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执行蒙特利尔议定书
多边基金执行委员会
第九十六次会议
2025 年 5 月 26 日至 30 日，蒙特利尔
临时议程[1]项目 9(c)和(d)

项目提案：埃及

本文件包括秘书处对以下项目提案的评论和建议：

淘汰

• 氟氯烃淘汰管理计划（第二阶段，第五次付款）	工发组织、开发署、环境署和德国政府	一揽子核准

逐步减少

• 基加利氢氟碳化物执行计划（第一阶段，第一次付款）	工发组织和开发计划署	单独审议

[1] UNEP/OzL.Pro/ExCom/96/1

项目评价表 — 多年期项目

埃及

(一) 项目名称	机构	核准项目的会议	控制措施
氟氯烃淘汰计划（第二阶段）	工发组织（牵头机构）、开发署、环境署、德国政府	第七十九次会议（在第八十四次会议上修订）	到 2025 年淘汰 67.5%

(二) 最新的第 7 条数据（附件 C，第一类物质）	年份：2023	236.65 ODP 吨

(三) 最新国家方案行业数据（ODP 吨）									年份：2024
化学品	气雾剂	泡沫塑料	消防	制冷		溶剂	加工剂	实验室用途	行业消费量总计
				制造	维修				
HCFC-22					215.09				215.09
HCFC-123									0.00
HCFC-141b									0.00

(四) 消费量数据（ODP 吨）			
2009–2010 年基准：	386.30	持续总削减量的起始基准值：	484.61
符合供资条件的消费量			
已核准：	386.41	剩余消费量：	98.20

(五) 核定业务计划		2025 年	2026 年	2027 年	共计
工发组织	ODS 淘汰量（ODP 吨）	18.8	0.00	0.00	18.8
	供资额（美元）	2,070,000	0	0	2,070,000
环境署	ODS 淘汰量（ODP 吨）	1.0	0.00	0.00	1.0
	供资额（美元）	1,611	0	0	1,611

(六) 项目数据			2017 年	2018 年	2019 年	2020 年	2021 年	2022 年	2023 年	2024 年	2025 年	共计
《蒙特利尔议定书》消费量限值（ODP 吨）			347.64	347.64	347.64	251.08	251.08	251.08	251.08	251.08	125.54	不适用
允许消费量上限（ODP 吨）			347.64	289.70	289.70	251.08	251.08	251.08	241.08*	241.08*	115.54*	不适用
原则上商定的供资额（美元）	工发组织	项目费用	3,356,641	0	4,668,214	0	4,664,196	0	4,039,413	0	195,000	16,923,464
		支助费用	234,965	0	326,775	0	326,494	0	282,759	0	13,650	1,184,643
	开发署	项目费用	1,042,352	0	1,836,750	0	816,620	0	0	0	0	3,695,722
		支助费用	72,965	0	128,573	0	57,163	0	0	0	0	258,701
	环境署	项目费用	230,000	0	279,500	0	260,000	0	180,000	0	105,500	1,055,000
		支助费用	27,480	0	33,394	0	31,064	0	21,506	0	12,605	126,049
	德国	项目费用	0	0	207,300	0	0	0	0	0	0	207,300
		支助费用	0	0	26,949	0	0	0	0	0	0	26,949
执委会核准供资总额（美元）		项目费用	4,628,993	0	6,991,764	0	5,740,816	0	0	2,480,298**	0	19,841,871
		支助费用	335,410	0	515,691	0	414,721	0	0	182,527**	0	1,448,349
建议本次会议核准供资总额（美元）		项目费用									2,039,615***	2,039,615
		支助费用									147,993***	147,993

* 第八十四次会议核准了作为第二阶段一部分的国内空调行业计划，从而将附件 C 第一类物质的允许消费总量上限减少了 10 ODP 吨。
**已核准，但注意到工发组织将代表该国政府在该国提交其基加利氢氟碳化物执行计划第一阶段的同一次会议上或在第九十六次会议（以较早者为准）上提交关于剩余 1,739,115 美元、外加 121,738 美元机构支助费用的申请。
***本次会议建议的金额，包括第五次亦即最后一次付款的剩余金额以及第四次付款延迟发放的金额。

秘书处建议：	一揽子核准

项目说明

1. 工发组织作为牵头执行机构，代表埃及政府提交了氟氯烃淘汰管理计划第二阶段第五次亦即最后一次付款的供资申请，申请费用总额为 2,187,608 美元，其中包括给工发组织的 1,934,115 美元，外加 135,388 美元的机构支助费用，以及给环境署的 105,500 美元，外加 12,605 美元的机构支助费用。[2] 提交的文件包括第四次付款执行进度报告、2024 年氟氯烃消费量核查报告以及 2025 年至 2026 年付款执行计划。

<u>氟氯烃消费量报告</u>

2. 埃及政府在国家方案执行情况报告中报告，2024 年的氟氯烃消费量为 215.09 ODP 吨，比该国的氟氯烃履约基准低 44%。尚未报告 2024 年第 7 条数据。2020-2024 年氟氯烃消费量见表 1。

表 1. 埃及氟氯烃消费量（2020-2024 年第 7 条数据）

氟氯烃	2020 年	2021 年	2022 年	2023 年	2024 年*	基准
公吨						
HCFC-22	4,481.91	3,759.59	3,244.76	4,302.55	3,910.80	4,367.16
HCFC-123	0.00	7.75	2.50	0.00	0.00	5.25
HCFC-124	0.00	0.34	0.00	0.54	0.00	0.00
HCFC-141b	0.00	0.00	0.00	0.00	0.00	1,178.26
HCFC-142b	52.93	34.13	18.37	0.00	0.00	251.69
共计（公吨）	**4,534.84**	**3,801.81**	**3,265.63**	**4,303.09**	**3,910.80**	**5,802.36**
进口预混多元醇中的 HCFC-141b *	0.00	0.00	0.00	0.00	0.00	894.00**
ODP 吨						
HCFC-22	246.51	206.78	178.46	236.64	215.09	240.19
HCFC-123	0.00	0.16	0.05	0.00	0.00	0.11
HCFC-124	0.00	0.01	0.00	0.01	0.00	0.00
HCFC-141b	0.00	0.00	0.00	0.00	0.00	129.61
HCFC-142b	3.44	2.22	1.19	0.00	0.00	16.36
共计（ODP 吨）	**249.95**	**209.16**	**179.71**	**236.65**	**215.09**	**386.27**
进口预混多元醇中的 HCFC-141b *	0.00	0.00	0.00	0.00	0.00	98.34**

* 国家方案数据
** 2007 年至 2009 年平均消费量

3. 正如向第九十四次会议报告的那样，专用于维修制冷和空调设备的 HCFC-22 在 2023 年有所增加，这是因为制冷剂供应商考虑到 HCFC-22 的价格预计上涨以及 2025 年配额预期减少，增加了其库存。[3] 自 2020 年以来，HCFC-22 总体减少，原因是将 5 家住宅空调制造企业技术改造为使用 HFC-32 的项目，以及淘汰挤塑聚苯乙烯泡沫塑料制造中 HCFC-142b 的项目，该泡沫塑料与 HCFC-22 一起用作共同发泡剂。根据 2023 年 1 月 1 日禁止在挤塑聚苯乙烯泡沫塑料制造中使用氟氯烃的规定，HCFC-22 已被淘汰。少量的 HCFC-123 和 HCFC-124 间或用于维修制冷和空调设备。

[2] 根据 2025 年 2 月 1 日埃及环境部致工发组织的信函。
[3] UNEP/OzL.Pro/ExCom/94/33。

国家方案执行情况报告

4. 埃及政府在 2023 年国家方案执行情况报告中报告了氟氯烃行业消费量数据，该数据与根据《蒙特利尔议定书》第 7 条报告的数据一致。

核查报告

5. 核查报告确认，该国政府正在实施氟氯烃进出口许可证和配额制度，2024 年在国家方案报告中报告的氟氯烃消费总量是正确的（如上文表 1 所示）。核查得出结论认为，埃及遵守了该国与执行委员会之间《协定》中规定的 2024 年允许消费量上限。该报告还指出，2024 年埃及由于气候变化和气温高于平均水平，导致旧空调设备的维修需求增加；这一情况预计将在 2025 年得到纠正，因为旧设备将被替换为适用 HFC-32 的新设备；埃及第一个制冷剂再生中心的启动和运行增加了再生制冷剂的数量。

氟氯烃淘汰管理计划第二阶段第四次付款的执行进度报告

法律框架

6. 氟氯烃许可证和配额制度（进口预混多元醇所含的 HCFC-141b 除外）于 2013 年生效。2018 年 1 月 1 日，禁止进口预混多元醇中所含的 HCFC-141b；2020 年 1 月 1 日禁止进口 HCFC-141b；2023 年 1 月 1 日禁止进口 R-406A 以及进口和制造使用 HCFC-22 的设备。预混多元醇中 HCFC-141b 的进口禁令由埃及环境事务局和海关当局合作实施，海关当局在国家臭氧机构的协助下，根据多元醇普遍协调制度编码检查所有进口产品。臭氧委员会 2024 年 4 月 16 日的一项决定禁止为使用 R-410A 的住宅空调新生产线发放批函或工业许可证。这项决定由工业发展总局、贸易与工业部以及环境部中央环境影响评估司联合作出。

7. 2024 年 1 月，埃及发布了第 502/2023 号部长令，采用 ES3795/2023 号标准对室内空调和管道式空调的季节性能效进行监管，并对定速和变频空调提出了统一要求。埃及标准与质量组织针对使用非消耗臭氧层物质和低全球升温潜能值制冷剂的制冷和空调设备的安装和售后领域，发布了技术员良好做法认证标准，包括处理易燃制冷剂的标准（标准编号 8938/2024）。

8. 正在与包括职业培训机构、技术教育机构、标准与质量组织和国家专家在内的主要有关利益方合作制定国家认证计划。国家臭氧机构和一个国家委员会将支持劳工部更新现有的制冷和空调技术员认证框架。

制造业

挤塑聚苯乙烯泡沫塑料和聚氨酯泡沫塑料制造业

9. 该行业的转型工作已按该国自 2023 年 1 月 1 日起实施的禁令顺利完成。[4] 相关谅解备忘录已最终确定，其中两家企业已收到其增支经营成本的拨款，而 Modern Plastics 和

[4] 在 CMB、Isutech、Chema-Foam 和 Modern Plastics 这几家企业中，将淘汰 24.3 公吨的 HCFC-141b（2.67 ODP 吨）以及 599.0 公吨的 HCFC-22（65.89 ODP 吨）。

Chem-foam 这两家企业仅收到了部分拨款，剩余款项预计将于 2025 年秋季前全部发放完毕。

10. 聚氨酯泡沫塑料制造业向环戊烷的转型工作已经完成。[5] 不过，与两家企业尚未就转型事宜达成协定：其中一家是 Siltal 公司，该公司实际上已经在使用环戊烷进行生产；另一家是 Bahgat 公司，该公司已停止生产。

住宅空调制造

11. 第二阶段工作包括将 5 家住宅空调制造企业（El Araby、Fresh、Miraco、Power 和 Unionaire）（这些企业 HCFC-22 的消费总量为 1,189.78 公吨）转向使用 HFC-32，若这些企业在技术成熟后决定采用，也可转向使用 R-454B（第 84/72(b)号决定）。在第九十四次会议上，成员对已转型企业尚未生产使用 HFC-32 的住宅空调设备表示关切，并指出目前缺乏有助于确保市场持续接纳该技术的监管措施，因此要求提供更多关于即将出台的监管措施的信息。同样，在第九十四次会议上，根据秘书处的评论，工发组织同意在提交基加利氢氟碳化合物执行计划第一阶段前，推迟申请在尚未签署增支经营成本合同的两家企业（即 Miraco 和 Power）商定增支经营成本第四次付款下分配给住宅空调制造业的剩余供资。

12. 已确定技术规格（在可行情况下，这些规格同样适用于 R-454B），选定了一家供应商，收到了相关设备，并完成了 El Araby、Fresh、Power 和 Unionaire 企业设备的安装、调试及培训工作。为响应第 84/72 号决定中提出的要求和规格，Unionaire 承诺将于 2025 年 1 月 1 日前仅为本地市场生产使用 HFC-32 的住宅空调设备；Power 则承诺于 2025 年 12 月 31 日前达成这一目标，而 El Araby 和 Fresh 则承诺在 2026 年 12 月 31 日前这样做。

13. 工发组织与 Miraco 已就企业转型事宜确定并签署了合同。Miraco 决定仅针对住宅空调将其生产线转向使用 HFC-32，并放弃使用 R-454B。该企业已提交一份针对第 84/72 号决定的意向书，相关设备也已接收并安装完毕，调试和培训工作均已完成。目前，已聘请一名独立专家进行安全审计，该审计工作预计将于 2025 年 5 月前完成。增支经营成本合同已拟定，该合同要求企业须在 2026 年 12 月 31 日前，仅为本地市场生产使用 HFC-32 的住宅空调设备；在本文件定稿之时，该合同正处于签署流程中。

商用空调制造

14. 第二阶段工作包括为 3 家制造轻型商用和住宅用中央空调设备（制冷量低于约 144,000 英热单位/小时（即 12 吨制冷量））的企业（即 EGAT、Volta 以及达力建筑和制造公司（DCM））提供技术援助，帮助其转向采用低全球升温潜能值的替代品；对于更大容量的系统，则将低全球升温潜能值替代品与间接蒸发冷却技术相结合，从而生产混合式间接蒸发冷却-直接膨胀式机组（IEC-H）。在第八十八次会议上，各方达成一致，同意

[5] 涉及 Bahgat、Electrostar、Fresh、Kiriazi、Ocean、Siltal、Star、TopMaker、Tredco 这九家企业，以及 Everest 和其他 28 家中小型企业，将淘汰 586.72 公吨的 HCFC-141b（64.539 ODP 吨）。

在不增加多边基金费用的情况下，将另外 3 家企业（Tiba 工程与工业公司、Misr 工程与工业公司以及 Miraco-Carrier 公司）纳入该项目。[6]

15. 在第九十四次会议上，工发组织提交了一份关于技术援助成果的报告，该报告特别指出，混合式间接蒸发冷却-直接膨胀式机组的性能表现优于传统的直接膨胀式系统。原型机的测试工作在开罗、尼罗河三角洲以及东部沿海地区夏季具有代表性的两个气候区域内展开。此外，工发组织还报告称，有 4 家企业（即达力建筑和制造公司、Volta 公司、Tiba 工程与工业公司以及 Misr 工程与工业公司）正在提供混合式间接蒸发冷却-直接膨胀式机组，将其作为常规生产的一部分。

16. 自第九十四次会议以来，在干球环境温度最高且湿度最低的气候区域内进行了更多测试，对 4 家制造商使用 HFC-32 制冷剂与混合式间接蒸发冷却-直接膨胀式系统的直接膨胀式机组进行了比较。正如本文件所附的提交给第九十四次会议的报告增编所述，[7] 这些测试结果显示，混合式间接蒸发冷却-直接膨胀式系统的节能率高达 40%至 50%，充分展示了该技术的优势。目前，这些企业正提供使用 HFC-32 的混合式间接蒸发冷却-直接膨胀式机组。3 家企业（即达力建筑和制造公司、Misr 工程与工业公司以及 Tiba 公司）已提交最终报告，且所有 6 家企业均已收到项目款项。项目成果已在第 14 届可持续建筑与纳米技术国际会议上分享，并在一场关于环境问题及供暖、通风与空调的特别活动中进行了展示。此外，在缔约方第三十五次会议及第二十八届联合国气候变化大会期间也组织了会外活动。

制冷维修业

17. 在第四次付款实施期间，已为教育和技术教育部下属的 4 家制冷和空调培训中心、人力资源部下属的两家制冷和空调培训中心，以及工业与贸易部下属的一家制冷与空调培训中心和一家英才中心升级设备。此前采购的 167 套回收工具包的分配工作正在进行中，其中 25 套将于 4 月底前交付。

18. 培训课程良好维修做法指南已定稿。共计 355 名技术员接受了培训，他们来自工业领域以及仅雇佣一至两名技术员且每月消耗两到三瓶制冷剂的小车间，并获得了参与培训的认证证书。在英才中心共为 31 名评估员（包括 3 名女性）举办了两期培训班。这些评估员将负责测试申请获得使用易燃制冷剂的制冷和空调维修认证的技术员。通过签订一份售后技术员认证的合同，推出技术员认证试点方案，共 61 名技术员（包括 6 名女性）获得了认证。

19. 两个再生中心中的第一个已建成并投入运营。截至 2025 年 3 月，该中心已累计回收并再利用了 80 公吨制冷剂，7 公吨制冷剂经过再生处理。此前为支持该再生中心而采购的 200 套设备（如回收机、真空泵与压力表、高精度压力表、气瓶、温度计等）的分配工

[6] 新增企业的参与不会给多边基金带来任何额外成本，且在本技术援助活动下，不会直接向这些企业提供资金支持；不过，它们的参与将有助于推动市场接受这项低全球升温潜能值技术，进而促进该技术援助活动的可持续性。

[7] 正如 UNEP/OzL.Pro/ExCom/94/67 号文件（即第九十四次会议报告）第 170 段所述。

作正在进行中。第二个再生中心的选址工作已完成，并已签署合同；预计将采购并交付该中心所需的设备，且该中心的许可证办理工作将于 2025 年 12 月底前完成。

项目执行与监测

20. 项目管理股负责协调并监督氟氯烃淘汰管理计划的实施工作，具体包括走访受益方及有关利益方、组织讲习班与会议，以及编制相关报告等。在第四次付款中，在项目管理股下共发放了 49,000 美元（分配额为 180,000 美元），其中包括人事费及经营成本（20,454 美元）、顾问费用（8,963 美元）、对住宅空调制造转型提供的支助费用（4,583 美元），以及应急费用（15,000 美元）。

资金发放量

21. 截至 2025 年 3 月，在迄今核准的 19,841,871 美元经费中，已发放 15,350,374 美元（其中，工发组织 11,890,003 美元，环境署 769,300 美元，开发署 2,483,771 美元，德国政府 207,300 美元），具体详见表 2。余额 4,491,497 美元将在 2025 年和 2026 年期间发放。

表 2. 埃及氟氯烃淘汰管理计划第二阶段财务报告（美元）

付款		工发组织	环境署	开发署	德国国际合作机构	共计	发放率（%）
第一次	核准金额	3,356,641	230,000	1,042,352	0	4,628,993	95
	发放金额	3,117,186	229,800	1,035,119	0	4,382,104	
第二次	核准金额	4,668,214	279,500	1,836,750	207,300	6,991,764	87
	发放金额	4,152,912	279,500	1,448,333	207,300	6,088,045	
第三次	核准金额	4,664,196	260,000	816,620	0	5,740,816	61
	发放金额	3,234,799	260,000	320	0	3,495,119	
第四次	核准金额	2,300,298	180,000	0	0	2,480,298	56
	发放金额	1,385,107	0	0	0	1,385,107	
共计	**核准金额**	**14,989,349**	**949,500**	**3,695,722**	**207,300**	**19,841,871**	**77**
	发放金额	**11,890,003**	**769,300**	**2,483,771**	**207,300**	**15,350,374**	
	余额	**3,099,346**	**180,200**	**1,211,951**	**0**	**4,491,497**	

氟氯烃淘汰管理计划第二阶段第五次亦即最后一次付款执行计划

22. 以下活动将于 2025 年 6 月至 2026 年 12 月期间实施：

(a) 住宅空调制造：完成 5 家住宅空调制造企业的转型工作（为 Miraco 公司和 Power 公司提供增支经营成本）（由工发组织负责）（资金：1,739,115 美元）；

(b) 政策与宣传：继续加强监管网络的执行力度，并努力更新国家法规；通过职业技术院校并发布宣传材料，就维修业的回收与再循环网络开展宣传推广活动；为 200 名参与者举办四期提高认识讲习班，介绍与制冷剂密封和防泄漏相关的最新准则与标准（由环境署负责）（资金：35,500 美元及来自前一次付款的款项）；

(c) 管控与执行：举办五期讲习班，就制冷剂气瓶追踪系统拟采用的快速响应代码技术，对来自消费者保护、供应调查以及工业控制机构的 250 名工作人员及利益方进行培训；为来自海关部门及其他参与受控物质进出口的组织的 100 名工作人员举办五期讲习班（由环境署负责）（资金：30,000 美元及来自前一次付款的款项）；采购 15 台制冷剂识别器，用于海关培训及制冷剂监督计划（由工发组织负责）（前一次付款的款项）；

(d) 制冷与维修：针对来自大中型车间的 345 名技术员，开展关于制冷和空调设备良好维修做法的培训与认证工作（由环境署负责）（资金：20,000 美元及来自前一次付款的款项）；为那些仅雇佣一两名技术员且每年消耗两到三瓶制冷剂的小型车间，举办共十期现场培训讲习班，培训对象总计 150 至 200 名技术员，培训内容为良好维修做法；完成向野外工作团队提供便携式维修工具包，以及为 5 家住宅空调制造商的售后服务中心提供工具的工作（由工发组织负责）（资金：20,000 美元及来自前一次付款的款项）；

(e) 制冷剂回收与再生：建立第二个再生中心，并继续为首个再生中心提供支助（该中心是在前一次付款下建立的）；同时，完成向配备有持证技术员的维修车间额外提供 200 套回收工具包的工作（由工发组织负责）（资金：50,000 美元及来自前一次付款的款项）；

(f) 项目监测：管理认证与培训活动的总费用为 145,000 美元，其中包括聘请国内和国际顾问、举办区域会议以及开展交流项目等费用（由环境署负责）（资金：20,000 美元及来自前一次付款的款项）；同时，对氟氯烃淘汰管理计划下的所有活动进行监测并提供支持，以及对制造投资项目的实施工作提供支持，包括提供咨询服务、监测和评估执行情况、差旅、编制并提交核查报告和付款报告等（由工发组织负责）（资金：125,000 美元及来自前一次付款的款项）。

秘书处的评论和建议

评论

<u>氟氯烃消费量报告</u>

23. 秘书处赞赏地注意到，埃及 2024 年的消费量低于其与执行委员会的《协定》中规定的消费量，但同时指出，为继续遵守其与执行委员会的《协定》，该国需要在 2025 年减少约 100 ODP 吨的 HCFC-22。工发组织表示相信该国能够实现这一目标，并指出该国 2025 年的配额是根据 2025 年目标发布的，该目标为该国 2024 年消费量的 53.5%。

<u>氟氯烃淘汰管理计划第二阶段第四次付款的执行进度报告</u>

法律框架

24. 埃及政府已发布，2025 年氟氯烃进口配额为 115.00 ODP 吨，这一数字低于《蒙特利尔议定书》规定的控制目标，且与氟氯烃淘汰管理计划《协定》为该年设定的目标一致。

制造业

25. 工发组织提供了关于住宅空调制造企业向 HFC-32 转型的现状的补充信息。5 家企业 2020 年至 2024 年的 R-410A 相关制造数据如下表 3 所示。正如向第九十四次会议报告的那样，2023 年这些企业生产了 110 台使用 HFC-32 的住宅空调设备；2024 年，这一数字大幅增长至 244,166 台（消耗了 169.70 公吨的 HFC-32）。截至 2025 年 3 月，Power 公司和 El Araby 公司约 10%的生产、Fresh 公司 30%的生产以及 Unionaire 公司 100%的生产均已使用 HFC-32。在本文件定稿时，工发组织正与 Unionaire 公司讨论拆除 R-410A 充注站。考虑到这些企业符合资格的消费量，工发组织已根据使用新制冷剂运行一年的情况，发放了增支资本成本和增支经营成本的部分款项。

表 3. El Araby、Fresh、Miraco、Power 和 Unionaire 的 R-410A 消费量及使用 R-410A 制造的住宅空调设备数量

年份	R-410A 消费量（公吨）	R-410 住宅空调设备
2020	716.92	828,632
2021	1,229.29	1,175,896
2022	1,407.25	1,269,675
2023	1,105.53	986,823
2024	1,212.28	1,063,735

26. 尽管这 5 家企业采用商定替代品进行生产的时间比预期要长，但自 2023 年以来，此类生产活动已飞速加快。所有企业都将在 2026 年 12 月 31 日前停止为本地市场生产使用 R-410A 的设备。如本文件第 40 至 155 段所述，该国已向本次会议提交了基加利氢氟碳化物执行计划第一阶段。所提交的项目包括对该国剩余的使用 R-410A 的住宅空调制造企业进行转型，以及实施禁止进口和生产使用 R-410A 的住宅空调设备的禁令，以确保转型工作的可持续性。

制冷维修业

27. 秘书处赞赏地注意到，工发组织已努力解决海关和进口代理采购和交付 15 台制冷剂识别器延迟的问题，之所以延迟是由于这种设备持续存在全球供应链问题，解决办法是确定一家供应商，该供应商初步将提供 5 台识别器，随后将采购更多识别器。

28. 维修业的一些原计划活动要么尚未开始，要么仍在执行中，包括：

(a) 为 75 名海关官员和相关利益方举办的关于控制受控物质进出口的 5 期讲习班尚未开展；

(b) 虽然技术员试行认证方案已经启动，且已有 61 名技术人员获得认证，但该项目计划总共认证 500 名技术员；

(c) 尚未对另外 375 名技术员进行制冷和空调设备良好维修做法方面的培训；

(d) 执行制冷和空调技术员认证方案的监管和体制工具仍在设计之中；

(e) 已完成对空调售后服务网络设备需求的评估工作，并为现场团队采购了便携式维修工具包，但为售后中心配备的支持工具的采购工作尚未完成；

(f) 制冷剂控制与防泄漏方案已付诸实施，该方案主要针对大型制冷和空调设备；然而，原计划于 2024 年 12 月前对一两栋建筑开展的试点检查与认证工作，现预计将于 2026 年 12 月前进行；

(g) 基于制冷剂气瓶快速响应代码的制冷剂追踪系统的开发工作已启动，但尚未完成，预计到 2026 年 12 月 31 日，制冷剂气瓶的快速响应代码将强制执行；

(h) 尚未为 60 名海关有关利益方举办五期关于快速响应代码-制冷剂跟踪系统的提高认识讲习班；

(i) 尚未更新地方法规和标准以支持制冷剂控制与防泄漏方案，也未举办四期提高认识讲习班以执行更新后的法规；以及

(j) 目前仍在制定政策和措施，以确保商用空调制造业转型工作的可持续性。

29. 工发组织确认，计划开展的活动将在项目完成日期之前全部完成。鉴于仍有活动有待启动或完成，秘书处要求，预计提交执行委员会第九十七次会议的氟氯烃淘汰管理计划第三阶段应包含一份关于第二阶段剩余活动实施进展情况的详细报告。

资金发放量

30. 环境署澄清称，尽管第四次付款的资金发放量为零，但一旦与该国政府的小额供资协定最终确定，预计到 2025 年 7 月将根据已开展的活动发放约 36,000 美元。秘书处敦促环境署尽快最终确定该协定，以及在获得批准后尽快确定第五次亦即最后一次付款的协定，以便该国能够受益于环境署的援助。

性别平等政策执行情况

31. 在第四次付款的实施过程中，跟踪记录了女性参与会议和培训活动的情况。在住宅空调项目中，两家受益方（El Araby 和 Fresh）的工程师均为女性。由于性别平等主流化宣传活动的开展，有三名女性参加了培训师培训活动。在一次庆祝仪式上，为表彰这三名女性在促进相关部门与国家臭氧机构之间合作方面所做的努力，环境部长、人力资源部长和社会团结部长为她们颁发了感谢证书。在第五次付款的实施过程中，将编写一份关于性别平等主流化的政策草案，并为制冷和空调行业的女性技术员组织专门的课程。

氟氯烃淘汰管理计划第二阶段的完成情况

32. 工发组织确认，根据该协定第 14 段的规定，埃及氟氯烃淘汰管理计划第二阶段将于 2026 年 12 月 31 日完成。

氟氯烃淘汰的可持续性与风险评估

33.　　工发组织评估认为，住宅空调中从 HCFC-22 进行转型的可持续性风险较低，当地和全球市场对 HFC-32 技术的接纳就是证明。工发组织进一步指出，使用 HFC-32 的变频压缩机的可用性将进一步提升转型的可持续性。秘书处认同工发组织的评估结果，并进一步指出，根据基加利氢氟碳化物执行计划所规划的活动将提升转型的可持续性以及对 HFC-32 的采用率。这些活动将通过禁止进口和制造使用 R-410A 的住宅空调设备，确保淘汰住宅空调生产中使用的 R-410A。这些活动将有助于确保 5 家在该国批准《基加利修正案》之前就主动提前进行转型的企业，能够在公平的环境中竞争。秘书处还赞赏地注意到，该国政府计划根据第 94/60 号决定向执行委员会第九十七次会议提交一个项目，除其他外，该项目旨在提高氟氯烃淘汰管理计划下 5 家企业以及参与基加利氢氟碳化物执行计划的企业所生产的住宅空调设备的能效。秘书处鼓励该国政府提交这样一个项目，并指出这将进一步增强转向商定替代品的可持续性，并进一步为纳入氟氯烃淘汰管理计划的企业提供支持。在这方面，工发组织确认，在氟氯烃淘汰管理计划下获得援助的 5 家企业了解到，它们将受到将于 2029 年 1 月 1 日生效、根据基加利氢氟碳化物执行计划实施的禁止生产使用 R-410A 的住宅空调设备的禁令的约束，届时它们将无法再生产用于出口的使用 R-410A 的住宅空调设备。

34.　　在第七十九次会议上，与会者指出，由于市场上在组合式空调机组、中央空调机组及冷水机等产品中使用高全球升温潜能值的氢氟碳化物，包括 HFC-134a 和 R-410A，商用空调制造业转型的可持续性令人担忧。因此，会议商定，该国政府将通过工发组织，在氟氯烃淘汰管理计划第二阶段付款执行进度报告中，报告相关政策和措施的执行情况，以确保转型的可持续性，直至替代品成功为市场接纳。[8] 为该行业提供的技术援助已表明，采用混合式间接蒸发冷却-直接膨胀式技术可大幅提高能效，这应有助于该技术在市场上的推广。目前，有 4 家企业（达力建筑和制造公司、Volta 公司、Tiba 工程与工业公司以及 Misr 工程与工业公司）已将采用混合式间接蒸发冷却-直接膨胀式技术设备纳入其常规生产中，另外两家企业仍在考虑其选择。制定并实施相关政策和措施，以促进市场上对低全球升温潜能值、高能效的混合式间接蒸发冷却-直接膨胀式技术机组的接受度，将进一步巩固转型成果，并推动该技术在市场上的接受度。

35.　　该国已建立的回收中心应该能够向市场提供再生的 HCFC-22，因为其价格随着淘汰而上涨。国家臭氧机构需进一步为现有及新建再生中心所再生的制冷剂的品牌、价格和分销渠道提供支持。持续开展培训并实施制冷和空调技术员认证方案，将有助于减少对维修所用 HCFC-22 的需求。

结论

36.　　埃及遵守了其与执行委员会的《协定》。挤塑聚苯乙烯泡沫塑料和聚氨酯泡沫塑料制造业的转型工作已完成，该国政府已实施了一系列禁令，以维持氟氯烃的淘汰成果。第四次付款的资金发放率为 56%，占迄今已核准资金的 77%。在第九十四次会议上，执行委员会决定不核准第四次付款下的所有供资，因为当时尚不清楚，在其他企业仍在生产使用 R-410A 的住宅空调设备的情况下，如何确保住宅空调制造企业向 HFC-32 转型的可持续

[8] UNEP/OzL.Pro/ExCom/79/32 号文件第 50(b)段。

性。如上文第 25 段所述，埃及已在其基加利氢氟碳化物执行计划第一阶段提出了一项全面计划，旨在让该国剩余的住宅空调制造企业转向使用 HFC-32，并计划于 2029 年 1 月 1 日前禁止进口和生产使用 R-410A 的住宅空调设备。

建议

37. 基金秘书处建议执行委员会：

(a) 注意到埃及氟氯烃淘汰管理计划第二阶段第四次付款执行进度报告；以及

(b) 请埃及政府通过作为牵头执行机构的工发组织，在提交氟氯烃淘汰管理计划第三阶段申请时，纳入一份关于第二阶段剩余活动执行进展的详细报告；

(c) 请埃及政府、工发组织、开发署、环境署以及德国政府于 2027 年向执行委员会第一次会议提交项目完成情况报告；以及

38. 基金秘书处进一步建议一揽子核准埃及氟氯烃淘汰管理计划第二阶段第五次亦即最后一次付款及相应的 2025-2026 年付款执行计划，供资水平见下表。

	项目名称	项目供资额（美元）	支助费用（美元）	执行机构
(a)	氟氯烃淘汰管理计划（第二阶段，第五次付款）	1,934,115	135,388	工发组织
(b)	氟氯烃淘汰管理计划（第二阶段，第五次付款）	105,500	12,605	环境署

项目评价表 — 多年期项目

埃及

项目名称	机构
基加利氢氟碳化物执行计划（第一阶段）	工发组织（牵头机构）、开发署

最新的第 7 条数据（附件 F）	年份：2023	7,686.28 公吨	14,890,881 吨二氧化碳当量

行业氢氟碳化物消费量数据（吨二氧化碳当量）和活动									
	气雾剂	泡沫塑料	消防	空调和制冷				溶剂	其他
				制造			维修		
				制冷	空调	其他			
最新国家方案报告（2024 年）	260,632	197,184	1,595,494	1,080,564	3,345,441	0	10,754,212	0	0
商定的基加利氢氟碳化物执行计划第一阶段活动（是/否）	否	是	否	是	是	否	是	否	否

2020-2022 年维修业氢氟碳化物平均消费量*	4,390.29 公吨	9,345,372 吨二氧化碳当量

*包括维修消防设备的消费量

基准消费量数据（吨二氧化碳当量）	2020 年	2021 年	2022 年	2020-2022 年平均数
氢氟碳化物年度消费量	12,498,835	12,840,128	14,317,946	13,218,970
氟氯烃基准数（65%）				6,071,380
氢氟碳化物基准数				19,290,350

符合供资条件的氢氟碳化物消费量	
持续总削减量的起始基准值	待定
以前核准的逐步减少氢氟碳化物投资项目	无
以前核准的项目的总削减量（吨二氧化碳当量）	不适用

商定的项目数据			2025 年*	2026 年	2027 年	2028 年	2029 年	2030 年	共计
消费量（吨二氧化碳当量）	《蒙特利尔议定书》消费量上限		19,290,350	19,290,350	19,290,350	19,290,350	17,361,315	17,361,315	不适用
	允许消费量上限		19,290,350	19,290,350	18,500,000	18,000,000	16,387,179	15,046,473	不适用
	基准消费量削减数（%）		0	0	4.1	6.7	15.0	22.0	不适用
原则上建议的数额（美元）	工发组织	项目费用	9,081,787	0	3,545,129	0	1,648,115	0	14,275,031
		支助费用	635,725	0	248,159	0	115,368	0	999,252
	开发署	项目费用	1,704,688	0	1,047,100	0	170,779	0	2,922,567
		支助费用	119,328	0	73,297	0	11,955	0	204,580
	项目费用合计		10,786,475	0	4,592,229	0	1,818,894	0	17,197,598
	支助费用合计		755,053	0	321,456	0	127,323	0	1,203,832
	供资合计		11,541,528	0	4,913,685	0	1,946,217	0	18,401,430

*建议本次会议核准

第一阶段符合供资条件的剩余消费量削减数（吨二氧化碳当量）	5,795,458*

*包括进口预混多元醇中所含的 35,850 吨二氧化碳当量氢氟碳化物。

秘书处的建议：	单独审议

项目说明

39. 本文件包含以下各节：

一. 所提交提案的摘要

二. 背景：氟氯烃淘汰管理计划的执行情况

三. 氢氟碳化物消费概况：氢氟碳化物消费水平、趋势和各行业的消费量

四. 所提交的基加利氢氟碳化物执行计划第一阶段：监管框架、逐步减少战略、阶段总费用和第一次付款执行计划

五. 秘书处的评论，包括商定的活动费用

六. 建议

一. 所提交提案的摘要

40. 工发组织作为牵头执行机构，代表埃及政府提交了基加利氢氟碳化物执行计划第一阶段的申请，总费用为 29,817,042 美元，其中给工发组织 22,197,232 美元，外加 1,553,806 美元的机构支助费用，给开发署 5,669,162 美元，外加 396,841 美元的机构支助费用，均与最初提交的申请相同。[9]

41. 基加利氢氟碳化物执行计划第一阶段的执行将协助埃及政府在 2029 年 1 月 1 日之前将氢氟碳化物消费量较基准数减少 21.40%，早于《蒙特利尔议定书》的管制时间表。

42. 向本次会议申请的 2025 年 6 月至 2027 年 12 月基加利氢氟碳化物执行计划第一阶段第一次付款为 17,392,844 美元，其中给工发组织 12,707,775 美元，外加 889,544 美元的机构支助费用，给开发署 3,547,220 美元，外加 248,305 美元的机构支助费用，均与最初提交的申请相同。

二. 背景

<u>氟氯烃淘汰管理计划的执行情况</u>

43. 表 1 开列了截至 2025 年 2 月埃及氟氯烃淘汰管理计划的信息。

表 1. 埃及氟氯烃淘汰管理计划执行情况

	第一阶段	**第二阶段**
核准/更新氟氯烃淘汰管理计划的会议	第六十五次会议	第七十九次会议/第八十四次会议
基准消费量削减数	到 2018 年淘汰 25%	到 2025 年淘汰 67.5%
项目费用合计（美元）	8,502,815	21,881,486
完成日期（实际日期/计划日期）	2019 年 12 月 1 日	2026 年 12 月 31 日

[9] 根据 2025 年 1 月 22 日埃及环境部致工发组织的信函。

之前氢氟碳化物相关活动的执行情况

44. 表 2 概括了由多边基金供资，在埃及开展的《基加利修正案》范围内的活动。

表 2. 以前核准的在埃及开展的氢氟碳化物相关活动

核准会议	项目名称	执行机构	费用（美元）	完成日期
第八十一次会议	逐步减少氢氟碳化物扶持活动	工发组织/环境署	250,000	2022 年 6 月
第九十三次会议	埃及制冷和空调行业的能效试点项目，目的是在逐步减少氢氟碳化物的情况下维持和（或）提高替代技术和设备的能效	工发组织	285,000	进行中

三. 氢氟碳化物消费概况

氢氟碳化物消费水平

45. 埃及仅进口氢氟碳化物用于制造和维修行业。2024 年消费量最大的物质是 HFC-134a（占氢氟碳化物总消费量（以吨二氧化碳当量计算）的 37.8%）、R-410A（34.3%）、R-404A（15.4%）和 HFC-227ea（9.4%），其他各种氢氟碳化物占总消费量的 3.1%。表 3 开列了埃及根据《蒙特利尔议定书》第 7 条向臭氧秘书处报告的氢氟碳化物消费量以及该国的氢氟碳化物基准数。

表 3. 埃及氢氟碳化物消费量（2020-2024 年第 7 条数据）和基准数

氢氟碳化物	全球升温潜能值	2020 年	2021 年	2022 年	2023 年	2024 年*
公吨						
HFC-134a	1,430	3,109.95	2,836.53	2,797.31	3,673.87	4,556.45
HFC-152a	124	275.45	454.66	429.90	227.00	281.22
HFC-227ea	3,220	539.55	429.94	460.20	502.41	500.50
HFC-245fa	1,030	22.53	67.62	115.61	64.00	116.50
HFC-365mfc	794	30.45	33.06	34.80	0.00	33.00
R-404A	3,922	720.60	621.96	607.22	669.47	677.88
R-410A	2,088	1,501.90	2,114.50	2,844.18	2,415.15	2,832.64
其他	不适用	132.48	226.29	226.51	134.38	222.16
共计（公吨）		**6,332.90**	**6,784.57**	**7,515.73**	**7,686.28**	**9,220.34**
预混多元醇所含的 HFC-245fa*	1,030	21.42	23.78	31.86	27.37	29.00
预混多元醇所含的 HFC-365mfc*	794	0.00	0.00	0.00	0.00	21.00
吨二氧化碳当量						
HFC-134a	1,430	4,447,229	4,056,238	4,000,162	5,253,638	6,515,716
HFC-152a	124	34,156	56,378	53,308	28,148	34,871
HFC-227ea	3,220	1,737,351	1,384,407	1,481,844	1,617,773	1,611,610
HFC-245fa	1,030	23,204	69,653	119,075	65,920	119,995
HFC-365mfc	794	24,177	26,250	27,631	0	26,202
R-404A	3,922	2,825,905	2,439,086	2,381,262	2,625,377	2,658,374
R-410A	2,088	3,135,216	4,414,019	5,937,217	5,041,627	5,913,136
其他**	不适用	271,598	394,098	317,447	258,398	353,623
共计（吨二氧化碳当量）		**12,498,835**	**12,840,128**	**14,317,946**	**14,890,881**	**17,233,528**

氢氟碳化物	全球升温潜能值	2020 年	2021 年	2022 年	2023 年	2024 年*
预混多元醇所含的 HFC-245fa*	1,030	22,062	24,493	32,816	28,191	29,870
预混多元醇所含的 HFC-365mfc*	794	0	0	0	0	16,674
氢氟碳化物基准数计算（吨二氧化碳当量）						
2020-2022 年氢氟碳化物平均消费量						13,218,970
氟氯烃基准数（65%）						6,071,380
氢氟碳化物基准数						**19,290,350**

*国家方案数据

**包括 HFC-32、HFC-125、HFC-143a、HFC-236fa、HFC-23、R-406A、R-407C、R-407F、R-408A、R-417A、R-507A 和 R-508B。

国家方案执行情况报告

46. 埃及政府在其 2023 年国家方案执行情况报告中提供的行业氢氟碳化物消费量数据与根据《蒙特利尔议定书》第 7 条报告的数据一致。

氢氟碳化物消费趋势

47. 自 2020 年以来，埃及的氢氟碳化物消费量逐年增加，其中 2022 年和 2024 年大幅增加。2022 年，消费量增长约 11.5%（以吨二氧化碳当量计），主要原因是空调中 R-410A 的使用量增加。2023 年，考虑到三种最常用的氢氟碳化物/混合物（HFC-134a、HFC-227ea 和 R-404A）消费量增长以及部分氢氟碳化物消费量降低，消费量小幅增长。2024 年，氢氟碳化物消费量增长了 16%（以吨二氧化碳当量计），部分原因是受到 2023 年货币贬值后的复苏推动。虽然在 2024 年增长量中，绝大部分是 HFC-134a 和 R-410A 消费量增长，但该国其他七种最常进口的氢氟碳化物也有所增加，[10]HFC-32 消费量大幅增加与 5 家住宅空调制造企业根据氟氯烃淘汰管理计划向该技术转型一致。三个基准年度中每种制冷剂的平均消费量显示，HFC-134a 和 R-410A 分别占埃及氢氟碳化物消费量的 73%（以公吨计）和 66%（以吨二氧化碳当量计）。在 2024 年之前，进口商预先向国家臭氧机构通报了与所有物质（包括预期将采取新措施的氢氟碳化物）有关的进口情况，使国家臭氧机构能够计算报告年度的氢氟碳化物消费量。

按行业分列的氢氟碳化物消费量

48. 维修行业（以吨二氧化碳当量计，占消费量的 59%）、各个制造次级行业（29%）以及消防（12%）均消费氢氟碳化物。在制造业中，氢氟碳化物消费占比最高的是住宅和商用空调设备的制造，是基准年度总消费量的 20%（以吨二氧化碳当量计），[11]其次是家用制冷设备制造（4%）、计量吸入器制造（1.3%）、商用制冷和运输制冷设备制造（各占 1%）、聚氨酯泡沫塑料制造（近 1%），以及移动空调和挤塑聚苯乙烯泡沫塑料制造（各不足 1%）。

[10] HFC-134a（24%）、HFC-152a（24%）、HFC-245fa（82%）、HFC-23（5%）、R-404A（1%）、R-407C（32%）、R-410A（17%）、R-417A（6%）以及 R-507A（3%）。

[11] 国家方案数据中将这两个行业的数据合并，编制基加利氢氟碳化物执行计划时的消费量调查未能确定商用空调制造中使用氢氟碳化物的全部企业，但表明所有报告的 R-410A 都集中在住宅空调行业。

49. 如表 4 和表 5 所示，维修行业的氢氟碳化物消费量主要集中在制冷次级行业（占基准年度氢氟碳化物总消费量的 37%（以公吨计）和 39%（以吨二氧化碳当量计））[12]，其次是空调次级行业（以公吨计，占 14%，以吨二氧化碳当量计，占 15%）[13]，以及移动空调次级行业（以公吨计，占 7%，以吨二氧化碳当量计，占 5%）。

[12] 由于数据存在差异，因此未进一步细分展示，制冷维修次级行业的氢氟碳化物总消费量大致占比情况如下：商用（以吨二氧化碳当量计，占 34%）、工业（15%）、家用（11%）和运输（7%）。

[13] 空调维修次级行业的氢氟碳化物总消费量大致占比情况如下：住宅（25%）以及商用（不足 1%）。

表 4. 埃及各行业氢氟碳化物消费量（公吨）（2020-2022 年）[14]

行业	HFC-32	HFC-134a	HFC-152a	HFC-227ea	HFC-245fa	HFC365mfc	R-404A	R-407C	R-410A	其他	合计	占总数的百分比（%）
制造业												
家用制冷	0.00	409.44	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	409.44	6
商用制冷	0.00	31.79	0.00	0.00	0.00	0.00	5.24	0.45	0.00	0.00	37.48	1
运输制冷	0.00	37.51	0.00	0.00	0.00	0.00	8.51	45.55	0.00	0.00	91.58	1
住宅和商用空调	3.35	41.71	0.00	0.00	0.00	0.00	0.00	1.18	1250.67	0.00	1,255.19	18
移动空调	0.00	41.71	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	41.71	1
聚氨酯泡沫塑料	0.00	0.00	0.00	4.90	68.59	32.77	0.00	0.00	0.00	0.00	106.25	2
挤塑聚苯乙烯泡沫塑料	0.00	0.00	386.67	0.00	0.00	0.00	0.00	0.00	0.00	0.00	386.67	6
气雾剂	0.00	118.98	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	118.98	2
制造业小计	***3.35***	***639.43***	***386.67***	***4.90***	***68.59***	***32.77***	***13.75***	***47.18***	***1250.67***	***0.00***	***2,447.29***	***36***
制冷和住宅空调维修												
制冷次级行业	0.00	1816.11	0.00	0.00	0.00	0.00	636.18	39.33	0.00	11.81	2,503.43	37
住宅空调次级行业	12.92	18.63	0.00	0.00	0.00	0.00	0.00	38.00	897.39	2.69	969.64	14
移动空调	0.00	440.39	0.00	0.00	0.00	0.00	0.00	0.00	5.47	0.00	445.86	7
维修行业小计	***12.92***	***2275.14***	***0.00***	***0.00***	***0.00***	***0.00***	***636.18***	***77.33***	***902.86***	***14.50***	***3,918.93***	***57***
其他行业												
消防	0.00	0.00	0.00	471.67	0.00	0.00	0.00	0.00	0.00	0.32	471.98	7
其他	5.41	0.37	0.00	0.00	0.00	0.00	0.00	0.00	0.00	10.12	15.90	0
其他行业小计	***5.41***	***0.37***	***0.00***	***471.67***	***0.00***	***0.00***	***0.00***	***0.00***	***0.00***	***10.44***	***487.88***	***7***
合计	**21.67**	**2,914.94**	**386.67**	**476.56**	**68.59**	**32.77**	**649.93**	**124.51**	**2,153.53**	**24.94**	**6,854.10**	**100**

*国家方案数据中还报告了泡沫塑料行业进口预混多元醇所含的 HFC-245a 平均消费量为 25.69 公吨。

[14] 本表中商用和住宅空调、消防和“ 其他”行业的数据来自国家方案报告，而其他行业的数据则来自调查。该数据与大多数行业的国家方案一致，但维修行业除外，该行业数据与国家方案报告的数据相差 0.62 公吨。

表 5. 埃及各行业氢氟碳化物消费量（吨二氧化碳当量）（2020-2022 年）[15]

行业	HFC-32	HFC-134a	HFC-152a	HFC-227ea	HFC-245fa	HFC-365mfc	R-404A	R-407C	R-410A	其他*	合计	占总数的百分比（%）
制造业												
家用制冷	0	585,499	0	0	0	0	0	0	0	0	585,499	4
商用制冷	0	45,465	0	0	0	0	20,542	793	0	0	66,800	1
运输制冷	0	53,643	0	0	0	0	33,382	80,807	0	0	167,832	1
住宅和商用空调	2,258	0	0	0	0	0	0	2,084	2,610,767	0	2,615,109	20
移动空调	0	59,641	0	0	0	0	0	0	0	0	59,641	0
聚氨酯泡沫塑料*	0	0	0	15,767	70,644	26,019	0	0	0	0	112,431	1
挤塑聚苯乙烯泡沫塑料	0	0	47,947	0	0	0	0	0	0	0	47,947	0
气雾剂	0	170,137	0	0	0	0	0	0	0	0	170,137	1
制造业小计	***2,258***	***914,385***	***47,947***	***15,767***	***70,644***	***26,019***	***53,922***	***83,684***	***2,610,767***	***0***	***3,825,393***	***29***
制冷和住宅空调维修												
制冷次级行业	0	2,597,040	0	0	0	0	2,494,840	69,767	0	8,184	5,202,265	39
住宅空调次级行业	8,721	26,645	0	0	0	0	0	67,406	1,873,306	6,320	1,982,398	15
移动空调	0	629,761	0	0	0	0	0	0	11,412	0	641,173	5
维修行业小计	***8,721***	***3,253,446***	***0***	***0***	***0***	***0***	***2,494,840***	***137,174***	***1,884,718***	***14,504***	***7,825,836***	***59***
其他行业												
消防	0	0	0	1,518,767	0	0	0	0	0	3,113	1,521,880	12
其他	3,650	529	0	0	0	0	0	0	0	41,921	46,099	0
其他行业小计	***3,650***	***529***	***0***	***1,518,767***	***0***	***0***	***0***	***0***	***0***	***45,034***	***1,567,979***	***12***
合计	**14,628**	**4,168,360**	**47,947**	**1,534,534**	**70,644**	**26,019**	**2,548,762**	**220,858**	**4,495,485**	**59,537**	**13,219,208**	**100**

*国家方案数据中还报告了泡沫塑料行业进口预混多元醇所含的 HFC-245a 平均消费量为 26,457 吨二氧化碳当量。

[15] 本表中商用和住宅空调、消防和“其他”行业的数据来自国家方案报告，而其他行业的数据则来自调查。该数据与大多数行业的国家方案一致，但维修行业除外，该行业数据与国家方案报告的数据相差 2,343 吨二氧化碳当量。

制造业

50. 埃及使用氢氟碳化物的制造业包括生产以下产品的企业：家用和商用制冷设备以及家用和商用空调设备、聚氨酯泡沫塑料、挤塑聚苯乙烯泡沫塑料和用于生产计量吸入器的气雾剂。

聚氨酯泡沫塑料制造业

51. 根据氟氯烃淘汰管理计划，八家国内制冷行业生产聚氨酯泡沫的企业获得协助，实现了从使用 HCFC-141b 转为环戊烷。然而，该行业的几家中小型企业在执行转型项目之前，就已经在使用纯 HFC-245fa 和进口预混多元醇所含的 HFC-245fa 作为发泡剂，还有一家生产热水器的企业正在使用 HFC-365mfc 和 HFC-227ea 的混合物作为发泡剂。该行业的氢氟碳化物消费量将在基加利氢氟碳化物执行计划第一阶段中进行处理。

挤塑聚苯乙烯泡沫塑料制造业

52. 埃及有两家公司使用 HFC-152a 制造建筑用非连续板材。以公吨计，该制造业占该国氢氟碳化物总消费量的 6%，但以吨二氧化碳当量计，仅占 0.4%。HFC-152a 仅用于挤塑聚苯乙烯行业，建议在第一阶段进行处理，之后将在 2028 年之前执行禁令。

家用制冷设备制造业

53. 在家用冰箱制造企业中，有 6 家企业的 HFC-134a 消费量超过 15 公吨，5 家企业的消费量在 1.5 公吨至 15 公吨之间，4 家企业的消费量低于 1.5 公吨。消费量低于 1.5 公吨的企业在现场对设备进行充注，尽管其中部分企业也生产其他制冷和空调产品，但仍将这些企业称为超小型企业。[16]这一行业的消费量目标是在基加利氢氟碳化物执行计划第一阶段淘汰氢氟碳化物。HFC-134a 是该行业消费的主要制冷剂；然而，也有一些企业使用 R-600a 生产家用制冷设备；该国还进口使用 R-600a 的家用冰箱。

商用制冷设备制造业

54. 在商用制冷设备制造业，有一家制造商、6 家中小型企业和 4 家超小型企业制造单机商用制冷设备。该行业使用的主要氢氟碳化物是 HFC-134a（约占 85%）；这些企业使用的其他氢氟碳化物包括 R-404A 和 R-407C。该行业的氢氟碳化物消费量将在基加利氢氟碳化物执行计划第一阶段中进行处理。

运输制冷设备制造业

55. 在冷藏运输设备的制造与安装领域，已确定有 3 家企业（其中两家为中小型企业，一家为超小型企业）。这些企业主要使用 R-404A 和 R-407C，同时也使用部分 HFC-134a。该制造业的相关问题将在未来的某个阶段加以处理。

[16] 在本文件中，消费量在 15 公吨以上的制造企业将被称为“制造商”，消费量在 1.5 至 15 公吨之间的企业被称为中小型企业，消费量在 1.5 公吨以下的企业被称为超小型企业。

家用空调制造业

56. 在氟氯烃淘汰管理计划第二阶段，支持 5 家企业 [17] 从使用 HCFC-22 转为使用 HFC-32 或 R-454B。[18] 第八十四次会议注意到，除一家企业外，所有企业都在其生产线上制造使用 HCFC-22 和 R-410A 的组件。在第八十八次会议上，各方达成一致，这些企业将在 2028 年前 [19] 淘汰为本地市场生产的使用 R-410A 的组件，以确保 HFC-32 能够成功引入。到 2024 年，这些企业生产的使用 HFC-32 的组件占 2023 年 1 月 1 日至 2024 年 3 月 13 日期间生产组件的 0.04%。工发组织注意到，其中 3 家企业已签署合同，以确保能够按时全面淘汰为本地市场生产的使用 R-410A 的组件，这些组件将在 2025 年 1 月 1 日或 2026 年 12 月 31 日前被 HFC-32 技术所取代。在 2024 年的第九十四次会议上，还进一步明确，这 5 家正在进行转型的企业并不涵盖整个家用空调制造业，该行业中还有多家企业正在生产使用 R-410A 的产品。随后，执行委员会决定，第四次付款（其中将包括为尚未签署氟氯烃淘汰管理计划增支经营成本合同的两家住宅空调制造企业供资）在同一次会议上提交作为基加利氢氟碳化物执行计划。[20]2024 年，HFC-32 消费量大幅增长的原因是这些企业使用 HFC-32 进行生产。

57. 在编制基加利氢氟碳化物执行计划期间，在住宅空调制造业确定了 4 家制造商、一家中小型企业和一家超小型企业，它们没有参加氟氯烃淘汰管理计划下的转型项目，但生产使用 R-410A 的组件，符合氢氟碳化物淘汰的条件。尽管 2020 年这些企业的氢氟碳化物消费量没有增长，但自 2021 年以来，消费量稳步增长，特别是在 2021 年和 2024 年，分别增长了 21%和 57%。虽然其中两家企业在 2019 年至 2021 年的氢氟碳化物消费量不足 15 公吨，因此原本可被视为中小型企业，但到 2023 年 4 家企业以及到 2024 年 5 家企业的 R-410A 消费量均已超过 15 公吨。该国所有 R-410A 消费量都来自这 11 家住宅空调企业（在氟氯烃淘汰管理计划下得到援助的企业和在基加利氢氟碳化物执行计划下确定的企业）。这一行业将在基加利氢氟碳化物执行计划第一阶段处理，以确保氟氯烃淘汰管理计划下转型的可持续性。

商用空调制造业

58. 商用空调制造业的 6 家企业在氟氯烃淘汰管理计划下获得了技术援助，以转换为低全球升温潜能值的氢氟碳化物，据报告，其中 4 家企业以及未被纳入该项目的第 7 家企业已开始制造间接蒸发冷却组件。虽然调查未能确定该行业使用氢氟碳化物的企业数量，但部分 R-407C 消费量可能来自该行业。在基加利氢氟碳化物执行计划第一阶段，已提议在商用空调行业中开展一个示范项目。

移动空调制造业

59. 在项目编制期间，在移动空调制造业确定了 12 家企业，其中部分是外国合资企业。该制造业依赖 HFC-134a，其消费量不到该国氢氟碳化物总消费量的 1%（以吨二氧化碳当

[17] El-Araby、Fresh、Miraco、Power 和 Unionaire 公司。
[18] 一旦相关技术可用，若企业决定采用该技术（第 84/72(b)号决定）。
[19] 有三个中期目标：到 2025 年向当地市场提供 25%的产品，到 2026 年向当地市场提供 50%的产品；以及到 2027 年，向当地市场提供 75%的产品（第 88/70(a)(二)a 号决定）。
[20] 第 94/35(c)(一)号决定。

量计）。这一消费量将在后续阶段加以处理。

气雾剂和溶剂

60. 在埃及，氢氟碳化物被用作计量吸入器的推进剂，并且消费量逐年增长。[21] 除此之外，该国工业溶剂中并无氢氟烃消费。埃及的计量吸入器制造业仅使用 HFC-134a，而 HFC-227ea 仅存在于进口的预充装计量吸入器中。埃及目前未使用 HFC-152a 和 HFO-1234ze 等低全球升温潜能值替代品。该行业的相关问题将在未来的某个阶段予以处理。

制冷和空调维修行业

61. 埃及约有 100,000 名技术员（其中女性约占 5%）和 24,000 个消费氢氟碳化物的车间。其中，75,000 名技术员（包括 3,000 名女性）专门从事空调维修，25,000 名技术员（包括 2,000 名女性）专门从事制冷维修。大约 35%的劳动力受雇于遵守行业标准和条例的正规车间，其余 65%的劳动力受雇于管理监督有限的非正规车间。从事移动空调维修行业的技术员估计有 20,000 人（估计女性技术员不足 5%）。

62. 埃及的制冷和空调技术教育和职业培训由三个主要实体负责：教育和技术教育部，负责监督 285 所技术学校，其制冷和空调部配备了 2,965 名专门从事制冷和空调教育的教师；人力资源部，负责管理 27 个职业培训中心，专门侧重于制冷和空调领域；以及工业部下属的生产力和职业培训司，该司负责监督若干制冷和空调培训中心。根据氟氯烃淘汰管理计划，对 21 个培训中心进行升级，建立了三个硕士培训中心和一个英才中心，对培训员进行了培训，并更新和引入了培训课程。已建立一个再生中心，另一个也在规划中并正在建设。

63. 2024 年，埃及标准组织发布了技术员认证的国家准则，埃及标准编号为 8938/2024。该准则基于使用低全球升温潜能值制冷剂运行的制冷和空调设备的良好做法，包括在安装和维修行业安全处理易燃制冷剂。国家臭氧机构、人力资源部和工业部的职业培训部门以及埃及标准组织开展了合作，着手更新制冷和空调技术员国家认证，以使其符合这一标准。

家用、商用、工业和运输制冷维修

64. 埃及使用氢氟碳化物的制冷维修次级行业包括家用、商用、工业和运输制冷。在调查基准年度期间，制冷次级行业中用于维修的氢氟碳化物消费量约占 37%（以公吨计）和 39%（以吨二氧化碳当量计），使其成为氢氟碳化物消费量最高的行业。HFC-134A 是制冷维修中使用的主要氢氟碳化物，其次是 R-404A 和 R-407C，R-407F、R-507A 和 R-508A 的使用有限。

住宅和商用空调维修

65. 埃及使用氢氟碳化物的空调维修次级行业包括住宅和商用空调。在调查基准年度期间，空调次级行业中用于维修的氢氟碳化物消费量约占 13.75%（以公吨计）和 14.6%（以

[21] 该国在国家方案报告中在溶剂项而非气雾剂项下报告了制造计量吸入器的氢氟碳化物消费量。因此，该国将提交经修订的国家方案数据。

吨二氧化碳当量计）。R-410A 是住宅空调中主要使用的氢氟碳化物，其次是 HFC-32。空调行业使用的其他氢氟碳化物包括部分 HFC-134a（约占该物质使用量的 1%）和 R-417A。

移动空调维修

66. 移动空调维修行业依赖 HFC-134a，按吨二氧化碳当量计，占该国氢氟碳化物总消费量的 5%。氟氯烃淘汰管理计划以前没有涉及这一行业，基加利氢氟碳化物执行计划第一阶段下的部分维修行业活动将述及这一行业。

消防

67. 所有消防系统均从国外进口至埃及，但在埃及国内进行充装和维护；该领域并无本土制造活动。在项目编制调查期间，确定了 14 个消防系统专业供应商和 16 个服务提供商。氢氟碳化物占消防系统市场的 75%，该行业使用的部分替代品包括氮气、二氧化碳、干粉灭火剂、水、细水雾和氢氟醚，尽管后者正在进行环境影响评估。HFC-227ea 是消防设备维修中使用的主要氢氟碳化物，HFC-236fa 的使用有限。以吨二氧化碳当量计，消防领域中氢氟碳化物消费量占该国总消费量的 12%。

本地安装及组装次级行业

68. 所提交提案将消费量低于 1.5 公吨的若干制造业的企业称为“安装商”。然而，这些企业在现场对设备进行充装，因此并不属于 UNEP/OzL.Pro/ExCom/92/49 号文件和 Corr.1 号文件中界定的“安装商”类别。在维修行业调查中，估计在基准年度该行业消费量为 62.15 公吨（243,727 吨二氧化碳当量）；然而，尚未对这一行业进行更详细的分析。

混合物制造

69. 2021 年，该国共生产了 39.89 公吨氢氟碳化物混合物（7.44 公吨 R-404A 和 32.45 公吨 R-410A）。在 2020 年至 2024 年期间的其他年份中，均未报告此类混合物的生产情况。

四. 所提交的基加利氢氟碳化物执行计划第一阶段

体制、政策和监管框架

70. 埃及于 2023 年 8 月 22 日批准了《基加利修正案》。该国已经更新了许可证和配额制度，在其中纳入了氢氟碳化物，并发布了 2024 年的配额。氢氟碳化物和其他消耗臭氧层物质通过以下单位进行监管和控制：国家臭氧委员会，负责监督氟氯烃淘汰管理计划和基加利氢氟碳化物执行计划的执行情况，并管理配额的发放；海关署，负责监测和管制受控物质的进出口；以及消费者保护局，该机构已建立了监测和遏制市场非法交易的机制。2024 年，国家臭氧委员会决定禁止为使用 R-410A 的住宅空调新生产线颁发工业许可证。埃及还将减少能耗和提高能效列为国家优先事项，为此，环境部长于 2023 年颁布了一项法令，增补电力和能源部的一名代表加入国家臭氧委员会。

基加利氢氟碳化物执行计划第一阶段的逐步减少战略

总体战略

71. 埃及的总体战略立足于通过维修行业活动来实现 2029 年履约要求，同时利用投资项目，推动重点行业企业转型，从而进一步降低该国今后的需求。

拟议削减

72. 埃及政府在“一切照旧”的场景下，预测氢氟碳化物消费量的年增长率为 4.3%。这一预测是根据2024年的消费量估计数以及埃及经济部预测2024-2025财政年度国内生产总值增长 4%和人口增长 1.3%计算得出的。如表 6 所示，在“一切照旧”场景中，氢氟碳化物消费量的增长预计到 2028 年将超过控制水平。

表 6. 分别根据无限制情景、《蒙特利尔议定书》规定的消费量上限和拟议的第一阶段氢氟碳化物削减量预测的氢氟碳化物消费量（吨二氧化碳当量）

	2025 年	2026 年	2027 年	2028 年	2029 年
预测氢氟碳化物消费量年增长 4.3%*	17,093,331	17,828,344	18,594,963	19,394,546	20,228,512
《蒙特利尔议定书》氢氟碳化物消费量上限	19,290,350	19,290,350	19,290,350	19,290,350	17,361,315
在基加利氢氟碳化物执行计划下拟议的氢氟碳化物消费水平	19,290,350	19,290,350	19,290,350	19,290,350	15,161,919*
拟议的氢氟碳化物消费量基准数削减量（%）	冻结	冻结	冻结	冻结	21.40

*根据提交材料中对吨二氧化碳当量减少量的初步计算。如表 27 所示，在项目审查期间对最初提案中的吨二氧化碳当量减少量进行了更正。

拟议活动

73. 第一阶段包括聚氨酯泡沫塑料和挤塑聚苯乙烯泡沫塑料制造业、家用和商用制冷制造业以及住宅空调制造业的投资项目，以及维修行业的非投资项目，包括监管和能力建设项目、宣传和外联，以及住宅空调、商用空调、计量吸入器行业、移动空调、制冷和空调及消防行业的行业项目，与最初提交的内容一致。

泡沫塑料制造业——开发署

74. 埃及提议在聚氨酯泡沫塑料和挤塑聚苯乙烯泡沫塑料行业进行技术转型，将由开发署执行。为这两个行业申请的供资总额为 4,131,206 美元，其中给聚氨酯泡沫塑料行业 1,560,431 美元，给挤塑聚苯乙烯泡沫塑料行业 2,195,211 美元，以及 10%的项目管理费用 375,564 美元。下文将分行业进行讨论。

一. 聚氨酯泡沫塑料制造业

75. 针对聚氨酯泡沫塑料制造业，拟在一家企业（成立于 2008 年的 El Araby 公司）实施一项投资项目，旨在通过改用环戊烷技术，淘汰 37.67 公吨（41,797 吨二氧化碳当

量）[22] 365mfc/227ea[23]，这贯穿热水器制造过程 [24]；还开展一个覆盖 30 家中小型和超小型企业的总体项目，通过环戊烷技术转型，淘汰 68.59 公吨纯 HFC-245fa 及进口预混多元醇中含有的 25.68 公吨 HFC-245fa。该行业消费量如下表 7 所示。

表 7. 2020-2024 年聚氨酯泡沫塑料制造商 HFC-365mfc/227ea、纯 HFC-245fa 和预混多元醇中所含 HFC-245fa 消费量

企业	物质	2020 年	2021 年	2022 年	2023 年	2024 年	2020-2022 年平均值
公吨							
El Araby 公司	HFC-365mfc/227ea	66.11	68.81	121.83	71.76	77.50	85.58*
30 家中小型和超小型企业	HFC-245fa	22.53	67.62	115.61	64.00	116.50	68.59
30 家中小型和超小型企业	预混多元醇中所含的 HFC-245fa	21.42	23.78	31.86	27.37	29.00	25.68

* 企业一级的消费量与国家方案数据存在差异，初步分析认为，这是由于该企业使用的库存量高于其进口量和国家方案中报告的数据。

76. 申请为以下方面供资：两台高压注塑发泡机费用（240,000 美元）、封装、环戊烷储罐费用、管道铺设和电气改造费用（47,200 美元）、安全审计、试验和调试费用（40,000 美元）、技术援助费用（50,000 美元）和 5%的应急费用（18,860 美元）；因此，增支资本成本为 396,060 美元。经计算，增支经营成本为负 27,687 美元；这些节余已从增支资本成本中扣除，项目费用总额为 368,373 美元。总体项目的费用是根据泡沫塑料行业氟氯烃的成本效益阈值 9.78 美元/千克计算的，用于淘汰 94.28 公吨纯 HFC-245fa 和进口预混多元醇中所含的 HFC-245fa（97,108 吨二氧化碳当量），共计 922,058 美元，另外还申请 270,000 美元，用于向参与配方开发和向中小型和超小型企业供货的 3 家配方厂家提供技术支持，涵盖项目管理、技术开发、试验、测试和培训。表 8 展示了以美元/千克和美元/吨二氧化碳当量表示的削减量、申请金额和成本效益。

表 8. 埃及聚氨酯泡沫塑料投资项目的削减量、申请供资额和成本效益

企业	物质	淘汰		申请供资额（美元）	成本效益	
		公吨	吨二氧化碳当量		美元/千克	美元/吨二氧化碳当量
El Araby 公司	HFC-365mfc	32.77	26,019	368,373	9.78	8.81
	HFC-227ea	4.90	15,778			
中小型和超小型企业总体项目	HFC-245fa	68.59	70,648	670,810	9.78	9.50
	预混多元醇中所含的 HFC-245fa	25.69	26,461	251,248	9.78	9.50
向配方厂家提供技术援助		不适用	不适用	270,000	不适用	不适用
聚氨酯泡沫塑料行业合计		**131.95**	**138,905**	**1,560,431**	**11.83**	**11.23**

[22] 根据所提交的内容，这一数据是基于国家方案数据中提交的 2020-2022 年平均值得出。

[23] 32.77 公吨（26,019 吨二氧化碳当量）HFC-365mfc 和 4.90 公吨（15,778 吨二氧化碳当量）HFC-227ea。常见的 HFC-365 mfc 和 HFC-227ea 混合物中氢氟碳化物的含量分别为 93%和 7%。由于埃及普遍是高温环境，以及为了更好地控制吸热发泡过程，El Araby 公司所使用的配方中含有更高比例的 HFC-227ea。

[24] 在氟氯烃淘汰管理计划第一阶段，El Araby 公司已获得援助，以淘汰其在生产家用制冷泡沫塑料时使用的 HCFC-141b，改用环戊烷。

二. 挤塑聚苯乙烯泡沫塑料制造业

77. 针对挤塑聚苯乙烯泡沫塑料制造业，拟在两家企业（埃及泡沫塑料公司（2019 年成立）和 Al Alamiya 保温材料公司（2019 年开始生产））实施一项投资项目，以淘汰该行业在挤塑聚苯乙烯泡沫塑料制造中用作发泡剂的 386.67 公吨（47,947 吨二氧化碳当量）[25] HFC-152a，并替换为二氧化碳。下表 9 展示了这两家企业和该行业的消费量。[26]

表 9. 挤塑聚苯乙烯泡沫塑料制造商的 HFC-152a 消费量（以公吨和吨二氧化碳当量计）（2020-2024 年）

企业	2020 年	2021 年	2022 年	2023 年	2024 年	2020-2022 年平均值
公吨						
埃及泡沫塑料公司	90	103	95	85	93	96.00
Al Alamiya	100	114	112	115	147	108.67
其他	85.45	237.66	222.9	27	41.22	182.00
行业合计	**275.45**	**454.66**	**429.9**	**227**	**281.22**	**386.67**
吨二氧化碳当量						
埃及泡沫塑料公司	11,160	12,772	11,780	10,540	11,532	11,904
Al Alamiya 保温材料公司	12,400	14,136	13,888	14,260	18,228	13,475
其他	10,596	29,470	27,640	3,348	5,111	22,568
行业合计	**34,156**	**56,378**	**53,308**	**28,148**	**34,871**	**47,947**

78. 申请的增支资本成本包括：因现有系统过于敏感，需对埃及泡沫塑料公司的挤压机进行改造（516,000 美元）和对 Al Alamiya 保温材料公司的挤压机进行改造（633,620 美元）；以及为每家企业提供技术援助费用（50,000 美元）；二甲醚储罐费用，包括安装和认证费用（85,000 美元）；单头发泡剂泵费用（60,000 美元）；管道改造费用（60,000 美元）；排气/通风系统改造费用（60,000美元）、气体传感器系统（30,000美元）、制造试验和安全审计费用（65,000 美元）和 10%的应急费用。由于技术成本较高，申请的增支经营成本为 0.57 美元/千克，基于 2020-2022 年平均消费量计算，埃及泡沫塑料公司的增支经营成本共计 54,720 美元，Al Alamiya 保温材料公司共计 61,940 美元。如表 10 所示，埃及泡沫塑料公司申请的总额为 1,029,320 美元，Al Alamiya 保温材料公司申请的总额为 1,165,891 美元。

表 10. 埃及挤塑聚苯乙烯泡沫塑料投资项目的淘汰量、申请供资额和成本效益

挤塑聚苯乙烯泡沫塑料行业	淘汰		申请供资额（美元）	成本效益	
	公吨	吨二氧化碳当量		美元/千克	美元/吨二氧化碳当量
埃及泡沫塑料公司	96.00	11,904	1,029,320	10.72	86.47
Al Alamiya 保温材料公司	108.67	13,475	1,165,891	10.73	86.52
其他	182.00	22,568	不适用	不适用	不适用
共计	**386.67**	**47,947**	**2,195,211**	**5.68**	**45.78**

[25] 根据所提交的内容，这一数据是基于国家方案数据中提交的 2020-2022 年平均值得出。
[26] 尽管这两家企业的消费量与国家方案报告中报告的 HFC-152a 消费量并不完全一致，但埃及政府已承诺将根据国家方案报告淘汰 HFC-152a 的全部消费量，这些消费量均源自该行业。

家用和商用制冷及住宅空调制造业——工发组织

79. 埃及已提议针对家用制冷、商用制冷及住宅空调行业的制造商、中小型和超小型企业开展技术转型项目。这些项目将通过工发组织执行，下文将按行业讨论。三个行业共申请资金 15,735,232 美元，其中给家用制冷行业 9,215,527 美元，商用制冷行业 1,366,823 美元，住宅空调行业 3,722,407 美元，以及 10%的项目管理费用 1,430,476 美元，用于淘汰 613.44 公吨（993,926 吨二氧化碳当量）氢氟碳化物 [27]。

一. 家用制冷制造业

80. 6 家家用制冷制造企业将通过技术转型项目淘汰 345.59 公吨 [28]（494,197 吨二氧化碳当量）HFC-134a，涉及 5 家企业 [29] 的共 22 条生产线。5 家中小型企业将淘汰五条生产线中的 17.38 公吨（24,858 吨二氧化碳当量）HFC-134a，4 家超小型企业将淘汰四条生产线中的 2.85 公吨（4,069 吨二氧化碳当量）HFC-134a。所有企业都将转为 R-600a，在 31 条家用制冷生产线中共淘汰 365.82 公吨（523,124 吨二氧化碳当量）HFC-134a。下表 11 提供了该行业企业的概况。

表 11. 家用制冷企业、生产设备量、生产线和消费量

<table>
<tr><th rowspan="2">企业</th><th rowspan="2">成立年份</th><th colspan="2">生产线</th><th rowspan="2">设备量（2023 年）</th><th colspan="2">消费量（2023 年）</th><th rowspan="2">拟议在基加利氢氟碳化物执行计划中进行技术转型或氟氯烃淘汰管理计划上一个阶段涵盖的行业</th></tr>
<tr><th>HFC-134a</th><th>HC-600a</th><th>公吨</th><th>吨二氧化碳当量</th></tr>
<tr><td colspan="8">制造商</td></tr>
<tr><td>Electrostar</td><td>1986 年</td><td>3</td><td>1</td><td>321,072</td><td>48.96</td><td>70,014</td><td>聚氨酯泡沫塑料氟氯烃淘汰管理计划第二阶段</td></tr>
<tr><td>Alaska</td><td>1978 年</td><td>5</td><td>0</td><td>230,000</td><td>49.00</td><td>70,070</td><td></td></tr>
<tr><td>Kiriazi</td><td>1986 年</td><td>6</td><td>1</td><td>244,238</td><td>38.82</td><td>55,518</td><td>住宅空调基加利氢氟碳化物执行计划；聚氨酯泡沫塑料氟氯烃淘汰管理计划第一阶段；聚氨酯泡沫塑料氟氯烃淘汰管理计划第二阶段</td></tr>
<tr><td>Fresh</td><td>2012 年</td><td>6</td><td>0</td><td>1,751,000</td><td>158.50</td><td>226,655</td><td>聚氨酯泡沫塑料氟氯烃淘汰管理计划第一阶段；氟氯烃淘汰管理计划第二阶段下的聚氨酯泡沫塑料和住宅空调</td></tr>
<tr><td>El Araby</td><td>2001 年</td><td colspan="2">3*</td><td>296,331</td><td>39.30</td><td>56,204</td><td>聚氨酯泡沫塑料基加利氢氟碳化物执行计划；聚氨酯泡沫塑料氟氯烃淘汰管理计划第一阶段；
住宅空调氟氯烃淘汰管理计划第二阶段</td></tr>
<tr><td>Unionaire</td><td>2013 年</td><td>2</td><td>0</td><td>100,038</td><td>11.00</td><td>15,736</td><td>住宅空调氟氯烃淘汰管理计划第二阶段</td></tr>
<tr><td>制造商小计</td><td>不适用</td><td>22</td><td>5</td><td>2,942,679</td><td>345.58</td><td>494,197</td><td>不适用</td></tr>
</table>

[27] HFC-134a——422.04 公吨/603,518 吨二氧化碳当量；R-404A——11.15 公吨/14,318 吨二氧化碳当量；R-407A——0.55 公吨/976 吨二氧化碳当量；和 R-410A——179.70 公吨/375,114 吨二氧化碳当量。

[28] 提交的转型项目基于 2023 年的消费量数据，但部分企业的数据后续已进行更新。

[29] 一家企业已经安装了能够生产使用 R-600a 的家用冰箱的设备，但同时仍继续生产使用 HFC-134a 的家用冰箱，但没有申请对该企业进行转型的供资。

企业	成立年份	生产线		设备量（2023 年）	消费量（2023 年）		拟议在基加利氢氟碳化物执行计划中进行技术转型或氟氯烃淘汰管理计划上一个阶段涵盖的行业
		HFC-134a	HC-600a		公吨	吨二氧化碳当量	
中小型企业							
Alradwan 国际	2008 年	1	0	33,000	3.24	4,633	商用制冷基加利氢氟碳化物执行计划
Minlo	2005 年	1		120,000	4.74	6,774	
Akwarj	2014 年	1	0	29,000	3.00	4,290	
Mas 电气	2018 年	1	0	21,000	2.10	3,003	
Trust for Ind.	2017 年	1	0	21,100	4.31	6,158	商用制冷基加利氢氟碳化物执行计划
中小型企业小计	**不适用**	**5**	**0**	**224,100**	**17.38**	**24,858**	**不适用**
超小型企业							
Tredco 工程与工业公司	1989 年	1	3	13,300	1.40	1,995	聚氨酯泡沫塑料氟氯烃淘汰管理计划第二阶段
东方工程企业	1996 年	1		10,000	0.90	1,287	
Elsaeedy 电子电器	2018 年	1		10,000	0.34	486	
Tiba	2010 年	1		680	2.11	301	住宅空调基加利氢氟碳化物执行计划；商用空调氟氯烃淘汰管理计划第二阶段
超小型企业小计	**不适用**	**4**	**3**	**33,980**	**2.85**	**4,069**	**不适用**
行业合计	**不适用**	**31**	**8**	**3,200,759**	**365.81**	**523,124**	**不适用**

* El Araby 公司有 3 家工厂，每家工厂各有一条生产线同时生产 HFC-134a 和 R-600a。因此，未就企业的转型申请供资。

81. 用于家用制冷制造商转型的增支资本成本包括氦气相关设备、R-600a 相关设备、超声波焊接机、安全设备和改造/升级、装配线改造和备件费用；以及安装、原型开发和测试、培训、安全认证和应急费用。该行业制造企业的增支资本成本总额为 6,999,685 美元。计算得出的各项增支资本成本详情见表 12。

表 12. 家用制冷行业制造商转型项目的增支资本成本

企业	Electrostar		Alaska		Kiriazi		Fresh		Unionaire	
项目	数量	美元	数量	美元	数量	美元	数量	美元	数量	美元
氦气检漏系统（充注设备；检测器和校准器；和回收设备）	3	215,550	1	71,850	1	71,850	6	431,100	2	143,700
R-600a 供应系统（充注机、泵和检漏仪	3	231,450	5	385,750	6	462,900	6	462,900	2	154,300
超声波焊接机	3	90,000	5	150,000	6	180,000	6	180,000	2	60,000
安全基础设施（通风；安全控制和气体监测；防静电地板）	3	188,100	5	313,500	6	376,200	6	376,200	2	125,400
装配线改造	3	27,000	5	45,000	6	54,000	6	54,000	2	18,000
备件	3	36,000	5	60,000	6	72,000	6	72,000	2	24,000
设备小计	**不适用**	**788,100**	**不适用**	**1,026,100**	**不适用**	**1,216,950**	**不适用**	**1,576,200**	**不适用**	**525,400**

企业	Electrostar		Alaska		Kiriazi		Fresh		Unionaire	
项目	数量	美元	数量	美元	数量	美元	数量	美元	数量	美元
安装、交付、原型开发、测试和培训	3	146,100	5	243,500	6	292,200	6	292,200	2	97,400
安全审计和认证	3	60,000	5	100,000	6	120,000	6	120,000	2	40,000
设备应急费用（6.4%至 7.3%）	不适用	57,300	不适用	66,760	不适用	78,675	不适用	114,600	不适用	38,200
增支资本成本共计	**不适用**	**1,051,500**	**不适用**	**1,436,360**	**不适用**	**1,707,825**	**不适用**	**2,103,000**	**不适用**	**701,000**

82. 根据第 95/86(a)号决定商定的阈值，家用制冷行业采用了 5.75 美元/千克的增支经营成本。表 13 展示了家用制冷制造商拟议的增支经营成本、项目总成本和成本效益。

表 13. 家用制冷制造商的增支经营成本、增支资本成本、申请供资额和成本效益

企业	生产线数量	消费量（2023 年）		申请供资额			成本效益	
		千克	吨二氧化碳当量	增支经营成本（美元）	增支资本成本（美元）	共计（美元）	美元/千克	美元/吨二氧化碳当量
Electrostar	3	48,961	70,014	281,526	1,051,500	1,333,026	27.23	19.04
Alaska	5	49,000	70,070	281,750	1,436,360	1,718,110	35.06	24.52
Kiriazi	6	38,824	55,518	223,238	1,707,825	1,931,063	49.74	34.78
Fresh	6	158,500	226,655	911,375	2,103,000	3,014,375	19.02	13.30
Unionaire	2	11,004	15,736	63,273	701,000	764,273	69.45	48.57
El Araby*	3	39,304	56,204	不适用	不适用	不适用	不适用	不适用
共计	**25**	**345,584**	**494,197**	**1,761,162**	**6,999,685**	**8,760,847**	**25.35**	**17.73**

*基准设备已经包括使用 R-600a 的设备，企业已经生产了一些使用 R-600a 的家用冰箱。

83. 家用制冷制造业 5 家中小型企业进行转型所需资金总额估计为 2,476,020 美元；然而，根据第 95/86(d)(一)号决定，所申请的 315,732 美元的金额按 18.16 美元/千克计算（较家用制冷行业中小型企业 13.76 美元/千克的成本效益阈值高 32%，适用于氢氟碳化物消费量 15 公吨及以下企业），以吨二氧化碳当量计算的成本效益为 12.70 美元/吨二氧化碳当量。表 14 详细列出了核算费用及申请金额。

表 14. 消费量低于 15 公吨的家用制冷行业中小型企业的核算费用、申请供资额和成本效益

企业	生产线数量	消费量（2023 年）		核算费用			申请供资额（美元）
		千克	吨二氧化碳当量	增支资本成本（美元）	增支经营成本（美元）	合计（美元）	
Alradwan 国际	1	3,240	4,633	350,500	106,590	457,090	58,849
Minlo	1	4,737	6,774	350,500	387,600	738,100	86,039
Akwarj	1	3,000	4,290	350,500	93,670	444,170	54,490
Mas 电气	1	2,100	3,003	350,500	67,830	418,330	38,143
Trust for Ind.	1	4,306	6,158	350,500	67,830	418,330	78,211
共计	**5**	**17,383**	**24,858**	**1,752,500**	**723,520**	**2,476,020**	**315,732**

84. 4 家超小型企业的消费量均低于 1.5 公吨，其申请供资基于 34.40 美元/千克的成本效益标准计算（依据第 95/86(e)号决定，对于消费量低于 1.5 公吨的企业，可获得的资助额度最高可达为制造商所设定的商定成本效益阈值的 2.5 倍）；但每家企业最低申请金额为 30,000 美元。表 15 详细列出了核算费用及申请金额。

表 15. 消费量低于 1.5 公吨的家用制冷行业超小型企业的申请供资额和成本效益

企业	生产线数量	消费量（2023 年）		申请的增支经营成本	成本效益	
		千克	吨二氧化碳当量	成本效益 34.40 美元/千克，最低 30,000 美元	美元/千克	美元/吨二氧化碳当量
Tredco	1	1,395	1,995	47,988	34.40	24.05
东方工程企业	1	900	1,287	30,960	34.40	24.06
Elsaeedy 电子电器	1	340	486	30,000	88.24	61.73
Tiba	1	211	301	30,000	142.31	99.67
共计	**4**	**2,846**	**4,069**	**138,948**	**48.82**	**34.15**

二. 商用制冷制造业

85. 如提交的内容所示，Miraco 公司作为制造商，将通过一条生产线淘汰总计 21.50 公吨（30,745 吨二氧化碳当量）HFC-134a 和 8.50 公吨（3,922 吨二氧化碳当量）R-404A。6 家中小型企业将淘汰九条生产线的 33.10 公吨（47,336 吨二氧化碳当量）HFC-134a，并淘汰一条生产线的 2.36 公吨（9,255 吨二氧化碳当量）R-404A；4 家超小型企业将淘汰四条生产线的 1.62 公吨（2,313 吨二氧化碳当量）HFC-134a、0.29 公吨（1,141 吨二氧化碳当量）R-404A 和 0.55 公吨（976 吨二氧化碳当量）R-407A。所有企业都将转用 R-290 或 R-452B 等氢氟烯烃混合物，共计将在 14 条生产线上淘汰 67.92 公吨（95,688 吨二氧化碳当量），如下表 16 所示。

表 16. 商用制冷企业、生产设备量、生产线和 2023 年消费量

企业	成立年份	氢氟碳化物	生产线数量	设备量 (2023 年)	消费量（2023 年）		拟议在基加利氢氟碳化物执行计划中进行转型或氟氯烃淘汰管理计划上一个阶段涵盖的行业
					公吨	吨二氧化碳当量	
制造商							
Miraco*	1995 年	HFC-134a	1	4,300	21.50	30,745	氟氯烃淘汰管理计划第二阶段下的住宅空调和商用空调
		R-404A		1,700	8.50	3,922	
制造商小计	**不适用**	**不适用**	**1**	**6,000**	**30.00**	**34,667**	**不适用**
中小型企业							
Alradwan 国际	2008 年	HFC-134a	1	65,000	13.00	18,590	家用制冷基加利氢氟碳化物执行计划
Trust for Ind.	2017 年	HFC-134a	1	14,650	4.33	6,188	家用制冷基加利氢氟碳化物执行计划
Everest 埃及工业公司**	2003 年	HFC-134a	1	35,349	9.50	13,587	聚氨酯泡沫塑料氟氯烃淘汰管理计划第二阶段
ICEBERG	2019 年	HFC-134a	1	2,500	1.07	1,530	
		R-404A		1,385	2.36	9,255	
埃及海湾公司	2006 年	HFC-134a	2	7,890	2.68	3,837	
Makka 冰箱	2006 年	HFC-134a	3	21,000	2.52	3,604	
中小型企业小计	**不适用**	**不适用**	**9**	**147,774**	**35.46**	**56,591**	**不适用**
超小型企业							
Ratomag	1975 年	HFC-134a	1	169	0.18	255	
		R-404A		40	0.04	165	
DRIC	1988 年	HFC-134a	1	3,333	1.00	1,430	
		R-407A		28	0.55	976	
MOG		HFC-134a	1	1,070	0.30	428	

企业	成立年份	氢氟碳化物	生产线数量	设备量 (2023年)	消费量（2023年）		拟议在基加利氢氟碳化物执行计划中进行转型或氟氯烃淘汰管理计划上一个阶段涵盖的行业
					公吨	吨二氧化碳当量	
	1961年	R-404A		830	0.25	976	聚氨酯泡沫塑料氟氯烃淘汰管理计划第一阶段
Masria	1985年	HFC-134a	1	1,550	0.14	200	
超小型企业小计	**不适用**	**不适用**	**4**	**7,020**	**2.46**	**4,430**	**不适用**
共计	**不适用**	**不适用**	**14**	**160,795**	**67.92**	**95,688**	**不适用**

*根据提交的内容，Miraco 公司的氢氟碳化物消费量为 30 公吨。该消费量随后修订为 2023 年总消费量为 7 公吨，产量为 6,000 台，2020-2022 年的平均消费量为 5.5 公吨，平均产量为 5,533 台。
**Everest 埃及工业公司还生产使用 R-290 的瓶装冷却器，该公司是阿联酋控股的企业。

86. 一家制造商转用 R-290 所需的增支资本成本，与上文第 78 段所述家用制冷行业类似，但需配备 R-290 相关设备。该行业制造企业的增支资本成本总额为 350,500 美元。表 17 详细列出了核算的各项增支资本成本。

表 17. 商用制冷行业制造商转型项目的增支资本成本

企业	Miraco	
项目	数量	美元
氦气检漏系统	1	71,850
R-290 相关供应系统、充注机和检漏仪	1	77,150
超声波焊接机（30,000 美元）	1	30,000
安全相关基础设施	1	62,700
装配线改造	1	9,000
备件	1	12,000
小计	**不适用**	**262,700**
安装、交付、原型开发、测试和培训	1	48,700
安全审计和认证	1	20,000
设备应急费用（6.4%至 7.3%）		19,100
增支资本成本合计	**不适用**	**350,500**

87. 针对商用制冷制造商，申请的增支经营成本按 3.00 美元/千克计算。表 18 展示了商用制冷制造商拟议的增支经营成本、项目总成本和成本效益。

表 18. 商用制冷制造商的增支经营成本、增支资本成本、申请供资额和成本效益

企业	生产线数量	消费量（2023年）		申请供资额			成本效益	
		千克	吨二氧化碳当量	增支经营成本(美元)	增支资本成本(美元)	合计（美元）	美元/千克	美元/吨二氧化碳当量
Miraco	1	30,000	34,667	90,000	350,500	440,500	14.68	12.71

88. 为商用制冷制造业的 6 家中小型企业转型核算的供资总额为 2,197,263 美元，其中 Trust for Ind.公司的增支资本成本未予计算，而对 ICEBERG 公司，则分别计算了 HFC-134a 和 R-404A 转型的增支经营成本。但是，根据第 95/86(d)(一)号决定，申请金额按 21.78 美元/千克计算（较商用制冷行业中小型企业 16.50 美元/千克的成本效益阈值高出 32%，适用于氢氟碳化物消费量 15 公吨及以下企业）。对于仅需转换 HFC-134a 的企业，按吨二氧化碳当量计算的成本效益为 15.23 美元/吨二氧化碳当量，对于同时转换 HFC-

134a 和 R-404A 的 ICEBERG 公司，成本效益为 6.93 美元/吨二氧化碳当量。表 19 详细列出了核算费用及申请金额。

表 19. 消费量低于 15 公吨的商用制冷行业中小型企业的核算费用、申请供资额和成本效益

企业	生产线数量	消费量（2023 年）		核算费用			申请供资额（美元）
		千克	吨二氧化碳当量	增支资本成本 (美元)	增支经营成本 (美元)	合计（美元）	
Alradwan 国际	1	13,000	18,590	350,500	227,500	578,000	283,140
Trust for Ind.	1	4,328	6,188	0	51,275	51,275	94,264
Everest 埃及工业公司	1	9,502	13,587	350,500	51,275	401,775	206,954
ICEBERG	1	3,430	10,785	350,500	13,598*	364,098	74,705
埃及海湾公司	2	2,683	3,837	350,500	27,615	378,115	58,436
Makka 冰箱	3	2,520	3,604	350,500	73,500	424,000	54,886
共计	**5**	**35,463**	**56,591**	**1,752,500**	**444,763**	**2,197,263**	**772,385**

* 经核算，HFC-134a 和 R-404A 的增支经营成本分别为 8,750 美元和 4,848 美元。

89. 4 家超小型企业的消费量均低于 1.5 公吨，其申请供资基于 41.25 美元/千克的成本效益标准计算（依据第 95/86(e)号决定，对于消费量低于 1.5 公吨的企业，可获得的资助额度最高可达为制造商所设定的商定成本效益阈值的 2.5 倍），或 30,000 美元，以较低数额为准。表 20 详细列出了核算费用及申请金额。

表 20. 消费量低于 1.5 公吨的商用制冷行业超小型企业的申请供资额和成本效益

企业	生产线数量	消费量（2023 年）		申请供资额（美元）	成本效益	
		千克	吨二氧化碳当量		美元/千克	美元/吨二氧化碳当量
Ratomag	1	220	420	30,000	136.26	71.43
DRIC	1	1,550	2,406	63,938	41.25	26.57
MOG	1	549	1,404	30,000	54.64	21.37
Masria	1	140	200	30,000	214.29	150.00
共计	**4**	**2,459**	**4,430**	**153,938**	**62.60**	**34.75**

三. 住宅空调制造业

90. 住宅空调行业的4家制造商将通过在六条生产线进行转型淘汰 169.25 公吨（353,320 吨二氧化碳当量）R-410A，[30] 一家中小型企业将通过一条生产线淘汰 9.95 公吨（20,779 吨二氧化碳当量）R-410A，一家超小型企业将通过一条生产线淘汰 0.49 公吨（1,015 吨二氧化碳当量）R-410A。所有企业将转用 HFC-32，共计在住宅空调行业的八条生产线中淘汰 179.70 公吨（375,114 吨二氧化碳当量）R-410A。下表 21 提供了该行业企业的概况。

表 21. 住宅空调企业、生产设备量、生产线和 2023 年消费量

企业	成立年份	生产线数量	生产设备量（2023 年）	消耗量（2023 年）	
				公吨	吨二氧化碳当量
制造商					
Kiriazi*	2017 年	1	39,440	41.40	86,431
Raya Electric	2019 年	1	30,738	27.66	57,749
Free Air	2016 年	3	62,650	64.55	134,754
Tiba**	2010 年	1	24,697	35.63	74,386

[30] 所提交的转型项目基于 2023 年的消费量。

企业	成立年份	生产线数量	生产设备量（2023年）	消耗量（2023年）	
				公吨	吨二氧化碳当量
制造商小计	**不适用**	**6**	**157,525**	**169.25**	**353,320**
中小型企业					
Elteriak	2018年	1	10,000	9.95	20,779
中小型企业小计	**不适用**	**1**	**10,000**	**9.95**	**20,779**
超小型企业					
Helwan 工业	?	1	400	0.49	1,015
超小型企业小计	**不适用**	**1**	**400**	**0.49**	**1,015**
合计	**不适用**	**8**	**167,925**	**179.70**	**375,114**

*基加利氢氟碳化物执行计划中拟进行转型或氟氯烃淘汰管理计划上一个阶段涵盖的行业：家用制冷基加利氢氟碳化物执行计划和聚氨酯泡沫塑料氟氯烃淘汰管理计划第二阶段。
**由于 Tiba 公司 2023 年产量下降（其他制造商未出现此情况），采用了其基准年消费量和产量数据以替代 2023 年数据。

91. 住宅空调制造商进行转型的增支资本成本包括：充注与回收相关设备、检漏设备、超声波焊接机、安全相关设备、装配线改造及备件（数量根据生产线数量确定）。此外，增支资本成本还包括安装费、交付费用、培训费、顾问费、安全认证费和应急费用。该行业制造企业的增支资本成本总额为 2,489,800 美元。表 22 详细列出了核算的增支资本成本。

表 22. 住宅空调行业制造商转型项目的增支资本成本

企业	Kiriazi	Raya 电气	Free Air	Tiba
生产线数量	1	1	3	1
充注和回收：充注机、制冷剂供应泵和回收机	92,000	92,000	276,000	92,000
检漏：工业检漏仪，包括校准和手持式碳氢化合物检漏仪	17,000	17,000	51,000	17,000
超声波焊接机	30,000	30,000	90,000	30,000
安全相关：通风系统；充注区安全控制及气体监测系统；充注区防静电地板；储存区通风；储存区防静电地板；	93,700	93,700	255,100	93,700
装配线改造和运行测试区	89,000	89,000	267,000	89,000
备件	20,000	20,000	60,000	20,000
小计	**341,700**	**341,700**	**999,100**	**341,700**
安装、交付、培训和顾问	33,700	33,700	101,100	33,700
安全认证	20,000	20,000	60,000	20,000
设备应急费用（7.0%至 7.2%）	23,900	23,900	71,700	23,900
增支资本成本合计	**419,300**	**419,300**	**1,231,900**	**419,300**

92. 住宅空调行业的增支经营成本按 6.5 美元/台（而非根据第 95/86(a)号决定按 7.60 美元/千克制冷剂消费量）计算。之所以提出这一要求，是因为该行业的生产更取决于生产线数量，而这些生产线均需进行转型，以确保成功淘汰 R-410A。表 23 展示了住宅空调制造商拟议的增支经营成本、项目总成本和成本效益。

表 23. 住宅空调制造商的增支经营成本、增支资本成本、申请供资额和成本效益

企业	生产线数量	生产设备量（2023年）	消费量（2023年）		申请供资额			成本效益	
			千克	吨二氧化碳当量	增支经营成本(美元)	增支资本成本(美元)	合计（美元）	美元/千克	美元/吨二氧化碳当量
Kiriazi	1	39,440	41,404	86,431	256,360	419,300	675,660	16.32	7.82

企业	生产线数量	生产设备量（2023年）	消费量（2023年）		申请供资额			成本效益	
			千克	吨二氧化碳当量	增支经营成本(美元)	增支资本成本(美元)	合计（美元）	美元/千克	美元/吨二氧化碳当量
Raya Electric	1	30,738	27,664	57,749	199,797	419,300	619,097	22.38	10.72
Free Air	3	62,650	64,553	134,754	407,225	1,231,900	1,639,125	25.39	12.16
Tiba	1	24,697*	31,321	65,383	160,531	419,300	579,831	16.27	7.79
共计	**6**	**157,525**	**169,255**	**353,320**	**1,023,913**	**2,489,800**	**3,513,713**	**20.76**	**9.94**

*Tiba 公司的计算基于 2020-2021 年平均产量（如表所示）。而这些企业的增支经营成本则使用 2023 年产量计算得出。

93. 根据 17.95 美元/千克的成本效益阈值（根据第 95/86(d)(一)号决定，比 13.60 美元的成本效益阈值高出 32%），住宅空调制造业一家中小型企业进行转型申请供资为 178,694 美元，申请金额计算如表 24 所示。

表 24. 消费量低于 15 公吨的住宅制冷行业中小型企业的核算费用、申请供资额和成本效益

企业	生产线数量	消费量（2023年）		核算费用			申请供资额（美元）
		千克	吨二氧化碳当量	增支资本成本（美元）	增支经营成本（美元）	合计（美元）	
Elteriak	1	9,954	20,779	419,300	65,000	484,300	178,694
共计	**1**	**9,954**	**20,779**	**419,300**	**65,000**	**484,300**	**178,694**

94. 根据 34.00 美元/千克的成本效益阈值，住宅空调制造业一家超小型企业进行转型申请供资为 30,000 美元（依据第 95/86(e)号决定，对于消费量低于 1.5 公吨的企业，可获得的资助额度最高可达为制造商所设定的商定成本效益阈值的 2.5 倍），并采用 30,000 美元的最低申请金额。表 25 详细列出了核算费用及申请金额。

表 25. 消费量 1.5 公吨或不足 1.5 公吨的住宅空调行业超小型企业的核算费用、申请供资额和成本效益

企业	生产线数量	生产设备量(2023年)	消费量（2023年）		申请的增支经营成本	成本效益	
			千克	吨二氧化碳当量	成本效益 34.40 美元/千克，最低 30,000 美元	美元/千克	美元/吨二氧化碳当量
Helwan 工业	1	400	486	1,015	30,000	61.73	29.57
共计	**1**	**400**	**486**	**1,015**	**30,000**	**61.73**	**29.57**

维修和其他行业的非投资活动

95. 维修、计量吸入器和消防行业的非投资活动拟在第一阶段和第一次付款下执行，其费用细目见表 26。

表 26. 埃及提交的基加利氢氟碳化物执行计划第一阶段和第一次付款下维修、计量吸入器和消防行业的非投资活动和费用

组成部分	活动	机构	费用（美元）	
			阶段	第一次付款
1. 监管框架和控制机制	加强氢氟碳化物政策和监管框架： • 审查和更新逐步减少氢氟碳化物的政策和监管框架； • 更新劳动能力标准，制定/更新天然制冷剂安全标准以及其他法规和标准； • 举办关于监管调整的有关利益方会议/讲习班/传播活动； • 对有关政府机构进行法律和监管措施方面的培训； • 制定制冷和空调行业循环经济模式；	开发署	250,000	125,000

组成部分	活动	机构	费用（美元）	
			阶段	第一次付款
	• 开展住宅制冷和空调行业补贴或税收措施的经济影响研究；以及 • 建立中型和大型最终用户的登记制度以及更新流程。			
	关于更新氢氟碳化物控制政策和法规的培训方案： • 为海关/边境管制官员举办六期培训班；为进口商举办三期培训班；设计/更新包含边境管控手册在内的培训材料； • 开发一款应用程序，以协助海关官员进行法规管控与执法工作，并制定一套电子化培训方案； • 为海关中央实验室采购十台制冷剂识别器和一台新型气相色谱仪；以及 • 审查和更新许可证和配额制度程序，包括核算以吨二氧化碳当量为单位进行配额控制。		322,000	88,700
	性别平等方案： • 聘请专家开展制冷和空调行业性别平等研究，包括确定障碍与关键行动领域，并制定性别平等行动计划；以及 • 鼓励妇女参与执行工作的宣传活动，包括举办六期讲习班，每次有 50 至 80 名有关利益方参加，并编制宣传材料。		156,000	78,000
	监管框架和控制机制小计	开发署	728,000	291,700
2. 技术员的能力建设	审查/更新标准、准则以及制冷和空调相关课程： • 审查/更新涵盖各行业和新技术的业务守则； • 制定移动空调维修标准与指南，并翻译相关材料，以供传播； • 为利益方开展提高认识运动和讲习班，包括培训机构的工作人员、国家协会成员、培训员、监管人员和再循环中心运营商；以及 • 更新移动空调培训课程，确保与国家采用的标准衔接。	工发组织	80,000	80,000
	将技术员认证扩展至移动空调行业： • 组建技术专家与国家有关利益方委员会，基于更新后的移动空调课程编制新的认证方式； • 建立有潜力成为移动空调维修技术员的数据库，以便进行认证； • 在全国各地举办 23 次宣传讲习班，以促进移动空调认证；以及 • 对 100 名评估员进行移动空调认证方面的培训。		250,000	95,000
	为 900 家移动空调及制冷和空调车间提供工具：[31] • 进行调查，以确定移动空调和制冷和空调车间分布及需求，并采购和交付设备。		2,295,000	510,000
	为五个地区设立五个移动空调培训中心，并建立/升级五个制冷和空调培训中心：[32] • 与移动空调制造商进行研究和协商，以确定中心选址和需求；		1,000,000	418,000

[31] 包括提供设备和工具，如氢氟碳化物回收装置、各种软管、过滤器、制冷剂瓶、电子秤、真空泵、电子检漏仪、成套螺丝刀、扩管和型锻工具、内六角扳手、切管器。

[32] 包括教学培训模块（每个中心三个）、回收装置、真空泵、制冷剂识别器、锁环装置、检漏仪、四阀歧管压力表和维修工具。其他费用包括安全评估和安全升级/准备（例如警报系统、强制通风系统、烟雾和检漏仪以及防爆电气连接）的相关费用。

组成部分	活动	机构	费用（美元）	
			阶段	第一次付款
	• 采购工具并聘请安全专家；以及 • 在建成的中心开展其他外联活动。			
	培训和测试 1,000 名移动空调和 1,000 名制冷和空调技术员： • 通过英才中心和培训机构举办为期三天的培训班，内容涉及良好做法、钎焊能力、易燃制冷剂的安全使用以及认证测试的准备工作。		400,000	160,000
	在主要品牌的制冷和空调及移动空调服务中心对 1,250 名技术员进行售后培训： • 使用适当的工具和技术，针对故障诊断与故障排除、安全规范以及行业标准，提供深入指导。		250,000	10,0000
技术员能力建设小计		工发组织	4,275,000	1,363,000
3. 外联和宣传	在各行业（计量吸入器、移动空调、制冷和空调）开展宣传运动，提高对逐步减少、提高能效和可持续冷却的认识： • 编制外联材料、举办一年两次的圆桌会议、开展四次有针对性的讲习班，并开展线上互动活动。	工发组织	400,000	160,000
	开展宣传活动，宣传泡沫塑料行业的活动，并提高对监管变化的认识： • 编制外联材料、开展有针对性的讲习班，并让多媒体参与其中。	开发署	180,000	65,000
外联和宣传小计		工发组织	400,000	160,000
		开发署	180,000	65,000
4. 行业项目 (a) 住宅空调	住宅空调中使用 R-290 的热泵示范项目： • 设定项目与受益方遴选流程； • 出台激励政策，鼓励企业向消费者提供最多 200 台设备； • 提供安装和预防性维护方面的技术援助，并为每个培训中心配备一台使用 R-290 的设备；以及 • 监测和报告方案成果。	工发组织	140,000	15,000
	住宅分体式空调应用的两种非同型[33]直接—间接蒸发冷却（D-IEC）技术[34]的示范项目： • 制造容量为 5 至 7.5 千瓦的 D-IEC 原型设备； • 在经认证的实验室中进行能效及其他功能测试，[35]并与相同容量的个别分体式空调机进行比较； • 进行财务分析，并准备相关材料，将原型设备的净现值与其他个别分体式空调机进行比较；以及 • 编制最后报告并传播成果，包括举办讲习班和参观新装设施。	工发组织	125,000	45,000

[33] 非同型冷却技术是指除蒸汽压缩冷却系统之外的任何替代性冷却系统。

[34] 直接—间接蒸发冷却：首先利用间接蒸发冷却对空气进行预冷，且过程中不增加空气湿度。预冷后的空气再经过直接蒸发冷却，使其温度进一步降低。这种组合方式能在控制湿度的同时最大限度地提高冷却效率，因而适用于广泛应用场景。

[35] 在埃及测试条件下，需测试的参数包括系统的能效、制冷量、室内干球温度以及室外干球温度和湿球温度。

组成部分	活动	机构	费用（美元）	
			阶段	第一次付款
	替代多分体式空调机的三项非同型冷水机组的示范项目： • 制造容量为 10 至 17.5 千瓦的冷水系统原型设备； • 在经认证的实验室进行能效及其他功能测试，并与相同容量多分体式空调机进行比较； • 进行财务分析，并准备相关材料，将原型设备的净现值与其他个别分体式空调机进行比较；以及 • 编制最后报告并传播成果，包括举办讲习班和参观新装设施。	工发组织	135,000	55,000
行业项目 (b) 商用空调	商用空调中非同型深海冷却[36]技术示范项目： • 聘请一名顾问，确定在两个新开发项目中利用深海冷却技术进行分区冷却的可行性； • 在亚喀巴湾深层水域使用遥控潜水器收集数据； • 确定一个受益方，用示范技术替换一家酒店的一台拟议容量为 350 千瓦的冷水机； • 对现有冷水机及替代技术进行为期六个月的性能测量；以及 • 编制最后报告并传播成果，包括举办讲习班、组织考察埃及现有设施并参观新装设施。	工发组织	360,000	40,000
4. 行业项目 (c) 移动空调和制冷和空调行业	移动空调行业考察、当地市场接受度和风险评估，以及制冷和空调行业考察： • 前往致力于低全球升温潜能值移动空调技术（包括 R-744 和 R-290）的研发中心和实验室进行考察研究，使利益方能够获取这些技术，并在其制造设施中采用这些技术。 • 调查当地市场对移动空调行业天然制冷剂的接受程度，并进行风险评估，配合考察活动提升行业对直接采用天然制冷剂的兴趣，并通过讲习班传播考察成果；以及 • 组织学习考察活动，观察正在使用的低全球升温潜能值制冷和空调替代技术，推广其应用，并了解相关法规如何帮助各国保持合规并实现逐步减少氢氟碳化物的目标。	工发组织	150,000	60,000
4. 行业项目 (d) 计量吸入器行业	计量吸入器行业和研究项目考察： • 对专门从事低全球升温潜能值推进剂技术（包括 HFO-1234 ze(E)和 R-290）的研发中心和实验室进行考察，以便相关利益方能够接触尖端创新技术，并将这项技术用于制造计量吸入器；以及 • 基于这些技术构建原型，并进行实地试验，进行涵盖技术引入障碍和环境效益的市场可行性研究，并举办讲习班以传播成果。	工发组织	160,000	60,000
4. 行业项目 (e) 消防行业	为将氢氟碳化物作为灭火剂提供技术援助与进行监测： • 编制一份进口、销售、使用、安装和重新充装氢氟碳化物消防设备和防洪系统的企业清单； • 宣传和编制/印刷关于维护和充装便携式灭火器的最佳做法手册； • 协调一个工作组，以提升海关编码方面的技术能力，以管控消防行业使用的气瓶的贸易；	开发署	520,000	162,000

[36] 深海冷却技术利用深海中的自然低温为建筑物和工业过程提供冷却。与传统的空调系统相比，这种方法可显著减少能耗和温室气体排放。

组成部分	活动	机构	费用（美元）	
			阶段	第一次付款
	• 为行业代表组织两期考察活动，前往具有无氢氟碳化物灭火器使用经验的组织学习； • 展示应用实例，并评估反应时间和损害减少情况； • 建立一个符合氟化气体消防防护、安全操作及回收处理国际标准的培训考核中心，该中心可获得职业资格机构认证；以及 • 为应用者和用户编制信息材料。			
4. 行业项目 (f) 制冷运输行业	向制冷运输次级行业提供技术援助： • 确定次级行业的所有有关利益方、相关技术和应用（集装箱卡车、小型卡车、冷藏船或船舶制冷）的，分析使用消费趋势，以及替代技术的准备情况；并评估售后维修能力； • 为中小型企业和安装人员举办关于新技术的讲习班，通过设计和采用合适的工具减少泄漏； • 通过安排个别参观为有关利益方提供技术援助。	工发组织	255,000	102,000
行业项目小计		工发组织	1,325,000	377,000
		开发署	520,000	162,000
维修行业活动合计*			**7,428,000**	**2,418,700**
工发组织小计			**6,000,000**	**1,900,000**
开发署小计			**1,428,000**	**518,700**

* 不包括第 96 段所讨论和下文表 27 所示项目监测。

项目执行、协调和监测

96. 项目监测和执行活动将通过国家臭氧机构执行，国家臭氧机构将负责数据收集、监测和报告编制，而项目管理股将负责项目执行，并为国家臭氧机构提供支持。开发署将与国家臭氧机构和项目管理股就泡沫塑料行业投资项目及其非投资活动进行协调，工发组织则将协调上文表 26 所列制冷和空调行业投资项目及其非投资活动的监测和执行工作。下文表 27 概述了监测和执行投资和非投资活动的费用。

基加利氢氟碳化物执行计划第一阶段的总费用

97. 第一阶段的拟议预算总额为 27,866,395 美元。根据第 92/37 号决定，制冷维修行业的活动费用拟议为 7,428,000 美元。基加利氢氟碳化物执行计划第一阶段的拟议组成部分和费用汇总于表 27。

表 27. 埃及基加利氢氟碳化物执行计划第一阶段要执行活动的拟议费用（美元）

行业	物质	淘汰		申请供资额（美元）	成本效益（美元/千克）	机构
		公吨	吨二氧化碳当量			
聚氨酯泡沫塑料	预混多元醇中的 HFC-365mfc/HFC-227ea、HFC-245fa、HFC-245fa	131.95	138,905	1,560,431	11.83	开发署
挤塑聚苯乙烯	HFC-152	386.67	47,947	2,195,211	5.68	开发署
泡沫塑料行业投资项目小计		518.62	186,852	3,755,642	7.24	开发署
泡沫塑料投资项目管理小计		不适用	不适用	375,564	不适用	开发署
家用制冷	HFC-134a	365.82	523,124	9,215,527	25.19	工发组织

行业	物质	淘汰		申请供资额（美元）	成本效益（美元/千克）	机构
		公吨	吨二氧化碳当量			
商用制冷	HFC-134a、R-404A、R-407A	67.92	95,688	1,366,823	20.12	工发组织
住宅空调	R-410A	179.70	375,114	3,722,407	20.72	工发组织
制冷和空调制造业投资项目小计		613.44	993,926	14,304,757	23.32	工发组织
制冷和空调投资项目管理小计		不适用	不适用	1,430,476	不适用	工发组织
维修行业	不适用	1,456.47	3,068,017	6,000,000	5.10	工发组织
				1,428,000		开发署
维修行业项目管理	不适用	不适用	不适用	462,000	不适用	工发组织
				109,956		开发署
总计	**不适用**	**2,558.53**	**4,248,795**	**27,866,395**	**10.77**	**不适用**

第一次付款执行计划

98. 目前已提交基加利氢氟碳化物执行计划第一阶段的第一次供资付款，总额为17,392,844 美元（包括上文表 26 所示用于维修行业活动的 2,418,700 美元)，将于 2025 年 6 月至 2027 年 12 月期间执行。关于第一次付款下将要开展的活动的详细信息，包括调整和商定的资金数额，载于下文第 145 段和本文件附件二。

秘书处的评论和建议

五. 评论

总体战略

99. 根据第 92/44 号决定，埃及政府表示坚定致力于在《蒙特利尔议定书》规定的目标日期前，支持削减氢氟碳化物消费量。[37]

100. 2023 年，埃及中央银行对埃及镑采取贬值策略，导致其对美元贬值约 40%，进而限制了氢氟碳化物的进口，无法满足增长的市场需求。2024 年，氢氟碳化物消费量增长16%（以吨二氧化碳当量计），部分原因是埃及在 2023 年货币贬值后实现复苏。尽管如此，2024 年的消费量仍较该国氢氟碳化物基准水平低 10.7%。

进口预混多元醇所含氢氟碳化物的受资助资格

101. 埃及是首个在其基加利氢氟碳化物执行计划中纳入纯氢氟碳化物及预混多元醇所含氢氟碳化物淘汰项目的国家。[38] 为了可持续地淘汰纯氢氟碳化物的消费，埃及还必须能够解决关于预混多元醇所含氢氟碳化物的问题。执行委员会正在本次会议的议程项目 10(c)下审议对第 5 条国家聚氨酯泡沫塑料行业进口预混多元醇所含氢氟碳化物问题的进一步分析（第 95/88(b)号决定）。尽管执行委员会尚未决定是否将资助淘汰进口预混多元醇所含氢氟碳化物，但秘书处根据其在 UNEP/OzL.Pro/ExCom/96/59 号文件中所提方法审议了埃

[37] 根据 2025 年 1 月 22 日埃及环境部致工发组织的信函。
[38] 此前，执行委员会决定，是否开展聚氨酯泡沫塑料行业进口预混多元醇所含氢氟碳化物淘汰项目，将取决于执行委员会就是否为淘汰进口预混多元醇所含氢氟碳化物提供资金而作出的决定。

及的聚氨酯泡沫塑料制造项目。具体而言，确定符合资助条件的费用所依据的是 2022 年至 2024 年在国内销售供聚氨酯泡沫塑料企业使用的氢氟碳化物的消费量。在其与工发组织和开发署的讨论中，秘书处强调，其关于列入聚氨酯泡沫塑料制造转型项目的建议取决于执行委员会在议程项目 10(c)下可能作出的决定。

102. 秘书处注意到，埃及的第一阶段提案包含 2022 年至 2024 年进口预混多元醇所含氢氟碳化物的数量和类型；2020 年 1 月 1 日之前成立并采用进口多元醇系统的 32 家聚氨酯泡沫塑料企业名单，包括其中所含氢氟碳化物的数量和类型；完成淘汰使用进口预混多元醇所含氢氟碳化物的计划；以及埃及的一项承诺，即到最后一家泡沫塑料制造厂也转用非氢氟碳化物技术时，制定法规或政策，禁止聚氨酯泡沫塑料行业进口和使用纯氢氟碳化物和预混多元醇所含氢氟碳化物。此外，秘书处注意到，埃及将聚氨酯泡沫塑料行业列为优先事项符合第 95/86(g)号决定，同时，参与该项目的企业将完全转用低全球升温潜能值的替代品。

体制、政策和监管框架

氢氟碳化物许可证和配额制度

103. 根据第 87/50(g)号决定，工发组织确认埃及已实行了一个成熟、可执行的许可证和配额制度，用于监测氢氟碳化物的进出口。2025 年的配额设定为 19,290,350 吨二氧化碳当量的基准水平。进口商配额分配依据为上年度消费量，并为新进口商留出 10%的国家配额。

技术和费用相关问题

聚氨酯泡沫塑料制造业

104. 为澄清聚氨酯泡沫塑料制造企业报告的氢氟碳化物使用量与国家方案报告下提交的使用量之间的区别，开发署解释称，企业可能在报告使用量时无意中包含了阻燃剂及其他添加剂。因此，根据第 34/18 号和第 41/16 号决定，同意通过国家方案报告中的行业用量数据对项目和费用进行评估，如下文表 28 所示。

表 28. 聚氨酯泡沫塑料制造业纯氢氟碳化物及进口预混多元醇所含氢氟碳化物消费量*

氢氟碳化物	2020 年	2021 年	2022 年	2023 年	2024 年	2022-2024 年平均值
HFC-227ea	4.55	4.94	5.20	5.16	0.00	3.45
HFC-245fa	22.53	67.62	115.61	64.00	116.50	98.70
HFC-365mfc	30.45	33.06	34.80	0.00	33.00	22.60
进口预混多元醇所含 HFC-245fa	21.42	23.78	31.86	27.37	29.00	29.41
进口预混多元醇所含 HFC-365mfc	0.00	0.00	0.00	0.00	21.00	7.00
行业合计	**78.95**	**129.40**	**187.47**	**96.53**	**199.50**	**161.17**

* 埃及国家方案报告数据

105. 关于 El Araby 公司热水器聚氨酯泡沫塑料生产线转型项目，秘书处注意到，由于疏忽出错，申请的增支经营成本是按每千克聚氨酯泡沫塑料系统而不是按每千克发泡剂计算的。鉴于环戊烷的价格（3 美元/千克）低于 HFC-365mfc/HFC-227ea 混合物的价格（12 美

元/千克），因此，纠正上述计算错误后，可在总体上节省转型工作的费用。此外，秘书处注意到，该公司的两台高压发泡机可继续使用环戊烷，不过，为安全起见，需对设备进行封装处理。

106.　尽管从长远来看，若企业从使用 HFC-365mfc/HFC-227ea 转为使用环戊烷，可节省成本，但迄今为止，该企业并未选择这样做。该企业若要转换为使用环戊烷（一种易燃发泡剂），需要进行一些投资。因此，秘书处认为有必要进行资助，以便该公司能够及时进行转型，进而使埃及政府能够在 2028 年 1 月 1 日之前实施一项禁令，禁止进口纯 HFC-365mfc 和 HFC-245fa 及进口预混多元醇所含 HFC-365mfc 和 HFC-245fa。因此，在不构成先例的情况下，破例同意不考虑增支经营节余，并由秘书处建议提供总额 101,420 美元的资金，促进该企业转用环戊烷。该笔款项具体分配如下：10,000 美元用于技术援助、试验和调试（需注意的是，该企业此前已在氟氯烃淘汰管理计划下获得援助，用于其家用冰箱聚氨酯泡沫塑料生产线转用环戊烷）；30,200 美元用于发泡机、环戊烷储罐及管道铺设；25,000 美元用于通风及气体检测系统；17,000 美元用于电器改造；10,000 美元用于安全审计；以及占上述费用 10%的应急费用（9,220 美元）。根据 2022–2024 年的平均氢氟碳化物消费量，El Araby 公司的转型将导致淘汰 22.60 公吨的 HFC-365mfc、3.45 公吨的 HFC-227ea，以及进口预混多元醇所含的 7.00 公吨 HFC-365mfc。

107.　关于将 31 家消费纯 HFC-245fa 和预混多元醇所含 HFC-245fa 的中小型企业转型的项目，秘书处注意到，HFC-245fa 的价格为 10 美元/千克、HFO-1233zd 的价格为 17 美元/千克和甲酸甲酯的价格为 6 美元/千克。若中小型公司转用甲酸甲酯，则可节余增支经营成本；而若中小型企业决定转用 HFO-1233zd，则会产生增支经营成本。秘书处认为，资助可使中小型企业受益，使其能够转用低全球升温潜能值替代品。因此，在不构成先例的情况下，并忆及埃及符合资助的系统厂家已在氟氯烃淘汰管理计划下获得援助，以便其能够为下游用户提供低全球升温潜能值系统，破例同意秘书处建议如下：

(a)　为系统厂家提供 124,000 美元，用于资助 31 家下游中小型企业，其中为每个下游用户提供 1,000 美元用于项目管理、3,000 美元用于试验、测试和培训；以及

(b)　根据 2022 年至 2024 年纯 HFC-245fa 及进口预混多元醇所含 HFC-245fa 平均进口量（128.11 公吨），并在不构成先例的情况下，破例根据 HFO-1233zd 的价格，为中小型企业提供 192,169 美元的增支经营成本。同时指出，在执行期间，中小型企业可灵活选择最适合其使用的低全球升温潜能值发泡剂。

108.　在此基础上，同意提供给 31 家中小型企业转用甲酸甲酯或 HFO-1233zd 的费用总额为 316,169 美元，该笔费用可实现淘汰 98.70 公吨的 HFC-245fa（101,663 吨二氧化碳当量）及进口预混多元醇所含的 29.41 公吨 HFC-245fa（30,292 吨二氧化碳当量）。开发署确认，没有任何中小型企业在氟氯烃淘汰管理计划获得过援助。若在执行过程中，发现任何中小型企业不符合资助条件，则将根据基加利氢氟碳化物执行计划第一阶段协定草案第 7(c)段向执行委员会报告，并根据协定草案第 7(d)段将转型工作相关资金退还给多边基金。

109.　为确保淘汰工作的可持续性，埃及政府将在 2028 年 1 月 1 日前实施一项禁令，禁止进口纯 HFC-245fa 和 HFC-365mfc 及进口预混多元醇所含 HFC-245fa 和 HFC-365mfc，

并禁止在聚氨酯泡沫塑料生产过程中使用氢氟碳化物。HFC-227ea 并非泡沫发泡剂，添加到 HFC-365mfc 中是为了降低可燃性，因此不会被禁用，将继续用于消防领域。

挤塑聚苯乙烯泡沫塑料制造业

110. 虽然挤塑聚苯乙烯制造业仅占将要实现的淘汰量的一小部分，但将其纳入基加利氢氟碳化物执行计划第一阶段，符合第 95/86(g)号决定和 XXVIII/2 号决定第 13 段为第 5 条国家提供的灵活性，其中规定，第 5 条国家可根据其具体需求和国情，按照国家驱动型方法，灵活地确定氢氟碳化物的优先次序、界定相关行业、选择技术和替代品，并制定和执行其战略，以履行商定的氢氟碳化物淘汰义务。

111. 在审查各企业的基准设备时，秘书处注意到，Al Almiya 公司的挤出机没有升级改造的必要，因为其与二氧化碳和二甲醚相兼容；同时，埃及泡沫塑料公司的挤出机生产于 2005 年，很可能已接近使用年限。为更好地掌握挤出机的升级改造成本，秘书处向一家挤塑聚苯乙烯泡沫塑料生产线供应商询价。兼容二氧化碳及二甲醚的全新挤塑聚苯乙烯泡沫塑料生产线单条离岸价格为 569,500 美元，其中包含自动上料搅拌系统、带液压滤网更换器的主挤出机、发泡剂计量系统、二级单螺杆挤出机和静态混合器、温控狭缝式模头、板材校准器和首段牵引系统、冷却架、纵切机、第二段牵引系统、在线定长切割系统、驱动辊、水平推料及边角切割机，以及控制系统。其中，主挤出机、发泡剂计量系统和二级单螺杆挤出机的报价为 238,000 美元。此外，秘书处注意到，HFC-152a 具有易燃性，各企业应已配备排气和通风系统以保证安全生产。

112. 基于上述对 Al Alamiya 公司挤出机以及各企业排气和通风系统所作调整；原申请中商定的费用（包括为每家企业配置二甲醚储罐、发泡剂泵和管道（165,000 美元）和气体传感器系统（30,000 美元）的费用和进行安全审计的费用（15,000 美元））；为每家企业提供的 50,000 美元技术援助和试验费用；根据第 18/25 号决定，还包括埃及泡沫塑料公司挤出机改造升级申请资金的 50%（即 258,000 美元）；以及 10%的应急费用，最终商定，为 Al Alamiya 公司和埃及泡沫塑料公司各提供 286,000 美元和 569,800 美元的增支资本成本。

113. 根据 HFC-152a（3.24 美元/千克）、二氧化碳（3.83 美元/千克）和二甲醚（2.00 美元/千克）的价格，以及含三分之二二氧化碳和三分之一二甲醚的发泡剂混合物的价格计算，经营成本每千克可节省 0.01 美元。根据 2023 年的消费量，Al Alamiya 公司和埃及泡沫塑料公司的增支经营成本可分别节省 1,599 美元和 1,182 美元。

114. 2020 年至 2024 年期间，HFC-152a 的进口量显著高于上述两家公司报告的消费量。开发署确认，埃及没有其他挤塑聚苯乙烯泡沫塑料制造公司使用 HFC-152a，玻璃制造业或气溶胶行业也没有使用 HFC-152a。因此，到 2028 年 1 月 1 日，埃及政府将禁止进口 HFC-152a，以确保转型工作的可持续性。

115. 基于上述情况，包括考虑到少量经营节余，Al Alamiya 公司转型的商定增支费用总额为 284,402 美元（用于淘汰 115 公吨 HFC-152a），埃及泡沫塑料公司转型的商定增支费用总额为 568,619 美元（用于淘汰 85 公吨 HFC-152a）。2023 年，HFC-152a 的进口量为 227 公吨。因此，剩余的 27 公吨 HFC-152a 将从埃及符合供资条件的剩余消费量中扣除。

家用制冷设备制造业

116. 关于制造商的拟议增支经营成本，秘书处注意到，根据埃及的报告，R-600a 的价格（4.74 美元/千克）低于 HFC-134a 的价格（6.43 美元/千克），从 HFC-134a 改用 R-600a，也可减少制冷剂的充注量，这可节省费用。此外，行业专家提供的信息表明，采用 R-600a 的家用冰箱制冷剂全球生产量超过了采用 HFC-134a 的压缩机生产量，前者的价格也通常更低，不过，两种压缩机的相对价格因本地供应链等因素而异。埃及的一家本土压缩机制造商能够为部分家用制冷设备制造业提供服务，[39] 与进口的 R-600a 压缩机相比，其提供的 HFC-134a 压缩机的价格具有竞争力。此外，建立 R-600a 压缩机供应链可能需要一定时间，这会导致初期成本相对高于建立 HFC-134a 压缩机供应链的成本。基于上述原因，并考虑到转用 R-600a 所需的安全相关调整费用，同意将增支经营成本定为零。

117. 秘书处和工发组织就用于 5 家大型制造企业转型的增支资本成本进行了详细讨论，商定进行以下调整：

(a) 根据提交的提案，原计划在充注区使用钢瓶存储 R-600a，由工作人员按需更换。考虑到生产线产能、R-600a 需求量以及与更换充注 R-600a 的钢瓶相关的潜在风险，秘书处建议改用配备相应管道、泵和安全装置的国际标准罐式集装箱，每家企业费用为 130,000 美元；但 Fresh 公司除外，鉴于该公司的产能较高，建议为该公司配备两套国际标准罐式集装箱、管道和相关安全装置；

(b) 由于 Fresh 公司消费量明显较高，产品型号更多，而且拥有两家工厂、合计六条生产线，因此相应增加供资，用于安全审计、培训以及原型开发和测试；

(c) 根据现行市场价格，大容量 R-600a 充注机的成本上调至 72,000 美元。工业级和手持式碳氢检漏仪的成本分别调整为每台 12,000 美元和 1,000 美元，超声波焊接机的成本调整为每台 25,000 美元。安全基础设施的成本下降至每条生产线 20,900 美元，应急费用调整为资本设备成本的 10%；

(d) 根据各企业的基准设备情况，Fresh 公司的超声波焊接机数量减少至 5 台；鉴于基准设备已具备 R-600a 检测能力，取消为 Fresh 公司和 Unionaire 公司配备工业级检漏仪；由于 Alaska 公司已拥有氦气检漏系统，Fresh 公司和 Unionaire 公司则已拥有碳氢检漏仪，因此取消相应供资；备件费用排除在供资范围之外，因为该费用属于企业常规的持续运营费用。

118. 基于上述调整，并根据第 95/86(a)号决定规定的成本效益阈值，商定的家 5 大型家用冰箱制造商转型的增支费用为 4,157,495 美元，如下文表 29 所示。

表 29. 2023 年 5 家大型家用冰箱制造商的消费量及商定增支费用

详情	Electrostar	Alasaka	Kiriazi	Fresh	Unionaire	合计
消费量（公吨）	48.96	49.00	49.97*	158.50	11.00	**317.43**

[39] 执行委员会在第八十七次会议上审议了该压缩机制造商从 HFC-134a 转用 R-600a 的项目，但未予核准。预计将根据第 95/87 号决定向第九十七次或第九十八次会议提交一个在逐步减少使用氢氟碳化物的背景下提高该公司所产压缩机能效的项目。

详情	Electrostar	Alasaka	Kiriazi	Fresh	Unionaire	合计
商定成本（美元）	673,703	674,240	687,601	1,970,536	151,415	4,157,494

*项目审查过程中对该企业的消费量数据进行了修正。

119. 秘书处和工发组织还详细讨论了 El Araby 公司的转型，该公司为纯本土企业，其家用冰箱生产线于 2020 年 1 月 1 日前建成，并未申请相应资助。公司已配备生产 R-600a 家用冰箱所需设备，因此无资格申请成本费用。不过，2020 年，该公司生产的冰箱有 88% 使用了 HFC-134a，2023 年这一比例仍高达 76%。秘书处注意到该企业超过四分之三的产能仍依赖 HFC-134a，因此认为有必要建议提供 50,000 美元技术援助资金，以使该公司能够按照本项目其他受援企业的时间节点（即 2028 年 1 月 1 日）完成向 R-600a 的转型。

120. 经过讨论，商定对于年消费量在 1.5 公吨到 15 公吨之间的中小型企业，每家企业进行转型的增支费用为 78,300 美元，该费用涵盖以下方面的费用：产品重新设计、原型开发和测试；制冷剂供应和充注系统改造；R-600a 检漏仪；安全基础设施和装配线改造；检查、调试和安全培训；技术援助；产品认证；以及应急费用。同样，对于年消费量在 1.5 公吨或不足 1.5 公吨的企业，商定每家企业进行转型的增支费用为 31,150 美元，这考虑到了上述要素，以及这些企业生产量较小的情况。

121. 虽然第 95/86(c)号决定所规定中小型企业定义中不包括家用制冷企业，但秘书处认为，在家用制冷设备制造领域，规模较小企业在逐步减少使用氢氟碳化物方面与制造商用制冷和空调领域的中小型企业类似，都面临财务和技术限制。因此，秘书处建议使用与第 95/86(c)号决定规定的中小型家用制冷和空调企业相同的定义，并以该决定(d) (一)和(e)段规定的中小型企业额外供资为准则。就后者而言，工发组织确认该项目包含该行业的所有剩余企业，并确认埃及将不再为家用制冷设备制造业的任何企业向多边基金申请供资。

122. 在氢氟碳化物年消费量低于 15 公吨的 9 家企业中，Alradwan 国际、Minlo、Tredco 工程与工业和 Tiba 不被视作是符合第 95/86(c)号决定定义的中小型企业（以企业消费总量或设备生产量为依据）。因此，这几家企业的增支费用是根据 78,300 美元与 13.76 美元/千克成本效益中的较低者商定的。对于消费量在 1.5 公吨以上的中小型企业（即 Akwarj、Mas Electric 和 Trust for Ind.），增支费用根据 78,300 美元与 18.16 美元/千克成本效益中的较低者商定；对于消费量在 1.5 公吨及以下的中小型企业，增量成本根据 31,150 美元与 34.40 美元/千克成本效益中的较低者商定（东方工程公司和 Elsaeedy 电子电器公司）。

123. 根据上述情况，如下文表 30 所示，家用制冷项目的商定供资总额为 4,552,856 美元。

表 30. 对家用制冷设备制造业的商定供资额

详情	数量	消费量（公吨）	商定供资额（美元）	成本效益（美元/千克）
大型企业（消费量高于 15 公吨）	5	317.43	4,157,494	13.10
El Araby	1	39.30	50,000	1.27
消费量在 1.5 公吨到 15 公吨之间的企业	5	17.38	280,607	16.14
消费量在 1.5 公吨及以下的企业	4	2.85	64,755	22.75
合计	**15**	**376.97**	**4,552,856**	**12.08**

商业制冷设备制造业

124. 秘书处力求更好地了解 Miraco 公司是否制造或组装冷凝机组，以及如何确保转型的可持续性，因为 Miraco 是唯一一家参与该项目的冷凝机组制造企业，在 Miraco 完成转型后，其他企业可继续组装和安装使用氢氟碳化物的冷凝机组。通过与工发组织开展讨论，并考虑到确保转型可持续性的挑战，同意将 Miraco 的转型从项目中移除。

125. 秘书处与工发组织详细讨论了单机商业制冷设备制造企业的转型问题。虽然 HFC-134a（6.43 美元/千克）与 R-290（6.40 美元/千克）的价格不相上下，但减少制冷剂充注量可节省经营成本。相比之下，R-290 压缩机的价格高于 HFC-134a 压缩机的价格，根据第 95/86(a)号决定，商定的增支经营成本为 5.5 美元/千克。

126. 根据第 23/14 号决定，在所提交的氢氟碳化物年消费量在 1.5 公吨到 15 公吨之间的 6 家中小型企业公司中，Everest 公司不符合资助条件，因为该企业为阿拉伯联合酋长国所有；根据第 95/96(c)(一)号决定，Alradwan 不属于中小型企业，因为其氢氟碳化物消费总量超过 15 公吨。鉴于 Alradwan 的制造产能较高，商定其增支资本成本为 82,496 美元。对于其余企业，商定每家企业的增支资本成本为 65,120 美元，涉及以下方面的费用：产品重新设计、原型开发和测试；制冷剂供应和充注系统改造；安全基础设施；技术援助；安全培训；产品认证和安全核查；以及 10%的应急费用。商定的 6 家企业转型成本依据为商定的增支资本成本和增支经营成本中的较低者，以及适用的成本效益阈值（Alradwan 为 16.50 美元/千克，其余中小型企业为 21.78 美元/千克），因此，6 家企业的商定转型成本为 430,947 美元，如下文表 31 所示。

127. 对于氢氟碳化物年消费量在 1.5 公吨及以下的 4 家企业，商定每家的增支资本成本为 25,300 美元。每家企业的商定转型成本基于商定增支资本成本和增支经营成本中的较低者，以及适用的成本效益阈值确定。虽然执行委员会规定了商业制冷的成本效益阈值（该阈值包含但不仅限于单机商业制冷设备），但秘书处注意到，工发组织也确认，该项目纳入了使用氢氟碳化物制造单机商业制冷设备的所有剩余企业，埃及政府将不再为任何制造此类设备的企业向多边基金提出供资申请。因此，秘书处建议对氢氟碳化物消费量在 1.5 公吨及以下的企业实行第 95/86(e)号决定规定的较高的成本效益阈值。在这方面，工发组织确认，DRIC 公司的消费量超过 1.5 吨，因此，该企业的适用阈值为 21.78 美元/千克，而对于其余 3 家企业，适用的成本效益阈值则为 41.25 美元/千克。故而，4 家企业的商定转型成本为 72,255 美元，如下文表 31 所示。

128. 根据上述情况，如下表 30 所示，商业制冷相关项目商定供资总额为 502,202 美元。

表 31. 对商业制冷设备制造商的商定供资额

详情	数量	消费量（公吨）	商定供资额（美元）	成本效益（美元/千克）
消费量在 1.5 公吨到 15 公吨之间的企业	6	35.46*	430,947	12.15
消费量在 1.5 公吨及以下的企业**	4	2.46	71,255	28.97
合计	**10**	**37.92**	**502,202**	**13.24**

* 包含 Everest 公司（不符合资助条件）的 9.50 公吨 HFC-134a 消费量。

** 包括消费量为 1.55 公吨的 DRIC 公司。

住宅空调制造

129. 秘书处回顾了埃及政府在氟氯烃淘汰管理计划下作出的承诺，即除其他外，确保对进口或投入本地市场的使用 R-410A 和 R-407C 的住宅空调机实行全面监管（第 84/72(e)(一)b 号决定），并确保本地市场采用 HFC-32（第 84/72(e)(一)b 号决定）；还回顾了参与氟氯烃淘汰管理计划第二阶段的 5 家企业作出的承诺，即除其他外，积极参与努力促进市场接受基于商定技术的住宅空调机（第 84/72(e)(四)号决定）。此外，秘书处还回顾了通过氟氯烃淘汰管理计划接受资助并签署了增支经营成本合同的企业在第九十四次会议上所做的承诺，即在 2025 年 1 月 1 日或 2026 年 12 月 31 日之前，按时完成当地市场向 HFC-32 技术的全面制造转型。基于上述承诺，以及如本文件第 25 至 26 段所述，这 5 家企业通过氟氯烃淘汰管理计划向采用 HFC-32 技术转型所取得的持续进展，秘书处认为，促进未在氟氯烃淘汰管理计划下获得援助且使用 R-410A 的制造商完成转型，对于埃及家用空调制造业的可持续转型具有关键意义。

130. 基于此，秘书处与工发组织就埃及其余使用 R-410A 制造住宅空调机的企业拟转用 HFC-32 的问题进行详细讨论，包括符合资助条件的成本，确保转型可持续性的政策措施，以及符合资助条件的氢氟碳化物消费量相关削减。将依次对这些问题进行讨论。

131. 行业专家提供的信息表明，过去五年间，HFC-32 压缩机的价格发生了显著变化。家用空调 HFC-32 压缩机的全球制造量已超过 R-410A 压缩机的制造量。制造量以及由此产生的规模经济是决定压缩机成本的主要因素，因此，HFC-32 压缩机的全球价格现在与 R-410A 压缩机的价格相当，甚至更低，不过，两种压缩机的相对价格可能因本地供应链等因素而存在一定差异。HFC-32 的价格（3.56 美元/千克）低于 R-410A 的价格（7.51 美元/千克），且从 R-410A 转换为 HFC-32 后，制冷剂充注量预计可减少 10%，这可节省经营成本。然而，考虑到企业需要建立 HFC-32 压缩机供应链，这可能会导致初期成本高于 R-410A 压缩机的制造成本，且需要做出小幅的安全相关调整，以完成向 HFC-32 的转型，因此同意将增支经营成本设定为零。

132. 秘书处和工发组织就用于 6 家企业中的五家企业（即 Kiriazi、Raya Electric、Free Air、Tiba 和 Elteriak）转型的增支资本成本开展了详细的讨论，商定进行以下调整：

(a) 根据既往项目的先例，对所有企业适用以下费用标准：超声波焊接机，价格为 25,000 美元；用于维修区域的 HFC-32 回收站（含气瓶），价格为 2,750 美元；工业级 HFC-32 检漏仪，价格为 12,000 美元；以及安全相关措施（包括通风系统、气体监测系统、防静电地板等），每条生产线 62,700 美元。另计占上述费用 10%的应急费用；

(b) 根据企业是否已经拥有能够处理 HFC-32 的基准设备，调整向企业提供的设备——因此，向每家企业各提供一台工业级检漏仪，Raya Electric 除外，该公司已有三台此类仪器；若基准设备是在 2020 年 1 月 1 日符合条件的产能截止日期之后购买的（如 Free Air 公司的供给泵），也要进行相应调整；

(c) 对于基准设备未配备回收站或手持式检漏仪的企业，破例按该设备费用的 50%提供资助，以满足良好做法的需要；以及

(d) 对消费量超过 20 公吨的企业，破例为每家额外再提供 25,000 美元，用于落实额外安全措施，包括外置制冷剂存储设备供应线、截止阀及其他安全措施。

133. 秘书处力求更好地了解 Helwan 工业公司的生产状况。该公司隶属埃及军工生产部，过去几年来未曾定期生产 R-410A 住宅空调机，名下一家工厂负责生产使用 R-600a 的家用冰箱。从该公司有限的 R-410A 消费量可以看出，其仅进口了少量的全散件组装套件，并在工厂内完成充注。基于此，商定由工发组织根据第 95/86 号决定规定的成本效益阈值向该公司提供技术援助（即 6,610 美元）。虽然 Helwan 和 Eletriak 两家公司的消费量均有限，但考虑到这两家公司还从事其他生产制造活动，同意不将其认定为中小型企业。不过，同意 Helwan 公司利用秘书处针对为家用和商用制冷设备制造行业提出的中小型企业专项技术援助方案所提供的技术援助，具体讨论见下文第 139 段。

134. 根据上文第 129 和 133 段所述的调整、企业 2023 年的消费量以及第 95/86 号决定规定的费用效益阈值，商定的 6 家企业转型的增支成本为 1,948,235 美元，如下文表 32 所示。

表 32. 6 家住宅空调机制造商转型的 R-410A 消费量和商定费用

	Kiriazi	Raya Electric	Free Air	Tiba	Eletriak	Helwan	合计
消费量（公吨）	41.40	27.66	64.55	19.69	9.95	0.49	**163.75**
商定费用（美元）	361,168	348,086	829,296	267,719	135,374	6,610	**1,948,253**

135. 虽然参加氟氯烃淘汰管理计划的住宅空调制造企业将于 2025 年 1 月 1 日（Unionaire）、2025 年 12 月 31 日（Power）或将于 2026 年 12 月 31 日前（El Araby、Fresh 和 Miraco）停止为当地市场生产使用 R-410A 的住宅空调，但参加基加利氢氟碳化物执行计划第一阶段的企业将需要更多时间来完成转型。因此，经商定，参与基加利氢氟碳化物执行计划的 6 家企业将在 2028 年 1 月 1 日之前停止生产使用 R-410A 的住宅空调机。为了确保行业转向 HFC-32 工作的可持续性，埃及政府将在 2029 年 1 月 1 日前禁止生产和进口使用 R-410A 的住宅空调机。

136. 工发组织指出，一家第 5 条国家所有的跨国企业在 2024 年建立了一条新的 R-410A 住宅空调生产线。随后，臭氧委员会做出了 2024 年第 2 号决定，禁止为使用 R-410A 的住宅空调新生产线颁发批准书或工业许可证。新建立的生产线将在 2029 年 1 月 1 日前利用自有资源转换为 HFC-32。

137. 如本文件第 25 段所述，氟氯烃淘汰管理计划下获得援助的 5 家企业的 R-410A 消费量从 2020 年的 716.92 公吨增加到 2022 年的 1,407.25 公吨，然后到 2024 年减少到 1,212.28 公吨。鉴于将这一消费量纳入基准年度，在确定有资格获得基加利氢氟碳化物执行计划第一阶段供资的剩余氢氟碳化物消费量的削减量时，应考虑氟氯烃淘汰管理计划下获得援助的 5 家住宅空调制造商从 R-410A 转为 HFC-32 的情况。注意到该国提议在《蒙特利尔议定书》的目标之前并根据第 92/44 号决定，作为例外情况逐步减少其消费量；并回顾在氟氯烃淘汰管理计划下获得援助的企业已承诺为国内市场生产使用 HFC-32 的住宅空调机，但可以继续生产用于出口的使用 R-410A 的住宅空调机，而且这些企业正在淘汰全部消费量，而无需多边基金在基加利氢氟碳化物执行计划第一阶段下提供额外援助，经商定，在评估符合供资条件的剩余消费量中的削减量时，仅考虑氟氯烃淘汰管理计划下获得援助的企业 2020 年的 R-410A 消费量（即 716.92 公吨，或 1,496,571 吨二氧化碳当量）。

138. 在第九十五次会议上，执行委员会核准为项目编制供资，该项目将根据第 94/60 号决定提交，除其他外，该项目旨在提高埃及企业生产的住宅空调设备的能效，作为其逐步减少氢氟碳化物的一部分（第 95/35 号决定）。秘书处赞赏地注意到该国政府打算向第九十七次会议提交这一项目。虽然从 R-410A 转换为 HFC-32 的增支经营成本为零，但根据第 94/60 号决定核准项目将允许向企业提供额外供资，以提高企业所制造设备的能效，作为其逐步减少氢氟碳化物的一部分。此外，为了确保根据第 94/60 号决定提交第九十七次会议的项目的可持续性，秘书处建议，无论第 84/72(e)(三)号决定如何，El Araby、Fresh、Miraco、Power 和 Unionaire 公司都有资格参加项目，以提高这些企业根据第 94/60 号决定生产的住宅空调设备的能效，但须符合第 94/60 号决定的标准。

维修行业和其他行业的非投资活动

139. 经秘书处与工发组织详细讨论后，商定对拟议活动作出以下调整：

(a) 鉴于该国有大量的制冷和移动空调技术员（估计分别为 100,000 人和 20,000 人），将移动空调及制冷和空调技术员分别从 1,000 人增加到 1,600 人，并相应增加供资额；

(b) 移动空调行业考察、当地市场接受度和风险评估、制冷和空调行业考察以及计量吸入器行业和研究项目考察，申请资金为 310,000 美元，将之替换为关于技术趋势的筹备技术有关利益方磋商，包括移动空调、大型制冷和空调设备、数据中心和计量吸入器的市场接受度和风险评估，商定供资额为 150,000 美元；

(c) 在对消防行业提供技术援助方面，工发组织确认，电信和计算机房、能源建筑、图书馆和档案馆以及石油和天然气行业是消防领域中氢氟碳化物的主要消费者，而惰性气体、二氧化碳系统、FK-5-1-12、粉末系统和细水雾系统可被视为替代品。因此，这两个示范项目将测试几种替代品在不同条件下的性能。测量的参数包括反应速度、材料受损程度、火灾造成的损坏百分比、对人类生命的潜在风险以及其他参数。在此基础上，并根据先前的项目，在取消考察并将讲习班数目增加到九个之后，费用调整为 515,000 美元；

(d) 注意到中小型企业可持续转向低全球升温潜能值替代品的风险高于大型企业，因为大型企业有更多的技术和财政能力来实现转型，因此纳入了一项专门的技术援助方案，以协助中小型企业并减轻这一风险，费用为 68,400 美元；

(e) 注意到关于运输制冷领域中小型企业的信息有限，而且该项目涉及向该行业的企业提供工具，受益方和所需工具只能在执行过程中根据将为此目的聘用的国家顾问的建议才能确定，因此，将供资调整为 205,000 美元；以及

(f) 根据上述调整，将用于评估计量吸入器、移动空调和制冷和空调行业替代品的宣传和外联活动以及其他促进可持续制冷活动的供资增加到 595,000 美元。

140. 消防行业活动供资将逐案审议。注意到拟议的活动与制冷维修行业的活动类似，经商定，与维修行业一起为这些活动供资，供资标准为 5.10 美元/千克。因此，符合供资条

件的氢氟碳化物消费量的削减量基于维修行业和消防行业的平均全球升温潜能值计算。据此，根据商定的维修行业（包括消防）活动费用为 7,576,400 美元，维修行业符合供资条件的剩余氢氟碳化物消费量的削减量为 3,162,252 吨二氧化碳当量，如表 33 所示。[40]

表 33. 维修*行业符合供资条件的剩余氢氟碳化物消费量削减量

基准年度维修行业的氢氟碳化物平均消费量*	公吨	4,390.29
	吨二氧化碳当量	9,345,372
商定供资额	美元	7,576,400
商定的成本效益阈值	美元/千克	5.10
维修行业剩余氢氟碳化物消费量削减量*	公吨	1,485.57
	吨二氧化碳当量	3,162,252

*包括用于维修消防设备的消费量。

项目管理股

141. 经商定，项目管理股的供资额为 1,347,277 美元，其中给工发组织 1,118,320 美元，用于制冷和空调制造业转型项目的执行和项目监测（595,281 美元）和工发组织牵头的维修行业活动（523,039 美元）；给开发署 228,957 美元，将用于泡沫塑料行业转型项目的执行和项目监测（108,002 美元）和开发署牵头的维修行业活动（120,955 美元）。

项目总费用

142. 埃及基加利氢氟碳化物执行计划第一阶段总费用为 17,197,598 美元，将使该国符合供资条件的氢氟碳化物消费量削减 5,795,458 吨二氧化碳当量，包括进口预混多元醇中所含的 35,850 吨二氧化碳当量氢氟碳化物和，以及氟氯烃淘汰管理计划第二阶段下获得援助的 5 家住宅空调制造企业的转型有关的 1,496,571 吨二氧化碳当量，如下文表 34 所示。

表 34. 埃及基加利氢氟碳化物执行计划第一阶段将开展活动的商定费用

行业	物质	淘汰		商定供资额（美元）	成本效益（美元/千克）	机构
		公吨	吨二氧化碳当量			
聚氨酯泡沫塑料	HFC-365mfc、HFC-227ea	26.05	29,066	101,420	3.07	开发署
	预混 HFC-365mfc	7.00	5,558			
	HFC-245fa	98.70	101,663	316,169	2.47	
	预混 HFC-245fa	29.41	30,292			
挤塑聚苯乙烯泡沫塑料	HFC-152a	227.00	28,148	853,021	3.76	开发署
泡沫塑料行业投资项目小计		*388.16*	*194,727*	*1,270,610*	*3.27*	开发署
泡沫塑料行业投资项目项目管理股		不适用	不适用	*108,002*	不适用	开发署
家用制冷	HFC-134a	376.97	539,066	4,552,856	12.08	工发组织
商用制冷	HFC-134a、R-404A、R-407C	*37.92	61,023	502,202	13.24	工发组织
住宅空调	R-410A	163.75	341,819	1,948,253	11.90	工发组织
	氟氯烃淘汰管理计划中的 R-410A**	716.92	1,496,571	0	不适用	不适用

[40] 根据 UNEP/OzL.Pro/ExCom/92/46 号文件附件一所载方法计算。

行业	物质	淘汰		商定供资额（美元）	成本效益（美元/千克）	机构
		公吨	吨二氧化碳当量			
制冷和空调制造业投资项目小计		*1,295.56*	*2,438,478*	*7,003,311*	***5.41*	工发组织
制冷和空调投资项目项目管理股		不适用	不适用	*595,281*	不适用	工发组织
维修行业	各种	1,206.55	2,568,318	6,153,400	5.10	工发组织
		279.02	593,934	1,423,000		开发署
维修行业活动小计		*1,485.57*	*3,162,253*	*7,576,400*	*5.10*	不适用
维修行业项目管理股		不适用	不适用	*523,039*	不适用	工发组织
				120,955		开发署
所有项目小计（不含项目管理股）		***3,169.29***	***5,795,458***	***15,850,320***	**5.00**	**不适用**
所有项目管理股小计		**不适用**	**不适用**	***1,347,277***	**不适用**	**不适用**
总计（包括氟氯烃淘汰管理计划下5家住宅空调企业的淘汰情况）**		**3,169.29**	**5,795,458*****	**17,197,598**	**5.43**	不适用

*包括与 Everest 有关、不符合资助条件的 9.50 公吨（13,588 吨二氧化碳当量）HFC-134a 消费量
**氟氯烃淘汰管理计划下住宅空调转型项目相关的 R-410 淘汰量为 716.92 公吨（1,496,571 吨二氧化碳当量）
***包括进口预混多元醇中所含的 35,850 吨二氧化碳当量氢氟碳化物

143. 该国符合供资条件的剩余消费量中扣除总量为5,795,458吨二氧化碳当量，包括与5家住宅空调制造企业转型相关的 1,496,571 吨二氧化碳当量，这 5 家企业根据氟氯烃淘汰管理计划转换为 HFC-32。预计这 5 家企业以及基加利氢氟碳化物执行计划第一阶段转向HFC-32的6家企业逐步减少使用氢氟碳化物，将导致采用535,004吨二氧化碳当量的HFC-32。考虑到这一采用，且不包括淘汰进口预混多元醇中所含的 35,850 吨二氧化碳当量氢氟碳化物，消费量的净削减量达 5,224,604 吨二氧化碳当量。在考虑适当的最终目标时，秘书处注意到 2024 年的消费量增加，这反映了该国对冷却的持续需求，并且可能需要一些时间来实施基加利氢氟碳化物执行计划下规划的活动并影响市场需求。在此基础上，经商定，将基加利氢氟碳化物执行计划第一阶段的最终目标定为15,046,473吨二氧化碳当量，该数值介于最初拟议目标（15,471,223 吨二氧化碳当量）与根据上述消费量削减数计算的结果（14,065,746 吨二氧化碳当量）中间。为确保该国政府有足够的时间实现这一最终目标，商定将基加利氢氟碳化物执行计划第一阶段延长至 2030 年。

144. 基加利氢氟碳化物执行计划第一阶段将分三次付款实施。尽管第 95/49(c)号决定规定第一阶段第一次付款不应超过第一阶段供资总额的60%，但鉴于需要为制造业转型提供增支资本费用，作为例外，商定第一次付款为第一阶段供资总额的 62.7%，占该次付款中开展活动所需资金的大部分（超过 80%）。

<u>基加利氢氟碳化物执行计划第一次付款的执行计划</u>

145. 根据上文第 104 至 142 段所述的变化，工发组织和开发署同意修订第一次付款行动计划，包括取消住宅热泵示范项目，增加针对中小型企业制造转型活动的专门技术援助方案，就移动空调行业和大型商用制冷行业的技术趋势进行有关利益方磋商，调整付款分配并修订若干活动的费用和目标。本文件附件二开列了经修订的第一次付款中开展活动的费用，为 10,786,475 美元。

高环境温度缔约方的豁免

146. 根据国家臭氧机构 2024 年 10 月 24 日致臭氧秘书处的信函建议，埃及将不享有高环境豁免。

共同出资

147. 该项目中确定的共同出资来源包括制冷和空调制造行业的中小型企业承担的费用，以涵盖计算得出的转型费用与转型项目申请金额之间的差额；参与示范项目的空调分销商为回收报废组件、回收制冷剂和确保妥善处置而承担的费用；来自住宅分体式空调机示范项目参与者的可能共同出资；计量吸入器制造商为促进原型开发和测试而承担的费用；来自冷水系统示范项目参与者的共同出资；以及培训中心提供的实物服务，这些服务将有助于利用其场地和工作人员开展基加利氢氟碳化物执行计划相关活动。

多边基金 2025-2027 年业务计划

148. 工发组织和开发署请求拨款 17,197,598 美元，外加机构支助费用，用于实施埃及基加利氢氟碳化物执行计划第一阶段。2025-2027 年期间请求拨款总额为 16,455,213 美元（包括机构支助费用），比业务计划金额高出 10,425,357 美元。

性别平等政策执行情况

149. 根据第 84/92(d)号、第 90/48(c)号和第 92/40(b)号决定，埃及已将关于多边基金性别政策的讨论纳入其基加利氢氟碳化物执行计划，其中包括开展一项研究，以查明公平参与该项目和制冷和空调行业面临的障碍，制定一项行动计划，并设计讲习班和材料；以及提供培训、讲习班和宣传活动。国家臭氧机构编制了一份促进性别平等的政策纲要草案，其中包括改进报告和监测系统，以跟踪和记录性别问题，包括具体的可衡量目标和强制性性别指标，并将成果列入项目提交文件。

逐步减少氢氟碳化物的可持续性和风险评估

150. 聚氨酯泡沫塑料和挤塑聚苯乙烯泡沫塑料制造业淘汰工作的可持续性将通过以下措施得以维持：禁止进口纯 HFC-245fa 和 HFC-365mfc，以及禁止进口预混多元醇中所含的 HFC-245fa 和 HFC-365mfc；实施禁令或禁止进口 HFC-152a；实施禁令或禁止生产使用氢氟碳化物的聚氨酯和挤塑聚苯乙烯泡沫塑料。家用制冷和单机商业制冷设备制造业中淘汰氢氟碳化物的工作，以及住宅空调制造业中逐步减少使用氢氟碳化物的工作，将通过自 2029 年 1 月 1 日起禁止制造和进口相关使用氢氟碳化物的设备来保障其可持续性。参与该项目的企业将在禁令生效前一年完成转型，届时将不得不与进口产品竞争，就住宅空调制造行业而言，一家不符合资助条件的企业将利用自身资源进行转型。秘书处认为，鉴于绝大多数市场将在 2028 年 1 月 1 日之前完成转型，因此完成转型和实施禁令之间的一年时间差，对逐步减少工作的可持续性造成的风险较低。在家用空调制造业，考虑到 5 家家用空调制造企业在氟氯烃淘汰管理计划第二阶段下进行转型，该国国内市场的大部分本地制造将在 2026 年 12 月 31 日之前完全转向使用 HFC-32。

151. 由于资金和技术能力有限，参与转型项目的中小型企业在实施转型方面可能比大型企业面临更大的挑战。为解决这一问题并减轻其转型工作可持续性的风险，基加利氢氟碳化物执行计划第一阶段纳入了专门技术援助方案。维修行业的培训和能力建设活动，包括加强制冷和空调技术员安全处理易燃制冷剂的能力，以及执行与氢氟碳化物逐步减少时间表相一致的许可证和配额制度，将进一步减轻该国逐步减少氢氟碳化物工作可持续性所面临的风险。

对气候的影响

152. 拟议开展的活动包括：家用制冷设备制造业转用 R-600a，单机商用制冷设备转用 R-290，住宅空调制造业转用 HFC-32，聚氨酯和挤塑聚苯乙烯泡沫塑料制造业转用低全球升温潜能值替代品，以及努力推广低全球升温潜能值替代品、制冷剂回收和再利用，指出实施基加利氢氟碳化物执行计划第一阶段将减少向大气排放制冷剂，从而带来气候惠益。对基加利氢氟碳化物执行计划中各项活动对气候影响的计算表明，到 2030 年，埃及将减少约 4,243,877 吨二氧化碳当量氢氟碳化物排放量，这是根据氢氟碳化物履约基准与 2030 年目标之间的差额计算得出的，假定所有氢氟碳化物消费量最终会被排放。

协定草案

153. 本文件附件一载有埃及政府与执行委员会之间关于基加利氢氟碳化物执行计划第一阶段的协定草案。执行委员会正在本次会议议程项目 10(c)下审议第 5 条国家聚氨酯泡沫塑料行业预混多元醇中所含氢氟碳化物的问题。如果就此问题通过决定，委员会可决定是否在《协定》中列入一项相关条款。

协调根据氟氯烃淘汰计划和逐步减少氢氟碳化物计划开展的维修行业活动

154. 制造和维修行业活动是对氟氯烃淘汰管理计划第二阶段下核准活动的补充，氟氯烃淘汰管理计划第二阶段的最后一次付款将与基加利氢氟碳化物执行计划第一阶段同时实施，直至 2026 年 12 月。氟氯烃淘汰管理计划第三阶段预计将提交第九十六次会议，目前正在根据基加利氢氟碳化物执行计划第一阶段活动进行规划。在提交氟氯烃淘汰管理计划第三阶段时，作为审查的一部分，将对活动协调进行评估。

六. 建议

155. 执行委员会不妨考虑：

(a) 原则上核准埃及 2025-2030 年基加利氢氟碳化物执行计划第一阶段，该国的氢氟碳化物消费量，削减幅度为基准水平的 22%，供资数额为 18,401,430 美元，其中给工发组织 14,275,031 美元，外加 999,252 美元的机构支助费用，给开发署 2,922,567 美元，外加 204,580 美元的机构支助费用；

(b) 注意到：

(一) 埃及政府将根据执行委员会提供的指导，确定其氢氟碳化物消费量持续总体削减的起点值；

(二) 一旦执行委员会提供了(b)(一)分段所述指导，将根据该指导确定埃及符合供资条件的剩余氢氟碳化物消费量的削减数；

(三) 将从(b)(一)分段所述起点值中扣除上文(b)(二)分段所述该国符合供资条件的剩余氢氟碳化物消费量的削减数；

(四) (b)(二)分段所述该国符合供资条件的剩余氢氟碳化物消费量的削减数包括进口预混多元醇中所含的 35,850 吨二氧化碳当量氢氟碳化物；

(五) 作为例外情况，将根据该国氟氯烃淘汰管理计划第二阶段下正在转向 HFC-32 的 5 家住宅空调制造企业（即 El Araby、Fresh、Miraco、Power 和 Unionaire）2020 年的 R-410A 消费量，从起点值中额外扣除 1,496,571 吨二氧化碳当量的削减量。

(六) 不论第 84/72(e)(三)号决定的规定如何，上文第(五)分段所述 5 家企业将符合项目资助条件，在第 94/60 号决定下提高其制造的住宅空调机能效，但须符合第 94/60 号决定规定的标准；

(c) 还注意到埃及政府承诺：

(一) 在 2028 年 1 月 1 日之前，实施禁令或以其他方式禁止进口纯 HFC-245fa 和 HFC-365mfc 以及预混多元醇中所含的 HFC-245fa 和 HFC-365mfc，并实施禁令或以其他方式禁止这些物质用于制造使用氢氟碳化物的聚氨酯泡沫塑料；

(二) 在 2028 年 1 月 1 日之前，实施禁令或以其他方式禁止进口 HFC-152a 和制造使用氢氟碳化物的挤塑聚苯乙烯泡沫塑料；

(三) 在 2029 年 1 月 1 日之前，实施禁令或以其他方式禁止进口和制造使用氢氟碳化物的家用冰箱，注意到在基加利氢氟碳化物执行计划第一阶段下获得供资进行转型的企业将在 2028 年 1 月 1 日之前停止制造使用 HFC-134a 的家用冰箱；

(四) 在 2029 年 1 月 1 日之前，实施禁令或以其他方式禁止进口和制造使用氢氟碳化物的单机商用制冷设备；以及

(五) 在 2029 年 1 月 1 日之前，实施禁令或以其他方式禁止进口和制造使用 R-410A 的住宅空调机，并注意到在基加利氢氟碳化物执行计划第一阶段下获得供资进行转型的企业将在 2028 年 1 月 1 日之前停止制造使用 R-410A 的住宅空调机；

(d) 核准载于本文件附件一的埃及政府与执行委员会之间关于根据基加利氢氟碳化物执行计划第一阶段削减氢氟碳化物消费量的协定草案；以及

(e) 核准埃及基加利氢氟碳化物执行计划第一阶段第一次付款及相应的付款执行计划，供资额为 11,541,528 美元，其中给工发组织 9,081,787 美元，外加 635,725 美元的机构支助费用，给开发署 1,704,688 美元，外加 119,328 美元的机构支助费用。

附件一

阿拉伯埃及共和国政府与多边基金执行委员会关于根据基加利氢氟碳化物执行计划第一阶段减少氢氟碳化物消费量的协定草案

（期间：2025-2030 年）

目的

1. 本协定是阿拉伯埃及共和国（“国家”）政府和执行委员会关于按照《蒙特利尔议定书》时间表和本协定的条款在 2030 年 1 月 1 日之前将附录 1-A 所列附件 F 物质（“物质”）的控制使用减少到 15,046,473 吨二氧化碳当量的持续水平的协定。

2. 国家同意遵守本协定附录 2-A（“目标和供资”）第 1.2 行以及附录 1-A 所述《蒙特利尔议定书》附件 F 物质削减时间表所列附件 F 物质的年度消费量限额。国家同意，在接受本协定以及执行委员会履行第 3 段所述供资义务的情况下，如果附件 F 物质的任何消费量超过附录 2-A 第 1.2 行规定的数量，即本协定针对附录 1-A 规定的附件 F 物质的最后削减步骤，以及附件 F 物质的消费量超过第 4.1.3[和 4.2.3]行所规定的数量（剩余的符合供资资格的消费量），该国将不得就这些物质的任何消费量申请或接受多边基金的进一步供资。

3. 以国家遵守本协定所规定义务为条件，执行委员会原则上同意向国家提供附录 2-A 第 3.1 行规定的资金。执行委员会原则上将在附录 3-A（“资金核准时间表”）所指明的执行委员会会议上提供此笔资金。

4. 国家同意根据核准的基加利氢氟碳化物执行计划（“《计划》”）第一阶段执行本协定。如本协定第 5(b)分段所述，国家应接受对实现本协定附录 2-A 第 1.2 行所示附件 F 物质的年度消费量限额的情况进行的独立核查。上述核查将由相关双边机构或执行机构授权进行。

发放资金的条件

5. 当国家至少在资金核准时间表所指明相应执行委员会会议之前 10 周满足了下列条件后，执行委员会才按照资金核准时间表提供资金：

(a) 国家已达到附录 2-A 第 1.2 行所规定的所有相关年度的目标。相关年度指的是核准本协定之年以来的所有年度。在向执行委员会会议提交供资申请之日没有应提交的国家方案执行情况报告的年度除外；

(b) 已对这些目标所有相关年度的实现情况进行了独立核查，除非执行委员会决定不需要进行此类核查；

(c) 国家已按照附录 4-A（“付款执行情况报告和计划格式”）提交了一份涵盖以前每一个日历年的年度执行情况报告；完成了之前已核准分次付款中发起的大部分活动；之前已核准分次付款可提供资金的发放率超过 20%；以及

(d) 国家按照附录 4-A 提交了涵盖每个日历年的付款执行计划，直至并包括供资核准日程表预计提交下一次付款的年度，如果是最后一次付款，则直至完成了所有预期活动。

监测

6. 国家将确保对本协定所规定活动进行准确的监测。附录 5-A（“监测机构和作用”）所述机构应按照同一附录规定的作用和职责，对以前付款执行计划的活动的开展情况进行监测，并提出报告。

资金重新分配的灵活性

7. 执行委员会商定，国家可根据情况变化，按照以下条件灵活地重新分配已核准的全部或部分资金，从而最平稳地减少附录 1-A 所述附件 F 物质的消费，逐步减少这些物质：

(a) 对资金分配有重大改变的，应该按上文第 5(d)分段的设想事先记入下一次付款的执行计划，或者作为对现有付款执行计划的修改，于任何一次执行委员会会议 10 周之前提交，供执行委员会核准。重大改变所涉及的是：

(一) 有可能涉及影响多边基金的规则和政策的问题；

(二) 可能修改本协定的任何条款的改变；

(三) 导致已分配给具体双边机构或执行机构的不同分次付款的资金年度数额发生变化；

(四) 为没有列入当前已核准付款执行计划的活动提供资金，或自付款执行计划中撤销其费用超过上一次所核准付款费用总额的 30%的某一项活动；

(五) 替代技术的改变，但有一项谅解是，提交的任何此种请求均须指明相关的增支费用、对气候的潜在影响以及将要淘汰的吨二氧化碳当量数的任何差别（如适用），同时确认：国家同意与改变技术相关的潜在节省将相应地减少本协定下的总体供资数额；

(b) 对于不被视为重大改变的资金重新分配，可纳入当时正在执行的已核准的付款执行计划，并在嗣后的付款执行情况报告中向执行委员会汇报；

(c) 《计划》中所列的任何企业，如根据多边基金政策被认定为不符合获得供资条件（即由于外国所有权或在适用截止日期之后设立的公司），将不会得到财政援助。这一信息将作为付款执行计划的一部分予以报告；以及

(d) 双边机构或执行机构或国家持有的任何剩余资金均应根据本协定设想的最后一次付款完成时退回多边基金。

8. 应特别注意《计划》中包括的制冷维修行业活动，尤其是国家可利用本协定所提供的灵活性处理项目执行过程中可能产生的具体需要。

双边机构和执行机构

9. 国家同意全面负责管理和执行本协定，以及为履行本协定的义务由国家或以国家名义开展的所有活动。工发组织同意担任牵头执行机构，开发署则同意在牵头执行机构领导下，担任国家根据本协定开展的活动的合作执行机构。国家同意接受各种评价，评价可能在多边基金监测和评价工作方案下或参与本协定的牵头执行机构和（或）合作执行机构的评价方案下进行。

10. 牵头执行机构将负责确保本协定下的所有活动的协调规划、实施和报告工作，包括但不限于根据第 5(b)分段进行的独立核查。合作执行机构将支持牵头执行机构，在牵头执行机构总体协调下执行计划。牵头执行机构与合作执行机构的角色分别载于附录 6-A 和附录 6-B。执行委员会原则上同意向牵头执行机构和合作执行机构提供附录 2-A 第 2.2 和 2.4 行所列费用。

不遵守协定目标的情事

11. 国家如果由于任何原因没有达到附录 2-A 第 1.2 行规定的消除附件 F 物质的目标，或以其他方式没有遵守本协定，则同意本国将无权按照资金核准时间表得到资金。如国家证明已履行在接受资金核准时间表所列下一次供资之前应当履行的所有义务之后，执行委员会将酌情处理，按照其确定的订正资金核准时间表恢复供资。国家确认，执行委员会可按照任何一年未能削减的消费量的每一 CO_2 当量公斤计算，减少附录 7-A 所述供资金额（“因未履约而减少供资”）。执行委员会将针对国家未能履行协定的每个具体个案进行讨论，并做出相关决定。根据上文第 5 段，一旦作出决定，不遵守此协定的具体个案将不会妨碍对未来分次付款的供资。

12. 如果执行委员会今后做出可能影响为任何其他消费行业项目或国家任何其他相关活动所作供资的决定，不会导致对本协定的供资进行修改。

13. 国家将遵照执行委员会、牵头执行机构和合作执行机构为促进本协定的执行而提出的任何合理要求行事。国家尤其将使牵头执行机构和合作执行机构能够获取为核查对本协定的遵守情况所必需的信息。

完成日期

14. 在附录 2-A 明确规定了最高允许总消费量的最后年度次年的年底，《计划》及相关协定即告完成。如果届时仍有第 5(d)分段和第 7 段所述最后一次付款执行计划及随后几次修订中规划的活动尚未完成，《计划》的完成将推迟至剩余活动实施后次年的年底。附录 4-A 第 1(a)、1(b)和 1(d)分段分段规定的报告要求将予继续，直至《计划》完成之时，除非执行委员会另有规定。

有效性

15. 本协定规定的所有条件仅在《蒙特利尔议定书》范围内并按本协定的规定执行。除非本协定另有规定，否则其中使用的所有术语均与《蒙特利尔议定书》赋予的含义相同。

16. 非经国家和多边基金执行委员会的共同书面协定，不得修改或终止本协定。

附录

附录 1-A：物质

物质	消费量合计减少量的起点
待定	

附录 2-A：目标和供资

行	详情		2025 年	2026 年	2027 年	2028 年	2029 年	2030 年	共计
1.1	《蒙特利尔议定书》削减附件 F 物质的时间表	%	冻结	冻结	冻结	冻结	10	10	不适用
		吨二氧化碳当量	19,290,350	19,290,350	19,290,350	19,290,350	17,361,315	17,361,315	不适用
1.2	附件 F 物质的最高允许总消费量	减少%	0	0	4.1	6.7	15.0	22.0	不适用
		吨 CO_2 当量	19,290,350	19,290,350	18,500,000	18,000,000	16,387,179	15,046,473	不适用
2.1	牵头执行机构（工发组织）议定的供资（美元）		9,081,787	0	3,545,129	0	1,648,115	0	14,275,031
2.2	牵头执行机构支助费用（美元）		635,725	0	248,159	0	115,368	0	999,252
2.3	合作执行机构（开发署）议定的供资（美元）		1,704,688	0	1,047,100	0	170,779	0	2,922,567
2.4	合作执行机构的支助费用（美元）		119,328	0	73,297	0	11,955	0	204,580
3.1	议定的供资总额（美元）		10,786,475	0	4,592,229	0	1,818,894	0	17,197,598
3.2	支助费用总额（美元）		755,053	0	321,456	0	127,323	0	1,203,832
3.3	议定的费用总额（美元）		11,541,528	0	4,913,685	0	1,946,217	0	18,401,430
4	待定								

附录 3-A：资金核准时间表

1. 将于附录 2-A 所规定年度的第一次会议上审议有待核准的今后分次付款。

附录 4-A：付款执行情况报告和计划格式

1. 为每次付款申请提交的付款执行情况报告和计划应包括四个部分：

(a) 说明自上次报告以来所实现进展的陈述报告，以及按照每次付款分列的数据，应反映国家在逐步减少附件 F 物质方面的情况，不同活动所起作用以及这些活动之间的关系，在适用情况下，应包括根据第 91/65 号决定，结合逐步减少氢氟碳化物所核准的能效相关活动。报告应包括根据物质分列的作为执行各项活动的直接结果所逐步减少的附件 F 物质的消费量，以及所使用的替代技术和所逐步采

用的相关替代品，以便让秘书处能够向执行委员会通报因此导致的气候相关排放的变化情况。报告还应包括关于所开展活动的量化信息，并进一步突出关于与列入《计划》的各种活动有关的成功、经验和挑战，反映国家情况的任何变化并提供其他相关信息。报告还应包括相对于以往呈交的执行计划的任何变化的信息以及变动的理由，例如拖延、按照本协定第 7 段之规定在执行付款期间运用资金重新分配方面的灵活性，或其他变化；

(b) 根据本协定第 5(b)分段提交的关于《计划》取得的结果以及附件 F 物质消费量的独立核查报告。如果执行委员会没有另做决定，必须按照本协定第 5(a)分段的规定，随每次付款申请提供对消费量数据的此种核查，涵盖其核查报告尚未得到执行委员会认可的所有相关年度；

(c) 书面说明付款申请所涵盖期间内开展的各项活动，包括量化信息，重点说明执行进度指标、完成的时间以及这些活动的相互依赖性，同时亦顾及执行前几次付款时积累的经验和取得的进展；《计划》中的数据须按日历年分列。说明还应提及总体计划和取得的进展，以及所预期的对总体计划的任何可能调整。说明还应具体列出并详细解释对总体计划做出的此种改变。对未来活动的说明可作为上文(b)分段所述作为陈述报告的同一文件的一部分提交；以及

(d) 总结上文第 1(a)至第 1(c)分段所述信息的执行摘要，大约五个自然段。

附录 5-A：监测机构和作用

1. 所有监测活动都将通过国家臭氧机构进行协调和管理。国家将确保对本协定下的活动进行准确监测。附录 6-A 和 6-B（牵头执行机构的作用和合作执行机构的作用）所列机构将根据这些附录所列作用和责任监测和报告活动的执行情况。

2. 国家臭氧机构是国家环境事务部的一个组成部分，由埃及环境事务局直接负责。国家臭氧机构将继续全面负责执行本协定规定的各项活动。为协助国家臭氧机构履行这些职责，在国家臭氧机构内设立了项目管理股，并接受其直接监督。

3. 项目管理股负责监督核准《计划》所核准项目、培训方案、技术援助和提高认识活动的日常执行，以确保这些活动对削减氢氟碳化物消费量和使用的影响具有长期可持续性。项目管理股将与利益攸关方和其他市场参与者保持持续联系，以监测趋势，并确保遵守制定的战略和计划。

4. 进出口管制总局和海关署通过与国家臭氧委员会签署的一项议定书，在监测氢氟碳化物进口和预防非法贸易方面发挥着特别突出的作用，海关记录被用作基加利氢氟碳化物执行计划内不同项目中所有监测方案交叉核对的参考依据。

5. 国家臭氧机构将在牵头执行机构和合作执行机构的协助下，与有关当局密切合作，管理监测进程。国家臭氧机构将负责监测通过本协定实现的消费量削减目标的可持续性。

6. 将对受控物质消费量进行监测，并根据该国政府相关部门记录的进出口官方数据确定消费量。国家臭氧机构应每年在相关到期日或之前汇编和报告有关物质的消费量以及《计划》的执行进展，分别提交臭氧秘书处和多边基金秘书处。

附录 6-A：牵头执行机构的作用

1. 牵头执行机构将负责一系列活动。至少应包括如下活动：

(a) 确保按照本协定及国家计划规定的具体内部程序和要求进行绩效和财务核查；

(b) 协助国家根据附录 4-A 编制付款执行报告和计划；

(c) 向执行委员会提供独立核查报告，说明各项目标已经实现且相关付款活动已经根据附录 4-A 按照付款执行计划的要求完成；

(d) 确保根据附录 4-A 中第 1(c)分段将经验和进展反映在最新总体计划和未来的付款执行计划中；

(e) 完成付款执行情况报告和计划以及附录 4-A 所列总体计划中的报告要求，以提交执行委员会并应包括报告合作执行机构实施的活动；

(f) 如果关于最后一次资金付款的申请是在确定了消费量指标的最后年度的前一年或更多年之前提出，则应提交年度付款执行情况报告，并在适用情况下提交关于《计划》的现阶段的核查报告，直至所有计划的活动均已完成，且氢氟碳化物消费量指标已经实现；

(g) 确保由胜任的独立技术专家进行技术审查；

(h) 按要求完成监督任务；

(i) 确保建立运作机制，从而能够以有效和透明的方式执行付款执行计划和提交准确的数据报告；

(j) 协调各合作执行机构的活动，并确保适当的活动排序；

(k) 如果因未遵守本协定第 11 段而减少供资，在与国家和合作执行机构协商后，确定将减款额分配到不同的预算项目和牵头执行机构以及每个合作执行机构的供资中；

(l) 确保向国家发放的资金系以指标为依据；

(m) 需要时提供政策、管理和技术支持等援助;

(n) 就便利实施计划所需的任何规划、协调和报告安排同合作执行机构达成共识；以及

(o) 向国家/参与企业及时发放资金以完成与项目相关的活动。

2. 经与国家磋商并考虑到提出的任何看法后，牵头执行机构将根据本协定第 5(b)分段和附录 4-A 第 1(b)分段挑选并任命一个独立实体，核查《计划》取得的结果和附录 1-A 中所述附件 F 物质的消费情况。

附录 6-B：合作执行机构的作用

1. 合作执行机构将负责一系列活动。这些活动在《计划》中有所规定，至少包括如下活动：

(a) 需要时为政策制订提供协助；

(b) 协助国家执行和评估合作执行机构所供资的活动，并咨询牵头执行机构以确保各项活动的排序得到协调；

(c) 向牵头执行机构提供关于这些活动的报告，以供根据附录 4-A 列入合并报告中；以及

(d) 就便利实施计划所需的任何规划、协调和报告安排同牵头执行机构达成共识。

附录 7-A：因未遵守《协定》的目标而减少供资

1. 依照本协定第 11 段，对于没有达到附录 2-A 第 1.2 行具体规定的目标的每一年度，消费量每超出附录 2-A 第 1.2 行所规定数量一吨二氧化碳当量，可减少供资 5.93 美元，且有一项谅解是，资金削减的最大限度不得超过所申请付款的供资金额。不履约情事连续超过两年时，可考虑采取额外措施。如果国家由于非法贸易而未遵守《协定》，但扣押了非法贸易中的受控物质并随后予以没收、销毁、出口或送回来源国，则不适用削减供资的规定。

Annex II

Details of the implementation plan for the first tranche of the KIP for Egypt

Component	Activity	Agency	Cost US$
Manufacturing activities			
Foam sectors	PU foam El Araby conversion	UNDP	101,420
	PU foam group project (SMEs)		124,000
	XPS foam conversion		853,021
	Subtotal first tranche investment projects for foam sectors		*1,078,441*
	Project management for investment projects for foam sectors		*91,667*
RAC manufacturing sectors	Domestic refrigeration	UNIDO	4,502,856
	El Araby domestic refrigeration		50,000
	Commercial refrigeration		502,202
	Residential AC		1,948,253
	Subtotal first tranche for investment projects for RAC manufacturing sectors		*7,003,310*
	Project management for investment projects for RAC manufacturing sectors		*595,281*
Servicing sector activities			
1. Regulatory framework and control mechanism	Strengthening the HFC policy and regulatory framework: • Consultancy to review and update policy and regulatory framework • Consultancy to strengthen national capacities • Updating labour competency standard • Development of a RAC sector circular economy model • Economic impact study on incentives and accelerated process • National registry system of medium and large installations	UNDP	125,000
	Training programme on updated HFC control policies and regulations: • International consultancy to design/update training materials • Training courses for customs/border control officers • Training courses for importers and brokers • Purchase of 10 refrigerant identifiers for customs • Review and update licensing and quota system procedures		88,700
	Gender mainstreaming programme: • Recruiting a gender specialist and identification of barriers and priorities for women in the RAC sector • Development of promotional materials and promotion of gender equity and application of gender policies • Workshops for 50 to 80 stakeholders each		62,000
	Subtotal regulatory framework and control mechanism	*UNDP*	*275,700*
2. Capacity building of technicians	Review/update of standards, guidelines and RAC curriculum: • Review/update codes of practices covering all sectors and newer technologies; • Developing standards and guidelines for MAC servicing and translation of materials for dissemination; • Conducting awareness campaigns and workshops for stakeholders, including staff from training institutions, national associations, trainers, regulators, and recycling centre operators; and • Updating the MAC training curriculum ensuring links to nationally adopted standards.	UNIDO	80,000
	Extending technician certification to the MAC sector: • Establishing committee with technical experts and national stakeholders to prepare new certification scheme • Creating a database of potential MAC service technician for certification • Training of 50 assessors for MAC certification.		95,000
	Provision of tools to 900 MAC and RAC workshops: • Survey to identify MAC and RAC workshops, identify needs and		255,000

Component	Activity	Agency	Cost US$
	purchase and delivery of equipment to 100 workshops in first tranche		
	Training and testing of 1,000 MAC and 1,000 RAC technicians: • Three-day training sessions through centres of excellence and training institutes on good practices for 725 MAC and 725 RAC technicians in first tranche.		290,000
	After-sales training of 1,250 technicians at major brand RAC and MAC service centres: • In-depth instruction in diagnostics and troubleshooting, using appropriate tools and techniques, safety and industry standards for 500 trainees in first tranche		100,000
	Subtotal capacity building of technicians	*UNIDO*	*820,000*
3. Outreach and communication	Campaigns in various sectors (MDI, MAC, RAC) raise awareness on phase-down and on energy efficiency and sustainable cooling: • Producing outreach materials, biannual round tables, four targeted workshops, and online engagement	UNIDO	230,000
	Campaigns to promote activities in the foam sectors, and raise awareness of regulatory changes: • Producing outreach materials, targeted workshops and multimedia engagement	UNDP	65,000
	Subtotal outreach and communications	*UNIDO*	*230,000*
		UNDP	*65,000*
4. Sectoral projects (a) residential AC	Demonstration project for two not-in-kind (NIK)[41] direct-indirect evaporative cooling (D-IEC) technologies[42] for residential split applications: • Consulting services to set up the project, advise the participants on the technology and guiding them through the R&D and production phases • Manufacturing prototype D-IEC units of 5 to 7.5 kW capacity	UNIDO	45,000
	Demonstration project of three NIK packaged chilled water systems replacing multi split units • Consulting services to set up the project, advise the participants on the technology and guiding them through the R&D and production phases • Manufacturing two prototypes chilled water systems of 10 to 17.5 kW capacity	UNIDO	55,000
Sectoral projects (b) Commercial AC	Demonstration project for NIK deep sea cooling[43] technology in commercial AC: • Hiring a consultant to determine the viability of district cooling using deep sea cooling technology in two new developments • Data collection using a remote operated vehicle in deep layers of the Gulf of Aqaba	UNIDO	40,000
	Subtotal sectoral projects	*UNIDO*	*190,000*
5. Technical assistance (a) RAC sector	Dedicated technical assistance programme for SMEs in manufacturing conversions • Provision of technical assistance and support towards the conversion of SMEs across the assisted manufacturing sectors	UNIDO	25,000

[41] The term of not-in-kind (NIK) cooling technologies refers to any alternative cooling systems other than vapor compression cooling systems.

[42] Direct-indirect evaporative cooling: First uses indirect evaporative cooling to pre-cool the air without adding moisture. The pre-cooled air then undergoes direct evaporative cooling, further reducing its temperature. The combination maximizes cooling efficiency while controlling humidity levels, making it suitable for a wide range of applications.

[43] Deep sea cooling technologies leverages the naturally cold temperatures found in deep waters to provide cooling for buildings and industrial processes. This method can substantially reduce energy consumption and greenhouse gas emissions compared to conventional air-conditioning systems.

Component	Activity	Agency	Cost US$
5. Technical assistance (b) firefighting sector	Technical assistance and monitoring the use of HFCs as fire extinguishing agents: • Developing an inventory of enterprises that import, sell, use, install and refill HFC-based fire control equipment and flood systems; • Promotion and development/printing of booklet on best practices in maintaining and recharging portable fire extinguishers; • Coordinating a working group to develop technical capacity on customs codes to control the trade of cylinders used in the firefighting sector; • Begin work to establishing a training and examination centre	UNDP	152,000
4. Technical assistance (c) refrigerated transport sector	Technical assistance to the refrigerated transport subsector: • Identification all stakeholders in the subsector, the technologies and the applications (container trucks, small trucks, reefers, or marine refrigeration) use consumption trends, and readiness for alternative technologies; and an assessment of the after-sales servicing capabilities • Workshops for SMEs and installers on new technologies, reducing leakage through design and proper tools • Technical assistance provided through individual visits arranged with stakeholders	UNIDO	102,000
	Subtotal technical assistance	*UNIDO*	*127,000*
		UNDP	*152,000*
	Subtotal UNIDO first tranche servicing sector activities		1,367,000
	Subtotal UNDP first tranche servicing sector activities		492,700
	Subtotal first tranche servicing sector activities		1,859,700
	Project management for first tranche	*UNIDO*	116,195
		UNDP	41,880
Total for UNIDO first tranche			**9,081,787**
Total for UNDP first tranche			**1,704,688**
Grand total			**10,786,475**

Transformation of Commercial Air Conditioning Companies
HCFC Phase-out Management Plan (HPMP) EGYPT (Stage II), UNIDO ID: 140400

DIRECT/INDIRECT EVAPORATIVE COOLING

Year: 2024
Climatic Zone: 8

Project supported by:

MULTILATERAL FUND FOR THE IMPLEMENTATION OF THE MONTREAL PROTOCOL

UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANIZATION

UNITED NATIONS ENVIRONMENT PROGRAMME

EUROPEAN INDUSTRY ASSOCIATION EUROVENT

Table of Contents

Disclaimer

While the information contained herein is believed to be accurate, it is of necessity presented in a summary and general fashion. The decision to implement one of the options presented in this document requires careful consideration of a wide range of situation-specific parameters, many of which may not be addressed by this document. Responsibility for this decision and all its resulting impacts rests exclusively with the individual or entity choosing to implement the option. UNIDO, UNEP, their consultants and the reviewers and their employees do not make any warranty or representation, either expressed or implied, with respect to the accuracy, completeness or utility of this document; nor do they assume any liability for events resulting from the use of, or reliance upon, any information, material or procedure described herein, including but not limited to any claims regarding health, safety, environmental effects, efficacy, performance, or cost made by the source of information.

Acknowledgment

We would like to acknowledge the assistance given by the governmental sectors and the National Ozone Unit Officers of Egypt and the Housing & Building National Research Center (HBRC) for their support in the implementation of the project and their assistance in facilitating communication with different stakeholders.

We also acknowledge the International Technical Review Team "EUROPEAN INDUSTRY ASSOCIATION EUROVENT" that assist the project team in reviewing the process, results and report of the project.

Acknowledgement also goes particularly to HBRC for providing the testing yard, facilities (Electrical feeding, water supply … etc.) and other logistic facilities at their installation in Toshky.

The project team also acknowledges the OEM manufacturers who built the IEC-H prototypes and DX systems to be tested at the location.

- Delta Construction & Manufacturing DCM
- TIBA Engineering Industries Co.
- VOLTA EGYPT
- SS Air Technology

Acknowledgement also goes to the team's technicians, technical assistance staff and drivers which assisted in the project successful completion in this remote location.

Project Team

This Project is contracted between the United Nations Industrial Development Organization "UNIDO" and Housing & Building National Research Center "HBRC". Whereas, UNIDO has been designated by the **Multilateral Fund for the Implementation of the Montreal Protocol** as Implementing Agency; and has agreed to provide assistance to the Egyptian Government in carrying out the project entitled "HCFC Phase-Out Management Plan (HPMP) Egypt (Stage II)".

The National Ozone Unit – Ministry of Environment, Egypt: The ministry team provided guidance and direction and participated at project meetings and discussions. The project is funded by the HCFC Phase- out Management Plan (HPMP) of Egypt.

The Project Management: UNIDO and UN Environment provided overall management and coordination of the project, established the link with the technology providers, and oversaw the development of the report of the project. The Project was managed by Mr. Ole Nielsen, Dr. Iino Fukuya, Dr. Yunrui Zhou, Program Officer – UNIDO and Eng. Ayman El-Talouny, International Partnership Coordinator, Ozone Action Program – UN Environment. The Coordination Consultant, Eng. Ahmed El-Korashy provided logistical support and coordination for the project.

EUROVENT (European Industry Association): Due to the absence of local testing standard or guidelines for IEC applications, the service of an International Advisory Partner was needed to offer recommendations, testing reference and quality review of the testing process.

The Project general Manager and Technical Consultant and writer of the report, Dr. Alaa Olama advised OEMs during prototype design and construction. Devised testing methodology and testing TOR, consulted with OEMs to provide technical solutions for problems as they arose wrote the report and provided analysis of data.

HBRC organized testing including testing results in both climatic zones, tabulated and created the excel sheets including figures, drawings and review and edit of the report

The project personnel provided by the HBRC are as follows:

Name	Project Function	Gender
Prof. Sayed Shebl Mohamed	Team Leader	Male
Eng. Sally Aladdin Ali	Expert Testing Engineer	Female
Eng. Aya Mohamed Zaki	Expert Testing Engineer	Female
Eng. Mariam Sayed Shebl	Expert Architecture Photographer	Female
Mrs. Elham Eid Said	Secretarial Work	Female
Mr. Mohamed Hassan Ahmed	Secretarial Work	Male
Mr. Farid Rashed Ibrahim	Specialized Testing Technician	Male
Mr. Ahmed Maher Mohamed	Specialized Testing Technician	Male
Mr. AbuElHagag Abbas Mohamed	Specialized Testing Technician	Male
Mr. Qassem Gad	Specialized Testing Technician	Male
Eng. Ahmed Ezzat Mahmoud	Specialized IT Assistant	Male
Mr. Mohamed Ibrahim Abdel Moiety	Driver	Male

Executive Summary:

This project is contracted to support the Egyptian Government in implementing the "HCFC Phase-Out Management Plan (HPMP) Egypt (Stage II)." As part of the project requirements, each Original Equipment Manufacturer (OEM) was tasked with independently developing custom-built prototypes of Direct/Indirect Evaporative Cooling Hybrid Air Conditioners (IEC-H) and a central Direct Expansion (DX) unit. These units were then tested and compared under real operating conditions in three of Egypt's eight climatic zones (CZ).

The 2022 final report presented test results from CZ 2 and CZ 5. This current report provides the performance results from CZ 8, Egypt's hottest and driest climatic zone.

The testing included a 24-hour performance comparison between a full fresh air IEC-H unit and the DX unit. Key parameters assessed included dry bulb and wet bulb temperatures exiting the IEC-H and DX units, Energy Efficiency Ratios (EERs), and the refrigeration capacities of each unit. Each OEM's IEC-H and DX units were tested simultaneously over the 24-hour period to ensure consistent comparative data.

All OEM results indicated that their IEC-H units achieved better Energy Efficiency Ratios (EER) compared to their respective DX units in the CZ 8 testing conditions. The highest and lowest EERs across all OEMs are highlighted below. This report on CZ 8 demonstrates that the IEC-H system outperforms the DX system thermodynamically, as it consistently achieves higher EERs.

Although the air discharge of both units for each OEM were the same, compressor capacity for each OEM varied considerably. OEMs used different capacity compressor in their IEC-H units compared to their respective DX unit tested. The tests showed that the capacity of the IEC-H unit when compared to the capacity of the respective DX unit also varied considerably. For a certain OEM, for some it was higher and for others inferior. The report breaks new ground for NIK air conditioning technologies and provides an alternative full fresh air system for air conditioning application that exceeds the efficiency of existing DX systems.

This report marks a significant advancement for NIK air conditioning technology by presenting an alternative full fresh air system that surpasses the efficiency of traditional DX systems. Although the final reports for CZ 2 & 5 (2022) and this report for CZ 8 (2024) provide a solid foundation for developing guidelines for a direct/indirect evaporative cooling code in Egypt, the report recommends further research. Specifically, it suggests deriving a mathematical model to predict EERs and refrigeration capacities for IEC-H prototypes across Egypt's remaining five climatic zones. the technical analysis of the results are included in the report issued by the technical consultant of the project.

Chapter 1: Tabulation formats for compiling and presenting the results of the project for the prototypes of four OEMs in Climatic Zone 8

1.1. The layout of the testing yard

The Housing and Building National Research Center (HBRC) has undertaken extensive preparations to establish a fully equipped testing yard in Climatic Zone 8, specifically in Aswan-Toshky. This location was chosen for its unique climatic conditions, providing a suitable environment for testing the Direct/Indirect Evaporative Cooling Hybrid (IEC-H) prototypes and Direct Expansion (DX) units. Below is a summary of the key preparations completed to ensure the site is fully operational and secure:

I. Infrastructure Setup:

- Testing Yard: Essential yard for running out the tests was arranged and coordinate with the Ministry of Water Resources & Irrigation to include both IEC-H and DX units in the same run.
- Electrical Cables, Electrical Panel and Water Supply: Essential site infrastructure was established, including electrical panel and cables and water piping systems. The water supply setup was coordinated through contracts with the Ministry of Water Resources & Irrigation to ensure adequate water availability for testing.
- Power Stability: Due to high summer energy demands in the region, a generator was rented to maintain stable power for the operation of the IEC-H prototypes and DX units. The generator, which required heavy equipment for transport, was essential to compensate for power instability during peak summer loads.

II. Security and Access:

- Safety Gate: A secure gate was installed at the testing yard to control access and ensure the safety of personnel and equipment.
- Road Preparation: Roads leading to the testing site were prepared to facilitate smooth access for equipment and personnel transport.

III. Logistics and Support:

- Weather Station Setup: The technical team installed a weather station at the site to monitor and log climate conditions essential for the testing data.
- Water Pipelines and Pump Purchase: water pipelines and pump was acquired to supply the IEC-H units with the necessary water feed.

IV. Transportation and Accommodation:

- HBRC arranged hotel accommodations in Abu Simbel for team members, and vehicles were rented to transport the team between the hotel and testing site daily.
- Four on-site rooms were prepared to house technicians and drivers from HBRC and the OEMs.
- Forklifts were rented to unload and move the tested prototypes and units within the

testing yard.

V. Continuous Communication:

HBRC ensured consistent communication with OEMs throughout the testing phase to coordinate the secure arrival of personnel and equipment. Additionally, HBRC facilitated OEM members’ local transportation by liaising with car rental agencies. HBRC supported OEMs with accommodation and flight reservations through the HBRC Relationship Department.

VI. Coordination and Site Inspections:

Prior to the testing phase, HBRC conducted three site inspections to ensure all arrangements were in place. One of these visits included the HBRC Chairman, Chairman Deputy, and the Project Team Leader to oversee the setup and ensure readiness.

Through these efforts, HBRC has established a well-prepared testing yard in Aswan-Toshky, fully equipped to support comprehensive testing in Egypt’s Climatic Zone 8.

VII. Location of the Testing Yard

The testing yard was set up in Climatic Zone 8, located in Aswan-Toshky (latitude: 22°49' 02" N, longitude: 31°28' 16" E, altitude: 196.07 meters above sea level) as in Figure (1). The tests were conducted under this region’s extreme climatic conditions, which are characterized by high temperatures and low humidity.

The layout and equipment setup for the testing yard included the following components and arrangements, as illustrated in Figure (2): Schematic diagram:

VIII. Tested Units:

- IEC Hybrid Unit: A Direct/Indirect Evaporative Cooling Hybrid (IEC-H) prototype.
- DX Unit: A Direct Expansion (DX) unit configured to match the airflow rate of the IEC-H unit.

Both the IEC-H prototype and DX unit were configured to operate with a low Global Warming Potential (GWP) refrigerant, R-32, and were set up for full fresh air intake, maintaining the same airflow rate for accurate comparison. Each OEM’s equipment was tested simultaneously over a continuous 24-hour period, with data recorded every hour.
The IEC-Hybrid prototype and DX Unit were positioned parallel, with both units set to intake fresh air from the same ambient source to ensure consistency in air conditions. Each unit was equipped with air ducts to facilitate controlled air discharge.

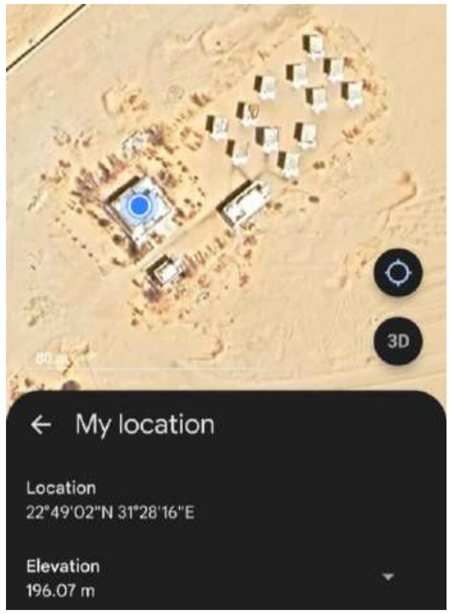

Figure (1): Testing Location

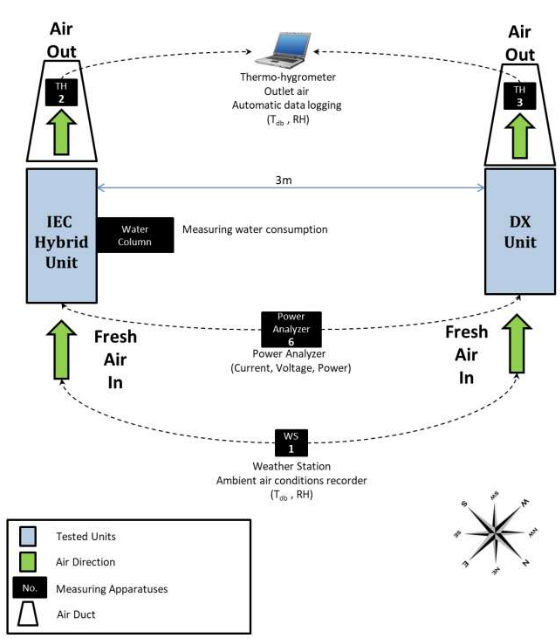

Figure (2): Schematic Diagram of the testing Units and Measuring Instruments

IX. Measurement Apparatus:

- Thermo-Hygrometers: Placed at the outlet of both the IEC-H prototypes and DX units, the thermo-hygrometers recorded the dry bulb temperature (Tdb_{out}) and relative humidity (RH_{out}) of the outlet air, automatically logging these values hourly for detailed analysis of the air conditioning performance.
- Weather Station (WS): Located on roof top of one building in the site away from the

exit of tested units. The weather station continuously recorded ambient air conditions, specifically the dry bulb temperature (Tdb_{amb}) and relative humidity (RH_{amb}), wind speed, wind direction, solar radiation, and barometric pressure providing a reference for evaluating the effectiveness of the cooling systems under local climate conditions.

- Power and Water Consumption Monitoring: Each DX unit was connected to a power meter to monitor the total power consumption ($Pw._{TotDX}$). While Each IEC-H prototype was connected to a power analyzer to monitor the total power consumption ($Pw._{TotIEC\text{-}H}$). Additionally, four power meters were connected to the IEC-H prototype to monitor the power consumption of the pump, supply fan, exhaust fan, and the compressor. A water level (W_{LVL}) sensor measured the water consumed by the IEC-H prototype, with hourly data logged to calculate the total water usage across the 24-hour test period.
- All measuring apparatuses are calibrated in accredited laboratories; the calibration certificates are included in Annex 2.

X. Supporting Equipment:

- Generator: A generator was provided to ensure stable power supply, as local electricity was inconsistent due to high summer loads. Heavy equipment was used to transport and position the generator on site.
- Water Pump: Installed to supply the IEC-H prototypes with the required water feed for evaporative cooling.
- Forklifts and Vehicles: Forklifts were rented to transport and position the units at the designated testing locations, while vehicles facilitated transport of personnel and equipment between the testing site and accommodations.

XI. Data Collection and Analysis:

- The tests were conducted for each OEM over a continuous 24-hour period, with all measurements (temperature, humidity, power consumption, and water usage) recorded on an hourly basis. This allowed for a comprehensive analysis of each unit's performance in terms of energy efficiency, cooling capacity, and resource consumption.
- This setup enabled a detailed comparison between the IEC-H and DX units, facilitating performance evaluation in Climatic Zone 8's challenging environmental conditions. The hourly readings and controlled testing environment ensured reliable data, which will contribute to assessing the thermodynamic efficiency of the IEC-H system compared to traditional DX systems under real-world conditions.

1.2. Method of tabulating results

The purpose of this report is to outline the methodology used to tabulate results for performance tests conducted on four OEMs

- VOLTA Egypt
- Delta Construction & Manufacturing (DCM)

- Smart Sustainable Air Technology (SS Air Technology)
- TIBA Engineering Industries Co. (TIBA).

These tests were conducted to assess the airflow characteristics of the IEC-H prototypes and DX units associated with each OEM. Testing was carried out on specific dates and with airflow rates held constant to ensure consistency in results.

The results for each OEM were tabulated as per **Annex 1: Results of Tests of All OEMs**

I. Test Details and Schedule:

Testing was conducted over four days, with each OEM's units being evaluated on a specific date:

- **OEM 2**: August 26, 2024
- **OEM 3**: August 28-29, 2024
- **OEM 7** : August 30-31, 2024
- **OEM 6**: August 31 – September 1, 2024

The testing dates modified from the scheduled plan as per specified in Table (1):

Table (1): The testing dates modified from the scheduled plan

Date	Scheduled Action	Changes in Scheduled Plan	Remarks
24rd August	Arrival of some of HBRC team & **OEM 2** Team at Abu-Simbel Airport Arrival of **OEM 2** units Connecting of **OEM2** units	No Changes	N.A
25th August	**Testing of OEM 2 units***	Testing postponed to the next day	Unstable electricity in the site. Power generator is rented to solve the problem.
26th August	**Disconnecting of OEM 2 units*** Arrival of **OEM 3** units Connecting of **OEM 3** units	Testing of **OEM 2** units started @ 12:00 am	A storm started at 6:30 pm, which sharply increased the ambient relative humidity and decreased the ambient dry bulb temperature
27th August	**Testing of OEM 3 units***	Testing postponed to the next day	Dew to the storm occurred on the previous day, the

Date	Scheduled Action	Changes in Scheduled Plan	Remarks
			ambient relative humidity was higher than usual values in this location.
28th August	**Disconnecting of OEM 3 units***	Testing of **OEM 3** units started @ 10:00 am	
29th August	Arrival of **OEM 7** units Connecting of **OEM 7** units	No Changes	**OEM 7** used the DX unit of **OEM 3** company A storm started at 8:00 pm
30th August	Testing of **OEM 7** units	Testing of **OEM 7** started @ 9:00 am	Testing of **OEM 7** was going to be started at 12:00 am, The storm caused a heavy rain and power shortage all over the city. The testing was postponed to 9:00 am when the weather became more stable Due to the storm, the ambient relative humidity throughout the testing day was higher than usual
31st August	Disconnecting of **OEM 7** units Arrival of **OEM 6** units Connection of TIBA units	Testing of **OEM 6** units started @ 8:00 pm	N.A
1st September	**Testing of OEM 6 units***	Testing started at the previous day Disconnection of the units	N.A
2nd September	departure of HBRC team & **OEM 6** Team at Abu-Simbel Airport		N.A
Note: (*): Changed from the original Schedule			

II. Standard Conditions for Testing:

To ensure comparability between results, the airflow rates for both the IEC-H prototype and DX unit were set as follows:

- **OEM 2**: 1189 CFM
- **OEM 3**: 1320 CFM
- **OEM 7**: 1320 CFM
- **OEM 6**: 1800 CFM

These values were used consistently throughout testing to provide a controlled environment for comparing the performance of each OEM's equipment under similar conditions.

III. Tabulating Results:

Results were monitored and automatically logged to provide clarity and ease of analysis. The tabulation process was organized according to the following principles:

a. Date and OEM Identification: Each set of results is associated with the specific OEM tested on a particular date, ensuring easy traceability and review of test data.

b. Airflow Measurements: The airflow rate was a critical variable in this testing process, and it was carefully documented for both the IEC-H prototype and DX units of each OEM. The values were kept constant as per the standard conditions, ensuring consistency.

c. Measured Metrics: For each OEM, performance metrics (such as ambient conditions, primary air outlet temperature and relative humidity, water consumption, and power consumption) were recorded for the IEC-H prototype and DX unit and organized into a table format. These values were measured under the constant airflow conditions outlined above to provide comparable results across all OEMs.

d. Calculated Parameters: The testing process involved comprehensive measurements at both ambient conditions and during operation of the IEC-H prototype and DX unit. These parameters were essential for evaluating the performance of each OEM’s system. Below is a summary of the specific metrics calculated in each case.

e. Ambient Condition Calculated parameters: The following parameters were calculated at ambient conditions to establish baseline environmental data for each test:

   - Pressure at Given Altitude (Pa): Calculated based on the testing location’s altitude to adjust for atmospheric pressure.
   - Saturation Vapor Pressure (hPa): The maximum vapor pressure at the ambient temperature.
   - Partial Vapor Pressure (Pa): The pressure exerted by water vapor present in the ambient air.

- Humidity Ratio: The ratio of the mass of water vapor to the mass of dry air.
- Partial Pressure of Dry Air (Pa): The pressure component of dry air in the ambient conditions.
- Density of Ambient Air (kg/m^3): Calculated based on pressure, temperature, and humidity conditions.
- Enthalpy of Ambient Air (kJ/kg): Total heat content of the ambient air per unit mass.

f. IEC-H Prototype and DX Unit Calculated parameters: For the IEC-H prototype and DX unit, the following parameters were calculated to evaluate its performance under operating conditions:

- Saturation Vapor Pressure (hPa): Calculated for the air exiting the tested unit to assess moisture content.
- Partial Vapor Pressure (Pa): The pressure component of water vapor in the outlet air.
- Humidity Ratio: Measured for the air exiting the tested unit.
- Partial Pressure of Dry Air (Pa): Calculated for the outlet air.
- Density of Outlet Primary Air (kg/m^3): The density of the air leaving the IEC-H prototype.
- Enthalpy of Outlet Primary Air (kJ/kg): Total heat content of the outlet air per unit mass.
- Water Consumed (mm^3/hr): The amount of water used by the IEC-H prototype during operation.
- Total Power Consumption (kW): The energy consumed during the operation of the IEC-H prototype.
- Mass Flow Rate (kg/s): The rate at which air is supplied through the tested unit.
- Total Refrigeration Capacity (BTU/hr): The cooling capacity of the tested unit.
- Coefficient of Performance (COP): The ratio of cooling capacity to power consumption, indicating efficiency.
- Energy Efficiency Ratio (EER) (BTU/W.hr): The cooling capacity per unit power input.

IV. Accuracy of Measuring Instruments:

In order to ensure reliable results, all measurements were carried out using instruments that have been calibrated at accredited laboratories. The accuracy of the measurements was scrutinized to determine the degree to which each calculated or measured value closely approximates the actual value. Since a measuring instrument can only record values within its specific precision limits, the selection and calibration of each instrument played a critical role in the accuracy of the results.

All instruments used in this testing were calibrated, and calibration certificates to this report to verify compliance with international standards. Calibration certificates are listed in Annex (2).

The accuracy of our measurements was guaranteed through the following procedures:

- Collecting Data: All measurement data were electronically recorded using the equipment's software, which facilitated the direct transfer of information to tools such as spreadsheets for further analysis.
- Sorting Values: Data points were sorted systematically to help determine the range of values collected, providing an initial view of consistency and variability.
- Average Value Calculation: The average value of each set of measurements was calculated, representing a central value that serves as a reference point for accuracy.
- Calculating Absolute Deviations: Each individual measurement was subtracted from the average value, producing a set of absolute deviations. These deviations illustrate how close each individual reading is to the average, providing insight into data consistency.
- Determining Precision: Precision was calculated as the average value plus or minus the average deviation, reflecting the repeatability and reliability of the measurements.
- Calculating Uncertainty: To determine overall measurement uncertainty, all potential sources of uncertainty were identified, and the uncertainty contributions from each source were combined for an overall estimation.
- Annex 3: provides details instrument used, including the model number, serial number, and measured parameter.

1.3. Ambient Conditions During the Tests:

The tests conducted on the OEM units (OEM 2, OEM 3, OEM 7, and OEM 6) between August 25, 2024, and September 1, 2024, were subject to varying ambient conditions, which significantly impacted the relative humidity levels throughout the testing period. Understanding these conditions and their relationship to relative humidity is essential for evaluating the performance results accurately.

a. Testing of OEM 2 Units (August 26, 2024)

- Initial Delay: Testing was initially scheduled for August 25 but was postponed due to unstable electricity at the site, requiring a power generator.
- Weather Impact on August 26: A storm began at 6:30 pm, which had a notable impact on the ambient conditions. The storm led to a sharp increase in relative humidity and a decrease in the ambient dry bulb temperature, creating a more humid environment than expected for this location.
- Effect on Testing: Higher relative humidity due to the storm likely affected the **OEM 2** unit's performance, as the system would have to account for increased moisture in the air. This may have impacted both cooling capacity and energy efficiency.

b. Testing of OEM 3 Units (August 28-29, 2024)

- Ambient Conditions on August 27: Testing was delayed by another day due to residual effects of the previous day's storm. The relative humidity remained unusually high because of dew formation, a direct consequence of the storm.
- Testing on August 28: Testing began at 10:00 am on August 28. Due to the delay, the ambient relative humidity returned to normal conditions.
- Effect on Testing: **OEM 3** units were tested under normal conditions.

c. Testing of OEM 7 Units (August 30-31, 2024)

- Weather on August 29: **OEM 7**'s units arrived and were connected, with no changes in the initial plan. However, on the evening of August 29, a storm started around 8:00 pm.
- Testing Delays on August 30: Testing for **OEM 7** was initially planned for midnight but was postponed to 9:00 am due to heavy rain and a power outage caused by the storm. As a result of the storm, relative humidity remained high throughout the day.
- Effect on Testing: Prolonged high relative humidity during the **OEM 7** unit testing would impact cooling efficiency and dehumidification load. The ambient conditions likely demanded more energy for maintaining required conditions, potentially influencing the power consumption and efficiency metrics.

d. Testing of OEM 6 Units (August 31 - September 1, 2024)

- Testing Start on August 31: The **OEM 6** units were installed and tested starting at 8:00 pm. No specific issues with ambient conditions were noted on this date.
- Continuation on September 1: Testing continued briefly into September 1 before the disconnection of the units.
- Effect on Testing: no storm or other significant weather impact on August 31. Therefore, it is reasonable to assume that ambient relative humidity levels returned to typical values, allowing **OEM 6** units to be tested under more normal conditions.

Summary of Ambient Condition Impact on Relative Humidity

The testing period experienced significant weather fluctuations, particularly during the first few days. The following conclusions can be drawn regarding the relationship between ambient conditions and relative humidity during testing:

- Storm Events: Storms on August 26 and August 29 caused spikes in relative humidity levels, which lingered for the following day or more. These high humidity levels would likely affected the performance metrics of the tested units.
- Impact on Performance: Increased humidity generally necessitates more energy for dehumidification, which could reduce the efficiency of the IEC-H prototypes. The increased humidity also impacts air density and enthalpy, which are critical factors in calculating the total refrigeration capacity and efficiency of the units.

- Environmental Control Considerations: These variations in ambient conditions emphasize the importance of accounting for external weather impacts in HVAC performance testing; as such conditions can affect system efficiency and load characteristics.

1.4. Summary of Results:

I. Results of OEM 2 (August 26, 2024):

a. Energy Saving:

- Power Consumption of DX Unit (over 1 day): **225501.9 Watts**
- Power Consumption of IEC-H Unit (over 1 day): **276501 Watts**
- **Energy Saved by IEC-H Prototype w.r.t DX Unit (%) ≈ 18.5 %**

b. Outlet Primary Air:

- DX Unit (Maximum Outlet Primary Temperature): **15.2 ^{o}C**
- IEC-H Prototype (Maximum Outlet Primary Temperature): **14.1 ^{o}C**
- DX Unit (Minimum Outlet Primary Temperature): **8.1 ^{o}C**
- IEC-H Prototype (Minimum Outlet Primary Temperature): **8.1 ^{o}C**

c. EER:

- DX Unit (Maximum EER): **7.3 BTU/W.hr**
- IEC-H Prototype (Maximum EER): **8.6 BTU/W.hr**
- DX Unit (Minimum EER): **4.5 BTU/W.hr**
- IEC-H Prototype (Minimum EER): **5.4 BTU/W.hr**

d. Total Refrigeration Capacity

- DX Unit (Maximum Total Refrigeration Capacity): **77,652 BTU/hr**
- IEC-H Prototype (Maximum Total Refrigeration Capacity): **79,101 BTU/hr**
- DX Unit (Minimum Total Refrigeration Capacity): **52,269 BTU/hr**
- IEC-H Prototype (Minimum Total Refrigeration Capacity): **50,537 BTU/hr**

II. Testing of OEM 3 (August 28-29, 2024):

a. Energy Saving:

- Power Consumption of DX Unit (over 1 day): **286451 Watts**
- Power Consumption of IEC-H Unit (over 1 day): **149606.7 Watts**
- **Energy Saved by IEC-H Prototype w.r.t DX Unit (%) ≈ 47.8 %**

b. Outlet Primary Air:

- DX Unit (Maximum Outlet Primary Temperature): **14.7 ^{o}C**

- IEC-H Prototype (Maximum Outlet Primary Temperature): **14 ^{o}C**
- DX Unit (Minimum Outlet Primary Temperature): **9.1 ^{o}C**
- IEC-H Prototype (Minimum Outlet Primary Temperature): **10.6 ^{o}C**

c. **EER:**

- DX Unit (Maximum EER): **8.1 BTU/W.hr**
- IEC-H Prototype (Maximum EER): **14.9 BTU/W.hr**
- DX Unit (Minimum EER): **5.8 BTU/W.hr**
- IEC-H Prototype (Minimum EER): **8.6 BTU/W.hr**

d. **Total Refrigeration Capacity**

- DX Unit (Maximum Total Refrigeration Capacity): **93,129 BTU/hr**
- IEC-H Prototype (Maximum Total Refrigeration Capacity): **90,984 BTU/hr**
- DX Unit (Minimum Total Refrigeration Capacity): **66,797 BTU/hr**
- IEC-H Prototype (Minimum Total Refrigeration Capacity): **49,524 BTU/hr**

III. Results of OEM 7 (August 30-31, 2024):

a. **Energy Saving:**

- Power Consumption of DX Unit (over 1 day): **278840 Watts**
- Power Consumption of IEC-H Unit (over 1 day): **189891 Watts**
- **Energy Saved by IEC-H Prototype w.r.t DX Unit (%) ≈ 31.9 %**

b. **Outlet Primary Air:**

- DX Unit (Maximum Outlet Primary Temperature): **17.3 ^{o}C**
- IEC-H Prototype (Maximum Outlet Primary Temperature): **17.4 ^{o}C**
- DX Unit (Minimum Outlet Primary Temperature): **13.4 ^{o}C**
- IEC-H Prototype (Minimum Outlet Primary Temperature): **12.3 ^{o}C**

c. **EER:**

- DX Unit (Maximum EER): **8.7 BTU/W.hr**
- IEC-H Prototype (Maximum EER): **11.6 BTU/W.hr**
- DX Unit (Minimum EER): **4.7 BTU/W.hr**
- IEC-H Prototype (Minimum EER): **6.8 BTU/W.hr**

d. **Total Refrigeration Capacity**

- DX Unit (Maximum Total Refrigeration Capacity): **96,172 BTU/hr**
- IEC-H Prototype (Maximum Total Refrigeration Capacity): **91,961 BTU/hr**

- DX Unit (Minimum Total Refrigeration Capacity): **57,482 BTU/hr**
- IEC-H Prototype (Minimum Total Refrigeration Capacity): **52,535 BTU/hr**

IV. Results of OEM 6 (August 31 – September 1, 2024):

a. Energy Saving:

- Power Consumption of DX Unit (over 1 day): **245209 Watts**
- Power Consumption of IEC-H Unit (over 1 day): **137732 Watts**
- **Energy Saved by IEC-H Prototype w.r.t DX Unit (%) ≈ 43.8 %**

b. Outlet Primary Air:

- DX Unit (Maximum Outlet Primary Temperature): **21.0 ^{o}C**
- IEC-H Prototype (Maximum Outlet Primary Temperature): **17.4 ^{o}C**
- DX Unit (Minimum Outlet Primary Temperature): **11.6 ^{o}C**
- IEC-H Prototype (Minimum Outlet Primary Temperature): **7.5 ^{o}C**

c. EER:

- DX Unit (Maximum EER): **11.2 BTU/W.hr**
- IEC-H Prototype (Maximum EER): **16.9 BTU/W.hr**
- DX Unit (Minimum EER): **7.4 BTU/W.hr**
- IEC-H Prototype (Minimum EER): **13 BTU/W.hr**

d. Total Refrigeration Capacity

- DX Unit (Maximum Total Refrigeration Capacity): **102,573 BTU/hr**
- IEC-H Prototype (Maximum Total Refrigeration Capacity): **123,792 BTU/hr**
- DX Unit (Minimum Total Refrigeration Capacity): **67,309 BTU/hr**
- IEC-H Prototype (Minimum Total Refrigeration Capacity): **39,442 BTU/hr**

1.5. Challenges and Problems Associated with the Testing:

During the testing period from August 25 to September 1, 2024, several challenges and technical problems arose that affected the testing schedule and potentially impacted the results. These issues ranged from environmental conditions, such as storms and humidity fluctuations, to technical and power-related challenges. Below is a summary of the main challenges encountered.

I. Unstable Electricity Supply

The testing site experienced unstable electricity, which led to several delays and operational difficulties:

- **OEM 2 Units:** Prior to the start of testing on August 25, the pump of the OEM 2 unit subjected to electrical shortage due to fluctuations in the power supply. This issue necessitated the postponement of testing and the rental of a power generator to stabilize the electricity supply. The delay disrupted the schedule and may have impacted the readiness of the unit for testing.
- **OEM 3 Units:** Similarly, OEM 3 units encountered issues with unstable electricity before testing could begin. This issue delayed the testing schedule, as additional steps were required to stabilize the power supply.
- **OEM 7 Units:** OEM 7 units also experienced power connection issues, causing further delays and the need for troubleshooting before testing could proceed.

These power-related challenges underscored the need for a stable and reliable electricity supply at the testing site. The lack of consistent power created interruptions and delays, which impacted the testing timeline and added unforeseen variables that could influence the performance metrics of each OEM's equipment.

II. Weather-Related Challenges

Several storms during the testing period added further complications:

- August 26 Storm: A storm on the evening of August 26 sharply increased the ambient relative humidity and lowered the dry bulb temperature. This change in weather conditions impacted the testing environment for the **OEM 2** units, adding an additional load on the system to handle the increased moisture in the air.
- August 29 Storm: Another storm on the night of August 29 caused heavy rain, which led to high humidity conditions and power outages throughout the city. This affected the testing of **OEM 7** units, which had to be postponed until the weather stabilized on the morning of August 30. The high humidity levels lingered, influencing the environmental conditions during the testing.

The weather-related challenges significantly impacted relative humidity levels, leading to higher latent loads and potentially skewing results for parameters such as cooling efficiency, power consumption, and the overall coefficient of performance (COP). These fluctuations made it challenging to maintain consistent ambient conditions across all tests.

III. Technical Problems with Testing Equipment

In addition to power and environmental issues, several technical problems with the tested unit emerged:

- **OEM 2** Pump Malfunction: Due to the initial unstable electricity, the pump encountered electrical issues before testing started. This necessitated repairs and recalibration, further delaying the testing schedule.
- **OEM 6** Fan Issues: Prior to the start of testing, the fan encountered technical problems, which required troubleshooting and repair.

- **OEM 7** Power Connection: the units faced connection problems with the power meters, delaying the setup and testing process. This issue required additional adjustments to ensure the unit was properly connected and ready for testing.

These delays and last-minute repairs also increased the workload for the testing team, potentially influencing the precision and timing of data collection.

IV. Impact of Challenges on Testing Results

Scheduling Delays: The frequent delays due to power instability, weather conditions, and equipment malfunctions disrupted the original testing schedule, resulting in adjustments that affected both the timeline and the operational flow.

These challenges highlight the complex and unpredictable nature of conducting environmental testing, especially when external factors like weather and power supply play a significant role. Moving forward, improved infrastructure for stable electricity, thorough pre-testing equipment checks, and contingency plans for weather fluctuations would enhance the reliability and consistency of test results. The issues encountered during this testing period underscore the importance of accounting for external factors when interpreting data and drawing conclusions from performance evaluations.

Chapter 2: Review and Recommend How to Update National Guidelines to Include New Technologies

2.1. Review of the results of testing in CZ 2, 5 and 8:

I. Developing Guidelines and Codes for Direct/Indirect Evaporative Cooling (IEC)

Establish specific guidelines and codes for IEC Systems: Given the promising results of IEC systems under various climatic conditions in Egypt, it is recommended that specific guidelines and codes for Direct Indirect Evaporative Cooling (IEC) be developed. These codes should define the design, testing, and performance requirements for IEC systems to ensure safety, efficiency, and adaptability across different climatic zones.

Include IEC Performance Metrics: The guidelines should specify essential performance metrics for IEC systems, such as Energy Efficiency Ratio (EER), cooling capacity, and water consumption. Testing results from climatic zones 2, 5 and 8 demonstrate that IEC systems perform well compared to conventional DX systems, particularly in high-temperature and low-humidity conditions.

II. Guidelines for Not-In-Kind (NIK) Cooling Technologies

Adopt Flexible Frameworks for Emerging Technologies: Not-In-Kind (NIK) cooling technologies, such as IEC, represent a significant shift from traditional vapor-compression systems. National guidelines should include frameworks that allow for the inclusion of other NIK technologies as they evolve, ensuring that national codes remain relevant and up-to-date.

Focus on Environmental Impact: As NIK technologies are generally less reliant on high-GWP refrigerants; the guidelines should emphasize lower GWP refrigerant options (such as R-32 or R-454B) and the potential for reduced greenhouse gas emissions. This aligns with international efforts to phase out HCFCs and other high-GWP substances.

III. Expand Testing Requirements Across Climatic Zones

Broaden Testing to All Egyptian Climatic Zones: Current testing has been conducted in climatic zones 2, 5 and 8, highlighting the adaptability of IEC systems in varying humidity and temperature conditions. To fully capture the potential of IEC across Egypt, guidelines should mandate testing in additional zones, where high dry bulb temperatures and low humidity conditions prevail. This would provide comprehensive data on the efficiency and practicality of IEC systems across the country.

IV. Establish Calibration and Certification Protocols

Regular Calibration of IEC Systems: Guidelines should include protocols for the calibration and maintenance of IEC systems to ensure ongoing accuracy in performance and efficiency measurements. This will maintain the systems' reliability over time and across different operational conditions.

Certification for Installers and Manufacturers: A certification program for installers and manufacturers of IEC systems should be established to standardize installation practices and ensure compliance with national guidelines.

V. Promote Awareness and Training for IEC Technology

Educational Campaigns: Implement educational and outreach campaigns targeting HVAC professionals, developers, and policymakers to promote the advantages of IEC technology, such as reduced energy consumption and environmental impact. The outreach conducted as part of this project demonstrated strong interest, highlighting the need for a wider, formalized program.

Technical Training: Provide specialized training for HVAC engineers and technicians on the design, installation, and maintenance of IEC systems. This training should emphasize the differences between IEC and conventional DX systems, including unique operational and environmental considerations.

VI. Economic Feasibility Analysis Requirements

Incorporate Life-Cycle Cost Analysis: The guidelines should mandate a comprehensive life-cycle cost analysis for IEC systems to evaluate their long-term economic benefits compared to traditional DX systems. This includes capital investment, operational costs, maintenance, water consumption, and savings in energy usage.

Financial Incentives: To encourage adoption, the government may consider offering financial incentives, such as tax credits or rebates, for projects implementing IEC technology. This would offset the initial higher investment cost, which the report identified as a barrier despite favorable IRRs and NPVs for IEC system.

VII. Define Quality Assurance and Testing Procedures

Quality Assurance Standards: National guidelines should include quality assurance standards specifically for IEC systems, based on both local and international benchmarks such as EUROVENT recommendations. These standards would ensure consistent product quality and reliable performance data.

Specific Testing Procedures: Define testing procedures for key metrics, including cooling capacity, EER, and water consumption, to provide standardized data that would help in evaluating the systems' efficiency across various conditions. This would help build a reference for further developments and improvements in IEC systems.

VIII. Conclusion

Updating national guidelines to include Direct Indirect Evaporative Cooling (IEC) and Not-In-Kind (NIK) technologies would provide a framework to support the adoption of more energy-efficient and environmentally friendly cooling options in Egypt. By implementing specific codes, expanding testing protocols, and providing financial and educational support, the guidelines can facilitate a transition towards sustainable cooling solutions aligned with Egypt's environmental goals and the HCFC Phase-Out Management Plan.

2.2. Recommendations for Updating National Guidelines

I. Develop Specific Guidelines and a Code for IEC Technology

Create national code for Design, Installation, and Performance: Introduce a national code specifically for IEC systems that covers design specifications, installation practices, and performance criteria. This code should provide clear definitions and minimum performance standards for IEC systems under different climatic conditions.

Align with International Standards: Reference international standards such as EUROVENT and ASHRAE for guidance on classification, testing, and certification of IEC systems. Adapt these standards to suit local conditions and market needs in Egypt.

II. Expand Testing and Performance Evaluation All Climate Zones

Broaden Testing to All Climate Zones: Current testing has been focused on specific zones (2, 5 and 8), which limits the understanding of IEC system performance in other climates. Guidelines should require testing in additional zones. This will validate IEC technology performance across the diverse climatic conditions of Egypt.

Standardize Testing Conditions and Procedures: Establish standardized testing procedures for IEC systems to ensure consistency and reliability in performance data. This includes defining metrics such as cooling capacity, water consumption, and EER under controlled conditions.

III. Promote Lower-GWP Refrigerants and Environmental Sustainability

Mandate Low-GWP Refrigerants: Given that IEC systems often work with lower GWP refrigerants or avoid traditional refrigerants altogether, the guidelines should prioritize refrigerants with minimal environmental impact, such as R-32 or R-454B. This supports Egypt’s HCFC Phase-Out Management Plan (HPMP) and aligns with global efforts to reduce greenhouse gas emissions.

Encourage Water and Energy Efficiency: Define water and energy efficiency benchmarks for IEC systems, given the increased use of water in evaporative cooling. National guidelines should require manufacturers to disclose water and energy consumption data for transparency.

IV. Incorporate Life-Cycle Cost Analysis and Economic Feasibility Assessments

Require Life-Cycle Cost Analysis for Project Approval: Include a requirement for life-cycle cost analysis to assess the economic feasibility of IEC systems compared to traditional DX systems. This analysis should consider initial investment, maintenance costs, water consumption, and energy savings over the system's lifespan.

Financial Incentives for IEC Adoption: Encourage the adoption of IEC systems by offering financial incentives, such as tax credits or rebates, for projects that utilize IEC or other NIK cooling technologies. This can offset initial higher costs and accelerate the market transition toward more sustainable technologies.

V. Develop Calibration and Quality Assurance Protocols

Regular Calibration and Maintenance Standards: Establish guidelines for the regular calibration and maintenance of IEC systems, especially for components like fans, pumps, and water distribution systems. This will ensure systems operate efficiently and provide reliable performance over time.

Certification for Installers and Technicians: To maintain installation quality, establish a certification program for HVAC installers and technicians specifically for IEC systems. This would ensure proper handling of IEC technology and compliance with national standards.

VI. Raise Awareness and Provide Training for IEC and NIK Technologies

Educational Campaigns for Stakeholders: Develop educational programs to increase awareness about the benefits of IEC and NIK technologies among HVAC professionals, policymakers, and the public. Highlight key advantages like energy efficiency, environmental sustainability, and cost-effectiveness.

Technical Training for Engineers and Technicians: Offer specialized training on the design, installation, and maintenance of IEC systems. This training should emphasize the differences between IEC and conventional DX systems, covering topics like water management, fan and pump controls, and evaporative cooling principles.

VII. Quality Assurance and Certification for IEC Technology

Quality Standards and Labeling for IEC Units: Introduce mandatory quality standards and efficiency labeling for IEC systems to provide a transparent comparison for consumers and to encourage manufacturers to maintain high performance standards.

Certification of IEC System Components: Ensure that all components used in IEC systems meet quality standards. Certification should cover key parts such as evaporative cooling pads, water pumps, and control systems.

VIII. Continuous Monitoring and Data Collection for IEC System Performance

Establish a National Database for IEC Performance Data: Collect data on IEC systems' performance across various climatic zones to continuously assess their efficiency and environmental impact. This data can help refine performance benchmarks and inform future updates to the guidelines.

Require Reporting of Operational Data: Implement requirements for reporting operational data, including water and energy usage, for large-scale IEC installations. This can provide insight into long-term performance and help in optimizing designs for future projects.

IX. Incorporate Environmental and Sustainability Criteria

Water Usage Management in Arid Regions: Due to the water requirements of IEC technology, introduce guidelines on water conservation strategies, such as water recycling or closed-loop systems, especially in arid regions. This will make IEC systems more sustainable in areas with water scarcity.

Carbon Footprint Reduction Targets: Set carbon footprint reduction targets for new HVAC projects utilizing IEC and other NIK technologies to align with national sustainability goals.

X. Summary

These recommendations aim to provide a comprehensive update to national guidelines, promoting the adoption of IEC and other NIK technologies as sustainable alternatives to traditional air conditioning systems. By addressing design standards, testing protocols, economic feasibility, environmental impact, and educational initiatives, these updated guidelines can drive a transition toward energy-efficient, environmentally friendly cooling solutions tailored to Egypt's diverse climate.

Chapter 3: Reporting on the Outreach Campaign

3.1. The outreach campaign:

Date: November 3, 2024

Location: Housing & Building National Research Center (HBRC), Cairo, Egypt

I. Introduction

The outreach campaign on Direct/Indirect Evaporative Cooling (IEC) technology was held on November 3, 2024, at HBRC in Cairo, Egypt. This event, supported by UNIDO, UNEP, the National Ozone Unit (NOU), aimed to raise awareness of the technological advances and environmental benefits of IEC systems, specifically focusing on their role in phasing out HCFC in the commercial air conditioning sector. The campaign was part of Egypt's HCFC Phase-out Management Plan (HPMP) under UNIDO's management, emphasizing sustainable alternatives to traditional cooling technologies; **Annex 4**.

II. Campaign Objective

The campaign focused on promoting IEC technology as a sustainable cooling solution. It encouraged stakeholders to contribute to the phase-out of HCFCs in the commercial air conditioning sector by adopting this innovative, energy-efficient technology. The event included presentations on technical findings, testing outcomes, and future recommendations to integrate IEC technology within the national guidelines.

III. Program Agenda:

The event's schedule included:

- Registration
- Welcome & Remarks by Prof. Sayed Shebl (Project Team Leader).
- Prof. Ezzat Lewis discussed the critical role of the Multilateral Fund, NOU, UNIDO, and UNEP in supporting Egypt's transition away from HCFCs and promoting sustainable cooling technologies.
- Presentation of Project Findings by Prof. Alaa Olama (Technical Consultant) and Prof. Sayed Shebl, summarizing key results from recent testing.
- Public Hearing Session, allowing stakeholders to discuss and question the research findings and recommendations.

IV. Key Presentations

Prof. Ezzat Lewis's emphasized the support provided by the Multilateral Fund and the collaboration between NOU, UNIDO, and UNEP in funding and guiding the project. He highlighted their role in addressing climate and environmental challenges through sustainable cooling solutions, facilitating Egypt's compliance with international environmental agreements, and fostering innovation in the HVAC industry.

The research team, led by Prof. Alaa Olama and Prof. Sayed Shebl, presented the following findings:

- Testing in Multiple Climatic Zones: The IEC systems were evaluated across different climatic conditions, including zones 2, 5, and recently, zone 8 (Aswan - Toshky). The latter presented extreme conditions, providing valuable insights into the systems' performance under high dry bulb temperatures and low humidity.
- Performance Metrics: Results indicated that IEC-H units generally demonstrated higher Energy Efficiency Ratios (EER) than traditional DX system, underscoring the technology's superior efficiency.
- Economic Advantages: IEC systems, despite their relatively lower initial compressor capacity, showed favorable cooling capacity and economic feasibility. Comparative financial analysis from previous testing in climatic zones 2 and 5 showed that IEC systems offer substantial operational savings over DX systems.
- Challenges in Testing: During testing in zone 8, environmental factors such as dust storms impacted results, causing transient spikes in relative humidity and occasional compressor instability. These anomalies were addressed to ensure data accuracy, highlighting the need for robust testing environments.

V. Discussions

About 30 persons attended the 4 hours Outreach campaign.

The following are the most important questions and answers made during the campaign:

a. **Question:** Eng. Mohamed Mansour asked about the humidity ratios and relative humidity of the ambient air.

   Answer: Dr. Olama responded, explaining the humidity measurements taken and their correlation with the two storms that occurred during testing, which significantly raised the area's humidity levels.

b. **Question:** Eng. Abdel Sallam Mahrous, a consulting engineer, inquired about which OEMs demonstrated the highest EERs.

   Answer: Prof. Olama clarified that a key principle of the program is to refrain from sharing data aimed at identifying the best-performing prototypes or DX units. For this reason, the OEMs are represented by code numbers rather than by their names.

c. **Question:** Eng. Maarouf, a consulting engineer, asked whether the maintenance requirements for IEC-H units, if produced regularly, would be higher or lower than those for DX units.

Answer: Prof. Olama responded that IEC-H units have higher maintenance costs compared to DX units due to the increased expenses associated with maintaining the evaporation pads.

d. Question: Posed by Eng. Abdel Sallam Mahrous, to provide clarification on the distinct roles of various UN agencies and bodies.

Answer: Dr. Ezzat Lewis, head of the Egyptian NOU, provided clarification on the distinct roles of various UN agencies and bodies. Dr. Ezzat elaborated on future funding opportunities for programs in Egypt and discussed the mechanisms for funding replenishment for individual countries.

e. Question: asked by Eng. Hassan el Mogi, chairman of the consulting firm El-AMAAR, when will the IEC-H specification code be ready to be used by consulting engineers?

Answer: Prof. Olama clarified that the first guidelines on IEC evaporative cooling will first be written as guidance for a forthcoming code, and then a complete code will be written when the third testing program is made and all Climatic Zones in Egypt are covered.

f. Question: An unnamed engineer asked if there is a plan to establish a code and legislate the use of IEC-H systems across Egypt's eight climatic zones.

Answer: Prof. Olama responded that there is hope for a future program phase that will enable OEMs and HVAC practitioners to use a formula to predict compressor sizes and key design parameters of IEC-H units for all eight climatic zones in Egypt. Once performance can be reliably predicted across these zones, binding legislation could be implemented to promote an energy-efficient cooling system nationwide using low-GWP and HC refrigerants.

VI. Outcomes and Future Recommendations

The outreach campaign emphasized the advantages of adopting IEC technology, presenting it as both a technically and economically viable alternative for Egypt's climate. The following recommendations were proposed:

- Development of National Guidelines and Code: Given the successful testing results, there is a need to develop national codes specifically for IEC systems, covering design, performance standards, and testing protocols. These guidelines should be applicable across all climatic zones in Egypt, especially focusing on zones with extreme conditions.
- Education and Training Initiatives: Stakeholder training programs were suggested to ensure proper understanding and implementation of IEC systems, encouraging industry-wide adoption of these sustainable cooling solutions.

VII. Conclusion

The outreach campaign successfully raised awareness about IEC technology and fostered a collaborative atmosphere among government agencies, industry professionals, and environmental organizations. The attendees expressed interest in the future development of national guidelines, continued testing, and integration of IEC systems in Egypt's HVAC sector. The campaign underscored the potential of IEC technology as a key component of Egypt's environmental strategy to reduce HCFC reliance and promote sustainable development.

Chapter 4: Conclusions and Future Work

The testing and evaluation of Direct/Indirect Evaporative Cooling (IEC) Hybrid prototypes across different climatic zones in Egypt (CZ 2, CZ 5, and CZ 8) have demonstrated the effectiveness and energy efficiency of IEC technology as a sustainable alternative to traditional Direct Expansion (DX) systems. The IEC-H systems consistently outperformed DX units in terms of Energy Efficiency Ratio (EER) and overall cooling capacity, even under Egypt's extreme climatic conditions. This performance advantage, along with the reduced environmental impact due to the use of lower Global Warming Potential (GWP) refrigerants, positions IEC technology as a promising solution for reducing reliance on HCFCs in Egypt's commercial air conditioning sector.

4.1. Key findings:

Superior EER: IEC-H systems showed higher EER compared to DX systems, particularly in arid climates with high dry bulb temperatures and low relative humidity, like those in CZ 8.

Economic Benefits: The life-cycle cost analysis showed that IEC-H systems offer significant operational savings, making them economically viable options for long-term applications.

Operational Resilience: The IEC-H systems performed effectively despite challenges such as dust storms and large fluctuations in humidity in a single day, reinforcing their suitability for Egypt’s diverse and challenging climates.

This report provides a strong foundation for developing national guidelines and standards for IEC technology in Egypt. By transitioning to IEC-H systems, Egypt can align with its HCFC Phase-out Management Plan (HPMP) and support global efforts to reduce greenhouse gas emissions.

4.2. Suggested Stage III

To further strengthen the implementation and scaling of IEC technology, the following future work is recommended:

a. Mathematical Modeling for IEC Performance Prediction: Develop a mathematical model to predict EER and refrigeration capacity of IEC-H prototypes across Egypt’s remaining five climatic zones. This model would enable stakeholders to estimate IEC-H performance in various conditions, supporting more targeted and optimized deployments.

b. Comprehensive Testing Across All Climatic Zones: Conduct additional testing in other climatic zones (beyond CZ 2, CZ 5, and CZ 8) to gather comprehensive data that will inform national guidelines. This will ensure that the IEC systems' performance is fully validated across Egypt's diverse climatic conditions.

c. Development of National Standards and Codes: Draft national standards and codes for IEC systems, encompassing design requirements, performance standards, and testing protocols. These standards should include specific guidelines for water and energy efficiency to maximize the sustainability of IEC systems.

d. Stakeholder Training and Capacity Building: Provide training and educational programs for HVAC professionals, policy makers, and industry stakeholders to promote the adoption of IEC technology. Training should cover IEC-specific installation, maintenance, and operational practices to ensure proper implementation.

e. Establishment of a National Database for IEC System Performance: Create a centralized database to monitor IEC performance across different regions and installations. This data will be valuable for ongoing analysis, improvements, and updates to the national standards as the technology matures.

f. Financial Incentives and Support Mechanisms: Encourage the adoption of IEC technology by implementing financial incentives, such as rebates, tax credits, or low-interest loans, for projects that use IEC or other Not-In-Kind (NIK) cooling technologies. Financial support will help offset the initial costs and accelerate market adoption.

g. Further Research on Water Conservation in Arid Regions: Investigate water conservation strategies for IEC systems in arid regions, including water recycling or closed-loop designs, to address water usage concerns in water-scarce areas.

h. By addressing these areas, Egypt can build a robust framework for integrating IEC technology nationwide, fostering a more sustainable, energy-efficient cooling industry and making significant progress toward environmental and climate goals.

Annex 1: Results of Tests of All OEMs:

A.1. Results of OEM 2:

Basic Information			
Tested Units Name	DX (Direct Expansion Unit)		
	IEC Hybrid (Indirect Evaporative Cooling Hybrid Unit)		
OEM No.	2		
Refrigerant	R-32		
Air Flow Rate	0.561 m3/s for DX and IEC hybrid Units		
Capacity	DX	2	Compressors
	IEC hybrid	2	Compressors
Water Bath Area	1000*900		mm2
Climatic Zone	8 (South Egypt)		
Altitude	196.07 meter (From Sea Level)		
Location	22°49' 02" N 31°28' 16" E		
Test Date	26-Aug-24		

Used Apparatus

Used Apparatus	Code of Used Apparatus	Measured Property	Measurement Unit
Weather Station, Dry bulb temperature	**WS; T-amb**	Ambient dry bulb temperature for both Units	°C
Weather Station, Relative Humidity	**WS; Rh-amb**	Ambient Relative humidity for both Units	%
Air Quality 4 - Dry bulb temperature	**AQ4; T-amb**	Ambient dry bulb temperature for both Units	°C
Air Quality 4 - Relative Humidity	**AQ4; RH-amb**	Ambient Relative humidity for both Units	%
Air Quality 6 - Dry bulb temperature	**AQ6; T-amb**	Ambient dry bulb temperature for both Units	°C
Air Quality 6 - Relative Humidity	**AQ6; RH-amb**	Ambient Relative humidity for both Units	%
Fluke 975 - Dry bulb temperature	**F975; T-amb**	Ambient dry bulb temperature for both Units	°C
Air Quality 1 - Dry bulb temperature	**AQ1; T-out; DX**	Outlet dry bulb temperature for DX Unit	°C
Air Quality 1 - Relative Humidity	**AQ1; RH-out; DX**	Outlet Relative humidity for DX Unit	%
Air Quality 3 - Dry bulb temperature	**AQ3; T-out; DX**	Outlet dry bulb temperature for DX Unit	°C
Air Quality 3 - Relative Humidity	**AQ3; RH-out; DX**	Outlet Relative humidity for DX Unit	%
Lutron 1 - Dry bulb temperature	**L1; T-out; DX**	Outlet dry bulb temperature for DX Unit	°C
Lutron 1 - Relative Humidity	**L1; RH-out; DX**	Outlet Relative humidity for DX Unit	%
Air Quality 2 - Dry bulb temperature	**AQ2; T-out; IEC-H**	Outlet dry bulb temperature for IEC Hybrid Prototype	°C
Air Quality 2 - Relative Humidity	**AQ2; RH-out; IEC-H**	Outlet Relative humidity for IEC Hybrid Prototype	%
Lutron 2 - Dry bulb temperature	**L2; T-out; IEC-H**	Outlet dry bulb temperature for IEC Hybrid Prototype	°C
Lutron 2 - Relative Humidity	**L2; RH-out; IEC-H**	Outlet Relative humidity for IEC Hybrid Prototype	%
UNI T - Dry bulb temperature	**U; T-out; IEC-H**	Outlet dry bulb temperature for IEC Hybrid Prototype	°C
UNI T - Relative Humidity	**U; RH-out; IEC-H**	Outlet Relative humidity for IEC Hybrid Prototype	%
Tabular level gauge for measuring the Water level change	**W.Lvl; IEC-H**	make up of evaporated water of the IEC hybrid unit	mm/hr
Water volume in Litres/hour (calculated)	**W.Vol; IEC-H**	hourly consumption rate of evaporated water for IEC hybrid unit	Litres/hr
Compressor power meter - IEC hybrid unit	**Comp.; IEC-H**	Power consumption of the Compressor of the IEC hybrid Unit	Watts
Pump power meter - IEC hybrid unit	**Pump; IEC-H**	Power consumption of the Pump of the IEC hybrid Unit	Watts
Evaporative Fan power meter - IEC hybrid unit	**Evap. Fan; IEC-H**	Power consumption of the Evaporator Fan of the IEC hybrid Prototype	Watts
Supply fan power meter - IEC hybrid unit	**Sup. Fan; IEC-H**	Power consumption of the Supply Fan of the IEC hybrid Prototype	Watts
Power meter of total power consumption of IEC hybrid Unit	**Pw.Tot; IEC-H**	Total Input power of IEC Hybrid Prototype	Watts
Power meter of total power consumption of DX Unit	**Pw.Tot; DX**	Total Input power of DX Unit	Watts

Time	Ambient Conditions								
	Dry Bulb Temperature; °F	Relative Humidity; %	Pressure at the given altitude Pa	Saturation vapor pressure hPa	Partial vapor pressure Pa	Humidity Ratio	Partial pressure of dry air Pa	Density of Ambient Air; kg/m3	Enthalpy of Ambient Air; kJ/kg
	Tdb amb	**RH amb**	**P**	**Psat amb**	**Pv amp**	**ω amb**	**Pd amb**	**ρ amb**	**h amb**
0:00	33.4	27.5	98992.08	51.37	1412.61	0.009004	97579.47	1.118995	56.62
1:00	32.6	30.3	98992.08	49.04	1487.67	0.009490	97504.41	1.121691	57.02
2:00	32.2	28.4	98992.08	48.15	1369.18	0.008724	97622.90	1.123396	54.73
3:00	32.2	22.5	98992.08	48.09	1083.54	0.006884	97908.54	1.124720	49.99
4:00	31.9	20.7	98992.08	47.35	978.46	0.006209	98013.62	1.126187	47.98
5:00	30.2	21.1	98992.08	42.98	906.88	0.005751	98085.21	1.132809	45.08
6:00	30.4	25.7	98992.08	43.35	1112.66	0.007071	97879.42	1.131356	48.61
7:00	31.4	26.1	98992.08	45.89	1196.26	0.007608	97795.82	1.127279	51.00
8:00	35.2	21.3	98992.08	56.93	1214.46	0.007726	97777.62	1.113128	55.23
9:00	36.1	17.5	98992.08	59.82	1044.80	0.006635	97947.28	1.110611	53.34
10:00	38.1	15.1	98992.08	66.51	1004.37	0.006375	97987.71	1.103823	54.66
11:00	39.8	12.2	98992.08	72.78	890.30	0.005645	98101.78	1.098395	54.48
12:00	39.8	13.2	98992.08	73.07	966.94	0.006136	98025.14	1.097809	55.82
13:00	40.6	12.5	98992.08	75.94	946.76	0.006006	98045.32	1.095356	56.23
14:00	43.2	11.0	98992.08	87.07	960.69	0.006095	98031.40	1.086295	59.10
15:00	41.1	10.9	98992.08	78.09	853.73	0.005411	98138.35	1.093916	55.23
16:00	40.4	11.3	98992.08	75.34	848.84	0.005380	98143.24	1.096292	54.46
17:00	40.7	11.3	98992.08	76.55	865.02	0.005483	98127.07	1.095176	55.03
18:00	40.0	10.4	98992.08	73.75	767.04	0.004857	98225.04	1.098036	52.71
19:00	31.3	36.3	98992.08	45.57	1654.11	0.010570	97337.97	1.125762	58.46
20:00	30.9	38.2	98992.08	44.61	1702.45	0.010884	97289.63	1.126941	58.87
21:00	32.1	33.1	98992.08	47.75	1582.05	0.010102	97410.03	1.123030	58.10
22:00	33.0	30.1	98992.08	50.16	1509.78	0.009633	97482.30	1.120130	57.80
23:00	31.7	35.2	98992.08	46.61	1642.36	0.010494	97349.72	1.124335	58.67
0:00	31.0	38.0	98992.08	44.80	1700.78	0.010873	97291.30	1.126670	58.92

IEC Hybrid Unit									
Dry Bulb Temperature; °F	Relative Humidity; %	Saturation vapor pressure hPa	Partial vapor pressure Pa	Humidity Ratio	Partial pressure of dry air Pa	Density of Ambient Air; kg/m3	Enthalpy of outlet Air; kJ/kg	Water Consumed; mm/hour	Water Consumed; m3/hour
Tdb out IEC-H	**RH out IEC-H**	**Psat out IEC-H**	**Pv out IEC-H**	**ω out IEC-H**	**Pd out IEC-H**	**ρ out IEC-H**	**h out IEC-H**	**W.Lvl IEC-H**	**W.Vol IEC-H**
11.4	82.9	13.51	1120.40	0.007120	97871.68	1.206622	29.4494051	0	0
11.2	83.5	13.30	1111.18	0.007061	97880.90	1.207655	29.06239976	10	0.009
11.4	83.1	13.45	1117.70	0.007103	97874.38	1.206918	29.33780956	23	0.0207
9.9	81.3	12.20	991.63	0.006294	98000.45	1.213758	25.80553815	14	0.0126
8.7	77.6	11.28	874.57	0.005544	98117.51	1.219328	22.73249885	27	0.0243
8.1	77.6	10.80	837.77	0.005309	98154.31	1.222247	21.49751699	35	0.0315
8.3	79.8	10.97	875.31	0.005549	98116.78	1.221058	22.33824467	20	0.018
8.8	81.8	11.30	924.76	0.005865	98067.32	1.218950	23.57481653	30	0.027
9.2	79.1	11.66	922.50	0.005851	98069.58	1.216946	24.01248916	33	0.0297
10.6	75.1	12.75	957.78	0.006077	98034.30	1.211063	25.93646559	30	0.027
11.4	71.2	13.48	959.76	0.006090	98032.32	1.207507	26.81549931	30	0.027
11.9	70.3	13.90	976.87	0.006199	98015.21	1.205451	27.56636153	40	0.036
15.2	66.2	17.27	1142.94	0.007265	97849.14	1.190758	33.65140652	18	0.0162
12.5	68.3	14.46	988.28	0.006272	98003.80	1.202866	28.36086296	12	0.0108
13.5	63.6	15.47	984.16	0.006246	98007.93	1.198549	29.34465218	30	0.027
12.2	64.2	14.24	914.36	0.005799	98077.72	1.204191	26.9287023	20	0.018
11.2	64.2	13.30	854.45	0.005416	98137.63	1.208844	24.91249156	20	0.018
11.5	65.5	13.57	888.80	0.005635	98103.29	1.207411	25.7711045	20	0.018
11.3	66.5	13.42	892.01	0.005656	98100.07	1.208104	25.65370663	20	0.018
10.8	65.4	12.92	845.26	0.005357	98146.82	1.210732	24.32460083	30	0.027
13.8	82.7	15.75	1301.59	0.008287	97690.49	1.195978	34.77342262	34	0.0306
13.3	85.3	15.24	1300.52	0.008280	97691.56	1.198071	34.24575608	30	0.027
11.7	83.7	13.75	1151.34	0.007319	97840.74	1.205350	30.22289336	20	0.018
11.3	68.8	13.42	923.32	0.005856	98068.76	1.207959	26.15915299	37	0.0333
11.5	83.8	13.60	1139.18	0.007241	97852.91	1.206112	29.85571674	30	0.027

IEC Hybrid Unit									
Compressor power consumption; Watts	Pump power consumption; Watts	Evaporative Fan power consumption; Watts	Supply Fan power consumption; Watts	IEC Hybrid Unit total power consumption; Watts	Mass flow rate; kg/s	Total Cooling Capacity kW	Total Cooling Capacity BTU/hr	Coefficient of Performance W/W	Energy Efficiency Ratio BTU/W.hr
Comp. IEC-H	Pump IEC-H	Evap. Fan IEC-H	Sup. Fan IEC-H	Pw.Tot IEC-H	m'	Qtot IEC-H	Qtot IEC-H	COP	EER
6947	805.2	405.0	756.0	8913.1	0.6769	18.3921	62756.4974	2.0635	7.0409
6884	808.7	412.1	766.4	8871.2	0.6775	18.9419	64632.5528	2.1352	7.2857
6348	810.7	410.2	756.6	8325.5	0.6771	17.1899	58654.3430	2.0647	7.0452
7427	809.3	401.7	764.4	9402.4	0.6809	16.4666	56186.3805	1.7513	5.9757
6573	810.3	416.7	750.8	8550.7	0.6840	17.2720	58934.6249	2.0200	6.8924
6970	811.1	423.8	753.4	8958.3	0.6857	16.1713	55178.7587	1.8052	6.1595
7106	814.1	429.0	755.3	9104.4	0.6850	17.9961	61405.3547	1.9766	6.7446
6898	815.7	428.4	756.0	8898.0	0.6838	18.7569	64001.0616	2.1080	7.1927
6378	817	410.8	845.0	8450.8	0.6827	21.3113	72717.1897	2.5218	8.6048
6642	817	416.7	744.3	8619.9	0.6794	18.6212	63538.1718	2.1603	7.3711
7045	816.3	397.8	738.4	8997.5	0.6774	18.8631	64363.4589	2.0965	7.1535
7315	817	405.6	730.6	9268.2	0.6763	18.2028	62110.4004	1.9640	6.7014
7323	841.8	413.4	728.0	9306.2	0.6680	14.8110	50537.0716	1.5915	5.4305
7285	941.2	424.5	746.2	9396.9	0.6748	18.8041	64162.3799	2.0011	6.8281
7283	834.1	440.7	756.0	9313.8	0.6724	20.0065	68264.9438	2.1481	7.3295
7210	837	446.6	757.9	9251.5	0.6756	19.1163	65227.4849	2.0663	7.0505
7301	836.7	458.9	758.6	9355.2	0.6782	20.0381	68372.9817	2.1419	7.3086
7294	832.4	459.6	767.7	9353.6	0.6774	19.8196	67627.2174	2.1189	7.2301
7216	834.5	470.0	767.7	9288.1	0.6777	18.3364	62566.5424	1.9742	6.7362
7239	837.1	472.6	773.5	9322.2	0.6792	23.1821	79100.5569	2.4868	8.4852
7021	801.2	457.6	764.4	9044.2	0.6709	16.1707	55176.7739	1.7880	6.1008
6893	801.8	447.9	769.6	8912.3	0.6721	16.0343	54711.3703	1.7991	6.1389
6868	799.5	450.5	774.2	8892.1	0.6762	18.6459	63622.3092	2.0969	7.1549
6896	790.7	414.1	752.7	8853.5	0.6777	22.0311	75173.1799	2.4884	8.4908
6888	802.6	408.9	753.4	8852.8	0.6766	19.6684	67111.4290	2.2217	7.5808

DX Unit						
Dry Bulb Temperature; °C	Relative Humidity; %	Saturation vapor pressure hPa	Partial vapor pressure Pa	Humidity Ratio	Partial pressure of dry air Pa	Density of Ambient Air; kg/m3
Tdb out DX	RH out DX	Psat out IEC-H	Pv out IEC-H	ω out IEC-H	Pd out IEC-H	ρ out IEC-H
8.9	79.4	11.38	903.35	0.005728	98088.73	1.218618
9.2	82.5	11.66	962.54	0.006107	98029.54	1.216759
10.2	82.2	12.42	1020.27	0.006477	97971.82	1.212483
9.2	81.7	11.61	948.93	0.006020	98043.15	1.217110
8.4	80.0	11.02	881.85	0.005591	98110.23	1.220738
8.1	82.0	10.80	885.65	0.005615	98106.43	1.222022
8.8	82.1	11.35	932.35	0.005914	98059.74	1.218626
9.9	82.7	12.17	1006.05	0.006386	97986.03	1.213834
9.4	85.1	11.77	1001.82	0.006359	97990.26	1.216002
10.6	76.7	12.78	979.93	0.006219	98012.15	1.210818
10.6	75.9	12.75	967.98	0.006142	98024.10	1.211016
11.2	74.6	13.33	994.99	0.006315	97997.09	1.208052
13.0	71.1	14.98	1065.38	0.006767	97926.70	1.200269
12.7	73.4	14.69	1078.43	0.006851	97913.65	1.201469
12.2	75.5	14.18	1071.07	0.006803	97921.01	1.203749
13.0	73.8	15.01	1108.23	0.007042	97883.85	1.199932
12.7	73.8	14.72	1086.68	0.006904	97905.41	1.201291
12.0	73.3	14.03	1028.51	0.006530	97963.57	1.204649
11.5	75.8	13.54	1025.84	0.006513	97966.24	1.206919
11.1	74.7	13.21	987.54	0.006268	98004.54	1.208653
14.1	84.0	16.12	1354.45	0.008628	97637.64	1.194209
13.6	86.2	15.54	1340.20	0.008536	97651.89	1.196635
12.5	85.4	14.46	1235.11	0.007859	97756.97	1.201728
12.5	85.0	14.46	1228.84	0.007818	97763.24	1.201757
12.8	86.4	14.75	1273.92	0.008109	97718.16	1.200288

DX Unit						
Enthalpy of outlet Air; kJ/kg	DX Unit total power consumption; Watts	Mass flow rate; kg/s	Total Cooling Capacity kW	Total Cooling Capacity BTU/hr	Coefficient of Performance W/W	Energy Efficiency Ratio BTU/W.hr
h out IEC-H	**Pw.Tot DX**	**m'**	**Qtot IEC-H**	**Qtot IEC-H**	**COP**	**EER**
23.33146224	10620	0.6836	22.7574	77651.6399	2.1429	7.3118
24.65825319	10708	0.6826	22.0910	75377.6363	2.0630	7.0394
26.53940038	10685	0.6802	19.1726	65419.7484	1.7944	6.1226
24.37101048	10560	0.6828	17.4916	59683.7185	1.6564	5.6519
22.51126106	10415	0.6848	17.4435	59519.7306	1.6748	5.7148
22.26783086	10403	0.6856	15.6402	53366.7119	1.5034	5.1299
23.76482472	10239	0.6836	16.9850	57955.2822	1.6589	5.6602
26.00454545	10181	0.6810	17.0236	58086.8891	1.6721	5.7054
25.4278966	10383	0.6822	20.3292	69366.1543	1.9579	6.6807
26.3282235	10918	0.6793	18.3513	62617.3113	1.6808	5.7352
26.10124023	11349	0.6794	19.4031	66206.2279	1.7097	5.8337
27.21544419	11603	0.6777	18.4799	63055.8848	1.5927	5.4344
30.15211431	11797	0.6734	17.2855	58980.6322	1.4652	4.9996
30.05839136	11361	0.6740	17.6381	60183.7649	1.5525	5.2974
29.39629044	12102	0.6753	20.0584	68442.1241	1.6574	5.6554
30.88111486	12333	0.6732	16.3881	55918.4320	1.3288	4.5340
30.22603827	12146	0.6739	16.3320	55727.1258	1.3446	4.5881
28.53747868	11994	0.6758	17.9047	61093.3669	1.4928	5.0937
27.95178484	12041	0.6771	16.7625	57195.9184	1.3921	4.7501
26.95950109	11728	0.6781	21.3557	72868.5815	1.8209	6.2132
36.00983074	10677	0.6700	15.3185	52268.7818	1.4347	4.8955
35.1987533	10637	0.6713	15.3753	52462.8553	1.4455	4.9321
32.36492534	10530	0.6742	17.1457	58503.6967	1.6283	5.5559
32.26300953	10607	0.6742	17.8028	60745.8126	1.6784	5.7270
33.30239352	10484	0.6734	17.2526	58868.2981	1.6456	5.6151

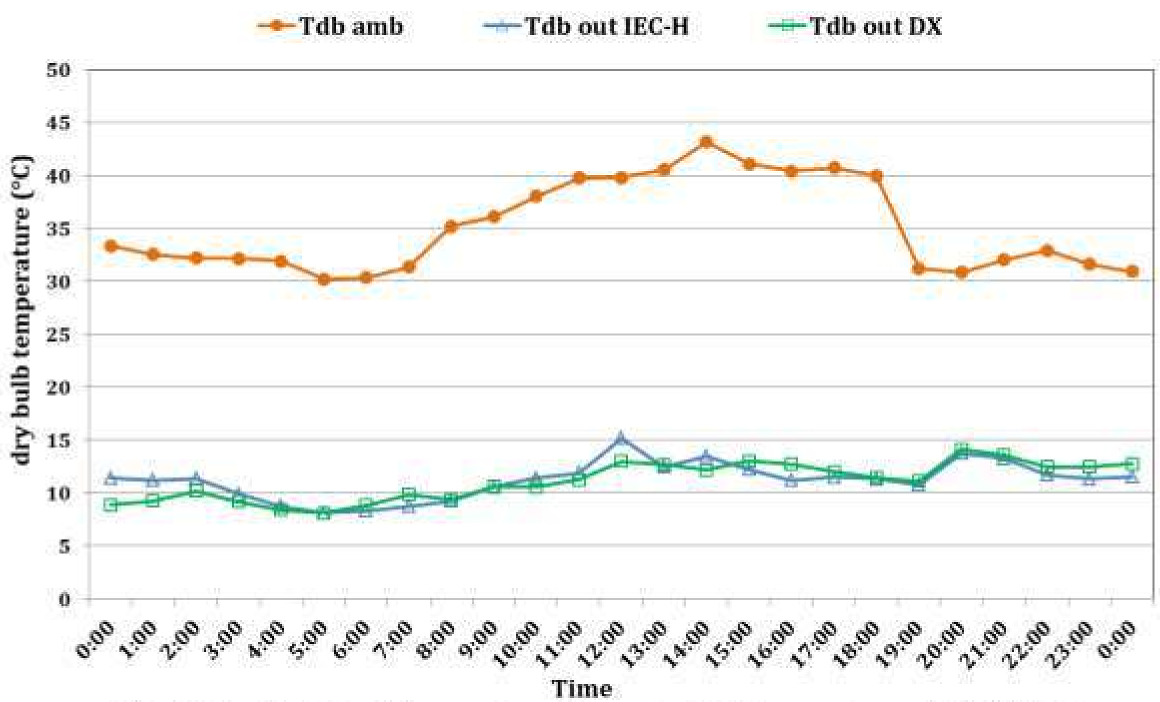

Fig. 1. Inlet Ambient Temperature Versus Outlet Temperature of IEC Hybrid and DX units for OEM 2 in CZ 8

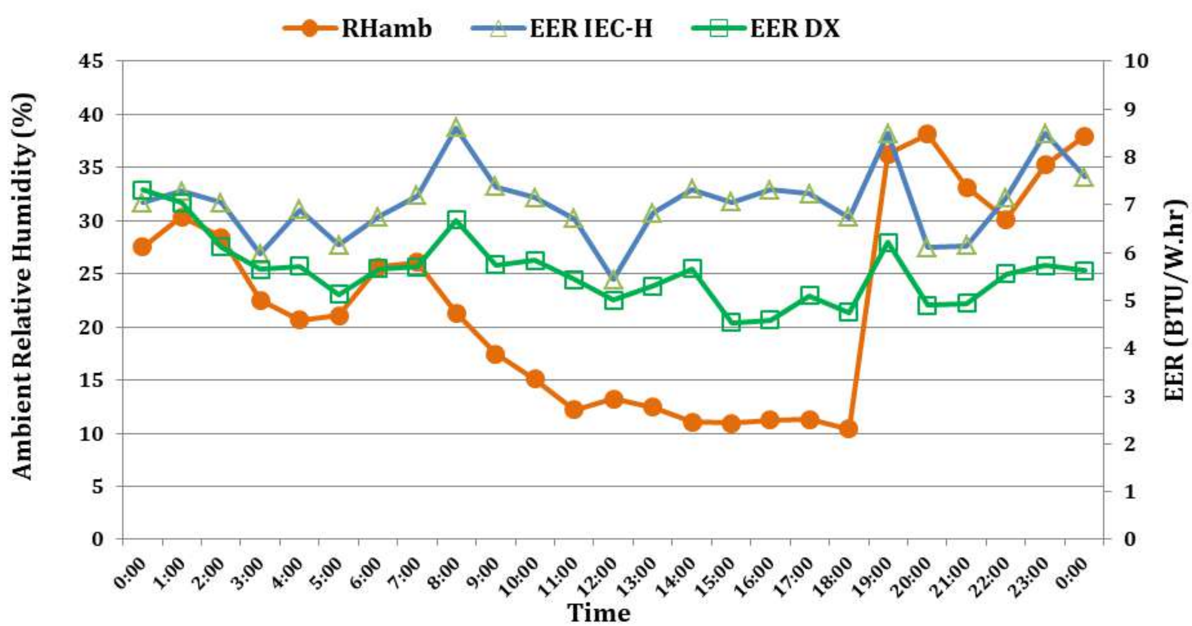

Fig. 2. EER for IEC Hybrid Unit & DX Unit Versus Ambient Relative Humidity for OEM 2 in CZ 8

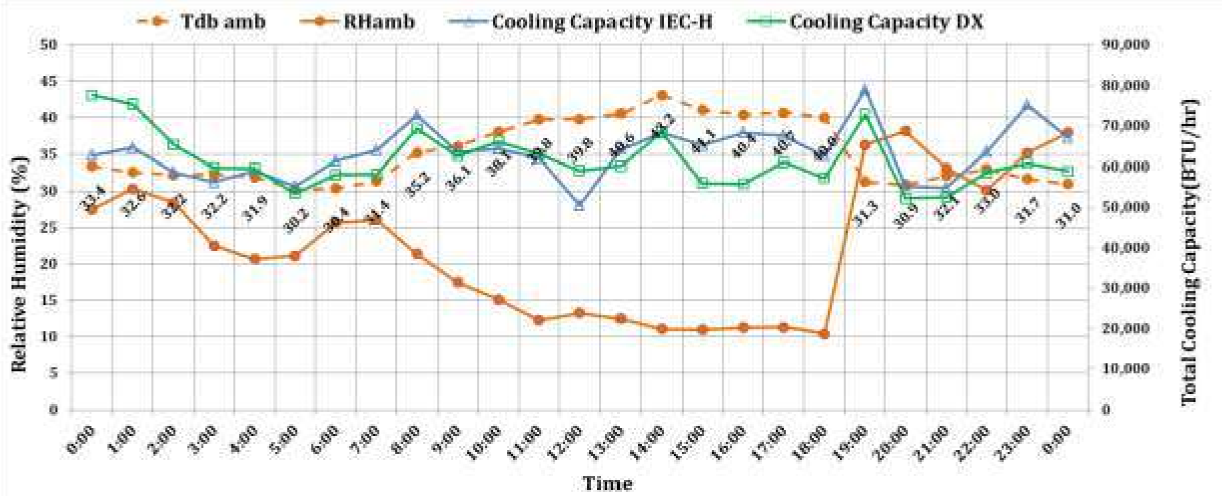

Fig. 3. Cooling Capacity for IEC Hybrid Unit & DX Unit Versus Ambient Conditions for OEM 2 in CZ 8

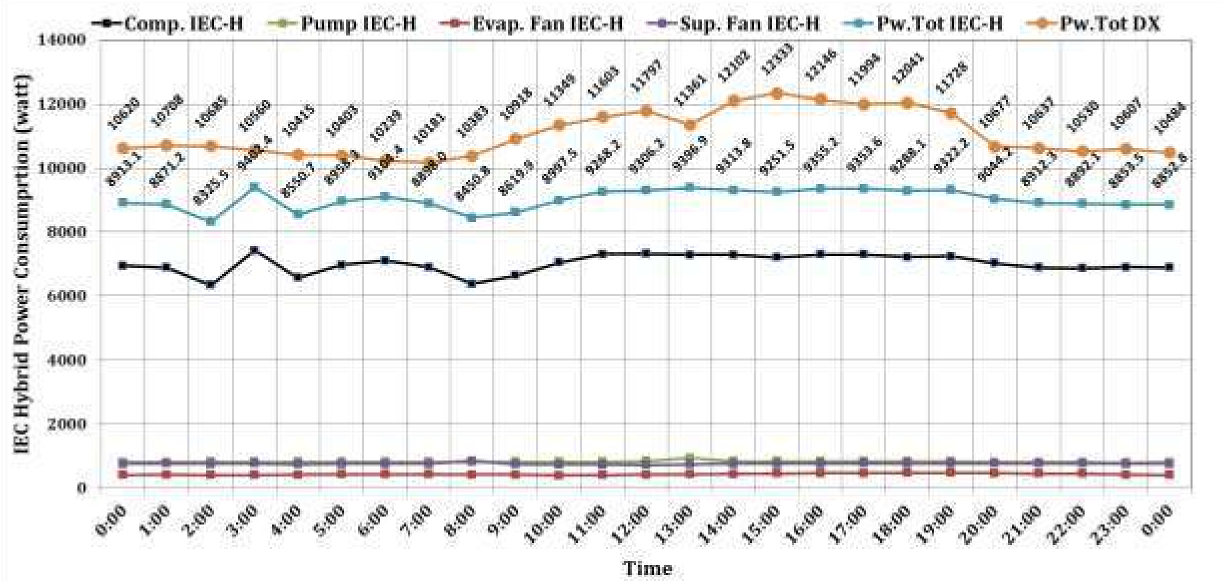

Fig. 4. Power Consumption of DX Unit and IEC Hybrid Unit Components for OEM2 in CZ 8

A.2. Results of OEM 3:

Basic Information			
Tested Units Name	DX (Direct Expansion Unit)		
	IEC Hybrid (Indirect Evaporative Cooling Hybrid Unit)		
OEM No.	3		
Refrigerant	R-32		
Air Flow Rate	1320 C.F.M for DX and IEC hybrid Units		
Capacity	DX	2	Compressors
	IEC hybrid	1	Compressor
Water Bath Area	1728.5*623		mm2
Climatic Zone	8 (South Egypt)		
Altitude	196.07 meter (From Sea Level)		
Location	22°49' 02" N 31°28' 16" E		
Test Date	28-Aug-24		

Used Apparatus

Used Apparatus	Code of Used Apparatus	Measured Property	Measurement Unit
Weather Station, Dry bulb temperature	**WS; T-amb**	Ambient dry bulb temperature for both Units	°C
Weather Station, Relative Humidity	**WS; Rh-amb**	Ambient Relative humidity for both Units	%
Air Quality 5 - Dry bulb temperature	**AQ4; T-amb**	Ambient dry bulb temperature for both Units	°C
Air Quality 5 - Relative Humidity	**AQ4; RH-amb**	Ambient Relative humidity for both Units	%
Air Quality 6 - Dry bulb temperature	**AQ6; T-amb**	Ambient dry bulb temperature for both Units	°C
Air Quality 6 - Relative Humidity	**AQ6; RH-amb**	Ambient Relative humidity for both Units	%
Fluke 975 - Dry bulb temperature	**F975; T-amb**	Ambient dry bulb temperature for both Units	°C
Air Quality 1 - Dry bulb temperature	**AQ1; T-out; DX**	Outlet dry bulb temperature for DX Unit	°C
Air Quality 1 - Relative Humidity	**AQ1; RH-out; DX**	Outlet Relative humidity for DX Unit	%
Air Quality 2 - Dry bulb temperature	**AQ3; T-out; DX**	Outlet dry bulb temperature for DX Unit	°C
Air Quality 2 - Relative Humidity	**AQ3; RH-out; DX**	Outlet Relative humidity for DX Unit	%
UNI T - Dry bulb temperature	**U; T-out; DX**	Outlet dry bulb temperature for DX Unit	°C
UNI T - Relative Humidity	**U; RH-out; DX**	Outlet Relative humidity for DX Unit	%
Lutron 1 - Dry bulb temperature	**L1; T-out; DX**	Outlet dry bulb temperature for DX Unit	°C
Lutron 1 - Relative Humidity	**L1; RH-out; DX**	Outlet Relative humidity for DX Unit	%
Air Quality 3 - Dry bulb temperature	**AQ2; T-out; IEC-H**	Outlet dry bulb temperature for IEC Hybrid Prototype	°C
Air Quality 3 - Relative Humidity	**AQ2; RH-out; IEC-H**	Outlet Relative humidity for IEC Hybrid Prototype	%
Air Quality 4 - Dry bulb temperature	**AQ2; T-out; IEC-H**	Outlet dry bulb temperature for IEC Hybrid Prototype	°C
Air Quality 4 - Relative Humidity	**AQ2; RH-out; IEC-H**	Outlet Relative humidity for IEC Hybrid Prototype	%
Lutron 2 - Dry bulb temperature	**L2; T-out; IEC-H**	Outlet dry bulb temperature for IEC Hybrid Prototype	°C
Lutron 2 - Relative Humidity	**L2; RH-out; IEC-H**	Outlet Relative humidity for IEC Hybrid Prototype	%
Tabular level gauge for measuring the Water level change	**W.Lvl; IEC-H**	make up of evaporated water of the IEC hybrid unit	mm/hr
Water volume in Litres/hour (calculated)	**W.Vol; IEC-H**	hourly consumption rate of evaporated water for IEC hybrid unit	Litres/hr
Compressor power meter - IEC hybrid unit	**Comp.; IEC-H**	Power consumption of the Compressor of the IEC hybrid Unit	Watts
Pump power meter - IEC hybrid unit	**Pump; IEC-H**	Power consumption of the Pump of the IEC hybrid Unit	Watts
Evaporative Fan power meter - IEC hybrid unit	**Evap. Fan; IEC-H**	Power consumption of the Evaporator Fan of the IEC hybrid Prototype	Watts
Supply fan power meter - IEC hybrid unit	**Sup. Fan; IEC-H**	Power consumption of the Supply Fan of the IEC hybrid Prototype	Watts
Power meter of total power consumption of IEC hybrid Unit	**Pw.Tot; IEC-H**	Total Input power of IEC Hybrid Prototype	Watts
Power meter of total power consumption of DX Unit	**Pw.Tot; DX**	Total Input power of DX Unit	Watts

Time	Ambient Conditions								
	Dry Bulb Temperature; °F	Relative Humidity; %	Pressure at the given altitude Pa	Saturation vapor pressure hPa	Partial vapor pressure Pa	Humidity Ratio	Partial pressure of dry air Pa	Density of Ambient Air; kg/m3	Enthalpy of Ambient Air; kJ/kg
	Tdb amb	**RH amb**	**P**	**Psat amb**	**Pv amp**	**ω amb**	**Pd amb**	**ρ amb**	**h amb**
10:00	42.2	19.1	98992.08	82.85	1579.72	0.010087	97412.37	1.086982	68.43
11:00	44.3	15.9	98992.08	92.43	1472.65	0.009393	97519.44	1.080236	68.79
12:00	44.7	14.2	98992.08	94.35	1339.82	0.008534	97652.27	1.079426	66.98
13:00	45.6	13.0	98992.08	98.82	1284.63	0.008178	97707.45	1.076607	66.97
14:00	45.8	12.0	98992.08	99.83	1201.34	0.007641	97790.74	1.076275	65.79
15:00	47.1	11.2	98992.08	106.66	1198.19	0.007621	97793.89	1.071919	67.06
16:00	46.5	11.1	98992.08	103.46	1151.89	0.007323	97840.19	1.074122	65.68
17:00	44.7	12.1	98992.08	94.35	1141.67	0.007257	97850.41	1.080247	63.68
18:00	43.0	12.2	98992.08	86.39	1051.11	0.006675	97940.97	1.086433	60.44
19:00	41.8	15.1	98992.08	81.13	1222.35	0.007776	97769.73	1.089857	62.06
20:00	39.0	18.6	98992.08	69.91	1302.70	0.008294	97689.38	1.099294	60.54
21:00	38.8	19.0	98992.08	69.17	1314.14	0.008368	97677.94	1.099950	60.53
22:00	37.9	20.0	98992.08	65.89	1317.76	0.008392	97674.32	1.103118	59.67
23:00	38.9	18.0	98992.08	69.54	1251.68	0.007965	97740.40	1.099861	59.59
0:00	37.4	17.0	98992.08	64.13	1090.14	0.006926	97901.94	1.105859	55.39
1:00	36.5	18.0	98992.08	61.06	1099.03	0.006983	97893.05	1.109035	54.62
2:00	35.5	18.0	98992.08	57.80	1040.36	0.006606	97951.73	1.112879	52.64
3:00	34.9	19.0	98992.08	55.91	1062.38	0.006748	97929.70	1.114952	52.39
4:00	34.5	21.6	98992.08	54.69	1179.47	0.007500	97812.61	1.115901	53.91
5:00	33.9	23.0	98992.08	52.90	1216.59	0.007739	97775.49	1.117922	53.91
6:00	33.8	25.2	98992.08	52.60	1323.80	0.008431	97668.28	1.117826	55.58
7:00	34.9	24.0	98992.08	55.91	1341.96	0.008548	97650.12	1.113757	57.01
8:00	37.9	23.0	98992.08	65.89	1515.42	0.009670	97476.66	1.102281	62.95
9:00	40.4	18.0	98992.08	75.34	1356.13	0.008639	97635.95	1.094161	62.86
10:00	41.6	16.0	98992.08	80.28	1284.47	0.008177	97707.61	1.090289	62.89

IEC Hybrid Unit								
Dry Bulb Temperature; °F	Relative Humidity; %	Saturation vapor pressure hPa	Partial vapor pressure Pa	Humidity Ratio	Partial pressure of dry air Pa	Density of Ambient Air; kg/m3	Enthalpy of outlet Air; kJ/kg	Water Consumed; mm/hour
Tdb out IEC-H	RH out IEC-H	Psat out IEC-H	Pv out IEC-H	ω out IEC-H	Pd out IEC-H	ρ out IEC-H	h out IEC-H	W.Lvl IEC-H
14.0	81.0	16.02	1297.63	0.008262	97694.45	1.194886	34.98094337	0
13.3	80.3	15.27	1225.97	0.007800	97766.11	1.198274	33.06585291	10
13.5	80.2	15.44	1238.85	0.007883	97753.23	1.197518	33.44542911	23
13.4	78.8	15.37	1210.93	0.007703	97781.15	1.197925	32.92316943	14
13.0	78.5	15.01	1178.78	0.007496	97813.30	1.199608	32.02674264	27
13.0	77.3	15.01	1160.27	0.007377	97831.82	1.199693	31.72595702	35
12.7	79.0	14.65	1157.65	0.007360	97834.44	1.201244	31.30989144	20
12.7	79.2	14.69	1163.12	0.007395	97828.96	1.201079	31.4326942	30
12.3	80.2	14.34	1149.78	0.007309	97842.30	1.202683	30.84266148	33
13.3	82.2	15.24	1253.28	0.007976	97738.81	1.198288	33.47629318	30
13.4	84.1	15.41	1295.22	0.008246	97696.86	1.197398	34.32946638	30
13.8	85.3	15.78	1345.44	0.008570	97646.64	1.195638	35.52255208	40
13.7	86.1	15.64	1346.34	0.008576	97645.74	1.196190	35.40108645	18
14.0	86.5	15.95	1380.29	0.008795	97611.79	1.194784	36.26157105	12
10.9	82.9	13.01	1079.03	0.006855	97913.05	1.209222	28.202277	30
11.3	83.8	13.42	1125.08	0.007151	97867.00	1.207025	29.42342696	20
10.6	83.3	12.78	1064.72	0.006763	97927.36	1.210425	27.69921696	20
11.4	83.8	13.45	1126.67	0.007161	97865.41	1.206876	29.48318097	20
13.5	83.0	15.47	1284.36	0.008176	97707.73	1.197170	34.22043981	20
13.7	82.3	15.64	1287.42	0.008196	97704.66	1.196460	34.44038634	30
13.6	82.7	15.61	1291.39	0.008222	97700.69	1.196581	34.47114019	34
13.6	83.1	15.58	1294.82	0.008244	97697.26	1.196704	34.493044	30
14.0	82.0	16.02	1313.65	0.008365	97678.43	1.194812	35.24215594	20
13.5	82.0	15.44	1265.61	0.008055	97726.47	1.197395	33.88115959	37
13.7	81.3	15.71	1277.30	0.008131	97714.78	1.196229	34.34357657	30

IEC Hybrid Unit										
Water Consumed; m3/hour	Compressor power consumption; Watts	Pump power consumption; Watts	Evaporative Fan power consumption; Watts	Supply Fan power consumption; Watts	IEC Hybrid Unit total power consumption; Watts	Mass flow rate; kg/s	Total Cooling Capacity kW	Total Cooling Capacity BTU/hr	Coefficient of Performance W/W	Energy Efficiency Ratio BTU/W.hr
W.Vol IEC-H	**Comp. IEC-H**	**Pump IEC-H**	**Evap. Fan IEC-H**	**Sup. Fan IEC-H**	**Pw.Tot IEC-H**	**m'**	**Qtot IEC-H**	**Qtot IEC-H**	**COP**	**EER**
0	4282.1	542.1	239.2	878.6	6057.4	0.7444	24.8980	84955.3823	4.1104	14.0251
0.010768555	4295.3	539.7	231.4	899.7	6089.5	0.7465	26.6647	90983.9017	4.3788	14.9412
0.024767677	4305.8	540.1	234.0	893.1	6149.2	0.7460	25.0142	85352.1263	4.0679	13.8802
0.015075977	4283.1	537.3	237.9	870.0	6107.4	0.7463	25.4110	86705.8366	4.1607	14.1967
0.029075099	4330.8	534.7	241.8	906.4	6097.7	0.7473	25.2317	86094.2556	4.1379	14.1191
0.037689943	4331.7	533.7	246.4	906.3	6064.5	0.7474	26.4094	90112.4670	4.3547	14.8589
0.02153711	4343.6	534.7	243.1	901.5	6066.7	0.7483	25.7204	87761.5122	4.2396	14.4662
0.032305665	4341.7	534.2	243.8	898.5	6068.6	0.7482	24.1260	82321.2025	3.9756	13.5651
0.035536232	4334.2	532.7	241.2	899.5	6065.0	0.7492	22.1779	75674.1976	3.6567	12.4772
0.032305665	4397.8	548.7	243.8	902.6	6141.5	0.7465	21.3390	72811.5803	3.4746	11.8557
0.032305665	4417.4	547.8	244.4	903.2	6203.0	0.7459	19.5518	66713.5207	3.1520	10.7551
0.04307422	4419	548.8	245.1	881.9	6230.8	0.7448	18.6238	63547.1949	2.9890	10.1989
0.019383399	4344.6	551.6	247.7	890.2	6123.4	0.7452	18.0833	61702.6531	2.9532	10.0766
0.012922266	4379.6	550.6	249.0	881.5	6156.4	0.7443	17.3649	59251.6248	2.8207	9.6245
0.032305665	4151.3	553	249.6	876.1	5862.5	0.7533	20.4808	69883.4422	3.4935	11.9204
0.02153711	4131.9	551.5	249.6	879.9	5863.4	0.7519	18.9468	64649.2243	3.2314	11.0259
0.02153711	4235.2	553.4	249.0	878.1	6091.0	0.7541	18.8034	64159.8962	3.0871	10.5336
0.02153711	3931.9	551.5	252.9	877.2	5670.0	0.7518	17.2209	58760.1151	3.0372	10.3633
0.02153711	3954.4	547.4	251.6	877.9	5792.0	0.7458	14.6856	50109.5059	2.5355	8.6515
0.032305665	3938.5	546.4	253.5	870.9	5732.0	0.7454	14.5140	49523.9553	2.5321	8.6399
0.036613087	3877	543.2	252.9	875.4	5613.0	0.7454	15.7376	53699.0605	2.8038	9.5669
0.032305665	3781.9	543.9	252.2	879.3	5669.0	0.7455	16.7842	57270.0208	2.9607	10.1023
0.02153711	4232	550.3	248.3	882.0	5932.0	0.7443	20.6274	70383.6012	3.4773	11.8651
0.039843654	4207	545.6	247.0	887.8	5936.0	0.7459	21.6146	73752.0675	3.6413	12.4245
0.032305665	4140.4	547	245.1	884.7	5825.0	0.7452	21.2734	72587.8429	3.6521	12.4614

DX Unit						
Dry Bulb Temperature; °C	**Relative Humidity; %**	**Saturation vapor pressure hPa**	**Partial vapor pressure Pa**	**Humidity Ratio**	**Partial pressure of dry air Pa**	**Density of Ambient Air; kg/m3**
Tdb out DX	**RH out DX**	**Psat out DX**	**Pv out DX**	**ω out DX**	**Pd out DX**	**ρ out DX**
13.6	73.0	15.60	1138.85	0.007239	97853.24	1.197316
13.8	72.2	15.78	1139.65	0.007244	97852.43	1.196582
14.1	72.4	16.12	1165.97	0.007413	97826.11	1.195108
14.7	71.5	16.75	1197.86	0.007619	97794.22	1.192471
14.4	70.9	16.41	1163.13	0.007395	97828.95	1.193978
14.6	71.1	16.57	1178.19	0.007492	97813.89	1.193287
14.5	71.6	16.54	1183.73	0.007528	97808.35	1.193365
14.0	72.0	15.96	1148.29	0.007300	97843.79	1.195813
14.2	71.1	16.14	1148.09	0.007298	97844.00	1.195086
13.8	71.7	15.75	1129.93	0.007182	97862.15	1.196731
13.8	75.6	15.73	1189.43	0.007564	97802.65	1.196562
13.4	77.7	15.40	1196.48	0.007610	97795.60	1.197887
13.0	77.4	14.95	1157.72	0.007360	97834.37	1.199949
13.4	80.5	15.37	1237.58	0.007875	97754.50	1.197803
10.6	74.3	12.78	949.36	0.006023	98042.72	1.210960
10.3	74.5	12.53	933.36	0.005920	98058.73	1.212316
9.9	75.0	12.16	911.12	0.005778	98080.96	1.214347
9.5	75.4	11.85	893.78	0.005667	98098.30	1.216039
9.3	76.1	11.71	891.51	0.005653	98100.57	1.216803
9.1	76.2	11.52	877.18	0.005561	98114.91	1.217948
9.5	76.4	11.85	905.63	0.005743	98086.45	1.215984
10.5	76.9	12.65	972.81	0.006173	98019.27	1.211492
11.8	78.5	13.86	1088.34	0.006914	97903.75	1.205112
11.5	74.0	13.59	1006.14	0.006387	97985.94	1.206763
12.0	72.2	14.05	1014.29	0.006439	97977.79	1.204609

DX Unit						
Enthalpy of outlet Air; kJ/kg	DX Unit total power consumption; Watts	Mass flow rate; kg/s	Total Cooling Capacity kW	Total Cooling Capacity BTU/hr	Coefficient of Performance W/W	Energy Efficiency Ratio BTU/W.hr
h out DX	Pw.Tot DX	m'	Qtot DX	Qtot DX	COP	EER
31.98067507	11637	0.7459	27.1865	92764.1492	2.3362	7.9715
32.17203516	11826	0.7454	27.2934	93128.8955	2.3079	7.8749
32.93076979	11898	0.7445	25.3471	86487.7810	2.1304	7.2691
34.06104187	12015	0.7429	24.4500	83426.8114	2.0350	6.9436
33.1647953	11801	0.7438	24.2668	82801.8365	2.0563	7.0165
33.56260419	11944	0.7434	24.9030	84972.5539	2.0850	7.1142
33.62727262	11838	0.7434	23.8288	81307.3782	2.0129	6.8683
32.49065914	11896	0.7450	23.2321	79271.0700	1.9529	6.6637
32.66551876	11840	0.7445	20.6807	70565.4829	1.7467	5.9599
31.98854965	11755	0.7455	22.4204	76501.5765	1.9073	6.5080
32.93022734	11584	0.7454	20.5812	70225.8899	1.7767	6.0623
32.7136392	11497	0.7462	20.7550	70819.0817	1.8053	6.1598
31.62511555	11497	0.7475	20.9628	71527.9201	1.8233	6.2214
33.35674085	11425	0.7462	19.5764	66797.3873	1.7135	5.8466
25.83448963	11189	0.7544	22.2965	76078.8041	1.9927	6.7994
25.27126425	11116	0.7552	22.1657	75632.6406	1.9940	6.8039
24.45539947	11137	0.7565	21.3183	72741.0648	1.9142	6.5315
23.7950707	11116	0.7576	21.6607	73909.3861	1.9486	6.6489
23.58076083	11001	0.7580	22.9917	78450.9821	2.0900	7.1313
23.09602817	10954	0.7587	23.3822	79783.3456	2.1346	7.2835
23.9861115	10952	0.7575	23.9355	81671.2366	2.1855	7.4572
26.06068097	10949	0.7547	23.3557	79692.9130	2.1331	7.2786
29.32841221	11174	0.7507	25.2450	86139.3776	2.2593	7.7089
27.69234025	11198	0.7518	26.4363	90204.4201	2.3608	8.0554
28.33265448	11212	0.7504	25.9332	88487.9106	2.3130	7.8922

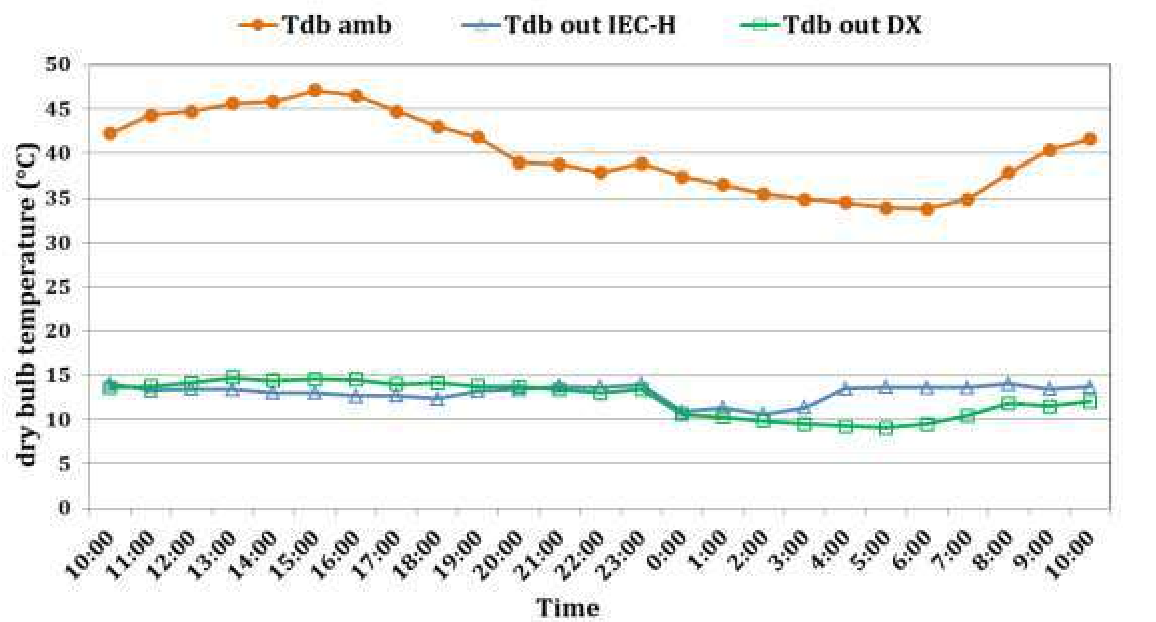

Fig. 1. Inlet Ambient Temperature Versus Outlet Temperature of IEC Hybrid and DX units for OEM3 in CZ 8

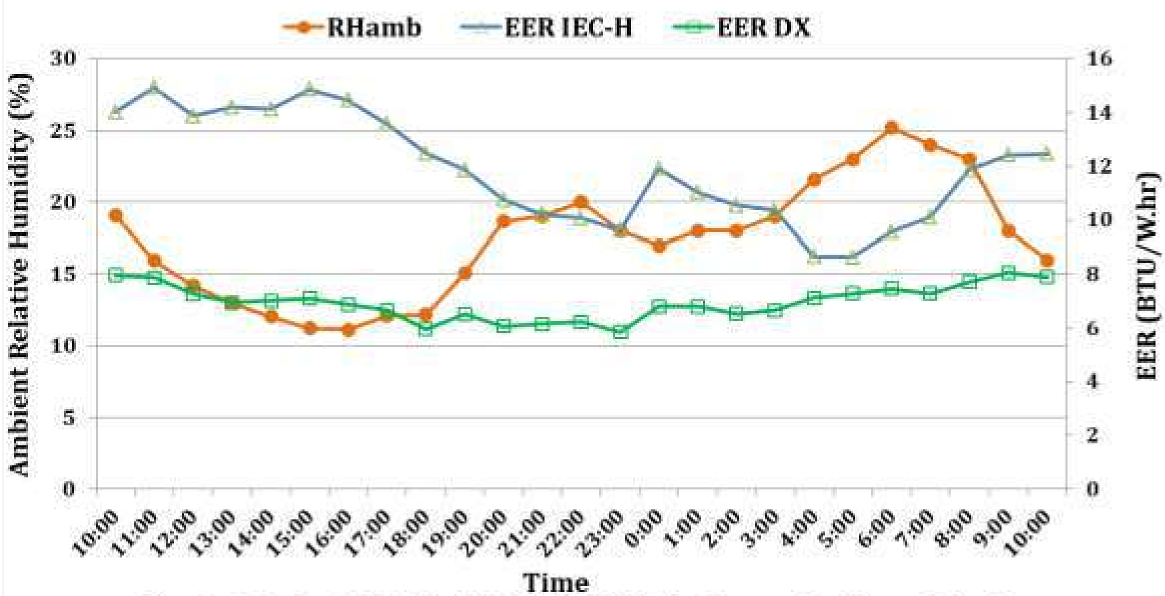

Fig. 2. EER for IEC Hybrid Unit & DX Unit Versus Ambient Relative Humidity for OEM3 in CZ 8

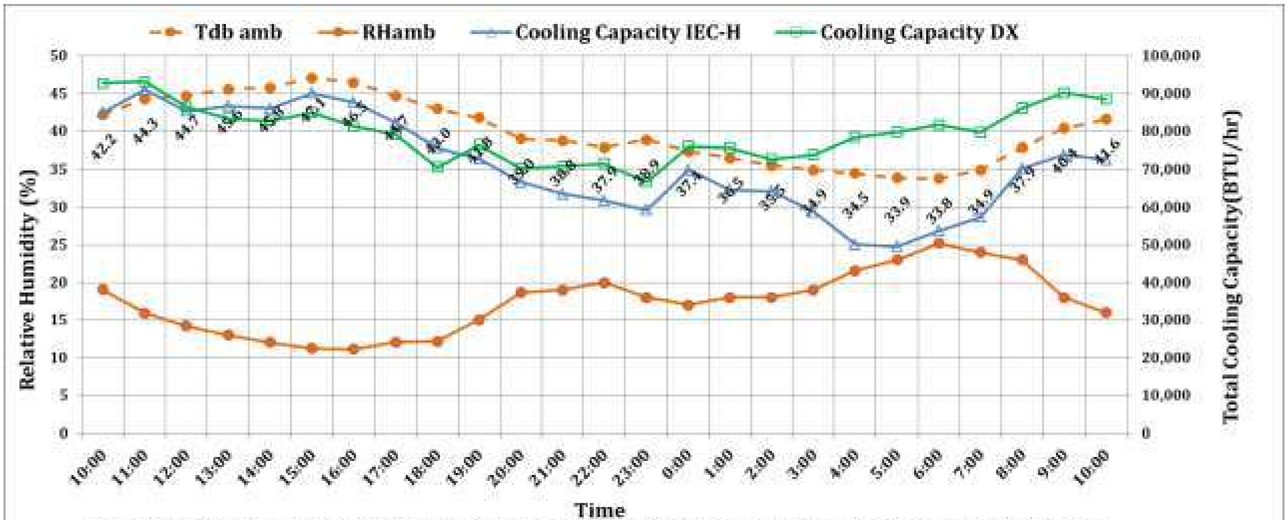

Fig. 3. Cooling Capacity for IEC Hybrid Unit & DX Unit Versus Ambient Conditions for OEM3 in CZ 8

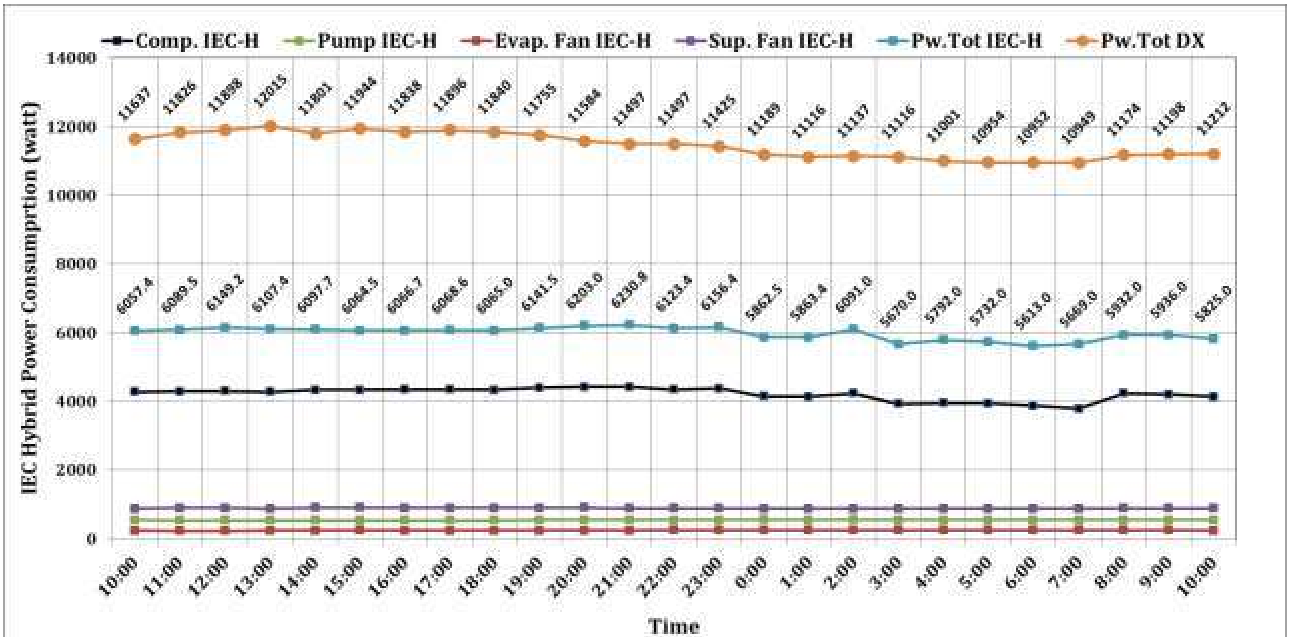

Fig. 4. Power Consumption of DX Unit and IEC Hybrid Unit Components for OEM3 in CZ 8

A.3. Results of OEM 7:

Basic Information			
Tested Units Name	DX (Direct Expansion Unit)		
	IEC Hybrid (Indirect Evaporative Cooling Hybrid Unit)		
OEM No.	7		
Refrigerant	R-32		
Air Flow Rate	1320 C.F.M for DX and IEC hybrid Units		
Capacity	DX	2	Compressors
	IEC hybrid	1	Compressor
Water Bath Area	560X1020		mm2
Climatic Zone	8 (South Egypt)		
Altitude	196.07 meter (From Sea Level)		
Location	22°49' 02" N 31°28' 16" E		
Test Date	30-Aug-24		

Used Apparatus

Used Apparatus	Code of Used Apparatus	Measured Property	Measurement Unit
Weather Station, Dry bulb temperature	**WS; T-amb**	Ambient dry bulb temperature for both Units	°C
Weather Station, Relative Humidity	**WS; Rh-amb**	Ambient Relative humidity for both Units	%
Air Quality 5 - Dry bulb temperature	**AQ5; T-amb**	Ambient dry bulb temperature for both Units	°C
Air Quality 5 - Relative Humidity	**AQ5; RH-amb**	Ambient Relative humidity for both Units	%
Air Quality 6 - Dry bulb temperature	**AQ6; T-amb**	Ambient dry bulb temperature for both Units	°C
Air Quality 6 - Relative Humidity	**AQ6; RH-amb**	Ambient Relative humidity for both Units	%
Fluke 975 - Dry bulb temperature	**F975; T-amb**	Ambient dry bulb temperature for both Units	°C
Air Quality 1 - Dry bulb temperature	**AQ1; T-out; DX**	Outlet dry bulb temperature for DX Unit	°C
Air Quality 1 - Relative Humidity	**AQ1; RH-out; DX**	Outlet Relative humidity for DX Unit	%
Air Quality 2 - Dry bulb temperature	**AQ2; T-out; DX**	Outlet dry bulb temperature for DX Unit	°C
Air Quality 2 - Relative Humidity	**AQ2; RH-out; DX**	Outlet Relative humidity for DX Unit	%
UNI T 1 - Dry bulb temperature	**U1; T-out; DX**	Outlet dry bulb temperature for DX Unit	°C
UNI T 1 - Relative Humidity	**U1; RH-out; DX**	Outlet Relative humidity for DX Unit	%
Lutron 1 - Dry bulb temperature	**L1; T-out; DX**	Outlet dry bulb temperature for DX Unit	°C
Lutron 1 - Relative Humidity	**L1; RH-out; DX**	Outlet Relative humidity for DX Unit	%
Air Quality 3 - Dry bulb temperature	**AQ3; T-out; IEC-H**	Outlet dry bulb temperature for IEC Hybrid Prototype	°C
Air Quality 3 - Relative Humidity	**AQ3; RH-out; IEC-H**	Outlet Relative humidity for IEC Hybrid Prototype	%
Air Quality 4 - Dry bulb temperature	**AQ4; T-out; IEC-H**	Outlet dry bulb temperature for IEC Hybrid Prototype	°C
Air Quality 4 - Relative Humidity	**AQ4; RH-out; IEC-H**	Outlet Relative humidity for IEC Hybrid Prototype	%
UNI T 2 - Dry bulb temperature	**U2; T-out; IEC-H**	Outlet dry bulb temperature for IEC Hybrid Prototype	°C
UNI T 2 - Relative Humidity	**U2; RH-out; IEC-H**	Outlet Relative humidity for IEC Hybrid Prototype	%
Lutron 2 - Dry bulb temperature	**L2; T-out; IEC-H**	Outlet dry bulb temperature for IEC Hybrid Prototype	°C

Lutron 2 - Relative Humidity	**L2; RH-out; IEC-H**	Outlet Relative humidity for IEC Hybrid Prototype	%
Tabular level gauge for measuring the Water level change	**W.Lvl; IEC-H**	make up of evaporated water of the IEC hybrid unit	mm/hr
Water volume in Litres/hour (calculated)	**W.Vol; IEC-H**	hourly consumption rate of evaporated water for IEC hybrid unit	Litres/hr
Compressor power meter - IEC hybrid unit	**Comp.; IEC-H**	Power consumption of the Compressor of the IEC hybrid Unit	Watts
Pump power meter - IEC hybrid unit	**Pump; IEC-H**	Power consumption of the Pump of the IEC hybrid Unit	Watts
Evaporative Fan power meter - IEC hybrid unit	**Evap. Fan; IEC-H**	Power consumption of the Evaporator Fan of the IEC hybrid Prototype	Watts
Supply fan power meter - IEC hybrid unit	**Sup. Fan; IEC-H**	Power consumption of the Supply Fan of the IEC hybrid Prototype	Watts
Power meter of total power consumption of IEC hybrid Unit	**Pw.Tot; IEC-H**	Total Input power of IEC Hybrid Prototype	Watts
Power meter of total power consumption of DX Unit	**Pw.Tot; DX**	Total Input power of DX Unit	Watts

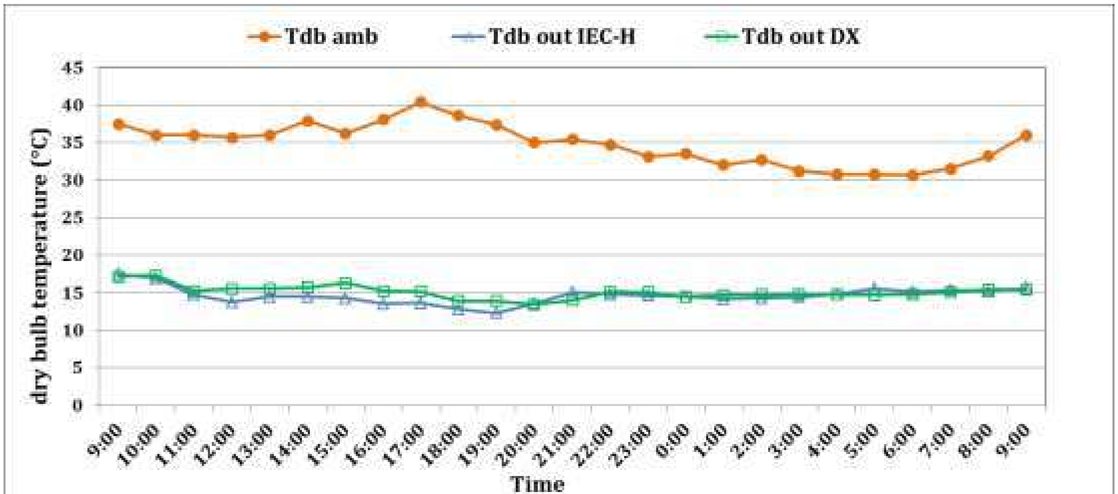

Fig. 1. Inlet Ambient Temperature Versus Outlet Temperature of IEC Hybrid and DX units for OEM7 in CZ 8

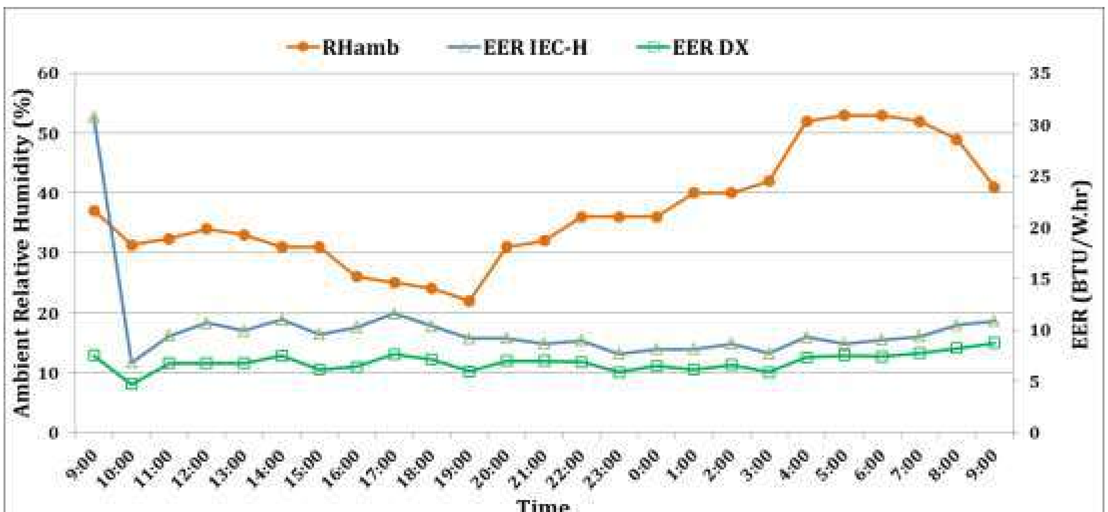

Fig. 2. EER for IEC Hybrid Unit & DX Unit Versus Ambient Relative Humidity for OEM7 in CZ 8

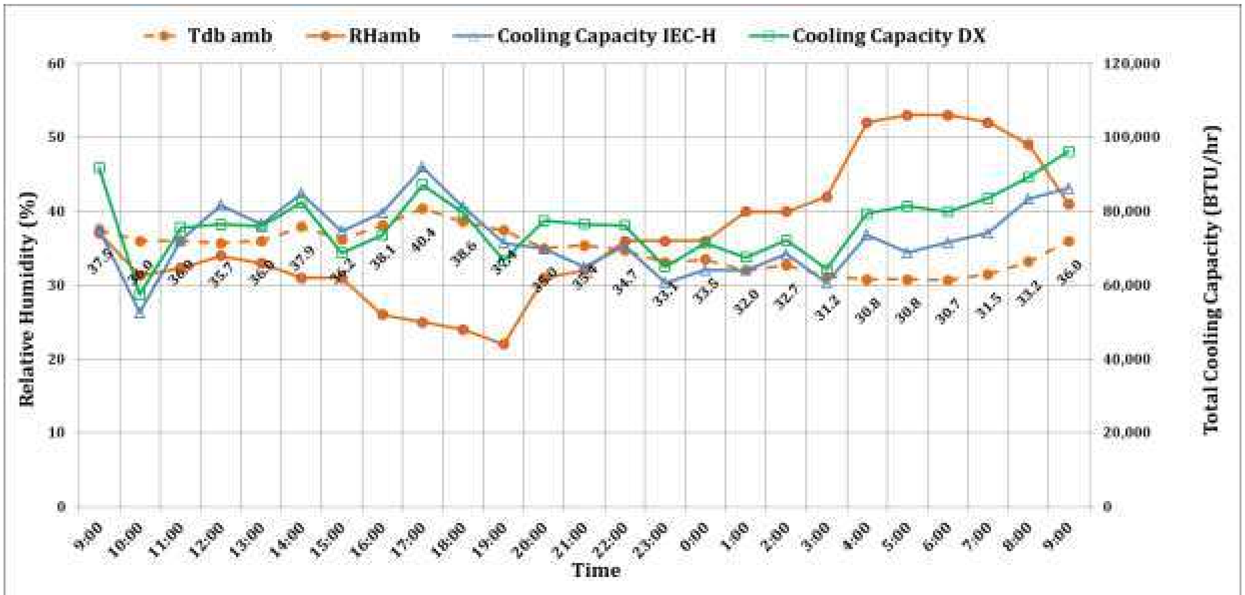

Fig. 3. Cooling Capacity for IEC Hybrid Unit & DX Unit Versus Ambient Conditions for OEM7 in CZ 8

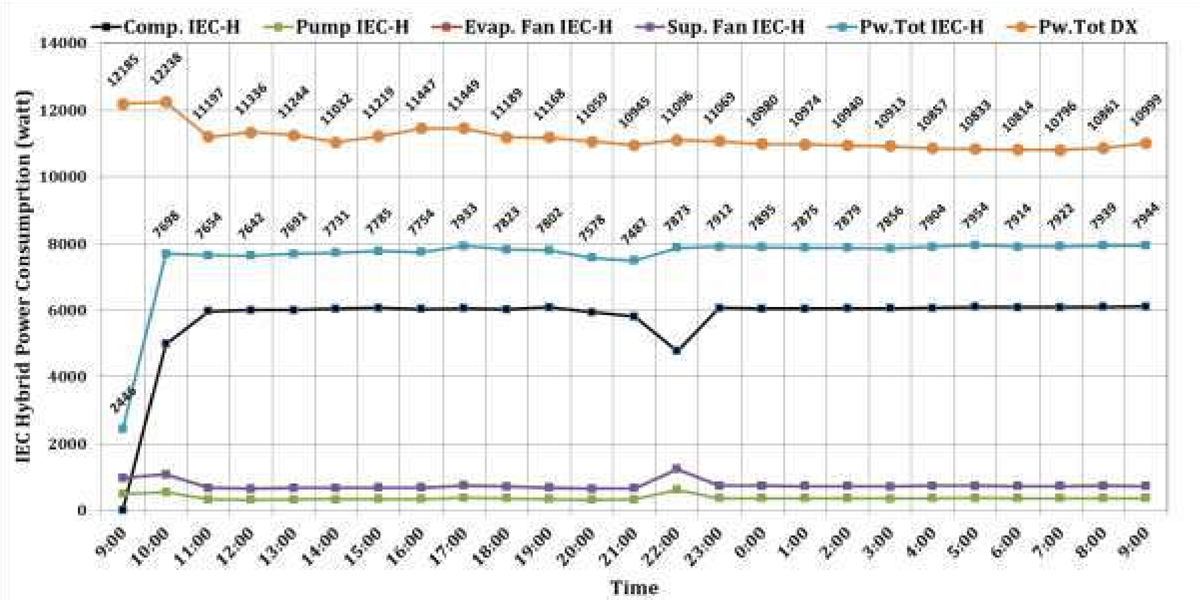

Fig. 4. Power Consumption of DX Unit and IEC Hybrid Unit Components for OEM7 in CZ 8

Time	Ambient Conditions								
	Dry Bulb Temperature; °F	Relative Humidity; %	Pressure at the given altitude Pa	Saturation vapor pressure hPa	Partial vapor pressure Pa	Humidity Ratio	Partial pressure of dry air Pa	Density of Ambient Air; kg/m3	Enthalpy of Ambient Air; kJ/kg
	Tdb amb	**RH amb**	**P**	**Psat amb**	**Pv amp**	**ω amb**	**Pd amb**	**ρ amb**	**h amb**
9:00	37.5	37.1	98992.08	64.48	2389.88	0.015388	96602.20	1.099993	77.24
10:00	36.0	31.3	98992.08	59.41	1861.45	0.011920	97130.63	1.107581	66.79
11:00	36.0	32.3	98992.08	59.41	1920.86	0.012308	97071.22	1.107328	67.79
12:00	35.7	34.0	98992.08	58.44	1986.86	0.012740	97005.22	1.108123	68.59
13:00	36.0	33.0	98992.08	59.41	1960.47	0.012567	97031.62	1.107160	68.45
14:00	37.9	31.0	98992.08	65.89	2042.53	0.013104	96949.55	1.100049	71.79
15:00	36.2	31.0	98992.08	60.06	1861.95	0.011924	97130.13	1.106863	67.00
16:00	38.1	26.0	98992.08	66.60	1731.72	0.011075	97260.37	1.100657	66.77
17:00	40.4	25.0	98992.08	75.34	1883.51	0.012064	97108.57	1.091946	71.68
18:00	38.6	24.0	98992.08	68.43	1642.20	0.010493	97349.88	1.099270	65.79
19:00	37.4	22.0	98992.08	64.13	1410.77	0.008993	97581.31	1.104499	60.70
20:00	35.0	31.0	98992.08	56.22	1742.97	0.011148	97249.11	1.111682	63.78
21:00	35.4	32.0	98992.08	57.48	1839.36	0.011776	97152.72	1.109829	65.80
22:00	34.7	36.0	98992.08	55.30	1990.78	0.012765	97001.30	1.111705	67.62
23:00	33.1	36.0	98992.08	50.58	1820.98	0.011656	97171.11	1.118244	63.13
0:00	33.5	36.0	98992.08	51.73	1862.20	0.011925	97129.88	1.116608	64.23
1:00	32.0	40.0	98992.08	47.55	1901.85	0.012184	97090.23	1.121926	63.36
2:00	32.7	40.0	98992.08	49.46	1978.38	0.012684	97013.70	1.119028	65.36
3:00	31.2	42.0	98992.08	45.44	1908.42	0.012227	97083.66	1.124846	62.64
4:00	30.8	52.0	98992.08	44.42	2309.60	0.014859	96682.48	1.124588	68.97
5:00	30.8	53.0	98992.08	44.42	2354.02	0.015151	96638.06	1.124396	69.71
6:00	30.7	53.0	98992.08	44.16	2340.63	0.015063	96651.45	1.124824	69.38
7:00	31.5	52.0	98992.08	46.22	2403.40	0.015477	96588.68	1.121599	71.27
8:00	33.2	49.0	98992.08	50.87	2492.48	0.016066	96499.61	1.114992	74.54
9:00	36.0	41.0	98992.08	59.41	2435.73	0.015691	96556.35	1.105135	76.47

IEC Hybrid Unit								
Dry Bulb Temperature; °F	Relative Humidity; %	Saturation vapor pressure hPa	Partial vapor pressure Pa	Humidity Ratio	Partial pressure of dry air Pa	Density of Ambient Air; kg/m3	Enthalpy of outlet Air; kJ/kg	Water Consumed; mm/hour
Tdb out IEC-H	RH out IEC-H	Psat out IEC-H	Pv out IEC-H	ω out IEC-H	Pd out IEC-H	ρ out IEC-H	h out IEC-H	W.Lvl IEC-H
17.4	92.3	19.87	1833.31	0.011737	97158.77	1.178612	47.21910525	0
16.9	92.3	19.28	1780.47	0.011392	97211.62	1.180782	45.85888147	50
14.8	90.1	16.81	1514.35	0.009663	97477.73	1.190817	39.28059584	100
13.8	89.3	15.73	1404.91	0.008955	97587.18	1.195573	36.44224867	100
14.5	89.0	16.51	1469.95	0.009375	97522.13	1.192158	38.27228531	100
14.5	89.1	16.51	1470.78	0.009381	97521.31	1.192155	38.2857968	100
14.3	88.4	16.30	1440.46	0.009185	97551.62	1.193123	37.58538915	100
13.6	87.4	15.52	1356.08	0.008639	97636.00	1.196632	35.44083252	100
13.6	86.9	15.60	1356.09	0.008639	97636.00	1.196319	35.51753913	80
12.8	88.7	14.76	1309.42	0.008338	97682.66	1.200090	33.88904029	80
12.3	88.6	14.31	1267.07	0.008065	97725.01	1.202282	32.7148644	80
13.6	90.3	15.58	1406.06	0.008962	97586.02	1.196193	36.30782049	75
15.1	90.5	17.11	1548.26	0.009883	97443.82	1.189525	40.11783613	70
14.8	91.1	16.86	1536.10	0.009804	97455.98	1.190510	39.68822553	100
14.7	90.9	16.67	1514.69	0.009665	97477.39	1.191332	39.15827392	75
14.5	91.4	16.51	1508.75	0.009627	97483.33	1.191981	38.90757293	80
14.2	91.6	16.17	1480.18	0.009442	97511.90	1.193460	38.10736121	80
14.3	91.6	16.27	1490.61	0.009509	97501.47	1.192997	38.38038957	70
14.4	91.5	16.43	1503.10	0.009590	97488.99	1.192317	38.73823723	70
14.8	92.0	16.83	1548.36	0.009883	97443.72	1.190558	39.86356968	75
15.6	93.4	17.72	1654.88	0.010575	97337.21	1.186773	42.43163952	70
15.1	93.4	17.16	1602.17	0.010233	97389.92	1.189073	41.05348143	70
15.4	93.7	17.47	1636.41	0.010455	97355.67	1.187783	41.89756618	80
15.3	93.5	17.33	1620.29	0.010350	97371.79	1.188372	41.50474299	70
15.6	92.5	17.75	1641.11	0.010485	97350.97	1.186733	42.23093238	70

IEC Hybrid Unit										
Water Consumed; m3/hour	Compressor power consumption; Watts	Pump power consumption; Watts	Evaporative Fan power consumption; Watts	Supply Fan power consumption; Watts	IEC Hybrid Unit total power consumption; Watts	Mass flow rate; kg/s	Total Cooling Capacity kW	Total Cooling Capacity BTU/hr	Coefficient of Performance W/W	Energy Efficiency Ratio BTU/W.hr
W.Vol IEC-H	**Comp. IEC-H**	**Pump IEC-H**	**Evap. Fan IEC-H**	**Sup. Fan IEC-H**	**Pw.Tot IEC-H**	**m'**	**Qtot IEC-H**	**Qtot IEC-H**	**COP**	**EER**
0	0	489.2	978.4	978.4	2446	0.7342	22.0458	75223.4637	9.0130	30.7536
0.02856	4985	542.6	1085.2	1085.2	7698	0.7356	15.3965	52534.9238	2.0001	6.8245
0.05712	5969	337	674	674	7654	0.7418	21.1464	72154.5628	2.7628	9.4270
0.05712	6004	327.6	655.2	655.2	7642	0.7448	23.9405	81688.3109	3.1328	10.6894
0.05712	6007	336.8	673.6	673.6	7691	0.7427	22.4128	76475.8203	2.9142	9.9435
0.05712	6049	336.4	672.8	672.8	7731	0.7427	24.8796	84892.8909	3.2182	10.9808
0.05712	6066	343.8	687.6	687.6	7785	0.7433	21.8659	74609.4228	2.8087	9.5837
0.05712	6040	342.8	685.6	685.6	7754	0.7455	23.3563	79695.0691	3.0122	10.2779
0.045696	6061	374.4	748.8	748.8	7933	0.7453	26.9510	91960.4886	3.3973	11.5921
0.045696	6023	360	720	720	7823	0.7476	23.8477	81371.7438	3.0484	10.4016
0.045696	6093	341.8	683.6	683.6	7802	0.7490	20.9619	71525.1485	2.6867	9.1675
0.04284	5943	327	654	654	7578	0.7452	20.4726	69855.4084	2.7016	9.2182
0.039984	5812	335	670	670	7487	0.7410	19.0339	64946.4383	2.5423	8.6746
0.05712	4770	620.6	1241.2	1241.2	7873	0.7417	20.7175	70691.1148	2.6315	8.9789
0.04284	6067	369	738	738	7912	0.7422	17.7941	60715.8308	2.2490	7.6739
0.045696	6048	369.4	738.8	738.8	7895	0.7426	18.8068	64171.3315	2.3821	8.1281
0.045696	6047	365.6	731.2	731.2	7875	0.7435	18.7723	64053.6786	2.3838	8.1338
0.039984	6060	363.8	727.6	727.6	7879	0.7432	20.0492	68410.8742	2.5446	8.6827
0.039984	6060	359.2	718.4	718.4	7856	0.7428	17.7566	60588.0863	2.2603	7.7123
0.04284	6065	367.8	735.6	735.6	7904	0.7417	21.5842	73648.4633	2.7308	9.3179
0.039984	6096	371.6	743.2	743.2	7954	0.7393	20.1706	68824.9073	2.5359	8.6529
0.039984	6092	364.4	728.8	728.8	7914	0.7408	20.9868	71609.8541	2.6519	9.0485
0.045696	6093	365.8	731.6	731.6	7922	0.7400	21.7350	74162.8495	2.7436	9.3616
0.039984	6100	367.8	735.6	735.6	7939	0.7403	24.4540	83440.6826	3.0802	10.5102
0.039984	6108	367.2	734.4	734.4	7944	0.7393	25.3138	86374.3190	3.1865	10.8729

DX Unit						
Dry Bulb Temperature; °C	Relative Humidity; %	Saturation vapor pressure hPa	Partial vapor pressure Pa	Humidity Ratio	Partial pressure of dry air Pa	Density of Ambient Air; kg/m3
Tdb out DX	**RH out DX**	**Psat out DX**	**Pv out DX**	**ω out DX**	**Pd out DX**	**ρ out DX**
17.2	74.2	19.56	1451.96	0.009259	97540.12	1.181357
17.3	83.3	19.69	1639.83	0.010477	97352.26	1.180099
15.2	81.0	17.30	1400.56	0.008926	97591.53	1.189478
15.6	79.5	17.67	1404.46	0.008952	97587.62	1.188121
15.6	79.7	17.69	1410.70	0.008992	97581.39	1.187990
15.7	81.2	17.84	1447.45	0.009230	97544.63	1.187308
16.3	78.1	18.50	1445.63	0.009218	97546.45	1.184958
15.2	80.2	17.30	1387.58	0.008843	97604.50	1.189537
15.2	78.7	17.27	1359.87	0.008664	97632.21	1.189767
13.9	80.4	15.86	1274.05	0.008110	97718.03	1.195653
13.9	80.3	15.88	1274.93	0.008115	97717.15	1.195545
13.4	80.5	15.37	1237.58	0.007875	97754.50	1.197803
14.0	83.7	16.01	1339.36	0.008531	97652.72	1.194729
15.2	80.3	17.22	1381.77	0.008805	97610.31	1.189873
15.1	80.7	17.14	1382.40	0.008809	97609.68	1.190180
14.5	80.8	16.51	1334.55	0.008500	97657.53	1.192778
14.7	81.1	16.75	1357.86	0.008651	97634.23	1.191739
14.8	81.5	16.78	1368.02	0.008716	97624.06	1.191589
14.8	82.5	16.83	1388.85	0.008851	97603.23	1.191287
14.8	84.1	16.78	1411.23	0.008995	97580.85	1.191392
14.7	84.4	16.75	1413.14	0.009008	97578.94	1.191486
14.8	84.2	16.86	1419.76	0.009051	97572.33	1.191042
15.1	83.7	17.11	1431.93	0.009129	97560.15	1.190057
15.5	83.5	17.55	1466.14	0.009351	97525.95	1.188251
15.4	81.3	17.50	1422.07	0.009066	97570.01	1.188658

DX Unit						
Enthalpy of outlet Air; kJ/kg	DX Unit total power consumption; Watts	Mass flow rate; kg/s	Total Cooling Capacity kW	Total Cooling Capacity BTU/hr	Coefficient of Performance W/W	Energy Efficiency Ratio BTU/W.hr
h out DX	**Pw.Tot DX**	**m'**	**Qtot DX**	**Qtot DX**	**COP**	**EER**
40.68682776	12185	0.7360	26.9046	91802.3062	2.2080	7.5340
43.87464465	12238	0.7352	16.8463	57481.9492	1.3766	4.6970
37.87807442	11197	0.7410	22.1619	75619.6328	1.9793	6.7536
38.27398013	11336	0.7402	22.4355	76553.0116	1.9791	6.7531
38.40148881	11244	0.7401	22.2389	75882.1436	1.9778	6.7487
39.13081276	11032	0.7397	24.1535	82415.1155	2.1894	7.4705
39.68874461	11219	0.7382	20.1635	68800.8472	1.7973	6.1325
37.66592577	11447	0.7410	21.5689	73596.3120	1.8842	6.4293
37.18760842	11449	0.7412	25.5655	87233.1798	2.2330	7.6193
34.43516994	11189	0.7449	23.3527	79682.8757	2.0871	7.1215
34.47499939	11168	0.7448	19.5336	66651.2465	1.7491	5.9681
33.35674085	11059	0.7462	22.7022	77463.2015	2.0528	7.0045
35.65301816	10945	0.7443	22.4403	76569.3703	2.0503	6.9958
37.49430249	11096	0.7413	22.3327	76202.3105	2.0127	6.8675
37.42803828	11069	0.7414	19.0597	65034.4697	1.7219	5.8754
36.05949116	10980	0.7431	20.9357	71435.4218	1.9067	6.5060
36.66963581	10974	0.7424	19.8126	67603.4323	1.8054	6.1603
36.86114719	10940	0.7423	21.1534	72178.2772	1.9336	6.5976
37.25258414	10913	0.7421	18.8438	64297.8159	1.7267	5.8919
37.56727378	10857	0.7422	23.3037	79515.4217	2.1464	7.3239
37.57302345	10833	0.7423	23.8571	81403.6472	2.2023	7.5144
37.78335577	10814	0.7420	23.4479	80007.6327	2.1683	7.3985
38.21237753	10796	0.7414	24.5087	83627.0990	2.2702	7.7461
39.18115937	10861	0.7402	26.1716	89301.2090	2.4097	8.2222
38.40879046	10999	0.7405	28.1852	96171.7890	2.5625	8.7437

A.4. Results of EOM 6:

Basic Information			
Tested Units Name	DX (Direct Expansion Unit)		
	IEC Hybrid (Indirect Evaporative Cooling Hybrid Unit)		
OEM No.	6		
Refrigerant	R-32		
Air Flow Rate	1800 C.F.M for DX and IEC hybrid Units		
Capacity	DX	2	Compressors
	IEC hybrid	1	Compressor
Water Bath Area	(1308.3^2-900.3^2)	mm2	
Climatic Zone	8 (South Egypt)		
Altitude	196.07 meter (From Sea Level)		
Location	22°49' 02" N 31°28' 16" E		
Test Date	31-Aug-24		

Used Apparatus

Used Apparatus	Code of Used Apparatus	Measured Property	Measurement Unit
Weather Station, Dry bulb temperature	**WS; T-amb**	Ambient dry bulb temperature for both Units	°C
Weather Station, Relative Humidity	**WS; Rh-amb**	Ambient Relative humidity for both Units	%
Air Quality 6 - Dry bulb temperature	**AQ6; T-amb**	Ambient dry bulb temperature for both Units	°C
Air Quality 6 - Relative Humidity	**AQ6; RH-amb**	Ambient Relative humidity for both Units	%
Fluke 975 - Dry bulb temperature	**F975; T-amb**	Ambient dry bulb temperature for both Units	°C
Air Quality 3 - Dry bulb temperature	**AQ3; T-out; DX**	Outlet dry bulb temperature for DX Unit	°C
Air Quality 3 - Relative Humidity	**AQ3; RH-out; DX**	Outlet Relative humidity for DX Unit	%
Air Quality 4 - Dry bulb temperature	**AQ4; T-out; DX**	Outlet dry bulb temperature for DX Unit	°C
Air Quality 4 - Relative Humidity	**AQ4; RH-out; DX**	Outlet Relative humidity for DX Unit	%
Lutron 1 - Dry bulb temperature	**L1; T-out; DX**	Outlet dry bulb temperature for DX Unit	°C
Lutron 1 - Relative Humidity	**L1; RH-out; DX**	Outlet Relative humidity for DX Unit	%
UNI T - Dry bulb temperature	**U; T-out; IEC-H**	Outlet dry bulb temperature for IEC Hybrid Prototype	°C
UNI T - Relative Humidity	**U; RH-out; IEC-H**	Outlet Relative humidity for IEC Hybrid Prototype	%
Lutron 2 - Dry bulb temperature	**L2; T-out; IEC-H**	Outlet dry bulb temperature for IEC Hybrid Prototype	°C
Lutron 2 - Relative Humidity	**L2; RH-out; IEC-H**	Outlet Relative humidity for IEC Hybrid Prototype	%
Tabular level gauge for measuring the Water level change	**W.Lvl; IEC-H**	make up of evaporated water of the IEC hybrid unit	mm/hr
Water volume in Litres/hour (calculated)	**W.Vol; IEC-H**	hourly consumption rate of evaporated water for IEC hybrid unit	Litres/hr
Compressor power meter - IEC hybrid unit	**Comp.; IEC-H**	Power consumption of the Compressor of the IEC hybrid Unit	Watts
Pump power meter - IEC hybrid unit	**Pump; IEC-H**	Power consumption of the Pump of the IEC hybrid Unit	Watts
Evaporative Fan power meter - IEC hybrid unit	**Evap. Fan; IEC-H**	Power consumption of the Evaporator Fan of the IEC hybrid Prototype	Watts
Supply fan power meter - IEC hybrid unit	**Sup. Fan; IEC-H**	Power consumption of the Supply Fan of the IEC hybrid Prototype	Watts
Power meter of total power consumption of IEC hybrid Unit	**Pw.Tot; IEC-H**	Total Input power of IEC Hybrid Prototype	Watts
Power meter of total power consumption of DX Unit	**Pw.Tot; DX**	Total Input power of DX Unit	Watts

Time	Ambient Conditions								
	Dry Bulb Temperature; °F	Relative Humidity; %	Pressure at the given altitude Pa	Saturation vapor pressure hPa	Partial vapor pressure Pa	Humidity Ratio	Partial pressure of dry air Pa	Density of Ambient Air; kg/m3	Enthalpy of Ambient Air; kJ/kg
	Tdb amb	RH amb	P	Psat amb	Pv amp	ω amb	Pd amb	ρ amb	h amb
20:00	38.9	17.3	98992.08	69.66	1201.68	0.007643	97790.40	1.099955	58.80
21:00	37.6	19.8	98992.08	64.83	1283.55	0.008171	97708.53	1.104328	58.79
22:00	36.7	22.3	98992.08	61.84	1379.04	0.008787	97613.04	1.107010	59.49
23:00	35.8	17.7	98992.08	58.65	1035.20	0.006573	97956.88	1.111940	52.82
0:00	35.1	17.6	98992.08	56.43	990.39	0.006286	98001.69	1.114657	51.37
1:00	34.1	19.6	98992.08	53.59	1050.31	0.006670	97941.78	1.117786	51.41
2:00	33.4	20.8	98992.08	51.44	1067.37	0.006780	97924.71	1.120387	50.94
3:00	32.7	21.3	98992.08	49.37	1049.05	0.006662	97943.03	1.123152	49.90
4:00	32.2	22.5	98992.08	48.18	1081.57	0.006871	97910.51	1.124606	49.99
5:00	31.6	23.2	98992.08	46.39	1074.03	0.006822	97918.06	1.127099	49.19
6:00	30.7	24.0	98992.08	44.16	1057.70	0.006718	97934.38	1.130384	48.04
7:00	32.4	22.0	98992.08	48.63	1069.89	0.006796	97922.19	1.124042	49.97
8:00	39.7	18.0	98992.08	72.58	1306.49	0.008319	97685.59	1.096818	61.32
9:00	38.7	17.4	98992.08	68.79	1197.02	0.007613	97795.06	1.100798	58.48
10:00	38.3	17.1	98992.08	67.45	1150.00	0.007311	97842.08	1.102292	57.33
11:00	41.2	13.0	98992.08	78.60	1021.84	0.006488	97970.24	1.092777	58.13
12:00	42.3	11.7	98992.08	83.43	972.00	0.006168	98020.08	1.089059	58.46
13:00	44.0	11.1	98992.08	91.16	1011.87	0.006424	97980.21	1.083057	60.84
14:00	44.4	9.5	98992.08	92.90	882.59	0.005595	98109.49	1.082342	59.08
15:00	45.6	9.7	98992.08	98.82	953.59	0.006050	98038.49	1.077974	61.47
16:00	44.3	9.5	98992.08	92.43	873.42	0.005537	98118.66	1.082721	58.82
17:00	43.4	10.4	98992.08	88.06	911.41	0.005780	98080.67	1.085756	58.50
18:00	42.4	11.3	98992.08	83.87	943.56	0.005986	98048.52	1.088833	58.09
19:00	39.9	15.1	98992.08	73.49	1109.73	0.007052	97882.35	1.096828	58.29
20:00	38.3	16.3	98992.08	67.45	1099.42	0.006986	97892.67	1.102506	56.49

IEC Hybrid Unit								
Dry Bulb Temperature; °F	Relative Humidity; %	Saturation vapor pressure hPa	Partial vapor pressure Pa	Humidity Ratio	Partial pressure of dry air Pa	Density of Ambient Air; kg/m3	Enthalpy of outlet Air; kJ/kg	Water Consumed; mm/hour
Tdb out IEC-H	**RH out IEC-H**	**Psat out IEC-H**	**Pv out IEC-H**	**ω out IEC-H**	**Pd out IEC-H**	**ρ out IEC-H**	**h out IEC-H**	**W.Lvl IEC-H**
8.2	94.4	10.84	1022.51	0.006492	97969.57	1.221164	24.52457591	0
8.6	94.9	11.17	1060.38	0.006735	97931.70	1.219037	25.59396471	40
8.8	95.4	11.33	1079.94	0.006860	97912.14	1.218081	26.11358688	40
17.3	96.3	19.69	1895.74	0.012144	97096.34	1.178938	48.09715373	40
10.4	96.6	12.57	1213.65	0.007720	97778.43	1.210800	29.8584185	40
14.4	96.9	16.35	1584.53	0.010118	97407.55	1.192255	39.99616046	40
16.3	97.1	18.53	1799.61	0.011517	97192.47	1.183245	45.53339571	25
16.3	97.3	18.47	1796.66	0.011498	97195.42	1.183463	45.43333048	20
16.0	97.4	18.18	1770.04	0.011324	97222.04	1.184607	44.73784686	35
15.8	97.3	17.89	1741.08	0.011136	97251.00	1.185764	44.00410947	25
15.8	97.4	17.89	1742.87	0.011147	97249.21	1.185756	44.03358563	20
13.4	97.6	15.37	1500.47	0.009573	97491.62	1.196594	37.64679275	15
17.3	96.5	19.69	1899.68	0.012170	97092.40	1.178920	48.16228927	30
7.8	93.7	10.55	988.16	0.006272	98003.92	1.223064	23.5637229	50
17.1	96.8	19.44	1880.64	0.012046	97111.44	1.179819	47.64190001	50
9.7	94.1	11.99	1128.65	0.007173	97863.43	1.214193	27.76717948	70
8.4	93.8	11.02	1033.97	0.006565	97958.11	1.220027	24.96382551	33
17.4	96.2	19.87	1910.82	0.012243	97081.26	1.178261	48.50081279	65
8.6	93.8	11.14	1043.99	0.006630	97948.10	1.219330	25.2782303	40
10.0	94.3	12.28	1157.32	0.007358	97834.77	1.212559	28.58804044	80
10.2	94.8	12.40	1175.20	0.007473	97816.88	1.211834	29.03081702	65
8.5	94.1	11.06	1040.25	0.006606	97951.83	1.219781	25.11610375	40
8.2	94.4	10.84	1023.05	0.006495	97969.03	1.221162	24.53332228	90
8.4	95.1	11.02	1048.30	0.006657	97943.78	1.219960	25.19525683	65
7.5	95.1	10.33	982.58	0.006236	98009.50	1.224398	23.16868544	90

IEC Hybrid Unit										
Water Consumed; m3/hour	Compressor power consumption; Watts	Pump power consumption; Watts	Evaporative Fan power consumption; Watts	Supply Fan power consumption; Watts	IEC Hybrid Unit total power consumption; Watts	Mass flow rate; kg/s	Total Cooling Capacity kW	Total Cooling Capacity BTU/hr	Coefficient of Performance W/W	Energy Efficiency Ratio BTU/W.hr
W.Vol IEC-H	Comp. IEC-H	Pump IEC-H	Evap. Fan IEC-H	Sup. Fan IEC-H	Pw.Tot IEC-H	m'	Qtot IEC-H	Qtot IEC-H	COP	EER
0	6683	196	579	390	7849	1.0374	35.5534	121313.3512	4.5298	15.4564
0.036044352	6600	187	602	389	7777	1.0356	34.3814	117314.1739	4.4208	15.0843
0.036044352	5854	167	602	389	7011	1.0348	34.5407	117857.7697	4.9268	16.8109
0.036044352	0	199	605	385	4767	1.0015	4.7319	16145.7488	0.9926	3.3869
0.036044352	5268	233	601	385	4911	1.0286	22.1287	75506.2948	4.5061	15.3756
0.036044352	4923	212	599	382	3034	1.0128	11.5592	39441.5834	3.8105	13.0020
0.02252772	0	211	601	389	2837	1.0052	5.4382	18555.9175	1.9170	6.5411
0.018022176	0	213	599	387	2848	1.0054	4.4867	15309.1076	1.5754	5.3755
0.031538808	0	217	597	385	2643	1.0063	5.2853	18034.2284	2.0000	6.8244
0.02252772	0	226	594	385	2595	1.0073	5.2212	17815.5601	2.0121	6.8655
0.018022176	0	240	592	386	2644	1.0073	4.0329	13760.9754	1.5250	5.2036
0.013516632	4898	244	592	385	2796	1.0165	12.5242	42734.3244	4.4789	15.2825
0.027033264	0	250	594	385	2220	1.0015	13.1749	44954.6599	5.9338	20.2470
0.04505544	6067	261	593	388	7310	1.0390	36.2798	123791.8201	4.9632	16.9352
0.04505544	0	264	594	387	3516	1.0023	9.7098	33131.1746	2.7612	9.4217
0.063077616	5808	272	593	386	7059	1.0315	31.3159	106854.2003	4.4361	15.1366
0.02973659	6054	278	595	388	7314	1.0364	34.7121	118442.4680	4.7458	16.1934
0.058572072	0	282	595	390	5565	1.0009	12.3551	42157.2319	2.2201	7.5751
0.036044352	6184	250	595	386	7414	1.0358	35.0106	119461.1014	4.7220	16.1122
0.072088704	6518	219	597	387	7721	1.0301	33.8726	115577.9976	4.3869	14.9688
0.058572072	6529	213	597	391	7730	1.0295	30.6717	104656.2261	3.9676	13.5381
0.036044352	6486	193	597	392	7669	1.0362	34.5976	118051.9284	4.5113	15.3932
0.081099792	6350	219	597	391	7557	1.0374	34.8087	118772.2967	4.6062	15.7168
0.058572072	6367	213	601	390	7571	1.0364	34.3010	117039.9237	4.5307	15.4593
0.081099792	6173	232	579	388	7373	1.0401	34.6620	118271.7184	4.7014	16.0419

DX Unit						
Dry Bulb Temperature; °C	Relative Humidity; %	Saturation vapor pressure hPa	Partial vapor pressure Pa	Humidity Ratio	Partial pressure of dry air Pa	Density of Ambient Air; kg/m3
Tdb out DX	**RH out DX**	**Psat out DX**	**Pv out DX**	**ω out DX**	**Pd out DX**	**ρ out DX**
15.5	56.8	17.61	999.64	0.006345	97992.44	1.190174
15.7	62.5	17.87	1117.18	0.007100	97874.90	1.188677
14.9	66.2	16.91	1118.68	0.007109	97873.40	1.192247
14.2	60.1	16.16	970.63	0.006159	98021.45	1.195830
13.2	59.3	15.17	899.33	0.005703	98092.75	1.200195
12.4	61.9	14.40	891.80	0.005654	98100.28	1.203592
12.1	64.7	14.15	915.44	0.005806	98076.64	1.204608
11.9	64.4	13.90	895.31	0.005677	98096.77	1.205828
11.6	64.8	13.66	885.14	0.005612	98106.95	1.207004
11.8	63.0	13.84	872.00	0.005528	98120.08	1.206218
13.4	57.3	15.41	882.31	0.005594	98109.77	1.199296
15.6	52.0	17.72	921.00	0.005841	98071.08	1.190120
16.5	49.2	18.81	926.13	0.005874	98065.95	1.186263
20.6	39.9	24.26	968.97	0.006149	98023.11	1.169648
16.0	52.9	18.18	961.24	0.006099	98030.85	1.188291
17.5	50.3	20.04	1008.08	0.006399	97984.00	1.181810
18.7	43.3	21.57	934.50	0.005928	98057.59	1.177418
19.3	45.2	22.39	1012.68	0.006429	97979.41	1.174650
19.9	43.5	23.24	1010.07	0.006412	97982.02	1.172257
21.0	44.2	24.92	1101.47	0.006999	97890.61	1.167332
18.7	47.0	21.57	1014.29	0.006439	97977.79	1.177058
18.2	48.3	20.86	1008.06	0.006399	97984.02	1.179241
17.8	49.2	20.42	1005.54	0.006383	97986.54	1.180603
16.5	54.5	18.81	1025.20	0.006509	97966.88	1.185812
15.7	55.6	17.80	989.61	0.006281	98002.47	1.189533

DX Unit						
Enthalpy of outlet Air; kJ/kg	DX Unit total power consumption; Watts	Mass flow rate; kg/s	Total Cooling Capacity kW	Total Cooling Capacity BTU/hr	Coefficient of Performance W/W	Energy Efficiency Ratio BTU/W.hr
h out DX	**Pw.Tot DX**	**m'**	**Qtot DX**	**Qtot DX**	**COP**	**EER**
31.6290197	9972	1.0111	27.4681	93725.2113	2.7545	9.3988
33.77549271	9900	1.0098	25.2635	86202.6812	2.5519	8.7073
32.91750321	9777	1.0128	26.9170	91844.5634	2.7531	9.3939
29.80331926	9781	1.0159	23.3837	79788.4959	2.3907	8.1575
27.66762419	9688	1.0196	24.1686	82466.5421	2.4947	8.5122
26.73360102	9614	1.0225	25.2295	86086.6491	2.6242	8.9543
26.84446954	9591	1.0233	24.6612	84147.3666	2.5713	8.7736
26.24860676	9548	1.0244	24.2235	82653.8801	2.5370	8.6567
25.81358545	9453	1.0254	24.7894	84584.8005	2.6224	8.9479
25.80470646	9394	1.0247	23.9600	81754.9442	2.5506	8.7029
27.6295885	9265	1.0188	20.7915	70943.6234	2.2441	7.6572
30.45597842	9013	1.0110	19.7264	67309.4199	2.1887	7.4680
31.48723404	9151	1.0077	30.0610	102572.4759	3.2850	11.2089
36.31550361	9259	0.9936	22.0248	75151.9128	2.3788	8.1166
31.51446214	9846	1.0095	26.0595	88918.7163	2.6467	9.0309
33.83360461	9829	1.0040	24.3903	83223.0293	2.4815	8.4671
33.82429167	10143	1.0002	24.6373	84066.0463	2.4290	8.2881
35.70493996	10444	0.9979	25.0858	85596.4600	2.4019	8.1957
36.27260129	10433	0.9958	22.7104	77490.9879	2.1768	7.4275
38.91559135	10168	0.9917	22.3678	76322.0866	2.1998	7.5061
35.12097607	10372	0.9999	23.7019	80874.1693	2.2852	7.7974
34.4773982	10274	1.0018	24.0699	82129.8107	2.3428	7.9939
34.09737243	10254	1.0029	24.0606	82098.0252	2.3465	8.0064
33.09471104	10084	1.0074	25.3834	86611.6351	2.5172	8.5890
31.63576743	9956	1.0105	25.1189	85709.2007	2.5230	8.6088

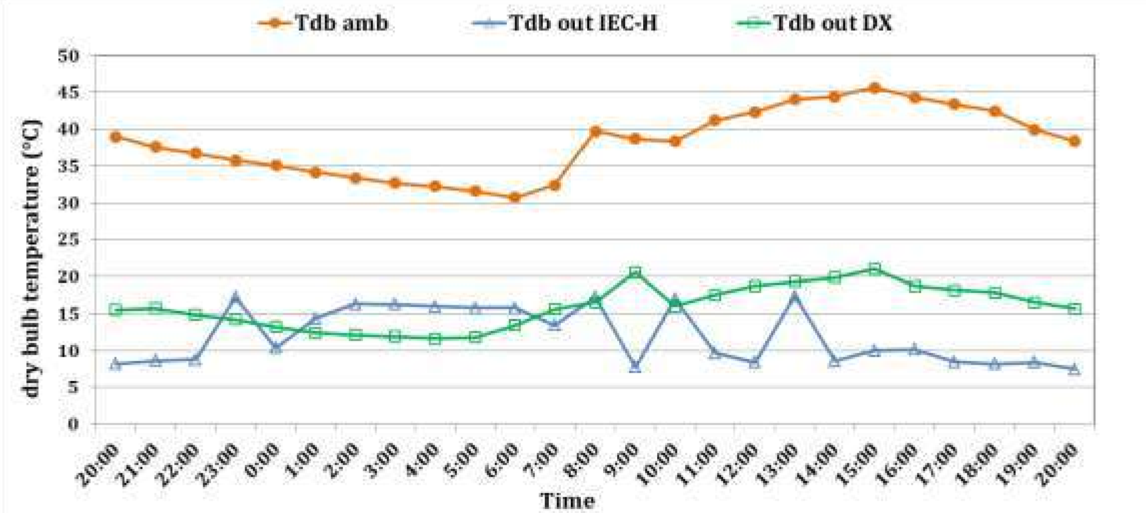

Fig. 1. Inlet Ambient Temperature Versus Outlet Temperature of IEC Hybrid and DX units for OEM6 in CZ 8

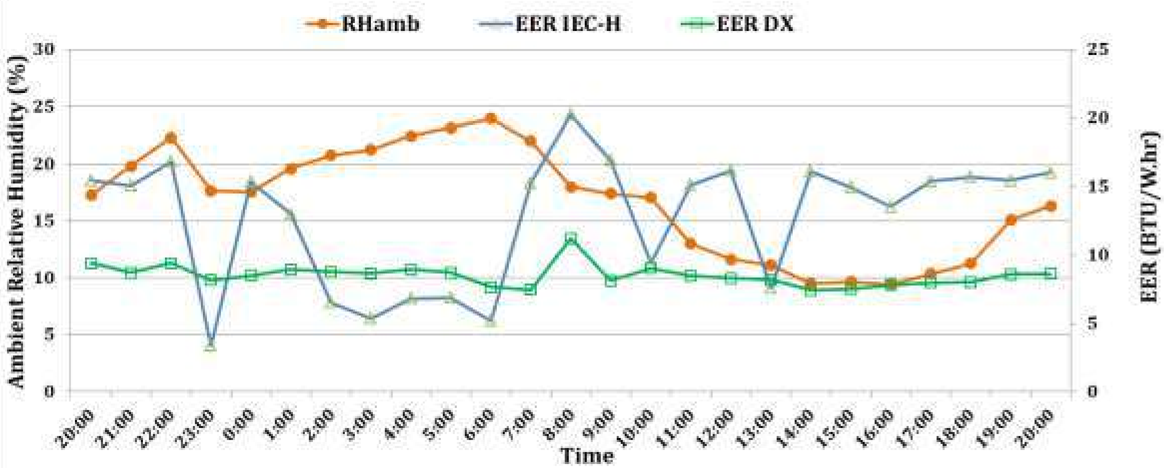

Fig. 2. EER for IEC Hybrid Unit & DX Unit Versus Ambient Relative Humidity for OEM6 in CZ 8

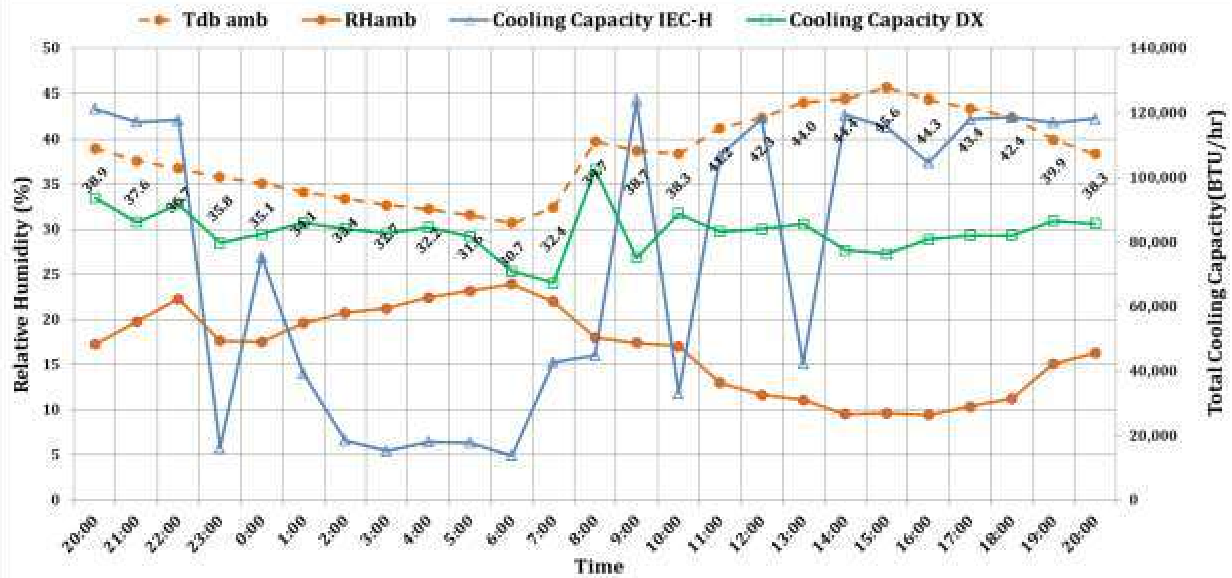

Fig. 3. Cooling Capacity for IEC Hybrid Unit & DX Unit Versus Ambient Conditions for OEM6 in CZ8

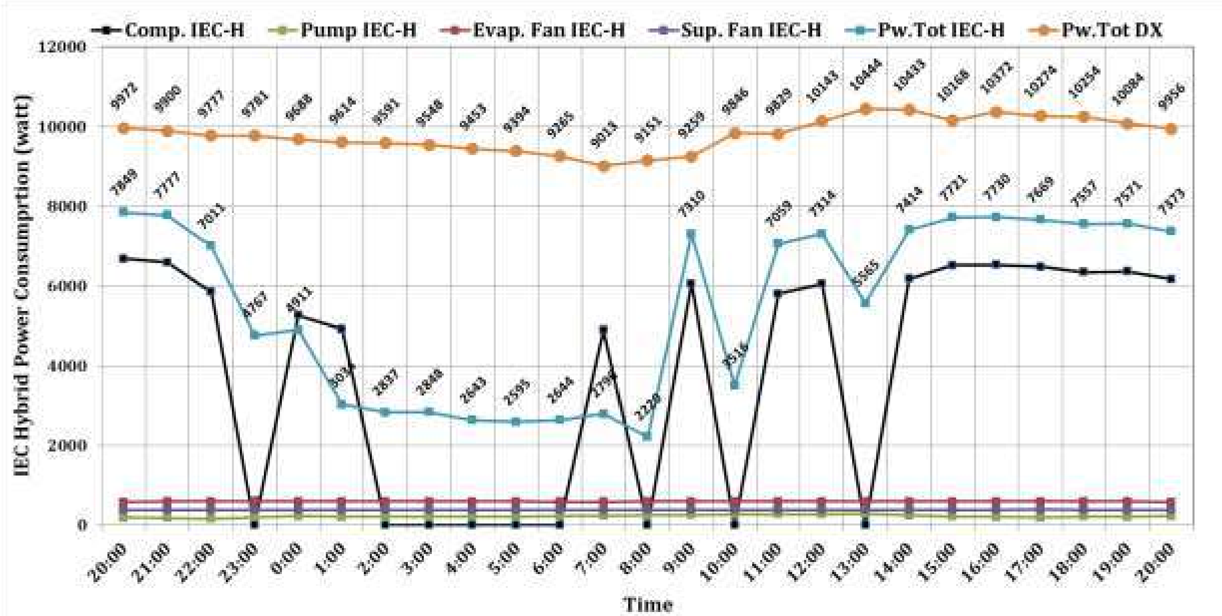

Fig. 4. Power Consumption of DX Unit and IEC Hybrid Unit Components for OEM6 in CZ 8

Annex 2: Calibration Certificates

Ministry of Higher Education
& Scientific Research
National Institute of Standards

وزارة التعليم العالى والبحث العلمى
المعهد القومى للمعايرة

El- Sadat (Tersa) St., El Haram, Giza, Egypt - P.O.Box 136 Giza - Code 12211 - Tel./ Fax: +202 - 33867462 - NIS Tel +202 - 37401113

CERTIFICATE OF CALIBRATION
شهادة معايرة

Certificate No:	762/32C012/290/1319/2024

- **NIS Lab** أسم المعمل : **Thermal Metrology Laboratory**
- **Issued For** صادر الى : المركز القومى لبحوث الاسكان والبناء -معهد بحوث الاعمال الكهروميكانيكية في المباني
- **Contact Information of the Customer** بيانات التواصل بالزبون : 01022852637
- **Location of Calibration** مكان اجراء المعايرة : NIS
- **Device Description** اسم ووصف الجهاز تحت المعايرة : Digital thermo-hygrometer, resolution 0.1°C for temperature & resolution 0.1% for relative humidity
  - **Manufacturer** اسم الشركة المنتجة : Lutron
  - **Model/Type** موديل الجهاز : PM-1064SD
  - **Serial Number** الرقم المسلسل للجهاز : 085019
  - **Code** كود : --------
- **Date of Receipt** تاريخ الاستلام : 01/05/2024
- **Date of Calibration** تاريخ المعايرة : 09/05/2024
- **Issue Date** تاريخ الإصدار : 15/05/2024
- **Due Date** تاريخ إعادة المعايرة : ------

Approved by

Head of Laboratory	**NIS President**
Prof. Dr.Essam El-Din Mahmoud	Prof. Dr. M. G. Ahmed

Ministry of Higher Education
& Scientific Research
National Institute of Standards

وزارة التعليم العالى والبحث العلمى
المعهد القومى للمعايرة

El- Sadat (Tersa) St., El Haram, Giza, Egypt - P.O.Box 136 Giza - Code 12211 - Tel./ Fax: +202 - 33867462 - NIS Tel +202 - 37401113

CERTIFICATE OF CALIBRATION
شهادة معايرة

▪ Certificate No.	762/32C012/290/1319/2024		
▪ Customer	المركز القومى لبحوث الاسكان والبناء -معهد بحوث الاعمال الكهروميكانيكية في المباني		
▪ Calibrated by	Ahmed Sayed Ahmed	▪ Date of Calibration	09/05/2024
▪ Number of pages	3	▪ File name	2570/13/24/02/HK

• Device Under Calibration

Device Description	**Digital thermo-hygrometer, resolution 0.1°C for temperature & resolution 0.1% for relative humidity**		
Serial Number	085019	Code	--------

• Enviromental Conditions

Temperature (°C)	(25±2)	Humidity (%)	(45±15)

• Calibration Method

The calibration was carried out according to calibration method No. NIS-32-OP-7.2.1.1-05 " Thermo hygrometers, Data loggers and Thermo hygrographs Calibration Method "

• Traceability

Description of Reference Device	Serial Number	Due Date	Certificate No.	Relative Expanded Uncertainty	Traceability
Standard thermo-hygrometer	0060957711	May,2024	4851/32C012/4 25/1522/2023	0.3 °C, 1%	NIS

• Uncertainty Statement

The combined standard uncertainty is calculated based on NIS-32-OP-6.4.10-01 which include at least the standard uncertainty reported for the reference standard, the standard uncertainty for the measurement process, the standard uncertainty for any uncorrected errors. The combined standard uncertainty is multiplied by a coverage factor (k) of 2 to provide an expanded uncertainty, which defines a level of confidence of approximately 95 percent (95.45 %). The expanded uncertainty presented in this certificate/report is consistent with the ISO/IEC GUIDE 98-3:2008 "Uncertainty of measurement — Part 3: Guide to the expression of uncertainty in measurement (GUM:1995)".

• ISO 17025 Statement

All NIS laboratories implement the NIS unified quality management system which was built to be in compliance with ISO 17025:2017. It is the customer responsibility to indicate - on the calibration label - the due date for calibration in accordance with the aforementioned ISO/SOP calibration procedure and in compliance with ISO 17025:2017.

• Conformity Statement

Conformity Criterion	Not applicable
Decision	-----

Calibrated by

AhmedSayed

Reviewed by

ElSayed

Ministry of Higher Education
& Scientific Research
National Institute of Standards

وزارة التعليم العالى والبحث العلمى
المعهد القومى للمعايرة

El- Sadat (Tersa) St., El Haram, Giza, Egypt - P.O.Box 136 Giza - Code 12211 - Tel./ Fax: +202 - 33867462 - NIS Tel +202 - 37401113

CERTIFICATE OF CALIBRATION
شهادة معايرة

Certificate No.	762/32C012/290/1319/2024		
Serial Number	085019	Code	--------

Calibration results of humidity

Standard relative humidity RHs %	Measured relative humidity RHm %	Correction ΔRH = RHs - RHm %
30.0	28.3	1.7
35.0	33.5	1.5
40.0	38.9	1.1
45.0	42.9	2.1
50.0	47.2	2.8
55.0	52.0	3.0
60.0	56.8	3.2
65.0	61.5	3.5
70.0	66.5	3.5

Uncertainty at C.L. 95 % (K=2): ± 1.7 %

Calibration results of temperature

Temperature on ITS-90 t_s °C	Measured temperature t_m °C	Correction $\Delta t = ts - tm$ °C
25.0	24.4	0.6
30.0	29.7	0.3
35.0	34.3	0.7
40.0	39.3	0.7
45.0	44.1	0.9

Uncertainty at C.L. 95 % (K=2): ± 0.4 °C

* The calibration points are selected according to customer's request

The data in the above table applies only to those items specifically listed on this calibration certificate

Calibrated by
Ahmed Sayed

Reviewed by
ElSayed

Ministry of Higher Education
& Scientific Research
National Institute of Standards

وزارة التعليم العالى والبحث العلمى
المعهد القومى للمعايرة

El- Sadat (Tersa) St., El Haram, Giza, Egypt - P.O.Box 136 Giza - Code 12211 - Tel./ Fax: +202 - 33867462 - NIS Tel +202 - 37401113

CERTIFICATE OF CALIBRATION
شهادة معايرة

Certificate No:	762/32C012/292/1322/2024

- **NIS Lab** اسم المعمل : **Thermal Metrology Laboratory**
- **Issued For** صادر إلى : المركز القومى لبحوث الاسكان والبناء -معهد بحوث الاعمال الكهروميكانيكية في المباني
- **Contact Information of the Customer** بيانات التواصل بالزبون : 01022852637
- **Location of Calibration** مكان اجراء المعايرة : NIS
- **Device Description** اسم ووصف الجهاز تحت المعايرة : Digital thermo-hygrometer, resolution 0.1°C for temperature & resolution 0.1% for relative humidity
  - **Manufacturer** اسم الشركة المنتجة : Lutron
  - **Model/Type** موديل الجهاز : PM-1064SD
  - **Serial Number** الرقم المسلسل للجهاز : 085018
  - **Code** كود : --------
- **Date of Receipt** تاريخ الاستلام : 01/05/2024
- **Date of Calibration** تاريخ المعايرة : 09/05/2024
- **Issue Date** تاريخ الإصدار : 15/05/2024
- **Due Date** تاريخ إعادة المعايرة : ------

Approved by

Head of Laboratory

F/ Mostafa

Prof. Dr.Essam El-Din Mahmoud

NIS President

Prof. Dr. M. G. Ahmed

CERTIFICATE OF CALIBRATION
شهادة معايرة

▪ Certificate No.	762/32C012/292/1322/2024		
▪ Customer	المركز القومى لبحوث الاسكان والبناء -معهد بحوث الاعمال الكهروميكانيكية في المباني		
▪ Calibrated by	Ahmed Sayed Ahmed	▪ Date of Calibration	09/05/2024
▪ Number of pages	3	▪ File name	2570/13/24/04/HK

• Device Under Calibration

Device Description	Digital thermo-hygrometer, resolution 0.1°C for temperature & resolution 0.1% for relative humidity		
Serial Number	085018	Code	--------

• Enviromental Conditions

Temperature (°C)	(25±2)	Humidity (%)	(45±15)

• Calibration Method

The calibration was carried out according to calibration method No. NIS-32-OP-7.2.1.1-05 " Thermo hygrometers, Data loggers and Thermo hygrographs Calibration Method "

• Traceability

Description of Reference Device	Serial Number	Due Date	Certificate No.	Relative Expanded Uncertainty	Traceability
Standard thermo-hygrometer	0060957711	May,2024	4851/32C012/425/1522/2023	0.3 °C, 1%	NIS

• Uncertainty Statement

The combined standard uncertainty is calculated based on NIS-32-OP-6.4.10-01 which include at least the standard uncertainty reported for the reference standard, the standard uncertainty for the measurement process, the standard uncertainty for any uncorrected errors. The combined standard uncertainty is multiplied by a coverage factor (k) of 2 to provide an expanded uncertainty, which defines a level of confidence of approximately 95 percent (95.45 %). The expanded uncertainty presented in this certificate/report is consistent with the ISO/IEC GUIDE 98-3:2008 "Uncertainty of measurement — Part 3: Guide to the expression of uncertainty in measurement (GUM:1995)".

• ISO 17025 Statement

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• Conformity Statement

Conformity Criterion	Not applicable
Decision	-----

Calibrated by
Ahmed Sayed

Reviewed by
Elsayed

Ministry of Higher Education
& Scientific Research
National Institute of Standards

وزارة التعليم العالى والبحث العلمى
المعهد القومى للمعايرة

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CERTIFICATE OF CALIBRATION
شهادة معايرة

Certificate No.	762/32C012/292/1322/2024		
Serial Number	085018	Code	--------

Calibration results of humidity

Standard relative humidity RHs %	Measured relative humidity RHm %	Correction ΔRH = RHs - RHm %
30.0	29.1	0.9
35.0	33.7	1.3
40.0	39.5	0.5
45.0	43.7	1.3
50.0	48.5	1.5
55.0	53.2	1.8
60.0	58.6	1.4
65.0	63.4	1.6
70.0	69.0	1.0

Uncertainty at C.L. 95 % (K=2): ± 1.7 %

Calibration results of temperature

Temperature on ITS-90 t_s °C	Measured temperature t_m °C	Correction $\Delta t = t_s - t_m$ °C
25.0	24.8	0.2
30.0	29.8	0.2
35.0	34.7	0.3
40.0	39.7	0.3
45.0	44.6	0.4

Uncertainty at C.L. 95 % (K=2): ± 0.4 °C

* The calibration points are selected according to customer's request

The data in the above table applies only to those items specifically listed on this calibration certificate

Calibrated by
AhmedRezk

Reviewed by
ElSayed

CERTIFICATE OF CALIBRATION
شهادة معايرة

Certificate No:	762/32C012/285/1312/2024

- **NIS Lab** أسم المعمل : **Thermal Metrology Laboratory**
- **Issued For** صادرالى : المركز القومى لبحوث الاسكان والبناء - معهد بحوث الاعمال الكهروميكانيكية في المباني
- **Contact Information of the Customer** بيانات التواصل بالزبون : 01022852637
- **Location of Calibration** مكان اجراء المعايرة : **NIS**
- **Device Description** اسم ووصف الجهاز تحت المعايرة : Digital thermo-hygrometer, resolution 0.1°C for temperature & resolution 0.1% for relative humidity
  - **Manufacturer** اسم الشركة المنتجة : Lutron
  - **Model/Type** موديل الجهاز : PM-1064SD
  - **Serial Number** الرقم المسلسل للجهاز : 085017
  - **Code** كود : --------
- **Date of Receipt** تاريخ الاستلام : 01/05/2024
- **Date of Calibration** تاريخ المعايرة : 09/05/2024
- **Issue Date** تاريخ الاصدار : 15/05/2024
- **Due Date** تاريخ إعادة المعايرة : ------

Approved by

Head of Laboratory	**NIS President**
F/ Mostafa	
Prof. Dr.Essam El-Din Mahmoud	Prof. Dr. M. G. Ahmed

Ministry of Higher Education
& Scientific Research
National Institute of Standards

وزارة التعليم العالى والبحث العلمى
المعهد القومى للمعايرة

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CERTIFICATE OF CALIBRATION
شهادة معايرة

▪ Certificate No.	762/32C012/285/1312/2024		
▪ Customer	المركز القومى لبحوث الاسكان والبناء - معهد بحوث الاعمال الكهروميكانيكية في المباني		
▪ Calibrated by	Ahmed Sayed Ahmed	▪ Date of Calibration	09/05/2024
▪ Number of pages	3	▪ File name	2570/13/24/01/HK

• Device Under Calibration

Device Description	**Digital thermo-hygrometer, resolution 0.1°C for temperature & resolution 0.1% for relative humidity**		
Serial Number	085017	Code	--------

• Enviromental Conditions

Temperature (°C)	(25±2)	Humidity (%)	(45±15)

• Calibration Method

The calibration was carried out according to calibration method No. NIS-32-OP-7.2.1.1-05 " Thermo hygrometers, Data loggers and Thermo hygrographs Calibration Method "

• Traceability

Description of Reference Device	Serial Number	Due Date	Certificate No.	Relative Expanded Uncertainty	Traceability
Standard thermo-hygrometer	0060957711	May,2024	4851/32C012/4 25/1522/2023	0.3 °C, 1%	NIS

• Uncertainty Statement

The combined standard uncertainty is calculated based on NIS-32-OP-6.4.10-01 which include at least the standard uncertainty reported for the reference standard, the standard uncertainty for the measurement process, the standard uncertainty for any uncorrected errors. The combined standard uncertainty is multiplied by a coverage factor (k) of 2 to provide an expanded uncertainty, which defines a level of confidence of approximately 95 percent (95.45 %). The expanded uncertainty presented in this certificate/report is consistent with the ISO/IEC GUIDE 98-3:2008 "Uncertainty of measurement — Part 3: Guide to the expression of uncertainty in measurement (GUM:1995)".

• ISO 17025 Statement

All NIS laboratories implement the NIS unified quality management system which was built to be in compliance with ISO 17025:2017. It is the customer responsibility to indicate - on the calibration label - the due date for calibration in accordance with the aforementioned ISO/SOP calibration procedure and in compliance with ISO 17025:2017.

• Conformity Statement

Conformity Criterion	Not applicable
Decision	-----

Calibrated by
AhmedSayed

Reviewed by
ElSayed

El- Sadat (Tersa) St., El Haram, Giza, Egypt - P.O.Box 136 Giza - Code 12211 - Tel./ Fax: +202 - 33867462 - NIS Tel +202 - 37401113

CERTIFICATE OF CALIBRATION
شهادة معايرة

Certificate No.	762/32C012/285/1312/2024		
Serial Number	085017	Code	--------

Calibration results of humidity

Standard relative humidity RHs %	Measured relative humidity RHm %	Correction ΔRH = RHs - RHm %
30.0	29.7	0.3
35.0	34.8	0.2
40.0	39.6	0.4
45.0	44.4	0.6
50.0	48.9	1.1
55.0	53.8	1.2
60.0	59.1	0.9
65.0	64.1	0.9
70.0	69.4	0.6

Uncertainty at C.L. 95 % (K=2): ± 1.7 %

Calibration results of temperature

Temperature on ITS-90 t_s °C	Measured temperature t_m °C	Correction $\Delta t = ts - tm$ °C
25.0	24.5	0.5
30.0	29.7	0.3
35.0	34.3	0.7
40.0	39.3	0.7
45.0	44.2	0.8

Uncertainty at C.L. 95 % (K=2): ± 0.4 °C

* The calibration points are selected according to customer's request

The data in the above table applies only to those items specifically listed on this calibration certificate

Calibrated by
AhmedSayed

Reviewed by
Elsayed

CERTIFICATE OF CALIBRATION
شهادة معايرة

Certificate No:	762/32C012/294/1324/2024

- **NIS Lab** اسم المعمل : **Thermal Metrology Laboratory**
- **Issued For** صادر الى : المركز القومى لبحوث الاسكان والبناء -معهد بحوث الاعمال الكهروميكانيكية في المباني
- **Contact Information of the Customer** بيانات التواصل بالزبون : 01022852637
- **Location of Calibration** مكان اجراء المعايرة : NIS
- **Device Description** اسم ووصف الجهاز تحت المعايرة : Digital thermo-hygrometer, resolution 0.1°C for temperature & resolution 0.1% for relative humidity
  - **Manufacturer** اسم الشركة المنتجة : Lutron
  - **Model/Type** موديل الجهاز : PM-1064SD
  - **Serial Number** الرقم المسلسل للجهاز : 085016
  - **Code** كود : --------
- **Date of Receipt** تاريخ الاستلام : 01/05/2024
- **Date of Calibration** تاريخ المعايرة : 09/05/2024
- **Issue Date** تاريخ الإصدار : 15/05/2024
- **Due Date** تاريخ إعادة المعايرة : ------

Approved by

Head of Laboratory	NIS President
Prof. Dr.Essam El-Din Mahmoud	Prof. Dr. M. G. Ahmed

CERTIFICATE OF CALIBRATION
شهادة معايرة

▪ Certificate No.	762/32C012/294/1324/2024		
▪ Customer	المركز القومى لبحوث الاسكان والبناء -معهد بحوث الاعمال الكهروميكانيكية في المباني		
▪ Calibrated by	Ahmed Sayed Ahmed	▪ Date of Calibration	09/05/2024
▪ Number of pages	3	▪ File name	2570/13/24/06/HK
• Device Under Calibration			
Device Description	**Digital thermo-hygrometer, resolution 0.1°C for temperature & resolution 0.1% for relative humidity**		
Serial Number	**085016**	**Code**	--------
• Enviromental Conditions			
Temperature (°C)	**(25±2)**	**Humidity (%)**	**(45±15)**

• Calibration Method

The calibration was carried out according to calibration method No. NIS-32-OP-7.2.1.1-05 " Thermo hygrometers, Data loggers and Thermo hygrographs Calibration Method "

• Traceability

Description of Reference Device	Serial Number	Due Date	Certificate No.	Relative Expanded Uncertainty	Traceability
Standard thermo-hygrometer	0060957711	May,2024	4851/32C012/4 25/1522/2023	0.3 °C, 1%	NIS

• Uncertainty Statement

The combined standard uncertainty is calculated based on NIS-32-OP-6.4.10-01 which include at least the standard uncertainty reported for the reference standard, the standard uncertainty for the measurement process, the standard uncertainty for any uncorrected errors. The combined standard uncertainty is multiplied by a coverage factor (k) of 2 to provide an expanded uncertainty, which defines a level of confidence of approximately 95 percent (95.45 %). The expanded uncertainty presented in this certificate/report is consistent with the ISO/IEC GUIDE 98-3:2008 "Uncertainty of measurement — Part 3: Guide to the expression of uncertainty in measurement (GUM:1995)".

• ISO 17025 Statement

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• Conformity Statement

Conformity Criterion	Not applicable
Decision	-----

Calibrated by
AhmedSayed

Reviewed by
Elsayed

CERTIFICATE OF CALIBRATION
شهادة معايرة

Certificate No.	762/32C012/294/1324/2024		
Serial Number	085016	Code	--------

Calibration results of humidity

Standard relative humidity RHs %	Measured relative humidity RHm %	Correction $\Delta RH = RHs - RHm$ %
30.0	29.3	0.7
35.0	34.0	1.0
40.0	39.9	0.1
45.0	43.8	1.2
50.0	49.0	1.0
55.0	53.6	1.4
60.0	59.1	0.9
65.0	64.2	0.8
70.0	69.6	0.4

Uncertainty at C.L. 95 % (K=2): ± 1.7 %

Calibration results of temperature

Temperature on ITS-90 t_s °C	Measured temperature t_m °C	Correction $\Delta t = ts - tm$ °C
25.0	24.4	0.6
30.0	30.0	0.0
35.0	34.6	0.4
40.0	39.7	0.3
45.0	44.5	0.5

Uncertainty at C.L. 95 % (K=2): ± 0.4 °C

* The calibration points are selected according to customer's request

The data in the above table applies only to those items specifically listed on this calibration certificate

Calibrated by

Ahmed Sobhy

Reviewed by

Elsayed

Ministry of Higher Education
& Scientific Research
National Institute of Standards

وزارة التعليم العالى والبحث العلمى
المعهد القومى للمعايرة

El- Sadat (Tersa) St., El Haram, Giza, Egypt - P.O.Box 136 Giza - Code 12211 - Tel./ Fax: +202 - 33867462 - NIS Tel +202 - 37401113

CERTIFICATE OF CALIBRATION
شهـادة معايـرة

Certificate No:	762/32C012/293/1323/2024

- **NIS Lab** أسم المعمل : **Thermal Metrology Laboratory**
- **Issued For** صادرالى : المركز القومى لبحوث الاسكان والبناء -معهد بحوث الاعمال الكهروميكانيكية في المباني
- **Contact Information of the Customer** بيانات التواصل بالزبون : 01022852637
- **Location of Calibration** مكان اجراء المعايرة : NIS
- **Device Description** اسم ووصف الجهاز تحت المعايرة : Digital thermo-hygrometer, resolution 0.1°C for temperature & resolution 0.1% for relative humidity
  - **Manufacturer** اسم الشركة المنتجة : Lutron
  - **Model/Type** موديل الجهاز : PM-1064SD
  - **Serial Number** الرقم المسلسل للجهاز : 085015
  - **Code** كود : --------

Date of Receipt تاريخ الاستلام	01/05/2024	**Date of Calibration** تاريخ المعايرة	09/05/2024
Issue Date تاريخ الإصدار	15/05/2024	**Due Date** تاريخ إعادة المعايرة	------

Approved by

Head of Laboratory	**NIS President**
F/ Mastafa. A	
Prof. Dr.Essam El-Din Mahmoud	Prof. Dr. M. G. Ahmed

CERTIFICATE OF CALIBRATION
شهادة معايرة

▪ Certificate No.	762/32C012/293/1323/2024		
▪ Customer	المركز القومى لبحوث الاسكان والبناء -معهد بحوث الاعمال الكهروميكانيكية في المباني		
▪ Calibrated by	Ahmed Sayed Ahmed	▪ Date of Calibration	09/05/2024
▪ Number of pages	3	▪ File name	2570/13/24/05/HK

• Device Under Calibration

Device Description	**Digital thermo-hygrometer, resolution 0.1°C for temperature & resolution 0.1% for relative humidity**		
Serial Number	085015	Code	--------

• Enviromental Conditions

Temperature (°C)	(25±2)	Humidity (%)	(45±15)

• Calibration Method

The calibration was carried out according to calibration method No. NIS-32-OP-7.2.1.1-05 " Thermo hygrometers, Data loggers and Thermo hygrographs Calibration Method "

• Traceability

Description of Reference Device	Serial Number	Due Date	Certificate No.	Relative Expanded Uncertainty	Traceability
Standard thermo-hygrometer	0060957711	May,2024	4851/32C012/425/1522/2023	0.3 °C, 1%	NIS

• Uncertainty Statement

The combined standard uncertainty is calculated based on NIS-32-OP-6.4.10-01 which include at least the standard uncertainty reported for the reference standard, the standard uncertainty for the measurement process, the standard uncertainty for any uncorrected errors. The combined standard uncertainty is multiplied by a coverage factor (k) of 2 to provide an expanded uncertainty, which defines a level of confidence of approximately 95 percent (95.45 %). The expanded uncertainty presented in this certificate/report is consistent with the ISO/IEC GUIDE 98-3:2008 "Uncertainty of measurement — Part 3: Guide to the expression of uncertainty in measurement (GUM:1995)".

• ISO 17025 Statement

All NIS laboratories implement the NIS unified quality management system which was built to be in compliance with ISO 17025:2017. It is the customer responsibility to indicate - on the calibration label - the due date for calibration in accordance with the aforementioned ISO/SOP calibration procedure and in compliance with ISO 17025:2017.

• Conformity Statement

Conformity Criterion	Not applicable
Decision	-----

Calibrated by
AhmedSayed

Reviewed by
Elsayed

Ministry of Higher Education
& Scientific Research
National Institute of Standards

وزارة التعليم العالى والبحث العلمى
المعهد القومى للمعايرة

El- Sadat (Tersa) St., El Haram, Giza, Egypt - P.O.Box 136 Giza - Code 12211 - Tel./ Fax: +202 - 33867462 - NIS Tel +202 - 37401113

CERTIFICATE OF CALIBRATION
شهادة معايرة

Certificate No.	762/32C012/293/1323/2024		
Serial Number	085015	Code	--------

Calibration results of humidity

Standard relative humidity RHs %	Measured relative humidity RHm %	Correction ΔRH = RHs - RHm %
30.0	28.9	1.1
35.0	33.7	1.3
40.0	39.6	0.4
45.0	43.5	1.5
50.0	48.6	1.4
55.0	53.0	2.0
60.0	58.3	1.7
65.0	63.2	1.8
70.0	68.7	1.3

Uncertainty at C.L. 95 % (K=2): ± 1.7 %

Calibration results of temperature

Temperature on ITS-90 t_s °C	Measured temperature t_m °C	Correction $\Delta t = t_s - t_m$ °C
25.0	24.8	0.2
30.0	29.8	0.2
35.0	34.7	0.3
40.0	39.7	0.3
45.0	44.5	0.5

Uncertainty at C.L. 95 % (K=2): ± 0.4 °C

* The calibration points are selected according to customer's request

The data in the above table applies only to those items specifically listed on this calibration certificate

Calibrated by

Ahmed Sayed

Reviewed by

Sayed

Ministry of Higher Education
& Scientific Research
National Institute of Standards

وزارة التعليم العالى والبحث العلمى
المعهد القومى للمعايرة

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CERTIFICATE OF CALIBRATION
شهادة معايرة

Certificate No:	762/32C012/291/1320/2024

- **NIS Lab** اسم المعمل : **Thermal Metrology Laboratory**
- **Issued For** صادرالى : المركز القومى لبحوث الاسكان والبناء -معهد بحوث الاعمال الكهروميكانيكية في المباني
- **Contact Information of the Customer** بيانات التواصل بالزبون : 01022852637
- **Location of Calibration** مكان اجراء المعايرة : **NIS**
- **Device Description** اسم ووصف الجهاز تحت المعايرة : Digital thermo-hygrometer, resolution 0.1°C for temperature & resolution 0.1% for relative humidity
  - **Manufacturer** اسم الشركة المنتجة : Lutron
  - **Model/Type** موديل الجهاز : PM-1064SD
  - **Serial Number** الرقم المسلسل للجهاز : 085014
  - **Code** كود : --------
- **Date of Receipt** تاريخ الاستلام : 01/05/2024
- **Date of Calibration** تاريخ المعايرة : 09/05/2024
- **Issue Date** تاريخ الإصدار : 15/05/2024
- **Due Date** تاريخ إعادة المعايرة : ------

Approved by

Head of Laboratory

Prof. Dr.Essam El-Din Mahmoud

NIS President

Prof. Dr. M. G. Ahmed

Ministry of Higher Education
& Scientific Research
National Institute of Standards

وزارة التعليم العالى والبحث العلمى
المعهد القومى للمعايرة

El- Sadat (Tersa) St., El Haram, Giza, Egypt - P.O.Box 136 Giza - Code 12211 - Tel./ Fax: +202 - 33867462 - NIS Tel +202 - 37401113

CERTIFICATE OF CALIBRATION
شهادة معايرة

▪ Certificate No.	762/32C012/291/1320/2024		
▪ Customer	المركز القومى لبحوث الاسكان والبناء -معهد بحوث الاعمال الكهروميكانيكية في المباني		
▪ Calibrated by	Ahmed Sayed Ahmed	▪ Date of Calibration	09/05/2024
▪ Number of pages	3	▪ File name	2570/13/24/03/HK

• Device Under Calibration

Device Description	Digital thermo-hygrometer, resolution 0.1°C for temperature & resolution 0.1% for relative humidity		
Serial Number	085014	Code	--------

• Enviromental Conditions

Temperature (°C)	(25±2)	Humidity (%)	(45±15)

• Calibration Method

The calibration was carried out according to calibration method No. NIS-32-OP-7.2.1.1-05 " Thermo hygrometers, Data loggers and Thermo hygrographs Calibration Method "

• Traceability

Description of Reference Device	Serial Number	Due Date	Certificate No.	Relative Expanded Uncertainty	Traceability
Standard thermo-hygrometer	0060957711	May,2024	4851/32C012/4 25/1522/2023	0.3 °C, 1%	NIS

• Uncertainty Statement

The combined standard uncertainty is calculated based on NIS-32-OP-6.4.10-01 which include at least the standard uncertainty reported for the reference standard, the standard uncertainty for the measurement process, the standard uncertainty for any uncorrected errors. The combined standard uncertainty is multiplied by a coverage factor (k) of 2 to provide an expanded uncertainty, which defines a level of confidence of approximately 95 percent (95.45 %). The expanded uncertainty presented in this certificate/report is consistent with the ISO/IEC GUIDE 98-3:2008 "Uncertainty of measurement — Part 3: Guide to the expression of uncertainty in measurement (GUM:1995)".

• ISO 17025 Statement

All NIS laboratories implement the NIS unified quality management system which was built to be in compliance with ISO 17025:2017. It is the customer responsibility to indicate - on the calibration label - the due date for calibration in accordance with the aforementioned ISO/SOP calibration procedure and in compliance with ISO 17025:2017.

• Conformity Statement

Conformity Criterion	Not applicable
Decision	-----

Calibrated by
Ahmed Sayed

Reviewed by
Elsayed

Ministry of Higher Education
& Scientific Research
National Institute of Standards

وزارة التعليم العالى والبحث العلمى
المعهد القومى للمعايرة

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CERTIFICATE OF CALIBRATION

شهادة معايرة

Certificate No.	762/32C012/291/1320/2024		
Serial Number	085014	Code	--------

Calibration results of humidity

Standard relative humidity RHs %	Measured relative humidity RHm %	Correction ΔRH = RHs - RHm %
30.0	28.4	1.6
35.0	33.1	1.9
40.0	38.4	1.6
45.0	42.7	2.3
50.0	47.0	3.0
55.0	51.7	3.3
60.0	58.6	1.4
65.0	61.3	3.7
70.0	66.5	3.5

Uncertainty at C.L. 95 % (K=2): ± 1.7 %

Calibration results of temperature

Temperature on ITS-90 t_s °C	Measured temperature t_m °C	Correction $\Delta t = ts - tm$ °C
25.0	24.7	0.3
30.0	30.0	0.0
35.0	34.6	0.4
40.0	39.5	0.5
45.0	44.3	0.7

Uncertainty at C.L. 95 % (K=2): ± 0.4 °C

* The calibration points are selected according to customer's request

The data in the above table applies only to those items specifically listed on this calibration certificate

Calibrated by
Ahmed Sayed

Reviewed by
E. Sayed

Ministry of Higher Education
& Scientific Research
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وزارة التعليم العالى والبحث العلمى
المعهد القومى للمعايرة

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CERTIFICATE OF CALIBRATION
شهـادة معايـرة

Certificate No:	8062/32C012/693/2698/2023

- **NIS Lab** اسم المعمل : **Thermal Metrology Laboratory**
- **Issued For** صادرالى : المركز القومي لبحوث الاسكان و البناء
- **Contact Information of the Customer** بيانات التواصل بالزبون : 01115196088
- **Location of Calibration** مكان اجراء المعايرة : **NIS**
- **Device Description** اسم ووصف الجهاز تحت المعايرة : Digital thermohygrometer, resolution 0.1% for relative humidity and resolution 0.1°C for temperature .
  - **Manufacturer** اسم الشركة المنتجة : Lutron
  - **Model/Type** موديل الجهاز : HT-305E
  - **Serial Number** الرقم المسلسل للجهاز : R.029189
  - **Code** كود : --------
- **Date of Receipt** تاريخ الاستلام : 11/10/2023
- **Date of Calibration** تاريخ المعايرة : 18/10/2023
- **Issue Date** تاريخ الإصدار : 29/10/2023
- **Due Date** تاريخ إعادة المعايرة : ---------

Approved by

Head of Laboratory	**NIS President**
Prof. Dr.Essam EL-Din Mahmoud	Prof. Dr. Noha E. Khaled

Ministry of Higher Education
& Scientific Research
National Institute of Standards

وزارة التعليم العالى والبحث العلمى
المعهد القومى للمعايرة

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CERTIFICATE OF CALIBRATION
شهادة معايرة

▪ Certificate No.	8062/32C012/693/2698/2023		
▪ Customer	المركز القومي لبحوث الاسكان و البناء		
▪ Calibrated by	Ahmed Sayed Ahmed	▪ Date of Calibration	18/10/2023
▪ Number of pages	3	▪ File name	5903/40/23/01/AS

• Device Under Calibration

Device Description	**Digital thermohygrometer, resolution 0.1% for relative humidity and resolution 0.1°C for temperature .**		
Serial Number	R.029189	Code	--------

• Enviromental Conditions

Temperature (°C)	(25±2)	Humidity (%)	(45±15)

• Calibration Method

The calibration was carried out according to calibration method No. NIS-32-OP-7.2.1.1-05 " Thermo hygrometers, Data loggers and Thermo hygrographs Calibration Method "

• Traceability

Description of Reference Device	Serial Number	Due Date	Certificate No.	Relative Expanded Uncertainty	Traceability
Standard thermo-hygrometer	0060957711	May,2024	4851/32C012/29 /1059/2023	0.3 °C, 1%	NIS

• Uncertainty Statement

The combined standard uncertainty is calculated based on NIS-32-OP-6.4.10-01 which include at least the standard uncertainty reported for the reference standard, the standard uncertainty for the measurement process, the standard uncertainty for any uncorrected errors. The combined standard uncertainty is multiplied by a coverage factor (k) of 2 to provide an expanded uncertainty, which defines a level of confidence of approximately 95 percent (95.45 %). The expanded uncertainty presented in this certificate/report is consistent with the ISO/IEC GUIDE 98-3:2008 "Uncertainty of measurement — Part 3: Guide to the expression of uncertainty in measurement (GUM:1995)".

• ISO 17025 Statement

All NIS laboratories implement the NIS unified quality management system which was built to be in compliance with ISO 17025:2017. It is the customer responsibility to indicate - on the calibration label - the due date for calibration in accordance with the aforementioned ISO/SOP calibration procedure and in compliance with ISO 17025:2017.

• Conformity Statement

Conformity Criterion	Not applicable
Decision	-----

Caibrated by
Ahmed Sayed

Reviewed by
Ebtesam

Ministry of Higher Education
& Scientific Research
National Institute of Standards

وزارة التعليم العالى والبحث العلمى
المعهد القومى للمعايرة

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CERTIFICATE OF CALIBRATION
شهادة معايرة

Certificate No.	8062/32C012/693/2698/2023		
Serial Number	R.029189	Code	--------

Calibration results of humidity

Standard relative humidity RHs %	Measured relative humidity RHm %	Correction ΔRH = RHs - RHm %
40.0	45.3	-5.3
50.0	55.0	-5.0
60.0	64.1	-4.1

Uncertainty a C.L. 95 % (K=2): ± 1.7 %

Calibration results of temperature

Temperature on ITS-90 t_s °C	Measured temperature t_m °C	Correction $\Delta t = ts - tm$ °C
18.0	18.3	-0.3
19.0	19.3	-0.3
20.0	20.3	-0.3
22.0	22.3	-0.3
24.0	24.2	-0.2
26.0	26.2	-0.2
28.0	28.1	-0.1
30.0	30.1	-0.1

Uncertainty a C.L. 95 % (K=2): ± 0.4 °C

*** The calibrated points are selected according to the customer's request**

The data in the above table applies only to those items specifically listed on this calibration certificate

Calibrated by

Ahmed Sayed

Reviewed by

Ebtesam

Ministry of Higher Education
& Scientific Research
National Institute of Standards

وزارة التعليم العالى والبحث العلمى
المعهد القومى للمعايرة

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CERTIFICATE OF CALIBRATION
شهادة معايرة

Certificate No:	882/23C012/75/339/2024

- **NIS Lab** أسم المعمل : **High Voltage Metrology Lab.**
- **Issued For** صادرالى : معهد بحوث الاعمال الكهروميكانيكية في المباني (مركز بحوث الاسكان والبناء)
- **Contact Information of the Customer** بيانات التواصل بالزبون : العنوان : 87 شارع التحرير
- **Location of Calibration** مكان اجراء المعايرة : High Voltage Metrology Lab., NIS.
- **Device Description** اسم ووصف الجهاز تحت المعايرة : POWER QUALITY AND ENERGY ANALYZER
  - **Manufacturer** اسم الشركة المنتجة : FLUKE
  - **Model/Type** موديل الجهاز : 434
  - **Serial Number** الرقم المسلسل للجهاز : DM9130018
  - **Code** كود : ----

- **Date of Receipt** تاريخ الاستلام : 9/5/2024
- **Date of Calibration** تاريخ المعايرة : 19/5/2024
- **Issue Date** تاريخ الإصدار : 22/5/2024
- **Due Date** تاريخ إعادة المعايرة : --------

Approved by

Head of Laboratory	**NIS President**
Dr. Eng. Ahmed S. Haiba	Prof. Dr. M. G. Ahmed

Ministry of Higher Education
& Scientific Research
National Institute of Standards

وزارة التعليم العالى والبحث العلمى
المعهد القومى للمعايرة

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CERTIFICATE OF CALIBRATION
شهادة معايرة

• Certificate No.	882/23C012/75/339/2024		
• Customer	معهد بحوث الاعمال الكهروميكانيكية في المباني (مركز بحوث الاسكان والبناء)		
• Location	High Voltage Metrology Lab., NIS	• Date of Receipt	9/5/2024
• Calibrated by	Eng. Eman Mohamed Hosny	• Date of Calibration	19/5/2024
• Number of pages	6	• Issue Date	22/5/2024
		• Due Date	--------

• Device Under Calibration

Device Description	POWER QUALITY AND ENERGY ANALYZER		
Manufacturer	FLUKE	other	-----
Model/Type	434	other	-----
Serial Number	DM9130018	other	-----
Code	-----	other	-----
Other	-----	-----	-----

• Enviromental Conditions

Temperature (°C)	(23±2)	Humidity (%)	(50±10)
Other	-----	-----	-----

• Calibration Method

The calibration was carried out according to E.S. 1021/2020 "معايرة اجهزة القياس الكهربية"

• Traceability

Description of Reference Device	Serial Number	Calibration Date	Certificate No.	Expanded Uncertainty	Traceability
3-Phase Comparator Reference Standard	98-717-1	2/2024	10175/23C012/28/148/2024	Uv=0.005%,Ui= 0.003%, Up=0.005%	NIS, Egypt.

• Uncertainty Statement

The combined standard uncertainty is calculated based on NIS-23-OP-7.6 which include at least the standard uncertainty reported for the reference standard, the standard uncertainty for the measurement process, the standard uncertainty for any uncorrected errors. The combined standard uncertainty is multiplied by a coverage factor (k) of 2 to provide an expanded uncertainty, which defines a level of confidence of approximately 95 percent (95.45 %). The expanded uncertainty presented in this certificate/report is consistent with the ISO/IEC GUIDE 98-3:2008 "Uncertainty of measurement — Part 3: Guide to the expression of uncertainty in measurement (GUM:1995)".

• ISO 17025 Statement

All NIS laboratories implement the NIS unified quality management system which was built to be in compliance with ISO 17025:2017. It is the customer responsibility to indicate - on the calibration label - the due date for calibration in accordance with the aforementioned ISO/SOP calibration procedure and in compliance with ISO 17025:2017.

Calibrated by
Eman M. Hosny

Reviewed by
Samah A. Mohamed

CERTIFICATE OF CALIBRATION
شهادة معايرة

Certificate No.	882/23C012/75/339/2024	Serial Number	DM9130018
• Conformity Statement			
Conformity Criterion	Not applicable		
Decision	-----		

• Calibration Results

1. AC Voltage Calibration, 50 Hz:-

1.1. Phase (1)

Nominal Value (V)	Measured Value (V) UUC*	Actual Value (V) Ref**	Error*** %	Expanded Uncertainty ±(mV)
60	59.9	59.890	0.017	58
120	119.8	119.774	0.022	58
220	219.6	219.565	0.016	59
300	299.4	299.403	-0.001	59

1.2. Phase (2)

Nominal Value (V)	Measured Value (V) UUC	Actual Value (V) Ref	Error %	Expanded Uncertainty ±(mV)
60	59.9	59.890	0.017	58
120	119.8	119.774	0.022	58
220	219.6	219.565	0.016	59
300	299.4	299.403	-0.001	59

1.3. Phase (3)

Nominal Value (V)	Measured Value (V) UUC	Actual Value (V) Ref	Error %	Expanded Uncertainty ±(mV)
60	59.9	59.890	0.017	58
120	119.8	119.774	0.022	58
220	219.6	219.565	0.016	59
300	299.4	299.403	-0.001	59

*UUC:Unit Under Calibration

**Ref.:Reference value of standard instrument

$$***Error = \frac{Measured\ Value - Actual\ Value}{Actual\ Value} \times 100$$

The data in the above table applies only to those items specifically listed on this calibration certificate

Calibrated by

Eman M. Hosny

Reviewed by

Samah A. Mohamed

CERTIFICATE OF CALIBRATION
شهادة معايرة

Certificate No.	882/23C012/75/339/2024	Serial Number	DM9130018
• Conformity Statement			
Conformity Criterion	Not applicable		
Decision	-----		

• Calibration Results

2. AC Current Calibration, 50 Hz:-

2.1. Phase (1), with clamp, S.N.: 90800112

Nominal Value (A)	Measured Value (A) UUC	Actual Value (A) Ref	Error %	Expanded Uncertainty ±(A)
10	10	9.986	0.140	0.58
20	20	19.994	0.030	0.58
50	50	49.984	0.032	0.58
100	99	99.966	-0.966	0.65
150	149	149.950	-0.634	0.73
300	298	299.834	-0.612	1.1
400	398	399.778	-0.445	1.3

2.2. Phase (2), with clamp, S.N.: 90780311

Nominal Value (A)	Measured Value (A) UUC	Actual Value (A) Ref	Error %	Expanded Uncertainty ±(A)
10	10	9.986	0.140	0.58
20	20	19.994	0.030	0.58
50	50	49.984	0.032	0.58
100	100	99.966	0.034	0.65
150	150	149.950	0.033	0.73
300	299	299.834	-0.278	1.1
400	399	399.778	-0.195	1.3

2.3. Phase (3), with clamp, S.N.: 90780313

Nominal Value (A)	Measured Value (A) UUC	Actual Value (A) Ref	Error %	Expanded Uncertainty ±(A)
10	10	9.986	0.140	0.58
20	20	19.994	0.030	0.58
50	50	49.984	0.032	0.58
100	99	99.966	-0.966	0.65
150	149	149.950	-0.634	0.73
300	299	299.834	-0.278	1.1
400	398	399.778	-0.445	1.3

The data in the above table applies only to those items specifically listed on this calibration certificate

Calibrated by: Eman M. Hosny

Reviewed by: Samah A-Mohamed

CERTIFICATE OF CALIBRATION
شهادة معايرة

Certificate No.	882/23C012/75/339/2024	Serial Number	DM91300018
• Conformity Statement			
Conformity Criterion	Not applicable		
Decision	-----		

• Calibration Results

3. AC Active Power Calibration, 220 V, 50 Hz:-

3.1. Phase (1), with clamp, S.N.: 90800112 :

Nominal Value I (A)	Nominal Value P.F	Measured Value (kW) UUC	Actual Value (kW) Ref	Error %	Expanded Uncertainty ±(W)
1	1	0.2	0.220	-9.091	0.06
5	1	1.1	1.097	0.273	0.09
5	0.5L*	0.6	0.551	8.893	0.06
5	0.5C**	0.5	0.546	-8.425	0.06
10	1.0	2.2	2.194	0.273	0.10
10	0.5L	1.1	1.102	-0.181	0.09
10	0.5C	1.1	1.092	0.733	0.09
20	1.0	4.4	4.389	0.251	0.12
20	0.5L	2.2	2.204	-0.181	0.12
20	0.5C	2.1	2.185	-3.890	0.12
50	1	10.9	10.973	-0.665	0.62
80	1	17.4	17.558	-0.900	0.77

L*: Inductive
C**: Capacitive

The data in the above table applies only to those items specifically listed on this calibration certificate

Calibrated by
Eman M. Hosny

Reviewed by
Asmaah A. Mohamed

CERTIFICATE OF CALIBRATION
شهادة معايرة

Certificate No.	882/23C012/75/339/2024	Serial Number	DM91.[illegible]
• Conformity Statement			
Conformity Criterion	Not applicable		
Decision	-----		

• Calibration Results

3.2. Phase (2), with clamp, S.N.: 90780311 :

Nominal Value		Measured Value (kW) UUC	Actual Value (kW) Ref	Error %	Expanded Uncertainty ±(W)
I (A)	P.F				
1	1	0.2	0.220	-9.091	0.06
5	1	1.1	1.097	0.273	0.09
5	0.5L	0.6	0.551	8.893	0.06
5	0.5C	0.5	0.546	-8.425	0.06
10	1	2.2	2.194	0.273	0.10
10	0.5L	1.1	1.102	-0.181	0.09
10	0.5C	1.1	1.092	0.733	0.09
20	1	4.4	4.389	0.251	0.12
20	0.5L	2.2	2.204	-0.181	0.12
20	0.5C	2.1	2.185	-3.890	0.12
50	1	10.9	10.973	-0.665	0.62
80	1	17.5	17.558	-0.330	0.77

3.3. Phase (3), with clamp, S.N.: 90780313 :

Nominal Value		Measured Value (kW) UUC	Actual Value (kW) Ref	Error %	Expanded Uncertainty ±(W)
I (A)	P.F				
1	1	0.2	0.220	-9.091	0.06
5	1	1.1	1.097	0.273	0.09
5	0.5L	0.5	0.551	-9.256	0.06
5	0.5C	0.5	0.546	-8.425	0.02
10	1	2.2	2.194	0.273	0.08
10	0.5L	1.1	1.102	-0.181	0.07
10	0.5C	1.1	1.092	0.733	0.08
20	1	4.3	4.389	-2.028	0.11
20	0.5L	2.2	2.204	-0.181	0.11
20	0.5C	2.1	2.185	-3.890	0.10
50	1	10.9	10.973	-0.665	0.62
80	1	17.4	17.558	-0.900	0.77

The data in the above table applies only to those items specifically listed on this calibration certificate

Calibrated by

Eman M. Hosny

Reviewed by

Samah A. Mohamed

Ministry of Higher Education
& Scientific Research
National Institute of Standards

وزارة التعليم العالى والبحث العلمى
المعهد القومى للمعايرة

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CERTIFICATE OF CALIBRATION
شهادة معايرة

Certificate No:	882/23C012/74/326/2024

- **NIS Lab** أسم المعمل : **High Voltage Metrology Lab.**
- **Issued For** صادرإلى : معهد بحوث الاعمال الكهروميكانيكية في المباني (مركز بحوث الاسكان والبناء)
- **Contact Information of the Customer** بيانات التواصل بالزبون : العنوان : 87 شارع التحرير
- **Location of Calibration** مكان اجراء المعايرة : High Voltage Metrology Lab., NIS.
- **Device Description** اسم ووصف الجهاز تحت المعايرة : POWER QUALITY AND ENERGY ANALYZER
  - **Manufacturer** اسم الشركة المنتجة : FLUKE
  - **Model/Type** موديل الجهاز : 435
  - **Serial Number** الرقم المسلسل للجهاز : 19673107
  - **Code** كود : ----

- **Date of Receipt** تاريخ الاستلام : 9/5/2024
- **Date of Calibration** تاريخ المعايرة : 19/5/2024
- **Issue Date** تاريخ الإصدار : 22/5/2024
- **Due Date** تاريخ إعادة المعايرة : --------

Approved by

Head of Laboratory	**NIS President**
Dr. Eng. Ahmed S. Haiba	Prof. Dr. M. G. Ahmed

CERTIFICATE OF CALIBRATION
شهادة معايرة

• Certificate No.	882/23C012/74/326/2024		
• Customer	معهد بحوث الاعمال الكهروميكانيكية في المباني (مركز بحوث الاسكان والبناء)		
• Location	High Voltage Metrology Lab., NIS	• Date of Receipt	9/5/2024
• Calibrated by	Eng. Eman Mohamed Hosny	• Date of Calibration	19/5/2024
• Number of pages	6	• Issue Date	22/5/2024
		• Due Date	--------

• Device Under Calibration

Device Description	POWER QUALITY AND ENERGY ANALYZER		
Manufacturer	FLUKE	other	-----
Model/Type	435	other	-----
Serial Number	19673107	other	-----
Code	----	other	-----
Other	-----	-----	-----

• Enviromental Conditions

Temperature (°C)	(23±2)	Humidity (%)	(50±10)
Other	-----	-----	-----

• Calibration Method

The calibration was carried out according to E.S. 1021/2020 " معايرة اجهزة القياس الكهربية"

• Traceability

Description of Reference Device	Serial Number	Calibration Date	Certificate No.	Expanded Uncertainty	Traceability
3-Phase Comparator Reference Standard	98-717-1	2/2024	10175/23C012/28/148/2024	Uv=0.005%,Ui=0.003%, Up= 0.005%	NIS, Egypt.

• Uncertainty Statement

The combined standard uncertainty is calculated based on NIS-23-OP-7.6 which include at least the standard uncertainty reported for the reference standard, the standard uncertainty for the measurement process, the standard uncertainty for any uncorrected errors. The combined standard uncertainty is multiplied by a coverage factor (k) of 2 to provide an expanded uncertainty, which defines a level of confidence of approximately 95 percent (95.45 %). The expanded uncertainty presented in this certificate/report is consistent with the ISO/IEC GUIDE 98-3:2008 "Uncertainty of measurement — Part 3: Guide to the expression of uncertainty in measurement (GUM:1995)".

• ISO 17025 Statement

All NIS laboratories implement the NIS unified quality management system which was built to be in compliance with ISO 17025:2017. It is the customer responsibility to indicate - on the calibration label - the due date for calibration in accordance with the aforementioned ISO/SOP calibration procedure and in compliance with ISO 17025:2017.

Calibrated by Eman M. Hosny

Reviewed by Samah A. Mohamed

Ministry of Higher Education
& Scientific Research
National Institute of Standards

وزارة التعليم العالى والبحث العلمى
المعهد القومى للمعايرة

El- Sadat (Tersa) St., El Haram, Giza, Egypt - P.O.Box 136 Giza - Code 12211 - Tel./ Fax: +202 - 33867462 - NIS Tel +202 - 37401113

CERTIFICATE OF CALIBRATION
شهادة معايرة

Certificate No.	882/23C012/74/326/2024	Serial Number	19673107
• Conformity Statement			
Conformity Criterion	Not applicable		
Decision	-----		

• Calibration Results

1. AC Voltage Calibration, 50 Hz:-

1.1. Phase (1)

Nominal Value (V)	Measured Value (V) UUC*	Actual Value (V) Ref**	Error*** %	Expanded Uncertainty ±(mV)
60	59.88	59.890	-0.017	5.9
120	119.72	119.774	-0.045	9.0
220	219.50	219.565	-0.030	12
300	299.27	299.400	-0.043	12

1.2. Phase (2)

Nominal Value (V)	Measured Value (V) UUC	Actual Value (V) Ref	Error %	Expanded Uncertainty ±(mV)
60	59.88	59.890	-0.017	5.9
120	119.72	119.774	-0.045	9.0
220	219.50	219.565	-0.030	12
300	299.25	299.400	-0.050	12

1.3. Phase (3)

Nominal Value (V)	Measured Value (V) UUC	Actual Value (V) Ref	Error %	Expanded Uncertainty ±(mV)
60	59.88	59.890	-0.017	5.9
120	119.72	119.774	-0.045	9.0
220	219.50	219.565	-0.030	12
300	299.25	299.400	-0.050	12

*UUC:Unit Under Calibration

**Ref.:Reference value of standard instrument

$$***Error = \frac{Measured\ Value - Actual\ Value}{Actual\ Value} \times 100$$

The data in the above table applies only to those items specifically listed on this calibration certificate

Calibrated by

Eman M. HoSny

Reviewed by

Sarah A. Mohamed

El- Sadat (Tersa) St., El Haram, Giza, Egypt - P.O.Box 136 Giza - Code 12211 - Tel./ Fax: +202 - 33867462 - NIS Tel +202 - 37401113

CERTIFICATE OF CALIBRATION
شهادة معايرة

Certificate No.	882/23C012/74/326/2024	Serial Number	19673107
• Conformity Statement			
Conformity Criterion	Not applicable		
Decision	-----		

• Calibration Results

2. AC Current Calibration, 50 Hz:-

2.1. Phase (1), with Ampflex, S.N.:208200120-230965

Nominal Value (A)	Measured Value (A) UUC	Actual Value (A) Ref	Error %	Expanded Uncertainty ±(A)
10	9.9	9.986	-0.861	0.06
20	20.0	19.994	0.030	0.06
50	50.2	49.984	0.432	0.07
100	100.8	99.966	0.834	0.31
150	151.1	149.950	0.767	0.45
300	302.4	299.834	0.856	0.90
400	403.2	399.778	0.856	1.2

2.2. Phase (2), with Ampflex, S.N.:208200149-230965

Nominal Value (A)	Measured Value (A) UUC	Actual Value (A) Ref	Error %	Expanded Uncertainty ±(A)
10	10.1	9.986	1.142	0.07
20	20.2	19.994	1.030	0.06
50	50.7	49.984	1.432	0.06
100	100.7	99.966	0.734	0.31
150	151.2	149.950	0.834	0.45
300	302.6	299.834	0.923	0.90
400	403.5	399.778	0.931	1.2

2.3. Phase (3), with Ampflex, S.N.:208200140-230965

Nominal Value (A)	Measured Value (A) UUC	Actual Value (A) Ref	Error %	Expanded Uncertainty ±(A)
10	9.9	9.986	-0.861	0.07
20	19.9	19.994	-0.470	0.06
50	49.9	49.984	-0.168	0.06
100	100.7	99.966	0.734	0.31
150	151.0	149.950	0.700	0.45
300	302.1	299.834	0.756	0.90
400	402.6	399.778	0.706	1.2

The data in the above table applies only to those items specifically listed on this calibration certificate

Calibrated by
Eman M. Hosny

Reviewed by
Samah A. Mohamed

Ministry of Higher Education
& Scientific Research
National Institute of Standards

وزارة التعليم العالى والبحث العلمى
المعهد القومى للمعايرة

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CERTIFICATE OF CALIBRATION
شهادة معايرة

Certificate No.	882/23C012/74/326/2024	Serial Number	19673109

• Conformity Statement

Conformity Criterion	Not applicable
Decision	-----

• Calibration Results

3. AC Active Power Calibration, 220 V, 50 Hz:-

3.1. Phase (1), with Ampflex, S.N.:208200120-230965 :

Nominal Value I (A)	Nominal Value P.F	Measured Value (kW) UUC	Actual Value (kW) Ref	Error %	Expanded Uncertainty ±(W)
1	1	0.2	0.220	-9.091	0.06
5	1	1.1	1.097	0.273	0.09
5	0.5L*	0.6	0.551	8.893	0.07
5	0.5C**	0.5	0.546	-8.425	0.06
10	1.0	2.2	2.194	0.273	0.10
10	0.5L	1.1	1.102	-0.181	0.09
10	0.5C	1.1	1.092	0.733	0.09
20	1.0	4.4	4.389	0.251	0.12
20	0.5L	2.2	2.204	-0.181	0.12
20	0.5C	2.2	2.185	0.686	0.12
50	1	11.0	10.973	0.246	0.62
80	1	17.6	17.558	0.239	0.77

L*: Inductive
C**: Capacitive

The data in the above table applies only to those items specifically listed on this calibration certificate

Calibrated by: Eman M. Hosny

Reviewed by: Sanah A. Mohamed

CERTIFICATE OF CALIBRATION
شهادة معايرة

Certificate No.	882/23C012/74/326/2024	Serial Number	19673107
• Conformity Statement			
Conformity Criterion	Not applicable		
Decision	-----		

• Calibration Results

3.2. Phase (2), with Ampflex, S.N.:208200149-230965 :

Nominal Value		Measured Value (kW) UUC	Actual Value (kW) Ref	Error %	Expanded Uncertainty ±(W)
I (A)	P.F				
1	1	0.2	0.220	-9.091	0.06
5	1	1.1	1.097	0.273	0.09
5	0.5L	0.6	0.551	8.893	0.07
5	0.5C	0.5	0.546	-8.425	0.06
10	1	2.2	2.194	0.273	0.10
10	0.5L	1.1	1.102	-0.181	0.09
10	0.5C	1.1	1.092	0.733	0.09
20	1	4.4	4.389	0.251	0.12
20	0.5L	2.2	2.204	-0.181	0.12
20	0.5C	2.2	2.185	0.686	0.12
50	1	11.1	10.973	1.157	0.62
80	1	17.8	17.558	1.378	0.77

3.3. Phase (3), with Ampflex, S.N.:208200140-230965 :

Nominal Value		Measured Value (kW) UUC	Actual Value (kW) Ref	Error %	Expanded Uncertainty ±(W)
I (A)	P.F				
1	1	0.2	0.220	-9.091	0.06
5	1	1.1	1.097	0.273	0.09
5	0.5L	0.6	0.551	8.893	0.07
5	0.5C	0.5	0.546	-8.425	0.02
10	1	2.2	2.194	0.273	0.08
10	0.5L	1.1	1.102	-0.181	0.07
10	0.5C	1.1	1.092	0.733	0.07
20	1	4.4	4.389	0.251	0.11
20	0.5L	2.2	2.204	-0.181	0.11
20	0.5C	2.1	2.185	-3.890	0.10
50	1	10.9	10.973	-0.665	0.62
80	1	17.5	17.558	-0.330	0.77

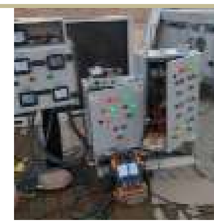
The data in the above table applies only to those items specifically listed on this calibration certificate

Calibrated by
Eman M. Hosny

Reviewed by
A. Mohamed

Annex 3: Testing Equipment Used:

Used Apparatus	Measured Property	Model	Serial Number	Item Photo
Air Flow Meter	Air flow	KIMO CP300	06072114	
Weather Station,	Inlet dry bulb temperature forboth Units	HOBO U30 ONSET	10221018	
	Inlet Relative humidity for bothUnits			
Thermo-Hygrometer	Outlet dry bulb temperature for IEC Hybrid Unit	KIMO TH300	MEH1000821	
	Outlet Relative humidity for IECHybrid Unit			
Air Quality Meter	Outlet dry bulb temperature for IEC Hybrid Unit	Lutron	085019	
			085018	
			085017	
	Outlet Relative humidity for IECHybrid Unit		085016	
			085015	
			085014	
Compressor power meter - IEC hybrid unit	Power consumptionof the Compressor of the IEC hybrid Unit	ENTES	---	
Pump power meter - IEC hybrid unit	Power consumptionof the Pump of the IEC hybrid Unit	ENTES	---	

Used Apparatus	Measured Property	Model	Serial Number	Item Photo
Evaporative Fan power meter - IEC hybrid unit	Power consumptionof the Evaporator Fan of the IEC hybrid Unit	ENTES	---	
Supply fan power meter - IEC hybrid unit	Power consumptionof the Supply Fan ofthe IEC hybrid Unit	ENTES	---	
Power Analyzer of total power consumption of IEC hybrid Unit	Total Input power of IEC Hybrid Unit	FLUKE	9340002	
Power Analyzer of total power consumption of IEC hybrid Unit	Total Input power of DX Unit	FLUKE	19673107	

Annex 4: Outreach Campaign

UNIDO

UN environment programme

NOU National Ozone Unit

Invitation to Outreach Campaign

DIRECT/INDIRECT EVAPORATIVE COOLING

TOGETHER, WE CAN SECURE PHASE OUT OF HCFC IN THE COMMERCIAL AIR CONDITIONING MANUFACTURING SECTOR.

GET INVOLVED TODAY AND MAKE A DIFFERENCE!

3 November 2024

HBRC - Cairo, Egypt

Info@hbrc.edu.eg www.hbrc.edu.eg 87 Tahrir st, Dokki, Giza

Program Outlines

(9:30 – 10:00 am)
Registration

(10:00 – 10:30 am)
Opening Session:

- Welcome & Open Remarks
  Prof. Mohamed Masoud - HBRC Chairman
  Prof. Ezzat Lewis - NOU
  Prof. Sayed Shebl

(10:30 –11:00 am)
Coffee Break

(11:00 am – 1:00 pm)

- Preview The Project Findings
  Prof. Alaa Olama
  Prof. Sayed Shebl
- Public Hearing Session

GUARANTEE YOUR LEAD.

Join us and contribute to an enlightened and collaborative spirit of sustainable ideas come to life.

Find Us!

+(20) 1065251505
87 Tahrir St., Dokki, Giza

Transformation of Commercial Air Conditioning Companies
HCFC Phase-out Management Plan (HPMP) EGYPT (Stage II), UNIDO ID:140400

Outreach Campaign

DIRECT/INDIRECT EVAPORATIVE COOLING

Presented by:

Prof. Alaa Olama;
The Project general Manager and Technical Consultant

Prof. Sayed Shebl;
Director of Electro-Mechanical Research Institute EMI, HBRC

وزارة الاسكان والمرافق والمجتمعات العمرانية
Ministry of Housing Utilities & Urban Communities

HBRC
المركز القومى لبحوث الإسكان والبناء
Housing and Building National Research Center

UNIDO

UN environment programme

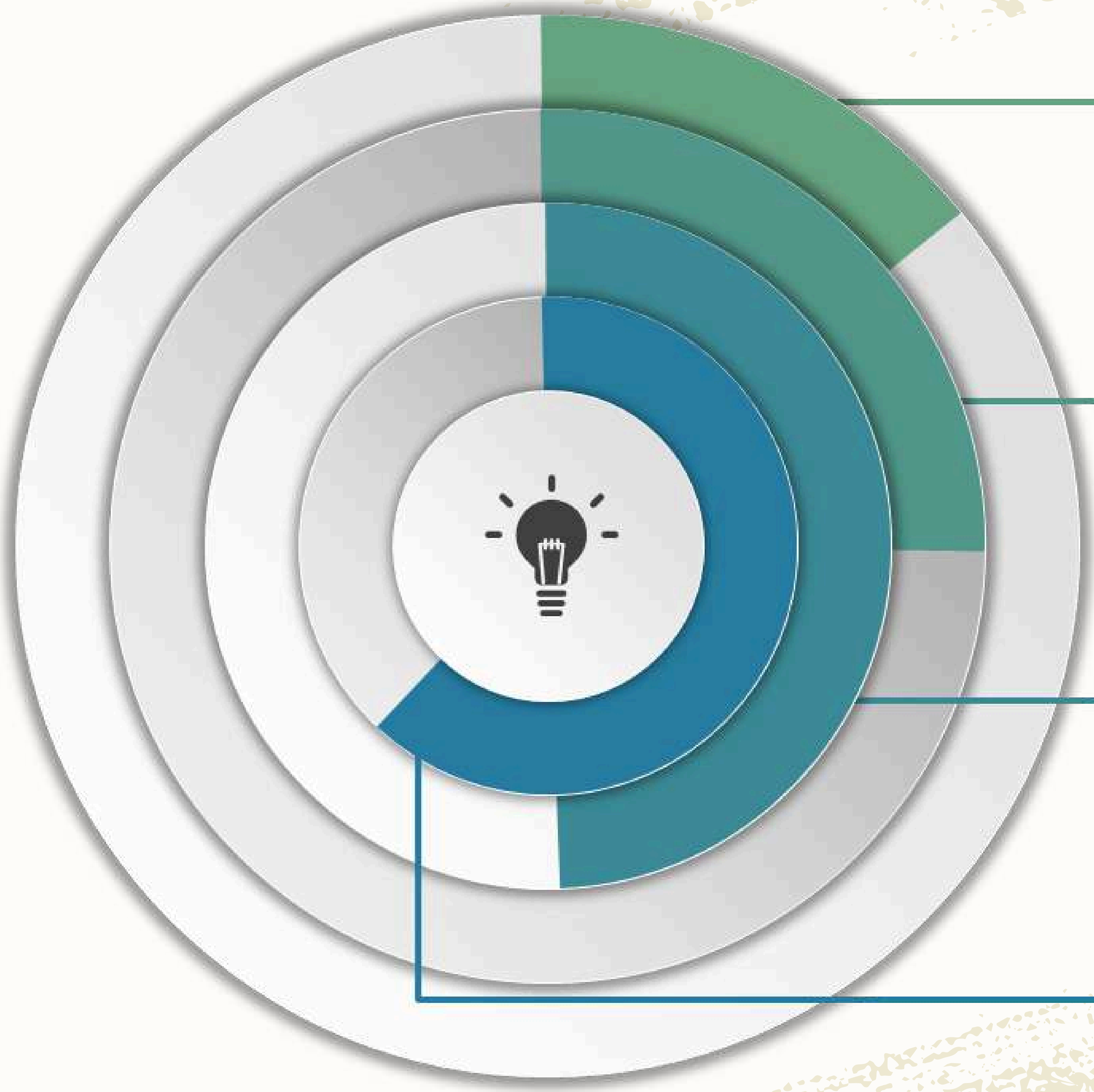
NOU
National Ozone Unit

OUR TEAM

Approval committee	
UNIDO & NOU	Steering Committee
UNEP	Advisor
EUROVENT	Provide a reference testing methodology for the IEC hybrid units suitable for Egypt's working conditions

OEMs	
Delta Construction & Manufacturing (DCM)	**TIBA Engineering Industries Co.**
SS Air Technology	**VOLTA EGYPT**

MILESTONES



- Phase-out of HCFC in the commercial air conditioning manufacturing sector.
- Incorporate IEC technology in existing systems
- Technical Assistance for product design
- Provide technical parameters obtained from field testing

PREVIOUS WORK

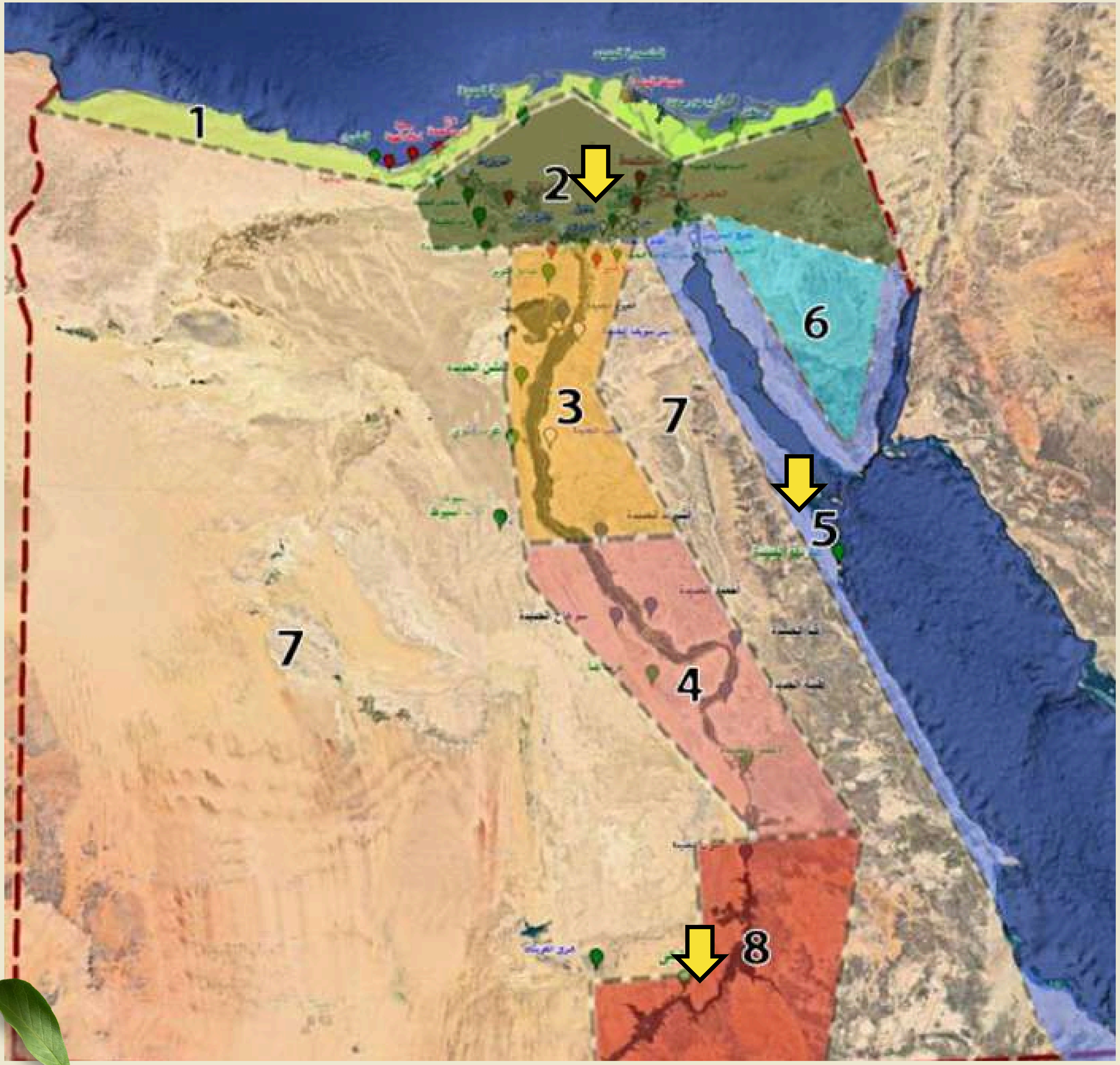
FOR ADOPTING THE NEW TECHNOLOGY

Which Climatic Zone?

Two climatic zones out of Eight representing Egypt

- ✔ Climatic Zone 2
- ✔ Climatic Zone 5

What about Climatic Zones 8?



TESTING LOCATION - CZ8 (ASWAN - TOSHKY)

Location

22°49' 02" N
31°28' 16" E

Altitude

196.07 m
(above sea level)

TESTING CONDITIONS

Full Fresh Air

Both units to be **full fresh air** with air discharge of one unit regulated so that it matches the other.

Compressor Size

Compressor size of IEC-H Unit left to each OEM to decide.

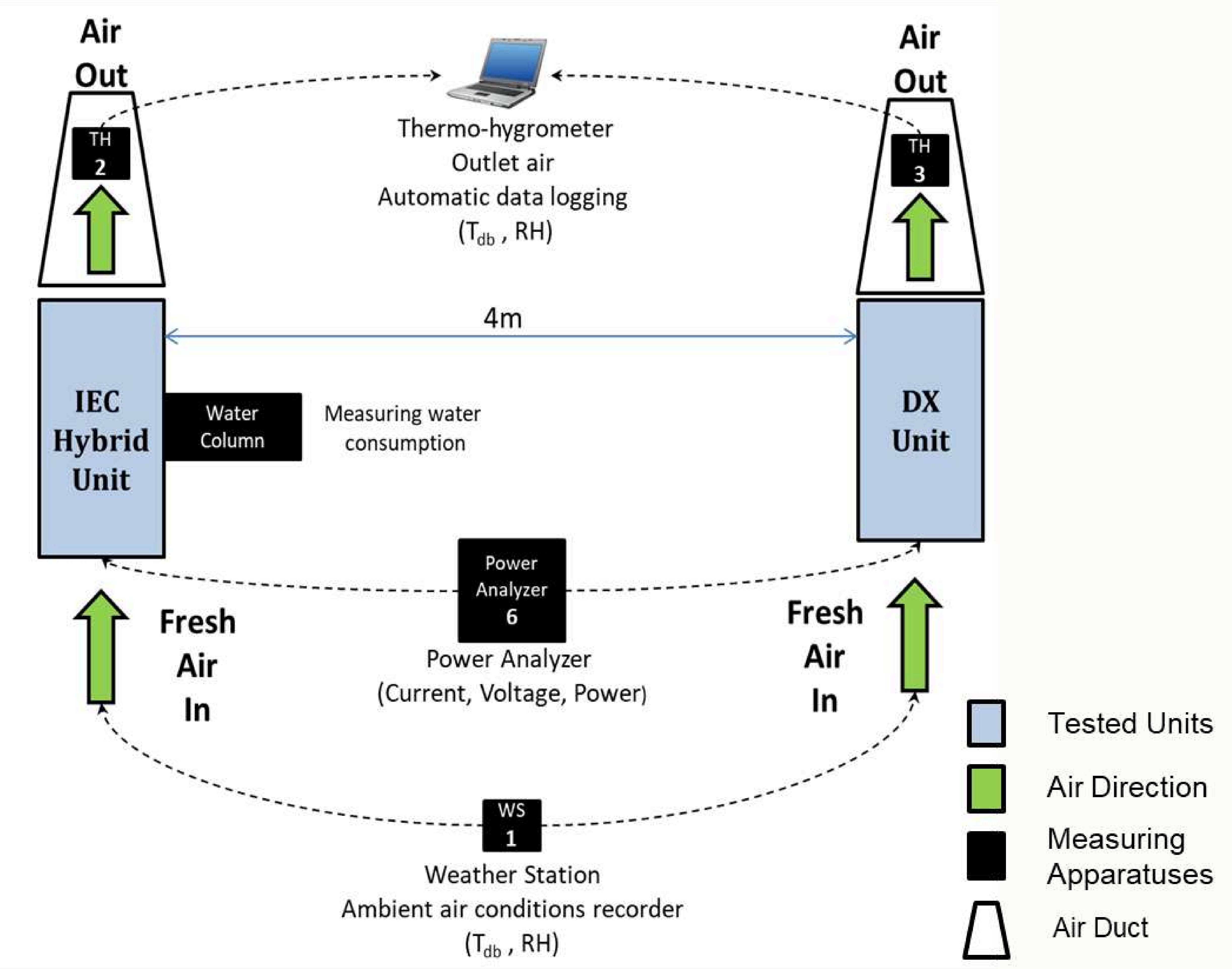
Primary Air Outlet

The primary air outlet dry bulb temperature maintained at 15°C

Low GWP refrigerant

Both units should use low GWP refrigerant, based on Montreal Protocol and Kigali Amendment

SCEMATIC DIAGRAM



THE PROJECT REQUIRED EACH OEM TO INDIVIDUALLY MANUFACTURE A CUSTOM-BUILT DIRECT/INDIRECT EVAPORATIVE COOLING HYBRID AIR CONDITIONER (IEC-H) PROTOTYPE AND A CENTRAL DX UNIT TO TEST AND COMPARE THEIR PERFORMANCES UNDER ACTUAL OPERATING CONDITIONS IN CLIMATIC ZONE 8 (CZ8) (ASWAN - TOSHKY).

USED EQUIPMENT

CALIBRATED HIGH ACCUARCY DEVICES ARE USED FOR MEASURMENTS

Ministry of Higher Education
& Scientific Research
National Institute of Standards

وزارة التعليم العالى والبحث العلمى
المعهد القومى للمعايرة

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CERTIFICATE OF CALIBRATION
شهادة معايرة

Certificate No:	882/23C012/74/326/2024

- NIS Lab : High Voltage Metrology Lab.
- Issued For : معهد بحوث الاعمال الكهروميكانيكية في المباني (مركز بحوث الاسكان والبناء)
- Contact Information of the Customer : العنوان : 87 شارع التحرير
- Location of Calibration : High Voltage Metrology Lab., NIS
- Device Description : POWER QUALITY AND ENERGY ANALYZER
  - Manufacturer : FLUKE
  - Model/Type : 435
  - Serial Number : 19673107 • Code : ----
- Date of Receipt : 9/5/2024 • Date of Calibration : 19/5/2024
- Issue Date : 22/5/2024 • Due Date : --------

Approved by

Head of Laboratory — Dr. Eng. Ahmed S. Haiba

NIS President — Prof. Dr. M. G. Ahmed

NIS-F-7.8.2

This certificate is issued in accordance with the laboratory accreditation requirements. It provides traceability of measurement to recognized National standards, and to the units of measurement realized at the NIS or other recognized national standards laboratories. This certificate May not be reproduced other than in full by photographic process. This certificate refers only to the particular item submitted for testing.

FIELD TEST

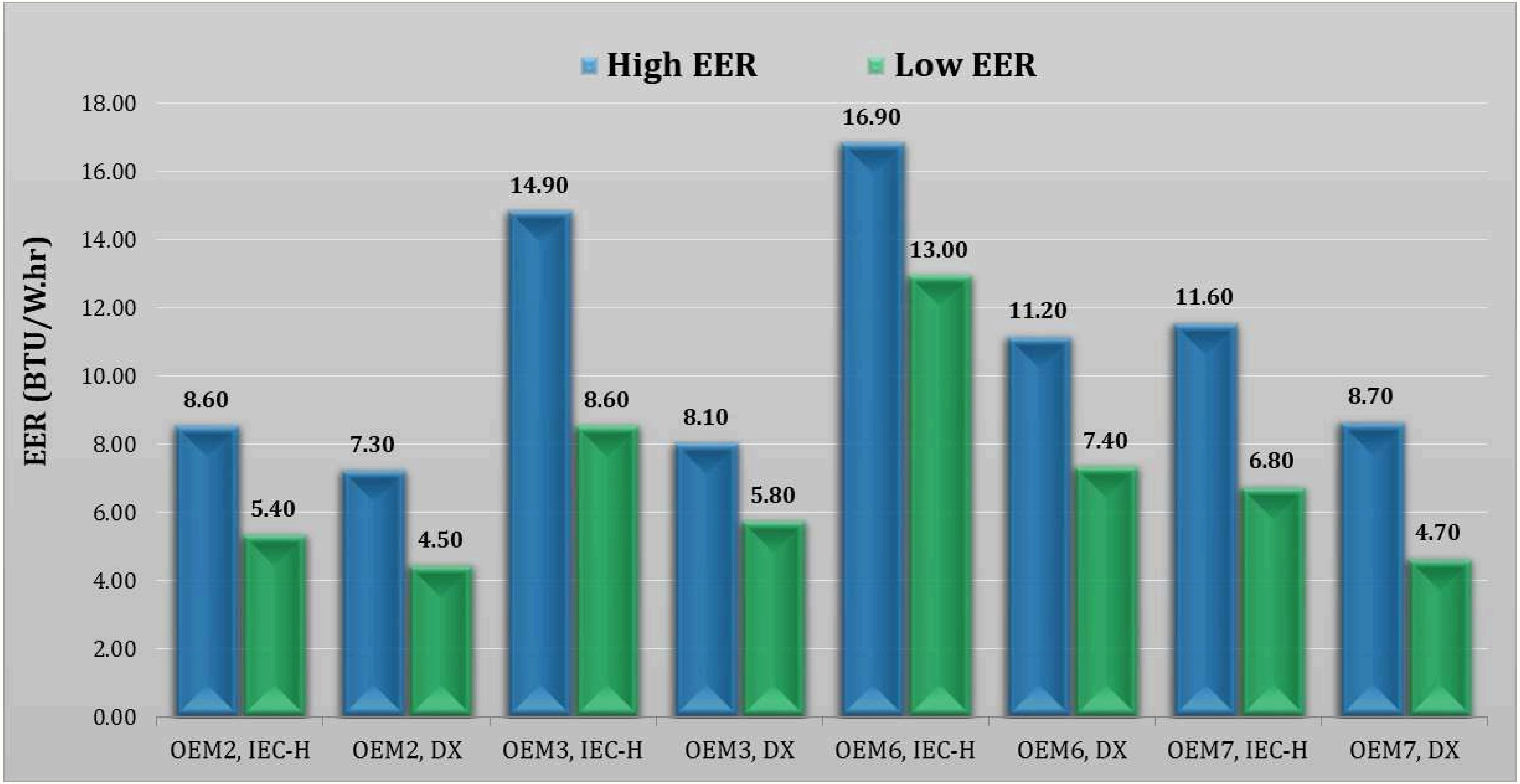
PROVIDE TECHNICAL PARAMETERS

Evaluate the performance

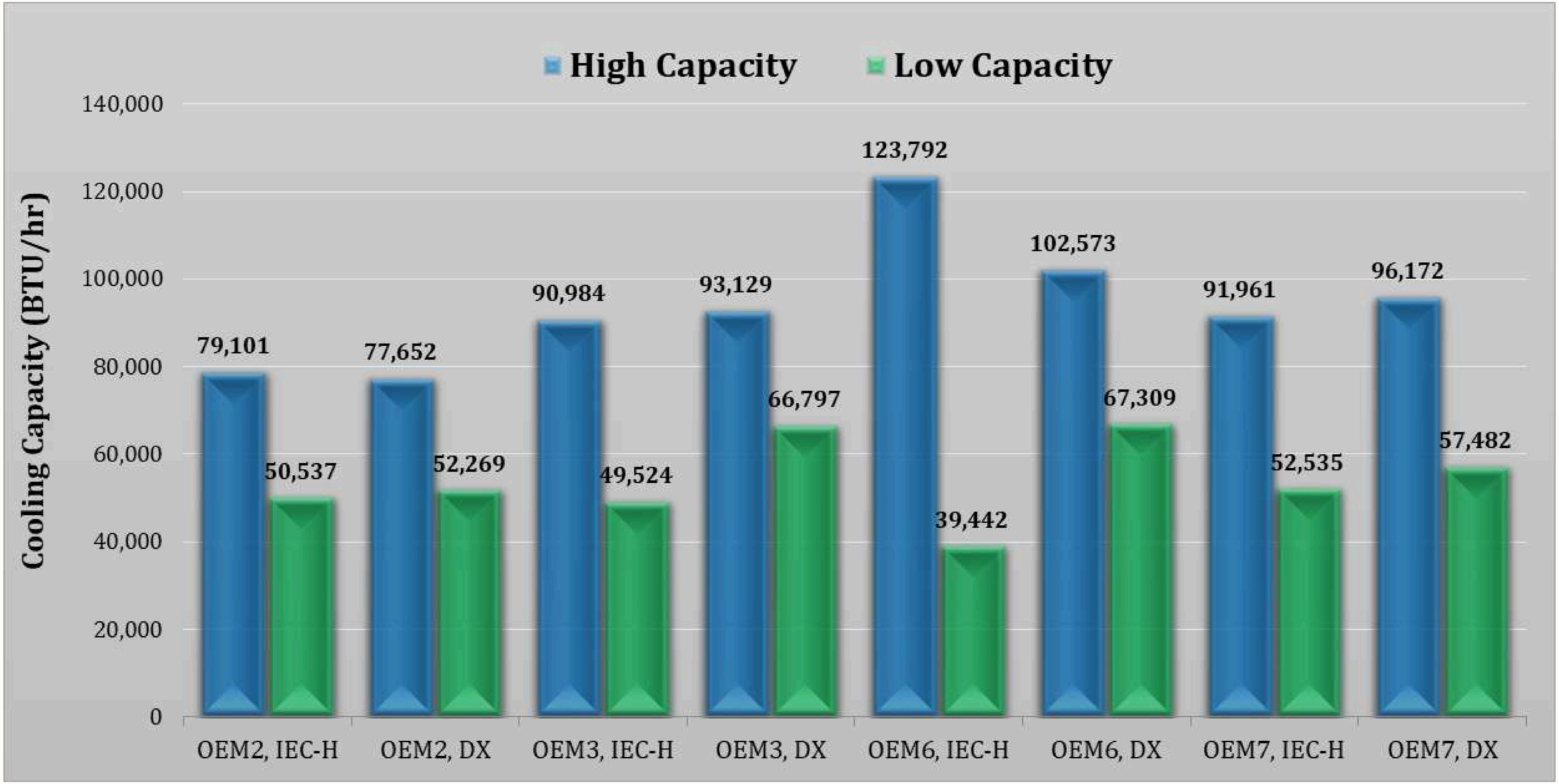
Compare DX Unit With IEC-H Unit at the Same operating conditions and record the measurements for 24 hours

- Energy Efficiency
- Total Cooling Capacity
- Operating Cost

TESTING RESULTS - EER



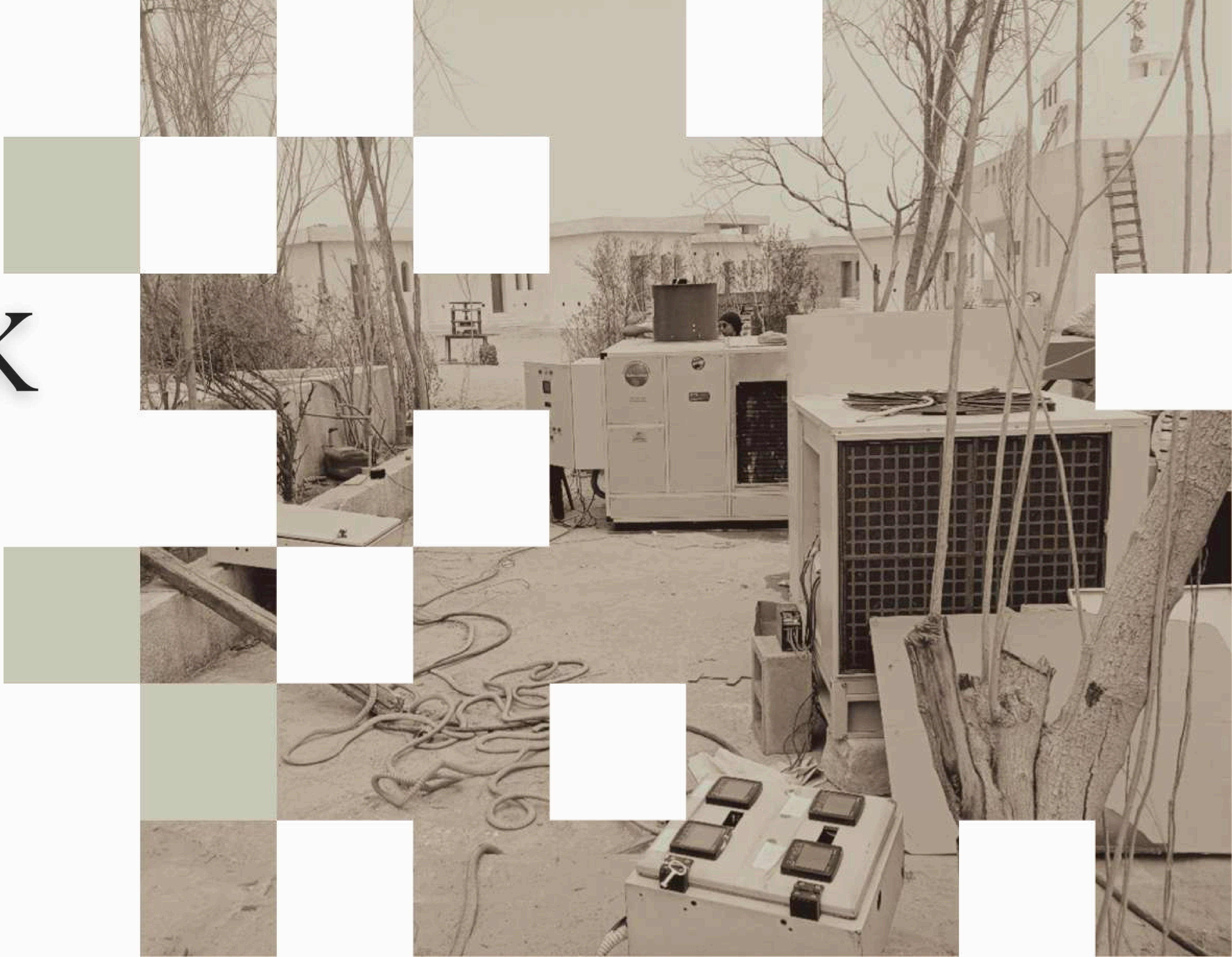
TESTING RESULTS - TOTAL COOLING CAPACITY



CONCLUSION

- All OEMs show EERs of the IEC-H units that are superior to corresponding DX units.
- IEC-H system is economically advantageous compared to a DX system
- Superior total cooling capacity of the IEC-H units despite the smaller capacity compressors used. The capacities of the IEC-H units.

THANK YOU

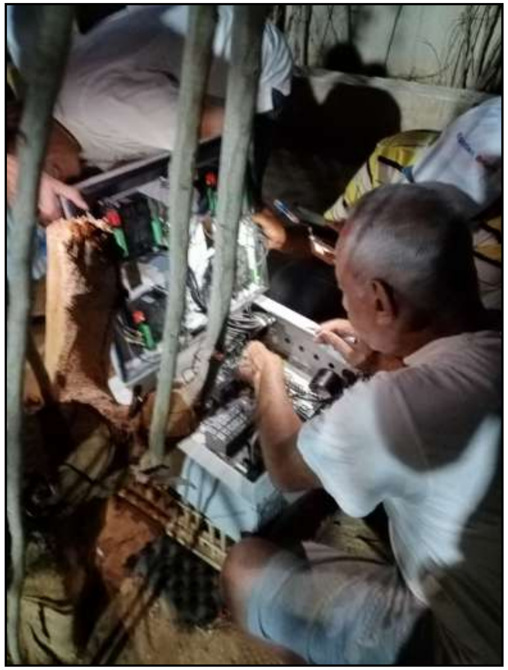


Annex 5: Testing Photos


CLIMA GREEN


POWER ON







Fan


Fan





Fan
Smart Fan technology


Fan
Smart Fan technology






TOYOTA

Technical Report for the Group Project for Transformation of Commercial Air Conditioning Companies (HCFC Phase-out Management Plan (HPMP) EGYPT (Stage II)), UNIDO ID:140400

2024

Climatic Zone 8

Report

Project supported by

MULTILATERAL FUND FOR THE IMPLEMENTATION OF THE MONTREAL PROTOCOL

UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANIZATION

UNITED NATIONS ENVIRONMENT

European Industry Association

By: Dr Alaa Olama

Disclaimer

While the information contained herein is believed to be accurate, it is of necessity presented in a summary and general fashion. The decision to implement one of the options presented in this document requires careful consideration of a wide range of situation-specific parameters, many of which may not be addressed by this document. Responsibility for this decision and all its resulting impacts rests exclusively with the individual or entity choosing to implement the option. UNIDO, UNEP, their consultants and the reviewers and their employees do not make any warranty or representation, either expressed or implied, with respect to the accuracy, completeness or utility of this document; nor do they assume any liability for events resulting from the use of, or reliance upon, any information, material or procedure described herein, including but not limited to any claims regarding health, safety, environmental effects, efficacy, performance, or cost made by the source of information.

Acknowledgement

We would like to acknowledge the assistance given by the governmental sectors and the National Ozone Unit Officers of Egypt and the National Housing & Building National Research Center (HBRC) for their support in the implementation of the project and their assistance in facilitating communication with different stakeholders.

We also acknowledge the International Technical Review Team "EUROPEAN INDUSTRY ASSOCIATION Eurovent" that assist the project team in reviewing the process, results and report of the project.

Acknowledgement also goes particularly to HBRC for providing the testing yard, facilities (Electrical feeding, water supply … etc.) and other logistic facilities at their installation in Toshka.

The project team also acknowledges the OEM manufacturers who built the IEC-H prototypes and DX systems to be tested at the location.

- Delta Construction & Manufacturing DCM
- TIBA Engineering Industries Co.
- VOLTA EGYPT
- SS Air

Acknowledgement also goes to the team's technicians, technical assistance staff and drivers that assisted in the project successful completion in this remote location.

This Project is contracted between the UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANIZATION "UNIDO" and Housing & Building National Research Center “HBRC”. WHEREAS, UNIDO has been designated by the MULTILATERAL FUND FOR THE IMPLEMENTATION OF THE MONTREAL PROTOCOL as
IMPLEMENTING AGENCY; and has agreed to provide assistance to the Egyptian Government in carrying out the project entitled “HCFC PHASE-OUT MANAGEMENT PLAN (HPMP) EGYPT (STAGE II)”

The National Ozone Unit – Ministry of Environment, Egypt: The ministry team provided guidance and direction and participated at project meetings and discussions. The project is funded by the HCFC Phase-out Management Plan (HPMP) of Egypt.

The Project Management: UNIDO and UN Environment provided overall management and coordination of the project, established the link with the technology providers, and oversaw the development of the report of the project. The Project was managed by **Mr. Ole Nielsen, Dr. Iino Fukuya**, Program Officer- UNIDO, **Dr. Yunrui Zhou** also program officer-UNIDO and **Eng. Ayman El-Talouny**, International Partnership Coordinator, Ozone Action Program – UN Environment

EUROVENT (European Industry Association): Due to the absence of local testing standard or guidelines for IEC applications, the service of an International Advisory Partner was needed to offer recommendations, testing reference and quality review of the testing process.

“Eurovent AISBL / IVZW / INPA. (2023). Eurovent 15/1 - 2023 — Hybrid Indirect Evaporative Cooling Equipment - Classification Requirements and Test Conditions. Brussels: Eurovent.”

Ms. Viktorria Kotlubei and the Coordination Consultant **Eng. Ahmed El-Korashy** from UNIDO provided logistical support and coordination for the project.

The Project general Manager and Technical Consultant and writer of the report, Dr. Alaa Olama advisedOEMs during prototype design and construction. Devised testing methodology and testing TOR, consultedwith OEMs to provide technical solutions for problems as they arose wrote the report and provided analysis of data.

HBRC organized testing including testing results in both climatic zones, tabulated and created the excel sheets including figures, drawings and review and edit their report.

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List of Figures

List of Tables

Acronyms

HPMP	HCFC Phase-out Management Plan
IEC-H	Indirect Evaporative Cooling - Hybrid
DX	Direct Expansion
CZ	Climatic Zone
GWP	Global Warming Potential
NPV	Net Present Value
EFLH	Equivalent Full Load Hours Per Year
EER	Energy Efficiency Ratio
COP	Coefficient of Performance
IRR	The internal rate of return
EGP	Egyptian Pound
$T_{db\ amb}$	Ambient dry bulb temperature for both Units
$T_{wb\ amb}$	Ambient wet bulb temperature for both Units
RH_{amb}	Ambient Relative Humidity for both Units
$T_{db\ out}$ IEC-H	Outlet dry bulb temperature for IEC Hybrid Unit
$T_{wb\ out}$ IEC-H	Outlet wet bulb temperature for IEC Hybrid Unit
RH_{out} IEC-H	Outlet Relative Humidity for IEC Hybrid Unit
W_{Lvl} IEC-H	Water level change for IEC Hybrid Unit per hour
W_{Vol} IEC-H	Evaporated Water Consumed for IEC Hybrid Unit per hour (Volumetric Flow Rate)
Comp. IEC-H	Compressor power consumption for IEC Hybrid Unit
Pump IEC-H	Pump consumption for IEC Hybrid Unit
Evap. Fan IEC-H	Evaporative Fan consumption for IEC Hybrid Unit
Sup. Fan IEC-H	Supply Fan consumption for IEC Hybrid Unit
Pw_{Tot} IEC-H	Total Power consumption for IEC Hybrid Unit
$T_{db\ out}$ DX	Outlet dry bulb temperature for DX Unit
$T_{wb\ out}$ DX	Outlet wet bulb temperature for DX Unit
RH_{out} DX	Outlet relative humidity for DX Unit
Pw_{Tot} DX	Total Power consumption for DX Unit
h_{amb}	Enthalpy of Ambient inlet Air
h_{out} DX	Enthalpy of outlet Air for DX Unit
h_{out} IEC-H	Enthalpy of outlet Air for IEC Hybrid Unit
ρ_{amb}	Density of Ambient Air

Executive Summary:

This Project is contracted to provide assistance to the Egyptian Government in carrying out the project entitled "HCFC PHASE-OUT MANAGEMENT PLAN (HPMP) EGYPT (STAGE II)"

The project required each OEMs to individually manufacture a custom-built Indirect Evaporative Cooling Hybrid Air Conditioner (IEC-H) prototypes and a central DX unit to test and compare their performances under actual operating conditions in three of the eight climatic zones (CZ) of Egypt.

The final report of 2022 showed the results of the tests in CZ 2 and 5. This report shows the results of the test in CZ 8, the hottest of all climatic zones in Egypt.

The four figures below show the results of OEM 3 only in the CZ 8. The figures belowshow the comparisons of the performance between the IEC-H unit and the DX unit over a 24 hours period.The tests results compared the values of the dry bulb temperatures out of the IEC-H and the DX unit, the wet bulb temperatures, the EERs and the unit's refrigeration capacity. The tests were conducted for each OEM's IEC-H and DX units simultaneously for a 24 hours period.

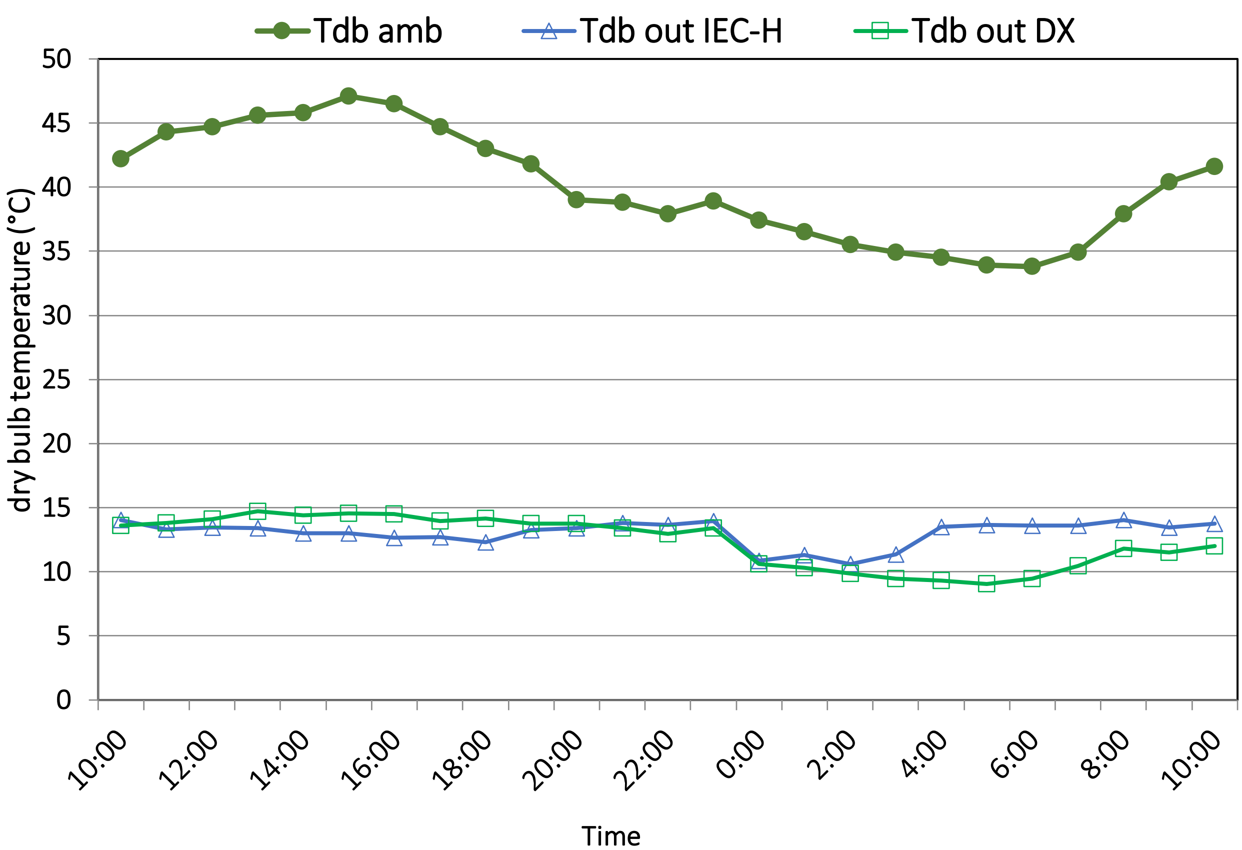


Fig. 1. Inlet Ambient Temperature Versus Outlet Temperature of IEC Hybrid and DX units, OEM 3 - CZ 8

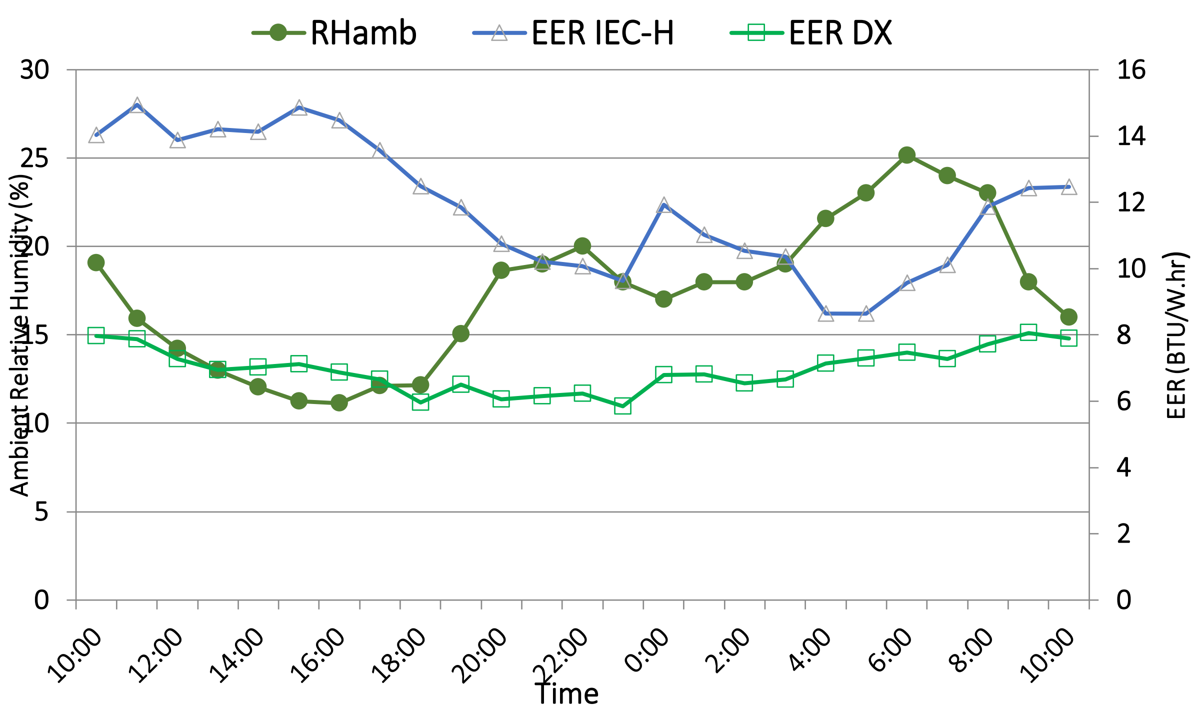


Fig. 2. EER for IEC Hybrid Unit & DX Unit Versus Ambient Relative Humidity - OEM 3- CZ 8

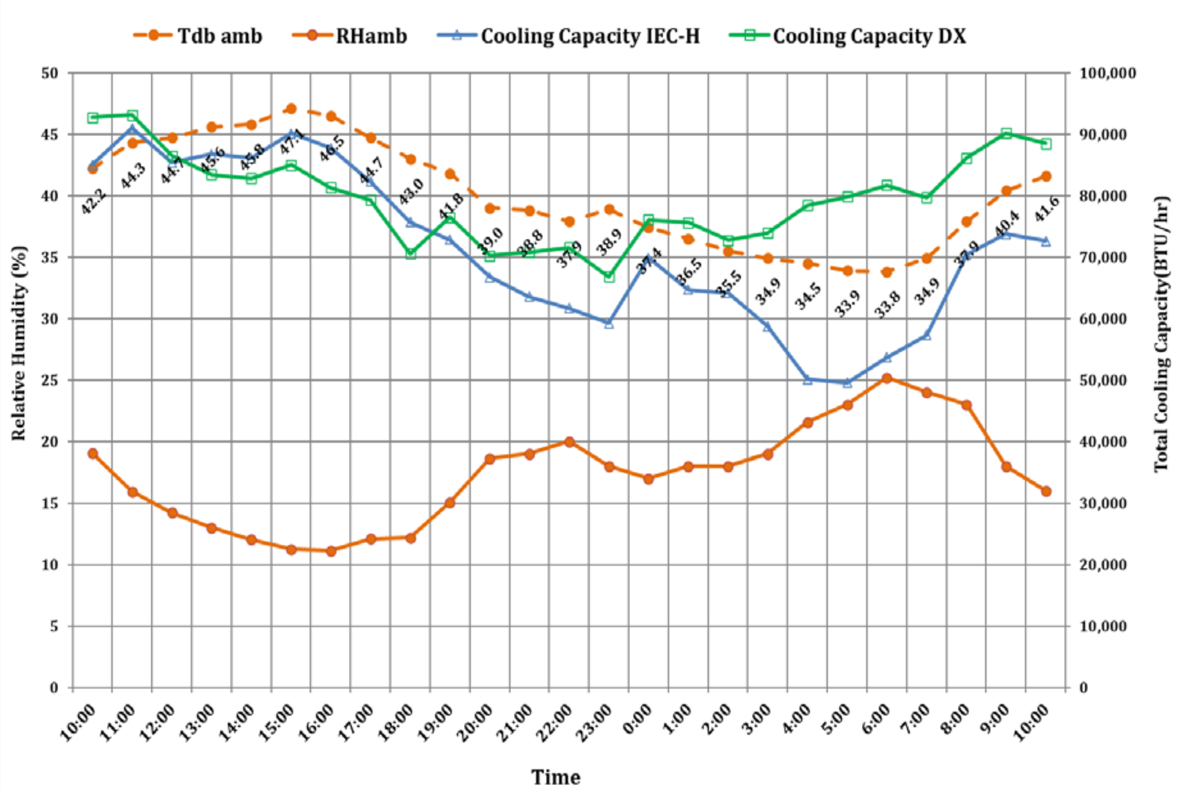


Fig. 3. Cooling Capacity for IEC Hybrid Unit & DX Unit Versus Ambient Conditions OEM 3- CZ 8

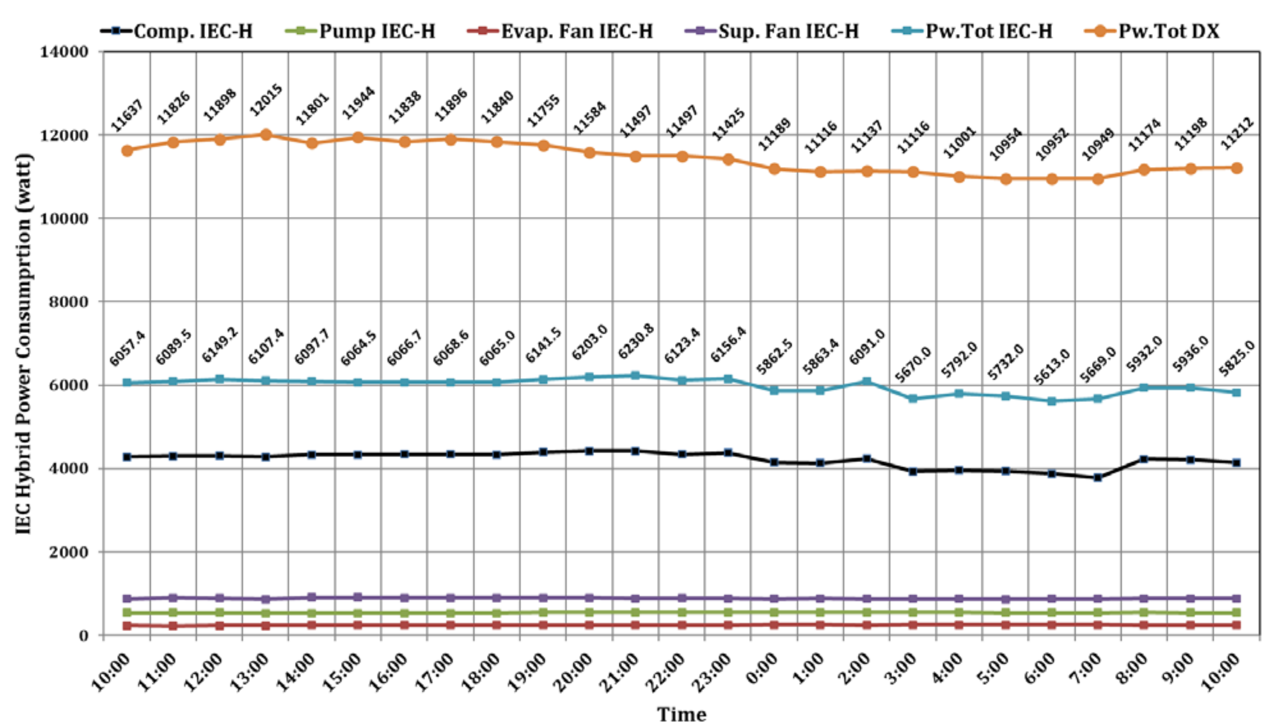


Fig. 4. Power Consumption of DX Unit and IEC Hybrid Unit Components
OEM 3- CZ 8

All OEMs results showed better EER for their IEC-H units compared to their respective DX unit in the CZ 8 where the tests were conducted. The highest and lowest EERs of all OEMs are shown below.

In that sense, this report for CZ 8 showed that an IEC-H system is superior thermodynamically to a DX system because it achieves higher EERs.

Fig 17: High and Low EER (in BTU/W.hr) for Climatic Zone 8

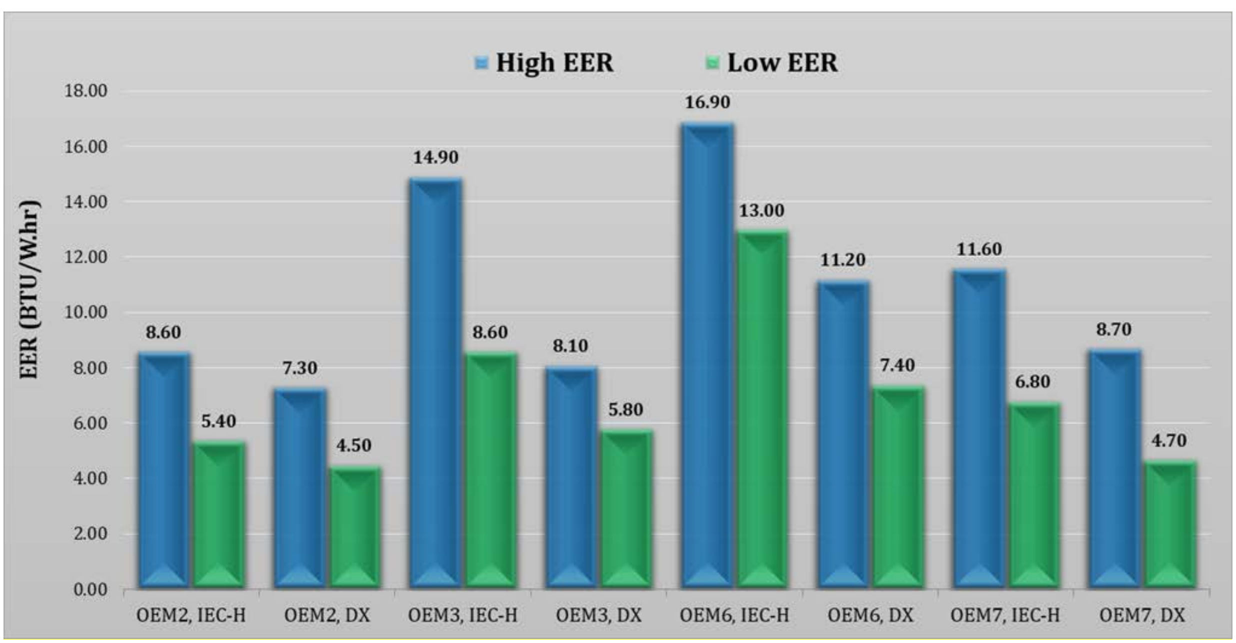
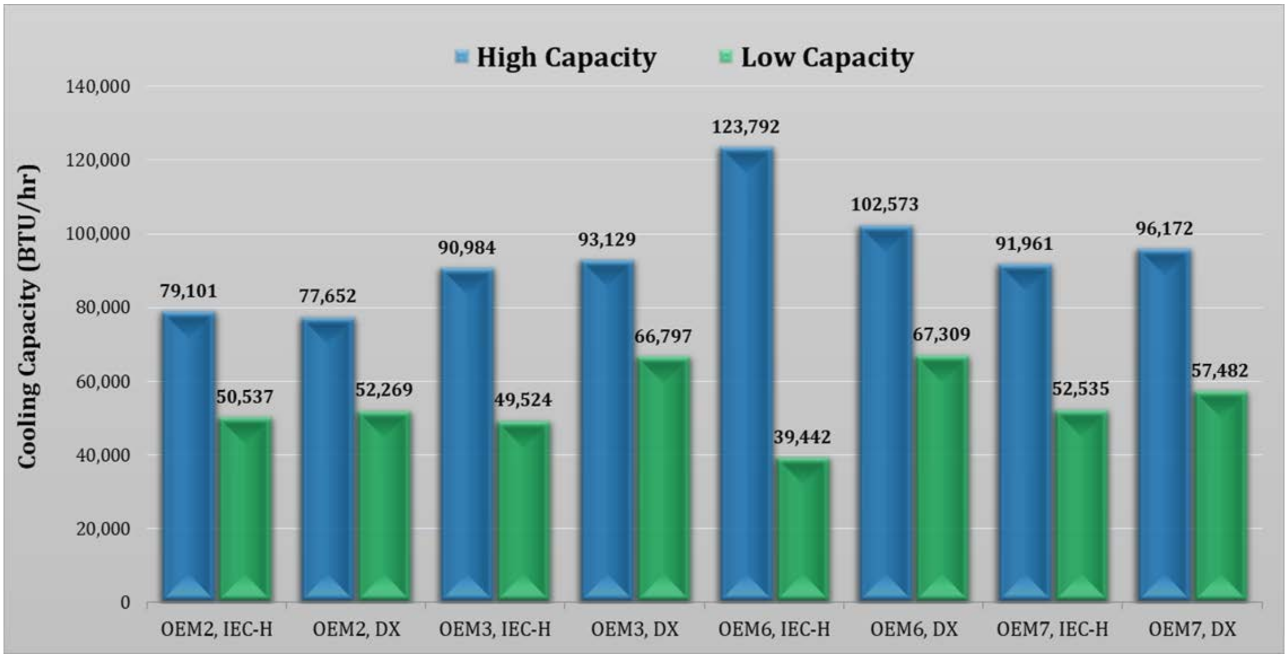


Fig 18: High and Low Capacity (in W) for Climatic Zone 8



The primary air discharge of both the IEC-H prototype and DX units for each OEM were the same and all fresh air. All compressors' capacities of all OEMs were also the same for IEC-H prototypes and DX units, except OEM 2 which used two compressors for its IEC-H prototype instead of one for all other OEMs.

The tests showed that the capacity of the IEC-H prototypes when compared to the refrigeration capacity of their respective DX unit also varied considerably, depending on the prototype design and the ambient relative humidity.

When the ambient relative humidity increased, the DX units tended to provide a better refrigeration capacity then corresponding IEC-H prototype, except OEM 2 which showed superior refrigeration capacity compared to the DX unit regardless of the relative humidity conditions.

Nevertheless, overall IEC-H refrigeration capacities at lower humidity periods, where higher than those of corresponding DX units.

The report breaks new ground for NIK air conditioning technologies and provides an alternative full fresh air system for air conditioning application that exceeds the efficiency of existing DX systems.

Although, both final reports for CZ 2 & 5 (2022) and this report for CZ 8 (2024) are sufficient to write guidelines for a code for direct/indirect evaporative cooling for Egypt, the report recommends further work to provide a mathematical formula and site testing to predict the EERs and refrigeration capacities for IEC-H prototypes for the remaining five climatic zones of Egypt, and substantiate the formula readings in other Climatic Zones of Egypt through site tests.

Chapter 1

1. Testing and Measurements of the Prototypes and DX units of all OEMs in Location CZ 8

1.1. Selection of CZ 8

Table 1: The Climatic Zones of Egypt

1	**North Coast Region**	**5**	**Eastern Coast Region**
2	**Delta and Cairo region**	**6**	**High Heights Region**
3	**North Upper Egypt Region**	**7**	**Desert Region**
4	**Southern Upper Egypt Region**	**8**	**South of Egypt Region**

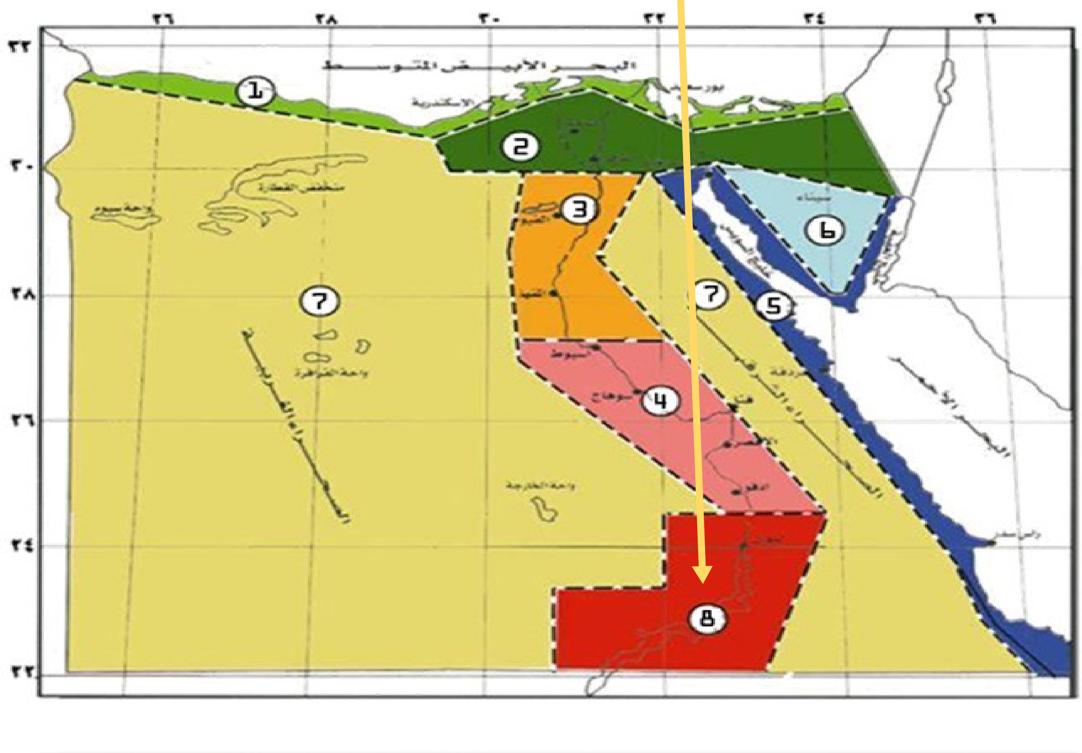


Fig 0: The eight Climatic Zones of Egypt

Ambient temperatures in Egypt's are at their highest during June, July and August. This is why these months were targeted for the tests.

The tests were performed in CZ 8 to show the effect of dry bulb temperature increaseversus relative humidity decrease on the efficiency and capacity of the prototypes at the hottest climatic zone in Egypt to complement tests made at CZ2 and CZ 5 in 2022. He results in these tests in CZ 8 would complement those done in CZ 2 and 5. With the tests in CZ 8 the viability of an IEC-H system in lower humidity/higher ambient climates when compared to a DX system.

Figure 0 shows the different climatic zones of Egypt. CZ 2 encompass the capital Cairoand its suburban cities across its latitude in the span west in the lower delta south of Alexandria's longitude and east across the Sinai Peninsula. CZ 2 would be generally characterized by its relatively higher humidity because it is in the lower delta with its extensive population clusters and its large agriculture fields. Tests in CZ 2 were performed at Badr city.

CZ 5 is the eco-climatic zone around the shores of the red sea from Suez in the north to Halayeb and Shalatein in the south and across south Sinai on the banks of the gulfs of Suez and Aqaba. Its dry bulb temperatures are moderate compared to further south in Egypt.

CZ 5 is characterized by its higher dry bulb temperatures compared to CZ 2 and its lower humidity. Tests were performed in Hurghada city in CZ 5.

Comparison between the results in these two climatic zones would indicate the feasibility of the IEC-H system compared to a DX system as the dry bulb increases and the humidity decreases.

CZ 8, is the hottest in Egypt with relatively lower humidity ratios compared to other climatic zones.

This is why testing in CZ 8 would complement the tests in CZ 2 & 5 done in 2022.

1.2. How the Tests were Performed?

Each OEM tested two of his units in the same 24 hours, one IEC-H prototype next to one DX unit.
Both units tested were full fresh air and had the same air flow rate.
All OEMs used R-32 for both their IEC-H prototype and their corresponding DX unit.

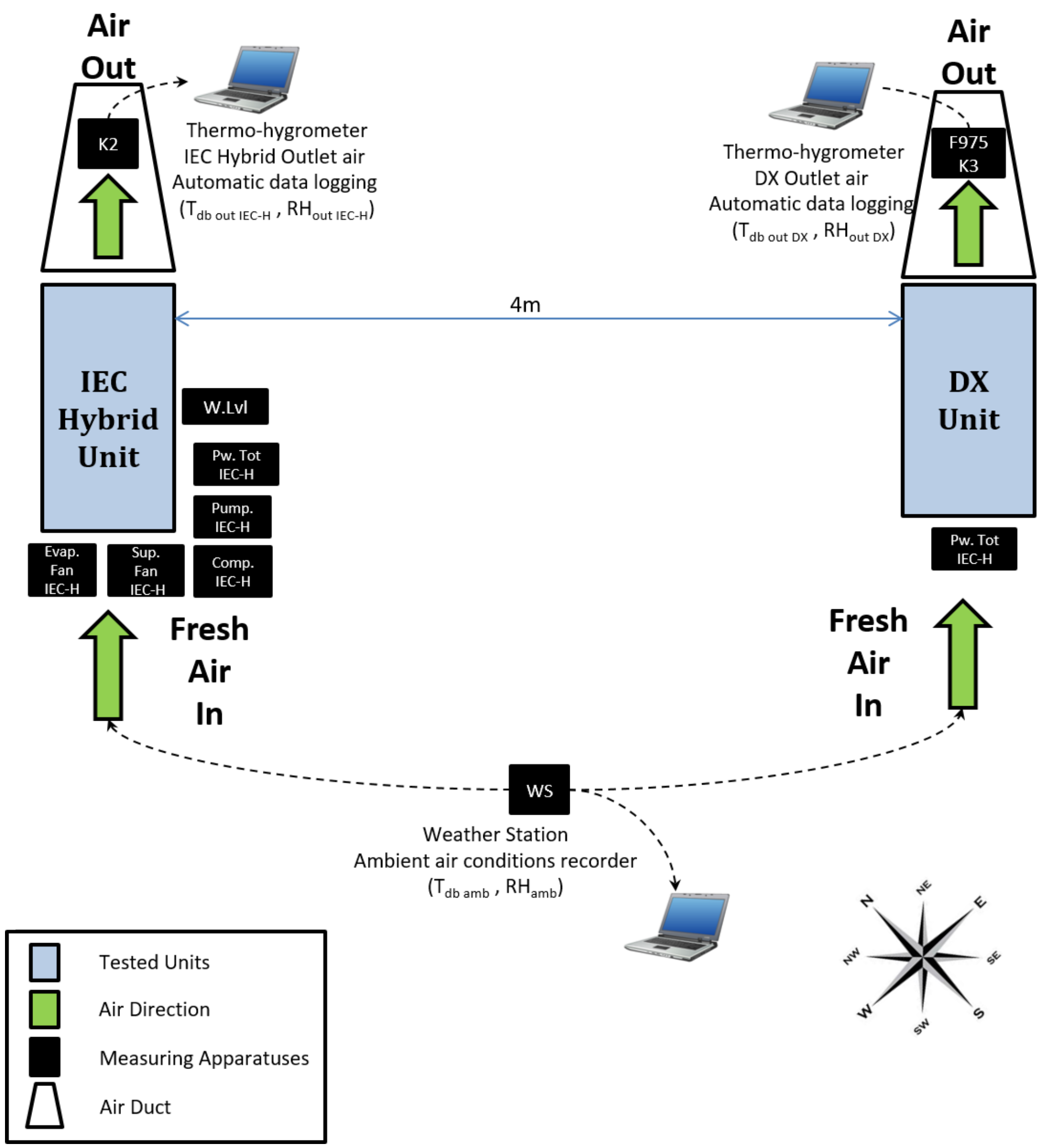
1.3. The Testing Methodology

This is a brief description of the testing methodology. The complete testing methodology is shown in **annex 3** of the final report of 2022. the testing methodology follows EUROVENT recommendations*

- There were no intentions to compare the performance of OEMs units, one against the other. This is why OEMs are labelled by a confidential number and not by their original name.
- The purpose of the tests is to find out if there are energy efficiency advantages obtained by adopting a hybrid IEC system, IEC-H, when compared to a DX or chilled water system for climatic CZ 8.
- Both IEC-H prototype and DX unit are tested simultaneously. Both units are full fresh air with rate of air discharge of one unit regulated so that it matches the other.
- To maintain 15 °C primary air outlet dry bulb temperature.
- For each OEM, testing was performed over a 24hr period for both units simultaneously.
- The tests performed for all OEMs, one after the other.
- The tests were considered completed once a 24 hours' cycle is recorded for both IEC hybrid and DX units. If any of the units stopped working during the test or suffered a performance anomaly such as freezing of the cooling coil the test result at this specific point were discarded.
- The tests meteorological readings were recorded.
- The tests were performed to obtain the total refrigeration capacities (Watts) and the energy efficiency ratio (BTU/W.hr) of both IEC-H and the DX unit for each OEM simultaneously and compare theresults over a 24 hours' period; see the Egyptian standard EOS 3795:2013.
- In this report, the test values are plotted and analyzed to help obtaining a definite understanding of the advantages of the system at various climatic zones.
- An economic comparison is made by an economic expert to compare the Net Present Value (NPV) of the IEC-H to a DX unit over its lifetime to check its economic feasibility for CZ 2 and 5 only.
- Figure 00 shows the Schematic Diagram of the Test Arrangement with Instrumentation.

* **"Eurovent AISBL / IVZW / INPA. (2023). Eurovent 15/1 - 2023 — Hybrid Indirect Evaporative Cooling Equipment - Classification Requirements and Test Conditions. Brussels: Eurovent."**

Fig 00: Schematic Diagram of the Test Arrangement with Instrumentation



Chapter 2

Tabulation Formats for Compiling and Presenting the Results of the Project (CZ 8)

The results obtained were tabulated in excel sheets tabs as follows:

- Basic information
- Graphs of capacities and EERs for IEC-H
- Graphs of capacities and EERs for DX

The tabs of the calculations of capacities and EERs for IEC-H units were used to plot the essential graphs.
The graphs show the following:

- The ambient dry bulb temperature and the outlet dry bulb temperatures of the IEC-H and the DX units across a whole day
- The EERs of both the IEC-H and the DX units and ambient RH across a whole day.
- The cooling capacities of the IEC-H and DX unit and the ambient dry bulb temperature and RH across a whole day
- The power consumptions of the DX unit and the IEC-H unit and its components.This was repeated for each OEM in CZ 8.

These graphs were used in calculating the highs and lows of each parameter that follows each OEM.
The final analysis, conclusions and recommendations for future work, in chapter 4 and 5 are derived from the results obtained and drawn from the graphs of chapter 3.
All tabulated excel sheets are made by HBRC and included HBRC final report.
HBRC were instrumental in setting-up the test site and testing rigs. They also collected the readings of the tests, tabulated the results and helped tremendously on the drawing process to obtain the best indicative graphs.

Chapter 3

Analysis of Testing Results and Measurements for the Prototypes and DX Units.

The testing results and measurements for the prototypes and DX units provide us with figures that show us if an IEC-H system is technically advantageous compared to a DX system. The testing results and measurements for all OEMs are listed in details in Annex.

3.1 OEM 3, Climatic Zone 8

Table 2: Basic Information for OEM3 at Climatic Zone 8

Basic Information

Tested Units Name	DX (Direct Expansion Unit)		
	IEC Hybrid (Indirect Evaporative Cooling Hybrid Unit)		
OEM No.	3		
Refrigerant	R-32		
Air Flow Rate	1320 C.F.M for DX and IEC hybrid Units		
Capacity	DX	2	Two compressors
	IEC hybrid	1	One compressor
Water Bath Area	1728.5*623		mm2
Climatic Zone	8 (South Egypt)		
Altitude	196.07 meter (From Sea Level)		
Location	22°49' 02" N 31°28' 16" E		
Test Date	28-Aug-24		

The figures below show the following

For OEM 3 in CZ 8, across a whole day:

- Figure 1: The ambient dry bulb temperature and the outlet dry bulb temperatures of the IEC-H and the DX units.
- Figure 2: The EERs of both the IEC-H and the DX units and ambient RH.
- Figure 3: The refrigeration capacity of the IEC-H and DX unit and the ambient dry bulb temperatureand RH.
- Figure 4: The power consumptions of the DX unit and the IEC-H unit and its components.

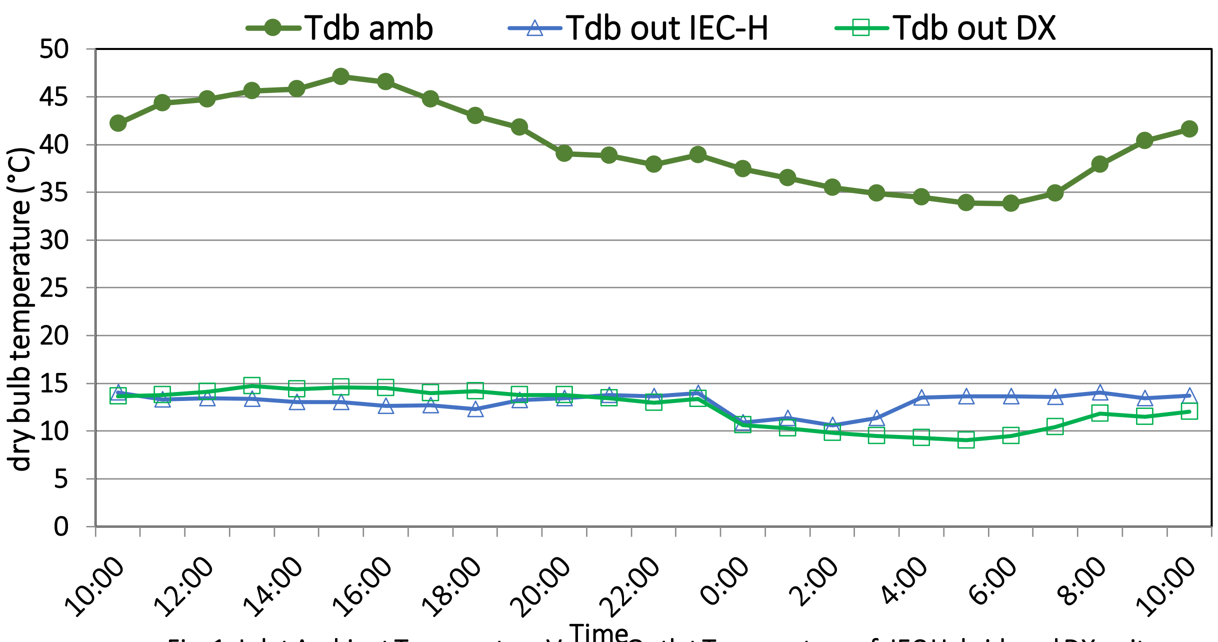


Fig. 1. Inlet Ambient Temperature Versus Outlet Temperature of IEC Hybrid and DX units, OEM 3- CZ 8

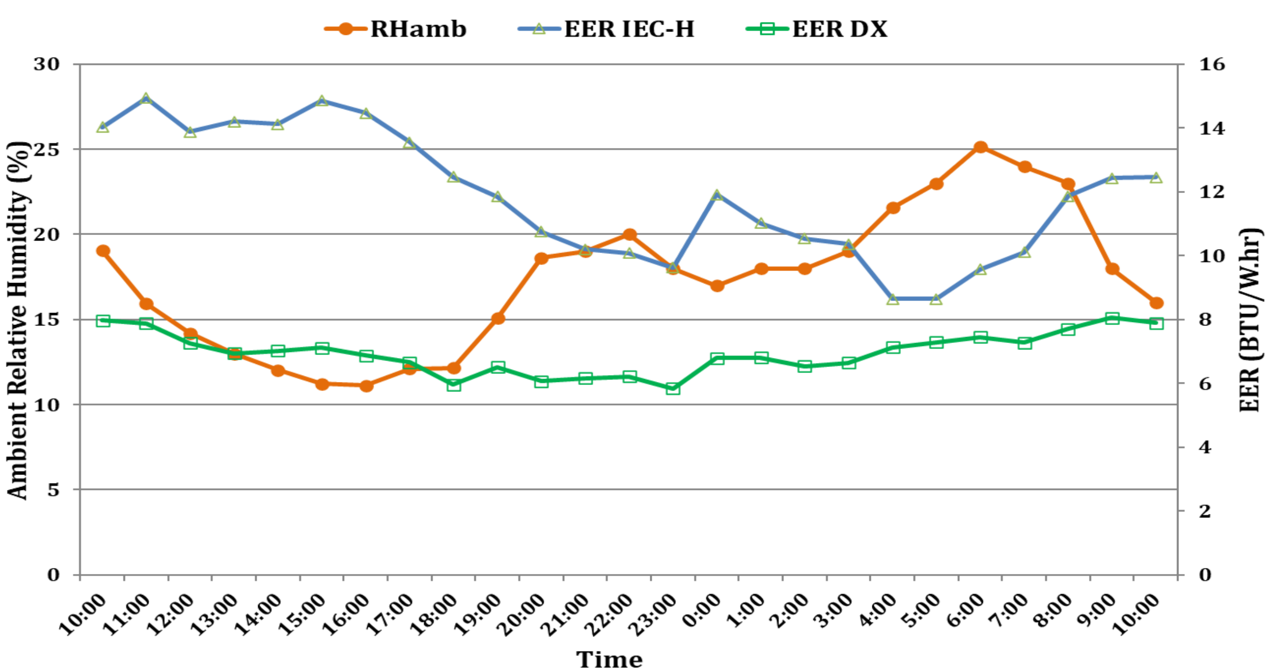


Fig. 2. EER for IEC Hybrid Unit & DX Unit Versus Ambient Relative Humidity OEM 3- CZ 8

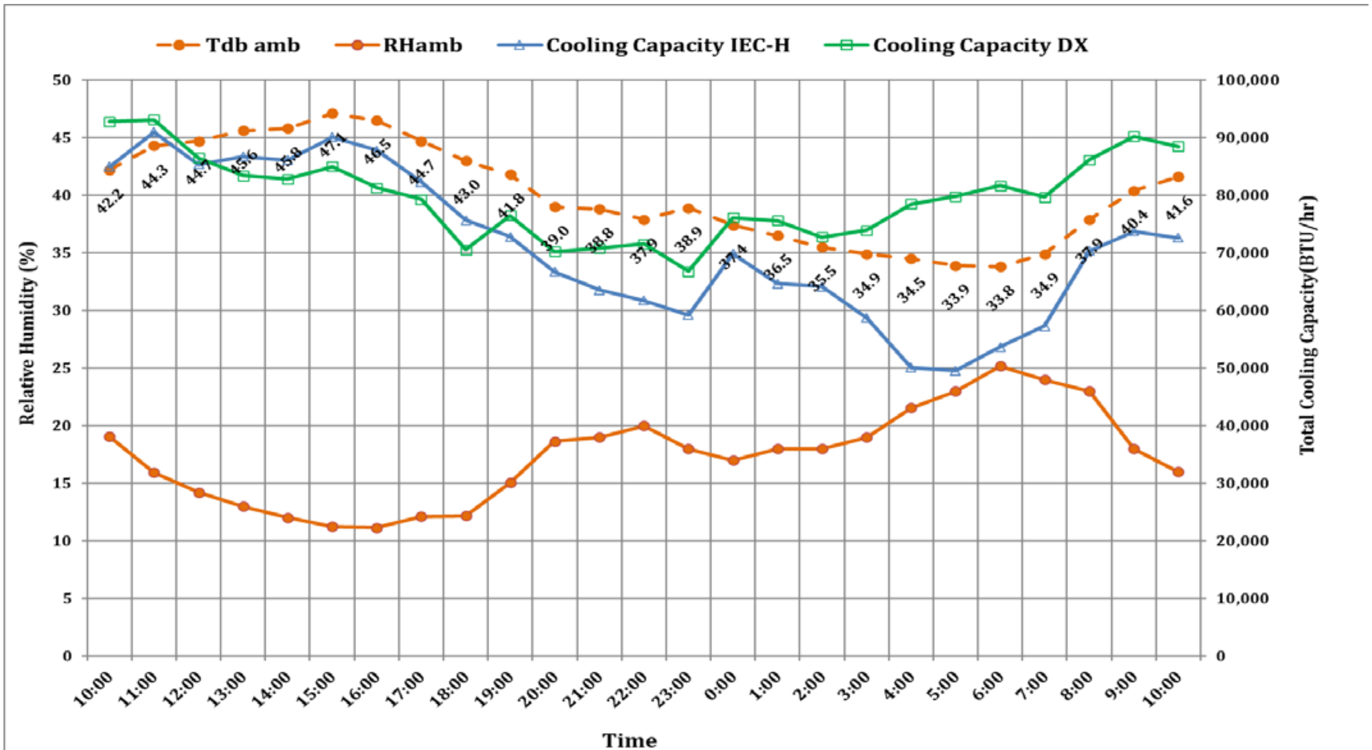


Fig. 3. Cooling Capacity for IEC Hybrid Unit & DX Unit Versus Ambient Conditions
OEM 3- CZ 8

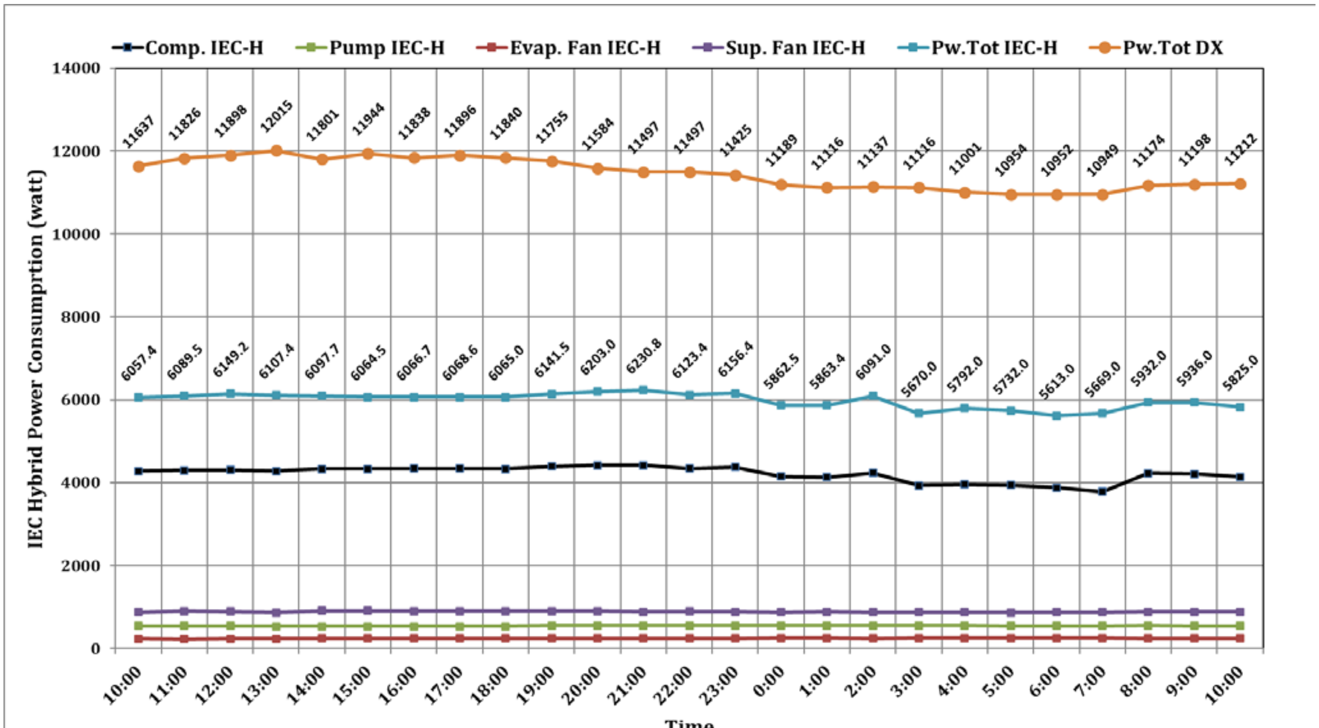


Fig. 4. Power Consumption of DX Unit and IEC Hybrid Unit Components
OEM 3- CZ 8

Analysis of the results of OEM 3 at CZ 8:

Table 3: High and Low readings for OEM3 at Climatic Zone 8

OEM 3, CZ 8				
High and Low Dry Bulb Temp. ℃, Relative humidity				
H and l	$T_{db\ out}$ IEC-H	$T_{db\ out}$ DX	RH_{amb}	$T_{db\ amb}$
High	14.0	14.7	24.0	47.1
Low	10.6	9.1	11.1	33.8

3.2 OEM 2, Climatic Zone 8

Basic Information

Table 4: Basic Information for OEM2 at Climatic Zone 8

Tested Units Name	DX (Direct Expansion Unit)		
	IEC Hybrid (Indirect Evaporative Cooling Hybrid Unit)		
OEM No.	2		
Refrigerant	R-32		
Air Flow Rate	1320 C.F.M for DX and IEC hybrid Units		
Capacity	DX	2	compressors
	IEC hybrid	2	compressors
Water Bath Area	1000*900		mm2
Climatic Zone	8 (South Egypt)		
Altitude	196.07 meter (From Sea Level)		
Location	22°49' 02" N 31°28' 16" E		
Test Date	26-Aug-24		

The figures below show the following

For OEM 2 in CZ 8, across a whole day:

- Figure 5: The ambient dry bulb temperature and the outlet dry bulb temperatures of the IEC-H and the DX units.
- Figure 6: The EERs of both the IEC-H and the DX units and ambient RH.
- Figure 7: The cooling capacity of the IEC-H and DX unit and the ambient dry bulb temperature and RH.
- Figure 8: The power consumptions of the DX unit and the IEC-H unit and its components.

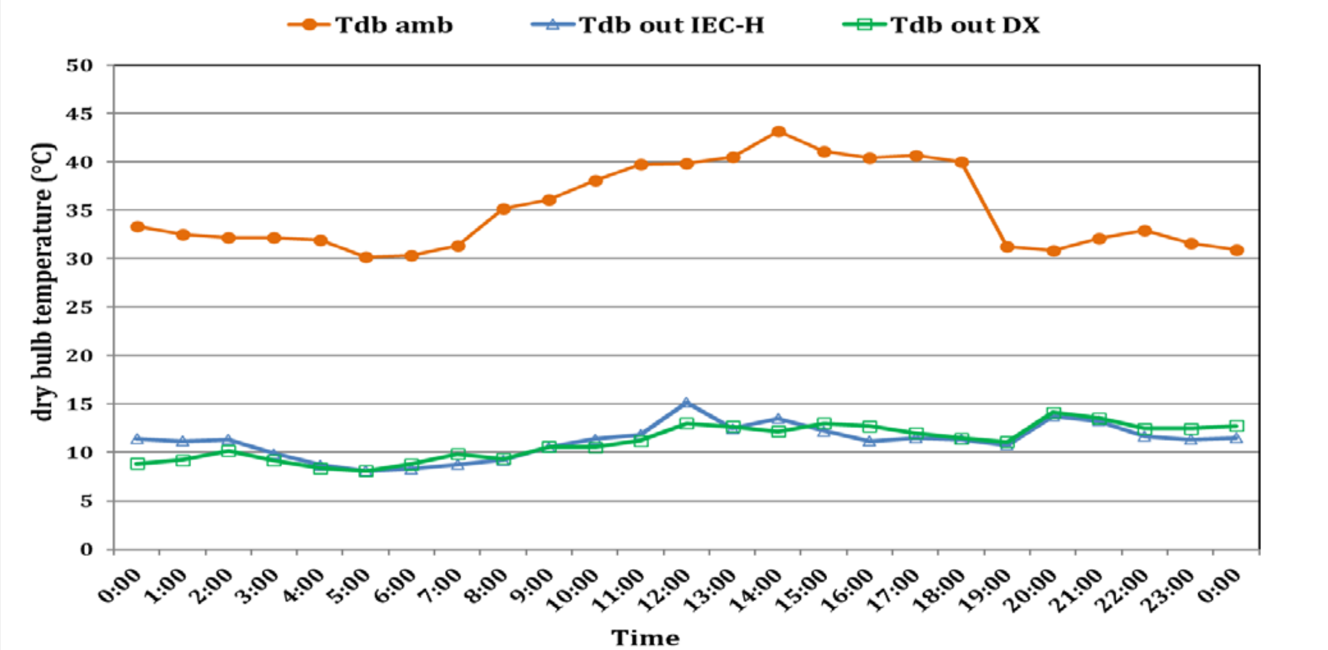


Fig. 5. Inlet Ambient Temperature Versus Outlet Temperature of IEC Hybrid and DX units OEM 2

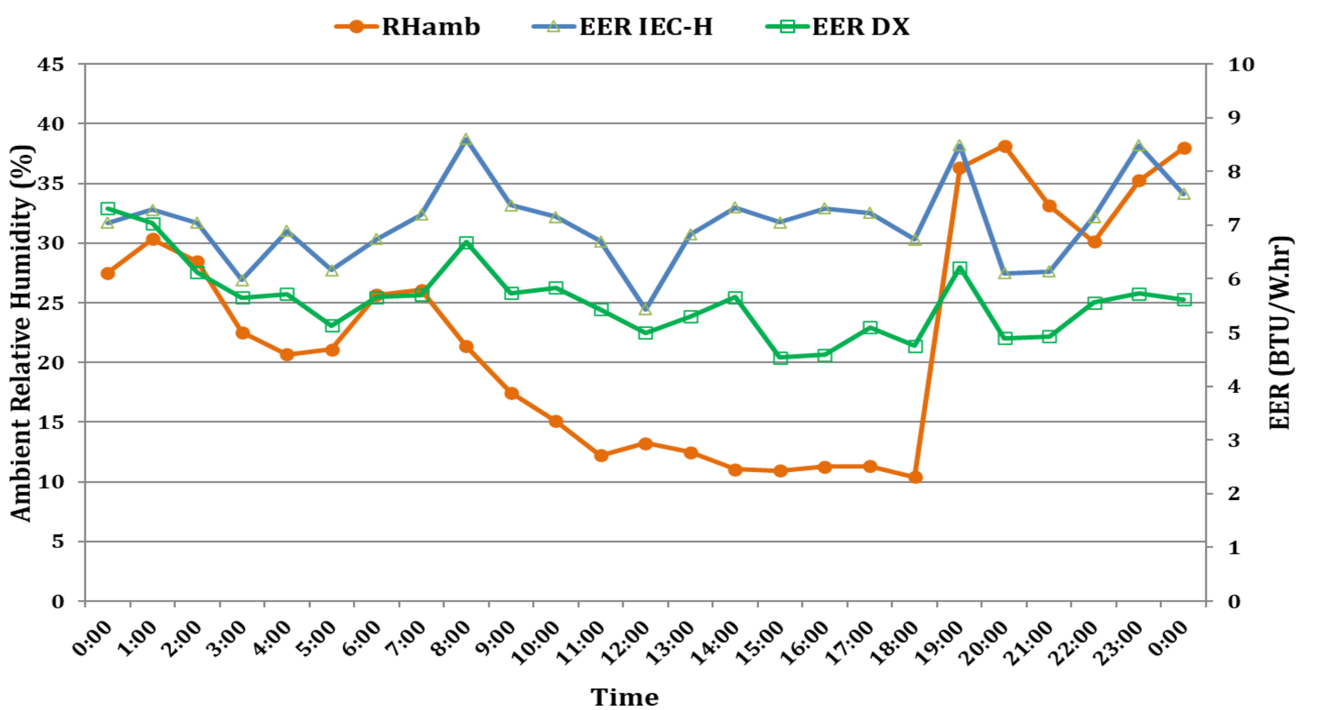


Fig. 6. EER for IEC Hybrid Unit & DX Unit Versus Ambient Relative Humidity- OEM2

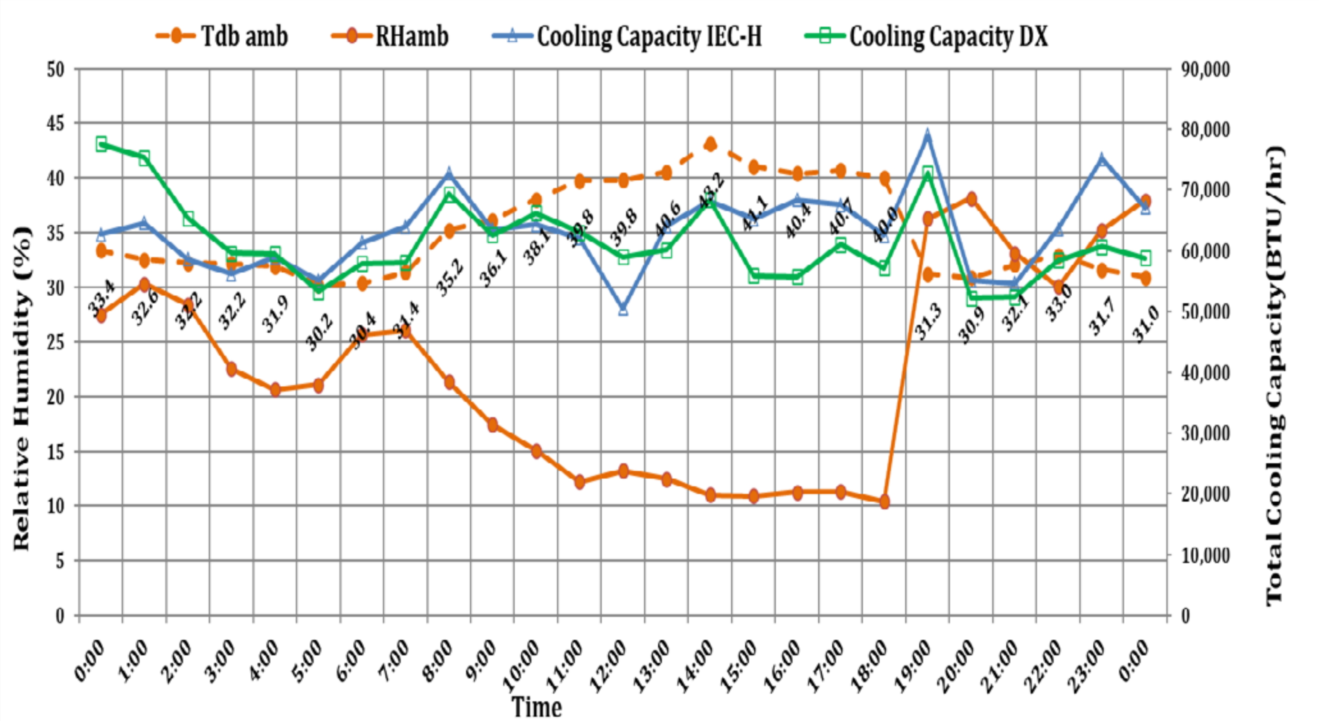


Fig. 7. Cooling Capacity for IEC Hybrid Unit & DX Unit Versus Ambient Conditions
OEM 2

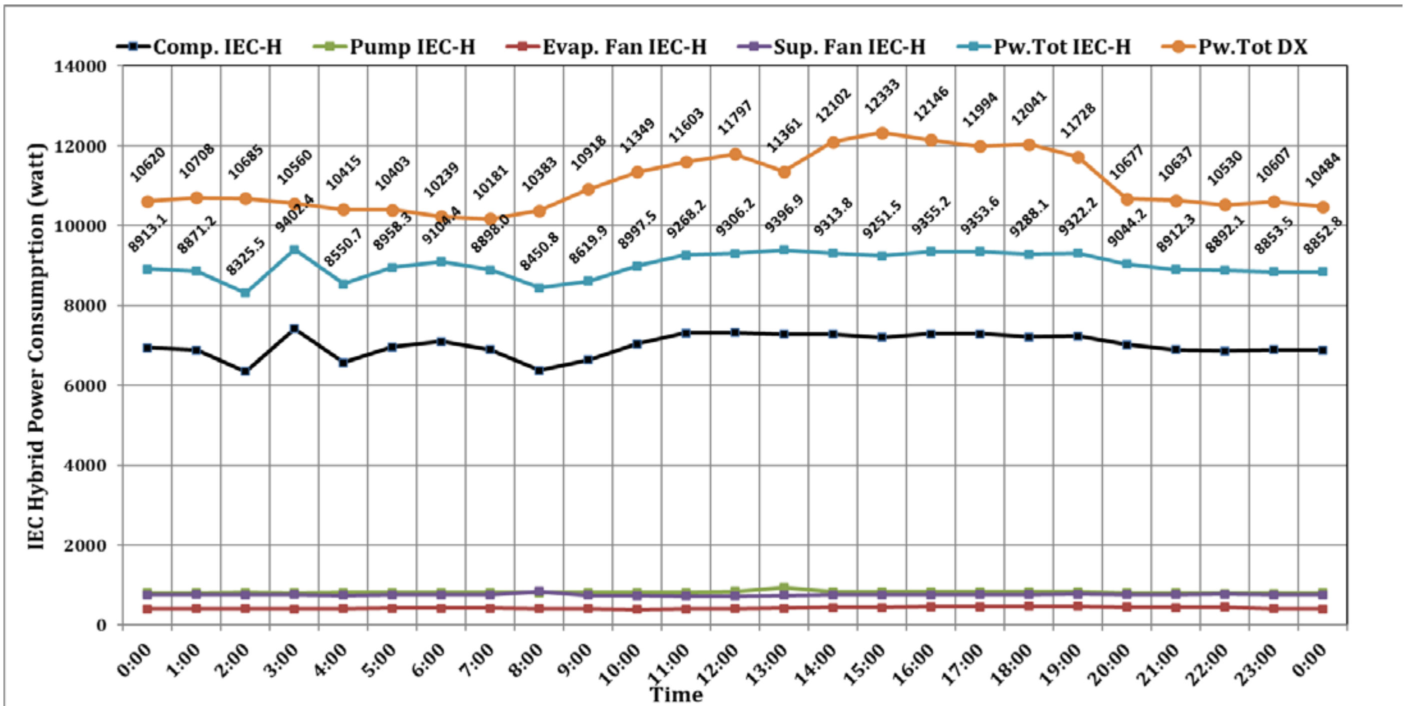


Fig. 8. Power Consumption of DX Unit and IEC Hybrid Unit Components
OEM 2

Table 5: High and Low readings for OEM2 at Climatic Zone 8

OEM 2, CZ 8				
High and Low Dry Bulb Temp. ℃ and Relative humidity				
H and l	$T_{db\ out}$ IEC-H	$T_{db\ out}$ DX	RH_{amb}	$T_{db\ amb}$
High	15.2	14.1	38.2	43.2
Low	8.3	8.1	10.4	30.2

3.3 OEM 6, Climatic Zone 8

Basic Information

Table 6: Basic Information for OEM 6 at Climatic Zone 8

Tested Units Name	DX (Direct Expansion Unit)		
	IEC Hybrid (Indirect Evaporative Cooling Hybrid Unit)		
OEM No.	6		
Refrigerant	R-32		
Air Flow Rate	1800 C.F.M for DX and IEC hybrid Units		
Capacity	DX	2	compressor
	IEC hybrid	1	compressors
Water Bath Area	(1308.3^2-900.3^2)		mm2
Climatic Zone	8 (South Egypt)		
Altitude	196.07 meter (From Sea Level)		
Location	22°49' 02" N 31°28' 16" E		
Test Date	31-Aug-24		

The figures below show the following

For OEM 6 in CZ 8, across a whole day:

- Figure 9: The ambient dry bulb temperature and the outlet dry bulb temperatures of the IEC-H and the DX units.
- Figure 10: The EERs of both the IEC-H and the DX units and ambient RH.
- Figure 11: The cooling capacity of the IEC-H and DX unit and the ambient dry bulb temperatureand RH.
- Figure 12: The power consumptions of the DX unit and the IEC-H unit and its components

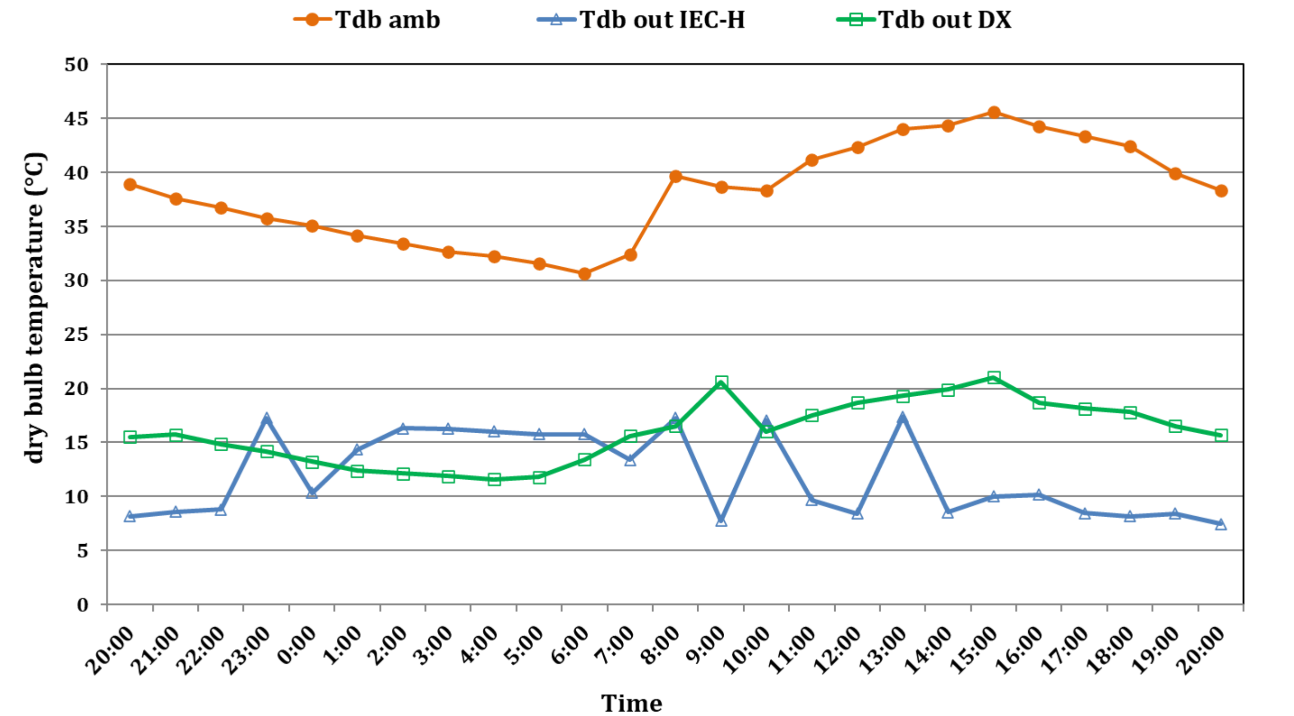


Fig. 9. Inlet Ambient Temperature Versus Outlet Temperature of IEC Hybrid and DX units- OEM 6 CZ 8

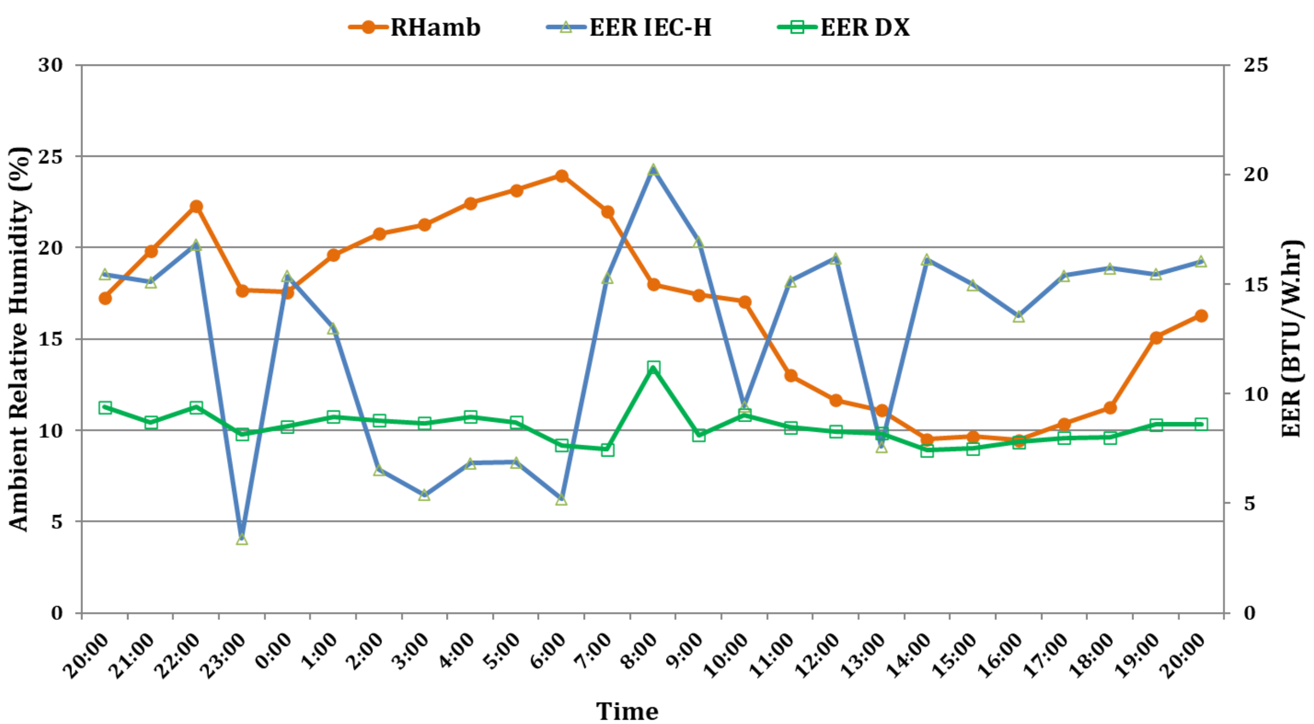


Fig. 10. EER for IEC Hybrid Unit & DX Unit Versus Ambient Relative Humidity OEM 6 CZ 8

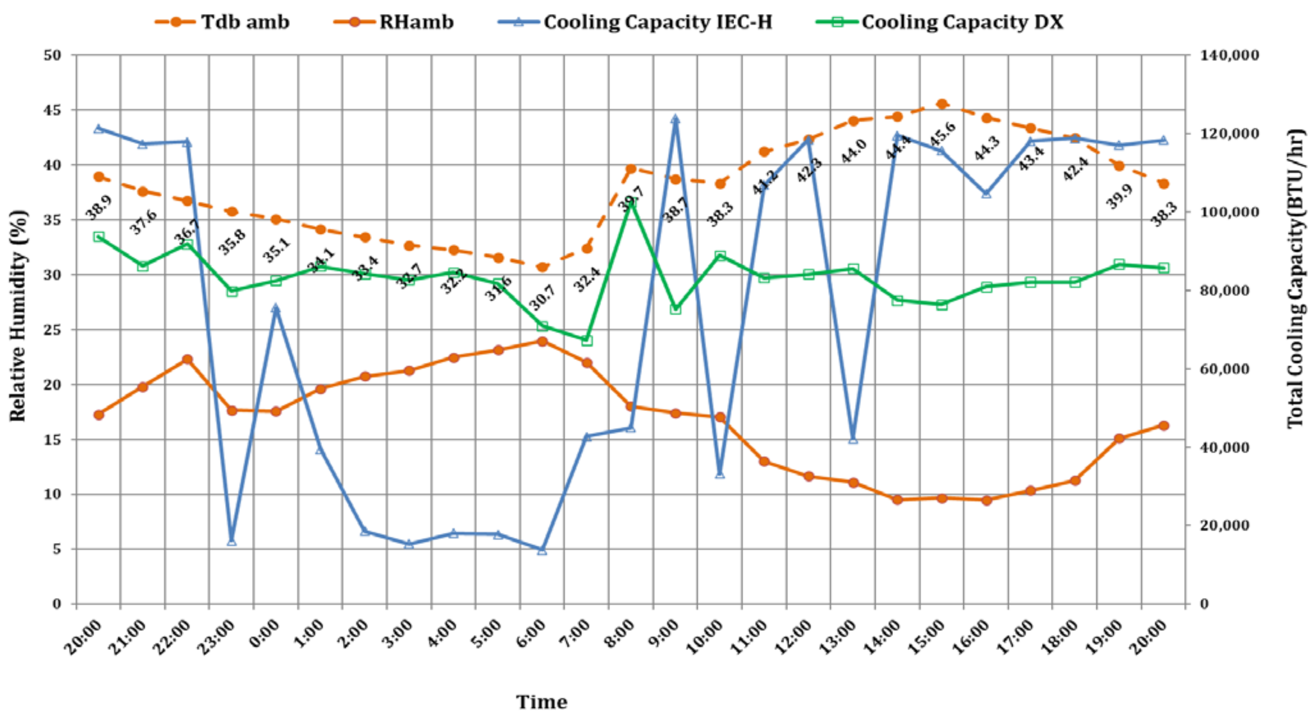


Fig. 11. Cooling Capacity for IEC Hybrid Unit & DX Unit Versus Ambient Conditions
OEM 6 CZ 8

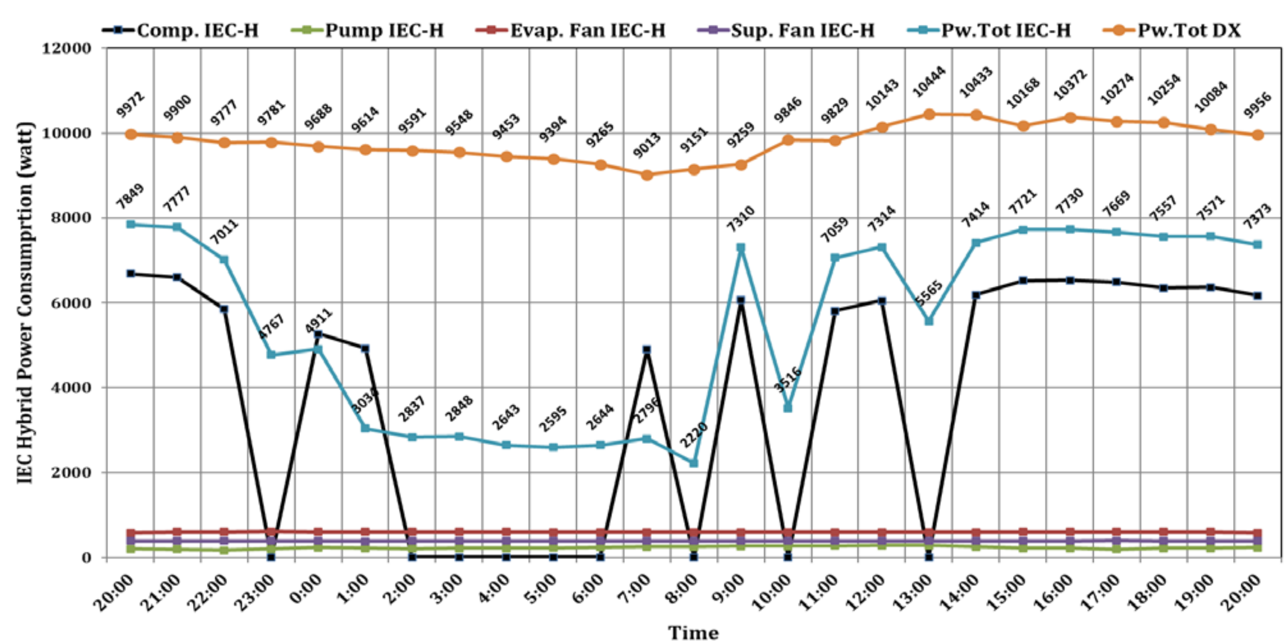


Fig. 12. Power Consumption of DX Unit and IEC Hybrid Unit Components
OEM 6 CZ 8

Table 7: High and Low readings for OEM 6 at Climatic Zone 8

OEM 6, CZ 8				
High and Low Dry Bulb Temp. ℃ and Relative humidity				
H and l	$T_{db\ out}$ IEC-H	$T_{db\ out}$ DX	RH_{amb}	$T_{db\ amb}$
High	17.4	17.8	24.0	45.6
Low	7.5	11.6	9.5	30.7

3.4 OEM 7, Climatic Zone 8

Basic Information

Table 8: Basic Information for OEM 7 at Climatic Zone 8

Tested Units Name	DX (Direct Expansion Unit)		
	IEC Hybrid (Indirect Evaborative Cooling Hybrid Unit)		
OEM No.	3		
Refrigerant	R-32		
Air Flow Rate	1320 C.F.M for DX and IEC hybrid Units		
Capacity	DX	1	compressor
	IEC hybrid	2	compressors
Water Bath Area	560X1020		mm2
Climatic Zone	8 (South Egypt)		
Altitude	196.07 meter (From Sea Level)		
Location	22°49' 02" N 31°28' 16" E		
Test Date	30-Aug-24		

The figures below show the following

For OEM 7 in CZ 8, across a whole day:

- Figure 13: The ambient dry bulb temperature and the outlet dry bulb temperatures of the IEC-Hand the DX units.
- Figure 14: The EERs of both the IEC-H and the DX units and ambient RH.
- Figure 15: The cooling capacity of the IEC-H and DX unit and the ambient dry bulb temperatureand RH.
- Figure 16: The power consumptions of the DX unit and the IEC-H unit and its components

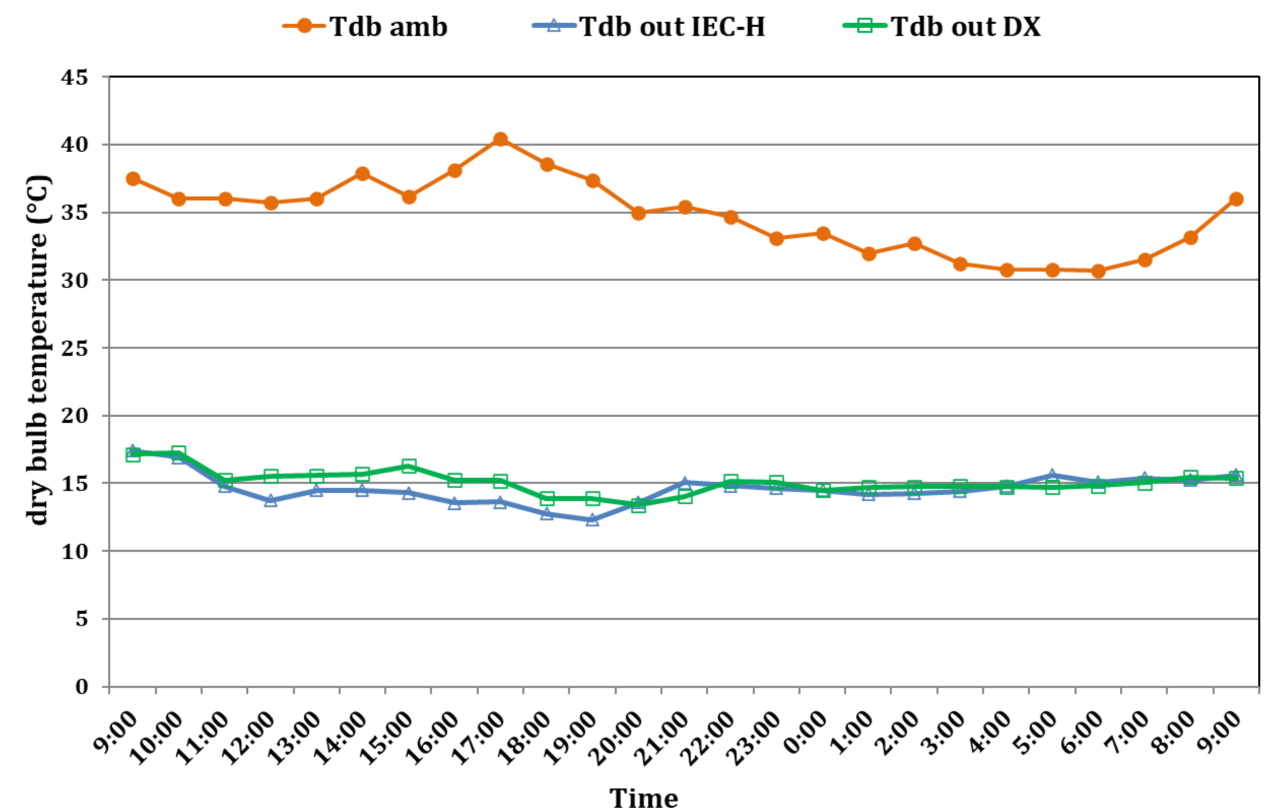


Fig. 13. Inlet Ambient Temperature Versus Outlet Temperature of IEC Hybrid and DX units, OEM 7 CZ 8

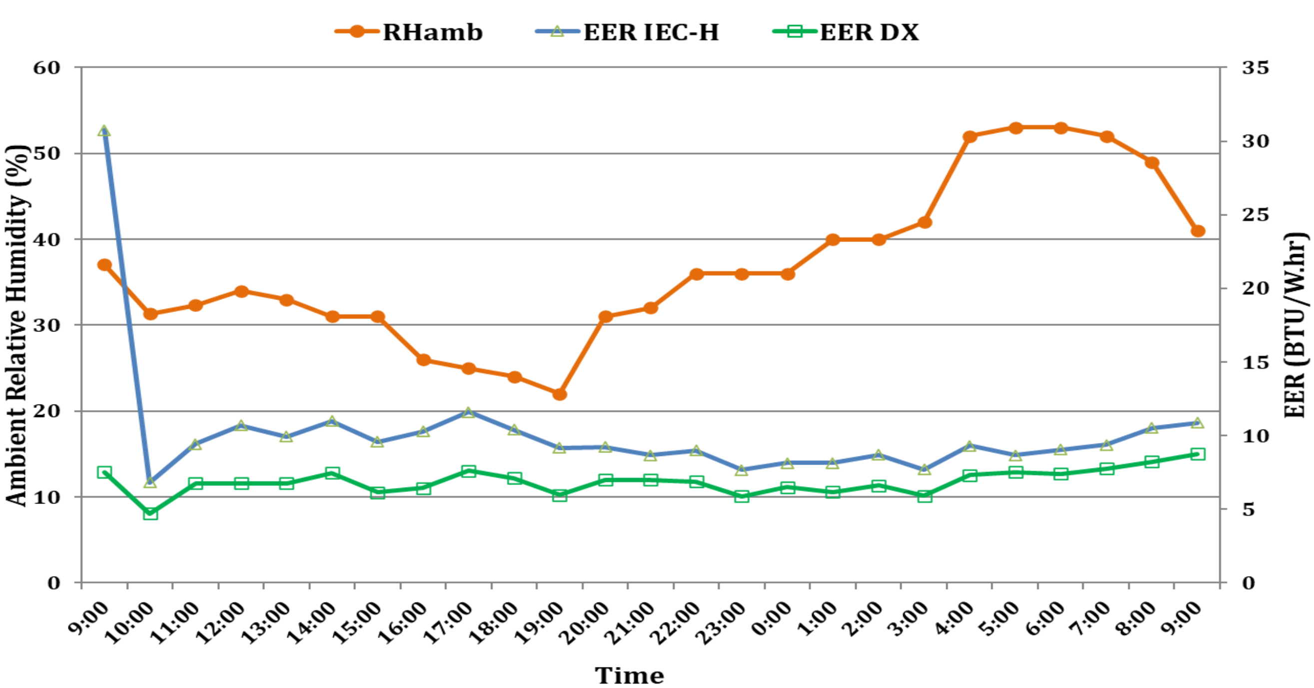


Fig. 14. EER for IEC Hybrid Unit & DX Unit Versus Ambient Relative Humidity, OEM 7 CZ 8

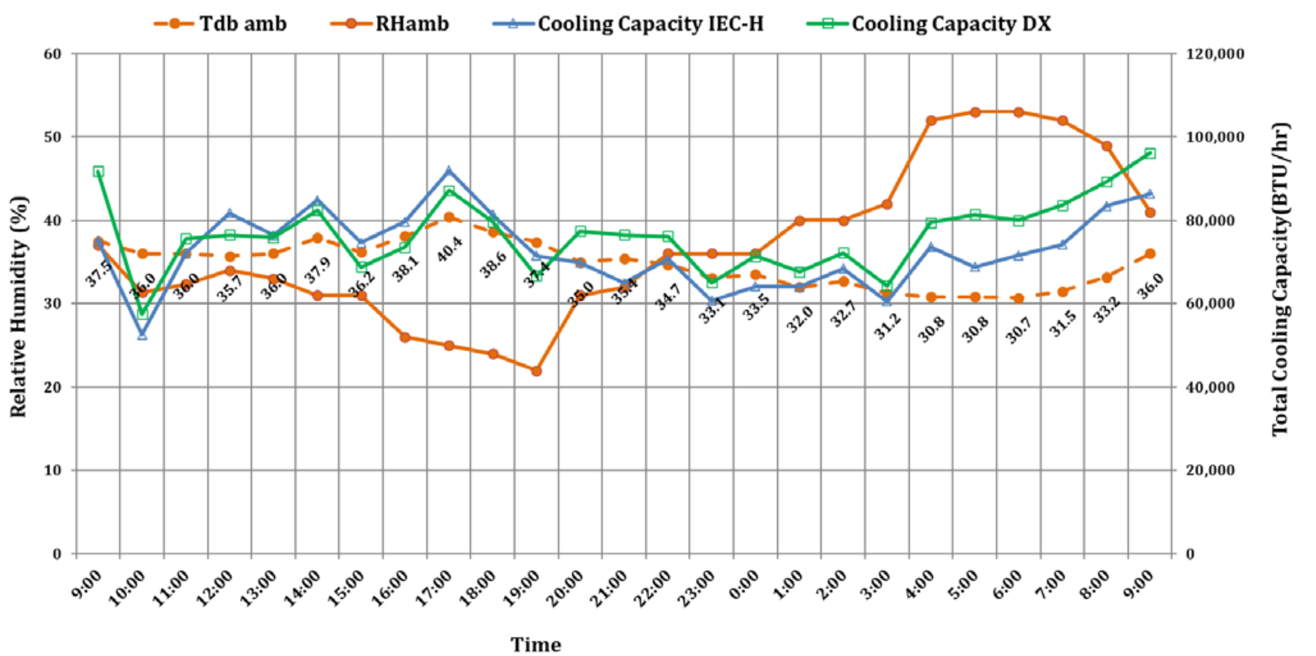


Fig. 15. Cooling Capacity for IEC Hybrid Unit & DX Unit Versus Ambient Conditions
OEM 7 CZ 8

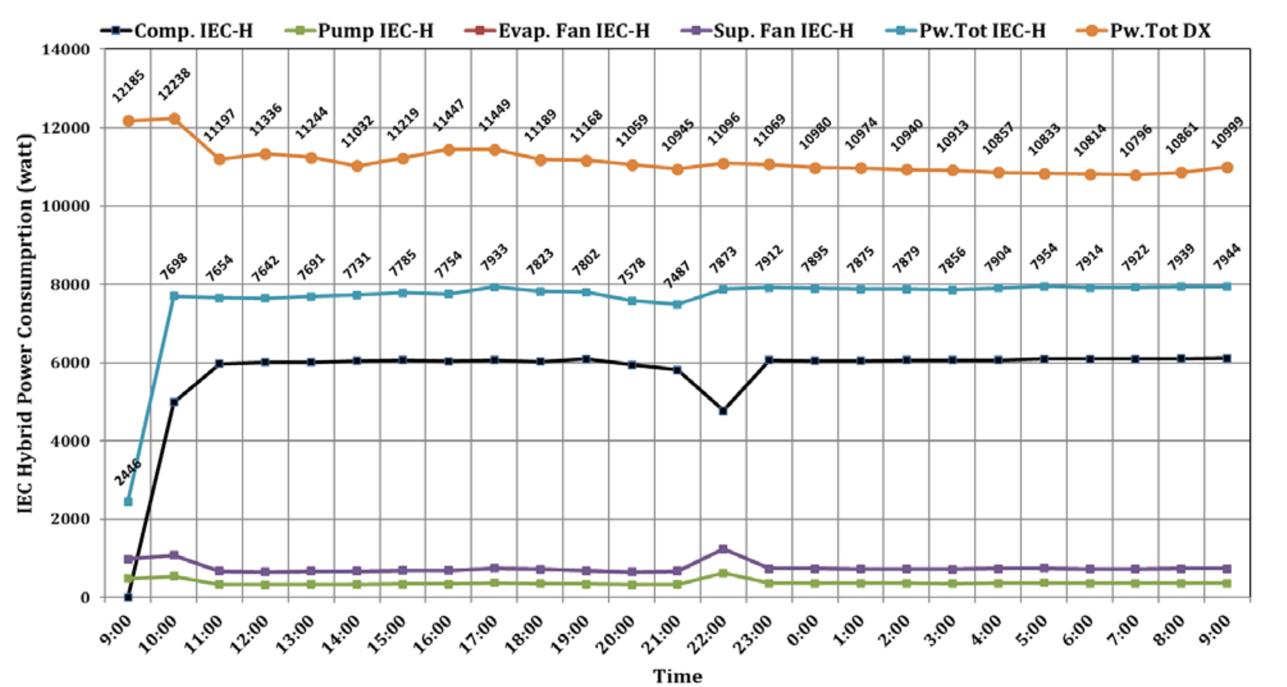


Fig. 16. Power Consumption of DX Unit and IEC Hybrid Unit Components
OEM 7 CZ 8

Table 9: High and Low readings for OEM 7 at Climatic Zone 8

OEM 7, CZ 8				
High and Low Dry Bulb Temp. ℃ and Relative humidity				
H and l	**$T_{db\ out}$ IEC-H**	**$T_{db\ out}$ DX**	**RH_{amb}**	**$T_{db\ amb}$**
High	**17.4**	**17.3**	**49.0**	**40.4**
Low	**12.3**	**13.4**	**22.0**	**30.7**

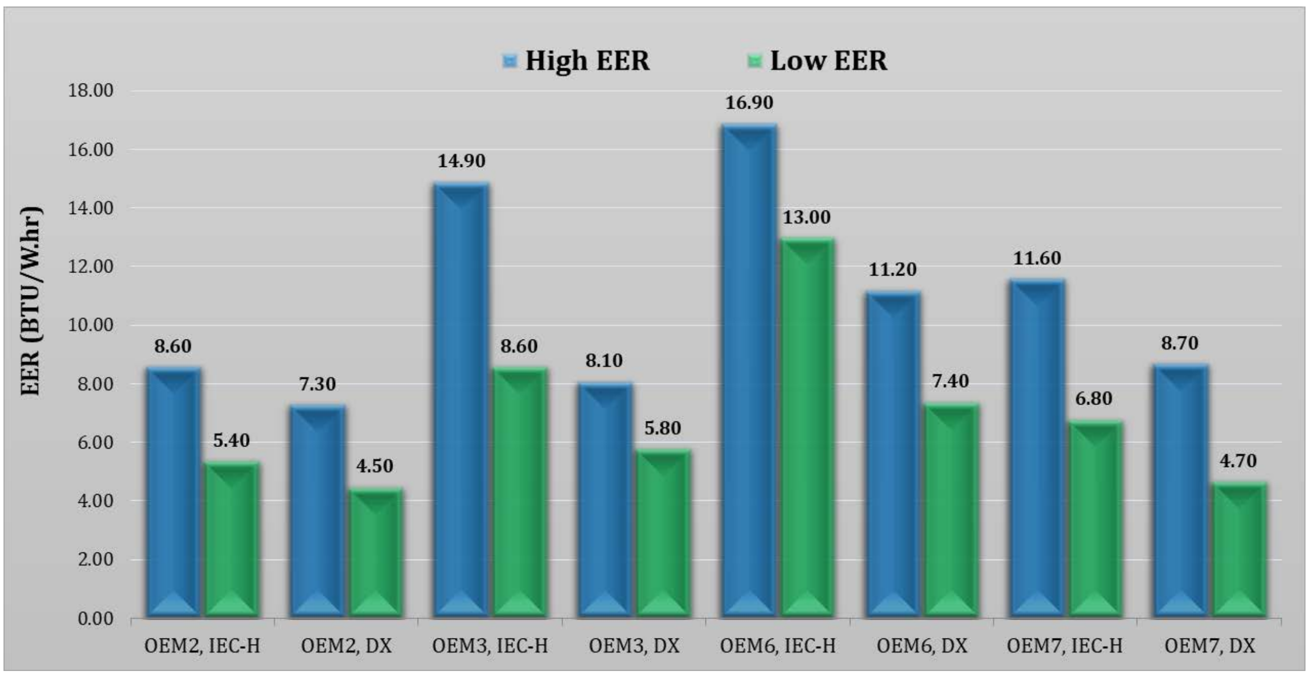
Chapter 4

The Final Results Analysis with Conclusion and Recommendation for Future Work

4.1 The Final Results Analysis

4.1.1 EER HIGH and LOW – CZ 8

Fig 17: High and Low EER (in BTU/W.hr) for Climatic Zone 8



4.1.2 CAPACITY HIGH and LOW – CZ 8

Fig 18: High and Low Cooling Capacity (in W) for Climatic Zone 8

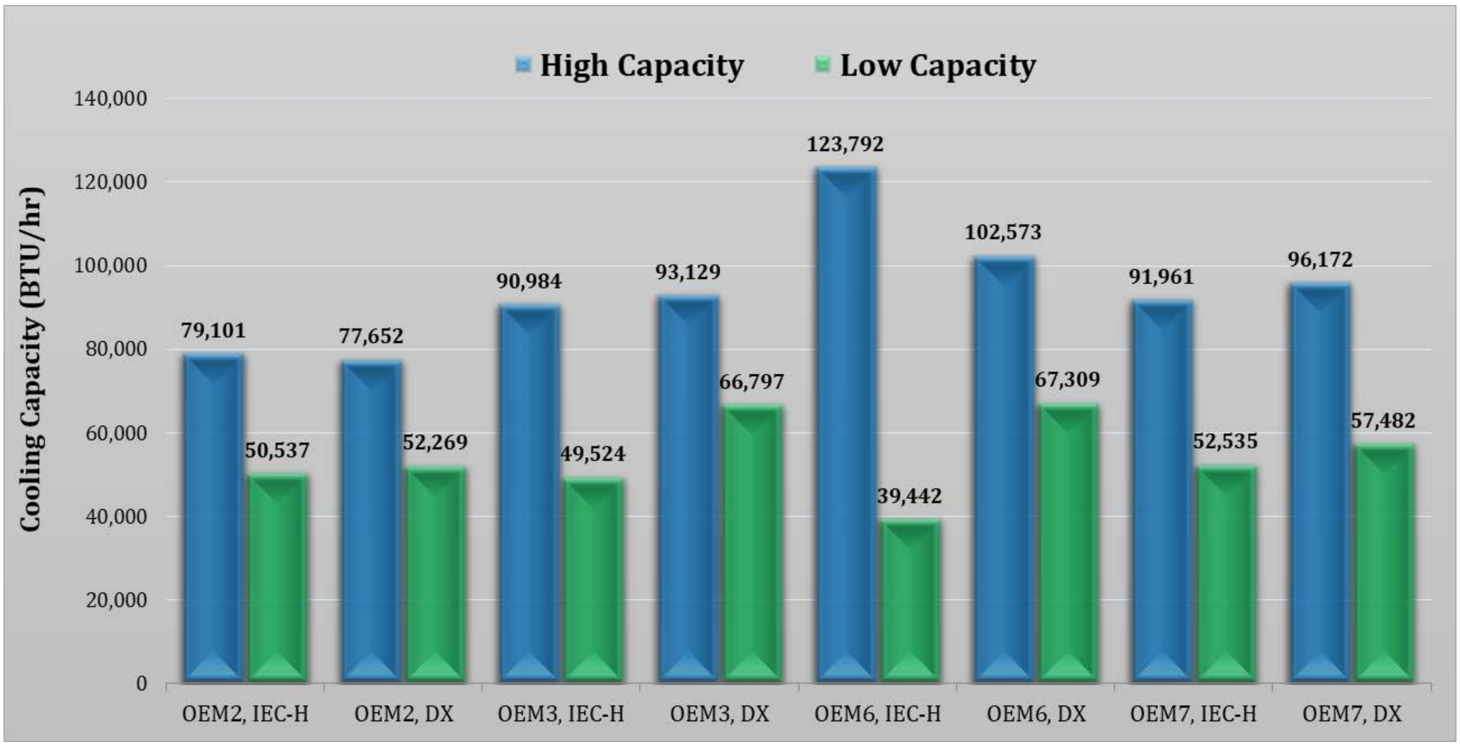


Table 10: High and Low EERs and Refrigeration capacity, all OEMs at Climatic Zone 8

EER				Capacities, W		
OEM #	High EER	Low EER		OEM #	High Capacity	Low Capacity
OEM2, IEC-H	8.60	5.40		OEM2, IEC-H	79,101	50,537
OEM2, DX	7.30	4.50		OEM2, DX	77,652	52,269
OEM3, IEC-H	14.90	8.60		OEM3, IEC-H	90,984	49,524
OEM3, DX	8.10	5.80		OEM3, DX	93,129	66,797
OEM6, IEC-H	16.90	13.00		OEM6, IEC-H	123,792	39,442
OEM6, DX	11.20	7.40		OEM6, DX	102,573	67,309
OEM7, IEC-H	11.60	6.80		OEM7, IEC-H	91,961	52,535
OEM7, DX	8.70	4.70		OEM7, DX	96,172	57,482

4.2 Conclusions

Due to the absence of local testing standard or guidelines for IEC applications, Eurovent Recommendation "Eurovent AISBL / IVZW / INPA. (2023). Eurovent 15/1 - 2023 — Hybrid Indirect Evaporative Cooling Equipment - Classification Requirements and Test Conditions. Brussels: Eurovent." provided testing reference and quality review of the testing process.
Eurovent recommendations are followed except for the points that contradicts with confidentiality agreement related to stating the name of the manufacturers or trade name.
The analysis of the final results of all OEMs shows the following:

- All OEMs show EERs of the IEC-H prototypes that are superior to corresponding DX units.
- The IEC-H prototype and DX units compressor's capacities are the same, 6 H.P at nominal conditions.
- Only one OEM used two compressors for its IEC-H prototype.

Table 11: Number of compressors, all OEMs at Climatic Zone 8

OEM	IEC-H	DX
3	One	Two
6	One	Two
7	One	Two
2	Two	Two

- The air discharge of both the IEC-H prototype and DX units for each OEM were the same.
- All OEMs used two compressors in their DX units.
- All OEMs used one compressor for their IEC-H prototypes, except OEM 2 whom used two compressors.
- The tests showed that the capacity of the IEC-H prototypes when compared to the capacity of their respective DX unit also varied considerably, depending on the prototype design and the ambient relative humidity.
- When the ambient relative humidity increased, the DX units tended to provide a better refrigeration capacity then corresponding IEC-H prototype.
- Except OEM 2, which used two compressors in its IEC-H prototype, higher refrigeration capacity was maintained even at high relative humidity ratios.

- Nevertheless, overall IEC-H refrigeration capacities at lower humidity periods, where higher than those of corresponding DX units.
- The report breaks new ground for NIK air conditioning technologies and provides an alternative full fresh air system for air conditioning application that exceeds the efficiency of existing DX systems.

4.3 Recommendation for Future Work

- Although, both final reports for CZ 2 & 5 (2022) and this report for CZ 8 (2024) are sufficient to write guidelines for a code for direct/indirect evaporative cooling for Egypt, the report recommends further work to provide a comprehensive formula to design IEC-H units in all Climatic Zones.
- There is a need for the industry to have a mathematical formula to predict the EERs and refrigeration capacities for IEC-H prototypes for the remaining five climatic zones of Egypt where tests were not performed in these locations.
- This formula once made, needs substantiation and proofing in the other Climatic Zones of Egypt where tests were not performed, through site tests.
- Therefore, future work would need to be made by OEMs to test IEC-H prototypes in these Climatic Zones and compare results with those obtained by the mathematical formula made in order to refine prediction on the design needed for IEC-H units in any of Egypt's climatic Zones.
- Only then can a definitive Direct/Indirect Evaporative Cooling Code be written which will help greatly in achieving energy efficiency for the industry and promote using lower GWP refrigerants.

Chapter 5

Reporting on the Advocacy and Outreach Campaign
3 November 2024

INTRODUCTION

Outreach marketing campaign helped in the enforcement of **Transformation of Commercial Air Conditioning Companies in EGYPT** by promoting and publishing the results of the technical study to stakeholders. The report of this outreach campaign are to be made available to all stakeholders. The outreach campaign was held on 3rd November 2024, at the auditorium of HBRC.

OUTREACH PLAN GOAL

The outreach marketing campaign had been targeting the following:

- ✓ Build awareness of the Phase-out Management Plan (HPMP).
- ✓ Promote and enhance transformation of commercial HVAC manufacturers in Egypt.
- ✓ Generate leads for the alternative refrigerants code and the forthcoming guidelines of direct/indirect evaporative cooling code.
- ✓ Effect collaborations between OEMs.

The objective of the outreach campaign is to disseminate the experience gained during testing the IEC-H prototypes and DX units in the additional Climatic Zones 8. The main discussions were on the results of the testing of IEC-H and DX units of all OEMs.

TARGET STAKEHOLDERS ATTENDING THE OUTREACH CAMPAIGN

The list of individuals/other entities having a role in the development and implementation of the Plan. The following are the stakeholder groups that were targeted in the outreach campaign:

1- The Ministry of Electricity

2- Organization of Specifications and Standards
3- Municipalities
4- All OEMs that were included in the program
5- Local Government Agency Officials and Department Heads
6- Public Sector HVAC Project Planners
7- Local Chapters of Regional/National Associations
8- Local Environmental Organizations
9- Local HVAC Organizations and Interest Groups
10- HVAC Companies
11- Developers
12- The General Public
13- Others interested parties

Question raised after the presentation

About 30 to 35 persons attended the 4 hours Outreach campaign. The following are the most important questions and answers made during the campaign:

I. Question by Eng Mohamed Mansour on humidity ratios and relative humidity of the ambient air:
   a. Dr Olama answered on the measurement of humidities made and their relations with the two storms encountered during testing that increased dramatically humidity in the area.

II. Question posed by Eng. Abdel Sallam Mahrous, consulting engineer on which of the OEMs exhibited the best EERs.
   a. Dr Olama replied that one of the cornerstones of the program is not to provide data for the purpose of determining which is the best performing prototypes or DX units. This is why the OEMs are listed by a numbering code and not by their names.

III. Question posed by Eng. Maarouf, consultant engineer, asking if the IEC-H units, when produced on a regular basis, would their maintenance will be higher or lower than that of DX units?
   a. Dr Olama answered that because of the higher costs of maintaining evaporation pads, IEC-H maintenance are higher than that of DX units.

IV. Comment posed by Dr. Ezzat Lewis (the head of the Egyptian NOU)
   a. Dr. Ezzat, explained clearly the different roles of the UN agencies and bodies. He talked about the future funding for programs for Egypt and the mechanisms of replenishment for individual nations.

V. Question asked by Eng. Hassan el Mogi, chairman of the consulting firm El-AMAAR, when will the IEC-H specification code be ready to be used by consulting engineers?

   a. Reply: first guidelines on IEC evaporative cooling will first be written as a guidance for a forthcoming code, then a complete code will be written when the third testing program is made and all Climatic Zines in Egypt are covered.

VI. An engineer (he has not given his name) inquired if there a plan to produce a code and then legislate the usage of IEC-H for the different eight climatic zones of Egypt?

   a. Reply: Dr Olama replied that we hope there will be a future phase in the program that will allow OEMs and all practitioners in HVAC to use a formula to predict the size of the compressors and the basic design parameters of IEC-H units for all eight Climatic Zones of Egypt. Binding legislation can then be enacted given the assured ability to predict the performance of IEC-H units in all Climatic Zones and thus provide a proven energy efficient system of cooling for the country utilizing lower GWR refrigerants and HC refrigerants.

Dr Alaa Olama.