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COMITÉ EJECUTIVO DEL FONDO MULTILATERAL
PARA LA APLICACIÓN DEL
PROTOCOLO DE MONTREAL
Septuagésima sexta Reunión
Montreal, 9 – 13 de mayo de 2016

PROPUESTA DE PROYECTO: COLOMBIA

Este documento contiene las observaciones y recomendaciones de la Secretaría del Fondo sobre la siguiente propuesta de proyecto:

Espumas

- Proyecto de demostración para validar el uso de hidrofluoroolefinas en la fabricación de paneles discontinuos en países amparados en el Artículo 5 mediante el desarrollo de formulaciones económicas. PNUD

COLOMBIA

TÍTULO(S) DEL PROYECTO	ORGANISMO BILATERAL / DE EJECUCIÓN
a) Proyecto de demostración para validar el uso de hidrofluoroolefinas en la fabricación de paneles discontinuos en países amparados en el Artículo 5 mediante el desarrollo de formulaciones económicas	PNUD

ORGANISMO NACIONAL DE COORDINACIÓN	Ministerio para el Medio Ambiente, Dependencia Nacional del Ozono

DATOS MÁS RECIENTES DE CONSUMO DE LOS SAO OBJETO DEL PROYECTO

A: DATOS DEL ARTÍCULO 7 (TONELADAS PAO, 2014, DATOS A MARZO DE 2016)

HCFC	156,03

B: DATOS SECTORIALES DEL PROGRAMA DEL PAÍS (TONELADAS PAO, 2014, DATOS A MARZO DE 2016)

HCFC-22	67,4
HCFC-123	2,1
HCFC-141b	86,3
HCFC-142b	0,3

Consumo de HCFC aún admisible para financiación (toneladas PAO)	146,63

ASIGNACIONES DEL PLAN DE ACTIVIDADES DEL AÑO EN CURSO		Financiación (millones de $EUA)	Toneladas PAO a eliminar
	a)	n/c	n/c

TÍTULO DEL PROYECTO	
Uso de SAO en empresas (toneladas PAO)	13,27
SAO a eliminar (toneladas PAO)	n/c
SAO a incorporar (toneladas PAO)	0,00
Duración del proyecto (meses)	12
Monto inicialmente solicitado ($EUA)	459.450
Costo final del proyecto ($EUA)	
Costos adicionales de capital	
Imprevistos (10%)	
Costo adicional de explotación	
Supervisión del proyecto y elaboración de informes	
Costo total del proyecto	248.380
Propiedad nacional (%)	100%
Componente de exportación (%)	0%
Subvención solicitada ($EUA)	248.380
Rentabilidad ($EUA/kg)	n/c
Gastos de apoyo del organismo de ejecución ($EUA)	22.354
Costo total del proyecto para el Fondo Multilateral ($EUA)	270.734
Financiación a cargo de la contraparte (sí/no)	Sí
Se prevé el seguimiento de los hitos del proyecto (sí/no)	Sí

RECOMENDACIÓN DE LA SECRETARÍA	Para consideración individual

DESCRIPCIÓN DEL PROYECTO

Antecedentes

1. El PNUD, en nombre del Gobierno de Colombia, presentó ante la 74ª reunión un proyecto de demostración para validar el uso de hidrofluoroolefinas (HFO) para la fabricación de paneles discontinuos y espumas pulverizadas en países amparados en el Artículo 5 mediante el desarrollo de formulaciones económicas, a un costo de 459.450 $EUA más 32.162 $EUA en concepto de gastos de apoyo del organismo, de acuerdo con la presentación original.[1] Tras deliberar sobre la cuestión, el Comité Ejecutivo decidió, en vista de la decisión 74/21[2], que podía volver a presentarse el proyecto a la 75ª reunión (decisión 74/38).

2. En respuesta a la decisión 74/38, el PNUD presentó nuevamente a la 75ª reunión el proyecto de demostración mencionado, con un costo total de 335.280 $EUA integrado por 282.480 $EUA más gastos de apoyo del organismo por 19.774 $EUA que se solicitaron al Fondo Multilateral[3]. Tras analizarse la cuestión en un grupo de contacto formado para considerar todos los proyectos dirigidos a demostrar tecnologías con bajo potencial de calentamiento atmosférico que se presentaron a la 75ª reunión, el Comité Ejecutivo decidió diferir la consideración de los siete proyectos de demostración, incluido el proyecto de espumas para Colombia, para tratarlos en la 76ª reunión (decisión 75/42).

3. En respuesta a la decisión 75/42, el PNUD ha presentado nuevamente a la 76ª reunión el proyecto de demostración arriba mencionado de la 75ª reunión. La propuesta de proyecto que se presentó figura en el Anexo I de este documento.

Objetivos del proyecto

4. Diversos países amparados en el Artículo 5 han reconvertido sus principales empresas fabricantes de espumas para utilizar agentes espumantes formulados con hidrocarburos durante la etapa I de sus planes de gestión de la eliminación de los HCFC (HPMP). Durante la etapa II, estos países deben ocuparse del consumo remanente de HCFC-141b que utilizan las microempresas y las pequeñas y medianas empresas (PME) en la producción de paneles discontinuos, espumas pulverizadas y revestimientos integrales, las cuales no disponen de los recursos técnicos y económicos para utilizar agentes espumantes inflamables en condiciones de seguridad. Los HFO desarrollados recientemente han demostrado un mejor comportamiento térmico en las aplicaciones para fabricación de espumas rígidas de poliuretano (PU) que los HFC saturados con alto potencial de calentamiento atmosférico; sin embargo, su incorporación se ve limitada por tener un alto costo por unidad y por la falta de experiencia de uso en los países amparados en el Artículo 5.

5. A partir de estas consideraciones, el proyecto de demostración se propone validar las formulaciones de PU para paneles discontinuos con contenido reducido de HFO (HFO-1233ze(E) y HFO-1336mzzm(z)), optimizar la relación costo/prestación a fin de lograr un comportamiento térmico similar al de las formulaciones con HCFC-141b y efectuar un análisis de costos de las diferentes formulaciones de HFO/agua frente a los sistemas formulados a base de HCFC-141b. Los resultados de este proyecto podrían replicarse en otras aplicaciones de espumas en Colombia y otros países amparados en el Artículo 5.

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[1] UNEP/OzL.Pro/ExCom/74/25.

[2] El Comité Ejecutivo decidió, entre otras cosas, permitir que se presente un número limitado de solicitudes adicionales para la preparación de proyectos de demostración de tecnologías con bajo potencial de calentamiento atmosférico en el sector de fabricación de equipos de climatización, que se presenten nuevamente dos proyectos de demostración que ya están totalmente elaborados (incluido el de Colombia) y estudios adicionales de factibilidad sobre refrigeración distrital a la 75ª reunión.

[3] UNEP/OzL.Pro/ExCom/75/42.

6. La empresa participante es Espumlatex[4], una proveedora de sistemas que tiene instalados 18 tanques de mezclado y dispone de un laboratorio de control de calidad certificado donde se ensayan las propiedades básicas de los sistemas de PU (densidad de subida libre, reactividad, conductividad térmica de la espuma, resistencia a la compresión, estabilidad dimensional y envejecimiento artificial).

Ejecución del proyecto

7. Se desarrollarán las siguientes actividades:

a) Elaboración del protocolo experimental (procedimiento y condiciones de las aplicaciones, propiedades que se ensayarán y método de ensayo) y preparación de muestra de espuma en Espumlatex utilizando una lanza de alta presión y un molde convencional;

b) Adquisición de equipamiento adicional de laboratorio para medir la friabilidad de la espuma (un factor esencial en razón del contenido de urea logrado en las formulaciones de PU con alto contenido de agua) y ensayar propiedades críticas de la espuma (conductividad térmica, resistencia a la compresión, estabilidad dimensional, etc.);

c) Ensayos en el terreno en ABC Poliuretanos, empresa local fabricante de paneles discontinuos, con una eliminación de 4,00 toneladas métricas (tm) (0,44 toneladas PAO) de consumo de HCFC-141b; y

d) Dos talleres de difusión para la industria colombiana y latinoamericana.

8. Se prevé que el proyecto tenga una duración de 12 meses.

Presupuesto del proyecto

9. Los costos del proyecto conforme a la presentación original a la 76ª reunión se detallan en el Cuadro 1.

[4] En la transición del CFC-11 a los HCFC se ejecutaron dos proyectos en Espumlatex: “Financiación retroactiva para la reconversión de CFC-11 a tecnología a base de agua en la fabricación de espuma moldeada flexible y revestimientos integrales en Espumlatex-Promicolda” (COL/FOA/32/INV/49) y “Reconversión de CFC-11 a HCFC-141b y tecnología a base de agua en la fabricación de diversas aplicaciones de espumas de PU en 25 pequeñas empresas centradas en torno al proveedor de sistemas en Espumlatex” (COL/FOA/32/INV/48). Además, Espumlatex se desempeñó en 2011-2013 como proveedor local de sistemas para el proyecto de demostración de la tecnología de CO_2 supercrítico para espumas pulverizadas en el marco de un proyecto bilateral entre Japón y Colombia con Achilles Corp. (COL/FOA/60/DEM/75)

Cuadro 1. Costo del proyecto por actividad ($EUA)

Descripción	Costo unitario	Cantidad	Financiación	Contribución	Costos totales
Asistencia técnica internacional	30.000	1	30.000		30.000
Planificación	5.000	1	5.000		5.000
Desarrollo de la formulación	110.000	1	110.000	36.000	74.000
Equipo de ensayo de friabilidad	10.000	1	10.000		10.000
Ensayo de espumas			30.000	10.000	20.000
Material para desarrollo de la formulación	240	20	4.800		4.800
Material para ensayo en el terreno	4	1.000	4.000		4.000
Ensayo de espumas/evaluación	5.000	1	5.000	2.000	3.000
Difusión de la tecnología	20.000	2	40.000		40.000
Consultor local	36.000	1	36.000		36.000
Supervisión del proyecto e informes	30.000	1	30.000		30.000
Subtotal			304.800	48.000	256.800
Imprevistos (10 %)			30.480	4.800	25.680
Costos totales			335.280	52.800	282.480

OBSERVACIONES Y RECOMENDACIONES DE LA SECRETARÍA

OBSERVACIONES

10. La Secretaría destacó complacida que el PNUD había elaborado la propuesta del proyecto presentada en primer lugar a la 74ª reunión y posteriormente a las 75ª y 76ª reuniones sin recibir financiación preparatoria del Fondo Multilateral. También observó que, de conformidad con la decisión 74/21 c)[5], la propuesta fue revisada para ocuparse únicamente de paneles discontinuos, con lo que se redujo la solicitud de subvención a 282.480 $EUA en lugar del monto original solicitado de 459.450 $EUA para paneles discontinuos y espumas pulverizadas. Se ha estimado que la contribución a cargo de Espumlatex es de 52.800 $EUA.

11. Las conversaciones entre la Secretaría y el PNUD respecto al proyecto de demostración presentado a las 74ª, 75ª y 76ª reuniones se centraron principalmente en la posible superposición de actividades incluidas en la etapa II del HPMP para Colombia[6] que se presentó a la 75ª reunión, donde se proponía encarar la completa eliminación del consumo de HCFC-141b que se utiliza como agente espumante, y el proyecto de demostración propuesto. Sobre este punto, el PNUD aclaró que el trabajo de desarrollo a cargo de Espumlatex que se proponía en la etapa II del HPMP obedecía a satisfacer los requisitos específicos de varios clientes de espumas en distintas aplicaciones, incluidos los paneles discontinuos, mientras que el proyecto de demostración tenía por objetivo atender a los requisitos generales para paneles discontinuos. Ambos desarrollos, bien que de distinta naturaleza, son necesarios. Dado que cada proveedor de sistemas tiene sus propias formulaciones que responden a los requisitos específicos de sus clientes, el proyecto de demostración serviría como guía general del desempeño de los sistemas con HFO reducidos. Ofrecería una prueba experimental como punto de partida para esa optimización.

12. En conversaciones adicionales sobre la racionalización de los costos, el PNUD accedió a ajustar más el costo total, llegando a una solicitud de 248.380 $EUA más gastos de apoyo del organismo. La Secretaría observó además que en la orientación fijada por el Comité Ejecutivo para que se presenten las

[5] En la decisión 74/21 c) se pidió a los organismos bilaterales y de ejecución que racionalizaran los costos de los proyectos de demostración para posibilitar la aprobación de un mayor número de proyectos de demostración con los 10 millones $EUA de financiación disponible, como se dispone en la decisión 72/40, y que siguieran investigando otras fuentes de financiación adicional.

[6] UNEP/OzL.Pro/ExCom/75/42.

mejores propuestas de proyectos de demostración se indica que los proyectos también debían considerar la distribución regional y geográfica (párrafo 97 e) del documento UNEP/OzL.Pro/ExCom/73/62). En la 75ª reunión, el Comité Ejecutivo aprobó el proyecto de demostración para el uso de R-290 (propano) como refrigerante alternativo en la fabricación de equipos de climatización comercial en Industrias Thermotar Ltda de Colombia.

Conclusión

13. La Secretaría toma nota de que el proyecto propone demostrar una alternativa con bajo potencial de calentamiento atmosférico en reemplazo del HCFC-141b para la producción de paneles discontinuos, una aplicación ampliamente utilizada en diversos países amparados en el Artículo 5. El proveedor de sistemas Espumlatex ha demostrado la seriedad de su compromiso para ejecutar el proyecto contribuyendo a su financiación por un valor estimado en más de 211.000 $EUA. Los ensayos en el terreno en el fabricante local de paneles discontinuos darán por resultado la eliminación de 0,44 toneladas PAO de consumo de HCFC-141b; sin embargo, este consumo no puede deducirse del consumo remanente de HCFC de Colombia admisible para recibir financiación, dado que el Gobierno se ha comprometido a eliminar completamente su consumo de HCFC-141b mediante la ejecución de la etapa II de su HPMP. En la 75ª reunión, el Comité Ejecutivo aprobó el proyecto de demostración para el uso de HC-290 (propano) como refrigerante alternativo en la fabricación de equipos de climatización comercial en Industrias Thermotar Ltda. de Colombia.

RECOMENDACIONES

14. El Comité Ejecutivo podrá estimar oportuno:

a) Considerar el proyecto de demostración para validar el uso de hidrofluoroolefinas en la fabricación de paneles discontinuos en países amparados en el Artículo 5 mediante el desarrollo de formulaciones económicas en Colombia cuando proceda a analizar las propuestas de proyectos de demostración de alternativas a los HCFC que tengan un bajo potencial de calentamiento atmosférico, como se describe en el documento donde se reseñan las cuestiones identificadas durante el examen de proyectos (UNEP/OzL.Pro/ExCom/76/12); y

b) Decidir si aprueba o no el proyecto de demostración para validar el uso de hidrofluoroolefinas para la fabricación de paneles discontinuos en países amparados en el Artículo 5 mediante el desarrollo de formulaciones económicas en Colombia, de conformidad con la decisión 72/40.

Annex I

PROJECT COVER SHEET

COUNTRY: Colombia **IMPLEMENTING AGENCY:** UNDP

PROJECT TITLE: Demonstration project to validate the use of Hydrofluoro Olefins (HFO) for discontinuous panels in Article 5 parties through the development of cost effective formulations

PROJECT IN CURRENT BUSINESS PLAN	
SECTOR	Foam
SUB-SECTOR	Rigid PU (discontinuous panels)
ODS USE IN SECTOR (2014)	668 metric tons (HCFC-141b)
ODS USE AT ENTERPRISE (2014)	120.6 MT of HCFC-141b
PROJECT DURATION	12 months
TOTAL PROJECT COST:	
Incremental Capital Cost	US $ 304,800
Contingency	US $ 30,480
Total Project Cost	US $ 335,280
LOCAL OWNERSHIP	100%
EXPORT COMPONENT	0 % to non-A5
REQUESTED GRANT	US $ 282,480
COST-EFFECTIVENESS	Non applicable
IMPLEMENTING AGENCY SUPPORT COST	US $ 19,774
TOTAL COST OF PROJECT TO MULTILATERAL FUND	US $ 302,254
STATUS OF COUNTERPARTS FUNDING	Received letter of commitment Included
NATIONAL COORDINATING AGENCY	Ministry of Environment - National Ozone Unit

Project summary

This project undertakes the validation of the Hydrofluoro Olefins (HFOs), a low GWP and non-flammable option, for discontinuous panels in the scenario of the Article 5 parties through the development of polyurethane (PU) foam formulations with reduced HFO contents that have CO_2, derived from the water-isocyanate reaction, as co-blowing agent. The aim is to optimise the cost/performance balance while achieving a similar foam thermal performance to that of HCFC-141b based formulations.

Impact of project on Country's Montreal Protocol Obligations

The project aims to contribute to the country obligation to reduce the HCFC consumption as per the Montreal Protocol obligation by converting the current HCFC-141b foam blowing technology to the HFO based formulations. The Colombian discontinuous panels subsector used 98.5 tonnes of HCFC-141b in 2014. With the results of this project, a significant portion of this HCFC-141b consumption would be replaced by this technology during the second stage of the HPMP. A direct impact of this project is the conversion of ABC Poliuretanos, 5.2 tonnes of HCFC-141b, in the mentioned second stage.
The results of this project would be applicable not only for the discontinuous panels subsector but the principles would also apply to other foam applications in Colombia and other developing countries.

Prepared by: Mr Miguel W. Quintero Date: September 11, 2015

1. BACKGROUND

1.1. PROJECT BACKGROUND

This project has been prepared as response to the Executive Committee Decision 72/40. It is part of a set of projects with the objective to validate chemical systems for use with non-HCFC blowing agents in the context of Decision XIX/6.
The developing countries will address in the short term the second phase of the HPMP (2015-2020) in the foam sector. One of the most critical subsectors that still uses HCFC-141b and accounts for a significant market portion is the manufacture of **discontinuous panels** for the construction and the commercial and industrial refrigeration industries. It is characterized by a great number of small and medium enterprises without the sufficient knowledge and discipline to handle flammable substances. This factor along with the lack of economies of scale prevents the adoption of hydrocarbons and the introduction of high GWP alternatives such as HFCs would result in a negative climate impact.
This projects undertakes the validation of the Hydrofluoro Olefins (HFOs), a low GWP and non-flammable option, for discontinuous panels in the scenario of the Article 5 parties through the development of polyurethane (PU) formulations with reduced HFO contents that have CO_2, derived from the water-isocyanate reaction, as co-blowing agent. The aim is to optimise the cost/performance balance while achieving a similar foam thermal performance to HCFC-141b based formulations.
Further, the project aims to contribute to the country obligation to reduce the HCFC consumption as per the Montreal Protocol obligation by converting the current HCFC-141b foam blowing technology to the HFO based formulations. The Colombian discontinuous panels subsector used in 2014 98.5 tonnes of HCFC-141b. With the results of this project, a significant portion of this HCFC-141b consumption would be replaced by this technology during the second stage of the HPMP.

It is important to note that the results of this project would be applicable not only for the discontinuous panels subsector but the principles would also apply to other foam applications in Colombia and other developing countries. Therefore, the results should be seen in a broader perspective.

1.2. SECTOR BACKGROUND IN COLOMBIA

Colombia became a party to the Vienna Convention and Montreal Protocol on October 16, 1990 and on March 6, 1994 respectively. Colombia also ratified the London, Copenhagen, Montreal and Beijing Amendments. The country is fully committed to the phase-out of HCFCs and willing to take the lead in assessing new HCFC phase-out technologies, particularly in the foam sector.

The Colombian PU market can be spread out in three different industrial sectors: flexible foam (flex-slab and moulded and integral skin), rigid foam and microcellular elastomers (shoe soles). HCFCs are used in rigid foam for thermal insulation and, in marginal quantities, in integral skin.

In PU rigid foam three different segments can be differentiated: domestic refrigeration (refrigerators and freezers), commercial refrigeration (mainly bottle and commercial displays) and industrial thermal insulation for the refrigeration and construction sectors (continuous and discontinuous panels, transportation and spray). While the domestic refrigeration and most of the commercial refrigeration have been converted to hydrocarbons the remaining market players still use HCFC-141b. The main suppliers are local "system houses" (Espumlatex, GMP, Olaflex,

Química Industrial y Comercial) that sell two-component systems: a fully formulated polyol, which includes the blowing agent (HCFC-141b), and an isocyanate (Polymeric MDI).
A recent market survey showed that in 2014 out of a total of 784.25 tonnes of imported HCFC-141b, 668 were used in foam manufacture. Table 1 shows the distribution by application. Discontinuous panels account for 15% of the total HCFC-141b consumption.

TABLE 1. 2014 USE OF HCFC-141b IN THE COLOMBIAN FOAM MARKET		
Foam Application	HCFC-141b, kg	%
Commercial Refrigeration	66,390	9.94%
Continuous Panels	80,920	12.12%
Industrial Refrigeration & Construction (Discontinuous Panels)	98,589	14.76%
Spray	51,958	7.78%
Integral Skin	3,428	0.51%
Polyol formulation	366,495	54.89%
TOTAL	667,780	100.0%

Source: Imports Declarations, Database of the Ministry of Commerce, Industry and Tourism. Personal interviews with key market players (system houses and end users)

2. PROJECT DESCRIPTION

2.1. PROJECT OBJECTIVES

The objectives of this project are:

1. To validate the use as foam blowing agents of the recently developed HFOs in blends with CO_2 for the production of discontinuous panels in the context of an Article 5 party. The aim is to optimise the HFO/CO_2 ratio in the cell gas to get a similar thermal performance to HCFC-141b at a minimum incremental operating cost. The results of this project would be applicable not only for the discontinuous panels subsector but the principles would also apply to other foam applications in Colombia and other developing countries.
2. To make a cost analysis of the different HFO/CO_2 formulations versus the currently used HCFC-141b based system.

2.2. JUSTIFICATION

The Article 5 parties are in the process of preparing the second stage of the HPMPs to be implemented in the 2016-2020 period. Taking into account the priorities defined in Decision XIX/6, particularly those referred to ODP and climate change impact, the developing countries opted for converting in the first phase (2011-2015) the largest foam enterprises typically found in the domestic refrigeration and continuous panels sectors. Hydrocarbons, basically pentanes, were the substances of choice based on their favourable cost/performance balance at large size operations.
Situation is different at the second stage where the countries have to address the remaining foam sectors still using HCFCs. These sectors (discontinuous panels, spray, integral skin) are characterised by a multitude of micro, small and medium size enterprises that do not have the

adequate knowledge and operating discipline to handle flammable substances in a safe manner. This factor along with the lack of economies of scale prevents the adoption of flammable blowing agents, while the introduction of high GWP alternatives such as HFCs results in high climate impact within processes which are typically less well engineered.
The recent developed unsaturated HFCs and HCFCs (commonly called HFOs), 1233zd(E) and 1336maam(z), marketed under the trademarks Forane (Arkema), Formacel (DuPont) and Solstice (Honeywell), have shown in rigid PU foam applications such as domestic refrigeration and spray a better thermal performance that the high GWP-saturated HFCs currently used in the developed countries. Their general properties are shown in table 2. They offer a unique opportunity for introducing safe non-flammable technologies that while enhancing energy efficiency will have a positive effect on climate change in terms of greenhouse emissions. Based on the physical properties of these substances (non flammability and relatively high boiling points) it is anticipated that their application does not require the retrofit of the foaming equipment currently in use. This is particularly true and important at the level of small and medium enterprises. Commercial availability has already been established for HFO-1233zd(E). Pilot scale production of HFO-1336mzzm(Z) commenced in late 2014, with full commercialisation expected in 2016. Although for these options availability is likely to be targeted mostly in markets within non-Article 5 Parties where the requirement for improved thermal efficiency is best identified, the demand to leapfrog high GWP alternatives to HCFCs could accelerate distribution to Article 5 regions. There are not legal or commercial barriers for the introduction of these products.

TABLE 2. HFO PROPERTIES			
	Formacel® 1100	***Solstice® Liquid BA***	***Forane® 1233zd***
Common name	1336mzz(Z)	1233zd(E)	1233zd(E)
Chemical Formula	Cis-CF_3-CH=CH-CF_3	Trans-ClCH=CH-CF_3	Trans-ClCH=CH-CF_3
Molecular weight	164	130.5	130.5
Boiling Point (°C)	33	19	19
GWP (100 years	2	1	<7

From the three market sectors mentioned above, the discontinuous panels application was chosen for the development of this project taking into consideration the high volume involved. According to the last FTOC assessment report (2010), in 2008 around 7,300 tonnes of CFCs and HCFCs were used in the discontinuous panels subsector in the developing countries.

Two are the main barriers for the introduction of these substances:
1. Their high unitary cost that is reflected in the final cost of the PU formulation.
2. The minimum experience with these products in developing country conditions. This technology has not been demonstrated in conditions prevailing in Article 5 parties.

The main objective of this project is precisely to remove or attenuate the mentioned obstacles. The formulation science associated to the PU technology and the excellent foam thermal characteristics provided by HFOs open the door for the development of PU formulations with reduced HFO contents that have CO_2, derived from the water-isocyanate reaction, as co-blowing agent. The aim is to optimise the cost/performance balance of these substances, achieving a similar foam thermal behaviour to HCFC-141b at the lowest possible cost, and, simultaneously, to carry out a comprehensive assessment of the HFO performance at developing countries conditions. The project will be conducted at Espumlatex, a recognised local system house equipped with the required injection and testing laboratory facilities, and a field test with selected formulations will be done at ABC Poliuretanos, a typical small manufacturer of discontinuous panels.

2.3. METHODOLOGY

With the aim of analysing the two HFO molecules, 1233zd(E) from Honeywell or Arkema and 1336maam(z) from Chemours, in comparison with HCFC-141b, six steps are contemplated for the project development:

1. PLANNING. A statistical experimental design (DOE) will be designed having as factors (or independent variables) the type of molecule and the composition of the cell gas (mole fraction of the physical blowing agent). The responses (or dependent variables) will be the foam properties critical for this application (Lambda value, compression strength, dimensional stability, friability). A commercial HCFC-141b based formulation will be used as control.
2. FORMULATION DEVELOPMENT. The resulting formulations will be prepared at laboratory scale and injected with a conventional high-pressure dispenser. Catalysis and overall blowing agent amounts will be adjusted to have among formulations a similar reactivity and free-rise density. A typical Brett or Lance mould with temperature control will be used to manufacture the panels to test the foam properties. Samples for testing will be done by duplicate.
3. TESTING. The critical immediate and aged foam properties for this application (Lambda value, compression strength, dimensional stability, friability) will be tested following ASTM or ISO standard procedures.
4. ANALYSIS OF RESULTS: foam performance and formulation cost. A detailed analysis of the resulting foam properties at different HFO levels and the associated formulation cost will be carried out. A typical HCFC-141b formulation will be used as standard.
5. FIELD TEST. A field test with selected formulations will be done at ABC Poliuretanos, a small manufacturer of discontinuous panels with typical market characteristics.
6. TECHNOLOGY REPLICATION/DISSEMINATION OF RESULTS. One of the critical outcomes of a demonstration project is the definition of the possibility to replicate the technology in other enterprises, in other regions and in other applications. In the case of HFOs, having in mind that the main barrier for their introduction is the associated formulation cost, it is anticipated that if results are positive and an adequate cost/performance balance is achieved, there is a great potential for the technology to be replicated in other system houses in the country, in Latin America and other regions, and even in other applications such as commercial refrigeration and spray. To assure this, it is planned to conduct two workshops, a first one at local level with the participation of the other Colombian system houses (GMP, Olaflex, Química Industrial y Comercial) and interested end users, and a second one at regional level, where regional system houses, importers and end users will be invited. It is important to note that all the Colombian and several Latin American system houses have shown interest in these products. In addition to the seminars, a detailed technical report will be written with the results of the project. Information on the performance of the HFOs at different mole fractions in the cell gas along with the associated formulation cost (incremental operation cost compared to HCFC-141b) will be delivered. It will serve as starting point for the other system houses to design/develop appropriate HFO based formulations.

2.4. INFORMATION ON PARTICIPATING COMPANIES

Espumlatex

Espumlatex was established in 1959 to serve the automotive industry in Colombia as the main supplier of PU based materials: RIM and sound insulation parts and flex moulded foam for car seats. Throughout all these years it became the leader of PU suppliers in the Andean countries with annual sales of 52 million dollars in 2008. It is certified QS9000/ISO9000, EAQF level Q1 status, ISO14000.

At the end of the eighties Espumlatex expanded its activities to formulate PU systems for the manufacture of thermal insulating and integral skin foams. Its current capacity is estimated in 500 MT per month with an annual current production of 4,000 MT of PU systems, from which 2,000 MT are dedicated to rigid foam materials. 15 % of their PU systems production is exported to Ecuador, Peru and Venezuela. Additional to PU systems they manufacture PU rigid foam sheets for insulation purpose in a process that involves the production of large foam blocks and their subsequent cutting.

The system house production facilities are equipped with 18 blending tanks with capacities that go from 1,500 to 3,000 l. They have mechanical agitation, recirculation and a direct feeding system from the raw materials drums as well as a closed pumping system for raw materials loading. The basic properties of the PU systems (free rise density, reactivity, foam thermal conductivity, compression strength, dimensional stability and accelerated aging) are tested in a certified quality control laboratory.

The consumption of chemicals for the PU systems sold for the manufacture of discontinuous panels during the last 5 years was:

Table 3. Consumption of PU chemicals for Discontinuous Panels at Espumlatex, tonnes

Substance	**2009**	**2010**	**2011**	**2012**	**2013**
Polyol	327	381	425	423	462
HCFC-141b	82	96	107	106	115
Polymeric MDI	445	518	578	575	628
TOTAL	854	995	1,110	1,104	1,205

During the transition from CFC-11 to HCFCs the following two projects were carried out with Espumlatex:

- The project COL/FOA/32/INV/49, “Retroactive funding for the conversion from CFC-11 to water-based technology in the manufacture of flexible molded and integral skin foam at Espumlatex-Promicolda”, retroactively funded one of the Espumlatex´ divisions, Promicolda, for the conversion from CFC-11 to water and HCFC-141b based technologies in the manufacture of flexible molded and integral skin foam respectively. Promicolda is the Expumlatex´ division that manufactures the car seats and several parts based on integral skin foam for the automotive industry in the Andean Countries. The grant received by Promicolda was US$ 82,020.00.
- The project COL/FOA/32/INV/48, “Conversion from CFC-11 to HCFC-141b and water based technology in the manufacture of various polyurethane foam applications at 25 small enterprises centred around their systems house Espumlatex”, was an umbrella project where 25 SMEs -centred around Espumlatex as the system house- were successfully converted from CFC-11 to HCFC-141b and water based technologies. Total cost of the project was US$ 332,768.00. Espumlatex received funds for the project administrative expenses and a laboratory equipment (one K factor indicator not suitable to measure lambda values at different temperatures).

Espumlatex also served in 2011-2013 as the local system house host for the demonstration project on Supercritical CO_2 technology for spray foam undertaken under a Japan-Colombia bilateral with Achilles Corp.

The company is fully committed to test new HCFC alternatives of low GWP and has the required capability (laboratory facilities, technical knowledge and human resource). Its contribution to the project has been quantified in US$ 52,800 (see table 5).

3. PROJECT IMPLEMENTATION MODALITY

Project will be implemented by UNDP as an executing agency. Relevant activity such as equipment procurement, recruitment of experts, foam testing will be arranged under the UNDP Financial Rule and Regulation.

The following activities will be executed:

- Work arrangement with local System House to be signed between UNDP and the beneficiary as well as the National Ozone Unit (NOU).
- Development of the experimental protocol which includes application procedure and conditions, properties to test, testing methods etc.
- Formulation development and foam sample preparation to be done at Espumlatex laboratory facilities using a high-pressure dispenser and a conventional Brett mould. Procurement of a laboratory equipment to measure foam friability. This foam property is considered critical having in mind the high urea content typical of PU high water formulations.
- Testing of foam critical immediate and aged properties such as thermal conductivity, compression strength, dimensional stability and friability.
- Conduction of a field test at ABC Poliuretanos, a local discontinuous panels manufacturer.
- Delivery of two dissemination workshops to the Colombian and Latin American industry.

<u>Project implementation time schedule</u>

Table 4. Project Implementation Time Schedule

ACTIVITY	2015	2016			
	Q4	Q1	Q2	Q3	Q4
Approval	*				
Grant transfer to UNDP		*			
Work Arrangement between UNDP and beneficiary		*			
Detailed project planning. Development of experimental protocol		*			
Import of HFO samples		*			
Procurement & delivery of equipment to measure friability		*	*		
Formulation Development		*	*	*	
Foam testing		*	*	*	
Analysis of results: performance versus cost				*	
Field testing at a local discontinuous panels manufacturer					*
Dissemination workshops					*
Reporting & Final review					*

4. PROJECT BUDGET

The summary of the project cost is as follows:

Table 5. Project cost by activity

Activity	Specification or detail	Unit cost, US$	Quantity	Total Cost US$	Espumlatex contribution US$	MLF US$
International technical assistance		30,000	1	30,000		30,000
Planning	Participation of Espumlatex, National Ozone Unit (NOU) and international consultant	5,000	1	5,000		5,000
Formulation Development	Estimated that one man year effort of a qualified engineer and lab technician are required	110,000	1	110,000	36,000	74,000
Acquisition of Friability tester		10,000	1	10,000		10,000
Foam Testing	It is anticipated that around 120 foam samples (5x3x4x2) x2 will be tested for lambda, value, compression strength, dimensional stability and friability			30,000	10,000	20,000
PU material for formulation development	Estimated that 60 kg of PU system (US$ 4/kg) are required for each trial	240	20	4,800		4,800
PU material for field testing	Estimated that 1000 kg (4 drums) are required	4	1,000	4,000		4,000
Foam testing - Field evaluation	Resulting foam will be tested for lambda, value, compression strength, dimensional stability and friability	5,000	1	5,000	2,000	3,000
Technology Dissemination Workshops	For Colombian industry and Latin American countries		2	40,000		40,000
Local Consultant	Technical support to project implementation.	36,000	1	36,000		36,000
Project monitoring & reporting		30,000	1	30,000		30,000
Sub-total Incremental Capital Cost				304,800	48,000	256,800
Contingencies (10%)				30,480	4,800	25,680
Total Cost				335,280	52,800	282,480

Notes:

Formulation Development: The formulations will be prepared at Espumlatex laboratory facilities by company personnel.

Provision of equipment: The project plans to acquire a laboratory equipment to measure foam friability according to ASTM test.

Foam testing: All the foam properties will be determined at Espumlatex laboratory facilities by company technicians.

Dissemination workshop: Cost to organize the dissemination workshops is included. Two workshops will be organized, both in Colombia, a first one for the local industry and a second one for Latin America.