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COMITE EXECUTIF
DU FONDS MULTILATERAL AUX FINS
D'APPLICATION DU PROTOCOLE DE MONTREAL
Soixante-seizième réunion
Montréal, 9 – 13 mai 2016

PROPOSITIONS DE PROJETS: ARABIE SAOUDITE

Le présent document contient les observations et recommandations du Secrétariat sur les propositions de projets ci-après :

Mousse

• Projet de démonstration pour l'élimination des HCFC en utilisant le HFO comme agent de gonflage dans les applications de mousse vaporisée à des températures ambiantes élevées	ONUDI

Réfrigération

• Projet de démonstration chez les fabricants de climatiseurs sur la mise au point de climatiseurs de fenêtre et de climatiseurs monoblocs utilisant des frigorigènes à faible potentiel de réchauffement planétaire	Banque mondiale
• Projet de démonstration sur la promotion de frigorigènes à faible potentiel de réchauffement planétaire à base de HFO pour le secteur de la climatisation à températures ambiantes élevées	ONUDI

FICHE D'ÉVALUATION DU PROJET – PROJET NON PLURIANNUEL

ARABIE SAOUDITE

TITRE DU PROJET	AGENCE D'EXÉCUTION BILATÉRALE
a) Projet de démonstration pour l'élimination des HCFC en utilisant le HFO comme agent de gonflage dans les applications de mousse vaporisée à des températures ambiantes élevées	ONUDI

AGENCE NATIONALE DE COORDINATION	Présidence de la météorologie et de la protection de l'environnement

DERNIÈRES DONNÉES DE CONSOMMATION COMMUNIQUÉES POUR LES SAO COUVERTES DANS LE PROJET

A: DONNÉES DE L'ARTICLE 7 (TONNES PAO, 2014, À COMPTER D'AVRIL 2016)

HCFC	1 376,63

B: DONNÉES SECTORIELLES DU PROGRAMME DU PAYS (TONNES PAO, 2014, À COMPTER D'AVRIL 2016)

HCFC-22	1 121,9
HCFC-123	1,5
HCFC-141b	253,2

Consommation restante de HCFC admissible au financement (tonnes PAO)	765,40

ALLOCATIONS POUR LE PLAN D'ACTIVITÉS DE L'ANNÉE EN COURS		**Financement ($US)**	**Élimination (tonnes PAO)**
	(a)	s.o.	s.o.

TITRE DU PROJET:	
Utilisation de SAO dans l'entreprise (tonnes PAO):	3,08
SAO à éliminer (tonnes PAO):	s.o.
SAO à introduire (tonnes PAO):	s.o.
Durée du projet (mois):	16
Montant initial demandé ($US):	274 016
Total des coûts du projet (US $):	
Coûts différentiels d'investissement:	87 500
Imprévus (10 %):	8 750
Coûts différentiels d'exploitation:	107 097
Coût total du projet:	203 347
Participation locale (%):	100%
Pourcentage d'exportation (%):	s.o.
Subvention demandée ($US):	96 250
Rapport coût-efficacité ($US/kg):	s.o.
Coût d'appui de l'agence d'exécution ($US):	8 663
Coût total du projet pour le Fonds multilatéral ($US):	104 913
Financement de contrepartie (O/N):	O
Suivi périodique du projet inclus (O/N):	O

RECOMMANDATION DU SECRÉTARIAT	À examiner individuellement

DESCRIPTION DU PROJET

1. À la 75e réunion, l'ONUDI a présenté un projet de démonstration pour l'élimination des HCFC en utilisant le HFO comme agent de gonflage dans les applications de mousse vaporisée à des températures ambiantes élevées, d'un montant de 274 016 $US, plus des coûts d'appui d'agence de 19 181 $US, conformément à sa soumission originale[1]. À l'issue de débats au sein d'un groupe de contact chargé d'examiner tous les projets de démonstration de technologies à faible potentiel de réchauffement planétaire (PRP) soumis à la 75e réunion, le Comité exécutif a décidé de reporter à sa 76e réunion l'examen des sept projets de démonstration, incluant le projet de vaporisation de mousse à base de HFO pour l'Arabie Saoudite (décision 75/42).

2. Au nom du Gouvernement de l'Arabie saoudite, l'ONUDI a soumis de nouveau à la 76e réunion le projet de démonstration susmentionné, au même niveau de financement[2].

Objectifs du projet

3. Dans plusieurs pays visés à l'article 5, le HCFC-141b est toujours utilisé comme agent de gonflage pour la mousse vaporisée dans un grand nombre de petites et moyennes entreprises (PME), aux capacités technologiques limitées et aux ressources en capitaux restreintes, ce qui empêche l'introduction de technologies à fable PRP. Dans les pays à températures ambiantes élevées, la chaleur peut avoir des incidences marquées sur le processus de gonflage et réduire la qualité de la mousse, comparé aux pays aux températures plus faibles. En conséquence, le projet propose les activités suivantes:

(a) Démontrer les avantages, l'applicabilité et la faisabilité récurrente d'utiliser le HFO-1233zd(E) et le HFO-1336mzz(Z)[3] comme co-agents de gonflage avec l'eau pour remplacer le HCFC-141b dans le secteur des mousses de polyuréthane (PU) vaporisées ;

(b) Déterminer les réductions des coûts d'investissement et des coûts d'exploitation résultant de l'utilisation d'un mélange optimal d'eau et d'agent de gonflage, d'une mousse à faible densité et d'une conductivité thermique réduite, comparé à d'autres solutions de rechange.

Mise en œuvre du projet

4. Le projet sera mis en œuvre par Sham Najd, entreprise disposant de cinq unités de vaporisation de mousse. Aux fins de la reconversion de ces équipements aux technologies de gonflage à base de HFO (HFO-1233ze(E) et HFO-1336maam(z)), un nouveau vaporisateur de mousse, des applicateurs de mousse vaporisée et des polyols prémélangés à base de HFO sont demandés. Les propriétés essentielles des systèmes PU (haute densité, réactivité, conductivité thermique de la mousse, résistance en compression, stabilité dimensionnelle, absorption d'eau à court terme, et influence de la réactivité au vieillissement) seront évaluées. L'entreprise s'est engagée à éliminer 3,02 tonnes PAO de HCFC-141b.

[1] UNEP/OzL.Pro/ExCom/75/64.
[2] Le financement de la préparation de ce projet a été approuvé pour un montant de 30 000 $US, plus des coûts d'appui d'agence de 2 100 $US, étant entendu qu'une telle approbation ne signifie pas l'approbation du projet, ni de son niveau de financement lors de la présentation (décision 74/33).
[3] Comparé au HCFC 141b, les HFO 1233zd(E) et HFO 1336mzz(Z) ont tous deux un très faible PRP, des points d'ébullition plus élevés, une pression de vapeur plus faible, et des valeurs lambda plus faibles; il peut en résulter une efficacité thermique accrue, une manutention plus simple, une surface de mousse plus lisse et une durée de vaporisation plus courte.

Budget du projet

5. Le tableau 1 fait le résumé des coûts du projet.

Tableau 1. Coûts proposés du projet

Description	Coût ($US)
Vaporisateur de mousse avec accessoires (tuyaux, pompes de transfert, compresseur d'air et tête malaxeuse)	55 000
Matériels pour des essais sur le terrain (3 essais) (1 000 m^2)	30 000
Mise à l'essai des propriétés physiques des produits de gonflage au laboratoire d'essai certifié de l'Arabie saoudite	50 000
Transfert de technologies, essais et mise en service	40 000
Atelier de diffusion d'information	20 000
Total partiel	195 000
Imprévus	19 500
Total	**214 500**
Total selon le seuil coût-efficacité	274 016
Coûts différentiels d'exploitation	107 097
Total des coûts	**321 597**

OBSERVATIONS ET RECOMMANDATION DU SECRÉTARIAT

OBSERVATIONS

6. À la suggestion du Secrétariat, une étude de stabilité a été incluse dans le projet de démonstration, pour déterminer si des agents de gonflage/mélanges de polyols contenus dans des fûts peuvent être entreposés dans un entrepôt dans la chaleur sans climatisation, pour être ensuite vaporisés dans les mêmes conditions que des mélanges plus frais, manipulés de façon approprié.

7. Le Secrétariat a pris note de la proposition d'acquérir un nouveau vaporisateur et ensuite de désaffecter un vaporisateur à la fin du projet. Étant donné qu'une telle machine peut fonctionner aussi bien avec des systèmes à base de HCFC-141b ou qu'à base de HFO, il a été convenu de ne pas acquérir de nouveau vaporisateur.

8. À la suggestion du Secrétariat, le calendrier proposé a été modifié pour terminer en 16 mois les essais sur le terrain, la mise en service et les essais et dans le mois ou les deux mois qui suivent la soumission du rapport d'achèvement du projet.

9. En application de la décision 74/21 c), le Secrétariat a proposé que l'ONU envisage de rationaliser les coûts des projets de démonstration pour permettre l'approbation d'un plus grand nombre de projets de démonstration dans le cadre du financement mis à disposition à hauteur de 10 millions $US, soit en réduisant la portée des projets sans en compromettre l'objectif principal, soit par d'autres moyens. Il a été noté par ailleurs qu'il ne reste aucune consommation de HCFC-141b en Arabie Saoudite, puisque l'élimination de l'ensemble de la consommation a été financée durant la phase I du plan de gestion de l'élimination des HCFC (PGEH)[4]. En conséquence, les coûts différentiels d'exploitation (107 097 $US) ne seraient pas admissibles au financement. L'ONUDI a étudié avec soin les observations du Secrétariat et a réduit les coûts du projet, comme il est indiqué au tableau 2, il en a été tenu compte dans la proposition de projet révisée présentée à l'Annexe I au présent document.

[4] UNEP/OzL.Pro/ExCom/68/39.

Tableau 2. Coûts révisés du projet

Description	Coût ($US)
Vaporisateur de mousse pour les essais	6 000
Matériels pour les essais sur le terrain (3 essais) (1 000 m^2)	11 500
Mise à l'essai des propriétés physiques des produits de gonflage au laboratoire d'essai certifié de l'Arabie saoudite	50 000
Transfert de technologies, essais et mise en service	20 000
Total	**87 500**
Imprévus	8 750
Total général	**96 250**

10. Le Secrétariat a noté par ailleurs que les 3,02 tonnes PAO de HCFC-141b liées au projet ne peuvent être déduites puisqu'il n'y a plus de consommation de HCFC-141b en Arabie Saoudite.

Conclusion

11. Le projet de démonstration relèvera le niveau de connaissances dans l'application de formules à taux réduit de HFO (comme technologie à faible PRP) dans un secteur (mousse vaporisée) peuplé d'un grand nombre de PME et où l'introduction de technologies à faible PRP se heurte à des difficultés identifiées. L'optimisation des formules à faible taux de HFO devrait réduire les coûts d'exploitation, et les enquêtes sur l'utilisation de technologies de rechange dans les pays à températures ambiantes élevées, notamment pour l'entreposage de produits chimiques, pourraient servir de démonstration. Le Gouvernement de l'Arabie Saoudite a modifié le coût global du projet de 274 016 $US (selon la soumission initiale) à 96 250 $US. Durant la phase I du PGEH for Arabie Saoudite, des fonds ont déjà été fournis aux entreprises de formulation locales pour adapter les formules, notamment les formules à base de HFO, et Sham Najd figure parmi les clients en aval de ces entreprises de formulation; il ne reste donc plus de consommation de HCFC-141b admissible au financement. Le Secrétariat constate que trois autres projets proposent la démonstration de HFO dans les mousses vaporisées ou d'autres applications,[5] et que deux autres projets ont été soumis proposant la démonstration de solutions de remplacement à faible PRP en Arabie Saoudite.

RECOMMANDATION

12. Le Comité exécutif est invité à envisager les mesures suivantes :

(a) Examiner le projet de démonstration de l'élimination de HCFC en utilisant le HFO comme agent de gonflage dans les applications de mousse vaporisée dans des conditions de températures ambiantes élevées en Arabie Saoudite dans le contexte de ses débats sur des propositions de projet de démonstrations de produits à faible potentiel de réchauffement planétaire (PRP) en remplacement des HCFC, décrits dans l'aperçu des questions soulevées durant l'examen des projets (UNEP/OzL.Pro/ExCom/76/12);

(b) Approuver le projet de démonstration de l'élimination de HCFC en utilisant le HFO comme agent de gonflage dans les applications de mousse vaporisée dans des conditions de températures ambiantes élevées en Arabie Saoudite, pour le montant de 96 250 $US, plus des coûts d'appui d'agence de 8 663 $US pour l'ONUDI, conformément à la décision 72/40; et

(c) Inviter instamment le Gouvernement de l'Arabie Saoudite et l'ONUDI à terminer le projet en 16 mois comme prévu, et à soumettre un rapport définitif complet peu de temps après l'achèvement du projet.

[5]Colombie (UNEP/OzL.Pro/ExCom/76/26), Inde (UNEP/OzL.Pro/ExCom/76/35) et Thaïlande (UNEP/OzL.Pro/ExCom/76/50).

FICHE D'ÉVALUATION DU PROJET – PROJET NON PLURIANNUEL

Arabie Saoudite

TITRE DU PROJET **AGENCE BILATÉRALE/D'EXÉCUTION**

(a)	Projet de démonstration chez les fabricants de climatiseurs sur la mise au point de climatiseurs de fenêtre et de climatiseurs monoblocs utilisant des frigorigènes à faible potentiel de réchauffement planétaire	Banque mondiale

AGENCE NATIONALE DE COORDINATION	Présidence de la météorologie et de la protection de l'environnement

DERNIÈRES DONNÉES DE CONSOMMATION COMMUNIQUÉES POUR LES SAO COUVERTES DANS LE PROJET

A: DONNÉES DE L'ARTICLE-7 (TONNES PAO, 2014, À COMPTER D'AVRIL 2016)

HCFC	1 376,63

B: DONNÉES SECTORIELLES DU PROGRAMME DE PAYS (TONNES PAO, 2014, À COMPTER D'AVRIL 2016)

HCFC-22	1 121,9
HCFC-123	1,5
HCFC-141b	253,2

Consommation restante de HCFC admissible au financement (tonnes PAO)	765,4

ALLOCATIONS POUR LE PLAN D'ACTIVITÉS DE L'ANNÉE EN COURS		Financement (millions $US)	Élimination (tonnes PAO)
	a)	s.o.	s.o.

TITRE DU PROJET:	
Utilisation de SAO dans l'entreprise (tonnes PAO):	8,31
SAO à éliminer (tonnes PAO):	3,59
SAO à introduire (tonnes PAO):	0,00
Durée du projet (mois):	12
Montant initial demandé ($US):	1 306 800
Coûts finals du projet ($US):	
Coût différentiel d'investissement:	1 188 000
Imprévu (10 %):	118 800
Coût différentiel d'exploitation:	0
Coût total du projet:	1 306 800
Participation locale (%):	100
Pourcentage d'exportation (%):	0
Subvention demandée ($US):	1 306 800
Rapport coût-efficacité ($US/kg):	20
Coût d'appui de l'agence d'exécution ($US):	91 476
Coût total du projet pour le Fonds multilatéral ($US):	1 398 276
Financement de contrepartie (O/N):	O
Suivi périodique du projet inclus (O/N):	O

RECOMMANDATION DU SECRÉTARIAT	À examiner individuellement

DESCRIPTION DU PROJET

Historique

13. À la 75e réunion, la Banque mondiale a soumis un projet de démonstration pour la fabrication de climatiseurs de fenêtre et de climatiseurs monobloc utilisant un frigorigène à faible potentiel de réchauffement planétaire (PRP) autre que le HFC-410A, pour un montant 1 306 800 $US, plus des coûts d'appui d'agence de 91 476 $US, comme il a été demandé initialement[6]. Le projet a été préparé sans demande de financement de préparation au Fonds multilatéral. À l'issue de débats au sein d'un groupe de contact chargé d'examiner tous les projets de démonstration de technologies à faible PRP soumis à la 75e réunion, le Comité exécutif a décidé de reporter à la 76e réunion l'examen des sept projets de démonstration, incluant le projet de climatisation pour l'Arabie saoudite (décision 75/42).

14. Au nom du Gouvernement de l'Arabie Saoudite, la Banque mondiale a soumis de nouveau à la 76e réunion le projet de démonstration susmentionné au même niveau de financement. L'Annexe II au présent document contient la proposition de projet soumise.

Objectif du projet

15. L'Arabie saoudite fabrique des équipements de réfrigération et de climatisation. En 2011, quelque 10 000 tonnes métriques (tm) (550 tonnes PAO) de HCFC-22 ont été utilisées dans la fabrication de la gamme complète d'équipements de réfrigération et de climatisation. Les fabricants locaux comptent cinq grandes entreprises consommant chacune plus de 500 tm de HCFC-22 et un certain nombre d'entreprises plus petites consommant moins de 100 tm. Environ 70 % de la consommation d'électricité dans le pays est due à l'utilisation de systèmes de climatisation.

16. En conséquence, le projet propose les activités suivantes : construire, de mettre à l'essai et d'optimiser des prototypes de climatiseurs de fenêtre et de climatiseurs monobloc utilisant des frigorigènes à base de HFC-32 et de HC-290; évaluer leur rendement énergétique et leur coût différentiel; et diffuser les résultats et les conclusions aux fabricants intéressés en Arabie saoudite et dans d'autres pays. Le secteur de la fabrication de réfrigérateurs et de climatiseurs n'ayant pas encore été couvert dans le PGEH, une démonstration effective des produits de remplacement à faible PRP aura un effet d'entraînement important.

Mise en œuvre du projet

17. Le projet sera mis en œuvre avec le concours de deux entreprises: Saudi Factory for Electrical Appliances Co. Ltd. (avec une capacité annuelle de 120 000 climatiseurs de fenêtre), qui mettra au point deux types de climatiseurs de fenêtre de deux grandeurs (18 000 Btu/h et 24 000 Btu/h) contenant des frigorigènes à base de HFC-32 et de HC-290; et Petra Engineering Industries (KSA) Co. Ltd.(avec une capacité annuelle de 852 climatiseurs monobloc), qui se penchera sur le problème de l'inflammabilité des climatiseurs monobloc combinant refroidisseur et prise d'air (40 à 100 kW), et utilisant des frigorigènes à base de HFC-32 et HC-290.

18. L'assistance technique sera fournie pour la conception de prototypes de climatiseurs utilisant des frigorigènes de rechange considérant la grandeur de la charge et les mesures de sécurité; spécifier les principaux éléments (à savoir, condenseurs, évaporateurs, ventilateurs et compresseurs) en fonction du rendement requis; et construire les prototypes en tenant compte de la disponibilité des éléments et des fournisseurs dans les pays à températures ambiantes élevées. Des essais pour déterminer les performances des prototypes seront réalisés dans les laboratoires de Petra, conformément aux normes internationales.

[6] UNEP/OzL.Pro/ExCom/75/64.

Les performances, la quantité des charges et les prix seront comparés à ceux des équipements à base de HCFC-22.

Budget du projet

19. Le tableau 1 indique les coûts estimatifs du projet.

Tableau 1. Coût du projet par activité

Activité	**Quantité**	**Coût unitaire ($US)**	**Coût total ($US)**
Saudi Factory for Electrical Appliances Co. Ltd.			
Mise au point de climatiseurs de fenêtre (18 000 Btu/h) utilisant des compresseurs rotatifs et des compresseurs alternatifs	2	55 000	110 000
Mise au point de climatiseurs de fenêtre (24 000 Btu/h) utilisant des compresseurs rotatifs et des compresseurs alternatifs	2	55 000	110 000
Petra KSA			
Conception, incluant de nouveau logiciel pour les HFC-32 et HC-290		38 000	38 000
Fabrication de prototypes (6 prototypes (40, 70 et 100 kW) pour deux frigorigènes de remplacement)	6	70 000	420 000
Essais des prototypes	6	50 000	300 000
Recherche et développement, conception, essai et approbation	6		170 000
Assistance technique			
Expert international	1	30 000	30 000
Atelier de diffusion de technologie	1	10 000	10 000
Total partiel			**1 188 000**
Imprévus (10%)			118 800
Coût total			**1 306 800**

OBSERVATIONS ET RECOMMANDATION DU SECRÉTARIAT

OBSERVATIONS

20. Le projet de démonstration resoumis à la 76e réunion apporte une description plus approuvées des technologies sélectionnées, des justifications supplémentaires sur la nécessité de renforcer les connaissances sur la production de climatiseurs utilisant le HFC-32 et le HC-290 dans des pays à températures ambiantes élevées, et la possibilité de reproduire l'expérience. Le Secrétariat a noté avec satisfaction que la Banque mondiale a soumis la proposition de projet sans demander des fonds de préparation au Fonds multilatéral;

21. Par souci de commodité, les résultats des débats entre le Secrétariat et la Banque mondiale sur le projet de démonstrations soumis aux 75e et 76e réunions sont résumés ci-après:

(a) Invitée à donner des éclaircissements sur les risques de chevauchements ou les synergies détectés dans les travaux réalisés par le projet de démonstration pour promouvoir les produits de remplacement à faible PRP pour l'industrie de climatisation dans les pays à températures ambiantes élevées de l'Asie occidentale (PRAHA)[7], la Banque mondiale a expliqué que dans le cadre du projet PRAHA, Petra KSA n'a reçu des fonds que pour des essais et pour l'expédition de prototypes de climatiseurs à deux blocs, les fonds n'étant

[7] Approuvé à la 69e réunion pour une mise en œuvre par le PNUE et l'ONUDI (UNEP/OzL.Pro/ExCom/69/19).

pas disponibles pour la mise au point de prototypes. Les technologies proposées pour les climatiseurs de fenêtre et les climatiseurs monobloc dans le projet de démonstration soumis à la 76e réunion n'ont pas été mis à l'essai dans le cadre du projet PRAHA; dans le cas des climatiseurs de fenêtre, d'importantes ressources de développement sont requises afin de réduire la quantité de la charge de frigorigène et appliquer des fonctions de sécurité;

(b) Le Secrétariat a également évoqué un projet de démonstration similaire dans le secteur de la climatisation en Arabie saoudite soumis par l'ONUDI à la 76e réunion, qui prévoit la mise au point, l'optimisation et la validation de climatiseurs de fenêtre et de climatiseurs bibloc utilisant des frigorigènes de remplacement, notamment le HC-290. Il y a donc chevauchement entre les projets concernant la technologie à base de HC-290 proposée pour les climatiseurs de fenêtre. À la date de publication du présent document, la Banque mondiale était encore en consultation avec le Gouvernement de l'Arabie saoudite pour résoudre un tel chevauchement;

(c) Le Secrétariat a noté que l'entreprise Petra KSA a été fondée en 2010 (soit après la date limite du 21 septembre 2007) et n'est donc pas admissible au financement. La Banque mondiale a expliqué que le projet de démonstration ne couvrait que l'assistance technique pour la mise au point de prototypes pour les essais et que la reconversion de Petra sera financée de façon autonome, et que la date limite ne s'appliquait donc pas. Par ailleurs l'entreprise est membre participant du projet PRAHA;

(d) La proposition de projet indique, entre autres, la volonté des entreprises participantes d'entreprendre la démonstration; par contre, il n'y a aucune indication qu'elles cesseront d'utiliser les HCFC, puisque le projet n'inclut pas la reconversion;

(e) Concernant la démonstration de la faisabilité de la production commerciale des prototypes mis au point au titre du projet de démonstration, la Banque mondiale a expliqué que ce sera seulement après que les prototypes répondent aux normes de performance et de sécurité que l'entreprise pourra décider de la production commerciale. Par ailleurs, compte tenu de la nature concurrentielle du secteur, une reconversion coordonnée du secteur serait l'option préférée; c'est pourquoi l'Arabie saoudite devra en premier lieu établir et modifier les normes et les codes de construction pour assurer la sécurité des installations de climatiseurs contenant des frigorigènes inflammables, ainsi que la formation et la certification des techniciens à manipuler des frigorigènes inflammables ;

(f) Le Secrétariat a étudié les possibilités de rationaliser le coût du projet en application de la décision 74/21 c). En réponse, la Banque mondiale a précisé que les fonds demandés pour la « fabrication des prototypes » (liée aux climatiseurs monobloc) concernent le matériel destiné à six prototypes différents, à trois capacités différentes et pour deux types de frigorigène, l'externalisation d'éléments spéciaux, les frigorigènes et les expéditions; par contre, les « coûts de développement » (liés aux climatiseurs de fenêtre) comprennent les travaux d'ingénierie pour les dessins des prototypes, l'étude des propriétés des frigorigènes, l'optimisation du système, la conception des échangeurs thermiques, la mise au point de logiciels, et les essais en laboratoire. En fonction de ces exigences, les niveaux de financement demandés ne peuvent être rationalisés;

(g) Le Secrétariat s'est inquiété de la nécessité de signer de nouveaux contrats avec les entreprises visées, processus qui avait pris beaucoup de temps dans le passé. La Banque mondiale a indiqué qu'un nouveau cycle de traitement simplifié sera utilisé pour traiter l'accord de subvention pour ce projet. Ce processus permettra à la mise en œuvre de démarrer plus rapidement et de reproduire l'expérience découlant de ce projet dans la Phase II des PGEH en 2018.

Conclusion

22. Le Secrétariat considère que ce projet relève d'un des secteurs prioritaires visés dans la décision 72/40 et pourrait avoir un effet positif sur l'introduction de technologies à faible PRP pour des climatiseurs utilisés dans des pays à températures ambiantes élevées, en notant cependant que la production de climatiseurs avec des frigorigènes à base de HFC-32 et HC-290 existe déjà dans plusieurs pays. Le Secrétariat considère que dans ce projet de démonstration, l'élément lié à Petra KSA, qui a été établi en 2010, n'est pas admissible à la lumière des décisions 60/44 et 74/50; et que l'élément lié à l'essai du HC-290 constitue un chevauchement avec le projet de démonstration soumis par l'ONUDI pour l'Arabie saoudite. Avec le projet de démonstration sur la mousse vaporisée, le nombre total de projets de démonstration pour l'Arabie saoudite est de trois. Dans ses directives[8], le Comité exécutif a indiqué que les projets devraient également tenir compte de la répartition régionale et géographique.

RECOMMANDATION

23. Le Comité exécutif est invité à:

(a) Examiner le projet de démonstration auprès des fabricants de climatiseurs, visant à mettre au point des climatiseurs de fenêtre et des climatiseurs monobloc utilisant des frigorigènes à faible potentiel de réchauffement planétaire (PRP) en Arabie Saoudite, à la lumière de ses débats sur les propositions de projets de démonstration de technologies à faible PRP en remplacement des HCFC, comme il est décrit dans le document « Aperçu des problèmes relevés durant l'examen des projets » (UNEP/OzL.Pro/ExCom/76/12); et

(b) Décider s'il approuve ou non le projet de démonstration auprès des fabricants de climatiseurs, visant à mettre au point des climatiseurs de fenêtre et des climatiseurs monobloc utilisant des frigorigènes à faible potentiel de réchauffement planétaire (PRP) en Arabie Saoudite.

[8]Paragraphe 97e) du document UNEP/OzL.Pro/ExCom/73/62.

FICHE D'ÉVALUATION DU PROJET – PROJET NON PLURIANNUEL

Arabie Saoudite

TITRE DU PROJET		AGENCE BILATÉRALE/D'EXÉCUTION
a)	Projet de démonstration sur la promotion de frigorigènes à faible potentiel de réchauffement planétaire à base de HFO pour le secteur de la climatisation à températures ambiantes élevées	ONUDI

AGENCE NATIONALE DE COORDINATION	Présidence de la météorologie et de la protection de l'environnement

DERNIÈRES DONNÉES DE CONSOMMATION COMMUNIQUÉES POUR LES SAO COUVERTES DANS LE PROJET

A: DONNÉES DE L'ARTICLE-7 (TONNES PAO, 2014, À COMPTER D'AVRIL 2016)

HCFC	1 376,63

B: DONNÉES SECTORIELLES DU PROGRAMME DE PAYS (TONNES PAO, 2014, À COMPTER D'AVRIL 2016)

HCFC-22	1 121,9
HCFC-123	1,5
HCFC-141b	253,2

Consommation restante de HCFC admissible au financement (tonnes PAO)	765,40

ALLOCATIONS POUR LE PLAN D'ACTIVITÉS DE L'ANNÉE EN COURS		**Financement ($US)**	**Élimination (tonnes PAO)**
	(a)	s.o.	s.o.

TITRE DU PROJET:	
Utilisation de SAO dans l'entreprise (tonnes PAO):	2 550 MT (2015)
SAO à éliminer (tonnes PAO):	0
SAO à intégrer (tonnes PAO):	0
Durée du projet (mois):	24
Montant initial demandé ($US):	1 690 000
Coûts finals du projet ($US):	
Coût différentiel d'investissement:	1 570 000*
Imprévu (10 %):	s.o.
Coût différentiel d'exploitation:	s.o.
Coût total du projet:	1 570 000*
Participation locale (%):	100
Pourcentage d'exportation (%):	s.o.
Subvention demandée ($US):	1 570 000*
Rapport coût-efficacité ($US/kg):	s.o.
Coût d'appui de l'agence d'exécution ($US):	109 900*
Coût total du projet pour le Fonds multilatéral ($US):	1 679 900*
Financement de contrepartie (O/N):	O
Suivi périodique du projet inclus (O/N):	O

*Si le projet « Promotion de frigorigènes de remplacement pour les pays à températures ambiantes élevées (PRAHA-II) » est approuvé, le niveau de financement sera réduit de 160 000 $US, plus les coûts d'appui d'agence correspondants

RECOMMANDATION DU SECRÉTARIAT	À examiner individuellement

DESCRIPTION DU PROJET

24. Au nom du Gouvernement de l'Arabie saoudite, l'ONUDI, en sa qualité d'agence d'exécution désignée, a soumis à la 76e réunion une demande de financement pour un projet de démonstration pour la promotion de frigorigènes à base de HFO, à faible potentiel de réchauffement planétaire (PRP), dans le secteur de la climatisation à des températures ambiantes élevées, pour un montant de 1 690 000 $US, plus des coûts d'appui d'agence de 118 300 $US, conformément à la demande initialement soumise[9].

25. Alessa est une entreprise à participation locale totale qui a pris part au projet de démonstration pour la promotion de solutions de rechange à faible PRP pour le secteur de la climatisation à des températures ambiantes élevées en Asie occidentale (PRAHA)[10], et qui fabrique des climatiseurs de fenêtre et des climatiseurs bibloc, ainsi que certains systèmes de plus grandes dimensions[11]. En 2015, la consommation de l'entreprise était d'environ 2 550 tonnes métriques (tm) de HCFC-22 et sa production était de quelque 700 000 climatiseurs de fenêtre, avec une capacité de 16 à 20 kBTU/h (4,7–5,9 kW) et une charge de fluide frigorigène à base de HCFC-22 de 1,75 kg, ainsi que quelque 700 000 climatiseurs bibloc d'une capacité de 19 à 22 kBTU/h (5,6 – 6,4 kW) et une charge de fluide frigorigène d'environ 1,9 kg.

26. Dans le cadre du projet, Alessa fabriquera et mettra à l'essai des modèles de climatiseurs de fenêtre et de climatiseurs bibloc utilisant des mélanges HFO/HFC[12] à faible PRP, ainsi que du R-290. Les appareils seront redessinés et optimisés, en respectant notamment des normes de rendement énergétique. Une fois les unités mises au point, une première série de production de démonstration sera lancée pour vérifier les procédures et la qualité d'exécution requises. Étant donné les limitations de la chaine de fabrication existante dans l'utilisation de frigorigènes inflammables, une chaine de production sera mise en place pour simuler la production, qui sera reconvertie ultérieurement en chaine de fabrication intégrale. La chaine reconvertie intègrera les mesures de sécurité nécessaires.

Mise en œuvre du projet

27. Le projet de démonstration répondra aux difficultés techniques associées à la conception de climatiseurs utilisant des produits de remplacement à faible PRP, aptes à une utilisation dans des conditions de températures ambiantes élevées, incluant les facteurs ci-après:

(a) Glissement de température[13] pour certains des mélanges de HFO proposés, qui sont des mélanges zootropes[14]. Ces mélanges doivent être chargés avec précision en phase fluide

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[9] Le financement de la préparation de ce projet a été approuvé pour un montant de 30 000 $US, plus des coûts d'appui d'agence de 2 100 $US, étant entendu que cette approbation ne signifie pas pour autant l'approbation du projet ni de son niveau de financement lorsqu'il sera soumis (décision 74/33).

[10] Approuvé à la 69e réunion aux fins de mise en œuvre par le PNUE et l'ONUDI (UNEP/OzL.Pro/ExCom/69/19).

[11] Alessa fabrique également du matériel de réfrigération et sa production de mousse a été incluse dans la Phase I. L'entreprise a été reconvertie pour remplacer le HCFC-141b par du cyclopentane.

[12] Des mélanges de HFO et de HFC seront mis à l'essai puisque de tels mélanges peuvent présenter une capacité de refroidissement volumétrique comparable au HCFC-22. Les HFO monocomposants ont une capacité de refroidissement volumétrique plus faible que le HCFC-22, ce qui exige un plus grand volume balayé du compresseur, entraînant des coûts plus élevés et un climatiseur de plus grandes dimensions. Les mélanges contiendront sans doute du HFC-32, qui augmente la capacité volumétrique, mais ils peuvent aussi contenir d'autres éléments comme du HFC-152a.

[13] Le glissement de température est la différence de température entre l'état de vapeur saturée et celui de fluide saturé sous pression constante.

[14] On appelle mélange zéotrope un mélange de frigorigènes présentant un glissement de température. Les frigorigènes monocomposants tels que le HCFC-22 ne présente pas un tel glissement. Les mélanges de frigorigènes qui présentent un faible glissement de température, tels que le HFC-410A, son des mélanges quasi-azéotropes.

et exige une optimisation du condenseur et de l'évaporateur, et éventuellement l'emploi de détendeurs capillaires plutôt que de robinets détendeurs;

(b) Nécessité d'une charge exacte du fluide frigorigène, et inflammabilité des mélanges de HFO, imposant des essais sous vide pour vérifier l'étanchéité;

(c) Meilleure étanchéité des connections pour minimiser les fuites en cours d'installation, ce qui exigera de nouveaux dessins des unités intérieures et extérieures, pour tenir compte d'un plus grand évaporateur.

28. Trois pavillons de 15-20m^2 seront construits pour simuler l'aménagement d'une maison typique et mener des essais pratiques sur les climatiseurs fabriqués. Les pavillons seront placés dans le voisinage d'Alessa pour une période de trois à six mois, aux fins des essais dans des conditions environnementales similaires à celles de l'Arabie saoudite, avec l'accumulation de sable dans les condenseurs, des journées chaudes où la température atteint 50°C et des nuits froides. Parallèlement, des unités fabriquées seront installées à divers emplacements de l'Arabie saoudite pour en tester le fonctionnement dans différentes conditions (par ex. : humidité). Les pavillons serviront en outre à former des techniciens d'entretien à l'utilisation des nouveaux frigorigènes et à organiser des activités de sensibilisation.

29. Une évaluation suivra la phase d'essais et des options seront retenues aux fins de production. Plusieurs produits de remplacement à faible PRP seront sans doute choisis. À l'issue de la mise en œuvre du projet, tous les équipements achetés dans le cadre du projet seront installés à une chaine de production de climatiseurs bibloc. Le projet sera achevé en 24 mois.

<u>Budget du projet</u>

30. Le tableau 1 résume les coûts du projet.

Tableau 1. Coûts du projet

Activité	Budget ($US)
Recherche et développement	320 000
Mise à l'essai des unités pilotes	35 000
Essais pratiques	30 000
Chaine de production	25 000
Investissement de capitaux	350 000
Investissement de capitaux – laboratoire	250 000
Investissement de capitaux – chaine de production	560 000
Sensibilisation et formation	30 000
Gestion du projet et soutien technique	90 000
Total	**1 690 000**

OBSERVATIONS ET RECOMMANDATION DU SECRÉTARIAT

OBSERVATIONS

31. En examinant le projet de démonstration, le Secrétariat a été saisi des informations pertinentes au projet de démonstration sur la fabrication de climatiseurs en Arabie saoudite soumis par la Banque mondiale, ainsi que de la proposition pour PRAHA-II et du rapport sur PRAHA-I[15]. Bien qu'une lettre d'engagement ait été reçue avec la demande de financement des préparatifs présentée à la 74e réunion, le Secrétariat n'a pas encore reçu de telle lettre pour le projet de démonstration et il a demandé à l'ONUDI de la lui fournir.

[15] UNEP/OzL.Pro/ExCom/76/10.

32. Le Secrétariat a noté que le projet de démonstration dans le secteur de la climatisation soumis par la Banque mondiale propose également de mettre au point des prototypes de climatiseurs de fenêtre utilisant le HC-290. À l'issue d'entretien avec l'ONUDI, il est noté que le chevauchement ne constitue qu'un élément mineur du projet de l'ONUDI projet, et que la Banque mondiale et l'ONUDI sont convenues de coopérer pour cet élément particulier s'il y a demande à cette fin.

33. Le Secrétariat a précisé qu'une fois le projet de démonstration achevé, le matériel sera intégré aux fins de reconversion à une chaine de production existante de climatiseurs bibloc qui remplacera le HCFC-22 par le produit de rechange retenu à faible PRP. Alessa est convenue qu'aucun autre financement ne sera demandé pour la reconversion de la chaine de production sélectionnée.

34. Compte tenu de la décision 74/21 c), le Secrétariat a proposé que l'ONUDI envisage la possibilité de rationaliser les coûts du projet de démonstration. En réponse, l'ONUDI a réduit les coûts du projet de 1 690 000 $US à 1 570 000 $US comme il est indiqué dans le tableau 2, et pris en compte dans la proposition de projet révisée qui figure à l'Annexe III au présent document.

Tableau 2. Coût du projet proposé

Activité	Budget ($US)
Recherche et développement	320 000*
Mise à l'essai des unités pilotes	35 000
Essais pratiques	30 000
Chaîne de production	25 000
Investissement de capitaux	315 000
Investissement de capitaux – laboratoire	225 000
Investissement de capitaux – chaîne de production	500 000
Sensibilisation et formation	30 000
Gestion du projet et soutien technique	90 000
Total	**1 570 000***

*Si le projet « Promotion de frigorigènes de remplacement pour les pays à températures ambiantes élevées (PRAHA-II) » est approuvé, le niveau de financement sera réduit de 160 000 $US, plus les coûts d'appui d'agence correspondants.

35. Le Secrétariat a noté par ailleurs les synergies potentielles avec la proposition PRAHA-II. Si le projet PRAHA-II était approuvé par le Comité exécutif, il pourrait présenter des occasions de rationaliser davantage les coûts, notamment pour la recherche et le développement. L'ONUDI, convenant de la possibilité d'une rationalisation, a suggéré que les coûts de recherche et de développement pourraient être réduits de moitié (réduction de 160 000 $US) si le projet PRAHA-II était approuvé.

<u>Conclusion</u>

36. Le projet couvre un des secteurs prioritaires découlant de la décision 72/40 et pourrait avoir un effet positif sur l'introduction de technologies à faible PRP pour la climatisation, en particulier pour une utilisation dans des pays à températures ambiantes élevées. Le projet se fonderait sur les résultats de PRAHA-I et serait complémentaire au projet PRAHA-II soumis à la 76e réunion, s'il était approuvé. Alessa utiliserait le matériel du projet pour reconvertir une chaine de production existante de climatiseurs bibloc en remplaçant le HCFC-22 par un produit de rechange à faible PRP; l'entreprise est convenue qu'aucun autre financement ne serait demandé pour une telle reconversion. Le Secrétariat considère que le projet présente un chevauchement partiel avec les essais d'utilisation du HC-290 dans des climatiseurs de fenêtre qui font partie du projet de démonstration soumis par la Banque mondiale pour l'Arabie saoudite. Avec le projet de démonstration sur la mousse vaporisée, cela donnera un total de trois propositions de projets de démonstration en Arabie Saoudite. Dans ses instructions le Comité exécutif a indiqué que les projets devraient tenir compte de la répartition régionale et géographique.[16] En outre, au

[16]Paragraphe 97 e) du document UNEP/OzL.Pro/ExCom/73/62.

moment de la rédaction du présent document, la lettre d'engagement pour ce projet de démonstration n'a toujours pas été reçue.

RECOMMANDATION

37. Le Comité exécutif est invité à:

(a) Examiner le projet de démonstration pour la promotion de frigorigènes à base de HFO, à faible potentiel de réchauffement planétaire (PRP), dans le secteur de la climatisation dans des conditions de températures ambiantes élevées, en Arabie saoudite, , à la lumière de ses débats sur les propositions de projets de démonstration de technologies à faible potentiel de réchauffement planétaire (PRP) en remplacement des HCFC, comme il est décrit dans le document « Aperçu des problèmes relevés durant l'examen des projets » (UNEP/OzL.Pro/ExCom/76/12); et

(b) Décider s'il approuve ou non le projet de démonstration pour la promotion de frigorigènes à base de HFO, à faible PRP, dans le secteur de la climatisation dans des conditions de températures ambiantes élevées, en Arabie saoudite.

Annex I

PROJECT COVER SHEET

COUNTRY: **Kingdom of Saudi-Arabia**

IMPLEMENTING AGENCY: UNIDO

PROJECT TITLE: Demonstration Project for the Phase-out of HCFCs by Using HFO as Foam Blowing Agent in the Spray Foam Applications in High Ambient Temperatures

PROJECT IN CURRENT BUSINESS PLAN	Yes
SECTOR	Foams
SUB-SECTOR	PU In-situ formed spray foam
ODS USE IN SECTOR (Average of 2014)	600 MT of HCFC-141b
ODS USE AT ENTERPRISES (Average of 2014)	28 MT
PROJECT IMPACT	28 MT (3.08 ODP tones) of HCFC-141b
PROJECT DURATION	18 months
TOTAL PROJECT COST:	
Incremental Capital Cost	US$ 87,500
Contingency	US$ 8,750
Incremental Operating Cost	US$ 107,097 (not requested for funding)
Total Project Cost	US$ 203,347
LOCAL OWNERSHIP	100%
EXPORT COMPONENT	Nil
REQUESTED GRANT	US$ 96,250
COST-EFFECTIVENESS	US$ 7,26/ kg (If IOC is calculated)
IMPLEMENTING AGENCY SUPPORT COST (9.0%)	US$ 8,663
TOTAL COST OF PROJECT TO MULTILATERAL FUND	US$ 104,913
STATUS OF COUNTERPART FUNDING	Yes
PROJECT MONITORING MILESTONES	Included
NATIONAL COORDINATING/ MONITORING AGENCY	Presidency of Meteorology and Environment (PME)

Project summary
HCFC-141b is used by Sham Najd International in in-situ formed sprayed rigid polyurethane (PUR) and polyisocyanurate foam (PIR) for insulating and water proofing walls, ceilings, roofs, suspended ceilings and floors at the construction sites and industrial sites in the Kingdom of Saudi-Arabia. Sham Najd will phase-out HCFC-141b by converting to HFO foaming agent technology. The chosen technology is a non-ozone depleting and low GWP foaming agent. This HFO technology, which is a definitive alternative under the Montreal Protocol and additionally has a positive impact on climate, and is in compliance with Decision XIX/6.
Impact of project on Country's Montreal Protocol Obligations
Immediate impact of this individual project is the phase-out of 28.00 MT of HCFC-141b, thereby, contributing to the country's obligation to meet 4.7% reduction target in 2018. With the successful implementation of this project, there will be no consumption of HCFC-141b for foam blowing purposes in this company.

Prepared by: UNIDO Date: 24 March 2016
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 the 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 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 HFOs in the hot climate for the application of alternatives in the spray foaming sector 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 74nd 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 Kingdom of Saudi-Arabia.

HFO-1233zd(E) and HFO-1336mzz(Z) have very low GWP, both less than 5, and HFO-1233zd (E) is claimed to be even less than 1. In calculations within this project proposal GWP factor 5 is used. The HFOs have higher boiling point and lower vapour pressure which improves handling and yields smoother foam surfaces. Due to the very low thermal conductivity, less than 10,7 mW/mK, which is comparable to the HCFC-141b's same of approximately 10 mW/mK, the HFOs provide a substitute chemical for the HCFC-141b with lower GWP.

Replacing HCFC-141b in spray foam in the Kingdom of Saudi Arabia (KSA) presents an opportunity and technical challenge, making it worthy of a demonstration project. The preliminary 2014 HCFC consumption estimates show that 600 MT of HCFC-141b or 66 ODP tonnes were consumed in 2014 for spray foam in the Kingdom of Saudi-Arabia (these figures include import of pre-blended polyurethane systems). Also in 2014, the Ministry of Municipal and Rural Affairs of KSA has made thermal insulation compulsory for all new buildings in the 24 districts of the country covering 80% of the populations. The addition of thermal insulation in new building is expected to reduce 40% of energy use in air conditioning. Today, air conditioners account for 70% of electricity consumption in the region and with 1.5 Million new homes needed to keep up with the population growth, energy demand is anticipated to double by 2030 if energy conservation measures are not put in place.

2 OBJECTIVE

- Demonstrate benefits from the use of the HFO-1233zd(E) and HFO-1336mzz(Z), which have very low GWP in replacement of HCFC-141b with water, in terms of lower GWP and CO2 release and insulation properties in the PU spray foam insulation sector
- Demonstrate the easy applicability of the technology and, consequently, the replicability of the results

- Demonstrate that lower cost structure than with other alternatives can be obtained by means of lower foam density and lower thermal conductivity
- Objectively analyze, if the incremental operating cost could be reduced overall in similar future projects by means of using optimized water / physical foam blowing agent applied in the foaming process. Thus, providing means of reducing the overall incremental operating cost. The operating cost comparison is analyzed in the section 5.2, in particular in the last paragraph of the section.
- Objectively analyze, if the incremental capital cost at the System Houses can be utilized by means of lesser focus on the flammable gas detection and ventilation. In particular the extensive exhaust ventilation in the hot countries may result unexpected expenses in the production area air-conditioning during the hot summer periods

3 METHODOLOGY

The range of properties exhibited by PUR products is very wide. The same is true for PIR products and these two ranges often overlap. Although not in every case, generally PIR products have a higher upper service temperature and can perform better in reaction to fire tests. In all cases, for both PIR and PUR products, their individual performance claimed by the manufacturer are described by the levels of properties obtained. Accordingly, therefore, all the declaration clauses will be completed using the term PU to include both PUR and PIR products.

<u>This demonstration project</u> is to provide means for the evaluation of spray foam manufactured with new technology in comparison and in regards to European in-situ formed sprayed PU foam standard EN 14315;

- Thermal resistance and thermal conductivity
    - Measurement of lambda values (thermal conductivity W/mK)
    - Ageing of lambda value
- Reaction to fire of the products
    - The reaction to fire classification of the products shall be determined in accordance with EN-13501-1 and using data obtained from tests carried out according to procedures EN ISO 11925-2 and EN 13823
- Dimensional stability under specified temperature and humidity conditions
    - Dimensional stability under specified temperature and humidity conditions shall be determined in accordance with EN 1604
- Reaction profile and free-rise density
- Durability characteristics
    - Durability of reaction to fire against ageing/degradation
    - Durability of thermal resistance against ageing/degradation
    - Durability of compression strength against ageing/degradation
    - Closed cell content
- Short-term water absorption by partial immersion
- Compressive stress or compressive strength

All tests above will be conducted according to EN 14315 (*Thermal insulating products for buildings — In-situ formed sprayed rigid polyurethane (PUR) and polyisocyanurate (PIR) foam products*)

3.1 Description of process expectations

Quality of in-situ formed spray PU spray foam relies, in most of the application, on the insulation property. Considering the PU physical properties, insulation of final construction can be influenced by the thermal conductivity of the blowing agent and the thickness of the foam.

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

Aim of this demonstration project is to recognize the advantages of HFO use in in-situ formed sprayed foam process, when using HFO-1233zd(E) and HFO-1336mzz(Z) as foam blowing agent instead of HCFC-141b.

The HFO technology will give advantages to HFC and other alternative foaming agent converted products in term of:

- Decreased lambda value
- Smoother foam surface, which can be benefitted in the consumption of acrylic water barrier applied on the top of sprayed PU foam
- Decreased spraying time compared to the other alternatives of 10% due to the faster cure between laying down new foam layers

The above is expected to generate substantial technical improvements in the final insulation as well as reduction of operation costs in comparison the other alternatives (reduction of time for spraying as well as reduction of raw materials).

The project results will be extremely relevant for those sectors where spray foaming is applied in hot countries and insulation property of final products is crucial and thickness of insulation cannot be increased

3.2 Detailed description of Methodology

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

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

1- HFO conversion of their spray foaming needs
2- Testing procedure described in para 3 (Methodology)

The HFO conversion will include:

1. Provision of new spray foaming unit and necessary changes in the mixing process at the System House

- The System House operations must be converted so that the polyol mixing vessel is to be replaced or upgraded with cooling and heating unit, so that HFO-1233zd(E) (boiling point of 19 C) can be mixed at lower temperature i.e. at 12 C, and to be kept at that temperature for 24 hrs. After that temperature can be raised to 25 C, and the mixed polyol (preblend) can be moved in the drums for the customer supply.

- It is anticipated that the other HFO, HFO-1336mzz(Z) can be mixed without any changes in the mixing process.

- The cost of equipment changes at the System House will be covered by the relevant component of the HPMP, which is under implementation

2. At the spray foam applicator, the provision of HFO preblended polyol and provision of new spray foaming unit for the demonstration project needs.

4 COMPANY BACKGROUND

System House:

A local system house will prepare the formulations with support from UNIDO Foam Sector Expert and HFO supplier.

Spray foam applicator:

Sham Najd International Co. Ltd is a 100% Saudi-Arabian national public company, originally founded in 2004. Their core focus is on quality in-situ formed sprayed rigid polyurethane (PUR) and polyisocyanurate foam (PIR) for insulating and water proofing walls, ceilings, roofs, suspended ceilings and floors at the construction sites (over metal, concrete and wooden substance) and industrial sites, where one of the most import application is the thermal energy storage tanks (TES). Sham Najd International is a successful business employing over 185 staff members. The spray foaming operation is operated with five teams with five spray foaming units, with three Gracos and two Gusmer machines. Each foaming machine unit consists closed trailer with one electrically operated spray foaming machine, 100 meters foaming hoses, electrical generator, air compressor, pneumatically operated transfer pumps to deliver PU chemicals from drums to the intermediate tanks of 2,000 liters or directly to the spray foaming machine, spare mixing heads and all maintenance tools and spare parts for the independent operations anywhere in the Kingdom of Saudi-Arabia.

Sham Najd International is based in Riaydh, and their operations are all over the Kingdom of Saudi-Arabia. Their address details are below.

Address:
Contact person: Eng. Abdulrazak Zahal (General Manager)
P.O. Box 27994
Riyadh
Tel office: +966 1 2064070
Tel: 00966505241420
Fax: +966 1 2064074
Website:
Members: Public Company
Reg No: C.R. 1010195476

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 200 liter drums. The polyol-blend and isocyanate are sifted by means of pneumatic pump to the intermediate working tanks within the trailer unit or directly in the spray foaming machine. The company Najd Sham has 5 foaming machines. The PU chemicals are in-situ sprayed on the construction sites in the desired quantity to achieve the required foam parameters. The production process is manual and fully man operated. The average foam per square meter applied is 3.125 kg.

The chemical composition of various chemical uses in the manufacturing in-situ formed PU sprayed foam is provided in the table below:

Description	HCFC 141b	Polyol	Isocyanate

Volymetric %-age mixing ratio	9%	41%	50%
Mass %-age	7 %	45 %	48 %

The description of the foaming machines is provided below.

Baseline Equipment

Sr. #	Type of Equipment	Model	No.	Design Capacity	Manufacturer Type	Year
1	Graco	E-XP1	3	12 kg/min	Spray foam	2007
2	Gusmer	H2	2	12 kg/min	Spray foam	2004
3	Graco	Mark V	4	7 kg/min	Coating / acrylic	2004
4	Trailer	30 m3	5	See below*	Locally made	2004 -2007

*Each foaming machine unit consists closed trailer with one electrically operated spray foaming machine, 100 meters foaming hoses, electrical generator, air compressor, pneumatically operated transfer pumps to deliver PU chemicals from drums to the intermediate tanks of 2,000 liters or directly to the spray foaming machine, spare mixing heads and all maintenance tools and spare parts for the independent operations anywhere in the Kingdom of Saudi-Arabia

Within this demonstration project it is proposed to provide comprehensive one foaming unit package for Sham Najd Company in order to be able to conduct the full-scale field-testing without compromising their normal foaming operations elsewhere in the Kingdom of Saudi-Arabia.

Two photographs taken at the company are provided below:

Sham Najd International Co., Ltd HQ

Graco electrically driven E-XP1 applicator

4.2 ANNUAL PRODUCTION PROFILE IN 2014

Sham Najd spray foam operations are applied to walls, ceilings, roofs, suspended ceilings and floors at the construction sites (over metal, concrete and wooden substance) and industrial sites, where one of the most important is the thermal energy storage tanks (TES).

Total annual foaming operations

Total sprayed area	128,000 m^2 average consumption 3.125 kg/m^2
Total consumed PU	400,000 kg
HCFC-141b (7%)	28,000 kg equivalent to 3.08 ODP tons

5 TECHNOLOGY OPTION

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

Although this project proposal is for demonstrating HFOs suitability as ozone depleting HCFC-141b replacement chemical, we are providing the other alternatives below.

HCFC-141b has mainly been used as a foam blowing agent in various formulations in the manufacturing of PU foam for the production of PU sprayed foam in the Kingdom of Saudi-Arabia.

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

- Mechanical properties
- Density
- Insulation properties
- Water absorption
- Reaction to fire
- Durability
- 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 (subject for this demonstration project)

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)*

Sector	*HCFCs*	*HFCs*	*HCs*	*HCOs*	*HFOs*	*CO2-based*
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 In-situ formed spray foam	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)*
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:

Commercially Available Options

Option	**Pros**	**Cons**	**Comments**
Cyclopentane & n-Pentane	Low GWP	High flammable	High incremental capital cost, may be uneconomic for SMEs
	Low operating costs		
	Good foam properties		
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	Moderate foam properties - high thermal conductivity-	Low incremental Capital Cost
	Non-flammable		
Methyl	Low GWP	Moderate foam	Moderate incremental capital

Formate/Methylal	Flammable although blends with polyols may not be flammable	properties - high thermal conductivity-	cost (corrosion protection recommended)

Emerging Options

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:

Assessment of criteria for commercially available options

	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			Methyl Formate			Water-blown / Formic Acid		
	Formula	%	Cost/kg	Formula	%	Cost/kg	Formula	%	Cost/kg	Formula	%	Cost/kg
Polyol	100	44,29%	2,70	100	46,08%	2,70	100	37,88%	2,70	100	37,95%	2,70
B.A	15,8	7,00%	2,70	7	3,23%	11,00	9	3,41%	2,70	3,5	1,33%	2,70
MDI	110	48,72%	2,70	110	50,69%	2,70	155	58,71%	2,70	160	60,72%	2,50
Total	**225,8**	**100,00%**	**2,70**	**217**	**100,00%**	**2,97**	**264**	**100,00%**	**2,70**	**263,5**	**100,00%**	**2,58**
Thermal conductivity mW/mK			**21**			**21**			**23**			**31**
Foam density			42			42			42			42
Equivalent cost USD			**2,70**			**2,97**			**2,96**			**3,81**
Total PU consumption 2015	400000	27,99	1080000	400000		1187097	400000		1182857	400000		1522577
IOC / year USD						**107097**			**102857**			**442577**

5.3 Selection of alternative technology for the Demonstration project

The technology chosen has been HFOs due to the following:

Spray foam is used to insulate, provide air sealing and improve structural strength in buildings. The insulation potential of spray foam is dependent upon the insulating gas in the cells of the polyurethane foam. In addition to the insulation performance, polyurethane foams used for the insulation purpose require inherently superior dimensional stability and resistance to fire.

The current zero ODP options for replacement of HCFC-141b in foam applications include hydrofluorocarbons (HFCs) and hydrocarbons. Both HFCs and hydrocarbons are characterized by increased thermal conductivities compared to the HCFC, resulting in inferior insulation performance.

Few alternatives exist for replacing 141b in spray foam. Hydrocarbons are not a viable alternative for spray foam, and HFC-245fa and HFC-365, while viable, have high global warming potential (GWP). Also, the low boiling point of HFC-245fa and the flammability of hydrocarbons and HFC-365mfc present significant challenges to blowing agents processing and handling that are critically important in spray foam applications. On the other hand, foam blowing agents HFO-1233zd(E) and HFO-1336mzz(Z) have very low GWP, both less than 5, and HFO-1233zd (E) is claimed to be even less than 1. These molecules are also non-flammable and stable liquids at ambient temperatures. The HFO-1233zd(E) is already commercialized and HFO-1336mzz(Z) will be commercially available from the year 2016.

6 Activities required for conversion

6.1 Modification of production process

- The project proposal includes provision of necessary equipment in order to conduct full scale foam testing on the real construction and industrial sites as “field testing” around the Kingdom of Saudi Arabia in various climate situations in both summer and winter conditions

- It is not expected that new technology is required for the foaming equipment. However, in order to allow the beneficiary company Sham Najd to operate their normal spray foam business operations, the baseline existing foaming units cannot be used for the testing and evaluation program. Therefore, it is foreseen that project provides similar type of a foaming unit for the demonstration project. After completion of the demonstration project, one of the existing foaming units (Gusmer) will be decommissioned.

6.2 Investigate impacts and possible corrective actions due to the high ambient temperature environment to pre-mixed polyol and produced rigid polyurethane spray foam as a product

- It is foreseen that the high ambient temperature environment has effects to following characteristics;
    - The maximum concentration of HFO in the polyol to be used without pressurization of polyol vessel
    - Impact to surfactants and catalysts
    - Impact of water level in the pre-blended polyol formulation to the PU-system reactivity
    - Storage time of polyol drums outdoor at the construction sites
    - Pre-mixed polyol storaging at the System House or Enuser's own storage
    - Surface of the polyurethane as a product
    - Dimensional stability of sprayed foam
    - Evaluate the correct timing for laying the protective coating for surface
    - Evaluate the performance of existing standard coating spray materials' applicability for the new product
- Prepare plan for the corrective actions such as;
    - Formulation by means of correct catalysts at the System House level
    - Formulation with optimum surfactants at the System House level
    - Maximum ambient temperature versus storing chemicals at the construction sites

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.

- Incremental operating costs for projects in the polyurethane foam sector would be considered at US $1.60/metric kilogram for HCFC-141b; however, for projects that make the transition to low-GWP alternatives, incremental operating costs would be considered at up to US $5.00/metric kilogram;

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 Sham Najd, the cost-effectiveness threshold of US$9,79/kg is applied.

7.2 Incremental capital cost

Expenses	Cost USD
Production	
Overhall Spray foaming unit for testing purpose	6 000
100 meters foaming hoses	
Pneumatically operated transfer pumps	
Air compressor	
Mixing head	
General Works	
Purchase of materials for full scale field testing (3 testing each 350 m2) (1,150 m2)	11 500
High temperature ambient effects investigation at System House and certified laboratory	50 000
Technology transfer, Trials and Commissioning	20 000
Total	87 500
Contingency	8 750
Grand Total	96 250

The above budget in "General Works" includes expert fees and travel as well as organization of consultation meetings with national stakeholders.

***Trials and commissioning include testing mentioned in the methodological chapter and according to the standard EN 14315:**

- Thermal resistance and thermal conductivity
  - Measurement of lambda values (thermal conductivity W/mK)
  - Ageing of lambda value
- Reaction to fire of the products
  - The reaction to fire classification of the products shall be determined in accordance with EN-13501-1 and using data obtained from tests carried out according to procedures EN ISO 11925-2 and EN 13823
- Dimensional stability under specified temperature and humidity conditions
  - Dimensional stability under specified temperature and humidity conditions shall be determined in accordance with EN 1604
- Reaction profile and free-rise density according to the standard requirements
- Durability characteristics
  - Durability of reaction to fire against ageing/degradation
  - Durability of thermal resistance against ageing/degradation
  - Durability of compression strength against ageing/degradation
  - Closed cell content

- Short-term water absorption by partial immersion
- Compressive stress or compressive strength

7.3 Incremental operating cost for demonstration purpose, but not for funding request

In calculating the Incremental Operating Costs it has been assumed based on the expectation that:

- The use of HFO-1233zd(E) or HFO-1336mzz(Z) is only about 46.1% of the use of HCFC 141b.

- It is expected that the foam insulation performance will not be substantially affected.

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

- HCFC-141b: US$ 2.70/kg
- Polyol: US$ 2.70/ kg
- Isocyanate: US$ 2.70/ kg
- HFO: US$ USD11.00/kg (in preblend)

IOC	**HCFC-141b**			**HFO-1233zd**		
	Formula	%	Cost/kg	Formula	%	Cost/kg
Polyol	100	44,29%	2,70	100	46,08%	2,70
B.A	15,8	7,00%	2,70	7	3,23%	11,00
MDI	110	48,72%	2,70	110	50,69%	2,70
Total	**225,8**	**100,00%**	**2,70**	**217**	**100,00%**	**2,97**
Equivalent cost USD			**2,70**			**2,97**

Difference: USD 0.27 /kg foam

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

Is	**Before conversion**	**Year I**
Foam production [kg]	400,000	400,000
Total annual cost of chemicals used	1,080,000	1,187,097
Cost difference per annum - Total IOC, US$		107,097

7.4 Total project cost

	US$
Incremental Capital Cost (ICC)	96,250
Incremental Operating Cost (IOC)	107,097 (not eligible for funding)
Total Cost	**96,250**

7.5 Cost Effectiveness

The total HCFC-141b planned to be phased out in this demonstration project is 28.00 MT and grant requested is **US$ 96,250**. Thus, representing of Cost Effectiveness of US$3,44/kg phased out of HCFC-141b. Note that the IOC is not requested and thus the CE is not comparable for ordinary projects. If the CE includes the IOC, then it is USD 96,250 + USD 107,097 = USD 203,347. USD 203,347/28,000 kg = USD 7,26/ kg 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 HFOs. The CO_2 emission before conversion (using HCFC 141-b as blowing agent with Global Warming Potential of 713) is expected as 154,529 metric ton per year whereas after conversion to HFO with GWP 5, it is estimated 64.5 metric ton per year. The net impact on the environment is positive. The CO_2 emission is expected to be reduced by 19,900 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	28	19,964
After Conversion				
Total CO_2 emission in M tonnes	HFO	5	12.9	64,5
Net Impact				-19,900

9 PROJECT IMPLEMENTATION MODALITIES

9.1 Implementation structure

The National Ozone Unit reporting to Presidency of Meteorology and Environment in Kingdom of Saudi-Arabia is responsible for the overall project, coordination, assessment and monitoring. The National Ozone Unit will clear agreements on implementation procedures and letters of commitments with the industries and other counterparts of this plan to ensure that outputs for different tasks and outcomes for different components of this plan are met to contribute to meeting project objectives. Terms of Reference (TOR) for each activity will be prepared by UNIDO in close collaboration and Sham Najd International (recipient company), which participate in implementation of different components of this plan and thus contributing to different outputs and outcomes of the Plan. Main objective of this Plan is to ensure project successful implementation and provision of process replication to the other parts of The Kingdom of Saudi-Arabia 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 Sham Najd International 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 above parties will sign the working arrangement, where the roles and responsibilities of each party are detailed.

9.3 Modification of production process

Procurement of equipment required for the spray unit overhaul / modification will be done through direct purchase from the existing equipment supplier 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 sites 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

Please revise the timetable according to the new milestones below

Milestone	**2015**	**2016**				**2017**				**2018**			
	Q4	**Q1**	**Q2**	**Q3**	**Q4**	**Q1**	**Q2**	**Q3**	**Q4**	**Q1**	**Q2**	**Q3**	**Q4**
Approval													
Working arrangement													
Preparation of TORs													
Purchase of items, chemicals, bidding & contract award													
Equipment Preparation													
Field testing													
Staff training													
Testing and result dissemination													
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	Bids prepared and requested	2
3	Contracts awarded	4

Sr. #	Milestone	Months
4	Equipment preparation for testing	4
5	Field testing, commissioning and trial runs	12
6	Submission of project completion report	16

Annex II

THE MONTREAL PROTOCOL ON SUBSTANCES THAT DEPLETE THE OZONE LAYER

PROJECT COVER SHEET

COUNTRY:	Kingdom of Saudi Arabia	
PROJECT TITLE:	Demonstration project at air-conditioning manufacturers in Saudi Arabia to develop window and packaged air-conditioners using lower-GWP refrigerant	
SECTOR COVERED:	Refrigeration and Air-Conditioning	
ODS USE IN SECTOR:	10,000 MT HCFC-22 in 2010 (RAC manufacturing)	
PROJECT IMPACT:	N/A	
PROJECT DURATION:	One year	
TOTAL PROJECT COST:	Incremental Capital Costs (Incl. 10% contingencies)	1,306,800 USD
	Incremental Operating Costs	0 USD
	Total Project Cost	1,306,800 USD
PROPOSED MLF GRANT:		1,306,800 USD
SUPPORT COST:		91,476 USD
TOTAL COST:		1,398,276 USD
COST-EFFECTIVENESS:	N/A	
IMPLEMENTING ENTERPRISE:	1. Saudi Arabia Factory for Electrical Appliances Co., Ltd 2. Petra KSA Co., Ltd	
IMPLEMENTING AGENCY:	The World Bank	
COORDINATING AGENCY:	Presidency of Meteorology and Environment	

PROJECT SUMMARY

Saudi Arabia is one of the world's largest market for air-conditioning. Due to high-ambient temperature conditions, the air-conditioning industry is facing difficult challenges in finding suitable alternatives to HCFC-22 that work well in high-ambient temperature while meeting existing minimum energy performance standards.

Main objective of the project is to:

1. Building, testing, and optimizing prototypes with two alternatives: HFC-32 and HC-290, including safety feature.
2. Evaluate energy performance of prototypes and assess incremental cost implications
3. To disseminate the findings and results to interested manufacturers in Saudi Arabia and other countries.

This project will develop prototypes for window and packaged air-conditioning using abovementioned alternatives that are commercially available. These combinations are not yet covered by previous

demonstration project, PRAHA. Two manufacturers will be involved in developing and testing prototypes. One will develop 4 prototypes for window air-conditioner and another to develop 6 prototypes for packaged AC system at 40, 70, and 100 kW cooling capacity.	
Prepared by:	Thanavat Junchaya
Reviewed by:	Piotr Domanski, OORG

1. INTRODUCTION

The Article 5 parties, especially those in high-ambient conditions, face serious challenge in finding out suitable alternatives to replace HCFC-22 in air-conditioning applications while maintaining minimum energy performance standards. To assist these Parties, the Executive Committee funded the demonstration project, PRAHA, to promote low-GWP alternatives for the A/C industry in high-ambient countries. PRAHA regional manufacturers develop prototypes according to the following test matrix:

Alternatives	Window	Decorative	Ducted	Packaged
Base	R22	R22	R22	R22
HFC base	R407	R410	R410	R407/R410
HFC-32	No	Yes	Yes	No
HFO-1	Yes	Yes	Yes	Yes
HFO-2	Yes	Yes	Yes	Yes
HC-290	No	Yes	No	No

As shown above, there are gaps in testing HFC-32 and HC-290 with window and packaged air-conditioners. Given the uncertainty in commercial availability of HFOs and increasing stock of air-conditioners using high-GWP refrigerant in absence of technology intervention, the Government of Saudi Arabia wishes to demonstrate HFC-32 and HC-290 alternatives which are commercially available. While, there have been commercial production of air-conditioner using these two alternatives, most products are small single-split and not specifically developed for high-ambient temperature conditions.

2. PROJECT OBJECTIVE

This projects proposes to fill in the missing gap through the development of prototypes and testing of window and packaged air-conditioner with HFC-32 and HC-290 for operation in high-ambient conditions. Therefore the objectives of the project would be:

- Building, testing, and optimizing prototypes with two alternatives: HFC-32 and HC-290, including addressing safety feature
- Evaluate energy performance of prototypes and assess incremental cost implications
- To disseminate the findings and results to interested manufacturers in Saudi Arabia and other countries.

3. SECTOR BACKGROUND

Saudi Arabia is the one of the world's largest markets for air conditioning - expected to surpass US$2.5 billion by 2019. Due to surge in constructions of educational institutions, hotels, office spaces, residential areas and expansions of development cities, there have been a massive increase in demand for air conditioning solutions. Increasing affluence, a developing tourism industry and high population growth have also contributed to increased demand in the industry. It has been estimated that air conditioning is responsible for 70% of electricity consumption in Saudi Arabia.

Saudi Arabia has active and diverse refrigeration and air-conditioning sector, with many medium and small companies operating in what can be generally categorized as manufacturer, assembly, and installation and servicing. There are a number of appliance manufacturers and manufacturers of commercial refrigeration equipment as well as companies assembling and installing unitary, packaged and central air-conditioning systems. There are also several companies supplying large scale and industrial refrigeration systems on a design and build basis to a relatively well developed industrial refrigeration sector serving food processing, brewing, fishing, cold storage, chemicals and other process industries. The petrochemical industry is also a major consumer of refrigerants, used in the installation and service of large scale refrigeration and air-conditioning equipment used refining and processing and liquefaction of gases.

Equipment manufactured and assembled in Saudi Arabia includes the full range of refrigeration and air-conditioning equipment, including ductless and ducted air-conditioners, packaged AC units, condensing units, large and small-scale commercial refrigeration equipment, cold stores, and process cooling. Chillers are imported through distributors and joint venture companies. In 2015, Saudi Arabia’s RAC market is approximately 2.3 million units, of which window-type units accounted for 60% and split-type units for 40% of the market.

There are 5 large-scale manufacturers with HCFC-22 more than 500 MT and a number of enterprises with consumption below 100 MT. A major sub-sector is the production of unitary and split air conditioners up to 18 kW installed in residential homes, restaurants, hotels, offices, shops, schools, computer rooms, clinics, laboratories etc., and central air-conditioning systems air handling units and chillers or large VRF (Variable Refrigerant Flow) systems above 18 kW installed in hospitals, hotels, office buildings, shopping malls.

The table below shows some of the larger AC manufacturers in Saudi Arabia.

Company	Brand
Al Salem Johnson Controls (AJIC)	York
Alessa for Refrigeration and Air-Conditioning Co. (ARAC)	Crafft, Gibson, Haas, Hitachi
Heating and Air Conditioning Enterprises (HACE)	Hace, Royal Temp, Goldenstar
LG Shaker Company (LGSC)	LG
Petra Engineering Industries Co. Ltd.	Petra
Saudi Air Conditioning Manufacturing Co. Ltd. (SAMCO)	Carrier
Saudi Factory For Electrical Appliances Co. Ltd. (SELECT)	Mitsubishi
Zamil Air Conditioners (ZAC)	Zamil, Cooline, Classic

4. PROJECT DESCRIPTION

The project will provide technical assistance to two air-conditioner manufacturers in Saudi Arabia to build, test, and optimize prototypes with HFC-32 and HC-290.

4.1 Description of technology

HFC-32 or R-32 is a single component refrigerant and is one of the two main components of R-410A (50:50 mixture with HFC-125). It is one of the potential candidates to replace HCFC-22 in the manufacture of residential and commercial air-conditioners due to its excellent refrigeration properties. Based on thermodynamic properties of the refrigerants, HCFC-22 has better theoretical COP than R-410A and HFC-32. However, HFC-32 refrigerant has a higher volumetric cooling capacity compared with HCFC-22 and has better heat transfer properties. Discharge temperatures are higher than R-410A and HCFC-22 and thus some mitigation device or controls may be necessary for handling the discharge temperature of the compressor especially at high ambient temperatures. There is a slight trade-off due to its GWP of 675 which is approximately one-third of R-410A. Furthermore R-32 is classified by both ISO 817-2014 and ASHRAE Standard 34-2010 to be under a new "A2L" rating for mildly flammable refrigerants with burning velocity less than 10 cm/s. Pressure and capacity are around 1.5 times higher than HCFC-22 and slightly higher than R-410A.

HC-290 has thermodynamic properties similar to HCFC-22, although slightly lower pressure and capacity. It is classified as A3. Due to its excellent thermophysical properties the efficiency is good under most conditions, including high ambient, as well as having low discharge temperatures. It is the most frequently used hydrocarbon refrigerant in air conditioning applications. It is also used as a major component in many HC blends.

The table below shows the key parameters of HFC-32 and HC-290 compared to HCFC-22 and R410A.

Table 6.16: Physical Properties of R-22 and Alternatives

Physical properties	HCFC-22	R-410A	HFC-32	HC-290
LFL (kg/m^3)	Not flammable	Not flammable	0.307	0.038
GWP*	1,810	2,090	675	5
Molecular weight	86.47	72.58	52.03	44.1
Boiling point (C)	-40.8	-51.6	-51.7	-42.1
Critical temperature (C)	96.2	72.5	78.25	96.7
Critical pressure (Mpa)	4.99	4.95	5.808	4.25
Specific heat of Liquid (KJ/(Kg˚C)	0.31	1.78	2.35	1.64

* Sources: IPCC the fourth assessment report

4.2 Challenges for Countries with High Ambient Temperature

For all refrigerants, including HCFC-22, R-410A, HFC-32, and HC-290, efficiency degraded with increased ambient temperature. Operation of an air-conditioning system at elevated ambient temperatures results in a lower Coefficient of Performance (COP).

Both R-32 and R-290 were included in the Oak Ridge National Laboratory (ORNL) High-Ambient Temperature Evaluation Program for Low-GWP Refrigerants[1] which aims to develop an understanding of the performance of low-GWP refrigerants in small single-split air conditioners under high-ambient temperature conditions. Two small single-split air conditioners, one is designed to operate on R-22 and another on R-410A, were used as base systems to conduct testing at different environmental testing conditions. After soft-optimization, R-290 was tested with R-22 system (9.5 EER) while R-32 was tested

[1] Alternative Refrigerant Evaluation for High-Ambient-Temperature Environments: R-22 and R-410a Alternatives for Mini-Split Air Conditioners, Omar Abdelaziz, et al., Oak Ridge National Laboratory, October 2015

with R-410A system (11.5 EER). Both R-22 and R-410A units have the same cooling capacity of 5.25 kW (18,000 BTU/hr). Compared to R-22 baseline, the test results show that R-290 has 7-8% higher COP but 9-10% lower cooling capacity at hot and extreme ambient testing conditions. R-32 has both COP (5-6%) and cooling capacity (11-13%) higher than R-410A baseline at similar testing conditions.

To further improve the efficiency and capacity, the manufacturers would need to make design modifications such as heat transfer circuiting and proper compressor sizing and selection while addressing performance loss, the increase in compressor discharge temperature, and any safety concerns associated with flammable alternatives.

4.3 Increase in Current Know-how

While there are commercial production of air-conditioners using R-32 and R-290, the products are primarily single-split models and are not designed for countries with high ambient temperature.

Window AC

China and India AC manufacturers are producing small single-split AC based on R-290 with capacity ranging from 2.6 kW to 5.3 kW or between 9,000 BTU/hr and 18,000 BTU/hr. The current limitation on the cooling capacity is due to maximum charge size for flammable refrigerants. For markets in Saudi Arabia and other countries with high ambient temperature, the cooling capacity of typical window AC models range from 18,000 BTU/hr to 24,000 BTU/hr.

While R-32 air-conditioners have been introduced in many countries, all models are small split-type AC units. Based on information from Daikin, it was confirmed that they do not produce any window AC based on R-32.

Packaged AC

Large packaged AC such as those with at 40, 70, and 100 kW cooling capacity being proposed in this demonstration project contain significant amount of refrigerant. This is one of the reasons that major AC manufacturers have not commercially introduced large AC system using flammable refrigerants.

For R-32, available residential AC models have capacity up to 7 kW and light commercial AC models up to 14 kW. There is no available information that there is a commercial production of packaged AC using R-32 as refrigerant. Daikin is still working on the risk analysis of using R-32 refrigerant in VRF multi-split system.

Developing the R-290 and R-32 AC prototypes for high-ambient temperature condition will need to overcome many challenges such as efficiency drop due to elevated temperature, increased compressor discharge temperature (specifically for R-32), and minimizing charge size (specifically for R-290) in order to comply with international standards such as ISO-5149 and applicable national standards and building codes.

4.4 Link to HPMP

Stage I of the HPMP for Saudi Arabia was approved at the 68th ExCom. It focused primarily on the phase-out of HCFC-141b from the foam sector and there was no investment component for the refrigeration and air-conditioning. Approximately 10,000 MT of HCFC-22 was used in the manufacturing of refrigeration and air-conditioning equipment in 2011 and similar amount was used for servicing purpose.

Based on Decision 71/42, request for project preparation funding for stage II of Saudi Arabia could be submitted in 2018, given that stage I HPMP was approved for the period 2012 to 2020 to reduce HCFC consumption by 40 per cent of the baseline. Results from this project will be used by Saudi Arabia to formulate their stage II HPMP in the refrigeration and air-conditioning sector.

4.5 Replication

Successful demonstration of low and lower-GWP alternatives will have significant replication effects. HPMP Stage I estimated there are 9 million window and 7 million small single-split units installed in Saudi

Arabia. For rooftop (packaged) and ducted split, there are approximately 0.5 million units with capacity ranging from 6 to 30 tons of refrigeration.

There are an excellent opportunities to replace these installations with low-GWP alternatives. There are also opportunities to export to other countries. For example, U.S. Environmental Protection Agency's (EPA) Significant New Alternatives Policy program recently approved, in 2015, the use of R-290 and R-32 in window AC with maximum design charge size for a 10,000 BTU/hr window AC unit up to 260g of R-290, and 3.47 kg of R-32.

However, since many of these low-GWP alternatives are classified[2] as either class 2L (mildly flammable) or class 3 (flammable) refrigerants, careful considerations must be undertaken to ensure safe installations depending on occupancy category and location of air-conditioning system. During the project implementation, the design and quantity of refrigerant in the air-conditioning system should comply with relevant international standards such as ISO-5149 in order to promote market confidence and acceptability of using flammable refrigerants.

5. PARTICIPATING ENTERPRISES

Saudi Factory for Electrical Appliances Co. Ltd. and Petra Engineering Industries Co. Ltd will be participating in the demonstration project. Saudi Factory for Electrical Appliances Co. Ltd. will focus on window air-conditioner and Petra KSA on the packaged air-conditioner.

5.1 Saudi Factory for Electrical Appliances Co., Ltd.

Saudi Factory for Electrical Appliances Co. Ltd. was established in 1986 and commenced its production on June 1, 1988 under Mitsubishi technical collaboration. The factory is located in Industry City, Jeddah and now produces their own brand "SELECT" window air conditioners with annual production capacity of 120,000 units. Annual consumption of HCFC-22 is approximately 90 MT/year. The factory has one assembly line and make their heat exchanger in house. The company would like to develop two sizes (18,000 BTU/hr and 24,000 BTU/hr) of their window AC with HFC-32 and HC-290.

5.2 Petra Engineering Industries (KSA) Co., Ltd

Petra KSA was established in 2010, and located in King Abdullah Economic City, Rabigh. There are 7 R&D engineers working on AC system development and production. Head of R&D has more than 20-year experience in air-conditioning sector and is also a member of RTOC. Its products are widely used in the Saudi Arabia and other gulf countries. To address the issue of flammability in higher refrigerant charge unit, Petra KSA want to demonstrate a packaged air-conditioning system that combine chiller and air-handling unit.

5.3 Technical Assistance Component

Based on their past experiences in development of new air-conditioner, the development process will be as followed:

5.3.1 Design and planning

In this phase, the manufacturer will study characteristics of the two alternatives based on the latest developments, scientific researches, reports, papers, case studies, etc. The R&D engineers will then design the prototypes and specify the main components (condensers, evaporators, fans and compressors) based on the required efficiency and existing manufacturing conditions. Supplier and availability of components for T3 conditions will be identified. The design will consider measures to reduce refrigerant charge size and other safety design measures to reduce risk of using flammable refrigerants.

[2] ISO-817 and ASHRAE-34

5.3.2 Prototype production

Under this phase, the manufacturer will fabricate and build the prototype. Safety precautions and training for production engineers and factory workers must be addressed during the production process (vacuum, charging and welding) since the two alternatives are flammable gas.

5.3.3 Testing and evaluation

This phase is considered to be the most important and critical phase for the success of the project. The test should be carried out in accredited laboratory which is equipped with the appropriate equipment to simulate any required conditions. The test will conduct in accordance with international standards such as AHRI under different ambient conditions (low and high ambient), to verify the performance of HFC-32 and HC-290 at all conditions. After analyzing test results, a full comparison included performance, quantity of charge, and prices will be prepared for HFC-32, HC-290 and HCFC-22.

5.4 IMPACT ON GWP

There is no impact on GWP at this stage. The impact will occur when the manufacturers convert their production to chosen alternatives.

6. PROJECT BUDGET

6.1 Technical Assistance

Cost include conceptual design, software development, components specification, prototype fabrication and testing and R&D engineer staff costs. Cost also included an international consultant to support the prototypes development and testing. Three full one-week visits are needed. The first visit is to carry out detailed planning of the project implementation (concept design, components specification 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 incremental cost/performance analysis and, in parallel, participate in the dissemination seminar.

6.2 Dissemination workshop

Cost to organize the dissemination workshops is included. One workshop will be organized in Saudi Arabia to AC manufacturers in Saudi Arabia and other from countries in the region.

6.3 Incremental operating cost

According to the supplier, the cost of the HFC-32 and HC-290 will be slightly higher than HCFC-22. Cost of components for T3 conditions for HFC-32 and HC-290 will also be higher than HCFC-22 or R-410A refrigerant.

However, IOC is not requested for participating AC manufacturers in the present demonstration project.

The summary of the project cost is as follows:

ITEMS	Qty.	Unit Cost (US$)	Total (US$)	Remark
Saudi Factory for Electrical Appliances Co. Ltd.				
• Development cost window AC (18,000 BTUH capacity) using rotary compressor and	2 sets	55,000	110,000	

ITEMS	Qty.	Unit Cost (US$)	Total (US$)	Remark
reciprocating compressor				
• Development cost for window AC (24,000 BTUH capacity) using rotary compressor and reciprocating compressor	2 sets	55,000	110,000	
Petra KSA				
• Conceptual design including development of new software for HFC-32 and HC-290			38,000	One senior software engineer and two HVAC engineers for developing new software
• Prototypes fabrication	6	70,000[3]	420,000	6 prototypes (40, 70, and 100 kW) for 2 alternative refrigerants
• Prototypes testing	6	50,000	300,000	
• R&D engineer			170,000	6 R&D engineers for study, develop, research, design, test, and approve.
International Expert			30,000	
Technology dissemination workshop	1	10,000	10,000	
Sub-total			1,188,000	
Contingencies (10%)			118,800	
Total			1,306,800	

6.4 Proposed Multilateral Fund Grant

The proposed grant request is US$ 1,306,800, the calculated cost based on actual situation of all participants.

7. PROJECT IMPLEMENTATION PLAN

The project will be implemented under the supervision of the Presidency of Meteorology and Environment.

[3] Average cost per unit across 40, 70, and 100 kW units

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											
Project appraisal	X											
Sub-project agreement		X										
Conceptual design for AC system development and planning for testing			X	X								
Specification of AC prototypes				X								
Procurement of components and fabrication of prototypes				X	X							
Trials/testing/analysis						X	X	X	X			
Report and review meeting.										X		
Technology dissemination workshop											X	
Completion report												X

8. PROJECT IMPACT

Not applicable.

ANNEX-1: OORG Review

REVIEW OF PROJECT PROPOSAL
DEMONSTRATION PROJECT FOR AIR-CONDITIONING MANUFACTURERS IN SAUDI ARABIA TO DEVELOP WINDOW AND PACKAGE AIR CONDITIONERS USING LOWER-GWP REFRIGERANT

INTRODUCTION

The technical objective of this project is to design, build, and optimize a vapor-compression window air conditioner (AC) and a package AC using propane (HC-290, GWP=9) and difluoromethane (HFC-32, GWP=675) by two Saudi Arabia equipment manufacturers. The overall strategic objective of the project is to demonstrate the viability of HC-290 and HFC-32 as refrigerants in the high-ambient temperature region as countries phase-out the use of R-22 (ODS) and need to implement efficient and lower-GWP fluids.

TECHNICAL ASSESSMENT

Currently, window ACs and package ACs predominantly use high–pressure refrigerants such as HCFC-22 (ODS, GWP=1810) and HFC-410A GWP=2090), which are non-flammable. Extensive studies has shown that no non-flammable, single-component fluids exist that can be used as their replacements. The available refrigerant options are limited to mixtures of existing HFCs with hydrofluoro-olefins (HFOs = unsaturated HFCs) or HC-290 and HFC-32, which are proposed in this project. Several HFC/HFO mixtures – both non-flammable and flammable – have been proposed in the literature; they are expected to be expensive due to the cost of HFOs. HC-290 and HFC-32 are readily available, and their thermophysical properties have been very well determined. HC-290 and HFC-32 are the less expensive options but their implementation faces fluid-specific challenges.

HC-290 has excellent thermophysical (thermodynamic and transport) properties. Its critical temperature is 96.7 °C, which makes it a suitable refrigerant for application in ACs even in high-ambient temperature climates. HC-290 is compatible with mineral oil and does not present unknown material compatibility issues; however, designs of compressor and heat exchangers need to be optimized to exploit the refrigerant's thermophysical properties. The significant challenge in implementing of HC-290 is its high flammability, which needs to be addressed for manufacturing, operation, and servicing based on applicable local codes and risk analysis. Because of its high flammability, HC-290 may be precluded from many applications based on the amount of HC-290 in the system, space size, and its intended occupancy.

HFC-32 has also excellent thermophysical properties. Its critical temperature is 78.1 °C. HFC-32 is a very good choice for application in ACs for moderate ambient temperatures, but its performance degrades at high-ambient temperatures faster than that of HC-290 (and HCFC-22), due to its lower critical temperature. Also, HFC-32 experiences high compressor discharge temperatures at elevated ambient temperatures, which may require special design features or appropriate lubricant. The drop in capacity can be addressed by oversizing. The lower flammability rating of HFC-32 is its advantage over HC-290; in colloquial terms HFC-32 is flammable but is rather difficult to ignite. Still, its flammability needs to be addressed for manufacturing, operation, and servicing based on applicable local codes and risk assessments.

The two candidate manufacturers proposed for this project have sufficient technical experience to pursue the use of HC-290 and HFC-32. A new paradigm of them will be flammable refrigerants. Some safety aspects of using flammable refrigerants are stated in the project description although a detailed description of the planned safety measures is not provided due to the description's format. To minimize the possibility of any accidents during execution of this project, it is a recommendation of this reviewer for the contract to implicitly obligate the candidate manufacturers to follow best safety practices. This should include handling of the flammable fluids, equipping their facilities (e.g., testing laboratory) with adequate sensors, and personal training.

The technical plan of the project stipulates the window AC manufacturer and the package unit manufacturer to develop overall designs of their new systems and heat exchangers. They will also develop specifications HC-290 and HFC-32 compressors, which will be procured. In the case of window ACs, the small size of these units should lend itself for using flammable fluids. The proposed package AC will be an indirect system – a chiller combined with an air-handling unit – which will separate the flammable refrigerants from the cooled air. The project includes testing of the built systems in an accredited laboratory in accordance with international standards. This is a workable plan which will provide a good learning path for both manufactures for further product developments.

ENVIRONMENTAL, HEALTH AND SAFETY CONSIDERATIONS

HC-290 (GWP=9, ODP=0) offers a potential of a high energetic efficiency of an air conditioner and presents no environmental concerns. It has short atmospheric life - of the order of two weeks – and its decomposition products are harmless. The safety considerations are related to the HC-290 flammability: the ASHRAE safety designation A3 indicates low toxicity and high flammability (low- toxicity is the lowest toxicity rating; lower flammability limit, LFL=0.038 $kg \cdot m^{-3}$).

HFC-32 (GWP=675, ODP=0) offers a potential of a high energetic efficiency of an air conditioner for moderate climates but suffers performance degradation at extreme high-ambient climates. Its atmospheric life is 5.2 years (short in a comparison to other currently used HFCs). Its decomposition products are well known and do not pose significant environmental risks. The safety considerations are related to its flammability: the ASHRAE safety designation A2L indicates low toxicity and mild flammability (LFL=0.307 $kg \cdot m^{-3}$).

There are no health concerns related to the project.

PROJECT COSTS

The proposed budget items are necessary and are supported.

IMPLEMENTATION TIMEFRAME AND MILESTONES

The proposed project schedule is feasible and is supported.

RECOMMENDATION

I recommend approving this project.

Piotr A. Domanski, PhD

September 21, 2015

Annex III

PROJECT COVER SHEET – DEMONSTRATION INVESTMENT PROJECTS

COUNTRY: Kingdom of Saudi Arabia

PROJECT TITLE

Demonstration Project on Promoting HFO-based Low GWP Refrigerants for Air-conditioning Sector in High Ambient Temperatures

IMPLEMENTING AGENCY

UNIDO

NATIONAL CO-ORDINATING AGENCY: PME

LATEST REPORTED CONSUMPTION DATA FOR ODS ADDRESSED IN PROJECT

A: ARTICLE-7 DATA (ODP TONNES)

HCFCS	1376.63		

CURRENT YEAR BUSINESS PLAN:		**2016**
PROJECT DURATION:	Months	24
PROJECT COSTS:		
Incremental Capital Cost	US$	1.570 000
Incremental Operating Cost	US$	0
Total Project Cost	US$	1.570,000
LOCAL OWNERSHIP:		100%
EXPORT COMPONENT:		n/a
REQUESTED GRANT:	US$	1,570,000
IMPLEMENTING AGENCY SUPPORT COST:	US $ 7%	109,900
TOTAL COST OF PROJECT TO MULTILATERAL FUND:	US $	1,679,900
STATUS OF COUNTERPART FUNDING:		**n/a**
PROJECT MONITORING MILESTONES INCLUDED:		Included

PROJECT SUMMARY

The Kingdom of Saudi Arabia is a Party to the Vienna Convention and the Montreal Protocol. It also ratified the London, Copenhagen and Montreal amendments. The country is fully committed to the phase-out of HCFCs and willing to take the lead in assessing and implementing new HCFC phase-out technologies, in the foam sector and RAC sector. KSA participated with the company Alessa to the PRAHA project and provided samples for testing. KSA and the company are very much interested seeing the initial results to pursue zero ODP and low GWP solutions.

The objective of this project is to introduce low GWP – 0 ODP refrigerants in the production of window and split unit air conditioners. Develop the technology and set the conditions for producing these air conditioners. The project will demonstrate, optimize, validate and disseminate the applicability of the technology and consequently, the reliability of the results to produce window and split unit air-conditioners with low GWP.

IMPACT OF PROJECT ON COUNTRY'S MONTREAL PROTOCOL OBLIGATIONS

This project is a demonstration project aimed to optimize low GWP refrigerants in the RAC sector and will contribute indirectly to the fulfillment of KSA Montreal Protocol obligations. If successfully validated, the optimized technology will contribute to availability of cost-effective options for Hot climate countries that are urgently needed to implement HCFC phase-out, particularly in KSA, GCC and several other countries.

Prepared by: Yuri Sorokin, Igor C. Croiset **Date:** 7 April 2016

Review: O.Nielson

PROJECT OF THE GOVERNMENT OF KINGDOM OF SAUDI ARABIA

LOW GWP AIRCONDITIONS FOR HOT CLIMATES DEMO PROJECT – DEMONSTRATION OF THE DEVELOPMENT OF THE USE OF LOW GWP REFRIGERANTS IN THE PRODUCTION OF WINDOW AND SPLIT UNT AIRCONDITIONERS - CONVERSION FROM HCFC-22 IN THE MANUFACTURE OF WINDOW AND SPLIT UNIT AIRCONDITIONERS AT ALESSA FOR REFRIGERATION AND AIR CONDITIONG CO. (ALESSA).

1.0 PROJECT OBJECTIVE

The objectives of this project are to:

- Development and validation of window and split unit air conditioners with the use of a low GWP refrigerants, e.g. L-20 (R-444B), L-41 (R447A), XL20 (R454C, previously DR-3), R290;
- Testing in laboratory and under real conditions of the different options;
- Demo production setup and validation of the procedures;
- Environmental and energy impact study (Saso requirement);
- Production of units and testing at customers;
- Training of service technicians and setting up curricula as well as documentation;
- Final reporting and workshop.

The project will therefore substantially contribute to the HCFC phase-out plan in the manufacture of window and split unit air conditioners in KSA and immediate surrounding countries of GCC, as planned under the agreement of KSA with the MLF.

2.0 BACKGROUND AND JUSTIFICATION

In the year 2007, Parties to the Montreal Protocol agreed to accelerate the phase-out of the hydrochlorofluorocarbons (HCFCs) because their increase in global consumption and taking into consideration the substantive climate benefits generated from their phase-out.

In the following years, Parties operating under the Montreal Protocol's Article 5 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).

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

In particular, Par (b)(i)a. of 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.

Alessa participated in the PRAHA project and produced and shipped for testing Window and split units with the provided low GWP refrigerants. The units have been tested and the results are promising but still need optimization for future commercial purposes.

3.0 PROJECT DESCRIPTION

The use of alternative refrigerants has proven in most climatic regions and the first step was made with the PRAHA project. Alessa received compressors and refrigerants for introducing them in their existing R22 units. It was clear from the beginning that Alessa did not have the time, sufficient data of the refrigerants to optimize the refrigeration circuits and components. The plan was also to test R290 but due to time Alessa wasn't able to implement the tests. The results of the PRAHA project however showed that this is also a candidate and Alessa wishes to have all the options open. The units which were produced were also tested in Alessa and the performance is at this stage not sufficient for commercialization, EER efficiency needs improvement. Note that R410A is not the ideal solution and therefore the gap in EER could increase further. The proposed HFO's are zeotropic blends and need to be charged accurately in liquid phase which requires adaptation of the refrigeration circuitry. The condenser and evaporator will need to be optimized and tests been done to cope with the glide, which is not present with R22 and can be neglected with R410A. The HFO's present a glide and the use of capillary tubes will need to be evaluated against expansion valves to improve the EER. At the moment inverter models are not commonly marketed in KSA but Alessa sees in this technology future EER improvement.

The objective of this proposal is to demonstrate alternative solutions to HCFC refrigerants with the introduction of low GWP solutions for hot climate countries.

By doing so, the roadmap will be set for the phase out of R22 in KSA and the neighboring region. Servicing capacity and knowledge build up. Standards developed

The project results will be extremely relevant for those beneficiaries to be largely covered under Stage II of HPMP, meaning those companies currently relying largely on pre-blended polyol systems.

Figure 1: production line detail

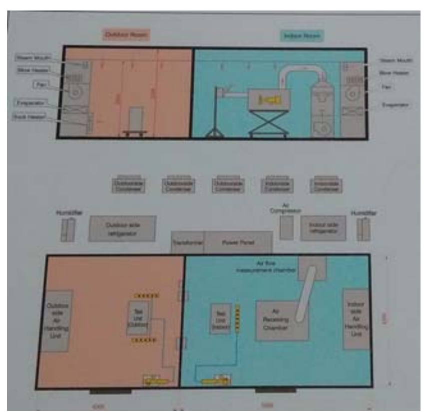

Figure 2: Lab layout

4.0 METHODOLOGY DESCRIPTION

There is therefore the need for development of the refrigeration system and e.g. with DR-3 (commercial name Opteon XL20) already thermodynamic data is available as well as R290. Nevertheless, also when the thermodynamic data is not yet available the experience gained will substantially simplify the development of the other HFO's. The differences are not substantial between the HFOs so the first to be developed will serve the others. Several theoretical runs will be made in accordance with available commercial components.

Components research will be done and Pilot models will be manufactured and tested. In this regard the existing laboratory will need to be replaced with a calometric type instead of the psychrometric existing lab. Alessa has 3 of these labs in the laboratory and other 2 in the production. A particular item will be the condenser and evaporator in-house build by Alessa. At this stage it is clear that most probable changes in piping diameters will be required. Therefore tooling will be needed; furthermore the testing will need to be done more accurately. State of the art is nowadays vacuum chamber as the existing water bad testing is not accurate. A setup with a vacuum chamber for testing the heat exchanger is part of the equipment to be purchased.

Several work study tours are planned to meet with the refrigerant suppliers and gain more knowledge as well as with component manufacturers. A lot of effort will be needed to remodel the indoor unit as none are available on the market with HFOs. Redesign of the exterior for accommodation of the modified, larger, evaporator unit. Better leakage tight connections for the piping as major leakage occurs in this area during installation.

Efficiency testing and optimization will be a focal issue as the bureau of standards in KSA SASO and the umbrella organization for GCC countries are focused on energy efficiency improvement.

Once the units are developed a demo production run will be made for verification of all the procedures and workmanship required. At this stage still the final selection of the refrigerant of choice will not be made. The existing production is not suitable for this purpose as the quality assurance standards are not sufficient for A2L or A3 refrigerants. Furthermore, the leakage testing due to space constraints is done in a limited manner and the charging unit is not suitable for operating with flammable refrigerants. A production line will be setup to simulate a production and later on to be converted to a full production line. The line will also be suitable for setting up the safety measures regarding leakage of refrigerants and flammability issues which all have independently if they are A2L or A3. A production line transports considerable quantities of refrigerant and although experience in different countries is available it is an issue to be taken into account and measures taken.

The produced units will be exposed to intensive testing and also to a real life exposure testing. This testing will be done by construction three cabins of insulated panels of about 15-20 m2 for simulation of a typical household placement of the unit. These cabins will be placed in the area around Alessa and during a period of 3 to 6 months tested under the environmental conditions of KSA. Features as sand accumulation on the condensers, hot days of 50°C and cold nights can then be simulated. This will be done with the existing and alternative refrigerants. The output of this activity will also be to assess the testing conditions which at this moment still are according to western countries with outdoor temperature of 35°C instead of actual nearly 50°C. The PRAHA project already considered a testing condition at 46°C and showed considerable lower EER.

In parallel units will be placed in different regions of KSA to consider also hot and humid conditions. Alessa is located in Riyadh which has a fairly dry climate but for example Jeddah is hot and humid.

The opportunity of the cabins is also to train service technician with the new refrigerants as well as awareness activities.

After the testing phase an assessment will be made and options selected for production purposes. The expectation will be that there will be more than 1 option considering that Alessa also produces substantial larger models.

All the equipment purchased under the current project will be moved to the actual production lines at Alessa after project implementation.

The objective of this proposal is to demonstrate alternative solutions to HCFC refrigerants with the introduction of low GWP solutions for hot climate countries.

By doing so, the roadmap will be set for the phase out of R22 in KSA and the neighboring region. Servicing capacity and knowledge build up. Standards developed

The project results will be extremely relevant for those beneficiaries to be largely covered under Stage II of HPMP.

5.0 PROJECT COSTS

Cost forecasts for demonstration projects are problematic as these projects are by nature unpredictable.
UNIDO has a good experience in projects regarding conversion of air conditioners conversion to R290 and other refrigerants. The budget has been setup to the best knowledge.

Item	Activity	sub-activity	Budget
1	**R&D**	Analysis	$320.000,00*
		Development condensor and evaporator	
		Capillary tubes assesment	
		Components research	
		Software, inverters development	
		In-door unit modification	
		Out door unit modification	
		Performance tool introduction	
		Safety analysis production line	
		Lab modification	
		Documentation	
		*in case of PRAHA II the cost could be reduced to 160,000	
2	**Pilot units testing**	Pre-assembly and verification	$35.000,00
		production qualification model setup	
		test evaluation and feedback	
3	**Testing real life**	setup of demo sheds	$30.000,00
		setup of measurement equipment	
		testing phase monitoring and data analysis	
4	**Production line**	site preparation, civil works	$25.000,00
		installation of equipment	
		preparation workprocedures	
		personnel instruction	
		production demo units	
5	**Capital investment**	Components pilot models	$315.000,00
		Measurement equipment real life tests	

		Refrigerants	
		Tools, vac pump, gauges, leakage tester, mechanical tools, electrical tester	
6	**Capital investment - Lab**	PU housing	$225.000,00
		safety system	
		temperature control system, ducts, refrigeration unit	
		measurement equipment - calometric	
		ancillary	
7	**Capital investment - Production line**	Pressure testing equipment (not available now)	$500.000,00
		3 x vacuum pumps, vacuum test equipment, bar code reader and controls	
		charging unit for flammable and zeotropic refrigerant	
		Ultrasonic welding	
		Vulcan sealing tools	
		Leakage testing equipment	
		Electrical safety tester and power distribution cabinet	
		Performance test evaluation electronics and controls	
		Final leak test unit	
		Handheld leak test vulcan	
		Safety system, gas sensors 8x, control cabinet, sensors calibration equipment	
		Ventilation and ducting production line and refrigerant feed pumps area	
		Safety cabinet and sensors labs. Each 2 sensors	
		Refrigerant feed pump 2x	
		Refrigerant feed pump valve distribution	
		Refrigerant bottle weighing system	
		Conveyor system	
8	**Awareness and training**	Documentation, 2 x workshops Riyadh, Jeddah	$30.000,00
9	**Projekt management and technical support**	International consultants, monitoring and travels	$90.000,00
		Total	**$1.570.000,00**

6.0 PROJECT IMPLEMENTATION AND MONITORING

The project will be implemented using UNIDO's International Execution Modality. Implementation is targeted as follows **(**measured from project approval)

TASK	MONTH
(a) Project document submitted to beneficiary for commitment	0
(b) Study tours organized	1
(c) Research and Development	2
(d) Bids prepared and requested	12
(e) Contracts Awarded	14
(f) Equipment Delivered	18
(g) Training Testing and Start of trial runs	20
(h) Interim dissemination of the results	22
(i) Final report with full sets of trial data	24

7.0 PROJECT IMPACT

Direct Benefits:
It is essential to replace the R22 units for the Phase out of HCFC and avoid high GWP HFC.

The project employs commercially available and environmentally acceptable technology.

Indirect Benefits:
The project will also boost significantly Montreal Protocol's efforts for solutions for hot climate countries and meet obligations under the HCFC phase-out targets by granting the application of low-GWP latest technologies.

8.0 DISSEMINATION STRATEGY

The dissemination of the different results of the new technology will be done with different tools, in order to reach national companies, regional interested parties (PME, companies, etc.) but also MLF and other implementing agencies and NOUs.

The dissemination Strategy will include a combination of activities such as: workshop, technical brochure, technical and economic data, etc. It will also boost the servicing sector in preparation of new refrigerants.

9.0 PROJECT REPORTING

A final report can be expected 24 months after project start. Interim reporting will follow existing reporting guidelines.

10.0 ANNEXES

Annex-1: List of refrigerants
Annex-2: Details of window and split unit air conditioners
Annex-3: Environmental Assessment

ANNEX-1

LIST OF REFRIGERANTS

Name	Chemical formula	Boiling point at 1.013 bar	Molecular weight	GWP 100 yr	Typology	Classification
R22	CHCLF2	-40.8	86.5		Azeotrope	A1
410a	R32/134a (50/50%pbw)	-51.51	72.6	1900	Near azeotropic	A1
R290	CH3CH2CH3	-42	44.1	5	Azeotrope	A3
R454C (DR-3)	R32/R1234yf (21.5/78.5%)			148	zeotrope	A2L
1233zd(E)	CF3CH=CHCL	18.1	130.5	1	Azeotrope	A2L
1234yf	CF3CF=CH2	-29.4	114	1	Azeotrope	A2L
1234ze(E)	CF3CF=CHF	-19	114	1	Azeotrope	A2L
L-20 (R448b)	R-32/1234ze(E)/152a (45/35/20)		67.8	330	zeotrope	A2L
L-41 (R447A)	R-32/1234ze(E)/600 (68/29/3)		62	460	zeotrope	A2L

No data yet available (grey)

No data available, Thermodynamic data available (yellow)

ANNEX-2

DETAILS OF WINDOW AND SPLUT UNIT AIR CONDITIONER

Split unit

Specifications

- 18K & 24K Btu
- Cool & H/C Models
- Anti-Bacterial Filter
- US Bristol compressor
- Super Quiet Operation
- Wireless LCD Remote Control
- Twenty Four (24) Hour Programming
- Cools Even at 55˚c
- Charge 1890 grams/ 410A abt. 22 K BTU at T1 and 19 K BTU at T3

Picture: Indoor unit

Picture: Outdoor unit split unit

Window Unit

Specifications

- 24K BTU/Hr
- Cool Model Only
- Adjustable Four Ways Air Direction (Auto Air Sweep)
- Super Quiet Operation
- Three (3) Fan speed Selection
- Powerful Compressor - withstand up to 55˚C Ambient Temperature
- High Cooling Efficient Model
- SASO Certified - 3 Stars Rating
- High Energy Efficiency Ratio (HEER) -Energy Saving (Low Power Consumption)
- Reciprocating Compressor
- Bristol Compressor
- One-touch Easy to Clean - Anti-Bacterial Filter
- High Efficiency Super Slit Fin Coil
- Charge app. 1720 grams/ R22 22.5 K Btu at T1 and 20 K BTU at T3

Picture : Window unit

ANNEX-3
ENVIRONMENTAL ASSESSMENT

category	Model	Refrigerant	charge	ODP	GWP	Unit gain GWP wrt Baseline (kg charge*GWP)
Window	D024E6H5Y	R22	1720	0.055	1810	3113.2
Window	D024E6H5Y	L20	1000	0	330	-89.40%
Window	D024E6H5Y	DR3 (Opteon XL20)	920	0	148	-95.63%
Window	D024E6H5Y	R290	220	0	5	-99.96%
Split	DS24CE6HY7/DS24FE6HY7	410A	1890	0	1900	3591
Split	DS24CE6HY7/DS24FE6HY7	L41	1630	0	460	-79.12%
Split	DS24CE6HY7/DS24FE6HY7	R290	220	0	5	-99.97%

Unit replacement will provide for the window units a 0 ODP and up to 99% improved GWP. For the split units up to 99% improved GWP. The indicated refrigerants have been trial tested. EER considerations have not been made at this stage as optimization of the equipment is required. Goal is to achieve similar EER as R22 for window units and split units.

Consider that production rate of window and split units is 150 K/year and R22 consumption around 25-27 T/year and 410A 28-30T/year.