UNITED
NATIONS

EP

United Nations
Environment
Programme

Distr.
LIMITED

UNEP/OzL.Pro/ExCom/17/36
30 June 1995

ORIGINAL: ENGLISH

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

Seventeenth Meeting
Montreal, 26-28 July 1995

PROJECT PROPOSAL: ISLAMIC REPUBLIC OF IRAN

This document includes the following project proposal:

- Phasing out CFC-11 through conversion of rigid PU-foam manufactured with the technique of continuous lamination — UNIDO

29/5/95

PROJECT COVER SHEET

Country:	The Islamic Republic of Iran
Project Title:	**Phasing out CFC 11 through conversion of rigid PU-foam manufactured with the technique of continuous lamination**
Sectors Covered:	Foam
ODS Use in Sector:	2400 MT of CFC 11
Project Impact:	Phase out of annual consumption of 1200 MT CFC 11, (Total ODP = 1200 MT)
Project Duration:	24 months
Project Economic Life:	10 years
Total Project Cost	US$ 5,825,690 (Total of capital cost)
Capital Cost:	US$ 5,068,350
Incremental Operating Cost:	
Implementing Agency's Overheads (13%):	US$ 757,340
Proposed MF Financing:	US$ 5,825,690
Cost Effectiveness:	US $ 4.22 / ODS kg
Counterpart Enterprise	Iranian rigid polyurethane foam manufacturers: Fabis Industries Co, Iran Steel Parts Industrial Co. Ltd. (I.S.P), Urethane Systems Company Mammoth Teheran Industrial Complex, and F.M Company.
Implementing Agency:	United Nations Industrial Development Organization (UNIDO)
Co-ordinating Ministry:	Department of the Environment (DOE)

PROJECT SUMMARY

This project will phase out 100 percent of the use of CFC-11 for the production of rigid polyurethane foam sandwich and insulation panels manufactured by the technique of continuous lamination. The chosen replacement alternative is n-pentane as a foam blowing agent. The conversion to pentane of double band lamination (DBL) production lines covers installing discharge equipment for pentane from drums into accumulation tank, feeding pentane to metering system, safe ventilation and pentane emission monitoring system at pentane drum handling and tank area and at liquid polyurethane lay-down section as well as at sawing station and on both side's of the double band conveyor. The fire protection and fighting is a relevant part of the conversion process.

I. BACKGROUND

A. Sector Background

The foam sector in the Islamic Republic of Iran consists of both flexible and rigid PU-foams. These foams are manufactured by both continuous and discontinuous processes. The estimated total CFC-11 consumption is about 2400 MT/a of which 1580 MT is used in the rigid PU industry and 755 MT in the flexible foam industry. The remainder 70 MT is used in the System House Operation, which is serving small scale industry.

Due to the fact that the Islamic Republic of Iran has a very diversified and large PU industry and some of the companies in the foam sector have both rigid and flexible foam production and also rigid foams are produced in the same company by both discontinuous and continuous processes, it was decided to proceed with CFC phase-out in the foam sector in several distinct stages. In order to rapidly reduce the country's large CFC consumption the priority is given to the continuous lamination industry of rigid foams (Construction - Boardstock / Flexible - Faced Lamination, Sandwich panels). The sub-sector, consisting five major companies, consumes 50 % (1200 MT/a) of the CFC consumption in the foam sector.

The companies; **Fabis Industries Co, Iran Steel Parts Industrial Co. Ltd. (I.S.P), Mammoth Teheran Industrial Complex, F.M Company and Urethane Systems Company** were selected by the Islamic Republic of Iran for conversion from CFC11 to pentane.

The primary products produced, rigid polyurethane foam cored sandwich panels and insulation boards, are consumed mainly in the home market with some export to neighboring countries. The product is mainly used for roofing, cladding, insulated doors, insulated shutters, cold store construction and cold room construction.

Company	Products	End use	Workers	ODS MT/a	Line origin
Fabis Industries Co	Wall Ceiling Roof	Cladding Cold Stores	70	390	Elastogran GmbH, Germany
Iran Steel Parts Industrial	Wall Ceiling Roof	Cladding Cold Stores	74	320	Metecno, Italy
Urethane Systems Company *	Insulation boards	Roofing Insulation	78	150	Viking, UK
Mammoth Teheran Industrial Group *	Wall Ceiling Roof	Cladding Cold Stores	350	240	UK / USA
F. M Company *	Wall Ceiling Insulation panels	Cold Stores	177	100	Hennecke, Germany

Note * Consumption of CFC-11 reflected in the table includes CFC-11 consumed only in the continuous rigid PU-foam manufacturing process.

The Islamic Republic of Iran does not produce any ODS. All ODS used in the country are directly imported by the users. In 1990 the total consumption was circa 3,784 MT of ODS. Although Iran has a large oil production capacity, none of the oil produced is used in the manufacture of base polyols; therefore, all raw materials are imported. Primary chemical companies importing polyurethane chemicals to Iran for the rigid foam market are: Dow Chemicals - Netherlands; Enichem - Italy, Bayer Ag - Germany; Basf Ag - Germany and ICI - Italy.

The total installed production capacity for rigid PUR-foams manufactured by the technique of continuous lamination is about 6.100.000 m² per year, the present production is approximately 5.000.000 m² per year. The manufacturers expect market growth to increase about five to ten per cent per year.

The selected companies covered by the project are prepared to phase out ODS as soon as the new technologies have been acquired, the necessary machinery and equipment installed and the technical staff trained.

Among the technological options currently available on a commercial basis and in line with the established policy of the Islamic Republic of Iran to phase out the use of ODS, all companies have chosen to replace CFC-11 with n-pentane systems.

As a blowing agent for rigid polyurethane foam, the companies decided to avoid the use of any transitional substances and to introduce n-pentane as an ultimate solution.

B. Companies' Background

B.1 Fabis Industries Co, (trade name: Fabis) is a private company, and it is one of the largest sandwich panel manufacturers in the foam sector of the Islamic Republic of Iran. Fabis polyurethane sandwich panels are used in a large variety of construction systems, such as:

- Large warehouses
- Cold rooms for storage of cereals & vegetables
- Cold storage for meat , fruits and dairies
- Walls and roofs of medium and large scale industrial buildings
- Indoor swimming pools and gymnasiums
- Mobile camping houses
- Residential houses and villas
- Administrative buildings
- False ceiling and room partitions
- Utility rooms

Fabis Industries Co. employs 70 people, and the installed annual production capacity is about 1,800,000 m². During March 1994 - March 1995, the actual production is 1,500,000 m² of panels.

During March 1993 - March 1994 Fabis used about 390 MT of CFC-11 in the production process.

The company manufactures sandwich panels in 40, 60, 100, and 150 mm thicknesses all in 1000 mm width and in variable length, in a variety of colours and covering material such as galvanized iron sheet with 0,5 mm thick and 275 g/ m² of zinc on both sides, aluminium 0,8 mm thick, polyester painted galvanized

sheet and specially designed trapezoidal profile for more mechanical strength of roof covers, all with core foam density of 40 kg/m.³

Fabis covers a share of some 45 % of the local sandwich panel market, and its main export market is to the countries: Georgia, Russia, Qatar and the United Arab Emirates. Export is some 15 % of production volume

Fabis Industries Co. established its continuous double belt line from the company Elastogran GmbH in 1976. In 1978, in one working shift company all ready produced 600,000 m² of sandwich panels. The production line is kept in good technical condition and has at least fifteen years lifetime after adapting the pentane dosing system.

The line is constituted of three main sections: Inlet section (uncoiling stations and profiling machines), middle section (foaming and press facility)and outlet section (cutter and cooling section)

Inlet section consists of:

- *Twin uncoiling* section for lower and upper facing.
- *Profiling machines* to shape surfaces and edges of the wall, ceiling and roof elements.

Middle section consists of

- *Preheating facility* for passing metal sheets.
  -Infrared heating elements give basic warming
  - Fan type gas burner gives the adjusting temperature
- *Foaming portal* to apply the raw material mixture by means of oscillating mixhead.
- *Casting mixhead* with casting rake to apply the reactive PUR raw material mixture to the lower metal width.
- *High pressure reaction casting machine* with premixing station for the main and additional components.
- *Temperature control equipment* (heat exchangers, temperature control units, water chiller) to condition the main components.
- *Storage and day tank facility* to store raw materials.
- *Reaction section* to guide and position the metal widths and calibrate the continuous element hank.
- *Double plate conveyor* as continuous press section to permit foaming pressures and produce evenness and parallelism of upper and lower facing.
- *Side sealing* to guide the facings and absorb the lateral foaming pressure.

Outlet section consists of

- *Cutter* to cut the continuous element hank to required lengths.
- *Stacking* with automatic vacuum lifter
- *After polymerization and cooling* inside the factory during cold season.

B.2 Iran Steel Parts Industrial Co. Ltd. (I.S.P), (Iran Steel Parts)is a private company, and it is one of the largest sandwich panel manufacturers in the foam sector of the Islamic Republic of Iran. Iran Steel Parts' polyurethane sandwich panels are used in a large variety of construction systems, such as:

- Large warehouses
- Cold rooms for storage of cereals & vegetables
- Cold storage for meat , fruits and dairy products
- Walls and roofs of medium and large scale industrial buildings
- Indoor swimming pools and gymnasiums
- Mobile camping houses
- Residential houses and villas
- Administrative buildings
- False ceiling and room partitions
- Utility rooms

Sandwich Panel Workshop of Iran Steel Parts employs 74 people and the installed annual production capacity is about 1,500.000 m². During March 1994 - March 1995, the actual production is 1,300,000 m² of panels.

Iran Steel Parts ODS (CFC-11) usage in their production process is as follows:

Time	CFC 11 consumption MT
March 1992- March 1993	180
March 1993- March 1994	250
March 1994- March 1995	320

The company manufactures sandwich panels in 30 to 100 mm thicknesses, all in 750 mm width and variable lengths, in a variety of colours and covering material such as galvanized iron sheet with 0,5 mm thick and 275 g/ m² of zinc on both sides, aluminium 0,8 mm thick, polyester painted galvanized sheet and specially designed trapezoidal profile for more mechanical strength of roof covers, all with a core foam density of 40 kg/m³.The company also has elements for renovation purposes; these have, as facing material, steel on one side and Al-foil or paper on the other side.

Iran Steel Parts Industrial Co. Ltd. (I.S.P), covers a share of 35 % of the local sandwich panel market and it's main export market is to the countries: Qatar, Kuwait, the United Arab Emirates and Georgia. Export is some 15 % of production volume.

Iran Steel Parts Industrial Co. Ltd. (I.S.P), established its continuous double belt line from the company Meteeno in 1991. In 1993 it allready produced 900,000 m² of sandwich panels. The production line is kept in good technical condition and has at least fifteen years lifetime after adapting the pentane dosing system.

The line is constituted of three main sections: Inlet section (uncoiling stations and profiling machines), middle section (foaming and press facility)and outlet section (cutter and cooling section)

Inlet section consists of:

- *Twin uncoiling* section for lower and upper facing.
- *Profiling machines* to shape surfaces and edges of the wall, ceiling and roof elements.

Middle section consists of

- *Preheating facility* for passing metal sheets. Heating with help of open fire gas burner.
- *Foaming portal* to apply the raw material mixture by means of oscillating mixhead.
- *Casting mixhead* with casting tube to apply the reactive PUR raw material mixture to the lower metal width.
- *Low pressure reaction casting machine* with mixing for the main and additional components at mixinghead.
- *Temperature control equipment* (heat exchangers, temperature control units, water chiller) to condition the main components.
- *Storage and day tank facility* to store raw materials.
- *Reaction section* to guide and position the metal widths and calibrate the continuous element hank.
- *Double plate conveyor* as continuous press section to permit foaming pressures and producing evenness and parallelism of upper and lower facing.
- *Side sealing* to guide the facings and absorb the lateral foaming pressure.

Outlet section consists of

- *Cutter* to cut the continuous element hank to required lengths.
- *Stacking* with automatic vacuum lifter.
- *After polymerization* and *cooling* inside the factory during cold season.

B.3 Urethane Systems Company (U.S.C)is a private company, founded in 1977. U.S.C. has three activities;

1. Flexible foam and conversion plant in 5000 m² factory area originally set up under technical agreement of British Vita UK consisting of Laader Berg, Norway 250 kg/min foaming plant vertical and horizontal cutting equipment from Hyma of Denmark and Baymer/Wapora of Germany.
2. Rigid Foam Division set up under licence of ICI UK consisting of *inverse laminator for panel production* with capacity of over 500.000 m² per shift from Cannon Viking Ltd UK and two separate dispensing machines MAXIM RS and SP 27 for discontinuous block/pipe section/ cold cure cushion etc. production also ex Viking.
3. A Systems House operation set up under license of Up John Polymer Europa AG (sold to DOW Europe a few years ago). System House is working for internal consumption..

U.S.C will participate also into two other project, which will be submitted in the later stage to the MFMP:

"Phasing out CFC 11 through conversion of flexible PU-foam manufactured by continuous technique".

"Phasing out CFC 11 through conversion of System House Operation".

U.S.C. employs 78 people, of which 18 are working in the Rigid Foam Division.The installed annual production capacity is about 500.000 m²/8 hrs shift. During March 1994 - March 1995 the actual production is 300.000 m² of panels.

Urethane Systems Company's ODS (CFC-11) usage in their rigid foam production process is as follows:

Time	CFC 11 MT
March 1992- March 1993	157
March 1993- March 1994	144
March 1994- March 1995	150

U.S.C covers a share of 50.% of the local insulation market.

The inverse lamination process is a development of horizontal lamination process. It is accurate technique converting flexible reelstock materials discrete rigid sheets and chemical foaming systems into rigid boards suitable for use in many building applications (as well as in other industries).

The special features of this process facilitate manufacturing rigid faced insulating panels, while still permitting the manufacture of "flexible"-faced panels for which the horizontal lamination process has been designed.

The lamination process consists of:

Inlet section

- At the upper machine level the flexible facing (laydown paper) is unreeled continuously at manufacturing line speed.
- The two preblended components of the chemical system are mixed and dispensed through a traversing low-pressure impingement mixing head with spraying nozzle, giving a "fanned" pattern on the laydown paper.
- This facing carrying the liquid chemical mixture as it flows out, passes over a heated platen to control the rate of rise as the foaming reaction takes place. This platen is curved in the vertical plane so that the foam is inverted until it is expanding downwards from laydown

paper. During this stage the foam may be cooled to control the condition of its exposed surface.

- With the foam gelled and risen but stil tacky, its exposed (now the lower) surface contacts the second facing which may be a discrete rigid sheet or a second flexible reelstock material.

Middle section

- The sandwich so formed passes beneath an upper conveyor, set at the required clearance. While within the conveyor , a low fixed pressure is applied to laminate to ensure uniform contact and good adhesion of foam to facings.
- Unlike "fixed cap" processes, this feature ensures that the foam cures under very low stress. Consequently the foam structure is undistorted and has the best possible properties.

Outlet section

- On emerging from the conveyor the edges can be trimmed continuously relative to the edges of the rigid sheet (or at preset width when both facings are flexible).
- The board is then automatically cut to the length, either a preset length or to match the length of the discrete rigid sheets. Where both facings are flexible, a centre saw is used often to slit the board to half -width.
- The boards are then stacked to allow them to cool ready for storage and despatch.
- *After polymerization* and *cooling* inside the factory during cold season.

B.4 Mammoth Tehran Industrial Group, (trade name: Mammoth) is a private company and is one of the biggest sandwich panel, trailer, refrigerated trucks and prefabricated houses manufacturers in the Middle East. Mammoth has also discontinuous PU-cored sandwich panel production, which is under the project *"Phasing out CFC 11 through conversion of rigid PU-foam manufactured by discontinuous technique"*, which will be submitted to the MFMP in the later stage.

Mammouth panels manufactured in continuous method are used in a large variety of areas:

- Large warehouses
- Cold rooms for storage of cereals & vegetables
- Cold storage for meat , fruits and dairy products
- Walls and roofs of medium and large scale industrial buildings
- Indoor swimming pools and gymnasiums
- Mobile camping houses
- Residential houses and villas
- Administrative buildings
- False ceiling and room partitions
- Utility rooms
- Refrigerated Trucks
- Dry fruit containers
- 20' and 40' containers
- Prefabricated houses

Mammoth Tehran Industrial Group employs 350 people and the installed annual production capacity is about 1.500.000 m². During March 1994-March 1995 the actual production will be 1.500.000 m² of panels.

Mammoth Tehran Industrial Group ODS (CFC-11)usage in their production process as follows:

Time	CFC 11 consumption Continuous	CFC 11 consumption Discontinuous
March 1992- March 1993	80	80
March 1993- March 1994	120	120
March 1994- March 1995	240	160

The company manufactures sandwich panels from 30 to 200 mm thickness, most of them in 900 mm width and variable length, in a variety of colours and covering material such as galvanized iron sheet from 0,5-0.8 mm thick and 275 g/ m² of zinc on both sides, aluminium 0,8 mm thick, polyester painted galvanized sheet and specially designed trapezoidal profile for more mechanical strength of roof covers, all with core foam density of 35-80 kg/m³ They also manufacture panels in a variety of widths from 500 mm to 3000 mm with discontinuous system.

Mammoth covers a share of some 30-50 % of all the sandwich panel market (roofs, walls, special elements etc.), and its main export market is to the countries: Germany, Italy, Russia, Qatar and United Arab Emirates. Export is some 15 % of production volume.

Mammoth established its continuous double belt line from UK at the end of 1989. The production line is kept in good technical condition and has at least fifteen years life time after adapting the pentane dosing system.

The line is constituted of three main sections: Inlet section (uncoiling stations and profiling machines), middle section (foaming and press facility) and outlet section (cutter and cooling section).

Inlet section consists of:

- Twin uncoiling section for lower and upper facing. The lower profiling section is done in advance in order to give an overlap to the panel.
- *Profiling machines* to shape surfaces and edges of the wall, ceiling and roof elements.

Middle section consists of:

- *Preheating facility* for passing metal sheets.
  -Infrared heating elements and fan heater gives basic warming
  -Gas burner type gives the adjusting temperature
- *Foaming portal* to apply the raw material mixture by means of oscillating spray unit and mixer is constant and not oscillating between facings.
- *Low-pressure dynamic mixer* with stirrer, to supply the reactive PUR raw material mixture through plastic tube to cast rake and on the lower metal width.
- *Low-pressure feeding pumps* to supply components to mixing head
- *Temperature control equipment* (heat exchangers, temperature control units, water chiller) to condition the main components.
- *Storage, week and process tanks* to store raw materials.
- *Reaction section* to guide and position the metal widths and calibrate the continuous element hank.
- *Double plate conveyor* as continuous press section to permit foaming pressures and produce evenness and parallelism of upper and lower facing.
- *Side sealing* to guide the facings and absorb the lateral foaming pressure.

Outlet section consists of

- *Cutter* to cut the continuous element hank to lengths.
- *Stacking* is manual.
- *After polymerization and cooling* inside the factory during cold season.

B.S F. M Company is a private company and the first and largest manufacturer of refrigerated truck bodies in the Islamic Republic of Iran. For this production, they use Elastogran low-pressure injection machines and two 3 x 13 m hydraulic presses; conversion of this production will be under the project *"Phasing out CFC 11 through conversion of rigid PU-foam manufactured by discontinuous technique", which will be submitted to the MFMP in the later stage.*

The relevant part of their activities is sandwich panel production. They manufacture sandwich panels with a core thickness range of 60 to 100 mm with steel, aluminium and paper facings. These panels are used for many insulation needs.

F.M. Company employs 177 people and the installed annual production capacity is about 800.000 m². During March 1994-March 1995, the actual production will be 400.000 m² of sandwich and insulation panels.

F.M. Company ODS (CFC-11) usage in their production process is as follows:

Time	CFC 11 consumption Continuous	CFC 11 consumption Discontinuous
March 1992- March 1993	80	20
March 1993- March 1994	85	35
March 1994- March 1995	100	50

The company manufactures sandwich and insulation panels of 30 to 100 mm thickness most of them in 1200 mm width and variable lengths, in variety of colours and covering material such as galvanized iron sheet from 0,5-0,8 mm thick and 275 g/ m² of zinc on both sides, aluminium 0,8 mm thick, polyester painted galvanized sheet, all with core foam density of 40 kg/m³. Flexible faced insulation panels are mainly used under refrigerator and chiller rooms as floor insulation material.

F.M. Company installed their Hennecke double band continuous PU-casting line in 1976 and they have kept about 50 -75 % market share of the insulation panel market. F.M. Company produces also wall panels with aluminium and steel facings and has a present market share of approximately 10 -15 % of this market.

II. PROJECT OBJECTIVE

The objective of this project is to eliminate the use of ODS (CFC-11) in the production of rigid polyurethane foam sandwich panels for walls, roofs, and cold-storage installations at *Fabis Industries Co., Iran Steel Parts Industrial Co. Ltd. (I.S.P), Urethane Systems Company, Mammoth Teheran Industrial Complex and F.M Company* through conversion to the use of n-pentane as a blowing agent.

III. PROJECT DESCRIPTION

The selected companies covered by the project are prepared to phase out ODS as soon as the new technologies have been acquired, the necessary machinery and equipment installed and technical staff trained.

Among the technological options currently available on a commercial basis and in line with the established policy of the Government of the Islamic Republic of Iran to phase out the use of ODS, all companies have chosen to replace CFC 11 as foam blowing agent to avoid the use of any transitional substance and to introduce n-pentane as the ultimate solution.

Assistance, through the project, is sought for:

(a) Procurement of new machinery and equipment;

(b) Rebuilding and partially replacing presently used equipment, such as ventilation, PUR machines, preheating facilities for passing metal width, etc.

(c) Testing of sandwich panels and insulation foam boards produced with the new technology ;

(d) Installation, commissioning, training of national personnel in Europe and on-the-job training, trial operation and start-up etc.

The following machinery and equipment needs to be rebuilt, replaced or new equipment has to be added:

A. *Storage of flammable blowing agent*

- In order to achieve vacant circumstances for foaming operation, the foaming agent is to be kept at a constant temperature or it has to be temperature conditioned. Storing pentane in underground tanks is the most economical and safest solution for this; to ensure safe unloading of pentane drums, the discharge equipment is needed. In factories where pentane usage is relatively small and their pentane is delivered in drums, it is possible to use this pentane drum unloading unit as a main process tank..
- Tank and pentane drum unloading unit must be designed and constructed in accordance with recognized standards of good engineering practice.
- Tank and unloading unit will be situated such that suitable access for emergency evacuation and fire-fighting is ensured.
- For tank, the fill pipe will reach to the base of the tank to prevent splashing.
- Tank will be adequately earthed and an earthing point provided for bulk delivery vecihles as electrostatic charges may be generated during handling operations.
- Level indicators will be fitted to prevent over-filling.
- Unloading takes place with the help of gravity or inert gas like nitrogen.
- Tank must be provided with 80 mm diameter vent pipe, which discharge at a minimum height of 3,75 m above ground. The vent will be fitted with a flame arrester.
- Tank will be contained in a concrete lined pit and back-filled with dry sand.
- Tank with double wall is to be constructed of steel with an outer fibreglass layer in order to protect it against corrosion, and pipes are constructed of stainless steel and all joints are to be welded to avoid any leakage.
- To reduce evaporation, the tank will have a back pressure system (pressure / vacuum valve).
- The use of drum supply is not generally recommended due to increased handling difficulties, but in Iran 20 m³ bulk containers are not available at the moment; therefore, the usage of the drum unloading system is recommended.

B. *Foam System*

In order to achieve a reliable and safe cleaning of mixing head and an acceptable foam quality and insulation value at the lowest price, high pressure dispensing units with high pressure impingement mixing need to be introduced. The polyol parts of the machines have to be made explosion proof after static mixer. It is also necessary to replace the electrical components of the polyurethane foam laydown area, and it is to be encapsulated.

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

According to our information collected in Iran, there is no domestic market for the second hand low pressure foaming machines. Therfore, once the machine is converted to a high-pressure dispensing system, the low-pressure system will not have any industrial use or value. But many companies tend to change their low-pressure dispensing units to high-pressure dispensing units. Therefore, as previously approved by the MFMP for foam sector projects, the conversion to high pressure machines is budgeted at their full cost.

Since continuous panel production requires constant changes in foam formulations, it will be necessary to provide a separate in-line mixing unit for the pentane to be adapted into the polyol high pressure line and a dynamic mixer for activator into the polyol's suction line.

C. *Ventilation, gas detection and monitoring system*

When using pentane as a blowing agent in the manufacture of rigid polyurethane foams, pentane emission occurs during the process. Adequate ventilation in combination with a pentane detection and monitoring system is needed to dilute the pentane concentration, and monitor the concentration of pentane to meet health and safety requirements. It is also important to classify areas of risk so that the appropriate health and safety measures can be taken.

In order to to maintain the local safety and health standards when using the highly flammable and explosive pentane a gas detecting system as well as a fire protection system should be installed. Pentane emission will be monitored at the following areas:

- Foaming station (several points, top and bottom)
- In the ventilation exhaust pipe from the foaming station
- At both sides of the double band conveyor
- At the sawing station
- In the ventilation exhaust pipe from the sawing station
- In the storage area for packed elements and at polymerization area
- In the pentane drum unloading area
- In the enclosure of metering unit for pentane
- Around the pentane tank area

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

All machinery and equipment which may come in contact with pentane or the mix of polyol and pentane must be monitored.

To make the foaming section explosion-proof, it is necessary to replace the infrared electric heating elements and gas burner type heating units by aluminium block/electric air heating units. All the electric valves and microswitches, which are used in connection with the foaming portal and head, need to be explosion-proof.

All parts at the foaming area must be equipped with a good earth connection to avoid the appearance of static electricity.

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

To keep control over the quality of the foam, it is recommended to introduce a minimum specification of test equipment.

D. *Justification for Selection of Alternative Technology*

The same mechanical properties can be achieved with pentane blown foam as with foams blown using other blowing agents. These mechanical properties are achieved using both n-pentane and cyclo-pentane. With cyclo-pentane however an improved λ-value is attainable. In the Islamic Republic of Iran n-pentane is commercially available, and in construction elements the advantage of better λ-value of cyclo-pentane is not possible to utilize. Although the λ-values obtained when using n-pentane are somewhat higher than those achieved using CFCs as the blowing agent, they are similar to those possible with HCFCs and HFCs. Normal-pentane is therefore chosen as a new blowing agent for the rigid polyurethane foam by the major manufacturers of the polyurethane panel manufacturing industry as replacement for CFC 11.

Some manufacturers use:

Blowing agent	*ODP*
100 % CO_2 (water - isocyanate reaction)	0
HCFC 141b	0.11
HCFC 22	0.065
HCFC 142b + HCFC 22	0.06
HFC 134a	0
Cyclo-pentane	0
N-pentane	0
HFC-356	0

The major advantages and disadvantages of the various alternatives are as follows:

100 % CO_2	
• Advantages Environmentally attractive	• Disadvantages Poorer physical properties Poorer foam adhesion 20-25 % increase in initial λ-factor (thermal conductivity) Fast foam ageing, due to gas diffusion, if foam not protected Higher exotherm limits production of thick elements Significant cost increase (+30%) Polyol viscosity limitations
HCFC-141b	
• Advantages Low flammability impact 10 % more efficient blowing agent than CFC-11 λ-factor comparable to CFC 11, when good foam quality is achieved Good foam ageing characteristics Cost effective No plant modifications required (if high pressure foaming is already used)	• Disadvantages Transitional substance Higher solvency effect Foam curing problems with thicker panels (after expansion)

UNIDO

HCFC-22	
• Advantages Lower ODP than HCFC-141b Non-flammable Low cost	• Disadvantages Lower boiling point requires significant changes to processing and handling equipment Frothing effect at higher levels Higher initial λ-factor Without impermeable facers λ-factor will increase rapidly due to gas diffusion Foam curing problems with thicker panels (after expansion)
HCFC-22/HCFC-142b blends	
• Advantages Low ODP Non-flammable Frothing effect less than HCFC-22 Slower rate of gas diffusion than HCFC-22	• Disadvantages Low boiling point Higher cost than HCFC-22 alone
Pentane	
• Advantages Zero ODP Halogen free Low cost Liquid at room temperature Good foam ageing characteristics Foam properties acceptable	• Disadvantages Highly flammable Plant modifications required Low solubility in most of the polyols 20 % increase in initial λ-factor (cyclo-pentane) and 27 % increase in initial λ-factor (n-pentane)
HFC-134a	
• Advantages Zero ODP No-toxicity Non-flammable	• Disadvantages Expensive Higher initial λ-factor Lower solubility in polyols Frothing effect worse than HCFC-22 Requires significant changes to processing and handling equipment
HFC-356	
• Advantages Environmentally attractive Boiling point 24 °C Non flammable Relatively soluble in standard PU-raw materials λ-factor similar to CFC-11 Good foam ageing characteristics	• Disadvantages Toxicity unknown Cost unknown Availability uncertain

Although 100 % CO_2 is a very attractive solution from an environmental point of view, it cannot be selected as an acceptable technology for the production of sandwich panels due to the poor insulating properties and dimensional stability problems as well as adhesion reliability between foam and facing materials.

Application of HCFC-356 and other new foaming agents are not mature technologies as yet.

The use of HFC-134a is incompatible with existing processes. The other drawback of this propellant is its higher cost.

HCFC-141b, HCFC-22 and HCFC-142b+HCFC-22 blend are transitional substances. The latter two, similarly to HFC-134a, are incompatible with existing processes.

N-pentane is an excellent solution when producing insulation and sandwich panels in continuous casting method and is widely used in Europe. Currently all major European manufacturers are carrying out tests or have already started using pentanes (n-iso-, cyclo-pentane or their mixtures). Therefore, the Government of the Islamic Republic of Iran recommends that rigid foam manufacturers having a continuous production method should introduce an ultimate solution as blowing agent and should not use any transitional substances.

IV. INPUTS

1. *Capital Goods Replacement*

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

List of new equipment is shown plant by plant in Annex A., due to differences of production facilities of each plant.

A. *Storage and metering of blowing agent*

I. Pentane unloading.
   - A. Discharge equipment for pentane from drums into accumulation tank feeding pentane to underground storage tank or directly to metering unit of blowing agent.

II. Pentane tank facilities, meeting " petroleum style, double wall" tank regulations
   - A. Piping
   - B. Double wall tank, with fibreglass lining. Volume 30 m^3
   - C. Leakage control unit, based on glycol filling into double wall space.
   - D. Tank will be contained in a concrete lined pit.

III. Metering unit for pentane
   - A. Frequency controlled metering unit for n-pentane. Consisting one (1) Diaphragm metering pump with three (3) diaphragm pump heads. Interconnecting piping, valves and wiring are included as well as contact pressure gauges.
   - B. Mass flow meter

C. Static mixer, designed for the maximum polyol stream, installed into the polyol's delivery line. Design is specially made for mixing high viscosity liquid into very low viscosy material

B. *Foam System*

1. Isocyanate Day Tank
2. Polyol Day Tank
3. Heat exchanger/chiller for MDI
4. Heat exchanger/chiller for polyol
5. Activator Day Tank
6. Activator Diaphragm pump
7. Mass flow meter for MDI,polyol and activators
8. Air loading unit
9. High pressure dispensing unit for foaming, POL, MDI and including in-line mixer for activator.
10. Pipe work and electrical controlls
11. Traversing unit with mixing head complete with injector cleaning via piston and pressure adjustment
12. Hot air preheating unit for lower facing
13. Hot air preheating unit for upper facing
14. Hot air preheating of conveyors
15. Antistatic floor
16. Fire protection system

C. *Ventilation, gas monitoring and alarm system*

I. Gas monitoring center
II. Extraction hood and fan for foam lay down area.
   A. Mix head and Traverse Unit are enclosed with ventilation box on reels and fitted with sliding doors. Ventilation is arranged with explosion proof motor, with differential pressure switch; to continuously monitor the suction efficiency, with sparkle free fan.
III. Gas detectors

2. *Conversion/Training*

Within the framework of this project, engineers, technicians, maintenance people and workers from panel manufacturers will be trained in the following areas:

1. management and production control;
2. quality control in relation to conversion;
3. operation of the new machinery and equipment;
4. maintenance of the new machinery and equipment;
5. new technologies for foam;

6. specifications for materials;
7. safety regulations for flammable/explosive chemicals;

The appointed General Contractor will be responsible for generating as part of project implementation, a manual addressing the training and safety issues:

I. Requirements for the company management on how to manage safe foam handling and foaming operation.
II. Initial training and safety instructions to all new operator or management personnel before they are involved with foam related operations.
III. General operator instructions for safe foaming procedure.
IV. Cleaning requirements of foam machinery and area, in practical and detailed manner.
V. Periodic sensor testing and other maintenance requirements related to pentane system.
VI. Safety drill
VII. Reporting system of training and safety program execution.

V. PROJECT IMPLEMENTATION

The project implementation will be carried out by UNIDO in close cooperation with the recipient company. Necessary local coordination will be done by the Department of the Environment.

Purchase of know-how is not considered in the project budget. However, to substantively assist and supervise the technical aspects of the conversion process, to perform troubleshooting and to provide assistance in product, redesign work specialized consultants will be appointed and fielded by UNIDO. The respective job descriptions will be prepared upon approval of the project.

After competitive bidding, performed according to UNIDO's rules and procedures, a General Contractor will be appointed by UNIDO for the implementation of the major project components. The General Contractor will be responsible for the supply of equipment, installation, commissioning and on-the-job training of local staff. The detailed Terms of Reference for the services to be provided by the General Contractor will be elaborated after project approval.

The final equipment specification and the work plan can only be elaborated after approval of the basic approach for project implementation by the MFMP.

The permission from the local authorities for the introduction of the new technologies under this project will have to be obtained by the recipient companies. They will also be responsible for the compliance of the new technologies with established national standards.

Having accepted the conversion of its plants to the use of non-ODS under this project, the Fabis Industries Co, Iran Steel Parts Industrial Co. Ltd (I.S.P), Mammoth Tehran Industrial Complex, F.M Company and Urethane Systems Company will be committed to provide the following inputs:

- All activities and costs related to the construction work needed (including the provision of technical infrastructure) to accommodate the new technologies introduced under this project. (The relevant construction work will have to be arranged by Fabis Industries Co. Iran Steel Parts Industrial Co. Ltd (I.S.P), Mammoth Tehran Industrial Complex, F.M Company and Urethane Systems Company under the supervision of the General Contractor and in line with the established milestones for this project. The costs for construction work are, therefore, not reflected in the project budget. The specification for construction work needed will be elaborated by the General Contractor after project approval and necessary site inspection.);

- Technical staff as required by the General Contractor;

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

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

UNIDO as Implementing Agency has the necessary experience and capabilities for the successful implementation of projects at enterprise level. Upon approval of the project by the MFMP the project's budget will be transferred to UNIDO. The respective project allotment document will then be issued by UNIDO's Finance Section. Any substantive or financial deviation from the approved project is subject to approval by the MFMP and UNIDO.

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

VI. PROJECT COSTS

I. INCREMENTAL OPERATING COSTS

N-pentane is lower in price than CFC-11 and the quantity needed in the formulation to produce foams of equal density using the technique of continuous lamination is reduced by a factor of circa four. This characteristic gives savings to the foam formulation, However, these savings are offset by the higher cost fire retardant polyol, costs of operation and maintenance, higher density (insulation boards), and annual safety training. These costs are difficult to calculate in advance as individual formulation changes and operating conditions are site specific.

However, expected annual savings on n-pentane over four years will approximately match that of the extra operating and chemical costs. Therefore, no recurrent incremental costs will be considered in this project.

II. CONTINGENCY FUND

A contingency fund (10 percent of the total investment cost) was calculated. The MFMP is proposed to cover unforeseen expenses which might be incurred during the project implementation, e.g. purchase of small testing instruments, which might be required during the conversion process, miscellaneous expenses, price escalation, etc.

III. TOTAL COSTS

Investment costs will cover capital investment costs (on CIF basis) for modification of existing manufacturing facilities, purchase of new machinery (see Table A: "Equipment Specification and Cost Breakdown"), training, installation and consultancy services for plant and product modifications (Table B: "Project Budget").

- The incremental operating costs associated with this project are as above.
- Implementing Agency's overhead costs are 13 percent.
- For the complete costs breakdown see Table Bs: "Project Budget".
- For the calculation of the cost-effectiveness see Table C on the summary page: "Cost-effectiveness".
- Requested funding by the MFMP: US$ 5,825,620

All above mentioned panel manufacturers have already recognized the need to be in compliance with the stipulations made in the Montreal Protocol and have agreed to participate in the ODS phase-out programme of the Islamic Republic of Iran.

Fabis Industries Co

Table A: Equipment Specification and Cost Breakdown

Item	Quantity	Unit costs $	Total costs $
Pentane processing			
Discharge equipment for drums	1	30,000	30,000
Pentane tank 30 m3	1	30,000	30,000
Pentane delivery pumps and pipes	1	40,000	40,000
Metering unit for pentane	1	150,000	150,000
Safety cabin for metering unit	1	60,000	60,000
Exhaust system for the safety cabin	1	40,000	40,000
Foaming portal	1	120,000	120,000
Reaction casting machine			
1. metering unit for the main components (MDI and polyol)			
2. premixing chamber for activators			
3. metering unit for activator I			
4. metring unit for activator II			
5. on-line gas loading	1	33,500	33,500
6. flow measuring unit for pol, MDI and activators	1	35000	35,000
Hot air preheating unit for upper and lower facing	1	10,000	10,000
Antistatic floor	1	5,000	5,000
Fire protection system	1	30,000	30,000
Ventilation, gas monitoring and alarm system			
Gas detector system with alarm	1	40,000	40,000
Detectors	12	3,000	36,000
Extraction hood and fan for foam lay down area	1	25,000	25,000
Comissioning and start-up of the plant			50,000
Total			734,500

Table B:Project Budget

Budget line	Duration, Work months	Cost, US$
11-01 General consultancy services	3	38,000
21-01 Subcontract		734,500
32-01 Study tour on pentane conversion, 2 technicians	0.5	10,000
51-00 Miscellaneous:		
contingency fund on capital cost	10%	78,250
Incremental operating cost		
Preparatory assistance		2,000
Total miscellaneous cost		80,250
99-00 Subtotal		862,750
Implementing Agency Overhead	13%	128,917
PROJECT TOTAL		991,667

Annex B. Implementation Schedule

MILESTONES/MONTH	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1. Sign the project, receive funding																		
2. Appointment of General Contractor, site inspection																		
3. Elaboration of a detailed project workplan																		
4. Draft of plant layouts																		
Conversion																		
5. Selection of equipment, bidding																		
6. Overseas training																		
7. Purchase Equipment																		
8. Packing/Shipping																		
9 Installation																		
10. Comissioning																		
11. On-site training																		

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

Technical Review

Prepared by: Kimmo J. Sahramaa
PUR-Technology Consultant
Date: May 24, 1995

1. Country of Origin: The Islamic Republic of Iran

2. Project Title: Phasing out CFC 11 through conversion of rigid PU-foam manufactured with the technique of continuous lamination.

3. Sub Sector: Rigid Foamed Plastics

4. Relationship with country program: Country's program calls for fast reduction of 50% CFC-11 consumption in the foam sector and is focusing on continuous lamination industry where five companies consume that very amount. The foam sector's total consumption is confirmed by the Government to be 2400 MT per annum.

The project represents, based on data given by Ministry and confirmed by the Government, an elimination of appr. 50% of the ODP used in foams in the country, representing 1200 MT.

The Government has chosen to consolidate all laminator projects under the same project umbrella. The companies involved are Fabis Industries Co, Iran Steel Parts Industrial Co. Ltd. (I.S.P.), Mammoth Teheran Industrial Complex, F.M. Company, and Urethane Systems Company. The total installed capacity is 6.1 mill m2 per annum and actual production utilized, about 5.0 mill m2.

5. Technology The primary products the participating companies produce are rigid core PU-foam core composite panels and foam insulation boards.

All the participating companies seem to be viable organizations and operating skillfully high capacity continuous production lines and most of them export 15% of their production.

Fabis operates an Elastogran line, ISP a Metecno line, USC a Viking Inverted line, Mammoth a U.K. modified Kornylack (US) line and F. M. Co. a Hennecke line.

The aim of the project is to convert all laminator applications to n-pentane as soon as new technologies have been acquired, machines and equipment installed and the operators trained.

The suggested conversions of the continuous lines are specified to use experienced and established technology. There is no reason to settle with transitional technology. We agree with the justification for Alternative Technology.

The technical life time expectancy of all the lines, after the system has been converted to pentane, is 15 years and exceeds the projected Project Economic Life of 10 years. Because in substance all the sensitive chemical processing components need to be replaced, the Projected Economic Life can be achieved.

All have bulk tanks and tempering systems for main chemical components.

The pentane supply needs to meet the requirements of continuous production system. A bulk storage system is the only practical way of inventorying the amounts needed. Although the country does not have a bulk delivery systems, it is still most probably only of question of time when this delivery form will be available. Meanwhile, the shipment will be done in drums and drums emptied into the bulk tank after they arrive at the plant. A 30 m^3 tank is a feasible size to accept full container deliveries in the future.

The underground tank is a good and safe technical solution. Suggested, detailed features are appropriate.

Pentane discharge pump feeding the pentane to the diaphragm measuring pump assembly are installed in a separate enclosure close to the bulk tank.

A mass flow meter is securing an accurate amount of pentane delivery to the high pressure side of the polyol and high viscosity pentane is mixed to the low viscosity polypreblend with a static, on-line mixer.

All the existing lines have now a multi-component chemical measuring and mixing approach but three lines are using low pressure units and the old Elastogran (Fabis) and Hen-

necke (FM), both made in 1976, utilize the high pressure system.

We also agree that continuous panel production requires constant changes in foam formulation and the respective technology, i.e., multi-component feed is a necessity. Also, a high pressure measuring system with practical auxiliary modules needs to be acquired as suggested for all the lines to establish safe, reliable operational technology.

All the production lines are integrated double belt laminators. The facing materials are fed from double roll forming units or preformed single skin metal panels are used and overlapped (or other flexible facings are used for insulation boards). The foam lay down is conventional in all except at Urethane Systems, which has an inverting foaming application. We agree that this inverted foam processing should be modified for manageable direct, vertical lay down.

The facings are preheated before they are fed to the foam lay down area where a foaming portal and casting mixing head distributes evenly the reaction mix on top of the lower facing. The old infrared preheaters need to be replaced with hot air heating units as suggested and the oscillating traverse unit for the high pressure mixing head needs to be acquired new as well.

The lay down area has to be encapsulated and equipped with an extraction hood and two speed, powered ventilation.

In order to maintain a safe operation environment and comply with regulations related to usage of flammable gases a gas detection system with multiple sensors and alarm center needs to be installed as suggested.

The double belt laminator (and possible side conveyors) secures the dimensional stability of the formed composite panel while the foam cures. The infrared heaters within the laminator have to be replaced with hot air supply as suggested. After the panel emerges from the rear end of the double belt laminator, it will be cut with a cross cutter and panels will be stacked or transferred to dispatch area.

Antistatic environment is required which is achieved by proper floor application as well as grounding of machine

components. Fire protection system is rightly suggested to be included in the installations.

The plan does address the need for operator and maintenance personnel training. We suggest that the training will be a well structured and prepared process. Also, the operator's and preventative maintenance manual is part of the project implementation, which we like very much.

6. Environmental Impact

The project proposes the best present technical solution also in regard to the environmental impact.

7.Project Implementation

All the companies participating have shown in the past success and technical skills in operating continuous lines. Thus, commissioning of the Alternative Technology with a contractual Technical Partner is not necessary and UNIDO's suggested implementation using specialty consultants, qualified General Contractors and supported with UNIDO's own in-house skills seems feasible to us.

We assume that the structural concrete pentane tank pit is included in the construction-related works. Also, all other listed input requirements are all paid by the participating companies, not only the construction-related work.
We note that the technical infrastructure referring to utility supplies (power, shop air, water, drainage) is suggested to be supplied by the companies without cost compensation.

8. Project Cost

During the review process we discussed with the UNIDO's technical specialist and some earlier cost items were adjusted lower. This had a reflection to the total price of about 11%. Although there has been lots of price fluctuation on the international market place regarding polyurethane machines as well, we feel that the total price recommendation is achievable.

8.1 Incremental Cost

We agree upon the incremental cost substantiation but assume that the companies are able to transfer most of the costs into the product prices because 95% of product suppliers are part of the project and the cost increase hit all of them at the same time and with the same magnitude.

8.2 Contingency Fund

The U.S. dollar may have hit the bottom and may appreciate during the fall of 1995 and ease the actual cost pressures. The cost data are reviewed in present U.S. dollars,

and in reflection of about 20% devaluation of the dollar against the major vendor country currencies during the early spring of 1995.

8.3 Itemized Costs

Regarding the budgeted, itemized costs, we would like to make the following observations based on experienced cost data available:

--the costs of pentane bulk tank, supply pump, and safety cabin with ventilation were suggested to be budgeted for no more than $200,000. This is a cost area where the general contractor can well manage costs by increasing the local content.

--the costs of pentane measuring system and complete gas detection system are costed for market price available from major vendors.

--the revised cost for traverse includes a complete oscillating traverse, and a new mixing head which price is also available from major vendors.

--commissioning cost is on the high side but the most difficult to estimate. The budgeted amounts can be accepted, though. The itemized budget takes into consideration that the start-up should be substantially easier for Fabis than with other companies where the total chemical system needs to be changed, tested, and newly commissioned.

9. Implementation timeframe:

There is no project time frame available.

10. Recommendations:

We recommend the project to be approved as revised and now budgeted.

We recommend the project for approval for a total of $5,825,690 where actual itemized costs are $$4,358,500, general consulting and other costs of preparatory services $250,000, and contingency $459,850, and implementation agency overhead $757,340.