UNITED
NATIONS

EP

United Nations
Environment
Programme

Distr.
GENERAL

UNEP/OzL.Pro/ExCom/75/66
30 October 2015

ORIGINAL: ENGLISH

EXECUTIVE COMMITTEE OF
THE MULTILATERAL FUND FOR THE
IMPLEMENTATION OF THE MONTREAL PROTOCOL
Seventy-fifth Meeting
Montreal, 16-20 November 2015

PROJECT PROPOSAL: SOUTH AFRICA

This document consists of the comments and recommendation of the Fund Secretariat on the following project proposal:

<u>Foam</u>

• Demonstration project on the technical and economical advantages of the vacuum assisted injection in discontinuous panel's plant retrofitted from HCFC-141b to pentane	UNIDO

PROJECT EVALUATION SHEET – NON-MULTI-YEAR PROJECT

SOUTH AFRICA

PROJECT TITLE(S)	BILATERAL/IMPLEMENTING AGENCY
(a) Demonstration project on the technical and economical advantages of the vacuum assisted injection in discontinuous panel's plant retrofitted from HCFC-141b to pentane	UNIDO

NATIONAL CO-ORDINATING AGENCY	Ozone Office

LATEST REPORTED CONSUMPTION DATA FOR ODS ADDRESSED IN PROJECT

A: ARTICLE-7 DATA (ODP TONNES, 2014, AS OF OCTOBER 2015)

HCFCs	238.58

B: COUNTRY PROGRAMME SECTORAL DATA (ODP TONNES, 2014, AS OF OCTOBER 2015)

HCFC-22	142.36
HCFC-123	1.33
HCFC-141b	93.5
HCFC-142b	1.71
HCFC-225	1.90

HCFC consumption remaining eligible for funding (ODP tonnes)	193.34

CURRENT YEAR BUSINESS PLAN ALLOCATIONS		**Funding US $**	**Phase-out ODP tonnes**
	(a)	n/a	n/a

PROJECT TITLE:	
ODS use at enterprise (ODP tonnes):	4.18
ODS to be phased out (ODP tonnes):	4.18
ODS to be phased in (ODP tonnes):	n/a
Project duration (months):	24
Initial amount requested (US $):	372,366
Final project costs (US $):	
Incremental capital cost:	418,000
Contingency (10 %):	41,800
Incremental operating cost:	(87,434)
Total project cost:	372,366
Local ownership (%):	100
Export component (%):	n/a
Requested grant (US $):	372,366
Cost-effectiveness (US $/kg):	9.79
Implementing agency support cost (US $):	26,066
Total cost of project to Multilateral Fund (US $):	398,432
Status of counterpart funding (Y/N):	Y
Project monitoring milestones included (Y/N):	Y

SECRETARIAT'S RECOMMENDATION	For individual consideration

PROJECT DESCRIPTION

1. On behalf of the Government of South Africa, UNIDO as the designated implementing agency, has submitted to the 75th meeting a request for funding a demonstration project on the technical and economical advantages of the vacuum assisted injection in discontinuous panel's plant retrofitted from HCFC-141b to pentane at the amount of US $372,366, plus agency support costs of US $26,066.

2. In line with decision 72/40[1] the Executive Committee approved funding for project preparation in the amount of US $40,000, on the understanding that its approval did not denote approval of the project or its level of funding when submitted (decision 74/33(a)(vii)). The proposal is contained in Annex I to the present document.

Project description

3. This project aims to evaluate the advantages of vacuum-assisted injection (VAI) in discontinuous panel production process when using cyclopentane as a foam blowing agent in an enterprise manufacturing commercial refrigeration equipment. VAI technology is expected to provide an advantage to the use of standard cyclopentane which may result in increased thermal efficiency (i.e., lower lambda values); better foam distribution; shorter manufacturing time; and reduction of raw material inputs. These improvements could result in substantial technical improvements in the final products.

4. The project is expected to result in the phase-out of 38.04 metric tonnes (mt) of HCFC-141b, thereby contributing to the country's stage I of its HCFC phase-out management plan (HPMP) reduction target in 2018.

Objectives

5. The project objectives are to:

(a) Demonstrate benefits from the application of the VAI in replacement of HCFC-141b with pentane in terms of insulation properties;

(b) Demonstrate the applicability in the discontinuous panels sector of the technology; and the replicability of the results;

(c) Demonstrate how lower cost structure can be obtained by means of shorter foaming time, lower foam density, lower thermal conductivity; and

(d) Establish the possibility of reducing the cost of exhaust ventilation system in pentane-based plant conversions, thereby reducing incremental capital costs.

Methodology

6. The project will be implemented at Dalucon Refrigeration Products (DRP), an enterprise that had signified its commitment to undertake the demonstration project using one line of their production process. It has also agreed to phase out 38.0 mt of HCFC-141b when the VAI technology is demonstrated as being successful.

[1] The Executive Committee decided *inter alia* to consider at its 75th and 76th meetings proposals for demonstration projects for low-global warming potential (GWP) alternatives to HCFCs within the framework established, and provided criteria for such projects.

7. At the enterprise level, the following will be undertaken: pentane conversion will include the provision of cyclopentane pre-blended polyol; retrofitting or replacing the dosing unit; retrofitting the existing presses to vacuum injection technology using a kit that includes vacuum unit, vacuum plant and vacuum moulds; safety considerations for the use of flammable blowing agent (safety control panel, gas sensors, ventilators); technical assistance; safety report and final certification.

8. Trials and testing of the product will be undertaken, as well as training of the staff in the use and adaptation of the VAI technology. DRP is also expected to provide co-financing for the project (estimated at US $112,200).

Project budget

9. The summary of the project cost is provided in Table 1.

Table 1. Proposed project costs

Cost component	Estimated cost (US $)
Production	
Retrofit of high pressure foaming machine	80,000
Modification of press for VAI*	80,000
Set of side profiles (60 and 80 mm)	20,000
Pre-mixing unit	84,000
Pentane tank and accessories including pump	20,000
Nitrogen supply system	2,000
Plant safety	
Ventilation and exhaust system (fans, piping, ductworks, grounding, electrical boards/connection) complete	95,000
Gas sensors, alarm, monitoring system	52,000
Safety audit / safety inspection and certification	2,000
General works	
Technology transfer / training	25,000
Trials and commissioning	60,000
Sub-total	**520,000**
Contingency	52,000
Grand total	**572,000**
Project costs less share of beneficiary	**459,800**
Incremental operating costs estimate	(87,434)
Total project budget available for the conversion	**372,366**

***** Vacuum unit (U$ 35,000), vacuum plant (U$ 24,000) and vacuum side moulds or profiles (U$ 21,000)

SECRETARIAT'S COMMENTS AND RECOMMENDATION

COMMENTS

10. At the 74th meeting, the Executive Committee agreed that the concept for a demonstration project for South Africa could be provided project preparation funding, noting that the Secretariat had indicated after its review that the project was of lower priority under decision 72/40, as it was for the foam sector. Furthermore, while the project could potentially demonstrate a reduction in operating costs it may increase capital cost. It was further noted that that there was no remaining eligible consumption of HCFC -141b for South Africa as stage I of the HPMP[2] had included the entire conversion of the rigid polyurethane (PU) foam industry, and therefore the 4.18 ODP tonnes used by the enterprise cannot be deducted. As agreed under stage I, South Africa will ban imports and exports of HCFC-141b, both pure

[2] UNEP/OzL.Pro/ExCom/67/29.

or as a component of blended chemicals for use in the production of foams or as solvents or any other application, as of 1 January 2016. The conversion is expected to take place at least one year after the ban has been implemented, suggesting the enterprise would have already converted from HCFC-141b.

11. In reviewing the project, the Secretariat noted that the production line envisaged to be converted was not eligible as it had started operation only in 2012. UNIDO explained there was an inadvertent typographical error in the proposal and that line no. 1 using the Cannon A-100 foaming machine, purchased in 2006, would be used.

12. The Secretariat also noted that VAI technology appears to be used by several enterprises in at least one Article 5 country for various applications.

13. The Secretariat noted that the technology proposed will result in a major technical improvement in the final foam products; however, the technology is independent of the blowing agent being used (e.g., HCFC-141b or other), and would constitute a technology upgrade and, as per decision 18/25(a), would not be eligible. UNIDO emphasized that the use of VAI, in the project will demonstrate a new technology which will enhance cyclopentane-blown technology, and could reduce exposure to dangerous gases (e.g., isocyanate) and improve containment of the flammable blowing agent. UNIDO suggested that the accelerated HCFC phase-out would not have been possible if "avoidable" costs are considered ineligible, and implementation of the Montreal Protocol has brought a number of technical, technological and techno-economic changes, and reiterated their belief that the project is eligible.

14. Noting that stage I of the HPMP for South Africa included the entire conversion of the rigid PU foam industry, the Secretariat inquired whether funding previously approved for DRP would be returned to the Fund upon approval of the project. UNIDO indicated that US $16,400, allocated to the enterprise under stage I, would be returned upon approval of the project. South Africa has no remaining consumption of HCFC-141b eligible for funding.

Conclusion

15. The Executive Committee may wish to consider approval of this project in light of the guidelines and other projects being considered under the allocated window of US $10 million for this purpose.

RECOMMENDATION

16. The Executive Committee may wish to consider:

(a) The demonstration project on the technical and economical advantages of the vacuum assisted injection in discontinuous panel's plant retrofitted from HCFC-141b to pentane in South Africa, in the context of its discussion on proposals for demonstration projects for low global warming potential alternatives to HCFCs as described in the document on the overview of issues identified during project review (UNEP/OzL.Pro/ExCom/75/27);

(b) Approving the demonstration project on the technical and economical advantages of the vacuum assisted injection in discontinuous panel's plant retrofitted from HCFC-141b to pentane in South Africa in the amount of US $372,366 plus agency support costs of US $26,066 for UNIDO in line with decision 72/40; and

(c) Noting the return at the 75th meeting by UNIDO of US $16,400 plus agency support costs of US $1,230 associated with the conversion at Dalucon Refrigeration Products under stage I of the HCFC phase-out management plan for South Africa.

Annex I

PROJECT COVER SHEET

COUNTRY: **South-Africa**

IMPLEMENTING AGENCY: UNIDO

PROJECT TITLE: Demonstration project on the technical and economic advantages of the Vacuum Assisted Injection in discontinuous panel's plant retrofitted from 141b to pentane

PROJECT IN CURRENT BUSINESS PLAN	Yes
SECTOR	Foams and commercial refrigeration
SUB-SECTOR	PU Discontinuous Sandwich Panel
ODS USE IN SECTOR (Average of 2009-10)	850 MT of HCFC-141b
ODS USE AT ENTERPRISES (Average of 2014)	38.04 MT
PROJECT IMPACT	38.04 MT (4.18 ODP tones) of HCFC-141b
PROJECT DURATION	24 months
TOTAL PROJECT COST:	
Incremental Capital Cost	US$ 418,000
Contingency	US$ 41,800
Incremental Operating Cost	US$ -87,434
Total Project Cost	US$ 372,366
LOCAL OWNERSHIP	100%
EXPORT COMPONENT	Nil
REQUESTED GRANT	US$ 372,366
COST-EFFECTIVENESS	US$ 9.79/ kg
IMPLEMENTING AGENCY SUPPORT COST (7.5%)	US$ 27,927
TOTAL COST OF PROJECT TO MULTILATERAL FUND	US$ 400,294
STATUS OF COUNTERPART FUNDING	
PROJECT MONITORING MILESTONES	Included
NATIONAL COORDINATING/ MONITORING AGENCY	Ozone Office

Project summary

HCFC-141b used in the manufacturing of PU Discontinuous Sandwich Panel for insulation at Dalucon, company will be phased-out by converting to Vacuum Assisted Injection (VAI)/Cyclopentane technology. The chosen technology is a novel method for the batch production of insulating panels. These panels for refrigerated trucks, reefers, walk-in refrigerators and industrial cold stores will be using the industrially proven VAI technology. This technology will enhance Cyclopentane blowing technology, which is a definitive alternative under the Montreal Protocol and additionally has a positive impact on climate, in compliance with MOP Decision XIX/6.

Impact of project on Country's Montreal Protocol Obligations

Immediate impact of this individual project is the phase-out of 38.04 MT of HCFC-141b, thereby, contributing to the country's HPMP Stage I reduction target in 2018. With the successful implementation of this project, there will be no consumption of HCFC-141b for foam blowing at Dalucon company.

Prepared by: UNIDO Date: 07 September 2015

Reviewed by: Date: _____________

1 BACKGROUND AND JUSTIFICATION

In 2007, the Parties to the Montreal Protocol agreed to accelerate the phase-out of the hydrochlorofluorocarbons (HCFCs) as the main ozone depleting substances largely because of the substantive climate benefits of the phase-out. In the following years, Parties operating under the Montreal Protocol's Article 5 (mostly developing countries) have formulated their HCFC Phase-out Management Plans (HPMPs) for implementation under financial assistance from the Multilateral Fund for the implementation of the Montreal Protocol (MLF).

The Executive Committee in decision 72/40 agreed to consider proposals for demonstration projects for low-GWP alternatives and invited bilateral and implementing agencies to submit demonstration project proposals for the conversion of HCFCs to low-global warming potential (GWP) technologies in order to identify all the steps required and to assess their associated costs.

In particular, Par (b)(i)a. of the Decision 72/40 indicates that project proposals should propose options to increase significantly in current know-how in terms of a low-GWP alternative technology, concept or approach or its application and practice in an Article 5 country, representing a significant technological step forward.

The use of the vacuum assisted technology for the application of alternatives to HCFCs fully fits the actual ExCom decision on Demonstration project proposals as defined in ExCom Decision 72/40.

The Executive Committee of Multilateral Fund for the Implementation of the Montreal Protocol approved at its 74th meeting held in Montreal, Canada in May 2015, the preparation of the demonstration project for foam and refrigeration sectors. The project was approved for UNIDO implementation in the republic of South Africa.

2 OBJECTIVE

- Demonstrate benefits from the application of the vacuum assisted injection in replacement of HCFC-141b with pentane in term of insulation properties in the panel's sector
- Demonstrate the easy applicability of the technology and, consequently, the replicability of the results
- Demonstrate that lower cost structure can be obtained by means of shorter foaming time, lower foam density, lower thermal conductivity
- Objectively analyze, if the incremental capital cost could be reduced overall in similar future projects by means of using Vacuum Assistance applied in the foaming process automatically used also for suction of flammable and harmful gaseous substances. Thus, providing means of reducing the cost of exhaust ventilation system in the hydrocarbon based plant conversions.

3 METHODOLOGY

Intention of this demonstration project is to provide means for the evaluation of sandwich panels manufactured with new technology in comparison and in regards to;

- Thermal transmittance
    - Measurement of lambda values (thermal conductivity W/mK)
    - Ageing of lambda value

- Mechanical resistance of the panels and its core material
  - Shear strength and shear modulus
  - Compressive strength
  - Cross panel tensile strength
  - Bending moment and wrinkling stress
- Foam density distribution through the foam matrix in various positions of the panels

All tests above will be conducted according to EN 14509 (Self-supporting double skin metal faced insulating panels - Factory made products – Specifications)

3.1 Description of process expectations

Quality of PU panel relies, in most of the application, on the insulation property. Considering the PU physical properties, insulation of final products can be influenced by the: a) thermal conductivity of the blowing agent b) thermal conductivity polymer matrix and c) overall foam structure, its uniformity and homogeneity. These factors of thermal conductivity then determine the thickness of the foam insulation.

Therefore, one of the critical points in the retrofitting from 141b to blowing agents with higher thermal conductivity value (e.g. pentane), is the losses in insulation properties.

Aim of this demonstration project is to evaluate the advantages of Vacuum Assisted Injection (VAI) in discontinuous panel production process, when using Cyclopentane as foam blowing agent instead of HCFC-141b.

The Vacuum injection technology will give advantages to a standard pentane converted plant in term of:

- Decreased lambda value
- Better overall foam structure/ foam distribution
- Decreased demolding time of 30%

The above is expected to generate substantial technical improvements in the final products as well as reduction of operation costs (reduction of time for manufacturing as well as reduction of raw materials imputs).

The project results will be extremely relevant for those sectors where insulation property of final products is crucial and thickness of panels cannot be increased (e.g. panels for refrigerated trucks, refrigerated containers, etc.)

3.2 Detailed description of Methodology

In the selection of the most suitable partner for the application of the vacuum assisted technology, priority was given a company, which is eligible and willing for the pentane conversion.

Dalucon is willing and eligible beneficiary which was selected and the project will include the implementation of:

1- Pentane conversion of the plant
2- Retrofitting kit to vacuum injection technology of the existing presses

The pentane conversion will include: Provision of Cyclopentane preblended polyol, Dosing unit (retrofit or substitute the existing one), Safeties for the use of flammable blowing agent (safety control panel, gas sensors, ventilators…), engineering services for the pentane conversion, safety report and White book and certification (TUV or similar).

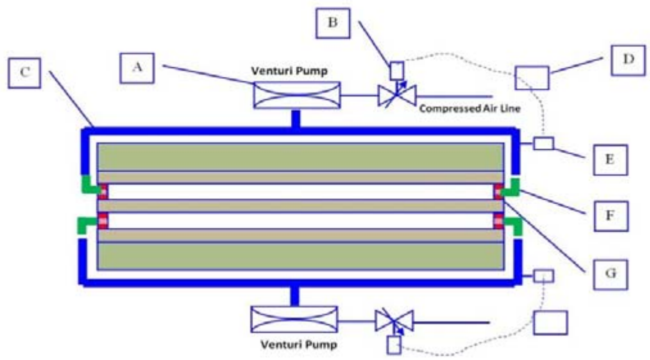
1- Retrofitting kit to vacuum injection technology

The retrofitting kit to vacuum injection technology will include three main components: vacuum unit, vacuum plant and vacuum molds, (as explained below).

<u>VACUUM UNIT</u>

System where the vacuum is generated and controlled.

This includes vacuum pumps, control valves, sensors, control hardware and software. The unit can control the level of vacuum in the cavity, the duration of the process and can store different recipes according to different kind of panel models, with optimized parameters.



<u>VACUUM PLANT</u>

This part is to connect the vacuum up to the cavities where PU foam is injected. Objective is to keep the normal movement of the press and the press platens and reduce costs of retrofitting.

<u>VACUUM MOULDS (SIDE MOULDS OR PROFILES)</u>

Molds are to define the shape of the panel, especially its external shape and dimensions. The scope of supply considers a complete additional set of molds designed to create the vacuum inside the press cavity.

Each side mold will be equipped with connections for connecting the cavity to the vacuum plant, vacuum distribution in the whole cavity and a dedicated injection holes able to maintain the vacuum level even at the insertion of the injection head.

4 COMPANY BACKGROUND

Dalucon Refrigeration Products (DRP) is a family owned business, originally founded by Aldo Martinelli in 1991 with combined company knowledge between its members of over 50 years. Their core focus is on quality and delivery time and therefore DRP has set a benchmark for all of its products that competitors find hard to match. DRP remains a successful business employing over 110 staff members and are situated in Centurion, with over 10,000 m² of manufacturing space available; 800m² office space; 3000 m² storage, assembly and stock area. DRP is situated in Highway Business Park, Centurion, Gauteng – a gateway between Johannesburg and Pretoria, which forms a natural extension to the rest of South Africa.

Address:

P.O. Box 7827
Centurion
0046
Tel: 012 661 8480/1/2
Fax: 012 661 0354
Website: www.dalucon.co.za
Members: A. Martinelli, M. Martinelli, S. Martinelli
Reg No: 2006-089100-23
Vat No: 444 0126 730

4.1 PRODUCTION PROCESS

The raw materials, including polyol blend with HCFC-141b as a pre-blend from the local system house, and isocyanate is being procured in 1,000 liter IBC containers. The polyol-blend, once received, is shifted to the polyol tank of 1,000 liters through pneumatic pump. This tank is kept in the temperature-controlled storage room. The blend of poly and HCFC-141b is taken to the day tank of the foaming machine. Iso is taken in similar process from the tank of 1,000 liter to the Iso day tank of the foaming machine. The plant has 3 foaming lines and 3 units 2 +2 Manni presses. The chemical is poured discontinuously in the panel in the desired quantity to achieve the required foam parameters. The production process is to a large extent automated.

The production cycle is as follows:

- Warehouse and storage for metal coils
- Cutting and profiling to length of the metal sheets
- Assembly of the panels
- Movement to the foaming tables of the press
- Foaming
- Extraction and transport to the warehouse for shipment

The chemical composition of various chemical uses in the manufacturing PU sandwich panels is provided in the table below:

Description	**HCFC 141b**	**Polyol**	**Isocyanate**
%age mixing ratio	11.90%	36.71%	51.39%

The higher than normal content of HCFC-141b is found and proven to provide the optimum thermal transmittance for the panels and enhanced PU mixture flowability, which is required, in particular in the transport vehicle use of insulated sandwich panels.

The description of the foaming machine, press and storage tanks are provided below.

Baseline Equipment

Sr. #	**Type of Equipment**	**Model**	**No.**	**Design Capacity**	**Manufacturer Type**	**Commissioning Year**
1	Polyol Preblend Storage Tank	Dalucon Stainless Steel	2	1000 liter	Dalucon	2006
2	Isocyanate Storage Tank	Dalucon Stainless Steel	2	1000 liter	Dalucon	2006
Foaming Line 1 (Mainly for the refrigerated truck panels) and subject for the conversion and demo project						

Sr. #	Type of Equipment	Model	No.	Design Capacity	Manufacturer Type	Commissioning Year
1	Polyol Day Tank	Cannon, Italy	1	200 liter	Cannon, Italy	2006
2	Isocyanate Day Tank	Cannon, Italy	1	200 liter	Cannon, Italy	2006
3	PU Foaming Machine with mixing heads	Cannon A-100 Basic, Italy	1	100 kg/min	Cannon, Italy	2006
4	Manni 2+2 Press	Manni/Cannon, Italy	1	9.5x1.45 meter	Cannon, Italy	2006
Foaming Line 2 for longer panels						
1	Polyol Day Tank	Cannon, Italy	1	350 liter	Cannon, Italy	2012
2	Isocyanate Day Tank	Cannon, Italy	1	350 liter	Cannon, Italy	2012
3	PU Foaming Machine with mixing heads	Cannon A-200 CMPT, Italy	1	200 kg/min	Cannon, Italy	2012
4	Manni 2+2 Press	Manni/Cannon, Italy	1	13.5x1.45 meter	Cannon, Italy	2012
Foaming line 3						
1	Polyol Day Tank	Cannon, Italy	1	350 liter	Cannon, Italy	2015
2	Isocyanate Day Tank	Cannon, Italy	1	350 liter	Cannon, Italy	2015
3	PU Foaming Machine with L-14 mixing head	Cannon A-100 Basic, Italy	1	100 kg/min	Cannon, Italy	2012
4	Manni 2+2 Press	Manni/Cannon, Italy	1	13.5x1.45 meter	Cannon, Italy	2015

The Cannon A-200 can be converted with lowest cost of Dalucon foaming machines for the pentane duty, and will be moved on the Foaming line 1 during the conversion implementation. Further, the electrical system of the hydraulic control of the presses needs to be adapted to ATEX requirement.

Few photographs taken at the plant is provided below:




4.2 ANNUAL PRODUCTION PROFILE IN 2014

Panel thickness mm	Capacity m2 / 8 hrs	Share of production %	PU m3	PU kgs	PU total kg/a	HCFC-141b kg	HCFC-141b Total / a
40	500	10,0	2,0	83,2	20800,0	9,9	2475
50	500	5,0	1,3	52,0	13000,0	6,2	1547
60	450	30,0	8,1	337,0	84240,0	40,1	10025
80	400	30,0	9,6	399,4	99840,0	47,5	11881
100	380	20,0	7,6	316,2	79040,0	37,6	9406
125	350	5,0	2,2	91,0	22750,0	10,8	2707
		100,0	30,7	1278,7	319670,0	152,2	38041

5 TECHNOLOGY OPTION FOR VACUUM ASSISTED INJECTION TECHNOLOGY (VAI)

5.1 Overview of alternatives to HCFC-141b for PU foam application

HCFC-141b has mainly been used as a blowing agent in various formulations in the manufacturing of PU foam for the production of PU sandwich panels for various sizes and thickness in South-Africa.

Factors that influence the technology selection include consideration of the following major features for PU foam.

- Mechanical properties
- Density
- Insulation properties
- Costs

5.2 Alternate Technologies Considered

In accordance with the 2014 report of the rigid and flexible foams technical options committee, there are a number of alternatives that are available to replace the use of HCFC 141b in rigid polyurethane foam. Several foaming technologies including the following are used as alternate technology.

- Cyclopentane
- HFC-245fa
- HFC-365mfc/227ea
- HFC-134a
- Methyl formate
- CO_2 (Water)
- u-HFC
- Liquid unsaturated HFC/HCFC (HFOs) as emerging technology

The below table provides an overview of the blowing agents that has been used in various sub-sectors of foam sector.

Sector	***HCFCs***	***HFCs***	***HCs***	***HCOs***	***HFOs***	***CO2-based***
PU Appliances	HCFC-141b HCFC-22	HFC-245fa HFC-365mfc/227ea	cyclo-pentane cyclo/iso-pentane	Methyl Formate	HFO-1233zd(E) HFO-1336mzzm(Z)	CO2 (water)*
PU Board	HCFC-141b	HFC-365mfc/227ea	n-pentane cyclo/iso pentane		HFO-1233zd(E) HFO-1336mzzm(Z)	
PU Panel	HCFC-141b	HFC-245fa HFC-365mfc/227ea	n-pentane /iso pentane		HFO-1233zd(E) HFO-1336mzzm(Z)	CO2 (water)*
PU Spray	HCFC-141b	HFC-245fa HFC-365mfc/227ea			HFO-1233zd(E) HFO-1336mzzm(Z)	CO2 (water)* Super-critical CO2
PU In-situ / Block	HCFC-141b	HFC-245fa HFC-365mfc/227ea	n-pentane cyclo/iso pentane		HFO-1233zd(E) HFO-1336mzzm(Z)	CO2 (water)*
PU Integral Skin	HCFC-141b HCFC-22	HFC-245fa HFC-134a		Methyl Formate Methylal		CO2 (water)*

Sector	***HCFCs***	***HFCs***	***HCs***	***HCOs***	***HFOs***	***CO2-based***
XPS Board	HCFC-142b HCFC-22	HFC-134a HFC-152a		DME	HFO-1234ze(E)	CO2 CO2/ethanol
Phenolic	HCFC-141b	HFC-245fa HFC-365mfc/227ea	n-pentane cyclo/iso pentane		HFO-1233zd(E) HFO-1336mzzm(Z)	

*CO_2 (water) blown foams rely on the generation of CO_2 from reaction of isocyanate with water in the PU system itself.

The pros & cons for commercially available options as well as emerging options as highlighted in the UNEP 2014 report of the rigid and flexible foams technical options committee for the manufacturing of PU foam are provided in the below tables:

<u>Commercially Available Options</u>

Option	**Pros**	**Cons**	**Comments**
Cyclopentane & n-Pentane	Low GWP Low operating costs Good foam properties	High flammable	High incremental capital cost, may be uneconomic for SMEs
HFC-245fa, HFC-365mfc/227ea, HFC-134a	Non-flammable	High GWP	Low incremental Capital Cost
	Good foam properties	High Operating Cost	Improved insulation (cf. HC)
CO2 (water)	Low GWP Non-flammable	Moderate foam properties -high thermal conductivity-	Low incremental Capital Cost
Methyl Formate/Methylal	Low GWP Flammable although blends with polyols may not be flammable	Moderate foam properties -high thermal conductivity-	Moderate incremental capital cost (corrosion protection recommended)

<u>Emerging Options</u>

Option	**Pros**	**Cons**	**Comments**
Liquid Unsaturated HFC/HCFC (HFOs)	Low GWP	High operating costs	First expected commercialization in 2013
	Non-flammable	Moderate operating costs	Trials in progress
			Low incremental capital cost

The Indicative assessment of criteria for commercially available options as well as emerging alternatives in PU foam is provided in the table below:

<u>Assessment of criteria for commercially available options</u>

	c-pentane	i-pentane n-pentane	HFC-245fa	HFC365mfc/ 227ea	CO_2 (water)	Methyl Formate
Proof of performance	+	++	++	++	++	+
Flammability	---	---	++	+(+)	+++	--
Other Health & Safety	0	0	+	+	-	0
Global Warming	+++	+++	--	---	++	++
Other Environmental	-	-	0	0	++	-
Cost Effectiveness (C)	--	---	++	++	++	0
Cost Effectiveness (O)	++	+++	--	--	+	+
Process Versatility	++	++	+	++	+	+

Assessment of criteria for Emerging Technology options

	HFO-1234ze(E)	HFO-1336mzzm(Z)	HFO-1233zd(E)
	Gaseous	liquid	Liquid
Proof of performance	0	+	+
Flammability	++	+++	+++
Other Health & Safety	+	+	+
Global Warming	+++	+++	+++
Other Environmental	+	+	+
Cost Effectiveness (C)	++	++	++
Cost Effectiveness (O)	--	--	--
Process Versatility	+	+	+

IOC comparison between major alternatives

IOC	HCFC-141b			HFO-1233zd			c-pentane / vacuum			Water-blown / Formic Acid		
	Formula	%	Cost/kg	Formula	%	Cost/kg	Formula	%	Cost/kg	Formula	%	Cost/kg
Polyol	100	36,71%	2,70	100	38,17%	2,70	100	37,88%	2,70	100	37,95%	2,70
B.A	32,42	11,90%	2,70	22	8,40%	13,00	9	3,41%	2,68	3,5	1,33%	2,70
MDI	140	51,39%	2,50	140	53,44%	2,50	155	58,71%	2,50	160	60,72%	2,50
Total	**272,42**	**100,00%**	**2,60**	**262**	**100,00%**	**3,46**	**264**	**100,00%**	**2,58**	**263,5**	**100,00%**	**2,58**
Thermal conductivity mW/mK			**23**			**21**			**23**			**31**
Foam density			42			42			37,8			
Equivalent cost USD			**2,60**			**3,16**			**2,32**			**3,48**
Total PU consumption 2015	319670	38,04	830253	319670		1009300	287703		742819	319670		1110996
IOC / year USD						**179047**			**-87434**			**280744**

5.3 Selection of alternative technology for the VAI

The technology chosen has been Cyclopentane due to the following:

- Experience has been gained and training, technology options costs are lower
- Cyclopentane is a well-established technology with zero ODP and is a low GWP
- The existing (VAI) foam formulations in the manufacture of domestic refrigerators and sandwich panels are based on the utilization of c-pentane as core foaming agent

6 Activities required for conversion

6.1 Modification of production process

The following modification and replacements in the existing process is assumed to implement the conversion.

- Retrofit of existing foam dispenser where applicable
- Replacement of pre-mixing unit, however, at Dalucon, the c-pentane polyol preblend will be supplied as preblend from the local nearby System House
- Modification of Press
- Hydrocarbon tank and accessories (piping and pumps, ventilation), however, at Dalucon, the c-pentane polyol preblend will be supplied as preblend from the local nearby System House
- Buffer tank for polyol, however, at Dalucon, it will not be required, since the storage tank of polyol blend will act as buffer tank
- Nitrogen supply system

- The following features need to be introduced

  - Ventilation system
  - Safety system controls
  - Adaptation of foaming equipment controls (software) and electrical equipment in order to comply with ATEX or equivalent safety regulations
  - Suitability of pressure equipment to comply with the regulations
  - Control of emissions of the equipment used which includes magnetic joints on electrical motors and EX parts for all equipment in contact with the liquid
  - Safety verification by the supplier or independent entity like TUV.

The training of the beneficiary staff for the adaptation of new technology is covered in this project. Further, the trials and testing of the product is also covered. Once the plant is put in commercial operation, the safety verification by the safety certifier shall be carried out and is being covered in the cost of the project.

After the successful completion of testing and commercial production, the removed equipment will be destroyed.

7 PROJECT COST

7.1 Project Cost as per MP Guideline decision 55/47

The conversion plan and costs are following the guidelines of decision 55/47 to the extent possible. Based on table **I**.1 (Sectoral cost-effectiveness threshold values established by the Executive Committee) of above referenced guideline, the sectoral cost effectiveness threshold value established by the executive committee for the PU foam is US$ 7.83 per kg.

Recently, in accordance with clause 162 (C) (i, iii & iv) of UNEP document 3 UNEP/OzL.Pro/ExCom/74/56 (Decision 74/50), the cost effective threshold is US$7.83/kg for phasing out of HCFCs in Stage-II HPMP projects. Further, the following is stipulated:

- Funding of up to a maximum of 25 per cent above the cost-effectiveness threshold is available for projects when needed for the introduction of low-GWP alternatives; however, for SMEs in the foam sector with consumption of less than 20 metric tonnes, the maximum would be up to 40 per cent above the cost-effectiveness threshold.

The cost effective threshold for this sub-sector is US$9.79/ kg (US$7.83+25%) for consumption greater than 20 metric ton and US$10.96/ kg (US$7.83+40%) for consumption less than 20 metric ton. In this demonstration project at Dalucon, the cost-effectiveness threshold of US$9.79/kg is applied.

7.2 Incremental capital cost

The foaming line 1 shall be converted to the use of Cyclopentane from HCFC-141b with VAI technology. Funds are requested to cover the modification, provision of the VAI Kit and retrofit of existing A-200 CMPT foaming machine and the provision of necessary equipment, accessories as well as technology transfer, training, trials and commissioning. The ICC calculation is based on Appendix-I of the above referenced guidelines. These guidelines are based on 2008 cost.
While calculating the incremental capital cost for each plant, the cost provided for 2008 basis has to be adjusted according to the inflation rate as a matter of acceptance of principles of market economy, as also manufacturers of equipment adjust to inflation.
The ICC of this project is calculated using only the base cost figures as provided in the guideline 55/47.

All cost in US$

	Guidelines US$	Project cost US$	With cost sharing US$
Production			
Retrofit of High pressure foaming machine A-CMP 200	100 000	80 000	80 000
Modification of press for VAI (detailed in table XX in project document)	80 000	80 000	80 000
Set of side profiles (60 and 80 mm)	20 000	20 000	20 000
Premixing unit	84 000	84 000	0
Hydrocarbon tank and accessories including polyol-pentane drum pump	55 000	20 000	20 000
Buffer tank for pentane-polyol tank 1,000 liters	100 000	0	0
Nitrogen supply system	15 000	2 000	3 000
Plant Safety			
Ventilation and exhaust system (fans, piping, ductworks, grounding, electrical boards/connection) complete	115 000	95 000	80 000
Gas sensors, alarm, monitoring system for entire plant	57 000	52 000	48 000
Fire protection/control system for the plant	10 000	0	0
Lightning protection and grounding	15 000	0	0

Antistatic floor	5 000	0	0
Safety Audit / Safety Inspection and certification	20 000	2 000	2 000
Stand by electric generator	15 000	0	0
General Works			
Civil work / Plant modifications	25 000	0	0
Technology transfer / training	25 000	25 000	25 000
Trials and commissioning*	60 000	60 000	60 000
Total	801 000	520 000	418 000
Contingency	80 100	52 000	41 800
Grand Total	**881 100**	**572 000**	**459 800**
IOC estimate (see para 7.3)			-87 434
Total project budget available for the conversion US$			**372 366**

***Trials and commissioning include testing mentioned in the methodological chapter(3):**

- Thermal transmittance
    - Measurement of lambda values (thermal conductivity W/mK)
    - Ageing of lambda value
- Mechanical resistance of the panels and its core material
    - Shear strength and shear modulus
    - Compressive strength
    - Cross panel tensile strength
    - Bending moment and wrinkling stress
- Foam density distribution through the foam matrix in various positions of the panels

7.3 Incremental operating cost

In calculating the Incremental Operating Costs it has been assumed based on the commercial Vacuum Assisted Injection (VAI) projects that:

- The use of Cyclo-Pentane is only about 28.6% of the use of HCFC 141b.

- The conversion of technology to VAI / Cyclo-pentane system shall reduce the density of the foam to 90% of present HCFC-141b based formulations.

Incremental operating cost related to the conversion of the foaming technology was calculated based on the formulations as applicable at Dalucon. Current prices are as follows:

- HCFC-141b: US$ 2.70/kg
- Polyol: US$ 2.70/ kg
- Isocyanate: US$ 2.50/ kg
- Cyclo-Pentane: US$ 2,68/kg (in preblend)

Chemicals	**R-141b system**			**VAI/Cyclo-pentane system**		
	Amount Kg	**Price US$/kg**	**Cost US$**	**Amount Kg**	**Price US$/kg**	**Cost US$**
Polyol	0.367	2.70	0.99	0.379	2.70	1.02
Isocyanate	0.514	2.50	1.28	0.587	2.50	1.47
Blowing agent	0.119	2.70	0.32	0.034	2.68	0.09
Total	**1.000**		**2.60**			**2.58**
				Difference per kg		**-0.02**

The IOC is calculated based on 1 year as provided in the table below

	Before conversion	**Year I**
Foam production [kg]	319,670	287,703
Total annual cost of chemicals used	830,253	742,819
Cost difference per annum - Total IOC, US$		-87,434

7.4 Total project cost

	US$
Incremental Capital Cost (ICC)	459,800
Incremental Operating Cost (IOC)	-87,434
Total Cost	**372,366**

7.5 Cost Effectiveness

The total HCFC-141b planned to be phased out in this demonstration project is 38.04 MT and grant requested is **US$ 372,366**. Thus, representing of Cost Effectiveness of US$9,79/kg phased out of HCFC-141b.

8 GLOBAL WARMING IMPACT ON THE ENVIRONMENT

8.1 Project Impact on the Environment

The project impact on the environment was studied for both the chemicals i.e. HCFC 141b and Cyclopentane. The CO_2 emission before conversion (using HCFC 141-b as blowing agent with Global Warming Potential of 713) is expected as 27,123 metric ton per year whereas after conversion to Cyclopentane with GWP 25, it is estimated 245 metric ton per year. The net impact on the environment is positive. The CO_2 emission is expected to be reduced by 26,878 MT after implementing the new technology. The net effect is provided in the table below:

Name of Industry	**Substance**	**GWP**	**Phase out amount MT/ year**	**Total equivalent warming impact CO2 eq. MT/ year**
Before Conversion				
Total CO_2 emission in M tonnes	HCFC 141b	713	38.04	27,123
After Conversion				
Total CO_2 emission in M tonnes	Cyclopentane	25	9.81	245

Net Impact				-26,878

9 PROJECT IMPLEMENTATION MODALITIES

9.1 Implementation structure

The National Ozone Unit reporting to the Department of Environmental Affairs, Government of South-Africa is responsible for the overall project, coordination, assessment and monitoring. The National Ozone Unit (NOU) cleared the Letter of Commitments with Dalucon DRP. NOU will clear Agreement on Implementation Procedures with the counterpart and other partners of this project (if any), to ensure that project objectives are met. Terms of Reference (TOR) for the implementation of this demonstration project will be prepared by UNIDO in close collaboration with his technology originator and provider(s) of equipment and Dalucon (recipient company). Main objective of this Plan is to ensure project successful implementation and provision of process replication to other companies in South-Africa and other Article 5 countries.

UNIDO as the implementing agency is responsible for the financial management of the respective grant. UNIDO will also assist the Dalucon in equipment procurement, technical information update, monitoring the progress of implementation, and reporting to the ExCom. The counterpart/enterprise is responsible to achieve the project objective by providing financial and personnel resources required for smooth project implementation. Financial management will be administered by UNIDO following UNIDO's Financial Rules and Regulation.

9.2 Working arrangement for implementation

After the approval of the project by the Executive Committee, the working arrangement will be signed by the above parties, where the roles and responsibilities of each party are detailed.

9.3 Modification of production process

Procurement of equipment required for the production line modification will be done through a single source purchase, however according to respective regulation stipulated by UNIDO's Financial Rules and Regulations. Smaller equipment and parts may be procured locally, if local procurement is found to be more economical. Local procurement will also be done based on UNIDO's Financial Rules and Regulations. This applies also for contracting with contractors for provision of technical services. Terms of references and technical specifications for the procurement of contracts and equipment will be prepared by UNIDO in consultation and agreement with the enterprise and the NOU.

9.4 Project monitoring

Project monitoring is done by the executing and implementing agencies through regular missions to the project site and continuous communications through e-mails and telephone/skype discussion. Occasional visits and communication by the NOU are also to be done to ensure adequate project implementation.

9.5 Project completion

Project completion report will be submitted by UNIDO within 6 months after project completion. Necessary data and information for the preparation of the project completion report is to be provided by the enterprise/NOU.

9.6 Timetable for implementation

Milestone	2015	2016				2017				2018			
	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
Approval													
Working arrangement													
Preparation of TORs													
Bidding & contract award													
Equipment Delivery													
Modification of line													
Staff training													
Safety certificate													
Project completion													

In conformity with the Montreal Protocol Executive Committee's decision 23/7 on standard components on monitoring and evaluation, milestones for project monitoring are proposed as follows:

Sr. #	Milestone	Months
1	Project approval	-
2	Start of implementation	1
3	Grant agreement submitted to beneficiary	2
4	Grant agreement signature	3
5	Bids prepared and requested	9
6	Contracts awarded	14
7	Equipment delivered	20
8	Commissioning and trial runs	22
9	De-commissioning/destruction of redundant baseline equipment	24
10	Submission of project completion report	24-30