NACIONES
UNIDAS

EP

Programa de las
Naciones Unidas
para el Medio Ambiente

Distr.
GENERAL

UNEP/OzL.Pro/ExCom/76/50
14 de abril de 2016

ESPAÑOL
ORIGINAL: INGLÉS

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: TAILANDIA

El presente documento consta de las observaciones y recomendaciones de la Secretaría del Fondo sobre la siguiente propuesta de proyecto:

<u>Espuma</u>

• Proyecto de demostración en las instalaciones de los proveedores de sistemas de Tailandia para formular polioles premezclados destinados a las aplicaciones de rociado de espumas de poliuretano utilizando un agente espumante de bajo potencial de calentamiento atmosférico.	Banco Mundial

HOJA DE EVALUACIÓN DE PROYECTO – PROYECTO NO PLURIANUAL

TAILANDIA

TÍTULO DEL PROYECTO **ORGANISMO BILATERAL/DE EJECUCIÓN**

a)	Proyecto de demostración en las instalaciones de los proveedores de sistemas de Tailandia para formular polioles premezclados destinados a las aplicaciones de rociado de espumas de poliuretano utilizando un agente espumante de bajo potencial de calentamiento atmosférico.	Banco Mundial

AGENCIA DE COORDINACIÓN NACIONAL	Departamento de obras industriales, Ministerio de Industria. Federación de Industrias de Tailandia

DATOS MÁS RECIENTES SOBRE EL CONSUMO DE SAO ABORDADOS EN EL PROYECTO

A: DATOS MÁS RECIENTES CON ARREGLO AL ARTÍCULO 7 (TON. PAO, 2014)

HCFC			864,45

B: DATOS SECTORIALES DEL PROGRAMA DE PAÍS MÁS RECIENTES (TON. PAO, 2014)

HCFC-22	647,04
HCFC-123	2,72
HCFC-141b	174,87
HCFC-124	0,10
HCFC-225	2,75
HCFC-141b en forma de polioles premezclados de importación	11,19

Consumo de HCFC admisible para financiación (toneladas PAO)	708,56

ASIGNACIONES EN EL PLAN ADMINISTRATIVO DEL AÑO EN CURSO		**Financiación $EUA**	**Eliminación de ton. PAO**
	a)	n.c.	n.c.

TÍTULO DEL PROYECTO:	
SAO consumida en la empresa (toneladas PAO):	38,94*
SAO a eliminar (toneladas PAO):	3,88
SAO a introducir (toneladas PAO):	3,88
Duración del proyecto (meses):	12
Monto inicial solicitado ($EUA):	355 905
Costos finales del proyecto ($EUA):	
Costo adicional de capital:	320 500
Gastos imprevistos (10 %):	32 050
Costo adicional de explotación:	0
Costo total del proyecto:	352 550
Propiedad local (%):	100%
Componente para exportación (%):	0%
Donación solicitada ($EUA):	352 550
Rentabilidad ($EUA/kg):	10
Gastos de apoyo para el organismo de ejecución ($EUA):	24 679
Costo total del proyecto para el Fondo Multilateral ($EUA):	377 229
Situación de la financiación de contraparte (S/N):	N
Hitos de vigilancia del proyecto incluidos (S/N):	S

*Todas las aplicaciones. Consumo de espumas de rociado: 4,14 toneladas PAO

RECOMENDACIÓN DE LA SECRETARÍA	Para consideración individual

DESCRIPCIÓN DEL PROYECTO

Antecedentes

1. En la 75ª reunión del Comité Ejecutivo el Banco Mundial presentó una solicitud de financiación de un proyecto de demostración, a realizar en las instalaciones de los proveedores de sistemas, para formular polioles premezclados destinados a las aplicaciones de rociado de espumas de poliuretano, utilizando un agente espumante de bajo potencial de calentamiento atmosférico, por un costo total de 397,100 $EUA, más gastos de apoyo al organismo por un valor de 27 797 $EUA, con arreglo a la presentación original[1][2]. Tras efectuar la Secretaría un examen, el costo del proyecto se ajustó a 355 905 $EUA, más gastos de apoyo al organismo. Tras las deliberaciones mantenidas en el seno de un grupo de contacto establecido para verificar que todos los proyectos presentados la 75ª reunión del Comité Ejecutivo demuestran una utilización de tecnologías de bajo potencial PCA, el Comité Ejecutivo decidió posponer la consideración de los siete proyectos de demostración, incluido el proyecto de espumas para Tailandia, hasta la 76ª reunión (decisión 75/42).

2. En nombre del Gobierno de Tailandia, el Banco Mundial ha vuelto a presentar a la 76ª reunión el proyecto de demostración indicado *supra*, por el monto de 355,905 $EUA, más gastos de apoyo al organismo de 24,913 $EUA. La propuesta de proyecto presentada se recoge en el anexo I del presente documento.

Objetivos del proyecto

3. El sector de espumas de poliuretano de Tailandia abarca a 215 empresas en las que se consumen 1 723 toneladas métricas (tm)[3] de HCFC-141b para la fabricación de espumas rígidas de poliuretano, incluyendo en ello a las aplicaciones de rociado. La etapa I del Plan de gestión de eliminación de HCFC de Tailandia[4] abordó el consumo de las 1 517 toneladas métricas (tm) de HCFC-141b que se emplean en todas las aplicaciones de espumas de poliuretano, salvo las 349,1 tm consumidas por 30 empresas dedicadas a las aplicaciones de rociado de espumas (es decir, tejados, sales de almacenamiento en frío, barcos de pesca, autobuses de pasajeros, cisternas de almacenamiento y depósitos aislados) ante la ausencia de alternativas a esta aplicación que fueran de bajo PCA. El consumo actual de HCFC-141b en aplicaciones de rociado de espumas ha incrementado hasta las 585 tm.

4. En el proyecto se propone:

a) Fortalecer la capacidad de dos proveedores locales de sistemas para formular, someter a ensayos y producir polioles premezclados utilizando hidrofluorocarbonos sin saturar (HFO) (a saber: HFO-1233zd(E) y HFO-1336mzz(Z)) para pequeñas y medianas empresas (PME) del sector de espumas de poliuretano por rociado;

b) Validar y optimizar el consumo de los HFO formulados conjuntamente con CO_2 para utilizarse en aplicaciones de rociado de espumas a fin de lograr un desempeño térmico similar al del HCFC-141b con costos adicionales de explotación mínimos (para optimizar la relación al 10 por ciento respecto los HFO);

c) Elaborar un análisis de costos de las diferentes formulaciones con HFO reducido en comparación con las formulaciones con HCFC-141b; y

[1] UNEP/OzL.Pro/ExCom/75/68.
[2] La financiación para la preparación de este proyecto se aprobó por un monto de 30 000 $EUA, más gastos de apoyo al organismo de 2 100 $EUA, dándose por entendido que su aprobación no denotaba la aprobación del proyecto ni su nivel de financiación en las fechas de presentación original (decisión 74/36).
[3] Año de referencia: 2010, con arreglo al Plan de gestión de eliminación de HCFC aprobado en la 68ª reunión.
[4] UNEP/OzL.Pro/ExCom/68/41.

d) Divulgar los resultados de la evaluación entre los proveedores de sistemas de Tailandia y de otros países.

5. Los principales impedimentos a la introducción de los dos HFO propuestos en el proyecto de demostración son su elevado costo unitario, la restringida disponibilidad en los países[5] que operan al amparo del artículo y lo limitado de la experiencia en las condiciones reinantes en dichos países.

Ejecución del proyecto

6. El proyecto se ejecutará con la ayuda de dos proveedores de sistemas, a saber: Bangkok Integrated Trading Co., Ltd (BIT) y South City Polychem Co., Ltd. (SCP), los cuales suministran polioles (principalmente formulados con HCFC-141b) a los clientes que tienen una amplia variedad de aplicaciones de espumas de poliuretano, incluyendo las de rociado de dichas espumas. Ambos proveedores de sistemas disponían de equipos básicos para implantar el proyecto de demostración.

7. BIT formulará espumas de alta densidad para rociado (50 kg/m^3) y SCP formulará espumas de densidad normal también para rociado (35 kg/m^3). Cada proveedor de sistemas elaborará y someterá a pruebas un mínimo de 110 formulaciones con HFO-1233zd(E) y HFO-1336mzz(Z); cinco formulaciones con relaciones HFO:CO_2 de 100:0, 75:25, 50:50, 25:75 y 0:100; cinco ciclos formulados con diferentes relaciones de polioles de poliéter, de poliéster y amínicos. Las formulaciones que resulten se aplicarán utilizando una nueva máquina rociadora de espumas (Graco) con una presión máxima de 3 500 psi y una relación poliol:isocianato ajustable. Los resultados de la fase inicial se analizarán para determinar las mejores combinaciones de polioles.

8. Las 30 formulaciones de espumas que resultaran más idóneas se someterían a ensayos (tres muestras de cada formulación), y las propiedades críticas de las espumas (es decir, la estabilidad dimensional, adhesión a diversos substratos, conductividad térmica y capacidad de tratamiento) se compararían con las de una formulación de HCFC-141b típica. Se efectuaría también una prueba de campo con una serie de formulaciones seleccionadas al caso.

9. Se organizará un taller técnico para divulgar los resultados. A los proveedores de sistemas y a los proveedores de los polioles se les pondrá en comunicación entre sí y se les dará acceso a los peritos y proveedores de tecnologías con objeto de poder transferir conocimientos y de fortalecer sus capacidades técnicas en el desarrollo de formulaciones.

10. Se prevé que el Proyecto culmine en el plazo de 12 meses.

Costos del proyecto

11. Se estima que el costo total del proyecto sea de 355 905 $EUA como se detalla en el Cuadro 1.

Cuadro 1. Costo del Proyecto por actividad

Elementos	**Cantidad**	**Costo unitario ($EUA)**	**Total ($EUA)**
Equipo productor de espumas:			
Máquina productora de espumas para rociado (presión de trabajo: 3 500 psi con relación poliol:isocianato ajustable)	2 juegos	40 000	80 000
Equipos de laboratorio:			
Comprobador de conductividad térmica	2 juegos	5 000	10 000
Desarrollo y ensayo de las formulaciones:			

[5] La disponibilidad comercial del HFO-1233zd(E) ha quedado establecida; y la producción a escala piloto de HFO-1336mzz(Z) comenzó a últimos de 2014, estando prevista su plena puesta a la venta en 2016.

Elementos	Cantidad	Costo unitario ($EUA)	Total ($EUA)
Desarrollo de formulaciones	2	45 000	90 000
Prueba externa por parte de un laboratorio acreditado (inflamabilidad, capacidad de compresión)	110	250	27 500
Prueba de campo	20	500	10 000
Material de poliuretano para ensayos (incluyendo el transporte)			
Polioles	1 100	3,0$EUA/kg	3 300
Inhaladores de dosis medida	1 100	2,5$EUA/kg	2 750
Asistencia técnica			
Asistencia tecnológica, incluido los viajes	1	80 000	80 000
Taller de divulgación de la tecnología	2	10 000	20 000
Total parcial			**323 550**
Imprevistos (10%)			32 355
Total			**355 905**

OBSERVACIONES Y RECOMENDACIONES DE LA SECRETARÍA

OBSERVACIONES

12. La propuesta de proyecto presentada a la 75ª reunión incluyó ensayos con una formulación que contenía HFC de un alto PCA propuesta para el caso de que los HFO no pudieran obtenerse comercialmente. Sin embargo, dicha formulación se ha eliminado del proyecto presentado ante la 76ª reunión y, por ende, el actual proyecto de demostración se centra sola y exclusivamente en formulaciones con HFO de concentración reducida.

13. A fin de poder remitirse a ellos más fácilmente, los resultados de las deliberaciones entre la Secretaría y el Banco Mundial, al respecto del proyecto de demostración presentado a las reuniones 75ª y 76ª, se recogen resumidas a continuación:

a) El Banco Mundial racionalizó el costo del proyecto pasando de 1 046 000 $EUA, como fue presentado por primera vez a la 74ª reunión[6], a 397 100 $EUA , como fue presentado a la 75ª reunión. El costo de la propuesta de proyecto, tal y como se presentó originalmente a la 76ª reunión, ha sido racionalizado aún más, llegando a reducirse hasta los 355 905 $EUA. Lo que es más, al eliminar la formulación con HFC del proyecto de demostración, el número de ensayos sería de 100 (en vez de 110), de lo que se derivarían ahorros de 3 355 $EUA. Por consiguiente, el costo total del proyecto de demostración sería de 352 550 $EUA;

b) A fin de ejecutar el Proyecto en el plazo de 12 meses, el Banco Mundial explicó que dicho Proyecto se implantaría sirviéndose de dos proveedores de sistemas (uno para ensayar espumas de rociado destinadas a aplicaciones de aislamiento de tejados y la otra para ensayar espumas de rociado destinadas a salas de almacenamiento en frío y edificios). Utilizar solo un proveedor de sistemas requeriría desarrollar y ensayar dos veces las formulaciones, lo que llevaría un tiempo considerablemente más largo;

c) El respaldo financiero lo aportó BIT en la etapa I del Plan de gestión de eliminación de HCFC para sufragar la asistencia técnica a las micro empresas encargadas de la conversión de la tecnología de espumación acuosa en todos los sectores, salvo en el de las espumas para rociado, que es el sector que se aborda en el proyecto de demostración;

[6] UNEP/OzL.Pro/ExCom/74/48.

d) La capacidad potencial de reproducción en el uso de la tecnología seleccionada es considerable, dado que actualmente se consumen 585 tm de HCFC-141b en las empresas de espumas para rociado en Tailandia. La situación es la misma en el caso de los países de la región, a saber: China (7 100 tm), Indonesia (5 5 tm) y Viet Nam (60 tm). Aunque Filipinas dejará de consumir HCFC-141b en las aplicaciones de espumas para rociado en 2015, bien podría beneficiarse del proyecto;

e) La ejecución del proyecto exige el desarrollo intensivo de la formulación dado que es la primera vez que se evaluará una menor concentración de HFO en las condiciones de los países que operan al amparo del artículo 5. Es necesaria la participación de un perito internacional en espumas para trabajar con los dos proveedores de sistemas durante todo el proceso. A fin de acelerar la ejecución, el proyecto de demostración podría incluirse en el marco del actual Acuerdo de donaciones para la etapa I del Plan de gestión de eliminación de HCFC para Tailandia; y

f) Como ya explicó el Banco Mundial, los riesgos potenciales de adoptar la tecnología alternativa se atribuyen a un incremento de la viscosidad en las nuevas formulaciones de espumas, junto con el coste final y la disponibilidad comercial de los HFO, que no pueden determinarse a fecha de hoy.

14. El Banco Mundial notificó que el Gobierno de Tailandia se ha comprometido a eliminar el consumo de 35,3 tm de HCFC-141b del consumo remanente de HCFC admisible para financiación.

Conclusiones

15. La Secretaría es de la opinión que el proyecto cumple con los criterios recogidos en la decisión 72/40 al ofrecer un incremento de los conocimientos actuales sobre la aplicación de formulaciones con menor concentración de HFO (una tecnología de bajo PCA) en el marco de un sector (espumas para rociado) en el que varios países que operan al amparo del artículo 5 han identificado dificultades dadas las limitaciones en el uso de agentes espumantes inflamables. Al mejorar las formulaciones con menor concentración de HFO con ayuda de dos proveedores locales de sistemas, se prevé reducir los costos de explotación para las PIME, especialmente en el caso de las formulaciones de concentración reducida al 25 o al 10 por ciento de HFO. Además, el planteamiento de la demostración se describe claramente y queda vinculado al Plan de gestión de eliminación de HCFC en Tailandia; describiéndose también el potencial de reproducción en el país y en la región en su conjunto. La Secretaría toma nota de que hay otros tres proyectos con propuestas de demostración de HFO para espumas de rociado y otras aplicaciones[7].

RECOMENDACIONES

16. El Comité Ejecutivo puede estimar oportuno considerar:

a) El proyecto de demostración a realizar en las instalaciones de proveedores de sistemas de Tailandia para formular polioles premezclados destinados a las aplicaciones de espumas de poliuretano rociado que contengan agentes espumantes con un bajo PCA, en el contexto de sus deliberaciones sobre las propuestas de proyectos de demostración de tecnologías de PCA alternativas a las formuladas con HCFC, como se recoge en el documento Reseña de las cuestiones identificadas durante el examen de proyectos (UNEP/OzL.Pro/ExCom/76/12);

[7] Colombia (UNEP/OzL.Pro/ExCom/76/26); India (UNEP/OzL.Pro/ExCom/76/35); y Arabia Saudita (UNEP/OzL.Pro/ExCom/76/46).

b) Aprobar el proyecto de demostración a realizar en las instalaciones de proveedores de sistemas de Tailandia para formular polioles premezclados destinados a las aplicaciones de espumas de poliuretano rociado con agentes espumantes de bajo PCA, por un monto de 352 550 $EUA, más gastos de apoyo al organismo por un valor de 24 679 $EUA para el Banco Mundial, conforme a la decisión 72/40;

c) Deducir 3,88 toneladas PAO de HCFC del consumo remanente de HCFC admisible para financiación; e

d) Instar al Gobierno de Tailandia y al Banco Mundial a terminar el proyecto conforme al plan de 12 meses, y presentar un informe final general a la mayor brevedad tras la terminación del proyecto.

Annex I

THE MONTREAL PROTOCOL ON SUBSTANCES THAT DEPLETE THE OZONE LAYER

PROJECT COVER SHEET

COUNTRY:	Thailand	
PROJECT TITLE:	Demonstration project at foam system houses in Thailand to formulate pre-blended polyol for spray polyurethane foam applications using low-GWP blowing agent	
SECTOR COVERED:	PU Foam	
ODS USE IN SECTOR:	349 MT HCFC-141b in 2010 (spray foam)	
PROJECT IMPACT:	N/A	
PROJECT DURATION:	One year	
TOTAL PROJECT COST:	Incremental Capital Costs (Incl. 10% contingencies)	355,905 USD
	Incremental Operating Costs	0 USD
	Total Project Cost	355,905 USD
PROPOSED MLF GRANT:		355,905 USD
SUPPORT COST:		24,913 USD
TOTAL COST:		380,818 USD
COST-EFFECTIVENESS:	N/A	
IMPLEMENTING ENTERPRISE:	1. Bangkok Integrated Trading Co., Ltd 2. South City Polychem Co., Ltd	
IMPLEMENTING AGENCY:	The World Bank	
COORDINATING AGENCY:	Department of Industrial Works, Ministry of Industry Federation of Thailand Industries	

PROJECT SUMMARY

This is a demonstration project to validate the use of two Hydrofluoroolefins (HFOs): HFO-1233zd(E) and HFO-1336mzz(Z) for spray foam applications in Thailand. These are low GWP and non-flammable blowing agent being developed to replace HCFC and HFC blowing agents.

The project consists two main components. The first component is the formulation development with participating system houses. Two local system houses are participating under this component, one to develop formulations at 35kg/m^3 density and another at 50kg/m^3 density in order to cover most spray foam applications in Thailand. The second component is technical replication and dissemination of results.

The development process consists the following steps: planning, experimental laboratory, formulation development, foam samples preparation and testing. An international expert will be engaged to provide

support during the planning and implantation of the project, analyze cost/performance, and participate in technical dissemination seminar.	
Prepared by:	
Reviewed by:	OORG

1. PROJECT OBJECTIVE

The Article 5 parties will address in the short term the second phase of the HPMP (2016-2020) in the foam sector. One of the most critical subsectors that still uses HCFC-141b and accounts for a significant market portion is the production of spray foam for different applications such as construction, refrigerated transportation, tanks insulation, etc. The sector is characterized by a great number of “micro” small enterprises without the sufficient knowledge and discipline to handle flammable substances, which prevents the adoption of hydrocarbons as HCFC replacement. In addition the introduction of high GWP alternatives such as HFCs (HFC-245fa, HFC-365mfc, etc.) would result in a negative climate impact.

This projects proposes the validation of the Hydrofluoro Olefins (HFOs), a low GWP and non flammable option, for spray foam applications in the scenario of the Article 5 parties through the development of polyurethane (PU) formulations with reduced HFO contents that have CO2, derived from the water-isocyanate reaction, as co-blowing gas. The aim is to optimize the cost/performance balance while achieving a similar foam thermal performance to HCFC-141b based formulations.

Therefore the objectives of the project would be:

1. To strengthen capacity of selected local system houses to formulate, test, and produce pre-blended polyol using low-GWP alternatives. This would lead to increased supply of cost-effective low-GWP pre-blended polyol to small and micro-enterprises.
2. The validation of the use as foam blowing agents of the recently developed HFOs in blends with CO2 for the production of spray foam in Thailand. The aim is to develop and optimize reduced HFO formulation to get a similar thermal performance to HCFC-141b at a minimum incremental operating cost.
3. To make a cost analysis of the HFO reduced formulations versus the currently used HCFC-141b based system.
4. To disseminate the technology to interested system houses in Thailand and other countries.

2. SECTOR BACKGROUND

Based on HPMP, the foam sector in Thailand is the largest manufacturing sector of Thai-owned enterprises with a 2010 consumption of HCFC-141b of 1,723 metric tonnes, most of it in the form of domestically blended polyol. There are 215 foam manufacturing enterprises active in manufacturing PU rigid foam, integral skin, flexible foam and extruded polystyrene. The majority uses pre-blended polyol that is supplied by the different polyol suppliers. Out of the 215 enterprises, 53 have a consumption of less than 1 ODP MT of HCFC-141b and can consequently be considered as “micro-enterprises.”

Table 1: Breakdown of HCFC Consumption in Foam Sector (MT)[1]

Sector/Application	No. of Enterprises	HCFC-141b Consumption (MT)

[1] Source: Thailand HCFC Phase-out Management Plan

		2007	2008	2009	2010
Rigid Polyurethane					
Box Foam	4	44.7	61.4	70.2	60.1
Commercial Refrigeration	14	110.4	136.6	132.8	147.5
Steel/Fiberglass door	6	29.0	32.6	32.5	28.5
Ice Box	44	592.3	604.4	634.1	602.8
Pipe Section/Pipe-in-pipe Insulation	6	41.3	39.3	50.4	62.7
Pipe Section and Sandwich Panel***	3	32.8	38.3	40.6	38.4
Refrigerated Truck, Reefer, Fishery vessel	13	43.2	59.3	59.7	70.3
Sandwich Panel	25	242.7	275.4	246.9	332.2
Spray Foam	30	295.9	330.1	298.6	349.1
Thermoware	7	46.6	54.5	47.9	45.7
Wood Imitation	6	27.6	32.2	39.2	49.0
Others	44	41.8	58.4	66.2	48.0
Sub-total Rigid Polyurethane Foam	202	1,548.2	1,722.6	1,719.1	1,834.4
Flexible Polyurethane	5	21.6	25.0	27.9	25.1
Integral Skin	8	19.3	28.0	24.3	24.1
Total Foam Sector	215	1,589.1	1,775.6	1,771.3	1,883.6

Under Stage I HPMP, the foam sector conversion will phase-out a total quantity of 1,517 MT of HCFC-141b used in bulk, in domestically pre-blended and imported pre-blended polyol. Of which, 639.6 MT of HCFC-141b will be replaced by cyclo-pentane and 844.6 MT of HCFC-141b will be replaced by a 50% reduced formulation with HFC-245fa as a blowing agent. The balance will be phased out by water blown technology. Thailand Stage I HPMP does not include spray foam application in 30 enterprises which consumed 349.1 MT of HCFC-141b in 2010. The reason for not including spray foam in Stage I was due to limited alternatives for spray foam either because of the capacity of enterprises needed to adequately apply the technology and the technology's maturity (CO_2), or because of the environmental impact of other commercially available alternatives (HFCs).

2.1 System House Background

Thailand's foam industry comprises not only polyol suppliers and manufacturers, but also system houses that both supply pure polyol to, as well as blend polyol and prepare formulations for the foam industry. In addition to direct supply by system houses, local polyol distributors authorized by the system houses also supply pure polyol and pre-blended polyol to foam enterprises across the country. Thailand has thirteen PU system houses and polyol suppliers. The local system houses/suppliers cater to small/micro enterprises (SME) with PU material, while international PU chemical manufacturers (BASF, Bayer, Dow and Huntsman) are represented and concentrate on the larger users.

To reach these small and micro-sized enterprises, the project will provide foaming equipment to two local system houses and assist in developing and supplying pre-blended polyol using low-GWP alternatives to spray PU foam to their customers. The two participating local system houses are:

2.1.1 Bangkok Integrated Trading Co., Ltd

Bangkok Integrated Trading (BIT) was established in 1989. It began as the sole distributor of PU foam of Dow Chemical in Thailand. They began to provide their own pre-blended polyol in 2009. Its products are widely used in the production of foam for appliances, sandwich panels, automotive, furniture, reefer container, cold store, pipe insulation, imitation wood and imitation ceramic, spray foam, etc. It is supplying polyols to customers all over the Thailand. The estimated HCFC-141b in system sales and spray foam from 2010 to 2015 are shown in Annex 1. Most of the products are pre-blended polyol with HCFC-141b blowing agents.

BIT facility includes a laboratory that performs chemical tests: reaction and cream/string tests, and foam water content (water titration). Physical tests are performed by external accredited laboratory either in Thailand and Singapore according to relevant national and international standards. The company has a 5-MT insulated blending tank to produce pre-blended polyol. BIT technical personnel consist a chemist with more than 17-year experiences in foam formulation and production.

2.1.2 South City Polychem Co., Ltd

South City Polychem (SCP) was founded in 1996, located in Rayong Province. SCP is the sub-company under South City Group. There are 3 people are working on polyol system development and production. Head of R&D has more than 20-year experience in PU foam development. South City Polychem has one 1-ton and one 5-ton blending tank. They also have a laboratory to perform basic tests (i.e., cream time, and tack free time). Their products are widely used in the production of foam for appliances, sandwich panels, automotive, furniture, reefer container, cold store, pipe insulation, imitation wood and imitation ceramic, etc. It is supplying polyols to customers all over the Thailand. Most of the products are pre-blended polyol with HCFC-141b blowing agents.

2.2 Spray Polyurethane foam (SPF)

Spray PU foams are closed-celled, air tight, resistant to mildew and fungal attack, provide no food value to rodents and have good vapor barrier properties. They find utility as an in situ applied insulation in applications where irregular shapes or the need for a monolithic layer of foam exists. These applications include building envelope, pipe insulation, tank insulation, rail cars, residential roofing and floors. Sprayed foam is now finding increasing applications in retrofitting/refurbishing roofs, walls, floors and windows of existing buildings as well as in new constructions such us commercial offices, industrial factories and warehouses, agricultural pig and chicken farms.

There are approximately 30 enterprises that provide spray foam services to their customers in Thailand. Main applications for spray foam in Thailand include the followings: roof, cold-storage room (including floor), fishing boat, passenger bus, storage tank, and insulated tanker. These enterprises either buy blowing agent and mixing it themselves with pre-blended polyol systems or purchase pre-blended polyol systems with HCFC-141b. Their baseline HCFC-141b consumption in 2010 was estimated to be 349.1 MT and increasing to 585 MT in 2013.

For normal applications, desired density is 35kg/m^3 for optimal insulation. For flooring applications that need high compressive strength, the desired density is 50 kg/m^3. Current SPF formulation in Thailand uses 20-30% HCFC-141b in pre-blended polyol. The system house can adjust the ratio of HCFC-141b in pre-blended polyol depending on the density requirement of the users. Foam systems used in SPF applications need to have fast reaction time (cream time: 3 sec. and tack-free time: 5-7 sec.). Other considerations include low odor.

For developed countries, the proven technical options to replace HCFC-141b as blowing agent for spray PU foam are exclusively limited to high GWP HFCs, specifically, HFC-245fa, which has a GWP of 1,030 (100yr ITH, IPCC 4th Assessment Report 2008). This constitutes a major drawback for developing countries, as this is an application with comparatively high emissions and having in mind Decision XIX/6, which promotes selection of alternatives that minimize environmental impacts, in particular impacts on climate. Reduced HFC-245fa formulation at 7.5-10% could reduce the climate impact but will increase the viscosity of the pre-blended polyol. This could pose problem for current crop of spray foam machines, with maximum working pressure up to 1600 psi, whether they can cope with higher viscosity polyol. The barrier for hydrocarbon technology in this application is safety during foaming because of their flammability.

2.3 Low-GWP alternatives

The unsaturated HFCs and HCFCs (commonly called HFOs), 1233zd(E) and 1336mzz(Z), marketed under the trademarks Forane (Arkema), Formacel (Chemours) and Solstice (Honeywell) and recently commercialized, 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** along with HCFC-141b, HFC245fa and HFC-365mfc. 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-1336mzz(Z) commenced in late 2014, with full commercialization expected in 2016. Although for these options availability is likely to be targeted mostly in markets within Article 2 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: HCFC, HFC and HFO Foam Blowing Agent Properties

Common name	HCFC-141b	HFC 245fa	HFC 365mfc	HFC1336mzz-Z	HCFC 1233zd	HCFC 1233zd
Manufacturer	Various	Honeywell	Solvay	DuPont	Honeywell	Arkema
Trade name		Enovate®	Solkane®	Formacel®	Solstice™ LBA	Forane®
Formula	CH_3CCl_2F	$CF_3CH_2CHF_2$	$CF_3CH_2CF_2CH_3$	Cis-CF_3-CH=CH-CF_3	Trans-ClCH=CH-CF_3	Trans-ClCH=CH-CF_3
Molecular Weight	116.9	134	148	164	130.5	130.5
Boiling Point (°C)	32.1	15.3	40.2	33	19	19
GWP (100yr ITH)*	725	1,030	794*	2	1	<7
Gas Thermal Conductivity (mW/mK, 10°C)	9	12.5	10.6	10.7	10.6**	9
LFL / UFL (vol % in air)	6.5-15.5	None	3.8-13.3	None	None	None

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 optimize the cost/performance balance of these substances, achieving a similar foam thermal behavior to HCFC-141b at the lowest possible cost, and, simultaneously, to carry out a comprehensive assessment of the HFO performance at developing countries conditions.

These alternatives could provide a long-term solution for spray PU foam applications as well as for other application. However, there are two main obstacles 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.

3. PROJECT DESCRIPTION

Currently, pre-blend polyol for SPF applications in Thailand contain 20-30% of HCFC-141b while the best reduced formulation used in developed countries can reach 7.5% of HFC-245fa. In this demonstration project, the goal is to validate reduced formulations at 10% HFOs. The project consists of two main components. The first component is the reduced formulation development with participating system houses. The second component is technical replication and dissemination of results.

3.1 Reduced Formulation Development with System House

Two local foam system houses (Bangkok Integrated Trading Co. Ltd. and South City Co. Ltd.) will be participating in the project. Bangkok Integrated Trading will focus their formulation on high density SPF ($50kg/m^3$) while South City will focus on normal density SPF ($35kg/m^3$). Based on their past experience in formulation development, the development process will be as followed:

i. **Planning.**

Definition of the independent variables: type of HFO, type of polyols, proportion of HFOs in the cell gas, and density. Definition of the dependent variables: Lambda value, compression strength, flame retardant, and dimensional stability. A commercial HCFC-141b based formulation will be used as control.

ii. **Selection of polyol candidates based on solubility.**

SPF uses a combination of polyether, polyester and amine polyols based on different requirements: dimension stability, flame retardant, and cell size. At this stage, candidates from each type of polyol will be shortlisted based on their solubility with the two HFOs. Different ratios of polyether, polyester and amine polyols will also be considered during formulation development.

iii. **Test options.**

Different spray foam applications require different combinations of polyol, surfactant, catalysts, fire retardant and other additives. With technical support from the international expert, one foam system house will develop formulations for under-roof application while another will develop formulations for cold storage room.

To reach 10% HFO reduced formulation, each system house will need to conduct different CO2 formulation for each HFO in order to get the characteristic curve. An additional formulation will be needed for matching the point where the characteristic curve intersects with the baseline HCFC-141b performance. Therefore, each HFO will need five formulations. For statistical purposes, three sets of tests are required for each HFOs. The total test will be equal to 30 tests plus 3 test for baseline HCFC-141b formulation. Three specimens for each test will be prepared and sent for laboratory testing. The total number of specimens and laboratory tests is about 100 (33 * 3). Three tests will be needed and additional 9 – 10 specimens will be sent for laboratory test.

iv. **Formulation development.**

Spray foam must meet a number of customer, government and specifier's criteria. The baseline for critical properties such as dimensional stability, adhesion to different substrates, thermal conductivity, processability will be determined to compare the values currently observed with the HCFC-141b based systems. The foams will be tested for reactivity, foam surface quality, density with and without skins, closed cell content, thermal performance, compressive strength, dimensional stability and on selected samples for flammability via standard test methods. The critical immediate and aged foam properties for these applications (Lambda value, compression strength, dimensional stability) will be tested following ASTM or ISO standard procedures and DIN for flammability.

The resulting formulations will be prepared at laboratory scale and then applied using a Gusmer (Graco) type dispenser with an adjustable isocyanate/polyol volume ratio.

The initial phase will be at laboratory scale testing minimum of 110 formulations Catalysis and overall blowing agent amount will be adjusted to have among formulations a similar reactivity, free-rise density, and dimension stability. The results of initial phase will be analyzed in order to identify best combinations of polyols before the next phase. The second phase, the system house will use a Gusmer (Graco) type dispenser to spray selected foam formulations to simulate real-world application. Three samples from each formulation will then be subjected to comprehensive tests.

Given that the new reduced formulations will most likely be more viscose than HCFC-141b formulation, the project will provide a spray foam machine with maximum working pressure at 3,500 psi and adjustable polyol to isocyanate ratio to each system house in order to carry out the spray foam test accurately. Other equipment will include additional laboratory equipment. The participating system houses will receive budget for testing different formulations and for cost of raw materials for the trial production and testing that they will develop with their customers.

v. Analysis of results.

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.

vi. Field test

A field test with selected formulations will be done.

3.2 Technical Replication and Dissemination of Results

Based on results from the first component, technical workshop will be made available to all system houses and polyol suppliers to share the results from the testing of foam formulations using low-GWP alternatives. Foam system houses and polyol suppliers will be given support in the form of access to experts and suppliers of alternative technologies to bring them up to speed on short and longer term options for a sector characterized by small users with capacity limitations. The technical assistance will transfer knowledge and strengthen technical capacity of the system house in formulation development. Foam properties depend on the interaction of all components: polyols, blowing agents, surfactants, catalysts, and isocyanate.

3.3 IMPACT ON GWP

There is no impact on GWP at this stage. The impact will occur when the system houses produce and commercialize the new low-GWP formulations.

4. PROJECT BUDGET

4.1 Technical Assistance

Cost for international expert is included. The expert is expected to provide technical advices for preparation, monitoring and reviewing of project, and recommendation on extension to other foam industry in the country. Three full one-week visits are needed. The first visit is to carry out detailed planning of the project implementation (experimental laboratory planning, formulation development, foam samples preparation and testing). The second visit is planned during the middle of the implementation to do a detailed project follow-up. Finally the third visit is to discuss the final report preparation including support on the cost/performance analysis and, in parallel, participate in the dissemination seminar.

4.2 Provision of equipment

The project plans to provide one full set spray foam machine (maximum working pressure 3,500 psi. The equipment consists of ordinary spray foam dispenser, super-critical CO2 module as well as water introduction module for PIR application. By this arrangement, any of potential difficulty to connect all modules can be avoided, so that fast implementation is ensured.

4.3 Laboratory tests

Some of essential properties of the foam are to be done by outsourcing (Flame retardancy and aging tests, SEM). Fundamental laboratory equipment for testing such as a thermal conductivity tester and are provided to the participating system houses. For the foam application, minimum amount of formulated polyol is to be provided from suppliers both for PUR and PIR applications.

4.4 Dissemination workshop

Cost to organize the dissemination workshops is included. Two workshops will be organized in Thailand to system houses in Thailand and support to interested system houses from countries in the region.

4.5 Incremental operating cost

According to the supplier, the cost of the low-GWP foam blowing agent material will be much higher than HCFC-141b. Though with reduced HFO PU formulation that have CO_2, derived from the water-isocyanate reaction, as co-blowing agent, the cost/performance balance of these substances, achieving a similar foam thermal behavior, could be slightly higher than HCFC-141b. Amount of PU material is nearly same as the HCFC-141b foams for almost all application, since the density is same and required thickness is same.

However, IOC is not requested for end users in the present demonstration project.

The summary of the project cost is as follows:

ITEMS	Qty.	Unit Cost (US$)	Total (US$)	Remark
Foaming equipment				
• Spray foam machine (maximum working pressure at 3,500 psi & adjustable polyol/isocyanate ratio)	2 sets	40,000	80,000	
Laboratory equipment				
• Thermal conductivity tester	2 sets	5,000	10,000	
Formulation development and testing				
• Formulation development	2	45,000	90,000	
• External test by accredited laboratory (flammability, compressibility)	110	250	27,500	

ITEMS	Qty.	Unit Cost (US$)	Total (US$)	Remark
• Field Test	20	500	10,000	
PU material for testing (including transportation)				
• Polyol	1,100 kg	3.0	3,300	
• MDI	1,100 kg	2.5	2,750	
Technology assistance including travel	1	80,000	80,000	
Technology dissemination workshop	2	10,000	20,000	
Sub-total			323,550	
Contingencies (10%)			32,355	
Total			355,905	

5. PROPOSED MULTILATERAL FUND GRANT

The proposed grant request is US$ 355,905, the calculated cost based on actual situation of all participants.

6. PROJECT IMPLEMENTATION

The project will be implemented under the supervision of the Department of Industrial Woks in coordination with Federation of Thai Industries. The following proposed schedule will be effective after the proposed MLF grant approved:

Activity	Month after approval											
	1	2	3	4	5	6	7	8	9	10	11	12
Project approval	X											
GSB appraisal	X											
Sub-project agreement		X										
Planning for system development and verification testing			X									
Specification of foaming equipment and site preparation			X									
Procurement and installation of equipment at the system houses				X								
Trials/testing/analysis				X	X	X	X	X	X			
Report and Review meeting.									X	X		

Technology dissemination workshop											X	
Completion report												X

7. PROJECT IMPACT

Not applicable.

8. ANNEXES

ANNEX-1: Information on system house consumption

ANNEX-2: OORG Review

Annex 1: HCFC-141b Consumption Summary

A. Bangkok Integrated Trading System Sales and HCFC-141b consumption

YEAR	2011	2012	2013	2014	2015 (forecast)
HCFC-141b Consumption (Total)	250	274	271	204	276
HCFC-141b Consumption (spray foam)	19.2	12.9	8.0	7.6	30

B. South City System Sales and HCFC-141b consumption (MT)

YEAR	2011	2012	2013	2014	2015 (forecast)
HCFC-141b Consumption (Total)	129	120	140	150	180
HCFC-141b Consumption (spray foam)	26	24	28	30	36

Annex 2: OORG Review

THAILAND – REVIEW OF SPRAY FOAM DEMONSTRATION PROJECT

INTRODUCTION

This project involves the validation of low GWP unsaturated HFCs (hereinafter referred to as "HFOs") as replacements for HCFC-141b in polyurethane rigid foam in the spray foam sub-sector. In particular, it involves the development of polyol formulations based on HFOs, in conjunction with two local system houses, which supply local SMEs and micro enterprises who are engaged in the application of spray foam systems in the Thailand market.

TECHNICAL ASSESSMENT

The replacement of HCFC-141b in the spray foam sub-sector has been particularly challenging. The main HCFC replacement technology for the global rigid polyurethane foam industry have been hydrocarbons (pentanes). These offer cost-effective low GWP solutions but the high flammability of these hydrocarbons (HCs) prohibit the use in spray foams on safety grounds. Further, the safety engineering modifications would be prohibitive for SMEs and the necessary safety management capacity would be beyond the resources of SMEs.

In developed countries the main replacements for HCFC-141b for spray foams have been one of the two saturated HFCs HFC-245fa or HFC-365mfc (note that HFC-365mfc is not mentioned in Section 2.2 where the use of HFCs is discussed – please rectify). These two HFCs offer excellent foam properties but their high GWPs indicate that they may not be long term solutions, particularly where compliance with Decision XIX/6 is required or is desirable. In addition, these HFCs do not, in themselves, offer cost effective solutions in comparison with HCFC141b and "reduced HFC" formulations involving co-blowing with CO2(water) is one approach to cost effectiveness being applied in developing countries.

The comparatively recent development of HFOs offer low GWP, non-flammable, alternatives to HFCs. These are HFC136mzz-Z (DuPont) and HCFC1233zd (Honeywell and/or Arkema). Their evaluation in developed countries and in applications such as appliances in developing countries are subject to intensive activity but the evaluation in SME-related applications such as spray foam is not being followed in the same time scale. However, their early evaluation in these applications indicates a significant improvement in insulation properties in comparison with the HFCs. It should be noted that the commercial availability of these new blowing agents is improving as new production facilities are built and commissioned.

The proposed project addresses the evaluation of these HFOs in a comprehensive manner. A key step is the partnership with two local systems houses in the development of suitable formulations for spray foams. These system houses are very experienced in polyurethane rigid foam technology. A further key step is the development of "reduced" formulation using HFOs in conjunction with partial co-blowing with CO2(water). This is covered in Section 1 (Project Objective) but is not further covered in Section 3.11 (iii) which concentrates on blend rations with HFC-245fa. It should be made clear to the reader that "reduced" formulations are used.

The development and evaluation of formulations involves a range of polyol types and this approach is fully supported. The formulations will be designed to give foam densities at two levels. These will be at ca 35 kg/m3 and ca 50 kg/m3 to cover optimum insulation and walls and floor/roof applications, respectively.

Another key step is involvement and the enhancement of the capabilities of the two system houses. This step includes a new spray foam dispenser and a thermal conductivity tester for each systems house. The dispensers are chosen to be capable of working with higher viscosity polyol formulations.

The reviewer queries the decision to have only one workshop to disseminate the results and learning from the study. Will this be enough to ensure the necessary attendance of SME foam manufacturers from different regions within and outside Thailand?

ENVIRONMENTAL, HEALTH AND SAFETY CONSIDERATIONS

The main environmental consideration is that HFO technology is of low GWP (and extremely low/negligible ODP) and represents a long-term option. The climate/energy impact (benefit) via the project results is low but may not be negligible, depending on whether or not improved insulation values are achieved in comparison to HCFC-141b. However, long term use of HFCs, even in blends, would have a negative impact

There are no health considerations due to the project per se but the opportunity should be taken during the technology dissemination workshop to emphasise, particularly to micro/SMEs, the importance of avoiding exposure to MDI vapour.

PROJECT COSTS

The proposed capital cost items are necessary and are supported.

In terms of operating costs, these will be higher than for HCFC-141b despite the measures such as the “reduced” HFO approach taken. However, it is noted that incremental operating costs are not requested.

The development of a comparative cost analysis will be a challenging target until market prices are known.

IMPLEMENTATION TIMEFRAME AND MILESTONES

The timetables should be feasible and are supported.

RECOMMENDATION - Approval (Please note points made\\0

Dr M Jeffs

17/09/2014