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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 PROPOSAL: IRAN

PROJECT EVALUATION SHEET

COUNTRY OR REGION:	The Islamic Republic of Iran
PROJECT TITLE:	Conversion of Domestic Refrigerator Production Facilities to Phase Out CFC-11 and CFC-12 at: (1) Arj (2) Azmayesh (3) Bahman (4) Iran Poya (5) Pars Appliances
BUDGET:	US $14,587,800
INCREMENTAL COSTS[1]:	Total: US $8,736,278 Phase I: US $3,648,086 Phase II: US $5,088,192
ODS PHASE-OUT:	590 MT of CFC-11 and 170 MT of CFC-12
COST EFFECTIVENESS[2]:	US $11.49 per Kg. ODP saved
PROJECT DURATION:	2 years
IMPLEMENTING AGENCY:	UNIDO
NATIONAL COORDINATING AGENCY :	Department of the Environment
TECHNICAL REVIEW COMPLETED:	YES _X_ NO _

SECRETARIAT'S COMMENTS

1. This project covers conversion of domestic refrigerator production at five companies in Iran to alternative technologies based on HFC-134a (refrigerant) and HCFC-141b (insulation foam).

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[1] Including contingency (15 per cent) and agency programme support costs (13 per cent).

[2] Determined as the ratio of incremental costs to the estimated annual saving of ODP ($/$ODP_{kg}$). For CFC-11, ODS=ODP

2. This project will be implemented in two phases. Phase I includes model redefinition at the five companies involved, and conversion of refrigerator manufacturing process at Pars Appliances. The duration of Phase I is two years. Phase II will be initiated following Phase I. Phase II includes conversion of refrigerator manufacturing process at the other four companies. The duration of Phase II is 12 months.

3. The requested funding under Phase I of US $2,807,300 covers costs of model redefinition at the five companies, cost of conversion and one-third of incremental recurrent costs for one year at Pars Appliances. The requested funding under Phase II of US $3,915,500 covers the conversion costs and one-third of incremental recurrent costs for one year for the other four companies (Arj, Azmayesh, Bahman, and Iran Poya).

4. In a previously approved project (Koldair Company), the Government and one of its domestic refrigerator and cooler manufacturers agreed to cover a substantial portion of recurrent costs and pass on cooler costs to consumers. In this project, the Government of Iran and the beneficiary enterprises have agreed to the incremental recurrent cost formulation whereby the Fund provides one-third of one year's estimate of recurrent costs with the balance shared by the company and its customers.

5. The estimated cost-effectiveness of the project is US $11.49 per kg. ODP phased out. This favourably compares with similar projects approved by the Executive Committee for Thailand. In the case of Thailand, the cost-effectiveness was in the range of US $7.8-32.7 per kg. ODP saved.

6. All companies are Iranian-owned.

SECRETARIAT'S RECOMMENDATION

7. It is recommended that Phase I of the project costs should receive final approval and funding in the amount of US $3,648,086 including 15 per cent contingency and 13 per cent support costs.

8. Phase II of this project is recommended for permission to proceed in the amount of US $5,088,192. This amount includes 15 per cent and 13 per cent agency support costs. If necessary, costs of individual items may be adjusted accordingly on the basis of prices which will prevail at this time. The results of the future appraisal should be reported to the Executive Committee.

9. Given the expensiveness of recurrent costs, it is further recommended that the recurrent cost formulation be used for similar projects in the future.

Project Cover

Country	The Islamic Republic of Iran
Project Title	Conversion of domestic refrigerator production facilities to phase out CFC-11 and CFC-12
Sectors Covered	Domestic Refrigeration / Rigid Foams
ODS use in Sector	1050 MT of CFC-11 and CFC-12 annually
Project Impact	Phase out of annual consumption of 590 MT of CFC-11, and 170 MT of CFC-12 (Total ODP=757 MT)
Project duration Phase I Phase II	24 months 12 months
Project Economic life	10 years
Total Project Cost (Phase I and II)	Total of capital cost and one year recurring cost US $ 14,587,800
Proposed MF Financing Phase I Phase II Total	 US $ 2,807,300 (excluding contingency and agency overhead) US $ 3,915,500 (excluding contingency and agency overhead) US $ 6,722,800 (excluding contingency and agency overhead)
Cost Effectiveness	Unit Abatement Cost 5.8 $/kg phased out annual ODP consumption
Counterpart enterprise	Arj, Azmayesh, Bahman, Iran Poya and Pars Appliances
Implementing Agency	UNIDO
Coordinating Ministry	Department of the Environment

Project Summary

This project will phase out an estimated 70% of the use of CFC-11 and CFC-12 for the production of domestic refrigerators in the Islamic Republic of Iran. The chosen replacement alternatives are HFC-134a and HCFC-141b respectively. The project will be implemented in five major companies which show an important similarity in products and production processes. These companies cooperate already in the field of research and testing. The project will be implemented in two phases; phase I consisting of redefinition of all current refrigerator models and the conversion of the production facilities of one company. Phase II covers the conversion of the production facilities of the remaining four companies.
The redefinition of the existing refrigerator models covers activities as research and development, prototyping, testing, trial manufacturing and adaption, and extensive reliability tests in the field.
The conversion of production facilities covers both refrigerant related and insulation foam blowing related installations.
Phase I covers a period of maximum two years.

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Background

Refrigeration subsector.

The subsector for domestic refrigeration in the Islamic Republic of Iran consists of 30 to 40 manufacturers, of which six to seven companies are responsible for over 80% of the ODS consumption of CFC-11 and CFC-12.

Consumption of ODS

The total 1991 consumption in the subsector according to the Country Programme was estimated at 350 MT CFC-11, and of 242 MT CFC-12, totalling 592 MT, while the total ODS consumption of CFC-11 and CFC-12 in 1991 in the Islamic Republic of Iran was 2245 MT. More recent figures lead to an estimated total ODS annual consumption of 1050 MT for 1,000,000 units produced in the sub sector. The Islamic Republic of Iran does not produce any ODS. All ODS used in the country are directly imported by the users.

Conversion strategy

For conversion of the production facilities in the domestic refrigeration sector, the first step is the conversion of five of the largest manufacturers. These are Arj, Azmayesh, Bahman, Iran Poya, and Pars Appliance. Their total production in 1992 was 715,000 units, while their total ODS consumption was 757 MT (CFC-11 MT 589 MT, CFC-12 168 MT), which makes an estimated 72% of the domestic refrigeration ODS consumption, and around 30% of the total ODS consumption in the Islamic Republic of Iran.

Used technologies

The companies use all the same ODSs, and show a great similarity in production methodology, although differences exist in quality assurance, accuracy and product finishing. For foam blowing in the insulation, CFC-11 with polyurethane and isocyanate is used. Glass wool has been used in the past in one case (Iran Poya) but since new production equipment has been commissioned it is not applied anymore. For the cooling systems, CFC-12 is used. Some specialized components like compressor, dryer, and evaporator are imported.

Chemicals are all seperately procured (ICI, Dow, Bayer, Waco/Plascofoam, Basf), since ready made mixes are only useable for a limited period of around three months. Companies change regularly their suppliers. On various occasions in the past, (western) suppliers have shown their willingness and capability to support the companies through practical assistance and expertise whith testing new products or changing production operation parameters. There is no reason to assume that this will change, since it serves both the interest of the companies and of the suppliers of sub assembly parts and raw materials.

The refrigerator models currently produced are mostly from foreign design, but adapted to the local circumstances. For instance several models are fit to operate under ambient temperature of 48 °C. Since the variety of models is limited, it is feasible and practical to assume for calculation purposes in this project, a standard refrigerator as calculation unit.

Ownership and licencies

All companies are 100 % nationally owned, either as a public company or a state company. The product models are own modifications to local conditions of foreign designs. No licensing agreements are applicable at the moment. One company (Bahman) is planning to start in the second quarter of 1994 a licence agreement with an Italian supplier (Aristo) for new production technology and know-how. The models and technology concerned have no relation with CFC free refrigerators or related technolgy and conversion, but focuss on new designs, and production methods. The old models will be phased out, and conversion of the new models is planned to be carried out according to this document, which is allowed under that agreement. Another company Azmayesh has held discussions with Liebherr for licencing of three different CFC free models to be produced in addition to their existing 5 models.(planned model diversification and production capacity increase) No definite agreement is signed however. Since the models from Liebherr use Cyclopentane as a foaming agent, Azmayesh has decided to invest in the required infrastructure for this. From expert's assessment however, the conversion to HCFC-141b is judged to be more cost effective. The higher cost related to conversion to cyclopentane of the existing 5 models are therefore not included in this proposal. Instead, the cost are calculated based on the more cost effective conversion to HCFC-141b.

Manufacturers are cooperating in several technical issues, and use each others laboratory facilities as the need arises. Their efforts are joined through the Research Centre for Home Appliances. The actual production quota are indicated by the Ministry of Industry, which plays a major role in coordination through its directives. In general, the technical level of the management of the visited enterprises is high, but knowledge and in certain cases awareness of the conversion technologies and legal issues is lacking.

Future developments

The overall unconstrained CFC consumption in the Islamic Republic of Iran is projected from 2445 MT in 1991 to 7778 MT in 2010. This corresponds to an annual growth rate of about 6.5%. The annual growth rate for the refrigeration production is estimated at 12% for the period 1991-1995, and 4% for 1996 to 2010. These fairly high figures are based on interviews with leading foam and refrigerator industries, as well as on population forecasts. The overall economic situation however is likely to cause a somewhat more modest but still substantial growth rate. Also the planned expansions of several companies, and the current trends in production figures, indicate that the growth in this sector is indeed substantial.

Project objective

The object of this project is to eliminate the use of CFC-11 and CFC-12 in five domestic refrigeration industrial enterprises through conversion of the production capacity to the use of HFC-134a and HCFC-141b.

Project description

The five selected companies show great similarity in their processes of use of ODSs. Therefore the project description gives the common factors first, but highlights relevant deviations.

Various alternatives for replacement of currently used CFCs are considered. These are mentioned hereunder, as well as an assessment of their suitability in the Islamic Republic of Iran.

Foam	Assessment	Consequences
Pentane	Flammable and explosive	special infrastructure needed
HCFC-142b plus R 22 (60/40)	Flammable and explosive if the concentration of 142-b exceeds 63.4%; Toxic. ODP = 0.11	special infrastructure needed special protection for health essential "intermediate solution"
HCFC-141b	ODP = 0.11. "intermediate solution" due to ODP value. Recom. for dev. countries	almost drop-in replacement. minor adjustments in production process and product design required
Refrigerant		
Blend of HFC-134a/ 125/ 143a 4/44 / 52% called FX-70 or HP-62 or aseotropic 125 / 143a 50%/50% called AZ 50	ODP = 0 high pressure, high cooling capacity polyeolester lubricant needed, increased sensitivity for moist and dirt	substantial changes required in product design: motor compressor, evaporator, (tubing required) etc. therefore not preferable for conversion. (only if no other alternative available)
Propane	Explosive Asphyxiant	Special infrastructure needed Special protection for health Substantial danger when servicing
HFC-134a	ODP = 0	Product design can largely stay the same, adjustments needed. Replacement of some production equipment, increased manufacturing process control required

Outline of enterprise assessment, and last year's performance and consumption.
(based on Iranian year March 1992 - March 1993)

		Arj	Azmayesh	Bahman	Iran Poya	Pars Appliances
		A good knowledge of the 134-a and 141-b. Some preliminary tests have been carried out in the laboratory. The company is ready to phase out CFCs, however not all refrigerator models are yet defined for 134-a. Clean plant.	Good knowledge of 134-a and 141-b. Company is planning to use Cyclopentane as replacement for R 11 inview of planned expansion of model range under licence agreement. Cyclopentane related cost are not included in this proposal.	Good knowledge of 134-a and 141-b. Clean plant and good aspect of the quality control. Some experiments for conversion done (on now obsolete models) (new models to be introduced through licencing agreement)	Models fully own developments; small evaporator, very thin capillary tube. One model fridge and one model freezer. Old plant. The conversion will be a good occasion to rationalize and clean production lines. Knowledge of 134-a and 141-b.	Very modern and clean facilities, good quality system. Good knowledge of 134a, but no tests yet done. Problems expected with the big model freezer to eliminate R 12. Therefore, conversion costs related to this model are not include in this proposal.
# empl.		600	700	650	820	850
# units	715,000	110,000	155,000	120,000	170,000	155,000
# models		5 (only fridge)	5	4	2	4
CFC-11 [MT]	589	90	126	120	103	150
CFC-12 [MT]	168	28	39	36	17	48
Total ODS [MT]	757	118	165	156	120	198
Total subsector	1,050					
Total ODS Country	2,445					

This grant request presents the *incremental costs* as additional cost that the enterprises incur in taking the action to phase out ODS, and is as such defined as the *difference* between the *actual cost* of the phase-out activity and the *baseline cost*. The baseline cost is the cost that the companies incur when staying at the same level of operation, without phasing out ODS.

With the rapid technology developments, and the experiences with alternative replacements, it is not certain that the here suggested replacements will be the most preferable ones at the time of

actual production facility conversion. Therefore conversion of only one company as a trial conversion exercise is included.

Baseline cost. The cost for maintaining the same level of operation is assumed to be zero for all the companies. Although several companies are involved in extension of their production facilities in order to respond to the increasing demand from the market, these extended capacities are not involved in the grant request. This request is based on the capacities and production levels as analyzed during July 1993 for the year March 1992 to March 1993. No decommissioning of existing production capacities is foreseen.

Discount rate. The used discount rate is 10%.

Time horizon. The project activities for phase I will cover a two year period, while for recurrent cost a one year period is assumed.

Costs of conversion of the production facilities which are eligible for grant financing comprise the following elements:

I. Incremental costs related to capital goods replacements, including training, redefinition of products, facility (re)construction, installation, start-up, etc. These are named **capital costs.**
II. Incremental operating cost for one year, in proportion to the operations such as labor, maintenance, and feedstock. These are called **recurrent costs.**
III. Contingency.

I. Capital Goods Replacement

A. Refrigeration system.

The technology for refrigeration with HFC-134a is well known. Critical elements as compressor and evaporator are imported.

When applying HFC-134a as refrigerant, the system has to be much cleaner and dryer. This prompts a need for *new vacuum pumps*, which have to operate for a longer duration and with a higher vacuum. Consequently, to maintain production capacity, slightly more single vacuum pumping units are needed than installed at the moment.

The machines to *charge the refrigerant* have to be replaced for reasons of density changes and CI pollution. Some companies have parallel production lines (incl. all the infrastructural requirements) with more than one charger. Therefor in some companies more than one charger has to be replaced to maintain capacity and flexibility. Since the *leak detectors* react on the CI molecule, they are to be replaced as well. For one company (Iran Poya), the design of the refrigerator is such that a substantially longer *capillary tube* has to be applied, leading to special investment for production and preparation of this item. Another company (Pars Appliances) produces smaller series of a larger model freezer. Because HFC-134a is not feasible as a replacement, a blend of HFC-134a and R22 could possibly be proposed. Since it is not clear which would be the preferred option, the activities and costs related to this model have been left out of this proposal.

B. Foam system

The technology for creating the insulation with HCFC-141b as the blowing propellant is well known and tested. The same production facilities can be used, with changes of some parts like the blowing nozzle etc. Due to increased volume, the utilization of HCFC-141b can remain 10 to 15% lower than that of R 11. Attention has to be given to the overall insulation capacity, and possible design consequences hereof have to be evaluated during the product redefinition activities in phase I.
The above issues are displayed in an overview in Annex C.

C. Model Redefinition

The redefinition of the current refrigerator models covers all activities to assure that the new

models are on the same level of functionality and reliability as the non converted models. Several stages in this process are essential:

- Design, calculation and drafting
- Prototyping
- Functionality and performance testing
- Production simulation and trial runs (testing for producability)
- Field tests for endurance and reliability
- External problem solving consultancy.

Annex B details the activities during this phase, as well as the related costs (ex taxes and duties). The equipment needed for the trial runs during model redefinition is capital equipment. Each company will need a full set for reasons of flexibility. After model redefinition, this equipment will be used for production conversion, but is not counted in the tables a second time under the heading production conversion. Since the conversion to HFC-134a is most complex, development and testing activities will be largely determined by these activities.

D. Conversion

Within the framework of the project, personnel from the enterprises will be trained in (among others) the following topics:

- management and production control
- quality assurance in relation to conversion

As common practice, modifications to the product lines will be carried out during evenings and weekends causing no loss in regular production. Cost for transport and insurance of capital equipment is included in the budgeted allocations for respective items.

II. Recurrent cost

The current models will require the following modifications:

Modification	Description	US $
Compressor with polyolester	All compressors are imported. Various types of compressors are available on the market. At the moment mostly compressors mark Goldstar, Matsushita, and Danfoss are used. It is estimated that the buy in price of the compressor will raise by at least 10 $. On top of that, increased care has to be taken in handling compressors during fridge assembly.	5
Condenser modification	Minor modifications expected, most cost encountered in increased handling, cleaning and drying, protection plugs, etc.	1.5
Increased length capillary tube	Negl.	-
Evaporator modification	Evaporators are imported. Minor modifications expected, most cost encountered in increased handling, cleaning and drying, protection plugs, etc.	1.5
New dryer for HFC-134a	All dryers are imported. The ones suitable for HFC-134a will cost .5$ more.	1.5
HFC-134a charge	Replacement of R12 by HFC-134a. Price increase per charge of app. 350 g is at the moment 1.5 $	2
New foaming agent HCFC-141b	Replacement of R11 by HCFC-141b. Price increase per charge of app. 700 g is at the moment 5 $, but less charge needed.	5
TOTAL		16.5

In these prices the estimated labor cost for increased handling and quality control are included, taxes and duties are excluded.

Recurrent Cost

Recurrent Incremental cost are partly dependent on the price differences between the ODSs to be phased out, and their replacements.

In this project document it is proposed to divide the recurrent cost for the current level of production equally between the manufacturers, the customers, and the Multilateral Fund. The total duration for calculation of the recurrent cost is for one production year, e.g. the number of units currently produced in one year.

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

III. Contingency

Contingency fund (15 % of the total project budget). The fund is proposed to cover unforeseen expenses which might be incurred during the project implementation, purchase of small testing instruments whose needs will be caused by the converted process, miscellaneous expenses, etc.

Project cost

An overview of the whole costing of the project is presented in Annex A

The project is divided in two phases:
Phase I: redefinition of all refrigerator models, and conversion of the production facilities of one enterprise.
Phase II: conversion of the production facilities of the remaining four enterprises.

The *total project cost* is US$ 14,587,800

Investment cost of US$ 2,790,300 include capital investment cost for modification of manufacturing facilities, materials, and testing equipment, training and consultancy for modifications.

The *recurrent operating costs* associated with this project are 100% caused by increased price of imported parts for each refrigerator, and their handling during further production and assembly. For a one year period these cost total to 11,797,500. which is based on actual production figures.
It is proposed to request the fund for one third of these cost. The remaining two thirds will be equally split between companies and their clients.
Local ownership fraction of 100% was considered the amount of eligible grant financing. The total project cost was multiplied by the fraction of local ownership to determine the proposed grant amount.

Other cost: A 15% contingency was included to ensure adequate funding of project costs following project appraisal. Executing agency's overhead is 13 %.

Requested funding:

The proposed grant for phase I and phase II is: US$ 6,722,800 (not including contingency and agency overhead).

Project implementation

The project will be coordinated by the Department of the Environment. The implementation will be carried out by UNIDO. UNIDO as executing agency has the necessary experience and capabilities for the successful implementation of projects on the enterprise level. Upon the approval by the Multilateral Fund the project's fund will be transferred to UNIDO. A respective project allotment document will then be issued by UNIDO financial section. Any substantive or financial deviation is subject to approval by the Executive Committee and the Department of the Environment (if required).

For the implementation of phase I, milestones are set hereunder.

		0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
1	Sign the project, receive funding	1																								
2	Make a detailed project workplan	1																								
3	Initial training of management	1																								
4	First redesign of models	4																								
5	Protoypes and testing	4																								
6	Selection of equipment + inst.	4																								
7	Trial Production	3																								
8	Reliability test	9																								
9	Final redefinition of models	3																								
10	Purchase, installation and commissioning (Pars A)	6																								
11	From start of production to full conversion of prod. facilities.	6																								

The above schedule presents a worst case scenario. It is likely that earlier completion of activities will take place.

Substantive and financial reporting will be in accordance with the Multilateral Fund requirements.

Annex A: Cost breakdown.

		Arj	Azmayesh	Bahman	Iran Poya	Pars Appliances
# empl.	3620	600	700	650	820	850
# units produced/yr.	715,000	110,000	155,000	120,000	170,000	160,000
# models.	21	5 (only fridge)	5	5	2	4
CFC-11[MT]/yr.	589	90	128	120	103	150
CFC-12[MT]/yr.	168	28	39	36	17	48
Total ODS [MT]/yr.	757	118	165	156	120	198
Total Subsector/yr.	1,050					
Total ODS Country/yr.	2,445					

Project cost specification

Model Redefinition

Design, calculation, and drafting		6,500	6,500	6,500	2,600	5,200
Prototyping		20,000	20,000	20,000	8,000	16,000
Prototype testing		20,000	20,000	20,000	8,000	16,000
Trial production equipment		114,000	114,000	114,000	114,000	114,000
# units/company		400	400	400	400	400
Trial production (100-400 units/model)		120,000	120,000	120,000	120,000	120,000
Testing for endurance and reliability		40,000	40,000	40,000	40,000	40,000
External Problem Solving Consultancy		20,000	20,000	20,000	20,000	20,000
Totals		340,500	340,500	340,500	312,600	331,200
Model Redefinition Total	**1,665,300**					

Production Conversion

Vacuumpump (4,000 $)	24	96,000	29	116,000	29	116,000	24	96,000	29	116,000	
Refrigerant charger (70,000 $)	0	0	1	70,000	0	0	1	70,000	1	70,000	
Leak detector (10,000 $)	1	10,000	2	20,000	1	10,000	1	10,000	2	20,000	
Capillary tubemach. modification							1	25,000			
Foam machine modifications (30,000 $)	1	30,000	1	30,000	1	30,000	1	30,000	1	30,000	
Training of production staff		10,000		10,000		10,000		10,000		10,000	
External Problem Solving Consultancy		16,000		16,000		16,000		16,000		16,000	
Totals		162,000		262,000		182,000		257,000		262,000	
Production Conversion Total	**1,125,000**										

Recurrent Cost (for one year) (16.5 $ per unit)

Customers ⅓	605,000	852,500	660,000	935,000	880,000
Companies⅓	605,000	852,500	660,000	935,000	880,000
Multilateral Fund ⅓	605,000	852,500	660,000	935,000	880,000
Total for 1 year production	1,815,000	2,557,500	1,980,000	2,805,000	2,640,000

Total Recurr. Cost	**11,797,500**	(for one year)
Total RIC from Multilateral Fund	**3,932,500**	(for one year)
Project Total:	**14,587,800**	Model Redefinition, Production Conversion, Net Incremental Recurrent Cost (1 yr.).
Total Finance Multilateral Fund	6,722,800	Model redefinition, Production Conversion, ⅓ Net Incremental Recurrent Cost (1 yr.).
Total Finance MF Phase I	**2,807,300**	Model Redefinition 5 companies (1,665,300) plus Production Conversion Pars Appliances (262,000) plus ⅓ Net Incremental Recurrent Cost Pars Appliances (880,000)
Total Finance Phase II	3,915,500	Production Conversion of four companies, Net Incr. Rec. Cost at level of 1992-1993 annual production

N.B. All figures are given without contingency and Agency overhead

Annex B: Overview activities and costing for Model Redefinition.

Activity	Explanation	cost per Unit	Cost for 21 Units
Design, calculation and drafting	Estimated 1 m/m of full time combined local expertise of engineer and draftsmen per model.	Draftsman costs 800 $ (earns 300 $) Senior Engineer costs 1800 $ (earns 800$), per m/m 1,300 $	27,300
Prototyping	4 prototypes per model (incl exp. failures etc.) cost including labor etc.	1000 $	84,000
Testing prototypes for functionality and performance (hot room tests)	Estimated 1 week per model, cost include use of equipment, energy, labor, reporting etc.	1000 $	84,000
Purchase of trial run equipment:	5 factories: each 1 vacuumpump 1 refrigerant charger 1 leak detector 1 foam machine modification	 4.000 70,000 10,000 30,000 Total 114,000	570,000
Testing for producability (if the design can be produced technically/economicall y or should be adapted)	Trial runs of 50 to 100 units per model depending on model differences. Cost of material and labor.	300 $	600,000
Testing of trial production results for endurance and reliability	6-12 month test of 50 to 400 units per model, cost cover transport, installation, questionnaires and data processing etc.	100 $	200,000
External consultancy	Assumed four days per model for design and development, selection and purchase of equipment, trial production set-up etc.(total 18 weeks) plus general issues: 5 m/m (split missions)	20,000	100,000
			1,665,300

Annex C: Overview costing capital goods replacement

All prices are including accessories , installation and commissioning, transport, insurance etc.
Between brackets are the numbers of units already covered in the model redefinition phase.

	Explanation	cost per Unit	
Vacuum pump incl. acc.	To maintain production capacity, more pumps are needed than installed at the moment, since the new time required for emptying the system is longer (3mm HG) Total units (140-5) = 135	4,000	540,000
Refrigerant charger	The same types are used in various factories, Total units (8-5)=3	70,000	210,000
Leak detector	The existing leak detectors trigger on the Cl molecule, and are therefore not usable. A fairly moderate, standard leakdetector has been assumed as replacement. Total units (12-5)=7	10,000	70,000
Capillary tube machine modification	The design of Iran Poya is such that a very long capillary tube is needed, which can not be series produced on the existing equipment without modification.	25,000	25,000
Foam machine modification	The foam plowing agent R-11 can easily be replaced by HCFC-141b. Adjustments have to be made to special parts like nozzles and the like. Pressures and charge are within the range of normal adjustment of the equipment. Existing molds can be used. The insulation capacity is slightly less, tests on prototypes will have to show if substantial redefinition of models is required, and if other production equipment has to be modified as a consequence of that. Total (10-5)=5 units	30,000	150,000
Training of production personnel	To obtain the same level of rejection as currently encountered, personnel has to be trained in new prooedures, quality checks and housekeeping. Mainly because HCFC-134b is extremely dirt- and moisture-sensitive. 7-10 days per company 2.5 m/m (split missions)	20,000	50,000
Ext. Consultancy	Problem solving External Consultancy, assumed to be 3 weeks per company in split missions: 4 m/m	20,000	80,000
			1,125,000

Annex D: Calculation of Unit Abatement Cost

A	ODS Phase out		Total Project	MF portion
A1	Average use of CFC 11 per year	MT	589	
A2	ODP of CFC 11		1.00	
A3	ODP-weighted CFC 11 phase out (A1*A2)	MT	589	
A4	Average use of CFC 12 per year	MT	168	
A5	ODP of CFC 12		1.00	
A6	ODP weighted CFC 12 phase out (A4*A5)	MT	168	
A7	TOTAL ODP-weighted phase-out	MT	757	
B	Annualized capital cost			
B1	Total investment cost (model redefinition + production conversion)	US $	2,790,300	
B2	Equipment life	Year	10	
B3	Discount rate	%	10	
B4	Annualized capital cost (B1* 0.1627)	US $	453,982	
C	Annual incremental recurrent cost	US $	11,797,500	3,932,500
D	Unit Abatement cost			
D1	Annualized capital cost per kg ODS phased out (B4/A7*1000)	$/kg	0.6	
D2	Annual incremental recurrent cost per kg ODP phased out (C/A7*1000)	$/kg	15.48	5.19
D3	Unit abatement cost (D1+D2)	$/kg	16.1	5.8

$$c = \frac{CC.CRF + (OC-OS)}{M.ODP} = \frac{B4}{A7} + \frac{C}{A7}$$

c Unit abatement cost
CC Incremental capital costs (including all one-time cots such as training, installation, freight etc.)
CRF capital recovery factor
OC incremental annual operating costs
OS incremental annual operating savings/benefits
M mass of ODS not released per year as a result of the phaseout action
ODP ozone depleting potential of the ODS