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执行蒙特利尔议定书
多边基金执行委员会
第七十六次会议
2016 年 5 月 9 日至 13 日，蒙特利尔

项目提案：沙特阿拉伯

本文件包括基金秘书处就以下项目提案提出的评论和建议：

泡沫塑料

• 关于淘汰氟氯烃的示范项目，即用氢氟烯烃作为发泡剂，用于高环境温度下喷雾泡沫的应用	工发组织

制　　冷

• 在空调制造厂家执行的示范项目，旨在使用较低全球升温潜能值的制冷剂，开发窗式和组装式空调机	世界银行
• 关于在高环境温度下的空调部门，推广基于氢氟烯烃的低全球升温潜能值制冷剂的示范项目。	工发组织

项目评价表—非多年期项目

沙特阿拉伯

项目名称	双边/执行机构
(a) 关于淘汰氟氯烃的示范项目，即用氢氟烯烃作为发泡剂，用于高环境温度下喷雾泡沫的应用	工发组织

国家协调机构	气象和环境机构负责人

供项目审议的消耗臭氧层物质消费最新报告数据
A: 第7条数据（截至2016年4月的2014年ODP吨）

氟氯烃	1 376.63

B: 国家方案行业数据（截至2016年4月的2014年ODP吨）

HCFC-22	1 121.9
HCFC-123	1.5
HCFC-141b	253.2

仍符合供资资格的氟氯烃消费量（ODP吨）	765.40

本年度业务计划分配款		资金 美元	淘汰ODP吨
	(a)	不详	不详

项目名称：	
企业所使用的ODS（ODP吨）：	3.08
将淘汰的ODS（ODP吨）：	不详
将使用的ODS（ODP吨）：	不详
项目期限（月）：	16
原申请数额（美元）：	274 016
最终项目费用（美元）：	
增支资金成本：	87 500
应急费用（10 %）：	8 750
增支经营成本：	107 097
项目总费用：	203 347
地方所有权（%）：	100%
出口成分（%）	不详
申请赠款（美元）：	96 250
成本效益（美元/公斤）：	不详
执行机构支助费用（美元）：	8 663
多边基金总共支付费用（美元）：	104 913
对应供资情况（有/无）：	有
是否包括项目监测进度指标（有/无）：	有

秘书处的建议	个别审议

项目说明

1. 在第 75 次会议上，工发组织提交了一份关于淘汰氟氯烃的示范项目，即用氢氟烯烃作为发泡剂，应用于高环境温度下喷雾泡沫，资金数额为最初提交的 274 016 美元，外加 19 181 美元的机构支助费用。[1]为审议向第 75 次会议提交的展示低全球升温潜能值技术所有项目而设立的联络小组进行了讨论，此后，执行委员会决定将包括沙特阿拉伯的氢氟烯烃喷雾泡沫项目在内的七个示范项目推迟至第 76 次会议审议（第 75/42 号决定）。

2. 工发组织代表沙特阿拉伯政府，向第 76 次会议再次提交了上述示范项目，资助数额相同。[2]

<u>项目目标</u>

3. 在几个第 5 条国家，有大量技术和资本投资能力有限的中小型企业仍把氟氯烃−141b 作为喷雾泡沫发泡剂使用，这阻碍了引进一些低全球升温潜能值技术。在环境温度较高的国家使用喷雾泡沫，而高温可能严重影响泡沫形成过程，因此，也影响在温度较温和的国家使用有关泡沫的质量。在此基础上，项目提议：

(a) 在聚氨酯喷涂泡沫部门，示范用 FHO−1233zd(E)和 FHO−1336mzz(Z)[3]与水混合共同发泡，以替代 HCFC−141b 的好处、可适用性和可复制性；

(b) 通过使用优化水/物质发泡剂，降低泡沫密度和热传导率，对比其他备选办法，评估资本费用和业务费用的减少情况。

<u>项目执行</u>

4. 此项目将在 Sham Najd 执行，该企业有五个喷雾泡沫机。为了转换到氢氟烯烃发泡技术（FHO−1233ze（E）和 FHO−1336maam（z）），请求购置一个新的喷雾泡沫机、喷雾泡沫应用器以及氢氟烯烃预混多元醇。将评价聚氨酯系统的基本特性（自由增加密度、反应度、泡沫热传导性、压缩力、层面稳定、短期水吸收以及老化中的反应力的影响）。该企业已承诺将逐步淘汰 3.02 耗氧潜能吨的氟氯烃-141 b。

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[1] UNEP/OzL.Pro/ExCom/75/64。

[2] 为筹备该项目，核准了 30 000 美元的资助，外加 2 100 美元的机构支助费用，但有一项谅解是，此项核准并不表示项目的批准，也不表示批准其提交时提出的供资水平（第 74/33 号决定）。

[3] 这两种氢氟烯烃 1233zd（E）和氢氟烯烃 1336mzz（Z），与 HCFC-141b 相比，均具有非常低的全球升温潜能值，较高的沸点，较低的蒸汽压力以及较低的拉姆达值；这可能会提高热效率，更好操作，泡沫表层更平顺，喷雾时间较短。

项目预算

5.　　表 1 载有项目预算的汇总表。

表 1.　拟议项目费用

说　　明	**费用（美元）**
喷撒泡沫机与配件（软管、转让水泵、空气压缩机和混合头）	55 000
现场测试材料（3 次测试）(1 000 平方米)	30 000
在沙特阿拉伯认证测试机构测试泡沫产品物理特性	50 000
技术转让、实验和委托	40 000
信息传播室	20 000
小　计	195 000
应急资金	19 500
共　计	**214 500**
根据成本效益阈值共计	274 016
递增业务费用	107 097
共计费用	**321 597**

秘书处的评论和建议

评　　论

6.　　根据秘书处的建议，在示范项目里，纳入一项稳定性研究，看能否将桶装发泡剂/多元醇混合剂储存在炎热而无空调的仓库里，而后，也可作为更新鲜的、经妥善处理的混合剂，在同样的条件下，予以喷洒。

7.　　秘书处注意到，关于采购新喷雾机的提案，在项目完成后还停用了一台喷雾机。考虑到喷雾机都可以兼容氟氯烃-141b 或氢氟烯烃基泡沫系统，经商定，不采购新的喷雾机。

8.　　根据秘书处的建议，对拟议时间表作了调整，以便在 16 个月内，完成实地测试、委托和测试，再用一到两个月，提交项目完成报告。

9.　　根据第 74/21 号决定，秘书处建议，工发组织考虑是否有可能使示范项目费用合理化，以确保在 1 000 万美元的窗口内，核准更多的示范项目，途径包括在不损及主要目标的情况下，缩小项目范围，或通过其他手段。此外，秘书处注意到，在沙特阿拉伯已不再有任何氟氯烃-141b 的消费量了。[4]因此，增加运营成本（107 097 美元）不具备获得资助的资格。工发组织仔细审议了秘书处的评论意见，减少了项目费用，如表 2 所示，并反映在本文件附件一所载订正项目提案中。

[4]UNEP/OzL.Pro/ExCom/68/39。

表 2. 经修正的项目费用

说　明	费用（美元）
测试用途整体喷撒泡沫机	6 000
实地测试材料（3 次测试）（1 000 平方米）	11 500
在沙特阿拉伯认证测试机构测试泡沫产品物理特性	50 000
技术转让、实验和委托	20 000
共　计	**87 500**
应急资金	8 750
总　计	**96 250**

10.　　秘书处还注意到，不能扣除与项目有关的 3.02 消耗臭氧潜能值吨的氟氯烃-141b，因为沙特阿拉伯已没有余留的氟氯烃-141b 的消费了。

<u>结　　论</u>

11.　　在许多中小企业，已查明在采用低全球升温潜能值技术方面面临挑战，而示范项目可在这些中小型企业喷射泡沫塑料部门应用降低氢氟烯烃制剂（低全球升温潜能值技术）方面增加知识。优化降低了氢氟烯烃的制剂，预期可减少业务费用。对在高环境温度国家使用替代技术，包括关于化学品的储存，进行调查，将具有示范价值。沙特阿拉伯政府已将项目总费用从 274 016 美元（最初提交的数字）调整至 96 250 美元。根据沙特阿拉伯氟氯烃逐步淘汰管理计划第一阶段，已向当地自有的系统单位提供了资金，以定制制剂，包括氢氟烯烃制剂配方。Sham Najd 是系统单位下游客户之一。因此，不存在够资格获得资助的余留氟氯烃-141b 的消费。秘书处注意到，在沙特阿拉伯，另外还有三个拟议示范喷洒泡沫形式的氢氟烯烃或其他应用的项目，[5]还提交了两个项目，即拟议示范低全球升温潜能值替代品。

建　　议

12.　　谨建议执行委员会考虑：

(a)　　淘汰氟氯烃的示范项目，即用氢氟烯烃作为发泡剂，用于沙特阿拉伯高环境温度下的喷雾泡沫，并结合执行委员会就以全球升温潜能值（低全球升温潜能值）替代品取代氟氯烃的示范项目的提案之讨论，讨论情况见项目审查期间查明问题概览的文件(UNEP/OzL.Pro/ExCom/76/12)；

(b)　　按照第 72/40 号决定核准淘汰氟氯烃，即用 FHO 作为发泡剂，应用于沙特阿拉伯高环境温度下喷雾泡沫，数额为 96 250 美元，外加拨给工发组织的机构支助费用 8 663 美元；

(c)　　敦促沙特阿拉伯政府和工发组织在 16 个月内，按计划完成该项目，并在项目完成后，尽快提交一份全面的最后报告。

[5]哥伦比亚 (UNEP/OzL.Pro/ExCom/76/26)、印度 (UNEP/OzL.Pro/ExCom/76/35) 和泰国 (UNEP/OzL.Pro/ExCom/76/50)。

项目评价表── 非多年期项目

沙特阿拉伯

项目名称	双边/执行机构
(a) 在空调制造厂家执行的示范项目，旨在使用较低全球升温潜能值的制冷剂，开发窗式和组装式空调机	世界银行

国家协调机构	气象和环境机构负责人

项目所涉消耗臭氧层物质消费数据的最新报表
A: 第 7 条数据（截至 2016 年 4 月的 2014 年 ODP 吨）

氟氯烃	1 376.63

B: 国家方案行业数据（截至 2016 年 4 月的 2014 年 ODP 吨）

HCFC-22	1 121.9
HCFC-123	1.5
HCFC-141b	253.2

仍符合供资资格的氟氯烃消费量（ODP 吨）	765.4

CURRENT YEAR BUSINESS PLAN ALLOCATIONS 本年度业务计划分配款		**资金 美元**	**淘汰 ODP 吨**
	(a)	不详	不详

项目名称：	
企业所使用的 ODS（ODP 吨）：	8.31
将淘汰的 ODS（ODP 吨）：	3.59
将使用的 ODS（ODP 吨）：	0.00
项目期限（月）：	12
原申请数额（美元）：	1 306 800
最终项目费用（美元）：	
增支资金成本：	1 188 000
应急费用（10 %）：	118 800
增支经营成本：	0
项目总费用：	1 306 800
地方所有权（%）：	100
出口成分（%）	0
申请赠款（美元）：	1 306 800
成本效益（美元/公斤）：	20
执行机构支助费用（美元）：	91 476
多边基金总共支付费用（美元）：	1 398 276
对应供资情况（有/无）：	有
所包括项目监测进度指标（有/无）：	有

秘书处的建议	个别审议

项目说明

背　　景

13.　在第 75 次会议上，世界银行提出了一项示范项目，旨在使用较低全球升温潜能值的制冷剂，而非 HFC-410A 制冷剂，开发窗式和组装式空调机，按最初提交数额为 1 306 800 美元，外加 91 476 美元的机构支助费用。[6]编制该项目时，并未要求多边基金提供资金。为审议向第 75 次会议提交的所有有关示范低全球升温潜能值技术的提案成立了一个联络小组，在该小组讨论后，执行委员会决定，将包括沙特阿拉伯空调项目在内的 7 个示范项目推迟至第 76 次会议审议。

14.　世界银行代表沙特阿拉伯政府，向第 76 次会议上重新提交了上述示范项目，资金数额不变。该项目提案载于本文件附件二。

项目目标

15.　沙特阿拉伯制造制冷和空调设备。2011 年，约有 10 000 公吨（550 ODP 吨）的氟氯烃-22 被用来制造各种制冷和空调设备。当地制造商包括五家大型企业，每家消费氟氯烃-22 超过 500 公吨，一些较小企业消费不到 100 公吨。该国约 70%的电力都消费在空调系统的运作上。

16.　因此，本项目提出构建、测试并优化基于 HFC-32 和 HC-290 制冷剂的窗式和组装式空调样机；评估其能源效益和增支费用；向沙特阿拉伯和其他国家感兴趣的制造商散播调查结果和成果。鉴于氟氯烃逐步淘汰管理计划尚未涉及制冷和空调制造部门，成功展示全球升温潜能值较低的替代品，将对推广产生重大影响。

项目的执行

17.　本项目由两个企业提供协助：沙特阿拉伯电器工厂有限公司（具有年产 120 000 台窗式空调的能力），该公司将研发两种规格的基于 HFC-32 和 HC-290 制冷剂的窗式空调（18 000 Btu/小时和 24 000 Btu /小时）；以及 Petra 工程有限公司（KSA）（具有年产 852 台组合式空调的能力），该公司将解决带有制冷剂和空气处理器的组装式空调系统（40-100 千瓦）具有易燃性的问题，办法就是使用 HFC-32 和 HC-290 制冷剂。

18.　将提供技术援助，以便参考注入量以及安全措施，设计出基于替代制冷剂的空调样机；根据所规定的能效，具体确定主要组件（即，冷凝器、蒸发器、风扇和压缩机）；考虑到高环境温度国家的部件供应和供应商情况，研发样机。将根据国际标准，在 Petra 公司的实验室进行测试，以评估样机的业绩。与基于氟氯烃-22 的设备，进行业绩、注入量数量和价格上的对比。

[6] UNEP/OzL.Pro/ExCom/75/64。

项目预算

19. 项目估计费用细节见表 1。

表 1. 按活动分列的项目费用

活　动	数　量	单位成本（美元）	费用共计（美元）
沙特电器工厂有限公司			
开发窗式空调（18 000 Btu/h）使用旋转翼和往复式压缩机	2	55 000	110 000
开发窗式空调（24 000 Btu/h）使用旋转翼和往复式压缩机	2	55 000	110 000
Petra KSA 公司			
为 HFC−32 和 HC−290 设计新的软件		38 000	38 000
两种替代制冷剂的样机制造(6 台样机（40，70 和 100 千瓦))	6	70 000	420 000
样机测试	6	50 000	300 000
研究和开发、设计、测试和批准	6		170 000
技术援助			
国际专家	1	30 000	30 000
技术传播讲习班	1	10 000	10 000
小　计			**1 188 000**
应急费用（10 %）			118 800
费用共计			**1 306 800**

秘书处的评论和建议

评　论

20. 重新向第 76 次会议提交的示范项目，更全面地描述了选定的技术、进一步证明有必要改进关于在环境温度高的国家生产使用 HFC−32 和 HC−290 的空调的技术、其潜在的可复制性。秘书处赞赏地注意到，世界银行提交的项目提案，没有要求多边基金提供筹备资金；

21. 秘书处和世界银行就向第 75 次和第 76 次会议提交的示范项目，进行了讨论。为便于参考，讨论结果概述如下:

(a) 有人要求澄清示范项目正开展的工作被查出可能有重叠或协同增效的问题，该示范项目旨在西亚高环境温度国家空调业界推广低全球升温潜能值替代产品（PRAHA），[7]世界银行解释说，根据 PRAHA 项目，Petra KSA 公司只收到用于测试和运输分离式空调样机的资助，并没有收到研发样机的资助。建议向第 76 次会议提交的示范项目所涉窗式和组装式空调的技术，并没有在 PRAHA 项目下进行测试；至于窗式空调，需要投入大量开发资源，以降低制冷剂的灌注量，并落实安全特性；

[7]第 69 次会议核准，由环境署和工发组织执行 (UNEP/OzL.Pro/ExCom/69/19)。

(b) 秘书处还提到了工发组织向第 76 次会议提交的关于沙特阿拉伯空调部门一个类似的示范项目，其中涉及研发、优化和验证使用包括 HC-290 在内的替代制冷剂的窗式和分离式空调。因此，在为窗式空调机拟议采取的 HC-290 技术方面，各项目间存在重叠问题。 在本文件印发之时，世界银行仍在同沙特阿拉伯政府就如何解决这一重叠进行协商；

(c) 秘书处注意到，Petra KSA 企业公司成立于 2010 年（即在 2007 年 9 月 21 日截止日期之后），因此没有资格获得供资。世界银行表示，示范项目的目的只是提供技术援助，以研制样机进行测试，Petra 的改装工作将自筹资金。截止日期并不适用。此外，该企业参与了 PRAHA 项目；

(d) 项目提案除其他外，表示了参与企业进行示范的意愿；但没有说明这些企业是否将停止使用氟氯烃，而该项目也不包括诸项转换。

(e) 关于将示范项目研发的样机进行商业生产的可行性，世界银行解释说，只有在样机达到业绩和安全标准之后，企业才能决定商业生产。此外，鉴于该部门的竞争性质，该部门协调转换，将是较好的选择；为此，沙特阿拉伯首先需要制定和修改标准和建筑法规，允许安全安装基于易燃制冷剂的空调，技术人员也应接受处理易燃制冷剂的培训并获得认证。

(f) 秘书处根据第 74/21 号决定(c)段，探讨了合理化项目费用问题。在回答这方面问题时，世界银行澄清说，要求为“制造样机”供资（与组装式空调有关），涉及六个不同样机的材料，三种不同的能力，两种制冷剂，特殊构件的外包，制冷剂以及运输；而“开发费用”（有关窗式空调机）包括设计样机的工程工作，审查制冷剂的特性，优化系统，设计热交换器，软件开发以及实验室测试。根据这些要求，所需供资数额可能无法合理使用；

(g) 秘书处对需要与参与企业签订新合同一事，表示关切，因为过去已证明，这一过程漫长。世界银行表示，将使用新的简化补助金项目处理周期，以处理本项目的赠款协议。这一进程能使项目执行更快启动，并使这一项目的经验在 2018 年氟氯烃逐步淘汰管理计划第二阶段得到推广。

结　论

22. 秘书处认为，这一项目涉及第 72/40 号决定提及的优先部门之一，可对高环境温度国家的空调采用低全球升温潜能值技术产生积极影响。但秘书处也注意到，在几个国家已经在生产使用 HFC-32 和 HC-290 的空调了。秘书处认为，根据第 60/44 号和第 74/50 号决定，成立于 2010 年的 Petra KSA 公司的示范项目构件不符合资格；而与测试 HC-290 有关的构件与工发组织提交的沙特阿拉伯示范项目重叠。 加上喷撒泡沫的示范项目，沙

特阿拉伯共有三个示范项目提案。执行委员会在其准则[8]里指出，各类项目均应考虑到区域和地域分配情况。

建　议

23. 谨建议执行委员会考虑：

(a) 在空调制造厂商执行示范项目，以便在沙特阿拉伯研发使用低全球升温潜能值（低全球升温潜能值）制冷剂的窗式和组装式空调，并结合执行委员会就以全球升温潜能值（低全球升温潜能值）替代品取代氟氯烃的示范项目的提案之讨论，讨论情况见项目审查期间查明问题概览的文件(UNEP/OzL.Pro/ExCom/76/12);

(b) 是否核准在沙特阿拉伯空调制造厂家研发低全球升温潜能值制冷剂的窗式和组装式空调。

[8] UNEP/OzL.Pro/ExCom/73/62 号文件第 97（e）段。

项目评价表–– 非多年期项目

沙特阿拉伯

项目名称	双边/执行机构
(a) 关于在高环境温度下的空调部门，推广基于氢氟烯烃的低全球升温潜能值制冷剂的示范项目	工发组织

国家协调机构	气象和环境机构负责人

最新报告的项目所涉消耗臭氧层物质消费数据
A: 第 7 条数据（截至 2016 年 4 月的 2014 年 ODP 吨）

氟氯烃	1 376.63

B: 国家方案行业数据（截至 2016 年 4 月的 2014 年 ODP 吨）

HCFC-22	1 121.9
HCFC-123	1.5
HCFC-141b	253.2

仍符合供资资格的氟氯烃消费量（ODP 吨）	765.40

本年度业务计划分配款		资金 美元	淘汰 ODP 吨
	(a)	不详	不详

项目名称：	
企业所使用的 ODS（ODP 吨）：	2 550 公吨(2015)
将淘汰的 ODS（ODP 吨）：	0
将使用的 ODS（ODP 吨）：	0
项目期限（月）：	24
原申请数额（美元）：	1 690 000
最终项目费用（美元）：	
增支资金成本:	1 570 000*
应急费用（10 %）：	不详
增支经营成本:	不详
项目总费用:	1 570 000*
地方所有权（%）：	100
出口成分（%）	不详
申请赠款（美元）：	1 570 000*
成本效益（美元/公斤）：	不详
执行机构支助费用（美元）：	109 900*
多边基金总共支付费用（美元）：	1 679 900*
对应供资情况（有/无）：	有
所包括项目监测进度指标（有/无）：	有

* 如果“在高环境温度国家促进制冷剂替代品（PRAHA-II）”项目得到核准，供资水平将减少 160 000 美元，外加相应的机构支助费用。

秘书处的建议	个别审议

项目说明

24. 工发组织作为指定的执行机构，代表沙特阿拉伯政府向第 76 次会议提交了一项供资要求，即资助在高环境温度下的空调部门，推广使用基于氢氟烯烃的低全球升温潜能值（低全球升温潜能值）制冷剂的示范项目，按最初提交[9]的数额 1 690 000 美元，外加 118 300 美元的机构支助费用。

25. Alessa 是一家 100%由当地拥有的企业，曾参与在西亚[10]高环境温度国家空调业促进使用低全球升温潜能值替代品的示范项目，生产窗式和分离式空调，以及一些较大的系统。[11]2015 年，该企业消费约 2 550 公吨氟氯烃-22，生产约 70 万台窗式空调，容量在 16 至 20 kBTU/小时（4.7-5.9 千瓦）之间，氟氯烃-22 制冷剂注充量为 1.75 公斤，还生产了约 70 万台分离式空调，容量在 19 至 22 kBTU/小时（5.6-6.4 千瓦）， 制冷剂充注量约 1.9 公斤。

26. 通过该项目，Alessa 将制造并测试使用低全球升温潜能值 FHO/HFC 混合剂[12]以及 R-290 窗式和分离式空调机样机。将重新设计和优化这些样机，包括满足能源效率标准。一旦研制成功，将进行一次示范生产流程，以核查程序和所需的工艺。鉴于现有生产线处理易燃制冷剂受限，将设置一条生产线，以进行模拟生产，而后转为全面生产线。经改进的生产线将包括必要的安全措施。

项目执行

27. 示范项目将解决诸项技术挑战，即涉及设计出适于高环境温度下使用低全球升温潜能值替代品的空调，包括：

(a) 拟议的一些氢氟烯烃混合剂温度滑移度，[13]即非共沸混合剂。[14]液体阶段，这些混合剂必须准确注入，这就需要优化制冷机和蒸发器，有可能的话，要使用细管而非膨胀阀；

[9] 核准为此项目的筹备供资 30 000 美元，外加 2 100 美元机构支助费用，但有一项谅解是此项核准并不意味着核准该项目或核准提交时的资助数额（第 74/33 号决定）。
[10] 第 69 次会议核准，由环境署和工发组织执行（UNEP/OzL.Pro/ExCom/69/19）。
[11]Alessa 公司也制造冷藏设备，该企业的泡沫塑料生产列入第一阶段。该企业已从氟氯烃-141b 转为环戊烷。
[12]氢氟烯烃与 HFCs 的混合将予以测试，因为这种混合剂可提供可比氟氯烃-22 的较低容量的制冷能力。单纯氢氟烯烃比氟氯烃的容量制冷能力低，反过来，需要加大压缩机的容积排量，从而导致空调机费用增多，体积更大。预计混合剂将含有 HFC-32，因为这将增加容量能力；但也可能包含其他成分，例如 HFC-152a。
[13]温度滑移是指饱和蒸汽温度与饱和液体的温度在持续压力下的温差。
[14]展现温度滑移的制冷体，被称为非共沸混合剂。单一组成部分的制冷剂，如氟氯烃-22 没有温度滑移。展现少量温度滑移的制冷剂混合体，如 HFC-410 a，被称为近共沸混合剂。

(b) 需要准确注入制冷剂以及易燃的氢氟烯烃混合剂，要求对渗漏进行真空测试；

(c) 最好进行防泄漏链接，在安装时尽量减少渗漏，需要重新设计室内和室外部分，并顾及较大型的蒸发机。

28. 将建造三个 15−20 平方米的隔热房子，作为模拟住家环境，对生产的空调机进行实际测试。这三个小房子将放置在 Alessa 公司附近三到六个月，以便进行沙特阿拉伯环境条件下的测试，包括冷凝器上蒙上沙土，摄氏 50° C 的热天以及寒冷的夜晚。与此同时，将制作的空调放到沙特阿拉伯不同地区，以测试不同条件下的业绩（如湿度）。这些小屋也将用于培训技术服务人员掌握新的制冷剂用法，并开展提高认识活动。

29. 测试阶段之后，将进行评估，选定用于生产目的机型。期望是选定一个以上的低全球升温潜能值的替代品。在执行项目后，根据项目采购的所有设备，将运至分离式空调生产线。项目执行期为 24 个月。

项目预算

30. 表 1 载列项目费用汇总表。

表 1. 项目费用

活　　动	预算（美元）
研究和开发	320 000
试点单位测试	35 000
仿真测试	30 000
生产线	25 000
资本投资	350 000
资本投资 – 实验室	250 000
资本投资 – 生产线	560 000
宣传和培训	30 000
项目管理和技术支助	90 000
共　计	**1 690 000**

秘书处评论和建议

评　论

31. 在审查示范项目时，秘书处审议了世界银行提交的沙特阿拉伯生产空调示范项目的资料，关于 PRAHA-II 的提案以及 PRAHA-I 的报告。[15]尽管在第 74 次会议上收到了请求提供筹备资金的担保信，但秘书处还没有收到示范项目的担保信，并请工发组织予以提供。

32. 秘书处注意到，世界银行提交的关于空调部门的示范项目还建议研发使用 HC−290 的窗式空调样机。在与工发组织展开进一步讨论后，有人指出，此事与工发组织项目某个次要组成部分有重叠，世界银行和工发组织商定，如果需要，将就此一特别部件进行合作。

[15] UNEP/OzL.Pro/ExCom/76/10。

33. 秘书处澄清说，在成功执行示范项目后，该项设备将纳入改造现有分离式生产线的工作，即将氟氯烃-22 转换成选定的低全球升温潜能值替代品。Alessa 公司同意，不再为改造选定的生产线进一步要求提供资金了。

34. 根据第 74/21 号决定（c）段，秘书处建议工发组织考虑是否有可能使示范项目费用合理化。因此，工发组织把项目费用从 1 690 000 美元减到 1 570 000 美元，如表 2 所示，并反映在本文件附件三所载经修订的项目提案中。

表 2. 建议的项目费用

活　　动	预算（美元）
研究和开发	320 000*
试点单位测试	35 000
仿真测试	30 000
生产线	25 000
资本投资	315 000
资本投资 – 实验室	225 000
资本投资 – 生产线	500 000
宣传和培训	30 000
项目管理和技术支助	90 000
共　　计	**1 570 000***

*如果“在高环境温度国家促进制冷剂替代品（PRAHA-II）”项目得到核准，供资水平将减少 160 000 美元，外加相应的机构支助费用。

35. 秘书处还注意到， PRAHA-II 提案具有潜在协同增效作用。如果执行委员会核准 PRAHA-II，可为进一步合理安排费用提供机会，特别是因为它涉及研究和发展。工发组织也认为合理化是可能的，并建议如果 PRAHA-II 获得批准，可以使一半的研究和开发费用（减少 160 000 美元）合理化。

<u>结　　论</u>

36. 该项目涉及第 72/40 号决定内的一个优先部门，可对空调采用低全球升温潜能值技术产生积极影响，特别是在高环境温度的国家。该项目借鉴了 PRAHA-I 的成果，如果得到核准，将补充提交第 76 次会议的 PRAHA－II。 Alessa 公司将使用项目设备，将现有的分离式生产线从氟氯烃-22 转为低全球升温潜能值替代品，该公司还同意不再要求为改装选定的生产线要求提供进一步的资金。秘书处认为，该项目与世界银行为沙特阿拉伯提交的测试窗式空调使用 HC-290 的示范项目有部分重叠。加上喷雾泡沫示范项目，沙特阿拉伯共有三个示范项目提案。执行委员会在其准则中指出，项目也应考虑到区域和地域分配。[16] 此外，在撰写本文件时，还没有收到这一示范项目的担保信。

[16] UNEP/OzL.Pro/ExCom/73/62 号文件第 97（e）段。

建 议

37. 谨建议执行委员会考虑：

(a) 在沙特阿拉伯高环境温度下空调部门推广基于氢氟烯烃的低全球升温潜能值制冷剂的示范项目，并结合执行委员会就以全球升温潜能值（低全球升温潜能值）替代品取代氟氯烃的示范项目的提案之讨论，讨论情况见项目审查期间查明问题概览的文件(UNEP/OzL.Pro/ExCom/76/12）；

(b) 是否核准在沙特阿拉伯高环境温度下空调部门推广基于氢氟烯烃的低全球升温潜能值的制冷剂。

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.

This demonstration project 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:

<u>Commercially Available Options</u>

Option	**Pros**	**Cons**	**Comments**
Cyclopentane & n-Pentane	Low GWP Low operating costs Good foam properties	High flammable	High incremental capital cost, may be uneconomic for SMEs
HFC-245fa, HFC-365mfc/227ea, HFC-134a	Non-flammable	High GWP	Low incremental Capital Cost
	Good foam properties	High Operating Cost	Improved insulation (cf. HC)
CO2 (water)	Low GWP Non-flammable	Moderate foam properties - high thermal conductivity-	Low incremental Capital Cost
Methyl	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.

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

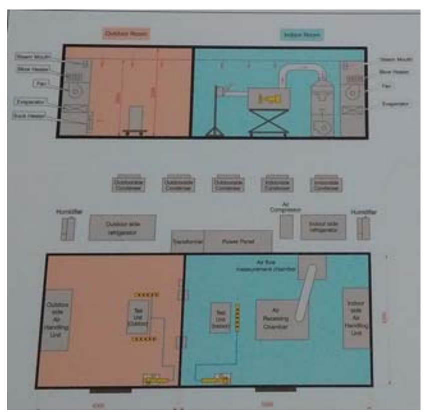

Figure 2: Lab layout

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.

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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

(grey)	No data yet available
(orange)	No data available, Thermodynamic data available

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.