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环 境 规 划 署

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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：地区

本文件包括基金秘书处关于以下项目提案的评论和建议：

制冷

• 在西亚地区高环境温度国家推广制冷剂替代品（PRAHA-II）	环境规划署和工发组织
• 建立欧洲和中亚低全球升温潜能值替代制冷剂培训、认证和示范区域卓越中心	俄罗斯联邦

项目评价表——非多年期项目

地区

项目名称	双边/执行机构
(a) 在西亚地区高环境温度国家推广制冷剂替代品（PRAHA-II）	环境规划署（牵头）与工发组织

国家协调机构：	高环境温度国家的国家臭氧机构、 研究机构以及空调行业 国际技术提供商、设施管理助理（HVAC）协会以及研究机构

最新报告的项目所涉消耗臭氧层物质消费量数据

A: **第 7 条数据**

氟氯烃	暂缺

B: 国家方案行业数据

氟氯烃	暂缺

仍符合供资条件的氟氯烃消费量（ODP 吨）	暂缺

本年度业务计划拨款		**供资（美元）**	**淘汰 ODP 吨**
	（a）	821 000	-

项目名称：	
企业所使用的消耗臭氧层物质（ODP 吨）：	暂缺
将淘汰消耗臭氧层物质（ODP 吨）：	暂缺
将采用消耗臭氧层物质（ODP 吨）：	暂缺
项目的期限（月）：	18
最初申请数额（美元）：	750 000
最终项目费用（美元）：	
增支资本费用：	700 000
应急费用（10 %）：	0
联合供资成本	450 000
项目费用总额：	1 150 000
当地所有权（%）：	暂缺
出口部分（%）：	暂缺
申请的赠款（美元）：	
环境规划署	375 000
工发组织	325 000
请求拨款共计：	700 000
成本效益值（美元/千克）：	暂缺
执行机构支助费用（美元）：	
环境规划署	48 750
工发组织	22 750
机构支助费用执行机构支助费用共计：	71 500
项目向多边基金申请的总费用（美元）：	771 500
对应供资状态（是/否）：	是
是否包括了项目监测阶段目标（是/否）：	暂缺

秘书处建议	个别审议

项目说明

背景

1. 环境规划署作为牵头执行机构，向第七十六次会议提交了关于为在西亚地区高环境温度国家推广制冷剂替代品（PRAHA-II）示范项目供资的请求，按最初提交来文，共计成本为 771 500 美元，其中包括 400 000 美元，加上给环境规划署的机构支助费用 52 000 美元；和 350 000 美元，加上给工发组织的机构支助费用 24 500 美元。

项目目标

2. 该地区国家当前可获得的许多非 HCFC-22 空调系统都是以高全球升暖潜能全球升暖潜能值制冷剂为基础的。在这些温度下，这些空调系统的能源效率降低。因此，就有必要证明基于全球升暖潜能值制冷剂的空调操作能够解决高环境温度条件国家对这些系统的需求。该项目旨在以示范项目进展为基础向西亚地区高环境温度国家空调行业推广低全球升暖潜能值替代品（PRAHA）[1]，并促进利益攸关方在高环境温度国家空调行业使用低全球升暖潜能值制冷剂。

项目执行

3. 该项目重点在与建设地方设计能力，制定空调系统低全球升暖潜能值制冷剂评估风险模型、知识共享和技术平台。为建设地方设计能力，将会对在 PRAHA-I 过程中制定的空调原型进行分析和优化，对低全球升暖潜能值制冷剂（即，HFC-32、R-290a 以及 HFO 混合物）进行测试，将会对高滑移[2]替代品性能有关泄漏物再充电影响进行分析。将会在中国和泰国组织三次设计原型培训研讨会、地方空调设备制造商和技术提供商之间的磋商、相关行业及研究中心实地调查。

4. 将会与地方机构和国际合作伙伴，即日本制冷与空调行业协会与中国家用电器协会，制定出适合在高环境温度国家普遍使用模式和操作条件的风险评估模式，所述协会已经制定出 A2L 和 A3 制冷剂风险评估模型。[3]咨询服务将会用于测试和项目管理。

项目预算

5. 预估项目成本详见表 1。

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[1] 环境规划署和工发组织在第六十九次会议上核准执行（UNEP/OzL.Pro/ExCom/69/19）。该项目的最终报告可查阅 UNEP/OzL.Pro/ExCom/76/10 号文件。

[2] 温度滑移是指饱和蒸汽与恒压饱和液体温度之间的温差。

[3] A2L 是一种低可燃性制冷剂，最大燃烧速度≤ 10 cm/sec 时，在 60°C 和 101.3 kPa 条件下接受测试会出现火焰传播。A3 是一种高可燃性制冷剂，在 60°C 和 101.3 kPa 条件下接受测试会出现火焰传播。

表 1. 按照活动分类的预估项目成本（美元）

说明	机构	请求	联合供资	总成本
详细工作计划编制	工发组织	30 000	30 000	60 000
分析 PRAHA-I 原型设计；设计优化；测试新制冷剂；分析有关高滑移替代品性能泄漏物再充电影响	环境规划署	355 000	50 000	405 000
建立研究和开发部门在低全球升暖潜能值替代制冷剂设计方面的能力	工发组织	120 000	100 000	220 000
制定和执行风险评估模型	环境规划署/工发组织	80 000	120 000	200 000
项目管理	环境规划署/工发组织	70 000	-	70 000
国际技术咨询小组	环境规划署/工发组织	60 000	-	60 000
项目成果宣传	环境规划署/工发组织	25 000	150 000	175 000
报告和记录	环境规划署/工发组织	10 000	-	10 000
总成本		750 000	450 000	1 200 000

6. 项目将在 18 个月内执行。

秘书处评论和建议

评论

7. 秘书处赞赏地指出，环境规划署和工发组织在没有多边基金预备供资的条件下准备项目提案。但是，秘书处还指出，还未收到项目认可信函，并要求环境规划署提供这些信函。

8. 在审查项目提案的过程中，秘书处考虑了工发组织和世界银行[4]向第七十六次会议提交的两个沙特阿拉伯空调制造业示范项目和环境规划署与工发组织向第七十六次会议提交的 PRAHA-I[5]示范项目完成报告。

9. 该项目将会使用 PRAHA-I 项目执行期间制定的原型；将会（基于在 PRAHA-I 项目执行过程中的经验）在橡树岭国家实验室（ORNL）[6]开展测试和评估工作，这将减少

[4] UNEP/OzL.Pro/ExCom/76/46。

[5] UNEP/OzL.Pro/ExCom/76/10。

[6] 最大的美国能源部科学与能源实验室，主要进行基础和应用研究，以提供有关能源和安全问题的解决方案。

在参与国家之间运输样本成分和最终原型所需的时间。必要时，将会利用更新或改变成分使用和测试现有原型。

10. 根据第 74/21（c）号决定，秘书处建议，环境规划署考虑使示范项目成本合理化的可能性。因此，环境规划署减少了项目成本，如表 2 所示，并反映在本文件附件一所包含的修改后的项目提案中。

表 2. 修改后的项目成本和时间表（美元）

说明	机构	请求	联合供资	总成本
详细工作计划编制	工发组织	30 000	30 000	60 000
分析 PRAHA-I 原型设计；设计优化；测试新制冷剂；分析有关高滑移替代品性能泄漏物再充电影响	环境规划署	340 000	50 000	390 000
建立研究和开发部门在低全球升暖潜能值替代制冷剂设计方面的能力	工发组织	100 000	100 000	200 000
制定和执行风险评估模型	环境规划署/工发组织	80 000	120 000	200 000
项目管理	环境规划署/工发组织	70 000	-	70 000
国际技术咨询小组	环境规划署/工发组织	45 000	-	45 000
项目成果宣传	环境规划署/工发组织	25 000	150 000	175 000
报告和记录	环境规划署/工发组织	10 000	-	10 000
总成本		700 000	450 000	1 150 000

11. 秘书处指出，工发组织提交的有关沙特阿拉伯空调制造业示范项目的潜在协同效应。如果两个项目获得核准，将有机会使成本进一步合理化。具体来说，沙特阿拉伯空调制造业示范项目研发和发展成本可以减少 160 000 美元。

结论

12. 示范项目旨在解决第 72/40 号决定所述重点行业之一，该项目可以对在高环境温度国家空调系统操作引入低全球升暖潜能值技术产生积极影响。该项目将建立在 PRAHA-I 结果基础之上，且会对沙特阿拉伯空调制造业示范项目进行补充。该项目还建立在从第 5 条促进这些国家行业与利益攸关方之间技术交流引入基于低全球升暖潜能值制冷剂的国家学习到的经验教训（例如，中国 R-290 制冷剂和泰国 HFC-32 制冷剂）之上。PRAHA-I 成功吸引了许多利益攸关方，且继续这种吸引将会进一步帮助在高环境温度国家发展和吸收低全球升暖潜能值替代品。但是，在编写本文件时，尚未收到认可信函。

建议

13. 执行委员会不妨考虑：

(a) 在有关项目审查期间所提出问题的概述文件（UNEP/OzL.Pro/ExCom/76/12）中说明的关于氟氯烃低全球升暖潜能值替代品示范项目提案的讨论背景下，在西亚地区高环境温度国家推广制冷剂替代品（PRAHA-II）示范项目；

(b) 是否核准在西亚地区高环境温度国家推广制冷剂替代品（PRAHA-II）示范项目。

项目评价表 – 非多年期项目

地区

项目名称 **双边/执行机构**

（a）	建立欧洲和中亚地区低全球升暖潜能值替代制冷剂培训、认证和展示国际区域卓越中心	俄罗斯联邦

国家协调机构	暂缺

最新报告的项目所涉消耗臭氧层物质的消费量数据

A：第七条数据

氟氯烃	暂缺

B：国家方案行业数据

氟氯烃	暂缺

仍符合供资条件的氟氯烃消费量（ODP 吨）	暂缺

本年度业务计划拨款		**供资（美元）**	**淘汰（ODP 吨）**
	（a）	暂缺	暂缺

项目名称：	
企业所使用的消耗臭氧层物质（ODP 吨）：	暂缺
讲淘汰的消耗臭氧层物质（ODP 吨）：	暂缺
讲采用的消耗臭氧层物质（ODP 吨）：	暂缺
项目的期限（月）：	36
最初申请数额（美元）：	852 600
最终项目费用（美元）：	591 600
增支资本费用：	暂缺
应急费用（10%）：	暂缺
增支经营费用：	暂缺
项目费用总额：	暂缺
当地所有权（%）：	暂缺
出口部分（%）：	暂缺
申请的赠款（美元）：	591 600
成本效益值（美元/千克）：	暂缺
执行机构支助费用（美元）：	75 076
项目向多边基金申请的总费用（美元）：	666 676
对应供资情况（是/否）：	否
是否包括了项目监测阶段目标（是/否）：	是

秘书处建议	**个别审议**

项目说明

14. 俄罗斯联邦政府已代表欧洲和中亚国家向第七十六次会议提交了为示范项目供资的申请，该示范项目旨在设立一个国际区域英才中心，用于进行欧洲和中亚地区低全球升暖潜能值替代制冷剂的培训、认证和展示，如最初提交的提案所述，[7]供资金额为 852 600 美元，外加机构支助费用 103 786 美元。所提交的提案载于本文件附件二。

项目目标

15. 本项目将建立一个区域英才中心，用于为技术人员和工程师进行欧洲和中亚国家[8]制冷和空调系统中低全球升暖潜能值制冷剂的安全操作和展示的培训。

16. 本项目将提高制冷和空调行业的技术能力、帮助克服使用低全球升暖潜能值制冷剂的障碍、提高服务实践、以及减少制冷剂排放；为专家提供关于制冷剂和空调设备的可能重新设计的建议，以提升能源效率和生命周期气候影响；帮助制定政策，以使法规与欧盟温室氟化气体法规相统一；制定小型示范项目，以推广臭氧和气候安全制冷和泡沫替代品；以及，宣传关于新技术的信息。

项目执行

17. 本项目包括第一阶段中三年期的区域中心的建立和运营。中心的核心活动包括：

(a) 提供经认可、认证和国际公认的培训方案和技术咨询服务；

(b) 帮助各国编制与欧盟温室氟化气体法规（欧盟第 517/2014 号）相统一的英语和俄语版普通氟化气体法规草案，尤其涉及以下方面：鼓励使用对气候无影响或影响小的技术。对进行与温室氟化气体有关的活动的自然人的培训应包括关于替代和减小使用温室氟化气体的技术信息；

(c) 执行一些示范项目，展示低全球升暖潜能值制冷剂的使用和节能设计，此类设计可供考察和分析，并可促进技术转让；

(d) 开设供职业和学术研究的公共课程，内容涵盖制冷剂和空调；以及

(e) 执行技术援助活动，并通过国家制冷协会的能力建设予以支持；制定手册、标准和电子学习模块；以及翻译技术和政策相关的出版物。

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7 经批准，本项目编制的资金为 50 000 美元，外加给工发组织的机构支助费用 3 500 美元，但有一项谅解，即当执行委员会提交提案供审议时，对项目编制的批准不代表对项目提案或其供资金额的批准（第 74/33 号决定）。

8 阿尔巴尼亚、亚美尼亚、波斯尼亚和黑塞哥维那、格鲁吉亚、吉尔吉斯斯坦、前南斯拉夫的马其顿共和国、摩尔多瓦共和国、黑山、塞尔维亚、土耳其和土库曼斯坦。

18. 工发组织将担任项目的执行机构，预计项目于 36 个月后完成。

项目预算

19. 预计项目的总成本为 591 600 美元，外加支助费用，见表 1。

表 1. 拟议项目成本

说明	共计（美元）
区域中心的建立	128 500
中心运营成本（3 年期）	39 600
改编和印刷方案和手册（英语和俄语）	51 500
开设在线互动培训课程（英语和俄语）	58 500
用于使用天然制冷剂的试点制冷工厂的设备	214 000
知晓度和宣传	8 500
网站/门户建设（英语和俄语）	28 500
管理	62 500
共计	591 600

秘书处评论和建议

评论

20. 在第七十四次会议上，批准了供工发组织编制本项目的资金。工发组织阐述了俄罗斯联邦欲通过其双边方案支持本项目的意向，因此提交本项目供双边援助。

21. 解释项目的示范性时，工发组织强调了服务行业的重要性，在服务行业中，技术人员培训的新的和标准化方法、对试点示范项目的访问、以及咨询将建立一个区域标准并鼓励专业知识和信息的交流。

22. 阐释中心活动与环境规划署履约协助方案下的欧洲和中亚区域网络的活动、或批准的氟氯烃淘汰管理计划下的活动重复时，工发组织解释到，中心提供未纳入履约协助方案和网络活动的活动，例如，包括：使用新替代品设计和执行生产线的建议，此类新代替品将有助于未来的转换；以及面向小中型企业的咨询服务。中心还将开设通过国际认可标准认证的培训课程，以补充氟氯烃淘汰管理计划中的活动，尤其是制冷服务行业中的活动，从而改进为各国提供的服务。

23. 工发组织告知，中心将位于亚美尼亚，由埃里温大学管理。据提议，中心运营初始阶段的三年内，中心将依靠自身实现可持续发展，并且还可能包括培训和咨询服务支付等选项。秘书处收到亚美尼亚政府寄来的认可函，支持中心的建立和运营。

24. 关于项目成本的进一步合理化，[9] 工发组织将项目总成本降至 591 600 美元，外加机构支助费用 75 076 美元。

结论

25. 秘书处注意到，虽然本项目的执行可提升欧洲和中亚地区国家的制冷行业实践，并通过中心运营使其上升到国际标准，从而使这些国家受益，但提案未说明代替氟氯烃的新的低全球升暖潜能值替代品。与项目相关的国家中，无氟氯烃削减。

建议

26. 执行委员会不妨考虑：

(a) 关于项目审查期间所确定问题的概述的文件（UNEP/OzL.Pro/ExCom/76/12）中所述的关于建立欧洲和中亚地区低全球升暖潜能值替代制冷剂培训、认证和展示区域卓越中心的示范项目；

(b) 核准关于建设欧洲和中亚地区低全球升暖潜能值替代制冷剂的培训、认证和展示区域卓越中心的示范项目，金额为 591 600 美元资金，外加批给俄罗斯联邦政府的机构支助费用 75 076 美元，作为双边供资的一部分；以及

(c) 敦促俄罗斯联邦政府按计划在 36 个月内完成项目，并于项目完成后立即提交最终综合报告。

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[9] 第 74/21（c）号决定要求双边和执行机构使示范项目成本合理化，以根据第 72/40 号决定使 1 000 万美元可用资金下的大量示范项目获得批准，以及进一步探索其他额外资金来源。

MULTILATERAL FUND FOR THE IMPLEMENTATION OF THE MONTREAL PROTOCOL ON SUBSTANCES THAT DEPLETE THE OZONE LAYER			
PROJECT COVER SHEET			
REGION	West Asia	**IMPLEMENTING AGENCIES**	UNEP (as lead) and UNIDO
PROJECT TITLE	Promoting refrigerant alternatives for high ambient temperature countries (PRAHA-II)		
PROJECT IN CURRENT BUSINESS PROGRAMME		Yes	
SECTOR		Refrigeration and air-conditioning sector	

PROJECT IMPACT		n/a	ODP tonnes
PROJECT DURATION – Demonstration Project			18 months
PROJECT COSTS	Incremental Capital Costs	US $	700,000
	Contingencies	US $	0
	Co-funding Costs	US $	450,000
	Policy and Management Support	US $	0
	Total Project Costs	US $	1,1500,000
LOCAL OWNERSHIP			n/a
EXPORT COMPONENT			n/a
REQUESTED MLF GRANT	UNEP	US $	375,000
	UNIDO	US $	325,000
	TOTAL	US $	700,000
COST EFFECTIVENESS		US $/kg	n/a
IMPLEMENTING AGENCY SUPPORT COSTS	UNEP (13%)	US $	48,750
	UNIDO (7%)	US $	22,750
	TOTAL	US $	71,500
TOTAL COST OF PROJECT TO THE MULTILATERAL FUND		US $	771,500
STATUS OF COUNTERPART FUNDING (Y/N)			Y
PROJECT MONITORING MILESTONES (Y/N)			n/a
NATIONAL COORDINATING BODIES		National Ozone Units, research institutes and A/C industry in HAT countries + International technology providers, HVAC associations and research institutes	

Project summary:

The project of promoting refrigerant alternatives for high ambient temperature countries, known as PRAHA, was concluded successfully creating notable momentum amongst air-conditioning industry in high ambient countries to seriously examine low-GWP alternatives. Building on PRAHA findings and conclusions, it's clear that this is a process that need to be preserved and promoted further to ensure achieving its ultimate goal i.e. adopting soundly long term feasible alternatives while complying with MP in high ambient countries.

PRAHA-II is designed to address key priorities issues identified from PRAHA-I mainly advancing the technical capacities of local industry and research institutes to design and optimize products with low-GWP alternatives as well as assist countries to build and examine comprehensive risk assessment model for soundly and safely deploy and manage flammable refrigerants in manufacturing, placing into markets and in servicing. The proposal includes a cost efficient approach that utilize assets from the previous project and benefit of partnerships with international technology providers, institutes and associations to provide state or art service and advice to industry and governments in high ambient temperature countries.

PREPARED BY

Lead Agency:
United Nations Environment Programme (UNEP) - Ayman Eltalouny
Cooperating Agency:
United Nations Industrial Development Organization (UNIDO) - Ole Nielsen

DATE April 2016

Project Proposal

Country/Region	Regional (West Asia)
Title	Promoting refrigerant alternatives for high ambient temperature countries (PRHAHA-II)
Project Duration	18 months
Demonstration Project Budget	US$ 700,000
Implementing Agency	UNEP as Lead Agency and UNIDO as co-operating agency
Cost to UNEP	US$ 375,000 (Excl. PSC)
Cost to UNIDO	US$ 325,000 (Excl. PSC)

1. BACKGROUND

The 69th meeting of ExCom approved PRAHA-I with the aim to support assessing the feasibility of low-GWP refrigerants suitable for high-ambient countries and particularly for air-conditioning applications. UNEP and UNIDO worked over the last two years with local industries, international technology providers and national ozone units in these countries to do such assessment through an agreeable, independent process that included as its core component building and testing 18 different prototypes and compared them with respective baseline units currently produced by the local industry, mainly using HCFC and high-GWP HFC. The process of building and testing the prototypes was completed by the end of 2015 and the final report is being released end March 2016. PRAHA also included additional components for assessing the technology transfer barriers, energy efficiency implications and economics of alternatives, in addition to assessment of district cooling opportunities to reduce dependency on high-GWP alternatives and technologies.

The main result of PRAHA is that it went beyond the level of being an individual project with specific planned outcomes and outputs, PRAHA turned to be a **PROCESS** now at different levels, i.e., governmental, local industry, institutional as well as international technology providers. A number of activities and projects are currently being implemented to address alternatives for high ambient conditions and they were all triggered by the PRAHA process which started in 2012, and they are following, more or less, a similar approach. A summary of these initiatives is provided in point 10 of this document.

The findings of PRAHA, in addition to observation of other relevant efforts to promote alternatives for high ambient conditions, and discussion with stakeholders informed UNEP and UNIDO’s proposal on how to keep the momentum and what are the gaps that can be addressed under this process. This project proposal, is not only a continuation of PRAHA-I project but it's also complementary and necessary work required to address emerging issues and technological gaps that can hinder the process of promoting low-GWP alternatives in high ambient temperature countries.

2. KEY FINDINGS FROM PRAHA-I

PRAHA project included several components, but the major one is the component of building and testing prototypes designed for high ambient temperature conditions. The full report of PRAHA-I project is under final editing and will be released by the end of March 2016.

Six local Original Equipment Manufacturers (OEMs) built 14 prototypes running with five refrigerant alternatives and in addition provided 9 other “base units’ operating with HCFC-22 and HFC-410A for comparison purposes. Testing was done at 35, 46, and 50 °C ambient temperatures with an “endurance” test at 55 °C ambient to ensure no tripping for two hours when units are run at that temperature. The indoor conditions are kept the same for all tests; dry bulb temperature of 27 ºC and a relative humidity of 50 % as per AHRI test procedures for T1 conditions (35 ºC) , and 29 ºC and 50% for T3 (46 ºC and 50 ºC) conditions

The project compared the following refrigerants: R-290, HFC-32, R-444B (herein referred to as L-20), R-447A (L-41), and DR-3 to HCFC-22 and R-410A. Prototypes operating with R-290, R-444B, and DR-3 are compared with HCFC-22 as they portray similar characteristics to HCFC-22, while HFC-32, and R-447A are compared with R-410A. The concluded matrix of tested prototypes vs. refrigerants is shown in figure (1) below:

	60 Hz		50 Hz	
Prototypes				
Refrigerant	**Window A/C**	**Decorative Split**	**Ducted Split**	**Package A/C**
HFC-32	Not Tested	Tested	Tested	Not Tested
R-444B (L-20)	Tested	Tested	Tested	Tested
R-447A (L-41)	Not Tested	Tested	Not Tested	Not Tested
DR-3	Tested	Tested	Tested	Tested
HC-290	Not Tested	Tested	Not Tested	Not Tested
Base Units				
HCFC-22	Tested	Tested	Tested	Tested
R-410A	Not Tested	Tested	Tested	Not Tested

Figure (1): Matrix of prototypes built under PRAHA

All units were tested at an independent testing facility selected through completive bidding. The summary of the technical results at high ambient conditions are shown in figure (2) below:

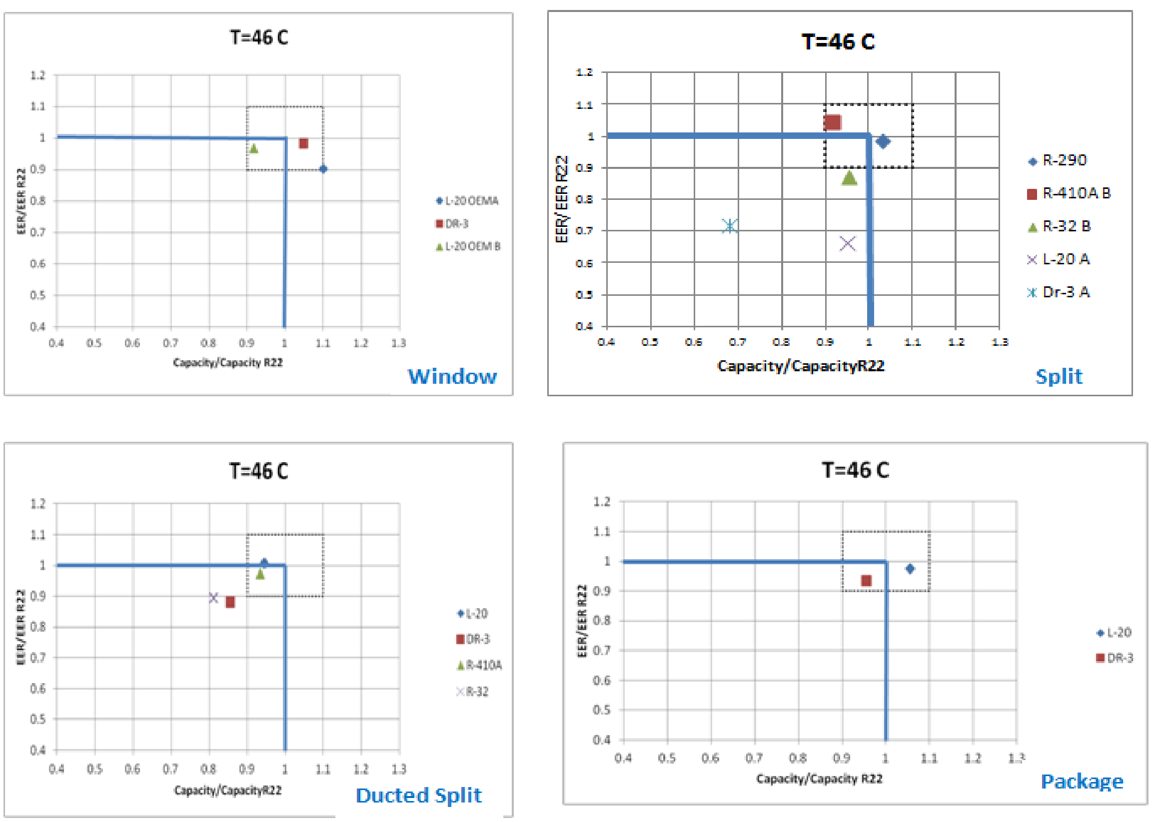


Figure (2): Summary of test results at T3 testing conditions; Cooling Capacity Vs. EER compared to base units.

The non-testing components under PRAHA-I assessed technological, economic and energy efficiency aspects in conjunction with high ambient temperature with the following key findings:

I. There are potential alternatives that are close to baseline refrigerants, or better in some cases, that worth further investigation. With further engineering those alternatives can be strong candidates for replacement of HCFC-22.
II. There is an obvious lack of R&D capacity in the local air-conditioning industry in high ambient temperature countries in terms of understanding how to design and optimize products using low-GWP alternatives with their specifics characteristics, such as flammability, higher operating pressures, temperature glide, etc.
III. Economic and technology transfer barriers (IPRs) will continue to be issues for some time before international and regional markets stabilize on a limited group of candidates that can continue in business compared to the current long list of options being examined.
IV. Due to the nature of future alternatives, a comprehensive risk assessment needs to be tailored to the needs of A5 countries, in particular for high ambient temperature conditions. Such an assessment needs to address manufacturing, placing into market, servicing and the end-of-life of the equipment.
V. There is a lack of institutional programs that address alternative technologies and reduce dependency on high-GWP alternatives in high ambient temperature countries. This is clearly reflected by the market directions during the phase-out of HCFCs.
VI. The process of improving energy efficiency (EE) standards for air-conditioning application in high ambient temperature countries is progressing at a much quicker pace compared to assessing alternative refrigerants. A smart approach is needed to jointly consider addressing EE and low-GWP alternatives in order to avoid promoting higher-GWP alternatives that are commercially available at this stage of time.

Figure 3 categorizes the findings of PRAHA:

Figure (3): Categories of key findings of PRAHA-I

Technical Feasibility of low-GWP Alternatives

- *Comparison to commercially existing options i.e. HCFCs & high-GWP HFCs*
- *Relation to Energy Effeceincy programs Directives*

Safety consideration and and Availbility of Materials

- *Risk assessment of A2L and A3 alternatives in industry and service*
- *Availability and cost of alternatives and components*
- *Technology transfer and IPR considerations*

Research and Development Capacities

- *Knowledge and capacity of industry to design with low-GWP alternatives*
- *Related research programs at global, regionla and nationla levels*

Contribution of District Cooling

- Size and potentiality of district cooling applications
- Use of low-GWP or not-in-kind technologies in district cooling applications

3. THE PROPOSAL

Accordingly, UNEP and UNIDO identified, in consultation with stakeholders, several areas that require further work to put the deployment of alternatives on the right track and address the technical, technological and economic concerns of industry and policy makers.

Taking into account the key findings of PRAHA as well as other ongoing research projects and initiatives at regional and/or international levels, it is clear that there are priority areas and others area that need time to be addressed and cannot be expedited beyond the ongoing pace of business. Table (1) identifies the priority areas for PRAHA-II.

Issue	Priority (Short- Medium- long)
1. Building the capacities of local OEM to design with low-GWP Alternatives	Short-Medium
2. Developing comprehensive risk assessment on use of A2L and A3 refrigerants	Short-Medium
3. Assess economical implication of use of low-GWP refrigerants	Medium-Long
4. Assess technological barriers and IPRs issues related to low-GWP refrigerants and components	Medium-Long
5. Institutionalizing the assessment of low-GWP alternatives in local research programs	Short-Medium
6. Building technical capacities of the servicing sector	Short-Medium-Long
7. Upgrading local standards and codes to allow deployment of low-GWP alternatives	Short-Medium

The above list is not exclusive but represents the most significant issues identified as priorities for advancing the process of promoting low-GWP alternatives in the air-conditioning industry. Some of the priority areas are partially and adequately covered by other projects and activities being funded by MLF including:

- Building technical capacities of the servicing sector: Which is part of training programs in most of HPMPs as well as other regional and international capacity-building programs.
- Upgrading local standards and codes to allow deployment of low-GWP alternatives: Several HPMPs, including those in West Asia, include components for upgrading local standards to allow use of future refrigerants. This is in addition to regional support being offered through UNEP's Compliance Assistance Programme (CAP).

Some priority areas, such as the availability of alternatives in local markets, issues related to intellectual property rights, and the realistic assessment of economic implications of the use of low-GWP alternatives, may be difficult to advance through the project due to their direct relation with the structure and business mechanism of the international HVAC&R market.The issues listed as items 3 and 4 in table 1 above, were preliminary assessed under PRAHA-I and it was concluded that more time is needed to reach the stage of building a real analysis of the technological and economic barriers due to current market considerations, availability and limitations to access information.

Therefore, the project proposal is built on addressing the emerging issues that are not addressed by other ongoing activities or projects and that can be realistically advanced at this point of time. Figure (4) represents the outline of PRAHA-II project. The proposal is built on two main components and two cross-cutting approaches that will be followed in the implementation of each component.

Component A **Building local design capacities**	Component B **Developing comprehensive Risk Assessment**

Approach (1): Institutionalizing the assessment of low-GWP alternatives in local research programs

Approach (2): Knowledge sharing and technical platforms

Figure (4): Outline of PRAHA-II

Details of each component is included in point (6) in this proposal.

4. OBJECTIVES OF PRAHA-II

This main objective of the project is to maintain the momentum generated by PRAHA-I and advance the technical capacities of stakeholders to enable the adoption and use of low-GWP sustainable technologies for high ambient temperature countries. The detailed objectives are:

- Support the process of decision-making related to the acceptance and promotion of low-GWP alternatives;
- Assess and address the local institutional and technical needs to soundly and safely deploy low-GWP refrigerants;
- Advance and build the technological capacity of local industry to design with future alternatives;
- Empower local institutes to play key roles in assessing the local technological needs related to the promotion of low-GWP alternatives; and
- Ensure creating and maintaining a sustainable technical platform to support the process of advancing the promotion of low-GWP alternatives and sharing knowledge about up-to-date technological developments.

5. PROJECT PREPARATION

The project preparation included a consultation process and coordination among several stakeholders: refrigerant manufactures who are researching new technologies, component manufacturers who provide the compressors compatible with the alternative refrigerants, and original equipment manufacturers (OEM) participated in PRAHA-I. The development of the project was made using:

- Outcomes and key finding of PRAHA-I;
- Analyzing results of other assessment projects, mainly US-DOE and AREP-I &II;
- Assessing development in alternatives since start of PRAHA-I;
- Consultation with PRAHA-I stakeholders, including OEM, technology providers and NOUs; and
- Negotiating partnering arrangement with new international partners.

UNEP and UNIDO team discussed with PRAHA-I stakeholders how to benefit from PRAHA-I resources where 23 prototypes were built and tested. The discussion also included analysing the lessons learned from the implementation of PRAHA-I, in particular the logistical considerations that caused unexpected delays in PRAHA-I. Accordingly, it was concluded to use the prototypes of PRAHA-I as basis for the testing and assessment work in PRAHA-II while partnering with Oak Ridge National Laboratory (ORNL) for conducting the analysis and testing work in PRAHA-II. Such an arrangement will substantially reduce the time needed to ship sample components and final prototypes between different countries as happened in PRAHA-I. All OEM that participated in PRAHA-I accepted to continue using their prototypes for the analysis and testing under PRAHA-II. In addition, international technology providers, i.e., refrigerant and compressor manufacturers also accepted to offer more and new samples for PRAHA-II.

The consultation process also included discussion on building the risk assessment model for A2L and A3 refrigerants. In this context, the project will cooperate with JRAIA (Japan Refrigeration and Air-Conditioning Industry Association) to build a model suitable for high ambient temperature countries and building the capacity of local institutes to use this model. A similar approach is also under discussion with the Chinese associations to bring similar experience but from an A5 perspective.

6. GEOGRAPHICAL SCOPE OF COVERAGE

This proposal covers the concern several countries around the globe with high ambient temperature operating conditions including countries in Asia, Africa and partially parts of North/Central America and Southern of Australia. However, Middle East countries and in particular Gulf countries are the most concerned regions about this case not only due to the very harsh climatic conditions but also because of the high demand on air-conditioning applications in all forms of daily life. This in addition to the relation of air-conditioning sector to national development plans not mentioning its high contribution to the consumption of energy where it represents around 60+ % of total electrical demand in gulf countries. The size of A/C industry and contribution of HCFCs consumption in this sector for those countries, is another important factor for giving priority for this group of countries under this demo project not mentioning benefiting of the momentum generated by PRAHA-I and building on it.

Therefore, this project proposal will be implemented in cooperation, with governments and stakeholders mainly from the gulf region (GCC countries) but its findings and results will be applicable and available to all other countries, in the same region and outside, concerned with alternatives suitable for high ambient temperature conditions.

7. PROJECT'S COMPONENTS

Component A: Building local design capacities

This component will examine the designs of local OEM, suggest modifications, test new refrigerants, potential upgrade of compressors and build capacity of R&D personnel at local OEM and at the same time integrate this work with the research programs at local institutes for future and continuous work in this regard. Accordingly, the following are the main sub-components under this component:

I. Advancing the designs of PRAHA-I for meeting/exceeding the baseline designs

This will include several elements using prototypes of PRAHA-I that had promising results and candidate refrigerants that are promising. Prototypes showing unexpectedly poor results will also be examined to identify shortcomings. The exercise will include mainly three stages of work:

a. Analyzing the design of PRAHA-I prototypes including:

   i. Physical inspection
   ii. Prior experimental results assessment
   iii. First order assessment of component and refrigerant performance
   iv. Power point slide summary of analysis
   v. Development of validated model
   vi. Detailed assessment of the performance and how it can be improved

b. Design optimization of PRAHA-I prototypes including:

i. Acquire performance maps for components (compressors, fans) that are more suitable for the application
ii. Evaluate alternate heat exchanger design configurations
iii. Performing detailed engineering optimization to match or exceed the baseline unit performance within an acceptable design space set forth by an expert committee. This may include installing new upgraded compressors, for same refrigerants used in PRAHA-I, that were not available at the time PRAHA-I prototypes were built; or compressors for refrigerants not tested under PRAHA-I; if so required.

c. Testing new refrigerants emerging since PRAHA-I using prototypes of PRAHA-I with change/upgrade of compressors

d. Analyzing leak-recharge effect on performance for high glide alternatives

Annex-I describes the type and capacities of prototypes that will be examined under this component, building on PRAHA-I prototypes.

II. Building the capacity of R&D sectors in designing with low-GWP alternatives

The approach for this component is based on the consultation with industry at OEM and technology providers levels. There are three technology schools when it comes to design air-conditioning units, excluding chiller systems, with low-GWP alternatives:

- Designing with R-32, which is quite advanced by the Japanese industry;
- Designing with R-290, which is advancing considerably in China and in other countries;
- Designing with HFO/HFC blends which is just starting to be examined in different places around the globe.

Accordingly, the design of this component will benefit from the experience of the most advanced industry for each technology for building the capacity of the local R&D in high ambient temperature countries. UNEP and UNIDO negotiated and tentatively concluded the setup of three dedicated training programs for each technology which will include:

- Three training workshops for designing with R-32, R-290 & HFO/HFC blends;
- One-to-One consultation process between local OEM and technology providers for specific design needs of each OEM;
- Field visits for R-32 and R-290 industry and research centers in A5 countries, agreed to take place in Thailand and China.

The R-32 program will be conducted in cooperation with JRAIA and Japanese industry and is planned to take place in Thailand during last quarter of 2016. The R-290 program will be conducted in cooperation and CHEAA and the Chinese industry and is planned to take place in China during last quarter of 2016. The HFO training program will be designed in cooperation with AHRI and the technology providers, i.e., refrigerant and compressor manufacturers and is planned to take place back-to-back with ASHRAE Conference in January 2017.

Component B: Developing comprehensive Risk Assessment

This will include designing, developing and examining a risk assessment model suitable for use pattern and operating conditions for high ambient conditions and in particular for the GCC region. JRAIA developed a comprehensive risk assessment model for A2L refrigerants. Similarly, Chinese associations and industry built their own local risk assessment for the use of A3 refrigerants in unitary air-conditioning applications. UNEP & UNIDO will work closely with local institutes and experts in high ambient countries for building special risk assessment model that suits their local needs and operating conditions. This process will be conducted through the following elements:

I. Developing comprehensive terms of reference for building the local risk assessment model;
II. Analyzing the needs of local institutes to implement the risk assessment model including the technical capacities of personnel and laboratories;
III. Examining the risk assessment model and validate its applicability at levels of manufacturing, installations, operation and servicing.

Each of the above elements will be led by local research institutes in consultation and cooperation with international associations that will be partnering in this project, which are initially JRAIA and the Chinese associations.

8. PROJECT MANAGEMENT

In order to ensure the effective implementation of all components of the project and achievement of the objectives, UNEP and UNIDO will use consultancy services to undertake the following assignments:

a. **Managing the testing**: This will include developing terms of reference for the assessment work at ORNL in consultation with local industry and institutes and coordinate with the technology providers the selection and supply of refrigerants and components needed for the assessment and optimization work at ORNL. It will also include reviewing the draft and final assessment report.
b. **Project Management**: This will include overall project management and coordinating of all activities and functions under the project, including the training program, field visits and consultation meetings. It will also include the development and conclusion of the final project report in consultation with the project Technical Advisory Team.

9. TECHNICAL ADVISORY TEAM

PRAHA-I mobilized and assembled an international Technical Review Team that supported the process of PRAHA, starting from the methodology followed in testing, reviewing the test results, and reviewing drafts of the project report.

The team offered excellent advisory service to the project and ensured the quality of the process and final report in a professional and independent manner. PRAHA-II will maintain this practice and will advance it by upgrading the duties of the team to be Advisory support starting from the design process of the project work-plan once the project is approved. The core members of the team from PRAHA-I will be maintained but might be supported by additional regional and international experts to cover the new areas included in PRAHA-II

10. PROPOSED IMPELMENTATION TIMEFRAME AND BUDGET OF THE PROJECT

The proposed project components and implementation timeframe are as follows:

#	Item	Time-frame	Agency	Estimated Co-funding (US$)	fund from MLF (US$)	Total (US$)
1	**Preparation of detailed work-plan including:** a. Finalizing TORs for the testing at ORNL b. Selecting the additional refrigerants to be examined c. Selecting the local institutes d. Forming the Advisory Team e. Concluding the details of the training program f. Concluding the cooperation agreement(s) on the risk assessment model	June/ July 2016	UNIDO	30,000[1]	30,000	60,000

#	Item	Time-frame	Agency	Estimated Co-funding (US$)	fund from MLF (US$)	Total (US$)
2	Analyzing the design of PRAHA-I prototypes	Aug 2016 - May 2017	UNEP	-	85,000	390,000
	Design optimization of PRAHA-I prototypes			-	95,000	
	Testing new refrigerants using prototypes of PRAHA-I with change/upgrade of compressors			50,000[2]	130,000	
	Analyzing leak-recharge effect on performance for high glide alternatives			-	30,000	
3	**Building the capacity of R&D sectors in designing with low-GWP alternatives, incl.:** • Three training workshops for designing with R-32, R-290 & HFOs (10-12 supported participants in each) including one-to-one consultation meetings • Field visits for R-32 and R-290 industry and research centers in relevant A5 countries (10-12 supported participants in each)	Sept 2016 - March 2017	UNIDO	100,000[3]	100,000	200,000
4	**Developing comprehensive Risk Assessment including:** I. Developing comprehensive terms of reference for building the local risk assessment model II. Analyzing the needs of local institutes to implement the risk assessment model including the technical capacities of personnel and laboratories II. Examining the risk assessment model and validate its applicability at levels of manufacturing, installations, operation and servicing	July 2016 - Dec 2017	UNEP/ UNIDO	120,000[4]	80,000	200,000
5	**Managing the overall project including:** consultancy services for 100 day over a period of 18 months @ US$ 500/day + travel costs	July 2016 - Dec 2017	UNEP/ UNIDO	-	70,000	70,000
6	**International Technical Advisory Team:** Including travel and organizational cost for the consultation meetings with the advisory team (at least 3 physical meetings during the project cycle) (6-8 members)	June 2016 - Dec 2017	UNEP/ UNIDO	-	45,000	60,000
7	**Dissemination of project outputs through regional technical workshops and policy-makers meeting**	Jan - Dec 2017	UNEP/ UNIDO	150,000[5]	25,000	175,000
11	**Reporting and documentation**	Jan - Dec 2017	UNEP/UNIDO	-	10,000	10,000
			Total for UNEP		375,000	
			Total for UNIDO		325,000	
			Grand Total (not including PSC)	450,000	700,000	1,150,000
				PSC for UNEP (13%)	48,750	
				PSC for UNIDO (7%)	22,750	
				Total request from MLF	771,500	

1. Cost of participation of local manufacturers/global technology providers + organizational cost of the meetings
2. Estimated of: cost of raw materials, from technology providers i.e. sample compressors and refrigerants, + cost to technical support from technology providers
3. Technical and organizational support cost from technology providers and supporting associations + Cost of the field visits will be 50% covered by the local manufacturers
4. Contribution from local institutes and international associations in form of staff time, travel cost and upgrade of local labs (as needed and based on the analysis)

5. Contribution from regional supporting institutes and authorities in organizing relevant technical meetings and fora including international conference on alternatives for high ambient (Upgrade on the sixth round of the annual high ambient symposium planned to take place during first half of 2017)

11. OTHER RELEVANT RESEARCH PROJECTS

There are key 4 international testing projects that are independently assessing the use of low-GWP alternatives in air-conditioning applications, except for AREP which includes also refrigeration applications. The four projects include testing on high ambient conditions with different approaches of optimizing the prototypes, refrigerants selected and capacities of units being tested. The table below summarizes the key characteristics of the 4 projects. There are also several other individual research projects on alternatives for HAT conditions, but the above are the independent collective efforts supported by governments.

The PRAHA-I report includes the full list of all international and individual research projects addressing alternatives for high ambient conditions. There are two main differences between PRAHA-I and other similar projects, except EGYPRA, which are:

- Compressors specifically built and optimized for high ambient temperature conditions;
- PRAHA includes other components to assess technology transfer, economics and risk assessment considerations related to low-GWP alternatives.

	Low-GWP AREP (AHRI)	**ORNL - DOE Evaluation Program**	**EGYPRA (UNEP, UNIDO, Egypt)**	**PRAHA-I (UNEP, UNIDO, High ambient countries)**
Type of test	Soft-optimization and drop-in tests of **several A/C, Heat Pumps, and Ref applications**	Soft-optimized tests, of **Two (2) base Split A/C units**	Build and test **36** prototypes **in 3 A/C split and one A/C package categories**	Build and test **23** prototypes **in one Window, 2 A/C split and one A/C package categories**
Status	**started 2014 and completed**	**Started 2015 and completed**	**Started in 2015 and planned to complete by 2016**	**Started 2013 and completed**
Testing	Units were manufactured or obtained by each party and tested at each party's facilities	The 2 units were optimized and tested at ORNL	Prototypes built at eight OEMs, test at NREA (local test laboratory in Egypt)	Prototypes built at 7 OEMs, test at Independent Lab
Refrigerants tested	R-1234yf, R-32, D2Y60, L-41a, D-52Y, ARM-71a, DR-5A, HPR-2A, L-41-1 and L-41-2	R-32, R-290, HFC/HFO blends. 4 types vs. R-22 HFC/HFO blends (4 types) vs. R-410A	R-32, R-290, HFC/HFO blends. 3 types vs. R-22 HFC/HFO blends (3 types) vs. R-410A	R-32, R-290, HFC/HFO blends 2 types) vs. R-22 HFC/HFO blend vs. R- 410A
Other components	**N/A**	**N/A**	**N/A**	**Several other assessment elements**

The design of PRAHA-II takes into account those other efforts to ensure avoiding any duplication and to instead complement such efforts and ensure that gaps are tackled.

Annex-I

Prototypes that will be examined under PRAHA-II utilizing PRAHA-I prototypes

	Window	Decorative split	Ducted split	Packaged unit	Number of prototypes under PRAHA-I	Prototype to be examined under PRAHA-II			
						Analysing the designs	Design Optimization	Testing new refrigerants	Leak/recharge testing for high-glide
HC-290	NA	1 N	A	NA	1	1	1	Yes	NA
R-32	NA	2	1	NA	3	3	3	NA	NA
L-20 & DR-3	3	2 2		2	9	9	2	Yes	Yes
L-41	NA	1		NA	1	1	1	Yes	Yes
R-22	2	2 1		1	6	NA	NA	NA	NA
HFC base	NA	2	1	NA	3	NA	NA	NA	NA
Total					**23**	**14**	**7**	Yes *	Yes *

* Single prototype will be used for each selected category but multiple refrigerants and tests will be conducted.

PROJECT	**Development of International Regional Centre of Excellence for Training and Certification and Demonstration of Low-GWP Alternative Refrigerants**
Country:	Regional
Sector Covered:	Refrigeration and Air-conditioning
Duration:	36 months
Project Budget	US$ 591,600 excluding 13% Agency Support Costs
Implementing Agency:	Russian Federation (executing agency - UNIDO)
Coordinating Agency:	Ministry of Natural Resources and Environment of the Russian Federation

Project Summary

This project will establish a Regional Centre of Excellence for training technicians and engineers in the safe handling of low-GWP refrigerants and the demonstration of the applications of low-GWP refrigerants in refrigeration and air-conditioning systems. It will provide a regional source of certification for technicians which will meet recognised European standards and provide accredited qualifications.

The Centre will also demonstrate existing technologies and emerging technologies to provide and ensure development of certified academic programmes for the refrigeration servicing and manufacturing/assembling sectors with special emphasis on energy efficiency of proposed solutions, including assistance in development of production with low-GWP refrigerants.

1. Background

The Regional Ozone Network for A 5 Countries in Europe & Central Asia (RON A5) includes 11 developing countries which spread from Central Asia and Caucasus to the Balkans: Albania, Armenia, Bosnia and Herzegovina, Georgia, Kyrgyzstan, the Former Yugoslav Republic of Macedonia, Republic of Moldova, Montenegro, Serbia, Turkey, and Turkmenistan.

The operational languages of the network are English and Russian. Several former network countries have already acceded to the European Union, Croatia being the most recent example. Further candidate countries may join in the future. Armenia and Kyrgyzstan joined the Eurasian Economic Union (EEU) between Belarus, Kazakhstan and the Russian Federation in 2015. Neighboring countries include major trade partners such as China and the European Union, countries with economies in transition (CEIT countries) as well as Afghanistan, Iran (Islamic Republic of), Iraq, and the Syrian Arab Republic & Lebanon to the south. The priorities of the network will continue to evolve according to the needs of network countries and include:

- Monitoring of Montreal Protocol implementation in terms of compliance, consumption trends, data reporting, operation of import/export licensing and quota system, etc.
- Cooperation with the private sector including representatives of industry and national RAC associations and with international stakeholders.
- Implementation of integrated policy measures to promote ozone- and climate-friendly technologies and the adoption of performance and safety standards applicable to the refrigeration & air-conditioning (RAC) sector.
- Establishment of training and certification schemes for refrigeration technicians and companies. This involves the promotion of e-learning courses as a complement to traditional face-to-face and practical training.
- Enforcement support related to the iPIC initiative, analysis of differences in reported trade data and the ECA Ozone Protection Award for Customs and Enforcement Officers (4th edition).
- Translation of technical & policy related publications, meeting documents and presentations (English, Russian), led by Armenia, 2016.
- Countries are encouraged to finance country-to-country (C2C) assistance using their HPMP or institutional strengthening funding.
- Promoting and updating ECAcool website with all events, news etc.

The Region has reacted effectively to the challenges of phasing out ozone depleting substances in the refrigeration and air-conditioning sector, however their success in implementing the Montreal Protocol has led (in common with article 2 countries) to the widespread adoption of hydrofluorocarbon (HFC) based refrigerants. HFCs are Fluorinated gases (F-gases), they are powerful greenhouse gases, with a global warming effect up to 23 000 times greater than carbon dioxide (CO_2), and their global emissions are rising rapidly.

The European Union, along with other countries including the US, Australia and Japan, is therefore taking regulatory action to control F-gases as part of its policy to combat climate change. In the EU the "F-gas Regulation" was first adopted in 2006 and succeeded in stabilising EU F-gas emissions at 2010 levels.

A new Regulation (EU No. 517/2014), which replaces the previous directive and applies from 1 January 2015, strengthens the existing measures and introduces a number of far-reaching changes. By 2030 it will cut the EU's F-gas emissions by 79% compared with 2014 levels.

The growing global requirement to reduce the negative climate impact of F-gas emissions is driving this and other regulatory changes, which in turn is driving innovation and the development of new technology based on less climate-harmful alternatives.

The EU and other parties to the Montreal Protocol consider that global action on HFCs can be best taken under the Montreal Protocol and a number of proposed amendments to the protocol to phase down the use of HFCs have already been submitted to MOP.

Although a global consensus has not yet been reached the impact of the F-gas regulations in Europe and other global phase down activities will certainly impact the region in terms of the sustainability of refrigeration and air-conditioning technology and the price and availability of HFCs in the region.

2. Introduction

Although there are certified academic programmes for RAC technicians in Article 2 countries, there are no such facilities in the RON A5 countries, despite several being in the process of harmonising regulations and codes of practice. A variety of training workshops and train the trainer programmes have been implemented through HPMP activities and these have certainly improved the level of knowledge and practice in the region but formal accredited certification for participants wasn't provided. Given the increasingly onerous requirements for operation, servicing, and maintenance of refrigeration and air-conditioning systems, brought about by the global pressure to address climate change and more stringent national and international regulations and safety standards, it is becoming increasingly important for Article 5 countries in the region to be able to operate to the same standards and improve their capacity to adopt new low-GWP refrigerants and natural refrigerants.

This project will therefore establish a regional training and assessment Centre in an Article 5 country, which will provide a training and certification programme for personnel and companies performing maintenance, servicing or manufacturing of products and equipment relying on or containing F-gases and or low-GWP refrigerants, in line with the requirements of article 10 of (EU) No 517/2014, Directive 2006/40/EC; Regulations (EC) No 303/2008 to (EC) No 306/2208 and Regulation (EC) No 307/2008. The Centre will also act as a demonstration hub and knowledge base for alternative refrigerant technology, specializing in the safe handling, application and system design for:

- R744 (carbon dioxide, CO2);
- R717 (ammonia, NH3);
- R290 (propane);
- R1270 (propene, propylene);
- R600a (isobutene);
- Low GWP HFO/HFC mixtures;

- R32 ;
- HFOs including R1234ze.

Although the existing training of technicians and customs officers which has been approved under the ongoing HPMPs is comprehensive, there is a number of complex issues related to the use of natural + low GWP refrigerants and green standards that need to be addressed. The new regulatory instruments require that target regional groups have the advanced knowledge and skills to implement and monitor these regulations.

There are issues related to the handling of the fluids such as flammability, toxicity, and higher pressures that are encountered when dealing with hydrocarbons, the new low-GWP HFC and HFO refrigerants, ammonia, or carbon dioxide. These handling issues are encountered throughout the refrigerant supply chain and throughout the lifetime of the products using these refrigerants and hence entail educating and training the different stakeholders throughout the chain from design engineers, to operational engineers, to installers, and to service technicians. Demonstration projects provide a good pool of referenced jobs with site visits that could be arranged for showcasing the technology and its operation.

There are also issues related to regulation and policy where standards on safety and energy efficiency need to be adapted, implemented, and controlled. A regional standard would encourage the exchange of expertise and allow for free trade by removing the barriers that multiple un-harmonized standards could bring. Such harmonization of standards is normally difficult to achieve even within states that are closely related; this obstacle can be overcome with a Regional Centre of Excellence able to act as the nucleus for such work by offering expert advice and technical knowhow. The Centre will also offer advice to design engineers coaching them in the proper use of standards and helping them adapt to the new regulations.

3. Overall Objectives

The overall objective of this project is to improve the technical capacity of the refrigeration and air-conditioning sectors of the RON A5 countries that will help to overcome the barriers to the adoption of low-GWP refrigerants; improve service practice and reduce the levels of F-gas emissions from existing refrigeration and air-conditions equipment. It will also provide technicians and designers with understanding and promoting energy efficient design and operation of domestic, commercial, and industrial refrigeration and air-conditioning systems.

4. Centre of Excellence Concept and Elements

The Regional Centre of Excellence will be designed to cater for three categories of stakeholders involved in the conversion to low-GWP, climate friendly refrigerants:

A. **Service engineers and technicians** on handling systems with flammable refrigerants, refrigerants with high pressure characteristics like CO_2 as well as toxic ones like ammonia. For this category there will be training programs and certification programs and the Centre will offer classroom for theoretical training and workshops for hands-on training;

B. **Design engineers and product development** on the choices available for the different sub-sectors. For this category there will be a library offering manuals, standards, and e-learning modules. Apart from the experts on hand, the Centre will also offer the possibility of technical expertise exchange with institutions, organizations, and associated companies;

C. **Production and operations engineers/technicians** on converting existing production lines to alternative refrigerants. For this category, a model production line simulator could highlight the production sections that need special design when handling alternative refrigerants with flammability characteristics in areas like brazing, welding leak detection, or testing. The Centre will allow for the possibility of technology exchange with interested foreign partners and by offering seminars and conferences on issues that are of concern to the regional manufacturing air-conditioning and refrigeration industry.

In addition, a workshop for small and medium (SME) designers and installers of commercial refrigeration products to offer advice on alternatives and display the steps taken in converting out of present climate unfriendly technologies that are becoming fast obsolete.

A schematic look at the Centre functions and set-up

Library • Manuals • Training material • Trade magazines • E-learning modules	**Classrooms** • Presentation material • Tools for Webinars (distance learning	**Management Offices**
Meeting room Meeting space for technical advice and information exchange	**Refrigeration workshop** Evacuation station; ,Charging station; Recovery station; Leak testing station; Electrical station; Brazing station.	
Study area • Computers with Internet access • E-learning material	**Production line demo** model production line simulator: • Charging area • Welding area • Testing area	**SME workshop** • Ammonia trainer • CO2 trainer • Commercial refrigeration trainer

4.1. Scope

The scope of the Centre will include the development of training and case studies specifically targeting barriers to energy efficiency investments in the residential, commercial and industrial refrigerating and air-conditioning equipment markets (including a program for small and medium enterprises) and in the public sector (a program for public buildings). These activities will provide information on climate and energy benefits of energy-efficient non-HFC systems and ensure support of the respective Ministries of Energy (energy efficiency units) through dissemination of EE best practices, carrying out of energy efficiency audit, and provision of information on financing options to financial institutions and other stakeholders.

4.2. Primary Functions of the Centre

The Centre will perform four primary functions:

1. Training, assessment, and certification of refrigeration and air-conditioning technicians.
2. Provision of free consultancy and design expertise for refrigeration and air-conditions systems (particularly in the redesign of refrigeration and air-conditioning systems and their components to minimize life cycle climate impact).
3. Development of draft regulatory instruments harmonized with progressive international F-gas legislation for countries participating in the Centre in English and Russian.
4. Installation and showcasing of demonstration projects for refrigeration and air-conditioning systems using low-GWP refrigerants including toxic and flammable refrigerants.

By collocating practical training and certification with the development of expertise in design and systems operation, the Centre will provide an ideal opportunity for private and public organisation to demonstrate new and innovative technology and the latest refrigeration and air-conditioning systems, components, controls, and operating practices. The operating model is therefore based on public-private partnerships where mutual benefit can be derived to achieve the common objectives of improving practice, performance, energy efficiency, and climate impact of refrigeration and air-conditioning systems.

4.3. Key Priorities

This project has therefore been conceived and designed to address a number of the key priorities of the RON A5 related to:

- Cooperation with the private sector and international stakeholders;
- Cooperation and capacity building in national RAC associations;
- Implementation of integrated policy measures in safety and F-gas emissions reduction;
- Establishment of training and certification schemes for refrigeration technicians and companies;
- Promotion of integrated face to face training, assessment and e-learning;
- Translation of technical & policy related publications.

By improving the level of skills and practice available in the partners countries and providing a common accreditation process for technicians, the Regional Centre of Excellence will not only enhance the adoption of climate-friendly refrigerants and more energy efficient benefits systems and practices, but it will also allow national association and governments to implement formal certification schemes to control the use of F-gases and raise safety standards across the industry. And since the objective for the Centre is to be internationally accredited, certificates issued on the basis of assessments taken at the Centre will be internationally recognised within region and across the European Union.

4.4. Key Outputs

The Project is designed to deliver a number of tangible and measurable outputs:

1. Centre of Excellence established and operational with fully equipped training and assessment facilities.
2. Training programmes and technical advisory services of the Centre are accredited, certified and internationally recognized.
3. A common draft F-gas regulation harmonized with (EU) No. 517/2014 in Russian and English for all partner countries.
4. Demonstration projects showing the use of low-GWP refrigerants and energy efficient designs are in place and accessible for study tours and analysis.
5. Development of common curriculum for vocational and academic studies covering refrigeration and air-conditioning.

As global pressure to address climate change increases it is regulation that is driving technology innovation and the development of climate friendly solutions, but it is essential that education and training are synchronised with these developments if countries are to be able to implement regulation and controls effectively. Safety standards are a particular issue for the RACHP sector as the alternative refrigerants can be flammable, toxic or as is the case with carbon dioxide, result in considerable higher system pressures, which require particular training and equipment. The Centre will therefore take an integrated approach with expertise and development capabilities in all aspects of the sector.

5. Training Programmes

Since new service practices, theoretical knowledge, practical skills, and standards are required, the Centre will be designed to offer programmes for refrigeration service technicians who are trained in state institutions of higher and secondary education colleges or in private educational Centres belonging to industry associations. Some local educational and training facilities lack state licenses and other offer only refresher courses that do not provide an up-to-date knowledge of the evolving technologies.

The aim is to include the experience of countries where the F-gas Regulations are being implemented in order to minimize HFC emissions. There are programmes that are general in nature and apply in any region of the world that can be transposed and used immediately. Other programs have either to be adapted or designed as bespoke for the region taking into consideration the level of available technical expertise and the local market and country situations.

5.1. F-gas Certification

As it in the EU, the ambition for the region is that all refrigeration service and maintenance engineers involved in the installation, commissioning, service, maintenance and leak testing of stationary refrigeration, air-conditioning and heat pump equipment containing or designed to contain refrigerants covered by the F-gas Regulations should to hold an F-gas qualification (even those who have trained abroad or hold degree level qualifications).

Courses will be designed to meet the EU standard and provide individual certificates which cover both theory and practice related to leak checking, leak prevention and basic refrigeration theory, including the safe handling of new and emerging refrigerants and toxic and flammable refrigerants (See Annex X).

5.2. E-learning

The Centre will also offer distance modular training, which will provide:

- The pre-learning required for technicians and practitioners, before attending a formal training and assessment programme;
- Further learning for practitioners in particular / specialist areas and in particular the use of hydrocarbons, ammonia, carbon dioxide and HFO refrigerants and systems.

This will be provided through an e-learning platform in cooperation with international organisations, initially using a combination of third party material, available publicly or through licence. During the first year of operation the Centre will develop more bespoke material in Russian and English in response to the needs and requests of partner countries.

5.3. Training of Trainers and Assessors

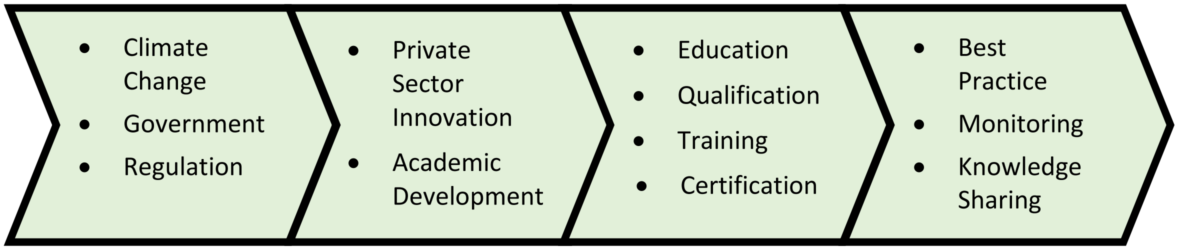
One of the main benefits of the Centre being internationally accredited will be the facility to train and accredit trainers from partner countries. This will allow the establishment over time of national training and accreditation facilities across the region.

5.4. Development of Training Courses

Special attention will be given to developing certified training courses in collaboration with international organizations and adapting / translating these courses for use by the partner countries. Cooperation with acknowledged academic partners and compliance with the latest European and international standards and regulations will ensure that the developed courses will be internationally recognised. All courses will allow partner countries to implement training at a national level that takes full account of amendments in the international legal framework regulating F-gases, improves practical and theoretical foundations (e.g. use of natural refrigerants and reduction of refrigerant leakage in existing equipment), improves refrigeration practices, and disseminates innovative energy-efficient green low-GWP technologies and processes to phase out HCFC in the refrigerating and air-conditioning sectors.

6. Other Activities

The Centre staff will also perform a valuable role in stimulating technical innovation knowledge-sharing within the partner countries through an integrated approach.



In this respect, the Centre will offer the following activities:

6.1. Company Certification

Since July 2009 it has been a legal requirement for all businesses that install, maintain, or service stationary refrigeration, air-conditioning, or heat-pump equipment that contains F-gas refrigerants to hold an F-gas Company Certificate. Within the EU It is an offence to carry out these activities without a Company Certificate. This applies to RAC maintenance contractors and installers, including sole traders or training providers, and to RAC end users and facility managers that employ their own qualified staff to carry out these activities.

The Centre will work with the partner countries to develop a suitable company certification scheme. This will involve detailed analysis.

6.2. Individual Registration of Operatives

The Regional Centre of Excellence will develop and maintain a public/institutional access database system on behalf of the partner countries holding details of registered and certified technicians and companies who hold the necessary qualifications. This will provide a convenient way of proving to employers and end users that an individual holds the correct qualification. Individuals will be issued with a photo ID card showing the validity of their qualifications, which will be valid in all partner countries.

6.3. Consultancy and Knowledge Management

In addition to the provision of training and certification the Centre will establish a Centre of excellence and provide a base for a highly skilled and qualified technicians, engineers, trainers, and policy specialists. The Centre will form a hub of knowledge exchange for partner countries through participation of technical and academic institutions, commercial enterprises, practitioners, and policy makers.

It will provide a pool of very skilled and well trained professionals and practitioners who as well as delivering the training and policy outputs of the Centre will act as a resource pool to promote climate-friendly and energy efficient alternative non-HFC technologies and new green jobs in the region.

The Centre will offer technical advisory services to public and private sector stakeholders from participating countries. These will include:

- product and system design and development in relation to ODS free low-GWP refrigeration and air-conditioning systems;
- system analysis, monitoring and diagnostics (performance and energy efficiency);
- service practice and implementing F-gas regulations.

The Centre will also provide a showcase for HVAC equipment and system manufacturer producers as well as refrigerant manufacturers, and allow them to introduce and promote new non-HFC refrigerants and the most up-to-date technologies. New systems and refrigerants will be demonstrated and tested by the Centre in collaboration with suppliers and the results made available to all partners through online and printed media.

This area of activity will facilitate a network of cooperation between academic and commercial institutions and facilitate the scale up, replication and adoption of new systems and practices and stimulate the growth of new employment (green jobs) opportunities.

6.4. Technology Transfer and Production Line Conversion

The transition out of HCFCs have led many industries to adopt the available technologies involving high-GWP HFC into their production facilities. These available technologies now offer a cheap and ready-to-make alternatives with a market that is already to accept them given the long time they have been on the market and the vigorous marketing techniques that manufacturers in both Article 2 and Article 5 countries have used. The conversion of these technologies into new alternatives having issues with flammability or high pressure require, training on the new skills, the conversion of the manufacturing lines to accommodate the new characteristics of the alternatives.

The Centre will provide a venue for manufacturers to learn the production line conversion requirements, get in touch and collaborate with technology providers who are partners at the Centre, and be able to select the technology that best suits their markets.

6.5. Application Centre for SMEs

Small and medium enterprises (SME) are most in countries the principal designers and installers of commercial refrigeration systems and products that require certain skills and expertise but don’t require the size and capabilities of the large central air-conditioning or industrial refrigeration installers. SMEs are sometimes left out of re-training programmes which tend to be designed towards the RAC sector, being the more prevalent one.

The Centre will have a speciality workshop for commercial refrigeration demonstration purposes. SMEs will get training, but also expert advice on design and the proper servicing of commercial refrigeration products installed in areas of high human presence like supermarkets requiring extensive safety precaution. The Centre will also act as a conduit for demonstration projects in the commercial refrigeration sector.

6.6. Development of Codes of Practice

The Project will also provide support to the development of national strategies for upgrading the refrigeration and air-conditioning service sectors in terms of training specifications, codes of practice and infrastructure required to deliver long-term support to the refrigeration sector in the adoption of a low GWP refrigerants approach to HCFC phase out. This will facilitate the upgrading of curricula at the national level and the adoption of standards of practice suitable for harmonization with European directives governing the use of F-gases and the safety standards.

In this context, it will develop a service sector strategy to support HCFC phase out activities and strengthen the current infrastructure to enable ongoing improvements in operating and service practice without introduction of high-GWP alternatives.

7. Justification

Providing a fully functioning world-class regional training facility to perform the functions described above will require initial investment and cooperation between the countries. For the Centre to reach its full potential it should be:

- located in a suitable well-appointed and convenient building / institution with appropriate infrastructure, access and services;
- equipped with good quality IT and training facilities and equipment;
- have a fully equipped practical training and assessment Centre capable of accommodating at least two groups of 15-16 participants simultaneously;
- have sufficient teaching rooms, meetings rooms and office accommodation to support the other activities described above.

Although this will require a significant investment, the benefits are substantial. The Centre will engage all public and private stakeholders from the refrigeration and air-conditioning sectors from participating countries in a way that addresses the key priorities of the RON A5 and also raises the level of training to an internationally recognised standard.

- ➢ As well as providing a hub for regional policy and regulatory development in issues related to climate, energy efficiency and F-gases it also has the flexibility to provide bespoke services to individual countries to ensure that training, policy and regulations are properly adapted to the specific needs of the country. This is particularly important in relation to national codes of practice and safety standards for the use of certain technologies such as flammable refrigerants, HFO, ammonia, CO_2 etc.

- ➢ By providing more advanced training and formal certification of technicians it provides the potential for upgrading the overall skills base of the sector and therefore enhances the value of the sector, particularly the servicing sector, which in many countries is devalued by the poor or unreliable practice by semi-qualified or unofficial technicians and lack of regulatory enforcement. The promotion of new technology and energy efficiency practice will also support the sector in creating new professional roles and expanding existing businesses through job creation.

- It will allow service engineers, technicians, suppliers and other relevant stakeholders to improve knowledge and upgrade skills in using the most advanced environment friendly technologies and processes.

- The Centre will create the foundation for harmonization of regulation and policy in the partner countries and provide an officially accredited hub for international organisations such as ASHRAE, ISO and IIR to engage with the sector. And it will provide a benchmark for international best practice both technically and in terms of inclusivity and the wider involvement of women.

- It will provide the necessary technical know-how and qualifications required for industry to adopt new technology such as flammable refrigerants which cannot be provided through informal training courses and workshops.

- It will provide a knowledge base and Centre for the development/adaptation of national regulations and standards covering production, storage, transportation, and use of commercial refrigeration equipment based on flammable alternatives, such as HCs, and enforcement of such regulations as well as standards for servicing, leak checking, and record keeping.

- It will provide a more cost effective and efficient mechanism for the development of policy, regulation, and training programmes through cooperation and resource sharing, and should ensure wider acceptance and replicability in various countries.

- It will also address significant technologies that have not been addressed under the HPMPs due to their high cost and limited funding provided to the countries due to the relatively “low” ODS base line/consumption.

8. Collaboration and Contributions

A key feature of the Regional Training Centre will be a wide ranging cooperation between governments, private sector international suppliers, international training and education organisations and national trade and professional associations.

The Centre will provide a mechanism for cooperation of national and international stakeholders and private sector/global suppliers of equipment, components, systems, controls, and refrigerants. The Centre provides an open platform for potential partners to contribute to the operation of the Centre in return for fair exposure of their goods and services and testing and demonstration of products and systems. Potential supplier partners include but are not limited to:

- DuPont;
- Honeywell;
- Mexichem;
- Daikin;
- Emerson;

- Gree;
- Midea;
- Nord;
- Ostrov;
- Godrej Group;
- GEA Refrigeration;
- Bitzer;
- Danfoss;
- Mayekawa;
- Johnson Controls;
- Tods Manufacturers;
- REFCO;
- Ekotez;
- Unicorn.

As well as providing an attractive platform for private sector partners, the Centre creates a regional hub which is attractive to international NGOs, associations and academic institutions concerned with training development and standards for the HVAC industry, potential partners include:

- AHSRAE;
- IIR;
- Centro Studi Galileo;
- Eurammon;
- AHRI;
- IOR;
- JRAIA;
- National HVAC&R associations;
- City and Guilds.

These partners are interested in supporting the HVAC sector globally and fostering research activities, including practical application of testing results (environmentally-safe techniques of handling refrigerants), energy-efficiency performance, and many other issues incorporated into certified academic programmes.

9. Existing & Potential Problems and the Solutions Offered by the Centre

- **Problem**: It is not possible to prevent the private sector from adopting HFC solutions through self-funded conversion, especially taking into account that the number of eligible enterprises directly addressed under the HPMPs does not cover the total ODS consumption.
  Solution: The capacity building, awareness, and stakeholder engagement activities in this project will aim to promote non-HFC solutions. The technologies funded by investment could include HC, HFO, ammonia, and carbon dioxide in the selection, design, and installation of refrigeration, and air-conditioning systems and equipment.

- **Problem**: There is a need to effectively address the safe use of ammonia, CO_2 or hydrocarbons in refrigeration and air-conditioning equipment.
  Solution: The Centre will provide a mechanism for the transposition of European safety standards EN 378- 1-4:2008 A2:2012, which will be integrated into all training programmes and educational material. The promotion of safety standards will be a key benefit of the regional Centre as it will provide a way of disseminating information and technical guidance as well as demonstrating safety standard and procedures on operational equipment in the Centre.

- **Problem**: Regional capacities need to be strengthened.
  Solution: the Centre will be adequately equipped with equipment for technical service of refrigerating and air-conditioning systems based on new refrigerants, including HC. The Centre will enable the promotion and use of the most advanced training methods, materials & manuals and knowledge-sharing among various stakeholders involved in these sectors.

- **Problem**: Existing technicians, in addition to new trainees, will have to acquire new skills and know-how required to deal with new systems using non-HFC solutions such as hydrocarbons and carbon dioxide.
  Solution: This will be done initially through the activities supported by this project but also significantly through the continued involvement of the enterprises and their foreign counterparts who are adopting new technologies in the manufacture and installation of refrigeration and air-conditioning equipment and systems.

- **Problem**: There is a need for enhanced cooperation between regional authorities, associations, and the industry.
  Solution: The Centre will be a meeting ground for the private and the public sector, with emphasis on programmes for small and medium enterprises, to create a well-functioning network of stakeholders, trained professionals, and experts. In this regard, cooperation and linkages with other similar Centres and institutes worldwide will be extended.

- **Problem**: Refrigeration service technicians are trained in state institutions of higher and secondary education and colleges, or in private educational centres belonging to industry associations or large enterprises usually without state licenses for educational activities.
  Solution: The Project aims to address this problem at the regional level through the development and promotion of regional licensing system.

- **Problem**: The majority of state educational institutions do not have modern technical and laboratory facilities for training students in practical skills of servicing the new generation of refrigerating and air-conditioning equipment.
  Solution: Both the training syllabus and infrastructure will have to be updated to take account of the developments in refrigeration and air-conditioning systems. However training will be provided free at the Centre and it is envisaged that up to 4,500 technicians could be trained and certified during the first three years operation of the Centre, creating a significant base level of qualified technicians in the region whilst partner countries develop national training and certification facilities.

10. Expected Project Beneficiaries:

The Regional Centre of Excellence will be designed to offer a wide range of benefits to the refrigeration and air-conditioning sector as a whole, there will also be spin off benefits for allied and associated industries, through access to market knowledge and stakeholder contact. The primary beneficiaries will be:

- Service engineers and service companies (particularly SME sector);
- RAC professionals (technicians with advanced education);
- Institutions of secondary and higher education;
- Educational centres belonging to air-conditioning and refrigerating industry associations;
- National and regional standards bodies;
- Commercial and educational training centres;
- Suppliers and producers of refrigerants and refrigerating & air-conditioning equipment;
- Professional associations and other related institutions in the refrigeration and air-conditioning sectors;
- Purchasers of refrigeration and air-conditioning systems;
- National Ozone Units (NOUs).

11. Operating Model

Phase I of the Project, which is covered by this document, will establish and operate the regional Centre for three years. The Project budget covers the cost of establishing and equipping the Centre, training the key technical staff, and the operational costs for three years.

The core activity of the Centre in the initial period will be the provision of training and certification courses for technicians from participating countries. These courses will be provided free of charge; however, travel, accommodation, and subsistence costs will be covered either by the participants or their organisation or through other funding sources such as HPMP funding or commercial or private sponsorship.

This model represents good value for money for participating countries, implementing agencies, and private sponsors given the average cost of a 4 to 5 day F-gas training & assessment course in Europe is around US$ 1,800 per participant. It is anticipated that funds that would be spent on local training workshops and meetings could be used in many cases to support participation of candidates at the Regional Centre of Excellence.

The development and coordination of regulations, policies, and standards and their translation into suitable Russian and English language publications will be carried out by Regional Centre staff in collaboration with all appropriate national stakeholders from participating countries. The project budget covers the cost of professional and support staff at the Centre and limited travel costs for coordination meetings, although it is envisaged that these could become a standing item on the RON A5 agenda. A nominal contribution of US$ 10,000 per year will be requested from participating countries to cover these costs.

Non-core activities such as technical consultancy and development of bespoke training courses for participating countries will be provided free of charge to the extent of the availability of Centre’s experts and trainers.

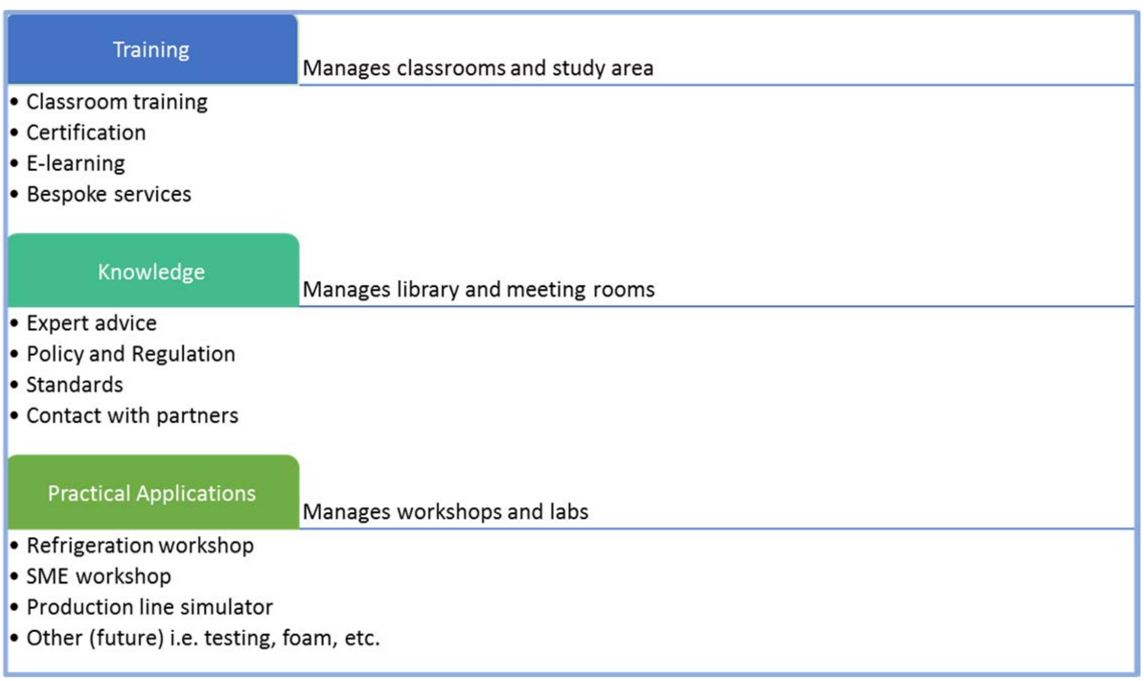
Demonstration projects, system testing and other technical projects not covered above will be funded by counterpart contributions and co-financing from other projects and programmes as appropriate.

12. Management Structure

The aim for the Centre staff will be to perform a number of related tasks in addition to the training and assessment of technicians’ functions. The staff will provide consultancy in the design, operation, and maintenance of RAC and HP systems and contribute to the development of academic and vocational curricula for partner countries. The goal is to have a common regional educational framework, which supports the needs of the sector in terms of knowledge and skills, and a common regulatory framework in line with the F-gas regulations.

The Centre will have experts/engineers/scientists who are managing the different functions supported by a core of technicians and administrative staff common to all functions. The Centre could have a traditional structure based on the services offered as seen in the chart below:

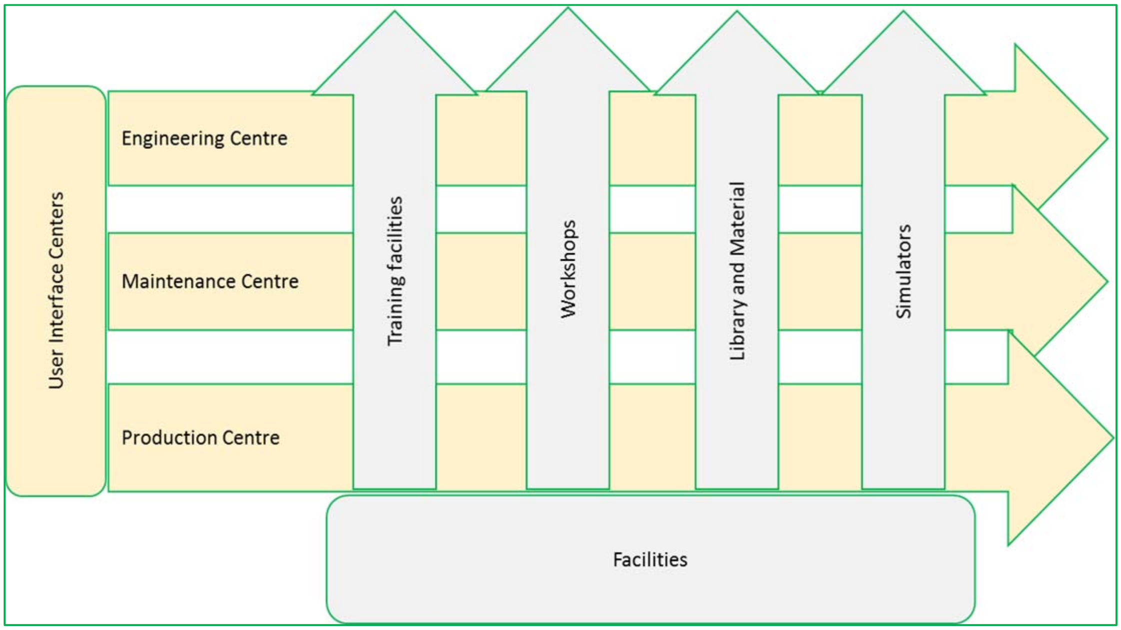
Centre of Excellence – Traditional Structure



The traditional structure would have three departments for training, knowledge exchange, and practical applications. Departments will coordinate user requests.

Alternatively the Centre can be organized in a matrix structure with three departments that are designed to cater for the type of user with a design or engineering centre, a service or maintenance centre, and a production centre as shown in the figure below. These centres represent the three category of users that were identified before.

Centre of Excellence – Matrix Structure



The idea is to make it easier for the individual, or the company, users to approach only one entity that will be able to help them with their different needs. These centres will tap into facilities like training, workshops etc. depending on the user need. The conventional disadvantage of a matrix organization is that accountability lines become somehow fuzzy and a lot of coordination is required to meet each need. This being a non-profit centre for professionals, this shortcoming should not pose a big problem.

13. Project Budget

Ref No.		Component	Amount Subcomponent, US$	Total Component, US$
1	**Infrastructure of the Regional Center**			**128,500**
	1.1.	Training simulator based on CO_2 as well as stand description and user manual for training purposes	18,000	
	1.2.	Training simulator based on HC as well as stand description and user manual for training purposes	13,500	

	1.3.	Welding/soldering training simulator with supply and exhaust ventilation as well as stand description and user manual for training purposes	20,500	
	1.4.	Training simulator for studying operation principles of refrigeration machines as well as stand description and user manual for training purposes	6,000	
	1.5.	Training simulator for studying types of refrigerants with samples of common refrigerants and refillable containers as well as stand description and user manual for training purposes	6,000	
	1.6.	Training simulator on refrigerant identification as well as stand description and manual on its use for training purposes	6,500	
	1.7.	Training simulator on recovery and regeneration of refrigerants for further use as well as stand description and user manual for training purposes	4,500	
	1.8.	Training simulator on the base of a mini-chiller as well as stand description and user manual for training purposes	13,500	
	1.9.	Training simulator on the base of a VRF-system as well as stand description and user manual for training purposes	13,500	
	1.10.	Furniture, office equipment (desks, chairs, tables, cases, racks for the back office), training equipment (PCs, interactive whiteboard, etc.), consumables for practice classes	17,500	
	1.11.	Training courses and software for 15 HVAC&R specialists	9,000	
2	**Operation of the Center**			**39,600**
	2.1.	Payment of instructors' work	29,600	
	2.2.	Expenses on operation of the office, presentations, consumables for classes mail, etc.	10,000	
3	**Adaptation and Printing of UNIDO Programmes and Manuals (English and Russian)**			**51,500**
	3.1.	Adaptation and printing of a training manual for the theoretical certification course (4 categories) (on the basis of developed kit of programmes)	9,500	
	3.2.	Adaptation and printing of a training manual on legislation regulating protection of the ozone layer and climate	4,500	
	3.3.	Development and printing of a manual on safe handling of natural refrigerants	13,500	

	3.4.	Development and printing of a training manual on use of natural refrigerants (CO_2, HC, ammonia) in various sectors	13,500	
	3.5.	Development of training courses for the theoretical certification course (4 categories)	2,000	
	3.6.	Development of training courses on safety of CO_2, HC, ammonia systems	3,100	
	3.9.	Development of training courses on use of natural refrigerants in various sectors	1,400	
	3.10.	Training presentations for theoretical classes of the course	4,000	
4	**Development of Online Interactive Courses (English and Russian)**			**58,500**
	4.1.	Training course on the legislation on protection of the ozone layer and climate	4,500	
	4.2.	Certification course (4 categories)	13,500	
	4.3.	Course on safe operation of ammonia systems	9,000	
	4.4.	Course on safe operation of HC systems	9,000	
	4.5.	Course on safe operation of CO_2 systems	9,000	
	4.6.	Course on the use of natural refrigerants at facilities of any purpose	13,500	
5	**Pilot Refrigeration Plant Based on Natural Refrigerants**			**214,000**
	5.1.	Development of project documentation and feasibility study (in Russian and English)	9,000	
	5.2.	Purchase of equipment and monitoring systems	160,000	
	5.3.	Installation and commissioning	27,000	
	5.4.	Preparation of presentation materials	4,500	
	5.5.	Development and printing of an information booklet	6,000	
	5.6.	Holding of 1 training for attendees from the Eastern Europe, Caucasus, and Central Asia	7,500	
6	**PR Activities**			**8,500**
7	**Internet-portal of the Project (in Russian and English)**			**28,500**
	7.1.	Design	2,700	
	7.2.	Layout (including online courses)	9,000	
	7.3.	Preparation of the content	14,400	
	7.4.	Support of the portal after commissioning during 12 months (news upgrade)	2,400	
8	**Management, Office**			**62,500**
			Total Project, US$	**591,600**

Sustainability

During the initial three year period of operation, the Centre will develop a commercial business plan for continued operation once funding support has expired.

Annex I

Counterpart Organizations

- Ministries of environmental protection and energy of participating countries;
- National Ozone Units (NOU) and implementing agencies of the Montreal Protocol;
- Trade and industry associations;
- Chambers of Commerce;
- Building and Construction associations;
- Service companies based in counterpart countries;
- Academic and vocational training and educational institutions;
- Manufacturers and suppliers of refrigerants, equipment, components and consumables;
- International standards organisations;
- Training accreditation bodies.

Annex II

Potential Partner Profile ASHRAE

ASHRAE, founded in 1894, is a global society advancing human well-being through sustainable technology for the built environment. The Society and its members focus on building systems, energy efficiency, indoor air quality, refrigeration and sustainability within the industry. Through research, standards writing, publishing and continuing education, ASHRAE shapes tomorrow's built environment today. ASHRAE was formed as the American Society of Heating, Refrigerating and Air-Conditioning Engineers by the merger in 1959 of American Society of Heating and Air-Conditioning Engineers (ASHAE) founded in 1894 and The American Society of Refrigerating Engineers (ASRE) founded in 1904.

ASHRAE develops standards for both its members and others professionally concerned with refrigeration processes and the design and maintenance of indoor environments.

ASHRAE writes standards for the purpose of establishing consensus for:

1) methods of test for use in commerce; and
2) performance criteria for use as facilitators with which to guide the industry.

ASHRAE publishes the following three types of voluntary consensus standards: Method of Measurement or Test, Standard Design and Standard Practice. ASHRAE does not write rating standards unless a suitable rating standard will not otherwise be available.

Consensus standards are developed and published to define minimum values or acceptable performance, whereas other documents, such as design guides, may be developed and published to encourage enhanced performance.

ASHRAE is accredited by the American National Standards Institute (ANSI) and follows ANSI's requirements for due process and standards development.

Annex III

Potential Partner Profile – City and Guilds

City and Guilds is a global supplier of skills development.

It operates in over 80 countries and with over 130 years of experience in designing qualifications and providing learners with real-life, practical skills needed to succeed in the modern workplace.

It collaborates with governments to develop skills solutions and embed qualifications into the national education system and curriculum.

City and Guilds' qualifications are widely accepted by employers around the world as the benchmark for excellence and help to create a mobile and flexible workforce suitably qualified to succeed even in today's challenging economic climate.

Over the last 20 years alone, more than 20 million learners received a City & Guilds certificate from over 10,000 approved training organisations around the world.

City and Guilds International Limited is a company (Reg. No. 1894671) and a charity (Reg. No. 312832) registered in England and Wales whose registered office is at 1 Giltspur Street London EC1A 9DD.

Annex IV

Typical Training and Assessment Equipment

The following is the equipment typically used to train and assess candidates for their F-gas qualification and for general training in refrigeration and air-conditioning, good practice, safety and leak testing:

- Metal bench onto which main components are bolted;
- Condensing unit, Copeland MC-D8-ZB15KE-TFD (air cooled unit with scroll compressor) or Bitzer LH32/2KC-05-2Y (air cooled with semi hermetic reciprocating compressor);
- Evaporator, LuVe SHA60 N32 with Copeland unit or LuVe SH40 N32 with Bitzer unit;
- TEV, Danfoss TE2 plus orifice 02 or 03 (plus spare);
- Suction line, 5/8” copper with 5/8” anaconda and section connected in with flared connections which can be replaced with a brazed test piece;
- Liquid line, 3/8” copper;
- Liquid line filter drier, Danfoss DML053 (plus spare);
- Liquid line solenoid valve and coil, Danfoss 018F6177;
- Liquid line sight glass;
- Liquid line ball valve;
- Pressure relief valve, Henry 5231A-CE, 24.8 bar g (plus spare);
- Dual pressure switch, Danfoss;
- Electrical control panel.

To be supplied assembled and wired, pressure tested for strength to 27.5 bar g on the high side and 15.4 bar g on the low side and for leak tightness to 24.8 bar g on the high side and 14 bar g on the low side, with a holding charge of oxygen free nitrogen, CE marked to appropriate European Directives.

Alternatively, the experts of the Centre will build their own system trainer from components supplied. Using local expertise to build the training tools will assert their knowledge of the concept and subject, and also ensures that the local training needs are met.

The following additional equipment is required:

- Virgin refrigerants;
- Recovery cylinder for refrigerants;
- Gauge set and hoses suitable for all refrigerants;
- Recovery machines;
- Vacuum pumps (225 l/min capacity);
- Scales;
- Nitrogen and nitrogen regulator for pressure testing;
- Gauge set and hoses suitable for R410A with no sight glass for pressure testing;
- Electronic leak detectors;
- Leak detection fluid for leak testing with nitrogen pressure in system;
- Temperature probe;

- Comparator;
- Gloves and goggles;
- Hand tools, including valve key, adjustable spanner, Philips and standard screwdrivers.

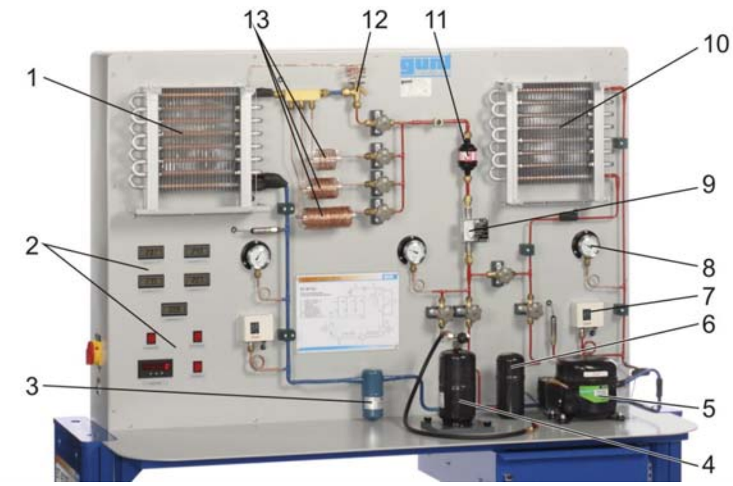
In addition to the above separate training rigs for CO_2 systems will be required for training and assessment including:

- Cascade system – a two compressor cascade system featuring Bitzer compressors and standby cooling together with inverter control.
- Transcritical Booster system – a multi compressor system comprising MT and LT booster compressors. The system is configured to utilise multiple Transcritical and flash gas solutions. The plant is equipped with inverters and standby cooling.
- Pumped system – featuring the latest hermetic refrigerant pump, and multiple regulation valve options.

Annex V

Typical AC and Commercial Refrigeration System Trainer

Legend:
1 Evaporator,
2 Displays and controls,
3 Suction line receiver,
4 Reservoir,
5 Compressor,
6 Receiver,
7 Compressor pressure switch,
8 Manometer,
9 Refrigerant flow meter,
10 Condenser,
11 Filter/drier,
12 Expansion valve,
13 Capillary tube



AC System Trainer

System trainers are used to simulate actual conditions in a refrigeration cycle. It can also be used to simulate faults and asking the trainees to correct them. Trainers are available assembled from sources like Gunt, P.A Hilton Ltd. among others

Commercial Refrigeration System Trainer

Annex VI

E-Learning Training Module

Real Alternatives e-learning: http://www.realalternatives.eu/home

The program covers the safety, efficiency, reliability and containment of low GWP alternative refrigerants – Carbon Dioxide, Ammonia, Hydrocarbon and low flammables (HFOs and R32). There are eight Modules in the program:

1. **Introduction to Alternative Refrigerants - safety, efficiency, reliability and good practice**

This module provides a general introduction to the different alternatives to high global warming potential (GWP) HFCs and compares their properties, performance, safety issues, environmental impact and ease of use. The main alternatives have low to zero GWP, but a refrigerant is not selected on the basis of low GWP alone; other characteristics should be taken into account such as:

- Operating pressures;
- Performance – capacity and efficiency;
- Material compatibility, including compressor lubricant;
- Safety, including flammability and toxicity;
- Temperature glide;
- Ease of use and skill level of design engineers and technicians who install, service and maintenance.

This is useful reference material for anyone working in the refrigeration, air-conditioning and heat pump (RACHP) industry.

2. **System design using alternative refrigerants**

This module provides an introduction to design differences with references to useful additional information from a range of sources that have been peer reviewed and are recommended technical guidance. The module looks at key differences in the design of new systems which operate with alternative refrigerants and reviews the basic principles of efficient design.

3. **Containment and leak detection of alternative refrigerants**

This module provides an introduction to the topic of leakage reduction and a look at containment and leak detection of charged, operating systems. Reducing leakage is important for all refrigerants for the following reasons:

- For safety - all refrigerants can asphyxiate, many of the alternatives are flammable or toxic;
- To maintain performance – a leaking system has less capacity and consumes more power

than a fully charged system;
- To minimise the cost associated with refrigerant replacement, service and the additional energy consumption;
- To improve reliability and minimize consequential losses;
- To minimise the direct effect on climate change – some of the alternatives have a significant global warming potential;
- To minimise indirect CO_2 emissions associated with additional power consumption;
- It is a legal requirement for fluorinated gases (F-gases).

Effective leak detection is important, but it is even more important to ensure that refrigerant containment is a high priority.

4. **Maintenance and repair of alternative refrigerant systems**

This module focusses on the differences when servicing and maintaining systems which use an alternative refrigerant with additional information relevant to working with flammable refrigerants, toxic refrigerants, and refrigerants with very high pressure. Information about the safe working environment is included as well as the following procedures, where relevant:

- Leak testing;
- Recovery / disposal;
- Evacuation;
- Un-brazing and brazing;
- Charging;
- Component replacement.

The information outlines the critical points which differ from those for conventional refrigerants. The information is intended for experienced service and maintenance technicians. It is recommended that technicians have an individual F-gas certificate to demonstrate competence in handling traditional refrigerants, and undergo additional training on the specific alternative refrigerant. Technicians should attend in depth training before working with alternative refrigerants.

5. **Retrofitting existing systems**

This module covers retrofitting with alternative refrigerants focusing on options for replacing R404A or R507A and other high-GWP refrigerants with lower GWP alternatives in existing systems. The emphasis is on emerging HFOs.

6. **Checklist of legal obligations when working with alternative refrigerants**

This module covers key legal obligations related to low GWP alternative refrigerants including information about the most important legislation and standards which apply specifically to RAC systems which use an alternative refrigerant.

7. **Measuring the financial and environmental impact of leakage**

This module provides an introduction to evaluating the financial, environmental, safety and reliability costs of refrigerant leakage. Most alternative refrigerants have a low direct global warming potential, but the other impacts of leakage (e.g. on energy consumption) are similar to those for traditional refrigerants. So leakage matters and must be minimised whatever the refrigerant.

8. **Tools and guidance for conducting site surveys**

This module covers Tools and Guidance for conducting site surveys and giving advice on containment strategies showing how information from site surveys should be structured and recorded so that it can be used to develop an effective leak reduction strategy. Advice is included on the preparation of reports and recommendations using appropriate tools and templates.

Outcomes of the Training:

On successful completion of the eight modules, the participants should be able to:

- Undertake effective site surveys;
- Assess how a system can be improved to reduce leak risk;
- Assess leakage risks and the potential for leakage reduction;
- Calculate the refrigerant charge in a system using a charge calculator and other methods;
- Collect and evaluate site survey data using the recommended site survey record sheet;
- Provide advice and recommendations to customers on reducing refrigerant leakage at their sites;
- Write a practical site survey report for customers;
- Evaluate the effectiveness of site surveys and follow up actions to reduce leakage and contain refrigerant.

Adapting Real Alternatives eLearning to the Centre of Excellence:

Translation of Real Alternatives into Russian: Real Alternatives offer translation rights on a licencing basis at a one off cost of around 2,500 euro to new participants. This is to cover costs for hosting the eLearning, registrations and websites etc. Translation costs for the contents of the modules is in addition.

Real Alternatives can organise a collaborative approach with national associations, institutes or bodies to raise funds, seek commercial sponsorship of the pages, and to enter into arrangements with local training providers to give them certification rights. It is proposed in the future to offer an Assessment and Certification service – the examination questions and papers are already prepared. This will enable the Centre to recoup some of the costs by charging a fee for issuing Certificates to candidates who pass the exams.

Annex VII

Programme Course on: Hydrocarbon Refrigeration Systems

Duration: 5 Days

- Refrigeration principles and fundamentals, Refrigerants, temperature-pressure relation and diagrams, refrigerant properties;
- Thermodynamic principles;
- Refrigeration cycle;
- Basic components of the refrigeration cycle;
- Practical applications of Hydrocarbons in the refrigeration servicing sector;
- Presentations of hydrocarbon applications in window and split type air-conditioners, chiller, etc.;
- Safe handling of flammable refrigerants;
- Equipment design and conversion for hydrocarbon/flammable refrigerants;
- Methodology for the conducting of risk assessments for systems and equipment using hydrocarbon/flammable refrigerants, e.g. electrical components;
- Methodology for the experimental and numerical performance evaluation of systems with alternative refrigerants and components.

Annex VIII

Programme Course on Ammonia and Carbon Dioxide Refrigeration Systems

Duration: 5 Days

Ammonia

- Classification and utilization:
  - Food industry, dry stores for the preservation of fruit, meat, fish and vegetables;
  - Chemical and pharmaceutical industries;
  - Air-conditioning, freezing tunnels.
- Compressors: screw, centrifugal, single and double phase compressors;
- Condensers: evaporative, tube condenser, plate condenser, air-condenser;
- Evaporators: static evaporator, ventilated evaporator, tube evaporators, flooded evaporators;
- Feeding systems: thermostatic systems, pump systems;
- Water and /or low temperature liquid (chillers);
- Separation and recovery of oil from wet evaporators;
- A few examples of different kinds of projects, application calculations and operations;
- List of the main problems. Detection methods and solutions;
- A wide selection of plant schemes, their components and comparison with their enthalpy diagram.

Carbon Dioxide

- Thermodynamic characteristic of carbon dioxide as refrigerant - p/h diagram;
- Subcritical and Transcritical operations;
- Specific components for carbon dioxide;
- Refrigeration and Air-conditioning applications with CO_2;
- Cascade Systems;
- Vacuum-Charging procedures;
- Leak testing
- Recovery or venting of CO_2;
- High pressures and safety issues, first aid;
- National and European Regulations and standards;
- Transport and storage requirements;
- Safe handling of the refrigerant;
- Logbook.

Tools required for Training

1. Nitrogen Regulator 0-50Bar (1/4” outlet);
2. Cylinder of High Purity Nitrogen;
3. Nitrogen Pressure Testing Rig;
4. Refrigerant Recovery Unit;

5. Electronic Weighing Platform;
6. Refrigerant Recovery Cylinder;
7. Refrigerant Charging Cylinder;
8. Electronic or analogue Vacuum gauge;
9. Manifold set (ideally 4 way);
10. Hoses for above (yellow, blue, red) with ball valves;
11. Vacuum Pumps (3-5cfm);
12. Vacuum Pump Hose (3/8”);
13. Electronic Leak Detector;
14. Propriety Leak Spray;
15. Temperature meter (with K probes);
16. Current Clamp (ammeter);
17. Selection of Screwdrivers;
18. Selection of Refrigeration Pipework;
19. Pipe Cutters;
20. Pipe Deburring Tool;
21. Pipework Expanders;
22. Hacksaws;
23. Brazing Rods;
24. Flaring Tool;
25. F-gas Log Book;
26. Example of a Waste transfer note;
27. Brazing facilities, Acetylenes – Oxygen;
28. Copper 16 mm;
29. Test Rig for Temperature and Pressure measurements.

Annex IX

Example of a Technology Guide

Emerson Climate Technologies "Commercial CO2 Refrigeration Systems, Guide for Subcritical and Transcritical CO_2 Applications"

Chapter 1. Introduction

Chapter 2. CO2 Basics and Considerations as a Refrigerant

Section 1. Criteria for Refrigerant Selection
Section 2. Properties of R744
Section 3. An Introduction to Transcritical Operation
Section 4. Behavior in the Reference Cycle
Section 5. R744 Hazards
Section 6. Comparison of R744 with other Refrigerants
Section 7. Advantages and Disadvantages of R744 as a Refrigerant

Chapter 3. Introduction to R744 Systems

Section 1. Introduction to Retail Transcritical Systems
Section 2. Introduction to Retail Cascade Systems
Section 3. Secondary Systems
Section 4. Selecting the Best System – Booster vs Cascade vs Secondary

Chapter 4. R744 System Design

Section 1. Transcritical Booster Systems
Section 2. Cascade Systems
Section 3. Secondary Systems
Section 4. Design for Pressure
Section 5. Design for Ease of Service
Section 6. Fixed Leak Detection
Section 7. Cooling Capacity
Section 8. Capacity Modulation
Section 9. Pipe Work and Jointing
Section 10. Lubricants and Oil Return
Section 11. Materials
Section 12. Potential for Heat Reclaim

Chapter 5. R744 Systems - Installation, Commissioning and Service

Section 1. Good Installation Practice
Section 2. Charging R744
Section 3. System Checks

Conclusion

Annex X

Certification Process

Levels of Qualification

Category I	To carry out all activities on all stationary refrigeration and air-conditioning systems and heat pumps (leak checking, recovery, installation or service and maintenance)
Category II	To carry out these activities in equipment with a charge of less than 3 kg, (6kg if hermetically sealed and labelled)
Category III	Recovery activity only
Category IV	Leak checking only

Category I Certificates cover all activities and most RACHP technicians will need this. Some larger end users may wish to train in-house maintenance engineers to carry out regular leak checking – but a Category I Certificate holder will be needed to fix any repairs identified.

Category II was designed for small equipment specialists such as domestic equipment operatives. Specialist qualifications are available for those working on mobile air-conditioning.

The amount of training required to pass this assessment varies according to the individual's knowledge, expertise and current qualifications. Typically training requires from 2 to 3 weeks in a properly equipped training facility.

The final assessment includes a theory and a practical test. Apprentices and trainees who do not hold these qualifications can only work under supervision of a qualified person.

Assessment

The F-gas Qualification will include practical assessments and a multiple choice examination to test knowledge of theory principles. The theory test will cover areas such as:

- Basic thermodynamics;
- Basic refrigeration cycle;
- Identifying condition and state of refrigerant;
- Determining operating conditions and efficiency;
- Monitoring system performance for indications of refrigerant leakage;
- Understanding of environmental impact of F-gases;
- Knowledge of equipment record keeping requirements;
- Knowledge of key components and risk of leakage associated with them.

The practical test is similar to existing refrigerant handling assessments but will incorporate some extra tasks. It will be carried out on a test rig and assessed on a standard marking sheet:

- Brazing pipe jointing as used to install components;
- Pressure Testing;
- Charging with Refrigerant;
- Inspecting for Leaks, Rectifying and Re-checking;
- Connecting and disconnecting Gauges;
- Recovery of refrigerant.

Successful candidates are issued with a Certificate stating which Category and type of work they can carry out. The Certificate may be withdrawn or suspended if necessary and end users or employers will be able to verify they are valid. An example of an assessment criteria is given in Annex XI.

Annex XI

Example of Test Specification for Handling Fluorinated Gases and Ozone Depleting Substances (Category I Personnel) – City and Guilds UK

The score reports will show five sections, one for each of the five unit learning outcomes:

- Be able to identify basic systems, terms, principles, units and how these relate to theory and thermodynamics of vapour compression cycles and refrigerants.
- Be able to identify the causes and effects of global warming and climate change.
- Be able to identify causes and effects of ozone depletion.
- Be able to identify stationary refrigerant, air-conditioning and heat pump system components, functions and leakage risk.
- Be able to identify hazard and safe working practices for installation, commissioning and handling of refrigerants.

A mapping document can be found below which shows how the current test section areas match the unit's assessment criteria and also the new test specification.

Test Spec 2079-101, 6187-230, 7189-209 Handling Fluorinated Gases and Ozone Depleting Substances (Category I Personnel)

Time: 80 minutes No of question: 40

Outcome	Assessment Criteria	Number of questions
Be able to identify basic systems, terms, principles, units and how these relate to theory and thermodynamics of vapour compression cycles and refrigerants	• identify the standard units relating to category I systems • Identify the terms and principles of basic theory/thermodynamics that relate to category I systems • (basic vapour compressions cycle, key terms and P-h diagrams) • Identify the terms and principles of basic theory/thermodynamics that relate to category I systems • (function of compressor, condenser, expansion device and evaporator) • Identify the terms and principles of basic theory/thermodynamics that relate to category I systems • (condition/state of refrigerant by use of a refrigerant comparator or service gauge) • Identify the terms and principles of basic theory/thermodynamics that relate to category I systems • (reasonable operating conditions for a condenser and evaporator for a range of applications) • Identify the terms and principles of basic theory/thermodynamics that relate to category I systems • (features of zeotropic blends)	11
Be able to identify the causes and effects of global warming and climate change	• Identify the stated causes of climate change • Identify how the Kyoto Protocol aims to reduce the effect of greenhouse gas emissions • Identify direct and indirect Global Warming Potential (GWP) of the common hydrofluorocarbon (HFC) and hydrocarbon (HC) refrigerants • Identify the importance of energy efficiency on greenhouse gas emissions to atmosphere • Identify the basic requirements of Regulation (EC) No 842/2006 and other relevant regulations • Identify the equipment records/commissioning data requirements of Regulation (EC) No 842/2006 and all appropriate regulations and standards.	8

Be able to identify causes and effects of ozone depletion	• Identify Ozone Depletion Potential (ODP) of hydrochloroflurocarbon (HCFC) refrigerants • Identify the effect of chlorine on ozone depletion • Identify the basic requirements of Regulation (EC) 2037/2000 • Identify the aims and impact of the Montreal Protocol	2
Be able to identify stationary refrigerant, air-conditioning and heat pump system components, functions and leakage risk	• Identify the function of and the role/importance of monitoring system performance for indications that leakage has occurred from equipment (control and line components) relating to category I systems • Identify potential leakage points of refrigeration/air-conditioning and heat pump equipment • Identify the requirements and procedures for handling, storage, transportation and disposal of contaminated refrigerant and oil • Identify the function of stationary refrigeration, air-conditioning and heat-pump system equipment (major components) • Identify the risks of refrigerant release associated with equipment (major, control and line components) • (Compressor) • Identify the function of stationary refrigeration, air-conditioning and heat-pump system equipment (major components) • Identify the risks of refrigerant release associated with equipment (major, control and line components) • (Condenser) • Identify the function of stationary refrigeration, air-conditioning and heat-pump system equipment (major components) • Identify the risks of refrigerant release associated with equipment (major, control and line components) • (Evaporator) • Identify the function of stationary refrigeration, air-conditioning and heat-pump system equipment (major components) • Identify the risks of refrigerant release associated with equipment (major, control and line components) • (Thermostatic expansion valve and capillary tube restrictor) • Identify how the state/condition of equipment (major components) can lead to refrigerant release • (Compressor) • Identify how the state/condition of equipment (major components) can lead to refrigerant release • (Condenser)	14

	• Identify how the state/condition of equipment (major components) can lead to refrigerant release • (Evaporator) • Identify how the state/condition of equipment (major components) can lead to refrigerant release • (Thermostatic expansion valve and capillary tube restrictor)	
Be able to identify hazard and safe working practices for installation, commissioning and handling of refrigerants	• Identify the hazards and safe working practices associated with flame brazing • Identify the hazards and safe working practices associated with nitrogen pressure testing • Identify the hazards and safe working practices associated with refrigerant release	5

Annex XII

Outline of Relevant Standards and Legislation

Document	Title	Guidance (relevant to flammable refrigerants)
ISO 817:2014	Refrigerants -- Designation and Safety Classification	An unambiguous system for numbering refrigerants. It includes safety classifications (A1, A2, and A3).
EN 378- 1:2008 A2:2012	Refrigerating systems and heat pumps – Safety and environmental requirements, Basic requirements, definitions, classification and selection criteria	Practical limit Maximum charge sizes
EN 378-2:2008 A2:2012	Refrigerating systems and heat pumps – Safety and environmental requirements, Design, construction, testing, marking and documentation	High pressure protection Ventilated enclosures
EN 378- 3:2008	Refrigerating systems and heat pumps – Safety and environmental requirements, Installation site and personal protection	Machinery rooms Refrigerant detectors
EN 378 4:2008 A2:2012	Refrigerating systems and heat pumps – Safety and environmental requirements, Operation, maintenance, repair and recovery	Repairs to flammable refrigerant systems Competence of personnel working on flammable refrigerant systems
EN 60079-10: 2009	Explosive atmospheres – Equipment – general requirements	Categorisation of flammable gases Classification of equipment Zones
EN0079-10-1: 2009	Explosive atmospheres – Classification of areas – explosive gas atmospheres	Zones and classification of equipment Leak simulation testing Air flow requirements
EN 60079-14:2008	Explosive atmospheres – Electrical installations design, selection and erection	Location of sources of ignition Wiring
EN 60079-15:2010	Explosive atmospheres – Equipment protection by type of protection “n”	Electrical equipment and enclosures for use in potentially flammable areas Labelling of electrical equipment

EN 60335-2-24:2010	Household & similar electrical appliances – Safety Part 2-24: Particular requirements for refrigerating appliances, ice-cream appliances & ice-makers	Systems with less than 150 g flammable refrigerant charge.
EN 60335-2-40:2003	Household & similar electrical appliances – Particular requirements for electrical heat pumps, air-conditioners and dehumidifiers	Design, application and servicing of AC systems using flammable refrigerants.
EN 60335-2- 89:2010	Household & similar electrical appliances – Safety Part 2-89: Particular requirements for commercial refrigerating appliances with an incorporated or remote refrigerant condensing unit or compressor	Systems with less than 150 g flammable refrigerant charge, leak simulation testing for area classification.
ADR	European Agreement concerning the International Carriage of Dangerous Goods by Road	Transport of flammable gases in systems or equipment by road
RID	Regulations concerning the international carriage of dangerous goods by rail	Transport of flammable gases in systems or equipment by rail

Annex XIII

Examples of ASHRAE Self-directed Learning Courses

FUNDAMENTALS OF REFRIGERATION

Chapter 1: Fundamentals of Refrigeration

Introduction
Types of Refrigeration Systems
Major Processes of Vapor-Compression Refrigeration
Heat-Pump Cycle
The Field of Refrigeration
Skill Development Exercises

Chapter 2: Fundamentals of Thermodynamics

Thermodynamic Properties of Fluids
Thermodynamic Laws and Applications
Efficiency of Refrigeration and Heat-Pump Cycles
Energy Calculations
Skill Development Exercises

Chapter 3: Multistage and Cascade Refrigeration Cycles

Single-Stage Ideal Refrigeration Cycle
Two-Stage Ideal Refrigeration Cycle
Cascade Refrigeration Cycle
Refrigeration-System Performance Parameters
Deviations of Actual Refrigeration Systems from
Ideal Systems
Refrigeration System Types
Skill Development Exercises

Chapter 4: Evaporators

Psychometrics of Moist-Air Cooling
Air-Cooling Evaporators
Liquid-Cooling Evaporators
Skill Development Exercises

Chapter 5: Compressors

Reciprocating Compressors
Rotary Screw Compressors
Rotary Vane Compressors

Scroll Compressors
Centrifugal Compressors
Skill Development Exercises

Chapter 6: Condensers

Condensation Processes
Air-Cooled Condensers
Water-Cooled Condensers
Evaporative Condensers
Skill Development Exercises

Chapter 7: Refrigerant Flow in Pipes, Valves, and Pumps

Fluid Flow in Pipes
Valve and Pipe-Fitting Equivalent Length
Pumps
Skill Development Exercises

Chapter 8: Expansion Devices

Capillary Tubes and Short Tube Restrictors
Pressure Control Valves
Thermostatic Expansion Devices
Electronic Expansion Valves
Hand Expansion Valves
Level Control Valves
Turbo Expanders
Skill Development Exercises

Chapter 9: Pressure Vessels and Refrigerant Management

Suction Line Accumulators
Receivers
Surge Drums
Flash Tanks and Intercoolers
Refrigerant Inventory
Skill Development Exercises

Chapter 10: Refrigerant Selection

Types of Refrigerants
Saturation Pressure and Temperature of a Refrigerant
Refrigeration Capacity and Efficiency
Safety of Refrigerants
Environmental Impact of Refrigerants
Codes and Standards

Skill Development Exercises

Chapter 11: Product Cooling, Freezing Loads, and Cooling Secondary Fluids

Cooling Food Products
Freezing Food Products
Food Freezing Equipment
Cooling Liquid-Food Products
Cooling Secondary Fluids
Skill Development Exercises

Chapter 12: Practical Guide to Refrigeration Systems

Refrigeration Racks and Display Cases
Refrigerated Warehouses
System Operation
Meat Processing
Pharmaceutical Refrigeration
Refrigeration
Skill Development Exercises

Appendix A: Sample Refrigerants

Appendix B: Pressure-Enthalpy Diagrams

Appendix C: Supplemental Tables

Skill Development Exercises

Annex XIV

Examples of ASHRAE On-Line Courses

AC and Refrigeration Principles

Explains the concepts of refrigeration, thermodynamics, refrigerants, and refrigeration cycles. 9 PDHs.

Explains the concepts of refrigeration, thermodynamics, refrigerants, single and multi–refrigeration cycles.

- Concept of refrigeration and the most commonly used refrigeration systems.
- Concepts of thermodynamic states, properties, and laws, efficiency (coefficient of performance) and defines the maximum coefficient of performance for a heat pump and refrigeration cycles.
- Components and the use of psychrometric charts.
- Differences between single and multi-stage refrigeration cycles.
- Overall system performance parameter.
- Concept of refrigerant and its economic viability.
- Changes in the list of available refrigerants.

The course is made of up 6 independent courses which may be taken separately:

- Heat Transfer and the Basic Refrigeration Cycle.
- Thermodynamic States, Properties, and Laws.
- Psychrometrics.
- Multi-Stage and Cascade Refrigeration Cycles.
- Refrigeration System Parameters and Performance.
- Refrigerants.

AC and Refrigeration Equipment

Describes air cooling and liquid cooling evaporators, positive displacement and aerodynamic compressors.

Describes the configurations and operation of air cooling and liquid cooling evaporators, positive displacement and aerodynamic compressors and the different heat transfer processes.

After completing this course package, you will understand the:

- Configuration and operation of air cooling and liquid cooling evaporators.
- Operating principles of positive displacement and aerodynamic compressors.
- Basic convection heat transfer processes involved in the condensation of the refrigerant vapor discharged from the compressor.

- Two modes of fluid flow in a pipe: laminar and turbulent.
- The Darcy-Weisbach equation and the Moody chart.
- Information concerning various expansion devices.
- Functions of vessels that may be included in a refrigeration system that store liquid refrigerant and to separate liquid from vapor.

The course is made of up 6 independent courses, which may be taken separately.

- Evaporators.
- Compressors.
- Condensers.
- Pipes, Valves and Pumps.
- Expansion Devices
- Pressure Vessels.

Annex XV

Conference Seminars 2011-2015

More than 600 hours of expert presentations on topics useful for project preparation, training, research, and updates on emerging technologies.

Examples:

2015-01	Alternative Refrigerants for Residential Refrigerator-Freezers: Low GWP Options for Self-Contained Refrigeration Systems
2015-01	International Codes and Standards Issues Impacting use of A2L Refrigerants in Unitary Heat Pump and Air-Conditioning Equipment: Standards Development for 2L Flammable Refrigerants
2014-06	Chiller Efficiency and Standard 90.1: Today and Future
2014-06	Advances in Low Global Warming Potential (GWP) Refrigerants: Considerations for the Development of Sustainable Refrigerants for Air-Conditioning
2014-06	Advances in Low Global Warming Potential (GWP) Refrigerant: Refrigerant/Lubricant Properties of New Low GWP Options
2014-06	Advances in Low Global Warming Potential (GWP) Refrigerants: Zero-Ozone Depleting Potential (ODP), Low-GWP Working Fluids for High Temperature Heat Pumps
2014-06	Advances in Low Global Warming Potential (GWP) Refrigerants: Sustainable Refrigerant Solutions for HVAC&R
2013-01	System and Components Performance and Efficiency with Low-GWP Refrigerants: Testing of Low GWP R-404A Alternatives in Commercial Refrigeration Systems
2013-01	System and Components Performance and Efficiency with Low-GWP Refrigerants: Developments in Very Low-GWP Refrigerants for Stationary HVAC&R Systems
2013-01	System and Components Performance and Efficiency with Low-GWP Refrigerants: Technology Issues Regarding Refrigeration Blends
2013-01	System and Components Performance and Efficiency with Low-GWP Refrigerants: A Multifunctional Two-Stage Transcritical CO2 System with Parallel Compression

GTP WM Ultrasonic Welder Flammable gas discharge system

Annex XVI

Pilot Refrigeration Plant Based on Natural Refrigerants

A pilot refrigeration plant based on natural refrigerants is an energy-efficient system with refrigerating, air-conditioning and/or heat pump equipment containing zero-ODP and zero- or low-GWP (<10) refrigerants together with supervisory and monitoring systems, information internet-site and other promotion means. An integral feature of such system is significantly higher energy efficiency performance as compared to systems containing ODSs and/or greenhouse gases.

The pilot refrigeration plant should have the following key features:

- Potential for wide ranging replication throughout the A 5 Countries in Europe & Central Asia.
- Refrigerating, air-conditioning and/or heat pump equipment containing zero-ODP and GWP<10 refrigerants installed at an existing facility of any purpose (supermarket, industrial plant, airport, sports facility, office building, hotel, etc.).
- At least 20 % improvement of energy efficiency performance as compared to similar systems containing ODS and F-gases.
- Availability of supervisory and monitoring systems ensuring improvement of energy efficiency performance, continuous control, and operation data output, recording and analysis.
- Project energy efficiency proved by documents and calculations that reflect increased energy efficiency obtained via transition from ODS (such as CFC, HCFC) or HFC to refrigerants with zero ODP and GWP<10.
- Availability of the informational internet-site with detailed regularly updated data on key parameters, system operation, and other appropriate technologies with zero ODP and low GWP (<10), database of such systems, respective legislation, etc.
- Use of refrigerants either widespread on the territory of the A 5 Countries in Europe & Central Asia for which proliferation conditions and/or the governments` support are already provided, which is important for the project's reproducibility. In respect of the Project document such substances may be, in particular, ammonia, carbon dioxide, hydrocarbons, water, and other GWP<10 refrigerants.
- Prepared informational materials, press-releases, and presentations for media publications.
- Location in large regional centres in an accessible location.
- Holding of a formal opening ceremony of the energy-efficient demo project.
- Opportunity for visits by specialists, governmental and international delegations on agreement, at least 3 times a month, to share advanced experience and study its implementation features.

Annex XVII

Target Audience of the Regional Centre of Excellence for Training and Certification and Demonstration of Low-GWP Alternative Refrigerants

The Regional Centre of Excellence will serve as a base knowledge and technology transfer center for the target groups:

A. **Service engineers and technicians** on handling systems with flammable refrigerants, refrigerants with high pressure characteristics like R744 (carbon dioxide, CO_2) as well as toxic ones like R717 (ammonia, NH_3);
B. **Design engineers** on the choices available for the different sub-sectors;
C. **Production and operations engineers/technicians** on converting existing production lines to alternative refrigerants.

In addition representatives of the following organizations may be trained:

- governmental executive bodies that perform as regulators and/or initiate ODS use legislation (such as ministries of environment protection, industry, trade, economic development, internal affairs, customs bodies, etc.), and their regional offices;
- law enforcement forces and environmental bodies in charge of control over ODS trans-border movement and circulation;
- purchasers of refrigeration and air-conditioning systems;
- business entities engaged in ODS production;
- business entities planning to establish production of ozone- and climate-safe alternatives;
- business entities using ODS and ozone- and climate-safe alternatives;
- business entities engaged in disposal of ODS-containing (and/or F-gas containing) equipment;
- business entities engaged in ODS export, import, and transfer;
- business entities engaged in ODS storage;
- business entities engaged in ODS recuperation;
- business entities engaged in ODS reclamation;
- business entities engaged in ODS recirculation (recycling);
- business entities engaged in ODS destruction.