,600
PROPOSED OTF GRANT	$1,710,000
IMPLEMENTING ENTERPRISE	Subros Limited
IMPLEMENTING AGENCY	The World Bank/IDBI
NATIONAL COORDINATING AGENCY	Ministry of Environment and Forests (MOEF)

PROJECT SUMMARY

This Project will phase out chlorofluorocarbons (CFC-12) used in Automotive Air Conditioning Systems. In Phase I of this project, Subros will modify its production capability enough to supply its export market with HFC-134a compressors. This Phase will therefore require changes in production equipment as well as compressor design modifications. The incremental capital cost for these items is the subject of this proposal. Phase II will be devoted to phase-out of CFC-12 from all compressors for the domestic market. The schedule has been planned to accommodate the phase-out envisaged in the India Country Program. Many of the costs involved in the Phase I proposal will also provide for some of the Phase II activities. A separate proposal will be submitted for Phase II.

TECHNICAL ASSESSMENT: This subproject has been reviewed and supported by the OORG technical reviewer, Mr. S. Oulouhojian. His comments are attached.

PROJECT OBJECTIVE. The project objective is to facilitate the phase out of CFC-12 used as refrigerant in the Automotive Air Conditioning Systems by producing compressor designed for use of HFC-134a in coordination with model changes by car manufacturers.

SECTOR BACKGROUND (modified as per draft India Country Programmme - July 1993)

The Automobile Industry in India underwent major growth in the early 1980's with the start-up of manufacturing facilities for late model cars. To provide Automotive Air Conditioning Systems for these cars, SUBROS LIMITED, India started production with foreign collaboration. India has a tropical climate coupled with heavy traffic and pollution conditions in the metropolitan cities and also poor rural road conditions. All these result in a lot of discomfort while travelling, due to high temperature, humidity, dust and pollution etc. It is estimated that during the year 1993-94 a total of approx. 105,000 Air Conditioning units shall be installed in India (including vehicles manufactured for export) and another 176,000 units may require fresh refrigerant charging. The total consumption of CFC-12 during 1993-94 is estimated to be 281 MT at one kg. per vehicle.

ENTERPRISE BACKGROUND. Subros Limited, India, is manufacturing Automotive Air Conditioning Systems in technical collaboration with M/s. Nippondenso Company Limited, Japan. Total Capital Investment of the Company is about US$7 million and expected turnover during the financial year 1993-94 is likely to be US$40 millions. Subros employs 400 people, is the largest manufacturer of Automotive Air Conditioning Systems in India and is the original equipment supplier to:

1) M/s. Maruti Udyog Limited (Subsidiary of M/s Suzuki Motor Company, Japan) - for their total requirement for domestic and export markets; and

2) Other leading manufacturers like M/s. Engg. & Locomotive Co. Limited and M/s. Premier Automobiles Limited.

Subros has a modern manufacturing facility located at Noida (30 Kms. from New Delhi). All the critical manufacturing equipment, instruments and tooling etc. have been imported from M/s. Nippondenso Company, Japan, who have trained Subros engineers. Some of their engineers are based at Subros to provide day to day input for making their products of international quality standards. Keeping in-line with the Montreal Protocol Agreement, of which Japan also is a signatory, M/s. Nippondenso Company, after extensive research and tests, developed the technology for use of alternate refrigerant HFC-134a. Subros plans to phase out the use of CFC-12 with technology available from M/s. Nippondenso Company, Japan and adopt HFC-134a based technology.

Subros manufactured 31,000 units during FY 1992-93. During the year 1993-94, it is expected that Subros shall manufacture and supply 50,000 Air Conditioning Systems both for domestic and export market. Considering the quantity of refrigerant required is one kg. per vehicle, approx. 50 MT of CFC-12 shall be consumed for Automotive Air Conditioning Systems supplied by Subros. Approximately 35 MT is used for recharging. In the years 1994-1999 an average of 100 MT/year is expected to be consumed. Subros is the original equipment supplier of Automotive Air Conditioning Systems to M/s. Maruti Udyog Limited (MUL), both for their domestic and export markets. At present M/s Maruti Udyog Limited is exporting their existing model of 800 CC (LHD) cars to various countries for which Air Conditioning Systems are supplied by Subros. During mid 1993, M/s. Maruti Udyog Limited shall be launching a new model of car primarily designed for export market. It is expected that during 1994-95, MUL shall require a total of 12,000 units for export market. M/s. Nippondenso, Japan has projected a demand for supply of 11,000 retrofit Compressors (for use with HFC-134a) per annum from 1994-95 onwards for export market to their various subsidiary companies.

PROJECT DESCRIPTION. The project involves:

(a) Transfer of Technology from M/s. Nippondenso Company Limited, Japan;

(b) Setting up infrastructure required for new production lines;

(c) Procurement of imported and indigenous equipment, toolings, instruments etc. for new production lines and modification of existing production lines; and

(d) Training of Subros manpower at Nippondenso, for changeover implementation and subsequent production.

The project will result in phasing out a total of 100 MT CFC-12 used for the initial charge and service.

JUSTIFICATION FOR SELECTION OF ALTERNATE TECHNOLOGY. Alternate technology based on refrigerant HFC-134a is being adopted for the following reasons:

(I) HFC-134a has been accepted world wide as replacement for CFC-12 for use in refrigeration and air conditioning applications including Automotive Air Conditioning Systems because of its good thermodynamic properties, zero ODP and non-flammability. Also, refrigerant HFC-134a has been recognised world-wide as the refrigerant of choice.

(II) M/s. Nippondenso Company, Japan, Subros collaborators, have carried out extensive research and testing using HFC-134a and have accordingly developed the technology. M/s. Nippondenso have agreed to transfer the technology free of charge.

PROJECT COSTS. Unless otherwise noted, all costs in this section are economic rather than financial costs.

Total Sub-Project Cost: The total capital cost is US$2,010,740. Since there are no non-ODS capital costs associated with this project, the total project cost equals ODS reduction portion of the overall project. This project will not provide Subros with any additional revenue. Major components included in the capital cost are, costs for infrastructure, additional production and testing lines, transfer of technology, training etc.

Operating Costs: The incremental operating costs for this project are estimated to be US$302,860.

Unit Abatement Cost (UAC). The UAC for Phase-I of the project is US$4.3 per ODP weighted kilogram of CFC-12. This number is derived from annualised incremental capital cost of US$2,64,360 first year incremental operating cost of US$95,544 and savings of 83.6 MT (weighted) of CFC-12 per annum.

Proposed OTF Grant. The proposed OTF grant of US$1.71 millions for Subros is calculated by multiplying the total ODS reduction project cost of US$2,313,600 by the percentage of ownership of the company by Indian owners (i.e. 74%).

FINANCIAL AND ECONOMIC ANALYSIS

Economic Rate of Return (ERR). Since the project entails initial capital and incremental operating cost only, the ERR is undefined and is not calculated.

Financial Rate of Return. (FRR). Since total incremental cost over 15 years is estimated to be US$302,860. Assuming that Subros receives a grant of US$1.71 million and since the enterprise has a cash flow in the first year followed by recurring cost, the project is equivalent to borrowing money rather than making an investment. Thus, as there is only a net recurring cash out flow every year, FRR is not calculated.

Implementation Schedule :

SL NO	Activity	1993				1994			
		Quarter				Quarter			
		I	II	III	IV	I	II	III	IV
01.z z	Technology Transfer	..	-<---->-						
02.	Fund receiving				<-->				
03.	Infrastructure Provision								
04.	Equipment Ordering		<------>						
05.	Training				<-->				
06.	Setting up production Lines						<->		
07.	Trial Production								.. ..
08.	Mass Production			(As per the country policy to be announced)					
09.	Supply of Domestic Market								

REQUIRED REGULATORY ACTIONS. No regulatory actions other than routine permission, are required to implement this project.

<u>Direct Project Impacts</u>. This project will phase out 85 MT per year of CFC-12 (1992 basis) equivalent to ODP weighted savings of 85 MT.

<u>Indirect Project Impacts</u>. This project will have no impact on performance or quality. However, since the cost for Phase-II has not been included in this project and shall be worked out separately, it is not possible to furnish the impact on price of Automotive Air Conditioning Systems for domestic market.

ENVIRONMENTAL IMPACT. This project is not expected to have any adverse Environmental impact at the factory level.

Changes in Project Scope and Costs Due to OORG Comments. Project costs was reduced as a result of earlier OORG review. Enterprise will make the maximum use of Japanese engineers already at site due to other work. However, this factor was already taken into account to determine training and technical assistance level required. All equipment wil be procured internationally to optimize costs.

Project Cost Estimate

Capital cost	US$
Compressor Assembly	512,484
Tube liquid	396,027
Hoses	159,181
Task Receiver	113,472
Condenser Evaporator	351,984
Compressor parts machinery	497,708
Training	38,258
Technology	9,590
Consultancy	6,000
Total cost	2,034,706
Less residual value	23,966
Capital cost	2,010,740

TO: NAIMEH HADJITARKHANI

(2)

SIMONE MANAGEMENT INC.

7425 West Chester Pike
Upper Darby, PA 19082
(215) 352-4600

DATE: August 9, 1993

TO: Don Brown
Project Manager

World Bank
Washington, D.C. 20433
Asia Information Center
Fax# 202-477-6619

FROM: Simon Oulouhojian
OORG Reviewer

Fax# 215-352-1345

SUBJECT: India - Review of Mobile Air Conditioning Project Proposal
Sub-Project Proposal For The Use Of Non-Ods Technology At
Subros Limited, India
File # 1-2R.PRJ

MESSAGE: Modification of CFC12 Mobile Air Conditioning systems manufacturing and compressors to HFC134A, a non-ozone depleting refrigerant.
Two phase project over a period of two years.
Impact is 84 metric tons of ozone depleting substances.
Project cost $2313600.00
Grant OTF $17100.00 $1,712,000

RECOMMENDATIONS: On the whole, I support this proposal. The bank should look at the possibility of reducing costs in both travel and additional support to bring in engineers through the utilization of the on site quality control engineers that Nippondenso has there. There may be a rotation of these personnel, who could be trained and retrain the staff at Subros Limited.
Based on the information in the proposal, Subros has a modern plant and qualified employees that could easily and quickly make the necessary changes for transition to non-ozone depleting HFC134A refrigerant in systems and compressor production.
This grant would accelerate the use of HFC134A compressors into the region as Subros also exports systems and parts.
The climate and temperature in India indicates a growth market for mobile air conditioning systems, by their own projections well over 110000 units in the next few years.
This project will provide cash flow the first year. This proposal should be beneficial to all parties and should be a model program as it comes to fruition.

(3)

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Nippondenso certainly has a fine reputation in the air conditioning industry maintaining a leadership position for its research and development programs, highest quality products and engineering. They should be commended for offering this technology for transfer.

ENVIRONMENTAL IMPACT: Phasing out 84 metric tons of CFC through accelerated transition to 134A in systems and compressors manufactured by Subros. I see nothing in this proposal with adverse environmental impact. I am sure proper material safety data information will accompany technology transfer; for example, proper handling of synthetic lubricants to avoid skin contact.

Simon Oulouhojian

THE MONTREAL PROTOCOL ON SUBSTANCES THAT DEPLETE THE OZONE LAYER PROJECT COVER SHEET

COUNTRY	India
SECTORS COVERED	Foam Systems
ODS CONSUMPTION IN AFFECTED SECTOR	1,200 Tonnes (1991)
PROJECT TITLE	Application Development for the conversion of CFC-11/Polyol Systems to low/non-ODS formulations
PROJECT DURATION	Phase I : Part A 1 years Phase I : Part B 2 years Phase II : To be determined later
PROJECT IMPACT	488 MT ODS by 1995
Unit Abatement Cost (UAC)	Not applicable to Phase I
PROJECT BUDGET	Incremental Capital Cost $729,000 Incremental Operating Cost $100,000 Total Project Cost $829,000
PROJECT OTF GRANT	$829,000
IMPLEMENTING ENTERPRISE	MANALI PETROCHEMICAL LTD., MADRAS
IMPLEMENTING AGENCY	The World Bank/IDBI
NATIONAL COORDINATING AGENCY	Ministry of Environment and Forests (MOEF)

PROJECT SUMMARY

This project will facilitate replacement of CFC-11 as the foam blowing agent in polyurethane (PU) chemical systems manufactured at Manali Petrochemicals plant near Madras. These systems have end-uses in rigid insulation and flexible moulded foam manufactured products. This project will source commercially proven technology for PU chemical systems containing low-ODP foam blowing agents. The technology will be adapted to suit Indian customer needs & specific end-use requirements with modifications to Manali Petrochemical's existing manufacturing infrastructure. The technology for the PU chemical systems will be obtained from ARCO (US) and Mitsui (Japan) under the terms of technology transfer agreements currently being negotiated. This project will provide a local source of essential materials with which industry can reduce CFC-11 usage in India by about 1,200 MT per year by 1996.

TECHNICAL ASSESSMENT: This subproject has been reviewed and supported by the OORG technical reviewer, Mr. M. Jeffs. His comments are attached.

PROJECT OBJECTIVES. The objectives of this project are to establish a source of proven technology in polyurethane Chemical foam containing low and zero ozone depletion potential (ODP) blowing agents. This project consists of two phases, (I) formulation development of polyol systems and (II) manufacture and supply of commercial quantities of the systems.

Phase I. Formulation development mainly using indigenous material and small quantities of imported material with emphasis on formulations using low or zero-ODP substitutes such as HCFC-22, HCFC-141b, HFC-134a, and hydrocarbons. Since a single solution is unlikely in the foreseeable future, the study should include at least the aforementioned chemicals.

Phase II. Phase II will be submitted as a separate project when information from Phase I enables better definition of scope and timing. It will cover the project for manufacture and supply of commercial quantities of alternative systems for replacement of CFC-11 in flexible moulded and rigid polyurethane formulations.

SECTOR BACKGROUND (modified based on draft India Country Programme - July 1993)

a) Flexible Moulded Foams (Automotive Sector). There are 8 major and 24 smaller foam manufacturers operating in the moulded foam sector. All are suppliers to the automotive industry. In 1991, all enterprises produced approximately 2,900 MT of foam using CFC-11-based indigenous formulations including 160 metric tonnes of CFC-11. The largest manufacturer, Bharat Seats, produces nearly 50% of country's requirement of seats using CFC-11 based imported polyol formulations containing an additional 80 tons of CFC-11. Bharat now is changing to CFC-free systems. One more large enterprise for manufacture of seats is expected to go into production by 1994. By 1994, the requirement of unconstrained consumption of polyol & isocyanate systems in automotive sector is expected to be of the order of 4600 MT, which would lead to consumption of 210 MT of CFC-11.

b) Rigid foam sector (Refrigeration). The domestic refrigerator industry of India consumed approximately 575 MT of CFC-11 in 1992 for use in polyurethane foaming operations. The production of refrigerators and freezers has increased significantly in the past three years with two new companies entering the field. In 1992 the production was approximately 1.4 million refrigerators per year and it is expected to increase to 2.3 million refrigerators by 1995. Domestic refrigerators are relatively small in size (about 165 litres). Each refrigerator uses approximately 3 kg. of foam, which requires about 450 grams of CFC-11 for foam production alone. Recently large refrigerators, using approximately 5.5 kg. of foam per refrigerator, have also entered the market. It is expected that by the year 1995, the refrigerator sector alone will consume approximately 8,000 MT of foam, which will require nearly 875 MT of CFC-11. The development of alternative polyol/blowing agent combinations as soon as possible will have a direct impact on these large, rapidly growing CFC consuming sectors.

ENTERPRISE BACKGROUND. Manali Petrochemical Limited is located in Madras, India. It is a 100% Indian owned company and employs about 350 people. The revenues in 1991, the first year of operation were approximately $16 million. Revenues grew in 1992 to $22 million due to penetration of the import market and new sales in flexible moulded and rigid insulation foams. In December 1990, Manali began polyol production at its Madras plant. Technology was purchased from ARCO (USA) on a one-time technology transfer agreement covering a broad range of polyether and polyester polyol formulations. A new technology transfer agreement covering CFC-free systems will need to be funded under Phase I.

Annual production capacity for polyols is 7,500 MT in two plants at the Madras site. Capacity utilization is about 25% but expected to reach 65-70% by 1996. Raw materials for manufacture of polyols, i.e. propylene and propylene oxide are also produced at the same location. Small quantities of polyol systems are exported to Middle East and to Asian Countries. Manali's domestic market share is about 45% for flexible moulded and around 50% for rigid grade polyol formulations (1993-94 expectations as per Manali).

PROJECT DESCRIPTION. The project consists of two phases:

Phase I - Application development for conversion of CFC-11/polyol systems to low/non-ODS formulations; and

Phase II - Establishment of manufacturing and supply capability for low/non-ODS systems.

This project will source commercially proven technology for polyurethane chemical systems containing low-ODP foam blowing agents. The technology will be adapted at Manali to suit Indian customer needs and specific end-use requirements with modifications to Manali's existing manufacturing infrastructure.

Phase I - Part A (Flexible Moulded Foams). In this part of the project, the company would develop technology leading to production of polyurethane foams for flexible moulded applications, which would be totally CFC free. Currently MPL manufactures polyol formulations based on conventional technology. Current CFC consumption rate is approximately 60 tonnes annually. MPL proposes to manufacture polyol formulations for flexible moulded foams which can eliminate use of CFC-11 with water-blown systems. These formulations will eliminate around 94 MT in 1994 and 140 MT in 1995 of CFC-11 in MPL sales to the automotive market. For this purpose, the company proposes the following action:

a) Acquire the technology at an estimated cost of $50,000 - $100,000 from ARCO Inc. of USA through their application centre at Singapore.

b) Training of MPL chemists at Singapore, (20 man-days).

c) ARCO Staff will work at MPL application centre to perfect formulation.

d) Carry out field trials at the foam manufacturers to gain acceptance and feed-back.

Phase I - Part A Capital Costs (Annex A) will cover purchase of technology, foam producing equipment, foam testing equipment, travel and training.

Phase I Part B: (Rigid Foams). This part concerns reduction/phase out of CFC-11 in production of polyurethane foams in the refrigeration and PU foam insulation sector. The main thrust of Part B is application development of Polyol formulations for insulation foam. In this part of the sub-project, MPL proposes to develop formulations to immediately achieve 50% CFC-11 reduction. This action is not expected to need any significant redesign or capital expenditure. MPL further proposes to support the Indian customers with formulations containing alternatives to CFCs, such as HCFC-22, HCFC-141b, and ultimately achieve 100% CFC-free systems with candidates such as HFC-134a and/or cyclopentane. To achieve this objective, the company proposes the following actions.

a) Enter into a technical consultancy agreement with Mitsui of Japan to provide the technical guidance in development of rigid formulations. A quotation from Mitsui of Japan is awaited. Estimated cost is $100,000.

b) Purchase required catalysts, chemicals and alternative blowing agents to carry out the experiments.

c) Buy additional high pressure dispensing equipment and large life size moulds to simulate operating conditions of refrigerator manufacturer.

The development of new formulations require special foam testing equipment. Major properties need to be monitored and to be kept within precise acceptable limits. The project also requires funding for extension of the present laboratory space to accomodate this additional foaming and testing equipment. The technology development also requires the visit of foreign technology sources i.e.

experts from Mitsui of Japan. MPL expects to develop the formulations within a period of twelve months, carry out laboratory trials and then field trials to gain acceptance with the refrigerator manufacturers. After successful development of rigid formulations, MPL will be in a position to supply formulations for use by the refrigerator manufacturers prior to commencement of commercial production. The incremental investment costs for manufacturing and supplying these formulations will be presented as a separate project in Phase II.

JUSTIFICATION FOR SELECTION OF ALTERNATIVE TECHNOLOGY:

PHASE-I: PART-A. World over the flexible moulded foams are produced using different technologies either cold-cured based totally on MDI or hot-cured or semi-hot cured with TDI and a mixture of MDI and TDI. Considerable use is now being made in developed countries using MDI/catalyst/water combinations to replace CFC-11 in flexible moulded foams. Since insulation performance is not a factor, such a system is both acceptable and less expensive for the consuming enterprise. This technology cannot apply to rigid insulation foams, as insulation values are poor. In the Indian context, the polyol industry is in its infancy stage and would require external assistance from a large "system house" from abroad to provide technical guidance and training to keep abreast with the rest of the world. Since large users of flexible moulded formulations in India have already started specifying CFC-11 free foams, MPL must equip itself with technology to produce the CFC-free polyol formulations.

MPL also currently exports polyol formulations to Middle East and to Asia. With the need for exporting CFC-free formulations, a technology tie up with a renowned technology supplier is necessary (i.e. ARCO-USA). MPL feels that it requires not only technical guidance in development of formulations but also requires the additional equipment listed in Phase-I Part-A of Annex I of the feasibility study (page 24) in addition to equipment they have already have for testing foams. The majority of expenditure is towards purchase of a bench dispensing machine and larger size moulds to check flow characteristics of the system due to increase in viscosity in polyol with elimination of CFC diluent.

PHASE-I : PART-B. In the rigid foam sector, the options available to the company have been scheduled as follows:

a) Development of 50% CFC-11 free formulations.

b) Development of CFC-free formulations with HCFC-22, HFC-141b, HCFC-134a, and/or cyclopentane, whichever the market demands.

Most refrigerators manufactured in India are of small size (165 litres) and moulds are not very intricate. MPL believes that by use of suitable enhancing surfactants and blends of low viscosity polyols, it is possible to use water blowing techniques to phase out 50% of CFC-11 used in the production of foams. However, this activity would require technical guidance from external sources who have already developed such formulations and testing for required properties. Critical properties are thermal conductivity, closed cell content, compression strength, dimensional stability, flowability, filling characteristics, flammability and adhesion to refrigerator liners. New formulations must replicate properties of CFC-11 blown foams as closely as possible. Hence these measurements are necessary on a realistically duplicated scale.

- The thermal conductivity will be higher due to the increased use of carbon dioxide, which is also likely to result in reduction in compression strength and also closed cell content. Therefore, a "K" factor meter, Pycnometer, UTM and rise rate meter would be required to test the properties of the foam. Detailed explanation for requirement of the equipment is found in Annex V of the feasibility study. Equipment at MPL is fully committed for testing existing production of polyol systems and cannot be spared for carrying out concentrated development work. After the 50% CFC-11 tests MPL will continue its work to eliminate CFC completely and develop HCFC-22, HCFC-141b or HFC-134a systems based on more detailed discussions with the collaborators (MITSUI, et. al.). MPL plans to procure the test equipment that could also be used for this part of application development work (100% CFC-11 phase out programme). No expenditure for equipment is foreseen at that stage for use in development work using HCFC-22, HCFC-141b or HFC-134a.

PROJECT COST. Total Project costs as shown in Annex A, for both parts A and B of Phase-I is $829,000.

CAPITAL COST. As detailed in Annex A, the total capital cost for this project is $729,000 and will be incurred in Phase-I.

OPERATING COST. Phase-I Part-A and B. The project envisages only development of systems and use of special chemicals, catalysts and blowing agents for laboratory and field trials. Hence incremental operating cost towards this has been incorporated in Annex II of the feasibily study. Along with this, the manpower cost and the power cost during the period of development have been considered as operating costs. The Net Present Value (NPV) operating costs for the development work are as follows:

Phase-I Part-A:	$49,800
Phase-I Part-B:	$50,400
Total	$100,200

Unit Abatement Cost (UAC). The Unit Abatement Cost (UAC) is not applicable for this kind of applications development work as of now.

FINANCIAL AND ECONOMICAL ANALYSIS:

Economic Rate of Return (ERR). The project is applied developmental work and hence ERR of the project is undefined.

Financial Rate of Return (FRR). The project is application development and hence FRR is undefined.

Financial status of the enterprise. To be completed at appraisal by IDBI.

Financing plan. To be completed at the appraisal by IDBI.

Project Implementation. To be executed by IDBI.

Project Schedules. Refer to Annex B

Changes in Project Scope and Costs Due to OORG Comments. Technology supply arrangements were better defined and project costs were lowered substantially after initial OORG review of the project. The project is supported by the OORG reviewer.

Annex A

PROJECT COST SUMMARY

	US$
CAPITAL COSTS	
Phase I - Part A	
Technology Transfer, Consultancy and Training	97,000
Testing Equipment	110,000
Freight/Insurance/etc.	9,000
SUB-TOTAL	216,000
Phase I - Part B	
Technology Transfer, Consultation and Training	122,000
Building Extension	16,000
Testing Equipment	337,000
Freight/Insurance/etc.	38,000
SUB-TOTAL	513,000
PHASE I - TOTAL CAPITAL COSTS	729,000
OPERATING COSTS (NPV)	
Phase I - Part A	50,000
Part B	50,000
TOTAL OPERATING COSTS	100,000
TOTAL PROJECT COST	829,000

Annex B

IMPLEMENTATION SCHEDULE

	From	To
Phase I - Part A - Flexible Moulded Formlations without Blowing Agents	4Q-'93	2H-'94
Technical assistance and visits	4Q-'93	2H-'94
Procurement	4Q-'93	2Q-'94
Bench trials and testing	1Q-'94	3Q-'94
Demonstration at MPL Lab. and at customer location	2H-'94	-
Ready for commercial production		
Part B-1 - 50% CFC Foam Formulations	4Q-'93	2H-'94
Tecnical assistance and visits	4Q-'93	2H-'94
Construction and procurement	2Q-'94	4Q-'94
Bench trials and Testing	4Q-'94	1Q-'95
Demo at MPL and customers	2Q-'95	-
Commercial production		
Part B-2 - 100% CFC-11 Free	3Q-'93	1Q-'94
Formlations	4Q-'93	3Q-'94
DEM discssions to define needs	2Q-'94	2Q-'95
Technical Assistance and visits	2Q-'95	4Q-'95
Bench trials and testing	4Q-'95	-
Demo at MP Lab of new technology		
Commercial production		

MANALI PETROCHEMICAL LTD. MADRAS, INDIA

Scope

The project under review covers the development of technology suitable for the Indian market in the fields of:

a) CFC-free systems for flexible moulded foams for the automotive sector.

b) CFC 11 reduced and CFC-free systems for rigid insulation foams for the domestic refrigerator sector.

It is the reviewer's understanding that other actions in which MANALI is engaged in, such as flexible slabstock, integral skin, general insulation (building) and structural foams, are outside the scope of this project.

Recommendation

The project is supported. As discussed in the section on "technical soundness" the time of phasing in HCFC/HFC technology for the rigid application and the choice of technology post "reduced CFC" will have to be decided as the project develops.

Relevancy and Adequacy of information

This is the most comprehensive and best prepared project that this reviewer has seen.

Technical soundness

Technology and technical support for this project is to be obtained from two (Arco Chemical and Mitsui) of the world leaders in the field.
For the flexible moulded application the proposed route is understood to be based on MDI/water blown technology, in line with general world trends.
For the rigid refrigerator application the project envisages the development of 50% reduced CFC 11 formulations followed by CFC-free formulations. The project plan calls for the market introduction of the CFC-free formulations only six months after the 50% reduced formulations. Because of the rapid implementation of CFC-free formulations in other markets, The Bank will be reviewing policy on the technologies to be supported during 1993 and this project should take note of any conclusions reached. The only way to progress towards ODS elimination during a period of technological change is cover several bases and constantly review technological choices as time passes. Twenty-twenty vision will be evident in hindsight.
It is noted that equipment capable of handling low boiling blowing agents such as HCFC 22 and HCF 134a is included in the quotations.

The reviewer repeats earlier comments that HCFC 22 alone is considered to be unsuitable for this application because of rapid loss of insulation value through diffusion out of the foam. There is an increasing interest in cyclopentane technology in the refrigerator sector and further equipment and procedures would be necessary to handle this flammable blowing agent.

Lesson from experience

This project shows the benefit of interchange between the project developers and reviewer during the earlier stages of project development.

Environmental Issues

The execution of the project should consider the time scale over which 50% reduced CFC 11 formulations are used when proven technology will be available in the short term for complete CFC replacement by either HCFC or zero ODP technology.
The centre of zero ODP rigid foam technology is currently Europe and other technology partners might be required for this stage.

Safety Issues

The issues raised at an earlier stage appear to be adequately addressed in Appendix III. It is recommended that these are incorporated in the main project and referred to under "training".

Cost Effectiveness

The project's effectiveness can be expressed as 1.7 $/kg of ODS phased out although this analysis does not take into account additional costs incurred at the production at MANALI or at the downstream production stage (foam or refrigerator factor). The figure expressed above is highly effective compared with the bulk of foam projects.

Other

No additional comments.

THE MONTREAL PROTOCOL ON
SUBSTANCES THAT DEPLETE THE OZONE LAYER
PROJECT COVER SHEET

COUNTRY	India
SECTORS COVERED	Foam systems.
ODS CONSUMPTION IN AFFECTED SECTOR	1,282 tons of CFC-11 (1991)
PROJECT TITLE	Applications development for the conversion of CFC-11/polyol systems to low/non-ODS formulations.
PROJECT DURATION	Phase I : 1 year (1994) Phase II : 2 years (1995-96)
PROJECT IMPACT	705 MT ODS in the period 1994-96
Unit Abatement Cost (UAC)	Not Available
PROPOSED BUDGET	Incremental Capital Cost $824,000 Incremental Operation Cost $105,000 Total Project Cost $929,000
PROPOSED OTF GRANT	$836,000
IMPLEMENTING ENTERPRISE	UB Petroproducts Ltd.
IMPLEMENTING AGENCY	The World Bank/IDBI
NATIONAL COORDINATING AGENCY	Ministry of Environment and Forests (MOEF)

PROJECT SUMMARY

This project aims at replacing CFC-11 as the blowing agent in polyurethane rigid insulation and flexible moulded foams with low/zero ODS alternatives. UB Petroproducts manufacture polyurethane chemical systems for these foam applications. The project will be implemented in two phases.
Phase I will involve: a) sourcing of appropriate technology, b) establishment of test facilities which include 'high pressure' foaming equipment, and c) evaluation of non-CFC alternates for each end-use.
Phase II will include: a) customer trials/testing/training of non-CFC systems, and b) commercial production of formulated polyols. Technology will be obtained from Enichem (Italy) for systems based on low ODP CFC-alternates. This technology will then be adapted to suit Indian customer needs & specific end-use requirements. The project will permit phasing out 705 MT of CFC-11 in manufacturing polyurethane foams during the period 1994-96.

TECHNICAL ASSESSMENT: This subproject has been reviewed and supported by OORG technical reviewer Mr. M. Jeffs. His comments are attached.

PROJECT OBJECTIVES. The objectives of this project are to provide polyols needed to replace CFC-11 as the blowing agent with low ODP alternates by: i) modifying the chemical system i.e., polyol + catalyst + isocynate and testing it extensively to make it suitable for use with CFC-alternate; and ii) Providing on-site demonstration capability to encourage a more rapid conversion to non-CFC blowing agents.

SECTOR BACKGROUND. (updated based on draft India Country Program - July 1993)

The consumption of CFC-11 in India for foam blowing was estimated at 1,282 Mt in 1991. This is expected to increase to 1,581 Mt in 1993. At present, there are two major and three smaller polyurethane system manufacturers in the country. UB Petroproducts Ltd. had approximately 14% share of the market in 1992. The major sectors using CFC-11 for foam blowing are:

	Percent	CFC-11 QTY (MT) (1991)
Rigid Insulation Foam:		
Insulation thermoware	17.5%	225
Refrigerator/appliance insulation	39%	500
General Insulation (Spray, slab panels, in-situ etc.)	19.5%	250
Flexible slabstock foams	3%	35
Flexible moulded foams	12.5%	160
Integral skin foams	1.5%	20
Phenolic Foams	1%	15
Extruded polyolefinic foams	5.5%	70
Misc.	0.5%	7
		1,282

The Indian foam industry is still in its infancy, and if CFC-11 usage is not constrained, the projected growth in CFC-11 use in the foam sector is expected to be as follows:

Year	1992	1993	1994	1995	1996	1997
QTY (MT)	1396	1581	1790	2027	2298	2572 (Updated)

ENTERPRISE BACKGROUND. UB Petroproducts Limited currently manufactures polyurethane chemical systems (Polyol + Isocyanate) with and without CFC-11 for the following end-uses:

1) Insulated thermoware;
2) General Insulation applications: Sprays, slabs, pipe-sections, etc;
3) Flexible moulded foams for automotive and furniture applications; and
4) Integral skin foams.

It also supplies systems for domestic refrigerator insulation. However, these systems are supplied without blowing agent - the addition of which is done by the refrigerator manufacturer at their works. UB Petroproducts Limited commenced manufacture of CFC-11 based products in 1992. Previously, the local demand was being met by imports.

Production Capacity

For Polyols : 8,000 MT/Annum
(Note: Only Polyols are manufactured locally, isocyanate component being imported and then supplied to end-users).

Current (1993) capacity utilization is at about 25% since the enterprise is still virtually in a start-up mode. Capacity utilization is expected to increase to about 55 to 60% in 5 years - mostly at the expense of imports. Corresponding to the production of formulated polyols, the consumption of ODS is expected to be:

ANNUAL ODS CONSUMPTION (MT CFC-11)
(Current/Projected)

	1992	1993	1994	1995	1996	1997
DIRECT	57	250	335	413	463	511
INDIRECT	106	214	282	340	391	438

Technology Source. Existing technology for conventional CFC-11 based polyurethane systems has been procured from Enichem, Italy.

Ownership. 90% - Indian (UB Group, Tamil Nadu Govt., Public); 10% - Foreign (Enichem, Italy)

PROJECT DESCRIPTION. The project will aim at developing polyurethane foam systems (Formulated Polyol + Isocyanate) that can be used with CFC-alternate blowing agents with low ODP's. This will, in turn, enable the reduction in usage of CFC-11 for polyurethane foam blowing. Part of the reduction will be in consumption of CFC-11 at UB Petroproducts itself (direct) and partly, by reduction at customers' works (indirect).

Phase I (1994) of the project envisages the following steps:

1) From Enichem (Italy), transfer commercially proven technologies for CFC-alternate based systems. These would apply to rigid insulation foams and to CO_2/water systems for flexible moulded foams;

2) Establish high pressure foam machinery & test facilities;

3) Evaluation of these alternate technologies and choice of appropriate blowing agents for each end-use application; and

4) Production of suitable base polyols, testing/characterization at the enterprise and at customer locations, and adaptation of systems to specific customer needs.

In view of the diversity of applications that use UB's products, it is considered necessary to have a range of different systems to choose from. However, they need to be thoroughly evaluated with various blowing agent candidates.

Phase II (1995-96) of the project will consist of:

1) Trials/testing at customers end; adaptation of low-ODP blowing agent technology to specific customer needs/requirements;

2) Train customer's technicians and provide assistance in equipment modification; and

3) Commercial production of formulated polyols.

JUSTIFICATION FOR SOURCE OF TECHNOLOGY. The proposed source of technology is Enichem (Italy). They have provided conventional CFC-based system technology for the current range of UB Petroproducts products, and as such are familiar with their product range and Indian manufacturing conditions. They are amongst the world leaders in PU systems/intermediates and have ongoing active research programs on CFC-replacements in foam blowing applications. Many of their CFC-reduced systems are being used successfully in Western Europe. UB Petroproducts will, on sourcing technology from Enichem, have the benefit of the latest and most appropriate technology for low ODP blowing agents when the actual transfer of the technology takes place.

JUSTIFICATION FOR TECHNOLOGY SELECTION:

For Flexible Moulded Foams: Proven CFC-free technologies based on TDI-isocyanates are currently used in W. Europe without any significant compromise on densities or performance. This will be the first area of concentration for UB Petroproducts - constitutes about 50% of the market - for adopting technology under Indian conditions. MDI based water systems will be tested and introduced next. All approaches are cost-effective, being approximately the same as current systems. The rationale for selection of technologies is outlined below:

For Rigid Foam Systems: Seven alternate routes are being considered for evaluation - under Indian conditions.

1) Reduced (50%) CFC-11 systems have been widely used and proven in Western Europe and developed countries for the last three years. The key benefits are the minimal engineering changes required for the conversion. This will enable an immediate reduction in CFC-11 usage, thus providing some time for implementing more lasting solutions.

2) HCFC-22 based systems - HCFC-22 is commercially available in India and promises some price stability. The factors would enable quick introduction/changeover from CFC-11.

3) HCFC-22/142 blends - Industry reports have suggested that systems based on these blends have displayed properties that are superior to HCFC-22 based systems - both in terms of processing and properties. Both HCFC-22 and HCFC-22/142b based systems require high pressure technology, and as such can be viewed as intermediate step to using HFC-134a - ODP=0 (which also requires high pressure technology).

4) HCFC-141b - use of HCFC-141b as a drop-in replacement to CFC-11 is clouded by its as-yet incomplete toxicity studies, flammability and the possible need for changes in auxiliary materials (e.g. liners) used in insulation applications. Once toxicity issues are clear, it may be considered for applications where use of high pressure technology is precluded.

5) HCFC-123 - Apart from toxicity, it is a very promising plugin replacement for CFC-11. Its use would be of interest to small industries where investments of the order of those required for high pressure machines may not be possible.

6) CO_2 - This will be a solution for applications where K values and dimensions are not the constraining factors.

7) Pentane - As one of the Indian appliance manufacturers is considering pentane as an alternative, this route would also be evaluated.

PROJECT COST. The total project incremental costs for Phase I were calculated at US$929,000. Since there are no non-ODS investment costs associated with this project, the total project cost is also the incremental cost.

CAPITAL COSTS. Capital costs of US$824,000 include:

a) capital investments in polyol/system testing and characterization, facility for high pressure polyol blending, and polyol plant modifications

b) Preliminary trial costs at customer's premises

The details of capital costs are included in Annex 1. All these are one-time costs.

INCREMENTAL OPERATING COSTS: PHASE 1 ONLY. Operating costs vary from year to year based on changes in proportions and prices of blowing agents, polyol and isocyanate. Given a discount rate of 10%, the net present value of incremental operating costs for the first four years is US$105,000. Only systems which involve direct usage of CFC-11 at UB Petroproducts have been considered for these calculations.

PROPOSED OTF FUNDING. The proposal requests US$836,000 as a grant for the project.

FINANCIAL AND ECONOMIC ANALYSIS. Economic Rate of Return (ERR): Since the project involves one time capital cost and recurring operating cost, the ERR is undefined. Financial Rate of Return (FRR): Since the project involved one time capital cost and recurring operating cost, the FRR is undefined.

REQUIRED REGULATORY ACTIONS: See general comments on taxes and duties.

Changes in Project Scope and Costs Due to OORG Comments. Costs were reduced substantially as a result of initial, detailed review by the OORG expert. The enterprise gave a better explanation of market position and technology employed. UB has an established technology agreement with Enichem and this would continue as long as the company thinks it is appropriate. Competition would be provided from other sources. The schedule for phasing in rigid foam applications can not be given until, the refrigeration sector phase out plan is better developed. These latter points will be reviewed during subproject appraisal. The revised projects is supported by the OORG reviewer.

Annex

Capital cost estimates Phase I

	US$
Technology transfer fees	200,000
Polyol testing/characterization	65,857
System testing/characterization	370,355
Production facilities	128,492
Materials/testing/characterization costs	59,300
Total (rounded)	824,000

UB PETROPRODUCTS, MADRAS, INDIA

SCOPE

The project under review covers the development of technology for CFC 11 reduction and elimination in the polyurethane rigid insulating foam and flexible moulded foam. The first phase under review covers the steps up to and including proving trials at customers' facilities.

RECOMMENDATION

The project is supported. As in other projects now undergoing the review process - the choice and timing of technologies to be implemented for rigid insulating foams need to be determined at a later stage in the project. These should be in line with guidelines to be developed by The Bank.

RELEVANCY AND ADEQUACY OF INFORMATION

Information is comprehensive and well set out to the high standard which should now be the norm. There should be some further technology exemplification as noted in the next section.

TECHNICAL SOUNDNESS

The technology and technical support is provided by Enichem, one of the leaders in the field. However, it would be beneficial to UB Petroproducts if they were exposed to technology from competitive suppliers.

For flexible moulded foams CFC-free technology is not fully explained for the TDI-based systems. There are several technologies which the enterprise could use.

The choice for MDI-based flexible foam systems is given.

For rigid foams several technologies are listed, including reduced CFC 11 systems. The proposed timetable for phasing in the various technologies should be given. Because of the rapid implementation of CFC-free technologies in other markets, The Bank will be reviewing policy on the technologies to be supported for refrigerator insulation during 1993 and the project should take note of the guidelines to be developed. The review may also be extended to other sectors.

The project envisages the evaluation of several options and this is a sound way to progress at a time of rapid technological change.

The following comments are offered on some of the technologies listed :

- HCFC 22 technology is not considered suitable except in those applications, such as steel-faced panels, where protection against rapid thermal conductivity ageing is provided. Plastic panels (liners), as in refrigerators, are not suitable.
- The project description should clarify exactly that pressurised blowing agent addition facilities (eg. Easy Froth) are required for blowing agents which boil at low temperatures.
- The reviewer considers that the toxicology issues which related to HCFC 141b are now resolved.
- HCFC 123 should not be considered since its OEL (occupational exposure limit) is considered to be 5 ppm by several potential suppliers - this should constitute an unnecessary health risk as other, cheaper, alternatives are available.

LESSON FROM EXPERIENCE

The project shows progress along the learning curve.

ENVIRONMENTAL ISSUES

As noted, the project in its execution phase should follow a rapid path to low or zero ODS technologies, always provided that there are proven technologies. Reduced CFC 11 is, at best, a short term stop-gap measure.

SAFETY ISSUES

The portable use of cyclopentane is noted and there must be adequate training if this option is followed through. Further capital expenditure should be required in addition. The sum involved would not be trivial.

COST EFFECTIVENESS

It is noted that additional expenditure is required over and above the technology fee for foreign experts, presumably from Enichem, to visit India. Nevertheless, the project is cost effective at $ 1.2/kg of ODS phased out. This figure depends on the growth rates being achieved which include the capture of market share by the enterprise and does not include production costs at UB Petroproducts or its down stream customers.

OTHERS

None.

10/8/93

THE MONTREAL PROTOCOL ON
SUBSTANCES THAT DEPLETE THE OZONE LAYER
PROJECT COVER SHEET

COUNTRY	India
SECTORS COVERED	Foamed plastics
ODS CONSUMPTION IN AFFECTED SECTOR	1,282 MT of CFC-11 (1991)
PROJECT TITLE	Replacement of CFC-11 blowing agent in polyurethane (PU) systems with low and non-ODS materials.
PROJECT DURATION	Phase I - 30 months Phase II - 18 months
PROJECT IMPACT	456 MT ODS annually
Unit Abatement Cost (UAC)	Phase I is for development and demonstration
PROPOSED BUDGET	Phase I Incremental Capital Cost $505,000 Phase II Incremental Capital Cost $114,000 Total Project Cost $619,000
PROPOSED OTF GRANT	$619,000
IMPLEMENTING ENTERPRISE	Expanded Incorporation
IMPLEMENTING AGENCY	The World Bank/IDBI
NATIONAL COORDINATING AGENCY:	Ministry of Environment & Forests (MOEF)

PROJECT SUMMARY

In Phase 1 of this project Expanded Incorporation will install laboratory & testing equipment and establish demonstration facilities for applications development in close cooperation with Indian Foam processors. The enterprise will use its own in-house technology to develop new polyols & systems for the production of ODS-free rigid polyurethane (PU) foams under Indian conditions. This project will enhance the early phase-out of CFC-11 consumption in Rigid PU Foams used in household refrigeration insulation, thermowares, sandwich panels and general insulation rigid PU foams manufactured by various companies using polyols supplied by Expanded Incorporation. In the second phase of the project, Expanded Incorporation will facilitate the phase out of CFC-11 consumption by manufacturing proprietary blended polyol formulations for use with new alternative blowing agents. After the application technology is established, the enterprise will modify present polyols suitable for CFC-free rigid foams using alternative blowing agents and also modify and relocate the blending plant to manufacture CFC-free blended polyols.

TECHNICAL ASSESSMENT: This subproject has been reviewed and supported by OORG technical reviewer Mr. M. Jeffs. His comments are attached.

PROJECT OBJECTIVE. The objectives of this project are not only to eliminate CFC-11 from pre-blended polyol systems manufactured by Expanded Incorporation but also to promote the phase out of CFC-11 at end users end by developing new polyols and systems for processors who normally make their own blends.

SECTOR BACKGROUND, (Updated based on draft India Country Programme - July 1993)

The Indian foam industry consumed 1,282 tons of CFC-11 in 1991.

Table-1
(metric tons)
ODS Consumption in Foams, 1991

Category		CFC-11	CFC-12	CFC-113
Polyurethane Foams (PUF)		160		
Flexible PUF		35		
Flexible Slabstock Foams		975		
Rigid PUF				
Refrigerator Insulation	500			
General Insulation	250			
Thermoware	225	20		
Integral Skin Foams				
Phenolic Foams		15		15
Thermoplastic Foams		70	280	
Misc.		7		
Total		1,282	280	15

Unconstrained demand would lead to an expected ODS use of about ten times the current consumption in year 2010. The sector consists of about 225 enterprises. About 15% of these companies are large or medium sized and have relatively sophisticated manufacturing equipment. The remaining enterprises operate small scale units and are technically and chemically unsophisticated. The support of the chemical suppliers will be crucial in reaching and educating this group.

ENTERPRISE BACKGROUND. Established in 1983 M/s. Expanded Incorporation, a 100% Indian owned company, has been first to produce rigid Polyurethane Foam chemical systems in India. Dependent entirely on its own in-house technology, the company has been highly successful in developing and manufacturing of various types of Polyols & formulations for such diverse industries as refrigerators, building roof spray, and packaging. With an annual production capacity of 2,400 MT of systems, the plant is located at New Bombay (30 Km North of Bombay) employing a staff of 50, skilled & semi-skilled personnel. This is the only plant in India, designed to produce polyurethane polyols, (based on propylene oxide), polyester polyols and amino polyols. As per Expanded Incorporation, it enjoys a market share of 45% based on Indian production. It also exports its polyols to Middle East countries. The enterprise has already initiated work on new polyols to be used with locally available HCFC-22 in place of CFC-11.

PROJECT DESCRIPTION. In Phase I of this project Expanded Incorporation will set up an application technology center since it is very important and compulsory for a Polyol manufacturing enterprise in India to promote & establish CFC-free technology among end-users of polyol systems. This application technology center will be installed in a separate building attached to the present plant where development, testing, trials & demonstration of CFC-free foam systems will be carried out as per end-users requirement under local conditions. New polyols suitable for blowing agents such as HCFC-22, HCFC-141b, cyclopentane, and HCFC-134a will be evaluated. In phase II, following successful development trials and testing of ODS-free rigid foam systems, the existing base polyol plant will be modified by installing necessary equipment to produce new base polyols suitable for the production of CFC-free rigid foams. Since the elimination of CFCs from blended polyols systems is entirely dependent on phase out programs of final foam processors, the enterprise will first modify & reinstall one of the three existing blending stations in a new building block. Subsequently, the other two blending stations will be modified for total phase out of CFC from blended polyol systems manufactured at Expanded Incorporation. Expanded Incorporation will incur costs for the following:

PHASE-I

I) Purchase Laboratory scale autoclave reactor.

II) Importing the Cannon high pressure foaming machine and Multi 'Easy Froth' polyol pre-blender.

III) Purchase testing equipment

IV) Importing the mold and fixtures for small domestic refrigerators and fabricate other small trial mould and fixtures.

V) Purchase of plot & construction of a small building block.

VI) Testing, trials, demonstrations etc.

PHASE-II

I) Modification and relocation of present pre-blending plant

II) Recurring operating costs.

Each of these project elements is explained and justified in detail below. New Polyols & systems will be developed in the laboratory and small quantities of new modified polyols (EO+PO based) will be produced in a laboratory scale autoclave reactor. Subsequently the formulations will be tried on high pressure foaming machine employing alternative blowing agents (including gaseous blowing agents). Multi Easy Froth will be used for pre-blending as the same is versatile enough to use different blowing agents including cyclopentane.

These foaming equipment will be used for demonstration & training purposes. Molds & fixtures will be used to evaluate and demonstrate the application technology. Demonstrations will be made to manufacturers of refrigerators, thermoware, sandwich panel and other insulation applications. Some simple molds will be fabricated in-house and a small fixture for domestic refrigerator will be purchased. So far testing of foam properties is done in outside laboratories because such testing equipments is not available at Expanded Incorporation. This process is laborious & time consuming. Three main testing devices namely, thermal conductivity meter, universal testing machine and closed cell content meter will be installed in the laboratory for spot evaluations, testing & demonstration of resultant CFC-free foams. Additional floor space will be constructed on adjacent land to install all the equipment involved in Phase-I. Also a small ethylene oxide tank needed for the second stage of plant modification will be installed on this additional space. The modified pre-blending stations will be relocated there. The additional construction will not increase plant capacity.

JUSTIFICATION FOR ALTERNATIVE TECHNOLOGY SELECTION. In the rigid polyurethane foam sector there is still uncertainly throughout the world on the selection of a permanent alternative to CFC-11. However there are currently three main options for CFC-free systems in rigid PU insulation foams.

a. CFC-11 > 50% CFC-11 or HCFC-141b
b. CFC-11 > HCFC-22 or HCFC-22/142b, as near to mid-term then HFC-134a
c. CFC-11 > Pentane or Cyclopentane.

In addition, compounds such as perflouroalkanes, HCFC-123, fluorinated ethers and 2 - chloropropane, have been suggested, but are immature in technology, have limited availability or are toxicologically questionable. Option a) also called the "liquid" solution employs technology that is closely related to existing one. The final step in this process is not yet decided although HFC-134a and hydrocarbons are possibilities. The second option, the "gas" solution, utilizes a gaseous mixture of blowing agents. It requires high pressure equipment, and sometimes extensive adjustments in formulation and handling. The final step in this process is seen as the introduction of (gaseous) HFC's. Hydrocarbon (Cyclopentane) technology was introduced recently in Germany. Its flammability characteristics require major attention for safety conditions and require extensive upgrading of facilities. Insulation quality is still an open question.

The acceptability of alternatives by the end processors will be decided by easy availability of local raw materials and production technology at economical cost, simple designed molds, fixtures and peripheral equipments (as there are large number of small processors), and very importantly for foreign partners of local companies on whose recommendations the local companies will adopt certain suggested alternatives. 50% CFC reduction adopted by some developed countries in initial stage of CFC phase out is not very attractive under Indian conditions as major changes will be called for in final product design and may prove expensive. In this case there is also a disadvantage of not being recognized as 100% CFC-free products. In view of the diverse selection of alternative blowing agents Expanded Incorporation will develop and manufacture polyols to be used with HCFC-22 as this is available locally and can be adopted economically for less critical foams particularly in thermowares. The enterprise will also manufacture blended polyol systems using HCFC-141b and cyclopentane as an alternative blowing agent.

PROJECT COSTS. Total Project Cost. As described below and detailed in the Annex 1 the total project cost is US$619,400.

Investment Cost. As shown in the Annex 1 the total investment cost for this project is US$619,400 and will be incurred in Phase-I & Phase-II. Major components of the costs include costs for construction of a separate building for application technology works, purchase of high pressure machine & pre-blending unit, testing equipments, trial moulds & fixtures in Phase-I. The total investment cost to be incurred in Phase-II is US$114,400.

Operating Cost. Incremental operating cost will be involved only in Phase-II, but not in Phase-I because full scale production of CFC-free blended Polyol systems will not have occurred until commissioning of Phase-II. The incremental operating cost is not included as part of this project. Incremental operating cost will be reexamined at a later date.

Unit Abatement Cost (UAC). The early phase of this project consists of only development trials and demonstrations as there will be no ODS savings in the first year of the project the unit abatement cost is undefined.

Proposed OTF Grant. US$619,400 is requested in OTF financing based on 100% Indian ownership of Expanded Incorporation and the fact that no incremental savings are available. The request solely reflects the total capital costs incurred during Phase-I & II. Financing for the operating costs may be requested from the multilateral fund at a later date.

Economic Rate of Return (ERR). Since the project entails an initial investment only with no cash flow, the ERR for the project is undefined.

Financial Rate of Return. Financial rate of return is undefined at present.

IMPLEMENTATION SCHEDULE

PHASE	ACTIVITY	YEAR 1	YEAR 2	YEAR 3	YEAR 4
I	Building Construction	XXXX			
I	Equipments & Machinery Purchase	XX			
I	Development & Testing	X	XXXX		
I	Trial & demonstrations		XX	XX	
II	Plant Modifications			XXXX	XX
II	Production of modified polyols & System with alternatives			X	XXXX

Note: X Represents one quarter of the year.

Required Regulatory Actions. The following regulatory action is required for the successful implementation of this project:

> Necessary permission and NOC will be granted to install Ethylene Oxide storage tank adjacent to the present plant.

Direct Project Impact. The direct project impact will be realized during Phase II after Phase I only. By the end of Phase II an annual average of at least 72 ODP weighted MT of CFC-11 will be eliminated as a result of replacing CFC-11 with alternate blowing agent in blended polyol systems manufactured at Expanded Incorporation.

Indirect Project Impact. The impact of the Phase I will be realized at the foam processors level as a result of direct efforts put in by Expanded Incorporation during Phase I & II. An estimated annual average of 384 ODP weighted MT of CFC-11 is likely to be eliminated.

Environmental Assessment. This project will not result in any additional emissions, effluents or wastes being produced at Expanded Incorporation plant. Installation of Ethylene Oxide storage tank in Phase II will require clearance from environment & explosive departments of Government of India.

Changes in Project Scope and Cost Due to OORG Comments. The technology employed uses ethylene oxide in the formulation. The enterprise is developing its own technology on this. EO is used by several other international suppliers, including Mitsui (Japan). The design includes safety provisions to handle EO.

ANNEX 1

BREAK DOWN OF INCREMENTAL INVESTMENT COSTS

PHASE I

			US$
1)	One time cost for application technology centre.		US$
	a) Plot & building construction		106,000
	b) Laboratory autoclave reactor		12,000
	c) High pressure foaming machine		142,000
	d) Cannon multi easy froth preblender		70,000
	e) Fixture & mold for 165 ltr. domestic refrigerators		58,000
	f) Other molds & fixtures		10,000
	g) Thermal conductivity meter		27,000
	h) Universal testing machine		16,000
	i) Closed cell content equipment		10,500
	Sub Total		451,500
2)	One time development testing demonstration and training costs:		
	a) Development & testing trials		
	Number of man days	500	
	Cost per man day	US$ 40	
	Material cost	US$4000	
	Sub Total		24,000
	b) Demonstrations		
	Number of man days	150	
	Cost per man day	US$ 50	
	Material cost	US$10000	
	Sub Total		17,500
	c) Training of personnels		
	Number of man days	100	
	Cost per man day	US$ 120	
	Sub Total		12,000
	Total Investment Cost For Phase-I		505,000

ANNEX 1 (contd.)

BREAK DOWN OF INCREMENTAL INVESTMENT COSTS

PHASE II

			US$
1)	One time equipment modifications costs		
	a) Ethylene Oxide storage tank (7500 Kgs)		30,000
	b) Piping, Structure piping valves, Pumps		45,000
	c) Blending station (3 nos.) Modifications		26,000
	d) Erection cost		7,000
	Sub Total		108,000
2)	One time production trial and training costs		
	a) Production trial		
	Number of production batches	2	
	Material quantity per batch MT	1	
	Average material cost per MT		
	Cost per ton	US$ 2,500	
		Sub Total	5,000
	b) Training of personnels		
	Number of man days	140	
	Cost per man day	US$ 10	
		Sub Total	1,400
	Total Investment Cost For Phase-II		114,400
	TOTAL PROJECT INVESTMENT COST (rounded)		619,000

ICI **Polyurethanes**

TELEFAX

Dr. Mike Jeffs
International Environmental
Affairs Manager

Everslaan 45
B-3078 Everberg
Belgium

Telephone (02) 758 9394
Telex 26332 ICIEVB B
Telefax (02) 758 9894

To Mr. N. Hadjitarkhani
The World Bank

16th September, 1993

I have reviewed the further information supplied by **EXPANDED CORPORATION** and am now satisfied that the enterprise has done its homework and thoroughly investigated the issues related to the use of EO. I therefore support the project.

Thank you for the additional information on UB Petroproducts.

Best regards,

Mike Jeffs

G. M. F. Jeffs
GMFJ/kd

12-06-1993 19:24 FROM TO 90013024752059 P.01

TO: Naimeh Hedjitarkhani

EXPANDED INCORPORATION
C-44/1, T.T.C. Area
M.I.D.C., Pawne Village
Vashi, New Bombay-400 705
Phone : (022) 767 0636/767 0800
Telex : 011-79266 EXPA IN
Fax : 91-22-7671095

AUGUST 12, 1993

TO : MR.DANIEL MADINABEITIA

FROM : MUKESH BHUTA

Thank you very much for your fax of 10th August. Sorry for delay in reply as I was out of station.

I am happy to note that our project may be supported by OORG Reviewer. I would like to answer the 2 questions as under :-

1. <u>REASON FOR USING ETHYLENE OXIDE:</u> As mentioned briefly in our project report Page No.20, Para 11, we propose to produce Polyether Polyol based on Propylene Oxide + Ethylene Oxide copolymer. At present we are producing Polyether Polyol based on Propylene Oxide only. However, the new Polyol will have 80 to 90% Propylene Oxide and 10 to 20% Ethylene Oxide.

   Ethylene Oxide - Propylene Oxide copolymer based polyols, alters the viscosity of the Polyol and hence improves the solubility of HCFC's. Also water miscibility of E.O. containing Polyol improves substantially, which will enable to produce formulation containing high water percentage. Because of E.O. enducing primary Hydroxyl Group the reactivity of the Polyol improves, which we feel would be advantageous, where the curing of the foam may be little poor due to the presence of alternative blowing agent.

   Regarding the hazardous nature of E.O. we are fully aware of the fire properties and explosive properties of the same. Even P.O. that we are using at present is equally hazardous and we have been handling the same in our plant.

   According to my knowledge there are few companies in the world manufacturing E.O./P.O. copolymers Polyols for Rigid foam. One such company is Mitsui Toatsu Chemical Inc., from Japan.

2. As for the Technology, we have based our project entirely on our own inhouse developments and it does not envisage any technology transfer from outside. As such the cost for technology transfer, training, visits, etc. has not been taken.

contd...2/-

Looking at the presently known alternative blowing agent, we do not anticipate any need of Technology Transfer.

I hope the above statements clarifies two questions mentioned in your fax.

I must thank you for all the help you provided us in preparation and submission of our project.

Hope to see you in SPI Conference in October.

With regards.

MUKESH BHUTA

ICI Polyurethanes

TELEFAX

To Mr. N. Hadjitarkhani
The World Bank

Dr. Mike Jeffs
International Environmental
Affairs Manager

Everslaan 45
B-3078 Everberg
Belgium

Telephone (02) 758 9394
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14th September, 1993

EXPANDED INCORPORATION

This is to follow up the comments in my OORG review on this enterprise (dated 9th August 1993) and subsequent letter (dated 16th August 1993).

- I have no objection to their proceeding without buying-in technology. Their efforts would probably be backed up by their isocyanate suppliers.

- My letter of 16/8/93 already commented on their reasons for the use of EO - this is the second time that I have received their fax dated 12th August 1993. The question I asked in reply was - has the enterprise tested their theory on the benefits of using EO ?

G. M. F. Jeffs
GMFJ/kd

EXPANDED INCORPORATION, NEW BOMBAY, INDIA

SCOPE

The project under review covers the development of technology for CFC 11 reduction and elimination in the rigid insulating foam sector, modifications to production plant and production trials.

RECOMMENDATION

The project is supported provided that the reviewer receives justification for the EO facilities included for Phase II and assurance that the Enterprise does not need to purchase technology. As for other projects, consideration should be given to the phasing in of appropriate technologies and there should be in line with Guidelines to be developed by The Bank.

RELEVANCY AND ADEQUACY OF INFORMATION

Generally good but clarification required, see photocopied attachment, on what is meant, in this instance, by "Phase 1".

TECHNICAL SOUNDNESS

The enterprise is to rely on its own technology. Whilst this approach can be cost effective (no license fee), there is much to be gained by adapting technology developed in other markets to Indian conditions. The reviewer appreciates that the enterprise has achieved a prominent position in the market and is already undertaking development programmes with HCFC 22.

The technology options listed are sound. As in other projects, it is appropriate to question the timing and use of reduced CFC 11 technology when zero CFC options are gaining prominence. This will be the subject of guidelines to be developed by The Bank in 1993 and this project during its execution should take account of these recommendations. The enterprise is, by its remarks, aware of some of these considerations.

The enterprise should note the limitations of HCFC 22 technology in terms of rapid ageing of thermal conductivity unless the foam is protected by impermeable barriers such as steel sheets, for example, as in sandwich panels.

The use of EO is proposed. This is uncommon for rigid foam applications and there should be justification given for its use.

LESSON FROM EXPERIENCE

This is the first occasion that the reviewer had been this project and it would have been beneficial to have had an opportunity to query items at a "draft" stage.

ENVIRONMENTAL ISSUES

As noted above, the technology choice decisions at the execution stage should follow a rapid path to the zero CFC stage - provided that the technologies are proven.

SAFETY ISSUES

If the enterprise follows up on cycoplentane technology then safety-related training is considered to be essential. In this instance it is recommended that know-how now being accumulated in W. Europe is sought. The use of this blowing agent requires modifications to the dispensing equipment and jigs which are already catered for in the common quotation.

COST EFFECTIVENESS

The cost effectiveness is 1.35 $/kg which compares well with other projects in this category but this does not include any costs incurred in the operations of the enterprises' customers. The cost effectiveness improves to 1.10 $/kg if the EO installation is not required.

OTHER

None.

10/8/93

GMFJ/kd/9/8/93

तार :
Telegram : PARYAVARAN,
NEW DELHI

दूरभाष :
Telephone :

टैलेक्स :
Telex : W-66185 DOE IN
Fax : 4360678

भारत सरकार
पर्यावरण एवं वन मंत्रालय
GOVERNMENT OF INDIA
MINISTRY OF ENVIRONMENT & FORESTS
पर्यावरण भवन, सी० जी० ओ० कॉम्पलेक्स
PARYAVARAN BHAWAN, C.G.O. COMPLEX
लोदी रोड, नई दिल्ली-110003
LODI ROAD, NEW DELHI-110003

ANIL AGARWAL
DEPUTY SECRETARY (OZONE)

No. 5(2)/50/93-IC-I
Dt. 23.9.1993.

Dear Dr. El Arini,

Please find enclosed a copy of sub project proposal from IICT, Hyderabad for development of basic data for design of a commercial HFC-134a plant with 2000 TPY capacity (OTF grant US$ 1,400,000) along with OORG comments received from the World Bank. The clarifications on these comments have been incorporated in the proposal. We are given to understand that the World Bank is not in a position to pres. . this project to the Executive Committee because of negative comments of their OORG reviewer.

The Government of India has approved this project for the following reasons:

This project proposal is for the development and commercialisation of technology for HFC-134a production for replacement CFC-12. IICT has developed a chromia based catalyst and a two stage process of HFC-134a production in a bench scale study. Now they want to design, erect and operate a prototype plant of 30 TPY capacity based on the knowhow developed by them indigenously. They will transfer the basic design so developed along with engineering package and technology for the commercial production of HFC-134a to units in the country without any charge. IICT has already established linkage with the two major CFC manufacturers viz., Navin Fluorine industries and SRF. The third major CFC manufacturer, Gujarat Fluoro Carbons and few others have also approached IICT for collaboration. The IICT is also prepared to transfer the technology on to units in other developing countries on most favourable and non-commercial terms.

Some other relevant facts are also given below:

a) IICT have been engaged in development of CFC substitute since 1991. This is an indigenous effort of development of technology for the HFC-134a production and commercialisation, which the country will adopt and absorb with indigenous know how.

b) Three major manufacturers of CFCs have agreed to adopt IICT technology for HFC-134a production on commercial scale.

c) The cost of this technology transfer for commercial use will be substantially lower than the cost of technology transfer from a developed country.

d) The cost of this technology to be used on prototype pilot plant of 5Kg/hr HFC-134a production is US$ 2.00 million which is much lower than the license fee proposed for import of technology by an Indian company at the cost of US$ 5.00 million, which does not include other costs. This proves the necessity and advantage of having countries indigenous technology.

e) IICT has excellent track record in developing technologies involving serious chemical engineering process conditions. It is also aware of the critical role played by the catalyst to be used in their process of manufacture of HFC-134a so also of the severe operating conditions and materials of construction used in the process.

f) Process safety centre of IICT is an integral part of process development for HFC-134a. The centre reviews all the safety and environmental aspect at various stages of process development and design of commercial plant.

g) The byporduct HFC-125 and HFC- 143a are value added CFC substitutes having zero ODP and are useful in blends. HCl is also a value added byproduct which will have outlets as raw material. HCFC-1122 is the only byproduct which is toxic. This will be destroyed by chemical treatment.

h) The vent gases consisting of organics and inorganics will be incinerated and scrubbed. Thus the IICT have taken care of the environmental impact/pollution as per the law of the land.

i) This project when implemented will be an indigenous technology development not only for the Indian Chemical industries but also for the other developing countries. This may also provide experience and knowledge for developing technology for other HFC in the country.

We shall request you to kindly take steps for presentation of this proposal in the next meeting of the Executive Committee in November, 1993. If we are required to take any action for this, kindly let us know.

With warm regards,

Yours sincerely,

(ANIL AGARWAL)

Dr. Omar E. El Arini,
Chief Officer,
The Multinational Fund for the Implementation
of the Montreal Protocol,
1800 Mc Gill College Ave, 27th Floor,
Montreal, Quebec,
CANADA H3A 3J6.
Fax: 1-(514)-282 0068

cc to: Mr. Sidney Thomas,
Industry Unit Chief
India Department
The World Bank
Fax : (202) 477 7352

THE MONTREAL PROTOCOL ON
SUBSTANCES THAT DEPLETE THE OZONE LAYER
PROJECT COVER SHEET

COUNTRY:	India
SECTORS COVERED:	CFC Producers
ODS CONSUMPTION IN AFFECTED SECTOR:	2040 MT CFCs (1991)
PROJECT TITLE:	Basic Data Development - HFC-134a Process
PROJECT DURATION:	2 Years
PROJECT IMPACT:	Indirect - 2040 MT ODS
PROPOSED BUDGET:	Incremental Capital Cost $1,400,000 Incremental Operation Cost 0 Total Project Cost $1,400,000
PROPOSED OTF GRANT:	$1,400,000
IMPLEMENTING ENTERPRISES:	Indian Institute of Chemical Technology
IMPLEMENTING AGENCY:	The World Bank/IDBI
NATIONAL COODINATING AGENCY:	Ministry of Environment & Forests (MOEF)

PROJECT SUMMARY

This OTF request is for funding of a 5 kg/hr prototype plant in which to develop basic data for design of a commercial HFC-134a plant with a 2000 TPY capacity. IICT have developed a catalyst and have demonstrated a process for preparation of HFC-134a on a bench on these technologies and will be equipped to secure the necessary basic data for a 55:1 scale up to commercial sized facilities. Upon completion of the prototype plant operation and data collection, basic data will be assembled in a format suitable for transfer to a commercial producer.

PROJECT OBJECTIVE

The objective of this project is to facilitate commercialization of an indigenous HFC-134a process in India.

SECTOR BACKGROUND

India's commercial and retail R&AC industry consumed 1759 tonnes of CFC-12 in 1991; unconstrained demand is projected to be 3725 tonnes in the year 1997. The Indian foam industry consumed 280 tonnes of CFC-12 in 1991 and the unconstrained demand is projected to be 580 tonnes by the year 1997. Thus, the present consumption of 2039 tonnes by these two sectors is projected to continue to grow to 4300 tonnes of CFC-12 by 1997 unless refrigerant and foam needs in these sub sectors are supplied with alternative chemicals such as HFC-134a and HCFC-22.

ENTERPRISE BACKGROUND

IICT is a premier and multi-disciplinary institute, under CSIR, engaged in the development and transfer of technologies for a variety of chemicals like drugs, pesticides and organic intermediates. IICT, during its 50 years of existence, has gained expertise to develop technologies for high-tech and complex prouducts and has to its credit technologies for cyanuric chloride, chlorpyriphos .O-based chemicals and a variety of drugs, which are transferred to and commercialized by the industry. The Institute has schools of international repute in the areas of organic synthesis and catalysis and has well experienced chemical and mechanical engineering groups that provide the vital inputs for the development and commercialization of a technology. The institute enjoys a good rapport and coperation with the chemical industry, which sponsors and supports technology developmental activities of the Institute.

IICT has developed the process know-how and a proprietary catalyst for the preparation of HFC-134a on bench scale and is fully equipped to design, erect and operate the proposed prototype plant and to develop and assemble the necessary basic data and technology for transfer to Indian industry.

WORK ON HFC-134a AT IICT

Genesis

Much before India signed Montreal Protocol, CSIR decided to undertake comprehensive studies on GLOBAL CHANGE as part of International Geosphere and Biosphere programmes. The project undertaken by CSIR envisaged studies on CFC substitutes and alterate technologies, greenhouse gases and warming, sea level monitoring, air sea interaction UV-B and temperature effects and mathematical modelling for global change to be carried out by different constituent laboratoreis of CSIR. IICT was made the nodal laboratory for CFC alternatives. Even at that stage it was recognised that it would be imperative for the country to have its own technologies for different CFC substitutes and the IICT was assigned the task of developing technologies for CFC substitutes.

Status of work at IICT

In pursuance of decision of CSIR, IICT initiated work on CFC substitutes in 1991. Considering the potential of HFC-134a as most likely substitute for CFC-12 and the substantial quantities of CFC-12 consumed by the Indian industries among the CFCs, it was decided to undertake development of technology for HFC-134a on priority basis, to be followed by other substitutes.

IICT initiated exploratory work on HFC-134a in 1991. In the meantime, special facilities were set up which include a specially designed separate building and special equipment. Knowing the hazards in handling HF, special facilities were erected to initiate bench scale experiments.

A bench scale unit was designed, fabricated/procured and installed for experimental work. After experimental work. IICT has developed process on the bench scale and also a proprietary catalyst for the preparation of HFC-134a.

Details of process worked out at IICT and other relevant information are given in the following paragraphs.

PROCESS DESCRIPTION:

a) The process for HFC-134a consists of two steps.

In step one trichloroethylene and anhydrous HF are mixed in a definite mole ratio in vapor phase, preheated and passed over a chromia based catalyst to obtain a product mixture from which HCFC-133a and unreacted HF are recovered by fractional distillation. The mixture of HCFC-133a and HF is replenished with additional amount of HF, preheated and passed over a chromia based catalyst to obtain a product mixture which is then subjected to a series of fractional distillations to obtain HFC-134a which is purified by chemical treatment to yield product of required specifications for use as a refrigerant. Unconverted HCFC-133a and HF are recyled.

The chemistry of the process is represented in the following equations:

```
  Cl      H                      F
   \     /    HF/Catalyst         \
    C = C     ------------>  F -- C -- CH2 -- Cl + 2HCl
   /     \    Vapour Phase        /
  Cl      Cl                     F


     F                                     F
      \               HF /Catalyst          \
  F-- C  --- CH2 -- Cl  ------------->  F--C -- CH2 -- F + HCl
      /               Vapour Phase          /
     F                                     F
```

PRODUCT SPECIFICATION:

Process development by the IICT is expected to give product of following specifications.

Appearance	colourless and transparent
Purity	99.9% minimum
Residue on evopration	0.0015 wt % maximum
Acidity (as HCl)	0.0001 wt % maximum
Water	0.001% maximum

Product quality will be adjusted to suit the requirements of refrigeration industry under Indian conditions.

BYPRODUCTS:

For 1 kg of HFC-134a produced the following byproducts are formed:

1. HFC-125 - 0.18 - 0.22 kg
2. HFC-143a - 0.12 - 0.15 kg
3. HCFC-1122 - 0.11 - 0.15 kg
4. HCl - 2.52 kg

All byproducts are gases at ambient temperature.

i) HFC-125 and HFC-143a are value added CFC substitutes having zero ODP and are useful in blends.

ii) HCl is a value added product which has outlets as raw material

iii) HCFC-1122 is highly toxic and will be destroyed by chemical treatment

EFFLUENTS:

Vent gases consisting of organics and in-organics will be incenerated and scrubbed.

RAW MATERIALS:

Trichloroethylene and hydrogen flouride are the raw materials in the process. Both the raw materials are indegenously manufactured and available . Major manufacturers are:

~~TCE:~~ Chemplast

HF: Navin Flourine Industires, SRF and TANFAL

Presently TCE is produced by chemplast in limited quantities. However, incourse of the workshop organized by the Ozone cell of Ministry of Environment & Forests in New Delhi on 12-13 July 1993, Chemplast informed their intentions to increase their production capacity for TCE to meet the requirements of HFC manufacture.

Chromia based catalyst is used in the process. Commercial preparation and supplies of the catalyst can be made by the catalyst manufacturers in the country like ACC or UCIL.

PROJECT DESCRIPTION

IICT will design, erect and operate a prototype plant of 5 kg/hr (30 TPY) capacity, based on the know-how already developed at the bench scale. Subsequently, IICT will transfer the technology, along with engineering package, for commercial plants to be set-up by the industry.

JUSTIFICATION FOR ALTERNATE TECHNOLOGY SELECTION

India is a signatory to the Montreal Protocol and it is committed to phaseout production and use of ozone depleting substances (ODS), such as CFC-12. A country program has been developed which identifies HFC-134a as a primary alternative for replacement of CFC-12.

Names of the existing manufacturers of CFC in India, their plant capacity and quantities manufactured in 1991 are given below:

Manufaturer	Capacity mt	Production in 1991 m tonne
1. Navin Fluorine Industries	7500	3114
2. SRF Ltd.	10000	104
3. Gujarat Fluorocarbons	10000	1200
4. Aegis Chemical Industries Limited	1200	364
5. Mettur Chemical Industries	2500	215
6. Hindustan Fluoro Carbons Ltd. (Produces HCFC-12)	1265	443

It is imperative that technology be made available to satisfy ~~the needs of Indian I~~ndustry throughout the transition to non-ODS technologies, particularly in the refrigerator and foam industries. The proposed prototype plant will produce 30 TPY of HFC-134a for testing purposes and will demonstrate the technology upon which industry can evaluate plans for commercial production of HFC-134a.

<u>LINKAGES WITH POTENTIAL MANUFACTURES OF HFC-134a:</u>

Existing manufacturers of CFCs will obviously be the most likely manufacturers of HFC-134a in India, because of their marketing network and contacts for the refrigerant gases and availability of raw material (HF) as in the case NFI and SRF. IICT has already established linkages with the two major manufacturers in the country viz. Navin Fluorine Industries and SRF through sponsorship contacts for bench scale development of process know-how for HFC-134a.

The third major manufacturer, Gujarat Flurocarbons, has also approached IICT for collaboration. Parties, other than the existing manufacturers have also approached IICT for the technology.

SUPPORT FROM THE GOVERNMENT DEPARTMENT.

Considering the significance and need for indigenous technology. Department of Science and Technology, Govt. of India providing funds to the tune of Rs.75.00 lakshs to IICT for development and eventual release for commercial exploitation of technology for HFC-134a. Also, the Ministry of Environment and Forest, Governement of India has also agreed for funding support of Rs.20 Lakhs to IICT for the development work at IICT on the project.

PROJECT COST

The total cost for the proposed prototype plant is US $ 1.9 million. A grant of US $ 0.5 million is to be provided from funds committed by Government Departments, CSIR and Indian industry. The net capital cost of the project is $ 1.4 million.

BENEFITS

The project results in the production of 30 TYP of HFC-134a in the proposed prototype plant and the transfer of technology to industry for commercial production of HFC-134a. Thus, the direct benefits of the project are:

i) production of 30 TPY of HFC-134a in the prototype plant

ii) transfer of technology for commercial production of HFC-134a to the Indian chemical industry as well as to other developing countries.

iii) making available an alternative chemical (HFC-134a) to the R&AC and foam industries that presently use CFC's.

iv) enable the fulfillment of the national commitment of phasing out the consumption of CFC's.

v) provide experience and knowledge and infrastructure for developing technologies for other HFCs.

vi) develop expertise for evaluation of proposals by multinationals to construct similar facilities in India.

LOCAL OWNERSHIP FRACTION

IICT is a constituent of CSIR, which is an autonomous body of the Government of India. There is no foreign equity or participation and the Institute meets its financial requirements from the CSIR grants and the earnings made by way of technology transfer and collaborative arrangements with the industry.

UNIT ABATEMENT COST (UAC)

Based on one-to-one relationship between ODS reduction and ODP of CFC-12, UAC works out to be US $ [illegible].0/kg ODP/year for the prototype plant.

FINANCIAL INTERNAL RATE OF RETURN (FRR) AND ECONOMICAL INTERNAL RATE OF RETURN (ERR)

As there is no revenue generated by the proposed project, and ERR and FRR can not be calculated.

FINANCIAL HEALTH OF ENTERPRISE

IICT received an annual grant of about US $ 3.7 million for the financial year 1992-93 and the Institute earned about US $ 1.0 million by way of transfer of technologies and collaborative arrangements with the industry.

FINANCIAL PLAN

An OTF grant in amount of US $ 1.4 million is sought from the miltilateral fund in additon US $ 0.5 million will be met from the funds already committed by the Government Departments, Indian industry and CSIR.

PROJECT IMPLEMENTATION

IICT will implement the project and MOEF & CSIR will oversee the implementation of the project. The project plans are:

SCHEDULE

		Start	Complete
Design of the prototype plant	-	July 93	Jan 94
Erection	-	Jan 94	July 94
Startup	-	July 94	Aug 94
Collection of basic data for design of commercial plant	-	Sept 94	Apr 95
Demonstration runs	-	Jan 95	Apr 95
Documentation	-		Dec 95

ENVIRONMENTAL IMPACT

All wastes and other unused materials generated during the prototype plant testing will be collected and disposed in the treatment facilities. The byproducts and effluents have been described along with the process det...

Annexure-I

INDIAN INSTITUTE OF CHEMICAL TECHNOLOGY
HYDERABAD

PROJECT: PROTOTYPE PLANT (5 Kg/hr) FOR HFC-134a

BREAK-UP OF CAPITAL COST

S.No.	Unit No.	Service	MOC	Price (Rs.) Lakhs
STORAGE TANKS				
1.	ST-101	TCE Storage	SS316	1.0
2.	ST-102	Anhydrous H F	HDPE	1.0
3.		Nitrogen Cylinder		-
4.	ST-201	Anhydrous H F		1.0
5.	ST-202	Product Storage-134a		1.0
6.	ST-203	Byproduct Storage-125		1.0
7.	ST-301	Alkali Storage Tank		1.0
8.	ST-302	Effluent Tank		1.0
.CTORS				
1.	R-101	Reactor for 133a 2 Nos	Ni/Monel	40.0
2.	R-201	Reactor for 134a 2 Nos	Ni/Monel	50.0
VAPOURISERS				
1.	E-101	TCE Vapouriser	Monel	5.0
2.	E-102	H F Vapouriser	Monel	5.0
3.	E-201	H F Vapouriser	Monel	5.0
REBOILERS				
1.	Rb-101		Monel	5.0
2.	Rb-102		Monel	5.0
3.	Rb-201		Monel	5.0
4.	Rb-202		SS-316	3.0
5.	Rb-203		SS-316	3.0
HEATERS				
1.	E-103	Preheater for TCE&HF	Monel	5.0
2.	E-202	Preheater	Monel	5.0
COOLERS				
1.	E-104	Reaction Mixture Cooler	Monel	5.0
2.	E-203	Product Cooler	Monel	5.0
3.	E-301	Effluent Cooler	SS-316	3.0

CONDENSERS

1.	E-105	Condenser for T-101	Hastelloy C	15.0
2.	E-106	Condenser for T-102	Hastelloy C	15.0
3.	E-204	Condenser for T-201	Hastelloy C	15.0
4.	E-205	Condenser for T-202	Hastelloy C	15.0
5.	E-206	Condenser for T-203	SS-316	3.0

TRAY TYPE DISTILLATION COLUMNS

1.	T-101		Cs/ss pack	1.5
2.	T-102		Cs/ss pack	1.5
3.	T-201		Cs/ss pack	1.5
4.	T-202		Cs/ss pack	1.5
5.	T-203		Cs/ss pack	1.5

PACKED TOWERS

1.	T-301	Scrubber	FRP	0.5
2.	T-302	Scrubber	FRP	0.5

Fabricated Eqpt. Total = 227.5

PUMPS

1.	P-101	TCE Metering Pump	
2.	P-102	Anhydrous H F Metering Pump	
3.	P-201	Anhydrous H F Metering Pump	
4.	P-301	Alkali Pump (Centrifugal)	
		Total =	10.0

COMPRESSORS

1.	C-101		
2.	C-201	Total =	10.0

INCINERATOR

1.	I-201	10.0

MIXER

1.	Mi-101	1.0

Vendor items Total = 31.0

Piping & Instrumentation	= 80.0
Utilities	= 60.0
Erection & Commissioning	= 30.0
Total	= 170.0

TOTAL COST = IND Rs.428.5 lakh
= US $ 1.4 million (IND Rs.30.5 = 1 US $)

Important Notes: (1) Costs indicated are estimated, subject to revision on receipt of quotation.
(2) Import component will also be arrived at after evaluation of indigenous offers and suitability of equipment/component offered to perform the required duties.

COMMENTS ON COMMENTS OF THE OZONE OPERATIONS RESOURCE GROUP-PRODUCTION SECTOR ON IICT PROPOSAL ON HFC-134a TECHNOLOGY.

1. Comments on recommendations of OORG.

The project ~~(proposal) is~~ disapproved by the OORG on the grounds that the project is to duplicate the work completed in the developed world and technology is available for transfer at costs believed to be substantially lower than the project cost.

Desirability of having own capability and technology for strategic materials is always a complex issue. A country has to take its own stand on the necessity or otherwise for having indegenous technology taking various considerations into account.

HFCs have been found as the most likely substitutes for CFCs. IICT has undertaken development of technology for HFC-134a on priority basis, as it has already been established as a substitute for CFC-12 but IICT plans to develope technologies for other HFCs & HCFC's also which have either been found or being explored as substitutes for other CFCs. The expertise gained and infrastructural facilities established in course of development work on HFC-134a will facilitate development of other HFC's and HCFC's like HFC-152a, HCFC-141b,HFC-143a,HCFC-142b,HCFC-123,HFC-125,HCFC-124,HCFC-23,HFC- [illegible] identified as CFC substitutes in various sectors. The proposed pilot plant for HFC-134a can be used, with minor modifications and adjustment, for development of technology for HFC-152a, another promising substitute for CFC-12. Though, at the outset, the proposal looks confined for HFC-134a, but it would enable the country to have expertise and skill to develop whole range of fluro-hydrocarbons, which are bound to become essential for many sectors in the country. In the absence of such expertise and infrastructural facilities the country will have to always depend either on continuous import of these chemicals or transfer of technology on product to product basis, or even repeated import of technology on party to party basis.

Time is also on the side of India, as the country has sufficient time to develop its own technology and start commercial production for HFC-134a in time to commence phasing out of CFC-12. There is no pressing need to immediately start manufacture of HFC-134a, where time required for development phase can be afforded.

The basis of statement that the cost of transfer of technology will be substantially lower than the project cost (by IICT) is questionable. On the contrary, IICT firmly believes that in addition to obvious advantages the cost of indegenous development of technology will be substantially lower, than the cost of transfer of technology from developed world.

The cost of development of technology for HFC-134a on pilot plant (5 kg/hr) at IICT is estimated at US $2.00 millions. On the other hand, it is understood from reliable source, that a proposal submitted by an Indian company for import of technology envisages licence fee alone at US $5.00 millions. This ~~licence fee~~ will be exclusive of other charges like cost of training, consultation which are generally charged extra. Moreover, the licence fee will be only for one plant (or to one licences) and other parties will have to go for fresh licencing at similar costs.

It is therefore considered imperative that India developes its own technology for HFC-134a and other CFC substitutes to be self reliant in these essential chemicals.

2. <u>Comments by OORG on relevance and adequacy of information provided:</u>

It is noted with pleasure that OORG found the information given in the prooposal was relevant and well presented. However, OORG found fundamental and technical information lacking for making technical evaluation. It may be mentioned in this regard, that proposal was prepared on a proforma prescribed and provided to IICT. Also, the proposal was prepared in consulation with a consultant from World Bank and no defecicency was pointed out.

IICT will be glad to provide all the non-classified technical information to assist OORG in making assessment of the proposal. As desired, details on process, including basic chemistry, raw materials, co-products and by-products, catalyst, specific effluent disposal processes are given in Annexure-I. Plant layout-line diagram, function of the capital items in the process, materials construction are given in Annexure-II.

3. <u>Comments by OORG on technical soundness:</u>

The comments by OORG recognises the choice of alternate (HFC-134a) as appropriate and relevant to India and the need for its domestic production. However OORG desired that the need for development of technology by India, or at least a lowest incremental cost option compared with acquisition by import of technology be demonstrated. These issues have been discussed in comments on recommendations of the OORG. It is reitrated that it will be advantageous to India to develop its own technologies for HFC-134a and CFC substitutes. Also, such a course will be cost effective.

In regard to the statement of Mr. B.C. Gosalia, Executive Vice-President of Navin Fluorine Industries quoted by OORG it may be mentioned that Navin Fluorine Industries has entered into a contract about a year back with IICT for the development of technology for HFC-134a on bench scale. In a recent dialogue, the party has shown interest in continuation of their association on pilot plant studies. This may be noted from the quotation given in his statement to "Business India", Mr. Gosalia has not specified the source of technology for their proposed plant for substitutes.

4. Comments by OORG on lessons from experience.

Necessity and advantages of having own technology have been discussed. The lowest incremental cost is likely to be achieved by develo[illegible]ing indegenous experience and expertise.

It is observed, in many cases, that the plant designs provided by MNCO from developing countreis are capital intensive larger in capacity and are required to be modified to suit industrial practices and skill prevalent and available in India. Most appropriate, cost effective and optional plant design for Indian conditions can be achieved through closer and continued interaction of plant design engineers with process development group throughout the various development phases. Such are interaction and resultant optimal design of the plant will be possible if the technology is developed indigenously.

IICT has excellent track record in developing technologies involving severe process conditions and evaluation and selection of most appropriate materials of constructions. Development of technology and plant design for cyanuric chloride, sodium azide, a number of organophosphorous pesticides are some of the recent examples.

IICT is fully aware to the critical role played by the catalyst in the process and also of the severe operating conditions and materials of construction used in the process. IICT has a full fledged Catalyst Di[illegible]on manned by highly qualified and professional staff. With the expertise availalble within the IICT and other groups in the country, all the problems associated with the catalyst will adequately be taken care of.

5. Comments by OORG on environment and safety issues.

Process Safety Centre of IICT is an integral part of process development for HFC-134a. The centre reviews all the safety and environment aspects at various stages of process development and design of commercial plant. IICT will incorporate all the safety aspects in the technology offered.

HCl obtained in the process is a saleable product and will be disposed accordingly.

6. Cost effectiveness.

The issue of effectiveness of cost of indegenous development against the acquisition of technology has already been discusedand demonstrated that development of technology indegenously will be cost effective.

As stated in the proposal, the cost of pilot plant indicated are estimated, subject to revision on receipt of quotations from the suppliers.

7. **Other comments.**

IICT is thankful to DDRE for its compliments in regard to skills and reputation of IICT. IICT would wish to use its expertise in developing technologies for essential chemicals, making the country self reliant in critical areas.

URGENT

OORG - Production Sector

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Date	12 August 1993	Time
No. of pages following cover sheet		ONE

Cover Note

Please find attached some supplementary comments on the IICT (India) proposal. I have now received the opinions of further engineering experts.

The overall conclusions are unchanged, but I hope that the additional comments are helpful.

Kind regards

SUBJECT: INDIA - IICT: Basic Data Development - HFC 134a Process

1. Confirmation that it is impossible to make any real technical assessment on the basis of the data provided.

2. Overall costs seem reasonable but:

   (a) minimal provision for civil and structural works; perhaps these are included in existing assets?

   (b) erection costs seem very low, even on the basis of Indian labour costs.

   (c) apparent major imbalance between Plant Item costs ($867,000) and Piping and Instrumentation costs. There seems to be little provision for the sophisticated instrumentation likely to be required for process control - all the more so as this is apparently intended as a plant for process characterization and development which would normally be expected to require extensive data logging.

3. There are possible explanations of some of the apparent discrepancies under (2) above. Provision of a full costing - including items which already exist or for which funding is not requested - would allow a better assessment.

4. However, it may not be worth pursuing this further for the general reasons stated in the formal assessment of 8 August.

Michael R Harris (Dr)
OORG Production Sector

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HCT

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Date	8 August 1993	Time
No. of pages following cover sheet		TWO

Cover Note

This is a preliminary assessment to meet your extremely short deadline. Proposals relating to production matters are both technically complex and raise many fundamental issues. We could serve the applicants better given just a little more time for a more considered appraisal of projects. Perhaps we could discuss this when we meet.

In the meantime, could someone please provide me with:

- the Indicative List of Categories of Incremental Cost.
- the Draft India Country Program - July 1993. (I have the earlier Touche Ross surveys).

Kind regards

MRH

SUBJECT: INDIA - IICT: Basic Data Development - HFC 134a Process

The following is the *preliminary* technical opinion of the OORG Production Sector.

1. RECOMMENDATION

The project is **disapproved.** There is insufficient information to make any in-depth judgement. The project appears to duplicate work long since completed in the developed world and available for technology transfer at costs believed to be substantially lower than the project cost. Technology transfer would also provide India with proven information much more rapidly. There is some evidence that at least one indigenous producer is already at a more advanced stage of development of a practical process and has plans to exploit it. Similar projects have been developed and then abandoned in other LDCs once it was recognised that technology could be acquired more cheaply and quickly from developed world sources. The test quantities of HFC 134a produced are too small to make *per se* any impact on Indian consumption of ODSs and are more cheaply available as imports without prejudice to future domestic production of the product.

2. RELEVANCE AND ADEQUACY OF INFORMATION PROVIDED

Only a **preliminary** judgement can be formed on the basis of the information provided. The information given is relevant and well presented. However, [illegible] are large, and fundamental, areas of technical information which are not provided at all. For example:

- process(es) to be investigated - basic chemistry, raw materials, co-products and by-products, catalyst (generic description).
- plant layout - line diagram, function of the capital items in the process(es), materials of construction (critical), specific effluent disposal processes.

3. TECHNICAL SOUNDNESS

The general choice of alternate technology (HFC 134a) is appropriate and relevant to Indian user industry needs. There is a good case for domestic production of HFC 134a at a future date - probably before the end of the decade. However, there is a need to demonstrate that *ab initio* development of basic process technology is necessary, or at least a lowest incremental cost option compared with acquisition. Technology currently available from the developed world is at least five years in advance of this stage of investigation. It is likely to be cheaper to adapt this technology to indigenous conditions than to start again from the beginning. In the meantime there is no evidence that there is, or will be, any shortage of HFC 134a to Indian users during the period prior to the establishment of commercial-scale indigenous production. Finally, there is some evidence that at least one indigenous producer has already developed HFC 134a production technology to a more advanced stage than would be the outcome of the present proposal[1].

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[1] Mr B C Gosalia, Executive VP of Navin Fluorine Industries, quoted in "Business India" (2-15 August 1993, p93): *"We are planning a 3,000 tpa plant to manufacture the whole range of substitutes ... whether these products will be available in 1995 or 1998 depends entirely on what our customers want and the prevailing duty structure"*. He is further quoted as saying the plant can be constructed in two years, will be viable at 300 tpa provided its products enjoy a 60% duty protection. Navin has imported HFC 134a and distributed samples to all the major refrigeration manufacturers to enable them to initiate R&D for a changeover.

4. LESSONS FROM EXPERIENCE

As stated above, there is considerable experience in the developed world of a variety of processes for the manufacture of HFC 134a. At least two competing processes are available for technology transfer. IICT has an excellent reputation and is already well placed to work with indigenous producers to assess the merits of these technologies. The lowest incremental cost is likely to be achieved by using available experience.

There is concern that the proposal may not take account of available experience of difficulties of catalyst performance in respect of product yield and selectivity, nor of the unexpectedly severe operating conditions which place special demands on materials of construction.

5. ENVIRONMENTAL AND SAFETY ISSUES

There are several potential hazardous waste streams to consider - according to the process adopted. This is not addressed, and it is not clear from the proposal whether existing treatment facilities would suffice. There are several potential hazardous intermediates to consider - according to the process adopted. This is not addressed; operating procedures and materials of construction will be important. Most processes produce an HCl side-stream. According to circumstances this may be saleable or incur a disposal cost. This should be addressed. Advice on these matters would be available, on the basis of actual operating experience, from at least some of the potential technology suppliers.

6. COST-EFFECTIVENESS

As suggested above, the proposal does not at first sight appear to represent the lowest incremental cost approach to resolving India's needs. The actual costs presented are not unreasonable, assuming that indigenous labour costs are minimal. The capital costs are probably slightly on the low side given the likely need for some items to use relatively costly alloys to handle highly aggressive process streams, but are of the right order of magnitude. In a process research project of this type a large proportion of the costs will be for skilled manpower. These costs will be relatively very low in India and are, in any case, not included in the proposal costing. However, these resources are also valuable to India and may better be employed in working with developed world technology providers and domestic producers to assess and choose foreign technology, and then to adapt it to domestic circumstances and install appropriately for domestic production. This route is likely to provide India more cheaply and more quickly with indigenous production of HFC 134a and to reduce the period of dependence on imports from the developed world.

7. OTHER

It is separately proposed that OORG should appoint someone from IICT to its Production Sector Workgroup. This was intended to maintain neutrality as between the four or five domestic fluorocarbon producers and yet provide a touchstone for "ground truth" in assessing proposals from India and other LDCs. In this connection there would be value to India and to the OORG if the Workgroup were not called upon to assess in detail a proposal from IICT. IICT's skills and reputation are very high, and may be better employed in assessing more "market ready" proposals than in revisiting the more basic aspects of the relevant process chemistry and technology.

OORG Production Sector would nevertheless be happy to re-examine the present proposal if the important missing information were provided and an economic case made for low(est) incremental cost.