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EXECUTIVE COMMITTEE OF
THE MULTILATERAL FUND FOR THE
IMPLEMENTATION OF THE MONTREAL PROTOCOL
Eighty-eighth Meeting
Montreal, 15-19 November 2021[1]

REPORTS ON PROJECTS WITH SPECIFIC REPORTING REQUIREMENTS

1. The present document presents reports on projects with specific reporting requirements that have been submitted to the present meeting. The request for extension of completion dates beyond 31 December 2022 for stage I and stage II of HCFC phase-out management plans (HPMPs) is also part of this document. In addition, reports that were submitted for individual consideration since the 85th meetings but were not considered in accordance with the agreed procedures for conducting Executive Committee meetings during the COVID-19 pandemic, are also included in the present document.

2. The document consists of the following four sections:

Section I: Reports on projects with specific reporting requirements for which there are no outstanding policy, cost or other issues, for which the Executive Committee may wish to take decision on the basis of the Secretariat's recommendations without further discussion ("blanket approval"). The report of the meeting of the Executive Committee will present each report contained in this section individually, together with the decision adopted by the Committee

Section II: Reports on projects with specific reporting requirements for individual consideration by the Executive Committee

Section III Requests for the extension of completion dates of stage I/stage II of HPMPs beyond 31 December 2022

Addendum I: Consists of five reports related to China:[2] Financial audit reports for the CFC production, halon, PU foam, process agent II, refrigeration servicing and solvent sectors; Report on progress in the implementation of activities listed in

[1] Online meetings and an intersessional approval process will be held in November and December 2021 due to coronavirus disease (COVID-19)

[2] UNEP/OzL.Pro/ExCom/88/18/Add.1

decision 83/41(e); Study to determine the regulatory, enforcement, policy or market circumstances that might have led to the illegal production and use of CFC-11 and CFC-12 (decision 83/41(d)); Updated report on the production of CTC and its feedstock uses; and Sector plan for the phase-out of methyl bromide production

REPORTS ON PROJECTS WITH SPECIFIC REPORTING REQUIREMENTS

3. Table 1 lists the reports on projects with specific reporting requirements submitted to the 88th meeting recommended for blanket approval.

Table 1: Reports on projects with specific reporting requirements recommended for blanket approval

Country	Project title	Paragraphs
Reports related to HCFC phase-out management plans		
Argentina	HCFC phase-out management plan (stage II – update on the financial viability of the enterprise Celpack)	5 – 9
Côte d'Ivoire	HCFC phase-out management plan (stage I – report on the adoption of the interministerial decree ("arrêté interministériel") for regulating import, export, transit, re-export and trade of ODS, and other measures on strengthening monitoring and reporting systems relating to HCFC import and export)	10 – 13
Ghana	HCFC phase-out management plan (stage I - progress report)	14 - 24
Honduras	HCFC phase-out management plan (stage I – an update on progress toward implementing the recommendations in the verification report)	25 – 32
Jamaica	HCFC phase-out management plan (stage II – Update on the status of implementation of the measures for strengthening the licensing and quota system and monitoring and reporting of HCFC consumption recommended in the verification report)	33 – 38
Kenya	HCFC phase-out management plan (stage II, second tranche – update on the status of the implementation of activities for strengthening monitoring and reporting of HCFC licensing and quota systems recommended in the verification report)	39 – 47
Mexico	HCFC phase-out management plan (stage I - progress report)	48 - 53
Saint Lucia	HCFC phase-out management plan (stage I, fifth tranche – Update on the status of the signing of the small scale funding agreement (SSFA) and disbursement of the first instalment under the SSFA)	54 - 59
Libya	HCFC phase-out management plan (stage I – progress report)	60 – 77
Saint Vincent and the Grenadines	HCFC phase-out management plan (report on the progress made in improving the licensing and quota system and strengthening customs' capacity for import control)	78 - 83
Saudi Arabia	HCFC phase-out management plan (stage I – progress report on the implementation of the remaining activities	84 - 89
Low-GWP projects		
Egypt	Final report on the project to promote low-global-warming-potential refrigerants for the air conditioning industry in Egypt (EGYPRA)	90 - 100
Saudi Arabia	Demonstration project on promoting HFO-based low-global-warming-potential refrigerants for the air-conditioning sector in high ambient temperatures (progress report)	101 - 109
Demonstration projects in servicing sector		
Tunisia	HCFC phase-out management plan (stage I – final progress report)	110 - 118
Tunisia	HCFC-phase out management plan (stage II - Change of technology for a foam manufacturing enterprise (Le Panneau))	119 - 127
ODS waste disposal projects		
Brazil	Pilot demonstration project on ODS waste management and disposal (progress report)	128 – 133
Change of implementing agency		
Mauritania	HCFC phase-out management plan (stage I - change of implementing agency)	134 – 149

Country	Project title	Paragraphs
Methyl bromide		
Argentina	Methyl bromide phase-out plan	150 - 152

4. Table 2 lists the reports on projects with specific reporting requirements submitted to the 88th meeting for individual consideration and a brief explanation of related issues.

Table 2: Reports on projects with specific reporting requirements for individual consideration

Country	Project title	Issue	Paragraphs
Reports related to HCFC phase-out management plans (HPMPs)			
Democratic People's Republic of Korea	HCFC phase out management plan (stage I – progress report on the implementation of activities)	Request for guidance in view of the challenges in implementing activities in light of the United Nations Security Council resolutions	153 - 167

SECTION I: REPORTS ON PROJECTS WITH SPECIFIC REPORTING REQUIREMENTS RECOMMENDED FOR BLANKET APPROVAL

Reports related to HPMPs[3]

Argentina: HCFC phase-out management plan (stage II – update on the financial viability of the enterprise Celpack) (UNIDO and the Government of Italy)

Background

5. At its 84th meeting, the Executive Committee considered the request for funding the second tranche of stage II of the HPMP for Argentina.[4] The tranche request included a progress report indicating *inter alia* that the conversion of the extruded polystyrene (XPS) foam enterprise Celpack, from HCFC-22 to CO_2, had been delayed due to economic difficulties that the enterprise was facing and to its interest in evaluating butane as an alternative to HCFCs. In approving the funding tranche, the Committee requested UNIDO to submit at the 85th meeting an update on the financial viability of the enterprise and whether it would be assisted by the Multilateral Fund, on the understanding that the funds from the conversion would be returned in the event that the enterprise were removed from the project (decision 84/64(d)(ii)).

6. In line with decision 84/64(d)(ii), UNIDO submitted progress reports at the 85th, 86th and 87th meetings,[5] indicating that the majority of Celpack's debt was with the Federal Agency for Public Incomes (AFIP), and that the Parliament of Argentina, recognizing the economic impact of COVID-19, approved a moratorium for financing debts due by 31 July 2020. Since then, Celpack has been paying off its debts, in accordance with the schedule approved by the Tax Authority. This was expected to have a positive impact on the financial viability of the enterprise.

Progress report

7. UNIDO has submitted an update to the 88th meeting indicating that Celpack has continued to fulfil all scheduled payments as approved by AFIP. The Government of Argentina and UNIDO affirmed that they would continue monitoring the financial situation of Celpack, and the Government further reiterated

[3] Reports related to the HPMPs for Brazil (temporary use of high-GWP technologies), Indonesia (stage I), and Senegal (stage I) are contained in documents UNEP/OzL.Pro/ExCom/88/39, UNEP/OzL.Pro/ExCom/88/51 and UNEP/OzL.Pro/ExCom/88/62, respectively

[4] UNEP/OzL.Pro/ExCom/84/39

[5] The Executive Committee has noted the progress reports submitted between the 85th and 87th meetings in decisions 85/4, 86/22 and 87/7.

that the funding associated with Celpack would not be disbursed until the issue had been resolved (i.e., the financial health of the enterprise is confirmed) and its resolution considered by the Executive Committee.

8. As indicated in previous reports, in the event that the enterprise were found to not be financially viable, the level of funds to be returned to the Multilateral Fund would be calculated taking into consideration the terms of flexibility used for the approval of funds for the XPS foam sector in Argentina.[6]

Recommendation

9. The Executive Committee may wish:

(a) To request the Government of Argentina, through UNIDO, to provide to the 90th meeting an update on the financial viability of the extruded polystyrene (XPS) foam enterprise Celpack and a decision on whether the enterprise would be assisted by the Multilateral Fund under stage II of the HCFC phase-out management plan (HPMP) for Argentina, in line with decision 84/64(d)(ii), and

(b) To note that, in the event that the enterprise referred to in sub-paragraph (a) above would not be assisted by the Multilateral Fund, the funds associated with its conversion would be calculated taking into consideration the flexibility in the allocation of funds approved to the Government of Argentina for the XPS foam sector, and would be deducted from the approval of the next tranche of stage II of the HPMP for Argentina.

Côte d'Ivoire: HCFC phase-out management plan (stage I – report on the adoption of the interministerial decree ("arrêté interministériel") for regulating import, export, transit, re-export and trade of ODS, and other measures on strengthening monitoring and reporting systems relating to HCFC import and export) (UNEP and UNIDO)

Background

10. At its 87th meeting, the Executive Committee noted the report on progress in the future adoption of the interministerial decree ("arrêté interministériel") for regulating import, export, transit, re-export and trade of ODS, and other measures on strengthening monitoring and reporting systems relating to HCFC import and export under stage I of the HPMP for Côte d'Ivoire and requested the Government of Côte d'Ivoire to provide an update, through UNEP, at the 88th meeting, on the adoption of the "arrêté interministériel" (decision 87/10).

11. In line with decision 87/10, the Government of Côte d'Ivoire, through UNEP, reported that the signature of the "arrêté interministériel" by the four ministries involved has been slow due to COVID-19 restrictions. As of 9 September 2021, the Ministers of Environment and Sustainable Development and of Commerce and Industry have signed the decree, while signatures by the Ministers of Budget and State Portfolio and of Economy and Finance are expected no later than 31 December 2021. Given this delay, UNEP would continue following up with the Government and will inform the Executive Committee until the decree is signed by all ministries concerned.

[6] The funding of US $348,767 approved for the two enterprises in the XPS foam sector, was lower than the estimated incremental cost of US $439,200; it was agreed that the Government of Argentina would have flexibility in the allocation of funds between the two enterprises, on the understanding that both enterprises would convert to the selected technology on time (paragraph 76 of document UNEP/OzL.Pro/ExCom/79/27).

Secretariat's comments

12. The Secretariat notes that although the "arrêté interministériel" is yet to be signed, the national ozone unit, under the guidance of the National Ozone Committee, continues to monitor the implementation of the ODS import/export licensing system.

Recommendation

13. The Executive Committee may wish:

(a) To note the report on progress in the future adoption of the interministerial decree ("arrêté interministériel") for regulating import, export, transit, re-export and trade of ODS, and other measures on strengthening monitoring and reporting systems relating to HCFC import and export under stage I of the HCFC phase-out management plan for Côte d'Ivoire, submitted by UNEP, in response to decision 87/10, and contained in document UNEP/OzL.Pro/ExCom/88/18; and

(b) To request the Government of Côte d'Ivoire to provide an update, through UNEP, at the 90th meeting, on the adoption of the "arrêté interministériel" mentioned in sub-paragraph (a) above.

Ghana: HCFC phase-out management plan (stage I - progress report) (UNDP and the Government of Italy)

Background

14. At its 84th meeting, the Executive Committee requested, *inter alia*, the Government of Ghana, UNDP and the Government of Italy to submit progress reports on the implementation of the work programme associated with the final tranche on a yearly basis until the completion of the project, and verification reports until approval of stage II of the HCFC phase-out management plan (HPMP) (decision 84/73(b)).

15. At its 86th meeting, UNDP on behalf of the Government of Ghana submitted stage II of the HPMP that included a progress report on the implementation of stage I and a request for extension of stage I of the HPMP. However, the required verification of HCFC consumption for 2020 was not submitted. The Executive Committee subsequently approved the extension of stage I to 30 June 2022 and requested the Government of Ghana to submit an updated progress report for stage I of the HPMP and a verification report on HCFC consumption to the 88th meeting, and a project completion report to the second meeting of 2022 (decision 87/39(a)(b)).

16. On behalf of the Government of Ghana, UNDP, as the lead implementing agency, has submitted the updated annual progress report on the implementation of the work programme associated with the sixth and final tranche of the HPMP,[7] and a verification report on HCFC consumption, in 2020, in line with the above decisions.

HCFC consumption

17. The Government of Ghana reported HCFC consumption of 15.97 ODP tonnes in 2020, which is 67 per cent below the target of 51.57 ODP tonnes for the same year in its Agreement with the Executive Committee, and 72 per cent below the HCFC baseline of 57.30 ODP tonnes. The Government also reported

[7] The sixth and final tranche of stage I of the HPMP was approved at the 84th meeting at a total cost of US $121,311, plus agency support costs of US $9,098 for UNDP.

HCFC sector consumption data under the 2020 country programme (CP) implementation report that is consistent with the data reported under Article 7 of the Protocol.

18. HCFC consumption has been decreasing gradually due to the implementation of the HPMP and the introduction of alternative technologies on the market, mainly HFCs and hydrocarbons. In 2020, HCFCs accounted for 52 per cent of total refrigerant imports, followed by HFCs (43 per cent, consisting of HFC-134a: 21 per cent; R-410A: 7 per cent; R-404A: 6 per cent; R-407C: 4 per cent; and other miscellaneous HFCs: 4 per cent), and hydrocarbons (5 per cent).

Verification report

19. The verification report confirmed that the Government was implementing a licensing and quota system for HCFC imports and exports, and the verified consumption was 15.97 ODP tonnes, consistent with the amount reported under Article 7 of the Montreal Protocol and in the CP report. The Government of Ghana was in compliance with the Montreal Protocol and its Agreement with the Executive Committee.

Activities in the refrigeration servicing sector

20. The following activities were implemented under stage I between April and October 2021:

(a) The update of Law LI 1812 has captured the requirement for safe handling of flammable refrigerants; Law LI 1812 is in the last stage of review and approval by parliament; and the NOU has been providing support during the process;

(b) An upgraded quick reference guide covering the safe use, storage, handling, charging techniques and transportation of hydrocarbon refrigerants was printed (1500 booklets) and distributed to refrigeration practitioners during training sessions;

(c) Bidding for general refrigeration cycle test boards was successful, a supplier was selected; and the delivery of the equipment is expected by the end of October 2021; and

(d) The fourth centre of excellence for training technicians has been selected (University of Development Studies of Tamale) and is being refurbished; and tools and equipment will be purchased to support the training; 250 technicians were trained in good servicing practices, refrigerant leakage control, safe handling of flammable refrigerants and servicing of equipment with alternatives; the eleven conversion centres have also started to provide training in the safe handling flammable refrigerants to technicians and apprentices.

Level of fund disbursement

21. As of 7 September 2021, of the US $1,356,311 approved for stage I of the HPMP, US $1,231,173 (91 per cent) had been disbursed (US $1,031,311 for UNDP, and US $325,000 for the Government of Italy). A balance of US $125,138 will be disbursed in 2021-2022.

Secretariat’s comments

<u>Progress report on the implementation of the sixth tranche of the HPMP</u>

Legal framework

22. The Government of Ghana has already issued HCFC import quotas for 2021 at 20 ODP tonnes, which is lower than the Montreal Protocol control target for the same year.

Refrigeration servicing sector

23. Although the implementation of activities in stage I was impeded due to the constraints imposed by the COVID-19 pandemic, the Government has been making progress in implementation. The various activities planned under stage I are progressing; and stage I will be completed by 30 June 2022.

Recommendation

24. The Executive Committee may wish to note the updated 2020 progress report on the implementation of stage I of the HCFC phase-out management plan for Ghana submitted by UNDP, contained in document UNEP/OzL.Pro/ExCom/88/18.

Honduras: HCFC phase-out management plan (stage I – an update on progress toward implementing the recommendations in the verification report) (UNIDO and UNEP)

Background

25. At the 86th meeting, the Executive Committee approved the fifth and last tranche of stage I of the HPMP for Honduras. The verification report associated with the tranche request confirmed that the licensing and quota system was robust and could guarantee compliance; however, verified HCFC consumption data for 2016 to 2019 were different from the data reported under Article 7 of the Montreal Protocol. These differences were caused by oversights in implementing the system or preparing the official HCFC consumption reports, including the recording of unfulfilled import authorizations as imports; omission of one export and one import during the preparation of official data reports; double recording of one import; and allocation of the same license number to two imports by the same importer.

26. Consequently, the verification report recommended *inter alia*: to continue efforts to get accurate customs declarations, especially regarding the declared net weight; to require export authorizations (licenses) for every export of HCFC (and ODS in general) without exception; to ensure that the numerical identification of each import authorization issued is unique; and to ensure the accuracy of consumption reports.

27. In approving the fifth tranche of stage I, the Executive Committee requested UNIDO to submit to the 88th meeting an update on progress toward implementing the recommendations in the verification report, including actions taken by the Government to ensure the accuracy of country programme (CP) implementation data and Article 7 data submitted to the Multilateral Fund and the Ozone Secretariats, respectively.[8]

Progress report

28. On behalf of the Government of Honduras, UNIDO submitted a progress report indicating that the customs administration has incorporated in its procedures the recommendations made by the independent verification associated with the fifth tranche of stage I. Specifically, the following adjustments have been made to the import/export process by the customs administration:

(a) The process of recording imports has been modified to ensure that the import/export declarations always include the national ozone unit (NOU) identifier code of the license being used and the expiration date of the license (noting that if the import takes place after the expiration date it should be rejected);

[8] Decision 86/53(a); provision contained in Annex XV of document UNEP/OzL.Pro/ExCom/86/100.

(b) The electronic system to record imports has been modified to ensure that:

(i) It does not accept import declarations by importers not included in the NOU's list of registered importers;

(ii) It does not accept import declarations if the declared net weight is equal to or above the declared gross weight;

(iii) It does not accept HCFC-22 import declarations if the declared net weight plus the cumulated net weight of previous imports of the same substance by the same importer during the same year is above the allocated annual import quota for the importer for HCFC-22; and

(c) The NOU has received access (user name and password) to consult the customs authority's electronic system.

29. In addition, the NOU submitted requests to the Fund Secretariat (14 October 2021) and the Ozone Secretariat (21 October 2020) to revise the HCFC consumption data reported in 2016-2019 under CP implementation report and Article 7 of the Protocol, respectively, based on the verification report.

Secretariat's comments

30. The Secretariat notes with appreciation the adjustments made by the Government of Honduras in the electronic system and the procedures for the implementation of the ODS import/export licensing and quota system. The Secretariat considers that these adjustments are consistent with the recommendations made by the independent verification and will significantly reduce the instances of oversights in the recording and verification of the import/export information. The Secretariat also notes that the electronic registration system for importers, suppliers, and end-users developed under stage I of the HPMP will also help facilitate the crosschecking of import/export data and contribute to a better implementation of the ODS import/export licensing and quota system.

31. The Secretariat further notes the requests submitted to the Fund and Ozone Secretariats to revise the reported HCFC consumption data for 2016 to 2019. The data has been accordingly corrected.

Recommendation

32. The Executive Committee may wish to note the update on progress toward implementing the recommendations in the verification report associated with the fifth tranche of stage I of the HCFC phase-out management plan for Honduras, including actions taken by the Government of Honduras to ensure the accuracy of country programme implementation data and Article 7 data submitted to the Multilateral Fund and Ozone Secretariats, respectively, submitted by UNIDO and contained in document UNEP/OzL.Pro/ExCom/88/18.

Jamaica: HCFC phase-out management plan (stage II – Update on the status of implementation of the measures for strengthening the licensing and quota system and monitoring and reporting of HCFC consumption recommended in the verification report) (UNDP and UNEP)

Background

33. At the 86th meeting, the Executive Committee approved in principle stage II of the HCFC phase-out management plan (HPMP) for Jamaica and the first funding tranche, and *inter alia* requested the Government of Jamaica and UNDP to provide, to the 87th meeting, an update on the status of implementation of the measures for strengthening the licensing and quota system, and the monitoring and

reporting of HCFC consumption, recommended in the verification report submitted to the 85th meeting[9] (decision 86/72(e)).

34. In response to decision 86/72(e), UNDP submitted to the 87th meeting a report on the status of implementation of activities to address the recommendations in the verification report. As not all the recommendations had been addressed, the Committee requested the Government of Jamaica and UNDP to provide to the 88th meeting, an update on the additional steps taken in relation to the recommendations in the verification report submitted to the 85th meeting (decision 87/11).

35. In response to decision 87/11, UNDP submitted to the 88th meeting a report providing the following information:

(a) The modified data reporting template for collecting HCFC and HFC data from importers was finalised after consultations with the Jamaica Air-Conditioning, Refrigeration and Ventilation Association and the importers, and would be used for data reporting for 2021 and onward;

(b) As reported to the 87th meeting, the Jamaica Customs Agency (JCA) had informed the Customs Brokers and Freight Forwarders Association of Jamaica of the correct tariff codes for HCFC blends following advice from the National Environment and Planning Agency. Subsequently, the national ozone unit, in cooperation with JCA, will continue implementing capacity building activities for custom brokers and relevant stakeholders on the use of correct tariff codes, under stage II of the HPMP;

(c) The task force on amendments to the Trade Order of 2014, for revising annual HCFC import allocations in line with stage II of the HPMP and drafting policies related to import of cooling equipment and refrigerants, met twice during the period April to September 2021; and an additional meeting has been scheduled to take place in October 2021 to finalize annual HCFC import allocations in line with stage II of the HPMP and make progress on policies related to import of cooling equipment and refrigerants; and

(d) Two national consultants have been recruited for identifying actions to further strengthen HCFC and HFC data collection and reporting systems. Based on their report to be finalized by December 2021, relevant actions will be implemented.

Secretariat's comments

36. The Secretariat noted that the Government of Jamaica, with the assistance from UNDP, continues to take steps for strengthening the licensing and quota system and monitoring and reporting of HCFC consumption. However, the amendments to the Trade Order of 2014, could not be finalised due to COVID-19-related restrictions. Upon a request for further clarification, UNDP explained that the Government continues to hold meetings of the task force to facilitate implementation of policies and regulations for HCFC controls and is taking steps to finalise expeditiously relevant regulations. Based on the report from the consultants, the relevant actions for strengthening HCFC and HFC data collection and reporting systems would be implemented during stage II of the HPMP and other HFC-related activities.

37. As not all the recommendations of the verification report submitted to the 85th meeting have been addressed, the Government of Jamaica and UNDP will provide an update to the 90th meeting.

[9] Paragraph 9 of document UNEP/OzL.Pro/ExCom/85/31 lists the actions to be implemented during the fourth tranche of stage I of the HPMP based on the recommendations in the verification report.

Recommendation

38. The Executive Committee may wish:

(a) To note the update on the status of implementation of the measures for strengthening the licensing and quota system and monitoring and reporting of HCFC consumption recommended in the verification report under stage II of the HCFC phase-out management plan for Jamaica, submitted by UNDP and contained in document UNEP/OzL.Pro/ExCom/88/18; and

(b) To request the Government of Jamaica and UNDP to provide, to the 90th meeting, an update on the additional steps taken in relation to the recommendations in the verification report submitted to the 85th meeting.

Kenya: HCFC phase-out management plan (stage II, second tranche – update on the status of the implementation of activities for strengthening monitoring and reporting of HCFC licensing and quota systems recommended in the verification report) (Government of France)

Background

39. At the 86th meeting, the Executive Committee approved the second tranche of stage II of the HPMP for Kenya. The verification report associated with the tranche request confirmed that the Government of Kenya was implementing a licensing and quota system; however, verified HCFC consumption data for 2017 to 2019 were different from the data reported under Article 7 of the Montreal Protocol. It was noted that in some instances, the data recorded by Customs did not fully capture the actual amounts that were imported, or HCFCs were imported without a license.

40. Consequently, the verification report recommended to strengthen data monitoring and reporting through *inter alia*: greater coordination and information sharing between the National Environment Management Authority (NEMA) and the Kenya Revenue Authority (KRA); implementation of information outreach programmes on an ongoing basis on HCFC monitoring and controls to importers, and regulatory agencies; and training and capacity building programmes for customs and enforcement officers on data reporting, and procedures relating to use of electronic data monitoring and reporting systems.

41. In approving the second tranche of stage II, the Executive Committee requested the Government of Kenya to submit, through the Government of France, a status report, to the last meeting of 2021, on the strengthening of the licensing and quota system for HCFCs and information sharing with KRA on HCFC imports in light of the recommendations made in the verification report.[10]

42. In response to decision 86/53(a), the Government of France submitted the following information:

(a) Representatives from the national ozone unit (NOU) and NEMA held consultations between June and September 2021 on *inter alia* the status of implementation of revised ODS regulations; ODS import licenses and permits issued; administrative matters relating to following-up on import permits with importers; issues relating to the harmonized customs (HS) codes; the integrated customs system and issues relating to HCFC customs clearances with supporting documents;

(b) Representatives from the NOU and NEMA have also discussed enforcement issues during workshops and meetings that they have been attending;

[10] Decision 86/53(a); provision contained in Annex XV of document UNEP/OzL.Pro/ExCom/86/100.

(c) Subsequent to the 2016 letters sent by the Ministry of Environment and Forestry requesting NEMA to submit copies of HCFC licenses and permits and data reports of refrigerant gases including quantities imported/exported, NEMA has been submitting copies of licenses and permits of imports and exports to KRA which helps the customs officers to check the import consignments with licenses and permits; and

(d) In February and March 2021, representatives from the NOU and NEMA visited HCFC importers to collect controlled substances data for 2020; during these visits, issues relating to HCFC importation processes, HCFC-22 phase-out deadlines applicable to Kenya, and the revised ODS Regulations that cover HFCs, were discussed.

43. The Government of France also reported that due to constraints imposed by the COVID-19 pandemic, only a training programme for 15 customs officers covering HCFC import-export licensing and quota system implementation, and monitoring and reporting issues was conducted in June 2021 (under the institutional strengthening (IS) project), and one workshop for clearing and forwarding agents was conducted in June 2021 in Mombasa covering provisions of ODS regulations, procedures for using single window system by clearing agents, procedures for issuing licenses/permits for HCFCs and update of HS codes of refrigerants and RAC equipment, as a part of IS project activities.

Secretariat's comments

44. The Secretariat noted that while the implementation of activities relating to in-person meetings and consultations for strengthening the licensing and quota system for HCFCs was affected due to COVID-19 restrictions, the NOU held discussions and exchanged information with customs and enforcement authorities, importers and clearing and forwarding agents.

45. In response to a query from the Secretariat, the Government of France explained that online training workshops are generally well accepted though there were some hesitations from trainers as they felt that in-person training and interactions would ensure better attention from trainees and serve as a better platform for sharing experiences relating to HCFC monitoring and control. Given the constraints as a result of the COVID-19 pandemic, online training of customs and enforcement officers, including those from all border control points, would need to be planned and conducted in the later part of 2021 and in 2022.

46. It was agreed that the Government of France would provide an update on activities implemented relating to strengthening of the licensing and quota system for HCFCs and information sharing with KRA on HCFC imports to the 90th meeting.

Recommendation

47. The Executive Committee may wish:

(a) To note the status report on the strengthening of the licensing and quota system for HCFCs and information sharing with Kenya Revenue Authority on HCFC imports, submitted by the Government of Kenya through the Government of France and contained in document UNEP/OzL.Pro/ExCom/88/18; and

(b) To request the Government of Kenya, through the Government of France, to provide an update on the status, at the 90th meeting, on the activities implemented for strengthening of the licensing and quota system for HCFCs and information sharing with Kenya Revenue Authority on HCFC imports.

Mexico: HCFC phase-out management plan (stage I - progress report) (UNIDO and UNDP)

Background

48. At its 84th meeting, the Executive Committee considered the last annual progress report on the implementation of the work programme associated with the fifth and final tranche of the HCFC phase-out management plan (HPMP) for Mexico,[11] in line with decision 75/29(a).[12]

49. The report indicated that all investment activities had been completed, activities in the refrigeration servicing sector were about to be completed, the funds associated with one extruded polystyrene (XPS) foam enterprise (Plásticos Espumados) that did not participate in the plan were going to be returned to the Fund, and that, in line with the Agreement between the Government and the Executive Committee, stage I of the HPMP was going to be operationally completed by 31 December 2019, and the project completion report (PCR) would be submitted no later than 30 June 2020, in line with decision 82/33(c). Accordingly, the Executive Committee decided *inter alia* to note:

(a) That the enterprise Plásticos Espumados had not participated in stage I of the HPMP and that the approved funds of US $683,300 would be returned to the Fund at the 87th meeting upon financial completion of stage I of the HPMP;

(b) The balance of US $24 that would be returned by UNIDO at the 85th meeting, and the estimated balance of US $300,000 from the conversion of the polyurethane (PU) foam sector and any remaining balance from the servicing sector, which would be returned by UNDP and UNIDO, respectively, at the 87th meeting, upon financial completion of stage I of the HPMP; and

(c) That UNDP and UNIDO would submit the final report on completion of the remaining activities under stage I of the HPMP as part of the subsequent progress report associated with stage II of the HPMP, and the stage I project completion report no later than 30 June 2020, in line with decision 82/33(c) (decision 84/22).

50. In response to decision 84/22(b) and (c), UNIDO submitted the PCR for stage I of the HPMP on 3 July 2020 and returned remaining balances from its foam and refrigeration servicing sector projects at the 86th meeting,[13] consisting of US $3,615, plus agency support costs of US $271, from the first tranche[14] and US $11,701, plus agency support costs of US $878, from the fifth tranche.[15] Furthermore, as part of the progress report associated with the request of the fourth tranche of stage II of the HPMP submitted to the 88th meeting,[16] UNIDO provided additional information corroborating the completion of all stage I activities.

51. Regarding the fund balances associated with UNDP projects (US $683,300 from the XPS foam enterprise Plásticos Espumados, US $300,000 estimated as the balance from the PU foam sector, as well as other balances from completed activities under stage I), at the 87th meeting UNDP explained that the foam sector plan had been operationally completed by the end of 2019, as agreed. However, the on-site

[11] The fifth and final tranche of stage I of the HPMP was approved at the 75th meeting at a total cost of US $1,449,982, consisting of US $226,317 plus agency support costs of US $16,974 for UNIDO, and US $1,122,503 plus agency support costs of US $84,188 for UNDP.
[12] Provision reflected in Annex XII of document UNEP/OzL.Pro/ExCom/75/85 (The Government of Mexico, UNIDO and UNDP were requested to submit progress reports on a yearly basis on the implementation of the work programme associated with the final tranche until the completion of the project).
[13] Annex IV of document UNEP/OzL.Pro/ExCom/86/4
[14] MEX/PHA/64/INV/157
[15] MEX/PHA/75/TAS/144
[16] The tranche request was withdrawn as the level of disbursement was below the 20 per cent threshold.

verification to conduct the safety evaluation and authorize the last payment to the last converted foam enterprise, which was expected to take place in December 2019, had to be rescheduled to early 2020, due to a fire in the neighbouring plant. Subsequently, due to the constraints associated with the COVID-19 pandemic, UNDP was only able to perform the final inspection and safety audit in early 2021. UNDP confirmed that it was in the process of financially completing the project and that the funds would be returned to the 88th meeting. Accordingly, the Executive Committee noted (decision 87/15):

(a) That UNDP had been unable to financially complete stage I of the HPMP for Mexico by 31 December 2020 and return balances at the 87th meeting as per decision 84/22(a) and (b), owing to delays in the final verification of and payment to one enterprise on account of restrictions imposed by the COVID-19 pandemic; and

(b) That UNDP would financially complete stage I of the HPMP for Mexico before the 88th meeting and return to the Multilateral Fund at the 88th meeting the approved funds of US $683,300 for the enterprise Plásticos Espumados, which had not participated in stage I of the HPMP, the estimated balance of US $300,000 from the conversion of the PU foam sector, and any remaining balances from stage I of the HPMP.

Secretariat's comments

52. In preparation for the 88th meeting, the Secretariat followed up with UNDP on the return of the balances referred to in decision 87/15. UNDP reported that a safety audit at the last converted foam enterprise identified a minor issue with the installed equipment that needed to be resolved before UNDP could authorize the last payment. UNDP indicated that the issue did not affect the chosen technology nor its efficiency, and that it had been addressed. UNDP has signed the handover protocol with the enterprise and the final technical visit was taking place in mid-October. However, even though the issue has now been resolved, UNDP will not be in a position to financially complete the project and return the funding prior to the 88th meeting. UNDP expects to complete this process before the end of this year. Accordingly, the Secretariat notes that UNDP will return the balances at the 90th meeting.[17]

Recommendation

53. The Executive Committee may wish to note:

(a) That UNDP was unable to financially complete stage I of the HCFC phase-out management plan (HPMP) for Mexico before the 88th meeting and return balances at the 88th meeting, as per decision 87/15(b), owing to the need to resolve an issue identified in the safety audit of the last converted enterprise to allow the release of the last payment; and

(b) That UNDP will financially complete stage I of the HPMP for Mexico before 31 December 2021 and return to the Multilateral Fund the approved funds of US $683,300 for the enterprise Plásticos Espumados, which did not participate in stage I of the HPMP, the estimated balance of US $300,000 from the conversion of the polyurethane foam sector, and any remaining balances from stage I of the HPMP at the 90th meeting.

[17] The 89th Executive Committee meeting will discuss policy issues only.

Saint Lucia: HCFC phase-out management plan (stage I, fifth tranche – Update on the status of the signing of the small-scale funding agreement (SSFA) and disbursement of the first instalment under the SSFA) (UNEP and UNIDO)

Background

54. At the 87th meeting, the Executive Committee approved the fifth tranche of stage I of the HPMP for Saint Lucia on the understanding that UNEP would sign the SSFA with the Government for the tranche no later than 15 November 2021 and requested UNEP to report to the 88th meeting on the status of signing the SSFA and disbursement of the first installment under the SSFA (decision 87/28(a)).[18]

55. In line with the decision, UNEP informed that the SSFA for the fifth tranche was drafted and shared with the country for comments on 27 August 2021. Due to restrictions relating to COVID-19 pandemic, comments from the Government were received on 16 September 2021. Subsequently, UNEP submitted a revised version to the Government for their final clearance which was expected by 1 October 2021.

56. UNEP informed that once clearance is received, the SSFA was expected to be signed by UNEP and by the Government no later than 29 October 2021, and the first installment under the SSFA would be transferred by 5 November 2021.

Secretariat comments

57. Upon a request for clarification, UNEP indicated that it will work closely with the national ozone unit to ensure that the SSFA is signed and the first installment is transferred within the expected timelines.

58. It was agreed that UNEP would provide an update on the signature of the SSFA and the transfer of first instalment during the intersessional approval process (IAP) established for the 88th meeting.

Recommendation

59. The Executive Committee may wish:

(a) To note the update on the status of the signing of the small-scale funding agreement (SSFA) for the implementation of the fifth tranche of HCFC phase-out management plan (HPMP) for Saint Lucia and disbursement of the first instalment under the SSFA, submitted by UNEP and contained in document UNEP/OzL.Pro/ExCom/88/18; and

(b) To request UNEP to provide an update, during the intersessional approval process established for the 88th meeting, on the signing of the SSFA for the fifth tranche of stage I of the HPMP for Saint Lucia and disbursement of the first instalment under the SSFA.

Libya: HCFC phase-out management plan (stage I – progress report) (UNIDO)

Background

60. At their Twenty-seventh Meeting, the Parties noted that the annual HCFC consumption of 144.0 ODP tonnes reported by Libya for 2013 and 122.4 ODP tonnes for 2014 exceeded the country's maximum allowable consumption of 118.38 ODP tonnes for those controlled substances for those years, and that Libya was therefore in non-compliance with the consumption control measures for HCFCs under the Protocol. The Parties also noted with appreciation the submission by Libya of a plan of action to ensure

[18] Annex XI of document UNEP/OzL.Pro/ExCom/87/58

its return to compliance with the Protocol's HCFC control measures, under which Libya specifically committed itself to reducing HCFC consumption from 122.4 ODP tonnes in 2014 to no greater than:

(a) 122.30 ODP tonnes in 2015;

(b) 118.40 ODP tonnes in 2016 and 2017;

(c) 106.50 ODP tonnes in 2018 and 2019;

(d) 76.95 ODP tonnes in 2020 and 2021; and

(e) The levels allowed under the Montreal Protocol in 2022 and subsequent years.

61. Subsequently, at its 75th meeting the Executive Committee approved stage I of the HCFC phase-out management plan (HPMP) for Libya to facilitate its implementation of the plan of action to return to compliance. The control targets proposed in the plan of action were used as the Montreal Protocol control targets for stage I.

62. At its 82nd meeting, the Committee approved the second and final tranche of stage I of the HPMP and requested the Government of Libya and UNIDO to submit a progress report on the implementation of the work programme associated with the final tranche, and a verification report on consumption each year until the completion of stage I (decision 82/75).

63. At its 84th meeting, the Executive Committee noted *inter alia* the challenging security situation in the country and extended stage I of the HPMP to 31 December 2021 on the understanding that a revised draft Agreement between the Government of Libya and the Executive Committee would be submitted at the 86th meeting, along with the progress report on implementation of the work programme and a verification report (decision 84/20).

64. At its 86th meeting, the Executive Committee took note of the annual progress report and that the Agreement between the Government of Libya and the Executive Committee covering the period from 2015 to 2021 had been updated.

65. In line with decision 82/75(c), on behalf of the Government of Libya, UNIDO as lead implementing agency, has submitted the above-mentioned progress report and the verification report.

HCFC consumption

66. The Government of Libya reported a consumption of 75.00 ODP tonnes of HCFCs in 2020, which is 1.95 ODP tonnes lower than the control target set in the plan of action for that year. HCFC consumption has been decreasing since 2014 due to the implementation of the HPMP, particularly through the enforcement of the licensing and quota system, which has limited imports of HCFCs; and the shifting of the market to HCFC alternatives, mainly to HFCs and HFC blends. The reduction in HCFC consumption is also due to the security and economic situation in the country.

Verification report

67. The verification report confirms that the Government is implementing a licensing and quota system for HCFC imports and exports, and that Libya was in compliance with the Montreal Protocol control target in 2020.

Progress report

68. The implementation of the HPMP has been hindered considerably by the unstable political and security situation in the country. In the last quarter of 2020, the security situation improved and a Government of National Unity was established. The new Government changed the Environment General Authority (EGA) to the Ministry of Environment. This would allow the national ozone unit (NOU) to implement the outstanding activities under the HPMP and further obtain Parliament's approval for the ratification of the Kigali Amendment.

69. The implementation of the foam conversion projects has resumed. Several equipment items for Al-Najah (using 105.37 metric tonnes (mt) of HCFC-141b in the manufacturing of polyurethane (PU) foam for continuous panel) has been delivered; additional equipment, including cyclopentane drums and a power generator, have been procured and are expected to be delivered by November 2021 followed by installation, commissioning and training. Due to the travel ban to Libya, the supplier's engineers and training personnel are unable to undertake the installation, commissioning and training. UNIDO is discussing with the supplier alternative options for the completion of the conversion. It is expected that the project will be completed by August 2022.

70. The conversion at Al-Amal Alkhadar Company (using 17.53 mt of HCFC-141b in the manufacturing of PU foam discontinuous panels) has been delayed due to the situation in the country. In 2017, UNIDO signed a purchase order with the equipment supplier and equipment was subsequently manufactured but delivery was interrupted; currently, the equipment supplier, UNIDO and the NOU have been discussing options to deliver the equipment to the country. It is expected that the conversion project will be completed by October 2022.

71. The following activities were conducted in the servicing sector:

(a) An international expert and a national expert were employed to develop the training curriculum and manual for customs officers; and the training of three master trainers and 25 customs officers in ODS trade control, enforcement of the licensing and quota system, data recording and identification of ODS, has been planned for November 2021;

(b) Updating the training curriculum and developing training manuals for technicians; the training of 35 technicians in HCFC phase-out, theory of cooling, and good servicing practices during installation, servicing, and maintenance of refrigeration and air-conditioning systems has been planned for January 2022;

(c) A list of equipment and tools for the training of servicing technicians and for practical use by technicians has been developed and agreed with the NOU (including refrigerant identifiers, dual stage vacuum pumps, refrigeration tool kits, leak detectors, portable charging station for hydrocarbons); procurement has been initiated; and the equipment is expected to be delivered to Libya by December 2021;

(d) Developing the national standard and code of good servicing practices; the draft version was expected to be finalized by October 2021;

(e) Developing the national guidelines for establishing national reclamation centres; provision of 30 portable recovery units to the NOU; procurement of equipment for national refrigerant reclamation centres; and the equipment was expected to be delivered by the end of October 2021; and

(f) A seminar/workshop was organized in November 2020 to present the Montreal Protocol, Libya’s commitment to HCFC phase-out and the licensing and quota system; and awareness materials were distributed.

Level of fund disbursement

72. As at October 2020, of the US $1,161,310 approved for stage I of the HPMP,[19] US $711,521 (representing 61 per cent) had been disbursed. The balance of US $449,789 will be disbursed in 2022 and 2023.

Secretariat’s comments

Legal framework

73. The Government has issued quotas for 2021 at the level of 75 ODP tonnes, which is below the Montreal Protocol control target for that year.

Progress report

74. Noting that, in paragraph 2(c) of decision XXVII/11, the Parties noted the commitment of the Government to imposing a ban on the procurement of HCFC-based air-conditioning equipment in the near future and to considering a ban on the import of such equipment, the Secretariat enquired about the status of implementation of such ban.

75. UNIDO responded that the Ministry of Environment will accelerate the coordination with concerned sectors to determine the timeframe of the control procedure for issuing the ban. The main obstacles in taking a decision is the division of state institutions that could hinder the implementation of the procedure in all provinces. It is expected that the Government will be able to start banning the import of HCFC-based equipment during 2023.

76. Stage I will be completed by 31 December 2022 as per paragraph 14 of the Agreement approved at the 86th meeting[20].

Recommendation

77. The Executive Committee may wish to note the progress report on the implementation of stage I of the HCFC phase-out management plan for Libya, submitted by UNIDO and contained in document UNEP/OzL.Pro/ExCom/88/18.

<u>Saint Vincent and the Grenadines: HCFC phase-out management plan (report on the progress made in improving the licensing and quota system and strengthening customs’ capacity for import control)</u> (UNEP and UNIDO)

Background

78. The Government of Saint Vincent and the Grenadines implemented a single-stage HCFC phase-out management plan (HPMP) and submitted the fourth tranche of the HPMP to the 86th meeting. While reviewing the submission, the Secretariat noted the data discrepancies highlighted in the verification report

[19] The funding tranche was adjusted after deducting US $747,533 associated with the cancellation of the conversion of one enterprise in the foam sector (Alyem); these funds have been returned to the Multilateral Fund.
[20] Annex VIII of document UNEP/OzL.Pro/ExCom/86/100.

and the deficiency in the licensing and quota system. It was agreed that the Government with the assistance from UNEP would take the following measures to further strengthen the licensing and quota system:

(a) Data reconciliation with customs on a half-yearly basis with a view to having a shared database between the national ozone unit (NOU) and customs; and reporting data under Article 7 of the Protocol based on the reconciled consumption starting from 2020;

(b) Updating to the new harmonized system (HS) codes to enable better identification of individual HCFCs no later than 30 June 2023; and training for customs brokers and importers on the use of correct HS codes and proper classification of HCFCs, refrigerants and their products and data entry in ASYCUDA;[21] and

(c) Providing customs with a list of importers and HCFC quotas issued before 1 January of each year to ensure that customs are prepared to support the enforcement of the licensing and quota system; and the Government will effect this change from 1 January 2022 to allow time for the sector to prepare for the adjustment.[22]

79. Subsequently, the Executive Committee approved the fourth tranche of the HPMP and requested the Government of Saint Vincent and the Grenadines, UNEP and UNIDO to submit a report to the 88th meeting on the progress made in improving the licensing and quota system and strengthening customs' capacity for import control (decision 86/53(a)).

80. In response to decision 86/53(a), on behalf of the Government of Saint Vincent and the Grenadines, UNEP has submitted the requested report, providing the status of implementation of the activities to strengthen the licensing and quota system as follows:

(a) The NOU under the Ministry of Finance, Economic Planning, Sustainable Development and Information Technology provided a list of all registered importers and HCFC quotas to the Customs Department on 4 January 2021, to ensure that customs is fully prepared to support the enforcement of the licensing and quota system;

(b) The half-year reconciliation of HCFC import data between customs and the NOU did not occur in June 2021 due to the eruption of the La Soufriere volcano and the subsequent recovery efforts. The Customs Department has been overwhelmingly engaged in urgent import activities related to relief operations; the reconciliation exercise is now planned for the end of 2021;

(c) Discussion with the Customs Department on the adoption of the new HS codes to enable better identification of individual HCFCs was delayed as the Government wishes to adopt the latest update by the World Customs Organization (WCO) in 2022; the discussion will begin once the latest version of the HS codes is released; and

(d) Training of customs brokers and importers on the use of correct HS codes, proper classification of HCFCs and their products, and data recording in the ASYDCUDA system was delayed due to the restrictions imposed by the COVID-19 pandemic and the subsequent volcano eruption; it has been rescheduled for 2022.

[21] The UN Conference on Trade and Development Automated System for Customs Data.
[22] Paragraph 14 of document UNEP/OzL.Pro/ExCom/86/73

Secretariat's comments

81. The Government of Saint Vincent and the Grenadines is planning to undertake a national process to legislate the HS codes to enable differentiation of individual HCFCs, which is a complex legislative amendment process, once the WCO releases the 2022 version of the HS codes.

82. The Secretariat noted that the Government has started to share the list of all registered importers and HCFC quotas with the Customs Department; however, due to the natural disaster, the COVID-19 pandemic and priority actions to address them, the Government was unable to implement some of the recommendations contained in the verifications report. The Secretariat considers it important that UNEP and UNIDO continue assisting the Government to further strengthen its licensing and quota system and its data reporting system and continue reporting on progress in this regard.

Recommendation

83. The Executive Committee may wish:

(a) To note the report on the progress made in improving the licensing and quota system and strengthening customs' capacity for import control under the HCFC phase-out management plan (HPMP) for Saint Vincent and the Grenadines, submitted by UNEP and contained in document UNEP/OzL.Pro/ExCom/88/18; and

(b) To request the Government of Saint Vincent and the Grenadines with the assistance of UNEP and UNIDO to continue implementing planned activities to further strengthen the licensing and quota system and to report on the progress achieved in the annual progress report of UNEP and when the request for the third tranche of the HPMP is submitted.

<u>Saudi Arabia: HCFC phase-out management plan (stage I – progress report on the implementation of the remaining activities</u> (UNEP)

84. On behalf of the Government of Saudi Arabia, UNEP submitted a progress report on the implementation of the remaining activities in the refrigeration servicing sector, customs training and monitoring of stage I of the HCFC phase-out management plan (HPMP), in line with decision 86/16(f)(ii).

Progress report

85. The following activities were undertaken:

(a) Continued meetings of the National Ozone Committee on the development of ODS policies and regulations; a new regulation for ODS entered into force on 13 January 2021 incorporating the updated Gulf Cooperation Council (GCC) regulations; two meetings for thirty participants, one in December 2020 and the second a virtual meeting in January 2021, to raise awareness on the new regulation; and development of a website on the new regulation. A regulation related to the certification of refrigeration and air-conditioning (RAC) technicians was issued on 22 January 2017, while the development of a regulation to ban disposable cylinders was ongoing;

(b) Development of an e-licensing system that allows importers and exporters to submit requests electronically; improvements to that website and integration of the national ozone unit (NOU) and relevant stakeholders to the e-licensing system are ongoing;

(c) A meeting in April 2021 with the Technical and Vocational Training Corporation (TVTC) on the development of a national code of good practice for RAC technicians, which is ongoing; and a meeting to discuss the technician certification scheme with the Saudi Council of Engineers, the entity responsible for certifying technicians;

(d) The training curriculum at the TVTC was updated to include safe handling, servicing, and installation of flammable refrigerant-based RAC equipment and a workshop on good servicing practices was held for 27 RAC technicians; the NOU was working with the TVTC to reactivate the memorandum of understanding (MOU), which had expired, to cooperate on the training and certification program implementation; and

(e) Three workshops were held in 2019 with foam manufacturing enterprises to raise awareness of low-global warming potential (GWP) blowing agents, and monitoring visits to converted manufacturers were undertaken.

Secretariat's comments

86. Regarding the regulation related to the certification of RAC technicians, UNEP clarified that under the law related to practicing engineering professions, engineers are only able to practice after obtaining their professional accreditation; technicians with a diploma, which includes TVTC graduates, are considered engineering professionals in Saudi Arabia. To date, 107 technicians have been trained under the HPMP, of which 59 were certified; it was not clear how many technicians are in the country, nor the prevalence of certification amongst those technicians.

87. Regarding the four conditions related to the servicing sector specified in Appendix 8-A of the Agreement between the Executive Committee and the Government of Saudi Arabia, the Secretariat noted:

(a) The development of the ban on disposable cylinders is ongoing; it was unclear when the ban was expected to be implemented;

(b) While there is a regulation requiring the engineering professions be certified, it appears that a small number of technicians in the country are certified; currently TVTC was discussing reactivating the previous MOU with the NOU to undertake trainings included under the HPMP; and the code of practice for technicians was in the process of being updated;

(c) Regarding the introduction of a system regulating access to refrigerants only to entities where certified technicians are carrying out and supervising the work on servicing RAC systems, UNEP clarified that while there is no regulation only allowing sale of refrigerants to certified technicians, the newly adopted regulation requires all entities to have certified technicians and that uncompliant entities would face penalties. The implementation of that regulation, combined with the training and certification of a substantial number of technicians, and the implementation of a code of good practice, would represent the implementation of such a system; and

(d) Regarding a strategy to encourage end-users of RAC equipment to carry out leak detection and repair measures, UNEP clarified that all control measures and ODS regulations are being introduced in the implementation of the new regulation. The Secretariat understands that the code of good practice, once finalized, would include such measures;

88. As the end date of the small-scale financing agreement (SSFA) between the Government of Saudi Arabia and UNEP was 31 December 2021, and noting a balance of US $129,400, UNEP was discussing with the Government on extending the SSFA. The Secretariat recalled that, in line with decision 86/16(f)(iii), the stage II of the HPMP for Saudi Arabia would be considered only after the project

completion report of stage I of the HPMP had been submitted, stage I of the HPMP had been financially completed and all funding balances had been returned to the Multilateral Fund.

Recommendation

89. The Executive Committee may wish to note the annual progress report on the implementation of the activities remaining from stage I of the HCFC phase-out management plan for Saudi Arabia (decision 86/16(f)(ii)) submitted by UNEP, and contained in document UNEP/OzL.Pro/ExCom/88/18.

Low-GWP projects

Egypt: Final report on the project to promote low-global-warming-potential refrigerants for the air-conditioning industry in Egypt (EGYPRA) (UNIDO)

Background

90. On behalf of the Government of Egypt, UNIDO submitted to the 84th meeting the report on the project on the promotion of low-global-warming-potential (GWP) refrigerants for the air-conditioning (AC) industry in Egypt (EGYPRA).[23] While almost all activities under EGYPRA had been completed by that time, additional time was required to complete the testing for the central AC units which have already been built, as an accredited independent laboratory to test units larger than 65,000 British Thermal Unit (BTU)/hr using flammable refrigerants could not be found, and to draft the final report, and develop a modelling tool that can be used by local manufacturers. Accordingly, the Executive Committee approved the extension of stage I of the HPMP to 30 June 2020 to allow completion of EGYPRA (decision 84/17(c)), and requested the Government of Egypt and UNIDO to submit the final report on EGYPRA at the 86th meeting (decision 84/17(d)).

91. At the 86th meeting, UNIDO reported[24] that the planned work on the modelling tool was completed; further improvements to the model would be conducted under the second tranche of stage II of the HPMP. However, testing of the central AC units had been delayed due to the unavailability of the testing laboratory due to the COVID-19 pandemic. UNIDO expected the testing could be carried out in the last quarter of 2020, the results analyzed, and the final report drafted in the first quarter of 2021. Upon a request by UNIDO the Executive Committee approved an extension of stage I of the HPMP to 30 June 2021, and requested the Government of Egypt and UNIDO to submit the final report on EGYPRA at the 87th meeting (decision 86/24).

92. In line with decision 86/24, on behalf of the Government of Egypt, UNIDO submitted to the present meeting the final report on EGYPRA.

93. An independent suitable laboratory to tests the units was found, and the tests were partially conducted since only two of the originally planned four prototypes could be tested. In particular, the prototypes working with one of the alternatives (R-448B) could not be tested due to a mechanical problem with the prototypes and the HCFC-22 baseline unit that could not be resolved in time; accordingly, only the prototypes with R-457A and R-454C could be tested. However, neither of the baseline HCFC-22 units provided by the original equipment manufacturers (OEMs) for those alternatives met the nameplate capacity.

94. The limited testing undertaken suggests that R-457A performed better than HCFC-22, while R-454C performed worse; however, it was difficult to draw a conclusion due to performance problems with both HCFC-22 baseline units provided by the OEMs. Moreover, the better performance of R-457A relative

[23] UNEP/OzL.Pro/ExCom/84/49
[24] UNEP/OzL.Pro/ExCom/86/21

to HCFC-22 for the central units is different from the finding with the split units, which generally performed worse than HCFC-22.

95. The final report is attached to the present document.

Secretariat's comments

96. UNIDO noted that one lesson from the project was that the Egyptian equipment manufacturers' lack of facilities capable to test equipment with capacities larger than 60,000 BTU/hr hinders their capability to manufacture units conforming to their base design, which slows industry's innovation and conversion to low-GWP technologies. The OEMs had redesigned the prototype and base units, but they could not be tested as their controls failed at the high temperatures of the tests. Although EGYPRA was now completed, OEMs were still optimizing prototype and base units, which can inform the ongoing conversions in the commercial AC sector under stage II of the HPMP.

97. The Secretariat recalled that at the 84th meeting, it was reported that an international manufacturer had provided a micro-channel heat exchanger for a central unit, and that an OEM was building R-444B-based central unit prototype with that micro-channel heat exchanger. UNIDO clarified that the prototype could not successfully be built and, therefore, was not tested. Additional work on the micro-channel heat exchanger may be included in the technical assistance to the commercial AC sector under stage II of the HPMP.

98. Neither R-457A nor R-454C are among the main refrigerants adopted for AC applications worldwide. UNIDO clarified that the selection of refrigerants for prototype testing was informed by transitions in the AC market at the time the prototypes were selected, designed and built. In particular, at that time, Egyptian equipment manufacturers were only using HCFC-22 for their central units and hence alternatives to HCFC-22 were selected. By the time the units were tested, R-410A and its alternatives were the dominant technology in the market, but it was not possible to rebuild new prototypes with R-410A alternatives. It should be noted that one of the alternatives tested (R-457A) is not currently offered by its manufacturer for commercial use.

99. At the 84th meeting, the Secretariat had prepared a comprehensive summary of the report submitted to that meeting given its relevance to the selection of low-GWP alternatives in the AC manufacturing sector. As the findings related to central AC units in the final report of EGYPRA were inconclusive, the Secretariat's summary from the 84th meeting is contained in Annex I of the present document for ease of reference.

Recommendation

100. The Executive Committee may wish:

(a) To note the final report on the project to promote low-global-warming-potential (GWP) refrigerants for the air-conditioning industry in Egypt (EGYPRA), submitted by UNIDO and contained in document UNEP/OzL.Pro/ExCom/88/18; and

(b) To invite bilateral and implementing agencies to take into account the report referred to in sub-paragraph (a) above when assisting Article 5 countries in preparing projects for the conversion of air-conditioning manufacturing to low-GWP refrigerants.

Saudi Arabia: Demonstration project on promoting HFO-based low-global-warming-potential refrigerants for the air-conditioning sector in high ambient temperatures (progress report) (UNIDO)

Background

101. On behalf of the Government of Saudi Arabia, UNIDO submitted to the 87th meeting a progress report on the demonstration project on promoting hydrofluoroolefin (HFO)-based low-global-warming-potential (GWP) refrigerants for the air-conditioning (AC) sector in high ambient temperatures.

102. The project was approved at the 76th meeting to manufacture, test and optimize pilot model air-conditioners with low-GWP HFO/HFC blends as well as R-290, to undertake a demonstration production run and to convert a production line, at the amount of US $1,300,000, plus agency support costs of US $91,000 for UNIDO.

103. At its 80th meeting, the Executive Committee agreed to extend the project, from May 2018 to 31 December 2018, on the understanding that no further extension would be requested, and to request the implementing agencies to submit the final report no later than the 83rd meeting (decision 80/26(g)). Subsequently, a succinct progress report was submitted to the 82nd meeting documenting substantial progress on many activities, including procurement of equipment and delivery of components (e.g., compressors), with delivery of production equipment and production of first R-290 units still pending. Those activities were expected to be completed by December 2018.

104. At the 83rd meeting, it was reported that while manufacturing equipment was delivered, installation was still pending as the enterprise had decided to move the manufacturing line. The enterprise was planning to nonetheless preliminarily install the equipment so that a test run could be undertaken and personnel trained; the line would be moved by September 2019. Further testing and optimization of the units was required. Completion of those activities, as well as a workshop to disseminate the project results, was expected by December 2019. Accordingly, the Executive Committee decided to extend, on an exceptional basis, noting the advanced progress in implementation and the potential replicability of the results in several Article 5 countries, the completion date of the project to 31 December 2019, on the understanding that no further extension of project implementation would be requested; and requested UNIDO to submit the final report for the project no later than the 85th meeting and to return all remaining balances by the 86th meeting (decision 83/33).

105. At the 85th meeting, it was reported that further testing and optimization of the units was undertaken; a fully functional prototype R-290 mini-split AC unit with a capacity of 18,000 British Thermal Unit (1.5 tonnes of refrigeration) was developed. However, third-party testing had not yet been performed pending the receipt of a new batch of prototype compressors and finding a suitable laboratory.

106. The manufacturing line was moved, civil works completed and all the equipment, including a complete quality control system, had been installed. However, commissioning of the line, which had been expected in February 2020, was delayed given the COVID-19 pandemic; testing of the manufacturing line was planned for as soon as travel restrictions that have been imposed due to COVID-19 are lifted. Similarly, while the laboratories and real-life testing rooms had been upgraded with the required equipment and instrumentation, commissioning was delayed. Other outstanding activities include conducting the training of the technicians on the manufacturing line and the final workshop to disseminate the project results to stakeholders. Accordingly, the Executive Committee decided to extend the completion date of the project to 15 December 2020, on an exceptional basis, given the COVID-19 pandemic and the advanced progress achieved; and requested UNIDO to submit the final report of the project no later than 1 January 2021 and to return all remaining balances by the 87th meeting (decision 85/17(b) and (c)).

Progress report

107. In line with decision 85/17, UNIDO submitted a report of the project on 1 October 2021. However, within the limited time available, the Secretariat was unable to conclude a thorough review of the report, including discussions with UNIDO.

108. In its preliminary review, the Secretariat noted that due to the continuous constrains from the COVID-19 pandemic, the following activities have not been completed: commissioning of the manufacturing line and safety components for the laboratories by the Italian equipment provider (who has not been able to travel); delivery of R-290 inverter compressors;[25] a trial manufacturing run of the converted line; certification of the R-290 AC equipment;[26] finalization of the servicing manual and training materials for technicians; and conducting a workshop to disseminate the project results. Noting that the ongoing activities could be completed in the near future, the Secretariat recommends, on an exceptional basis, extending the date of completion of the project to 15 March 2022, and requesting UNIDO to submit the final report of the project no later than 28 March 2022.

Recommendation

109. The Executive Committee may wish:

(a) To note the progress report on the demonstration project on promoting hydrofluoroolefin-based low-global-warming-potential refrigerants for the air-conditioning sector in high ambient temperatures in Saudi Arabia, submitted by UNIDO and contained in document UNEP/OzL.Pro/ExCom/88/18;

(b) To extend the completion date of the project referred to in sub-paragraph (a) above to 15 March 2022 on an exceptional basis given the COVID-19 pandemic and the advanced progress achieved; and

(c) To request UNIDO to submit the final report of the project referred to in sub-paragraph (a) above no later than 28 March 2022 and to return all remaining balances by the 90th meeting.

[25] An initial batch of R-290 compressors that had been procured were not delivered as they did not pass the manufacturer quality criteria; the compressor manufacturer was able to resolve the quality problem and shipment of the compressors is pending due to the COVID-19 pandemic.
[26] In line with Gulf Cooperation Council (GCC) regulations for placement on the market of air-conditioners, certification (referred to as G-mark certification) is required.

Demonstration projects in servicing sector

Tunisia: HCFC phase-out management plan (stage I – final progress report) (UNIDO/UNEP/Government of France)

Background

110. In response to decision 86/30(c),[27] UNIDO as the lead implementing agency, submitted on behalf of the Government of Tunisia the annual progress report on the implementation of the work programme associated with the third and final tranche of the HCFC phase-out management plan (HPMP) as summarized below.

HCFC consumption

111. The Government of Tunisia reported a consumption of 23.24 ODP tonnes of HCFCs in 2020, which is 43 per cent below the HCFC baseline for compliance of 40.7 ODP tonnes and 10 per cent below the maximum allowable consumption of 25.91 ODP tonnes set in its Agreement with the Executive Committee.

112. The Government of Tunisia had issued a quota of 23.63 ODP tonnes for 2021, which is lower than the maximum allowable consumption in its Agreement with the Executive Committee.

Progress report

113. As at September 2021, the following activities were implemented:

(a) The refrigeration technician certification system was made consistent with the requirements of the European F-gas regulation, and the minimum requirements for the training centres (i.e., vocational schools organizing the training activities) have been finalized. The regulation is expected to be approved before the end of 2021, and the certification programme is currently being implemented under stage II of the HPMP;

(b) A new module for certification training on safety measures when handling natural and flammable refrigerants was developed and used in 15 training sessions resulting in the training of 112 refrigeration and air-conditioning technicians (of which 50 are trainers);

(c) The criteria for the pilot conversion demonstration project had been finalized, and a supermarket (Magasin Central) has been selected as the beneficiary end-user; the commercial refrigeration cabinets in the supermarket will be converted to R-290-based technology; and

(d) Fifteen customs officers were trained on control and identification of HCFCs and HFCs and on the monitoring of the import and export license system for HCFCs/HFCs.

Level of fund disbursement

114. As at September 2021, of the total of US $700,458 approved for stage I of the HPMP, US $678,816 (representing 97 per cent) had been disbursed. The balance of US $21,642 will be disbursed by December 2021.

[27] The Government of Tunisia, UNIDO, UNEP, and the Government of France were requested to submit progress reports on the implementation of the work programme associated with the final tranche on a yearly basis until the completion of the project, verification reports until approval of stage II of the HPMP and the project completion report to the 88th meeting.

Secretariat's comments

115. The Secretariat noted that despite the COVID-19 pandemic, some activities for the third tranche were conducted.

116. UNIDO explained that the end-user incentive programme (to be implemented through the Government of France), while it had experienced delays due to the pandemic, the conversion to R-290 technology will take place in November 2021, followed by a field workshop to disseminate technical assistance and advice for owners of small installations to encourage their conversion to low-global warming potential refrigerants relevant to their applications. The activity will be completed by end of December 2021. In line with decision 84/84(d), the Government of France will submit a detailed report on the results of the pilot demonstration project to the 90th meeting to allow the Secretariat to develop fact sheets to inform future projects.

117. UNIDO also confirmed that the completion of stage I of the HPMP is as scheduled for 31 December 2021.

Recommendation

118. The Executive Committee may wish:

(a) To note the final progress report on the implementation of stage I of the HCFC phase-out management plan for Tunisia, submitted by UNIDO and contained in document UNEP/OzL.Pro/ExCom/88/18; and

(b) To request the Government of France to submit a detailed report on the results of the pilot demonstration project for the use of zero-ODP and low-global warming potential alternative technologies by small and medium users in the servicing sector to the 90th meeting, to allow the Secretariat to develop fact sheets to inform future projects, in line with decision 84/84(d).

<u>Tunisia: HCFC-phase out management plan (stage II - Change of technology for a foam manufacturing enterprise (Le Panneau))</u> (UNIDO)

Background

119. At the 84th meeting, the Executive Committee approved in principle, stage II of the HCFC phase-out management plan (HPMP) for Tunisia[28] for the period 2020 to 2025, to reduce HCFC consumption by 67.5 per cent of the baseline, in the amount of US $1,564,946, plus agency support costs.

120. Stage II of the HPMP included a foam sector plan for the conversion of two enterprises, GAN and Le Panneau, to hydrocarbon blowing agents that would result in the phase out of 7.38 ODP tonnes of HCFC-141b, of which 5.02 ODP tonnes were eligible for funding. Funding approved was based on the eligible consumption as shown in Table 3.

[28] UNEP/OzL.Pro/ExCom/84/60

Table 3. Incremental costs approved for the polyurethane foam sector in stage II

Enterprise	Consumption (HCFC-141b in imported polyols)				Cost (US $)	Cost-effectiveness (US $/kg)
	Actual		Eligible for funding			
	Metric tonnes	ODP tonnes	Metric tonnes	ODP tonnes		
GAN	52.5	5.78	35.76	3.93	350,001	9.79
Le Panneau	14.5	1.60	9.88	1.09	108,305	10.96
Total	**67.0**	**7.38**	**45.64**	**5.02**	**458,306**	**10.04**

121. Given the low level of eligible consumption, the conversion to n-pentane at Le Panneau would require a high funding contribution by the enterprise for retrofitting the foaming machine and installing all the safety systems and equipment for the use of a flammable blowing agent (estimated at US $313,500[29]). On this basis, the enterprise had technical discussions with a local systems house that could provide HFO-polyol system and understood the technical requirements and the additional costs of HFO-systems as compared to n-pentane-systems (i.e., US $131,133). Further to those discussions, the enterprise submitted a request to change the originally requested technology to HFO-1233zd(E)-based technology.[30] The enterprise has committed to cover the higher cost of the HFO blowing agent.

122. Subsequently, in accordance with paragraph 7(a)(v) of the Agreement between the Government of Tunisia and the Executive Committee, the Government through UNIDO has submitted a request to change the technology for Le Panneau from n-pentane-based foam blowing agents to HFO-1233zd.

Secretariat's comments

123. Upon a request for clarification, UNIDO explained that the other enterprise GAN was proceeding with the conversion to cyclopentane as originally approved without cost-related issues, and that there were no other foam enterprises using HCFC-141b in Tunisia.

124. UNIDO further explained that HFO-1233zd is readily available, and can be imported from Egypt and European countries. Concerning the price of HFO, UNIDO emphasized that the incremental operating costs provided to the enterprise would be sufficient for them to convert, and that the enterprise commits to continue using the HFO-technology once the enterprise has been converted ensuring the long-term sustainability of the conversion.

125. The Secretariat reviewed the proposed costs for the conversion based on the new technology vis-à-vis the project costs for Le Panneau approved at the 84th meeting. Based on the information provided, UNIDO indicated that the enterprise will utilize the funding provided of US $108,305 to Le Panneau to convert to HFO noting that the total cost calculated was US $131,133; the enterprise will finance the remaining amount. Since both HFO and cyclopentane blowing agents are low-global-warming potential (GWP) technologies, the greenhouse gas impact is expected to be negligible. UNIDO also indicated that with this technology change, the enterprise will be able to convert their manufacturing operations by June 2022.

126. The Secretariat also noted that the technology change would result in sustained adoption of low-GWP technologies in the enterprise and will facilitate the achievement of compliance targets of Tunisia.

[29] The total incremental capital costs agreed for Le Panneau at the 84th meeting was US $313,500 out of which only US $108,000 was approved, adjusted based on the remaining eligible consumption for funding.
[30] Letters confirming this technology change from the Ministry of Local Affairs and the Environment of Tunisia dated 16 August 2021, were provided.

Recommendation

127. The Executive Committee may wish:

(a) To note the request submitted by UNIDO on behalf of the Government of Tunisia for a change of technology in the conversion of an enterprise, Le Panneau, from n-pentane based foam blowing agent to HFO-1233zd in stage II of the HCFC phase-out management plan for Tunisia as contained in document UNEP/OzL.Pro/ExCom/88/18; and

(b) To approve the change of technology mentioned in sub-paragraph (a) above, on the understanding that any additional costs for the conversion would be covered by the enterprise.

ODS waste disposal

Brazil: Pilot demonstration project on ODS waste management and disposal (progress report) (UNDP)

Background

128. UNDP, as designated implementing agency, submitted the progress report on the implementation of the pilot demonstration project on ODS waste management and disposal in Brazil, in line with decision 79/18(c)(iii).[31]

Progress report

129. At the 86th meeting, UNDP reported that Essencis[32] had incinerated 3,386 kg of waste ODS from one of the reclaim centres (Ecosuporte), and that additional waste ODS from two additional reclaim centres (Frigelar and CRN[33]) was in the pipeline for incineration.

130. UNDP has reported to the present meeting that the license given to Essencis for waste ODS incineration was renewed in August 2021, and that in total, 14,223 kg of waste ODS had been received from five reclaim centres, out of which 8,655 kg have been incinerated (including the 3,386 kg that was previously incinerated); the remaining 5,568 kg will be incinerated by mid-2022. Another reclaim centre (Regentech) has also indicated that some waste ODS will be transported to Essencis for incineration in early 2022.

131. As stipulated in the MOUs between UNDP and the reclaim centres,[34] their laboratories are regularly monitored and reports are prepared by these centres containing information on purity analysis tests of the waste ODS carried out, and licenses related to the laboratories activities. The gas chromatography

[31] To request UNDP to submit annual progress reports for the pilot ODS disposal projects in Brazil and Colombia as "projects with specific reporting requirements" until the projects had been completed.
[32] Incineration facility in Brazil that has authorization from CETESB (Companhia Ambiental do Estado de São Paulo) for destruction of waste ODS.
[33] Centro de Regeneração e Reciclagem do Nordeste.
[34] MOUs were signed with four reclaim centres to enable them to implement activities such as increased storage capacity and adaptations/improvements in their laboratories to analyse whether the waste collected can still be recovered and re-used, or is ready for disposal; these centres provide quarterly reports detailing the amount of analyzed refrigerants and demonstrate that the laboratory is operating under the legal Brazilian regulations.

equipment[35] has been successfully installed at CRN, and training of laboratory employees are ongoing to support the system's operation.

Secretariat's comments

132. The Secretariat noted that the pilot demonstration project is progressing in accordance with the revised plan of action approved at the 79th meeting. Upon a request for clarification, UNDP explained that the destruction facility has been continuously operating since June 2020 and the reclaim centres have been sending waste ODS to the facility. A full report containing an assessment of the ODS waste management and disposal would be provided at the completion of the project in December 2022, to the first meeting of the Executive Committee in 2023, as stipulated in decision 79/18(c)(i).[36]

Recommendation

133. The Executive Committee may wish to note the progress report on the pilot demonstration project on ODS waste management and disposal in Brazil, submitted by UNDP, contained in document UNEP/OzL.Pro/ExCom/88/18.

Change of implementing agency

Mauritania: HCFC phase-out management plan (stage I - change of implementing agency) (UNEP, UNDP and UNIDO)

Background

134. Through an official communication of 9 September 2020, the Government of Mauritania requested to replace UNDP with UNIDO as the cooperating agency for stage I of the HCFC phase-out management plan (HPMP).

135. A request for the second tranche of the HPMP for Mauritania was expected to be submitted to the 87th meeting, at which time the change of cooperating agency would have been requested, and relevant changes to the Agreement between the Government and the Executive Committee would have been introduced.

136. At the 87th meeting, the Executive Committee noted that the request for the second tranche of the HPMP could not be submitted due to *inter alia* non-submission of the progress and financial reports, and the request by the Government to change the cooperating agency. Accordingly, the Executive Committee requested the Secretariat to send a letter to the Government of Mauritania, urging the Government to work with UNEP to submit the required progress and financial reports, requesting UNDP to return to the Multilateral Fund all funding approved under stage I, and further urging the Government to work with UNEP and UNIDO so that the second tranche could be submitted to the 88th meeting with a revised plan of action to take into account the reallocation of the 2020 and subsequent tranches and the change of cooperating agency (decision 87/26).

[35] UNDP noted that gas chromatography equipment was provided to improve and strengthen the analysis of collected refrigerant waste and confirm whether they require destruction, as part of the revised action plan that allowed for the extension of the pilot project in Brazil.

[36] To complete the pilot ODS waste disposal project in Brazil by December 2022, to submit the final report of the project to the first meeting of 2023 and a project completion report no later than July 2023, and to return fund balances no later than December 2023, on the understanding that no further extensions of the completion date of the project would be considered by the Executive Committee

137. Subsequently, in preparation for the 88th meeting, the Secretariat had discussions with UNEP as the lead agency, UNDP and UNIDO on the way forward in addressing decision 87/26. UNEP explained that it was unlikely that the tranche request would be submitted to the meeting due to the low level of disbursement, caused in part by the delay in implementing technical assistance by UNDP, and in part by the need to complete a comprehensive survey to determine the actual level of consumption in Mauritania, which had been delayed due to the constraints imposed by the COVID-19 pandemic. Accordingly, in order to allow progress in the implementation of the component by the cooperating agency, the Secretariat suggested to submit, prior to the submission of the second tranche, the request for change of the cooperating agency, along with the plan of action for the implementation of the component by UNIDO, and the revised Agreement between the Government of Mauritania and the Executive Committee reflecting the change of cooperating agency and the reallocation of the 2020 and subsequent tranches due to the delay in implementation.

Submission of the plan of action and the revised Agreement

138. On behalf of the Government of Mauritania, UNEP submitted to the 88th meeting the request for change of cooperating agency, including the plan of action for UNIDO's component and the revised Agreement between the Government and the Executive Committee.

139. The plan of action for the first tranche of UNIDO's component includes the procurement and distribution of 10 refrigerant identifiers to strengthen the customs' capacity to control ODS imports (US $40,000); procurement and distribution of equipment (including vacuum pumps, recovery cylinders, leak detectors, brazing kits, and basic tools) for two training centres for refrigeration technicians (US $20,000); procurement and distribution of equipment (i.e., audiovisual equipment, laptops, and consumables) to enable seven chapters of the Association of Refrigeration Engineers and Technicians to provide refrigeration training to technicians (US $35,000); and associated technical assistance to be provided by an international expert (US $10,000).

140. UNIDO's plan of action as cooperating agency will follow, to the extent possible, the original scope of activities agreed for UNDP, including the strengthening of two training centres and five recovery centres and the establishment of a central storage centre (some of these activities to be initiated in UNIDO's plan of action for the first tranche). If a need for minor modifications of the planned activities emerges during the implementation of the first tranche, these adjustments will be included in the plan of action for future tranches.

141. The submitted revised Agreement includes the change of cooperating agency, combines the 2020 and 2022 tranches into only one tranche in 2022, and reflects the transfer of funding approved for the first tranche from UNDP to UNIDO. The duration of stage I was maintained as originally proposed, with the last target year in 2025 and operational completion by December 2026.

Secretariat's comments

142. The Secretariat notes that the request to change the cooperating agency from UNDP to UNIDO for stage I of the HPMP was presented upon consultation and agreement among the relevant parties, and that the consideration of the change of cooperating agency at the present meeting will allow the country to achieve further progress in the implementation of the first tranche of stage I.

143. In addition, UNDP confirmed that the funding approved under the first tranche (US $105,000 plus agency support cost of US $7,350) was not disbursed. These funds will be returned to the Multilateral Fund and transferred to UNIDO. In addition, the transfer from UNDP to UNIDO of funds approved in principle for future tranches of stage I has been introduced in the updated Agreement between the Government and

the Executive Committee as contained in Annex II to the present document. The level of approved funds to be returned by UNDP and of funds approved in principle to be transferred to UNIDO are presented in Table 4.

Table 4. Funds to be transferred from UNDP to UNIDO for stage I of the HPMP (US $)

Description	Value	Agency support costs	Total
First tranche (approved) (MAU/PHA/80/TAS/25)	105,000	7,350	112,350
Funds approved in principle for the second and third tranches	200,000	14,000	214,000
Total	**305,000**	**21,350**	**326,350**

144. The proposed updates to the Agreement between the Government of Mauritania and the Executive Committee, i.e. the change of cooperating agency and tranche reallocation, are also contained in Annex II to the present document. Table 5 presents the relevant changes.

Table 5. Proposed reallocation of tranches for stage I of the HPMP for Mauritania (US $)

Particulars	2017	2018 2019	2020	2021	2022	2023 2024	2025	Total
As approved at the 80th meeting								
Lead IA (UNEP) agreed funding	150,000	0	25,000	0	41,750	0	85,750	302,500
Support costs for Lead IA	19,500	0	3,250	0	5,428	0	11,148	39,325
Cooperating IA (UNDP) agreed funding	105,000	0	50,000	0	150,000	0	0	305,000
Support costs for Cooperating IA	7,350	0	3,500	0	10,500	0	0	21,350
Total agreed funding	255,000	0	75,000	0	191,750	0	85,750	607,500
Total support costs	26,850	0	6,750	0	15,928	0	11,148	60,675
Total agreed costs	281,850	0	81,750	0	207,678	0	96,898	668,175
As proposed at the 88th meeting								
Lead IA (UNEP) agreed funding	150,000	0	**0**	0	**66,750**	0	85,750	302,500
Support costs for Lead IA	19,500	0	**0**	0	**8,678**	0	11,148	39,325
Cooperating IA **(UNIDO)** agreed funding	105,000	0	**0**	0	**200,000**	0	0	305,000
Support costs for Cooperating IA	7,350	0	**0**	0	**14,000**	0	0	21,350
Total agreed funding	255,000	0	**0**	0	**266,750**	0	85,750	607,500
Total support costs	26,850	0	**0**	0	**22,678**	0	11,148	60,675
Total agreed costs	281,850	0	**0**	0	**289,428**	0	96,898	668,175

Status of the HCFC consumption survey and revision of the reported HCFC consumption data

145. During the approval of stage I at the 80th meeting, the Government of Mauritania reported HCFC consumption of 17 ODP tonnes based on the best estimate, as the licensing and quota system was not yet operational, and the national ozone unit (NOU) had been re-established only in early 2016 after not being operational between 2008 and 2015.

146. At the time of project review, HCFC consumption was estimated at approximately 6.60 ODP tonnes based on the country's population count and geographical distribution, access to electricity, and gross domestic product *per capita*. The starting point for aggregate reductions in HCFC consumption was established at that level, on the understanding that it could be revised once a comprehensive survey to determine the actual level of consumption was conducted, and an independent verification was undertaken to corroborate the validity of the data surveyed and to ascertain that an effective HCFC import, licensing, and quota system was operational. It was also agreed that the clause on reductions in funding for failure to comply contained in the Agreement would not be applied in case of the verified

HCFC consumption being higher than the estimated starting point of 6.60 ODP tonnes.[37]

147. In reviewing the proposal for the change of cooperating agency, the Secretariat noted that the levels of HCFC consumption reported between 2017 and 2020 (i.e., 15.95, 15.13, 13.92 and 13.75 ODP tonnes, respectively) had exceeded the estimated starting point. UNEP explained that this consumption data was provisional until the survey on HCFC consumption was completed and the actual level of consumption in Mauritania was determined. Accordingly, the level of consumption reported will be corrected based on the completed and independently verified survey.

148. As the HCFC consumption survey has not been completed, these potential additional changes to the Agreement could not be undertaken at this time. However, the Secretariat considers that the revision to the Agreement to reflect the change of cooperating agency is needed at this time to allow Mauritania to procure the equipment required to complete the training of customs officers and refrigeration technicians initiated under the first tranche.

Recommendation

149. The Executive Committee may wish:

(a) To note:

(i) The request by the Government of Mauritania to transfer to UNIDO all activities included in stage I of the HCFC phase-out management plan (HPMP) initially planned for implementation by UNDP;

(ii) That the Fund Secretariat has updated the Agreement between the Government of Mauritania and the Executive Committee for stage I of the HPMP, as contained in Annex II to the present document, specifically Appendix 2-A and paragraph 9, on the basis of the transfer of UNDP's component to UNIDO, and paragraph 16, which has been added to indicate that the updated Agreement supersedes that reached at the 80th meeting;

(b) With regard to the first tranche of stage I of the HPMP:

(i) To request UNDP to return to the Multilateral Fund at the 88th meeting the funding of US $105,000, plus agency support costs of US $7,350 (MAU/PHA/80/TAS/25);

(ii) To approve the transfer to UNIDO of the funding of US $105,000, plus agency support costs of US $7,350; and

(c) Further to approve the transfer from UNDP to UNIDO of the funding of US $200,000, plus agency support costs of US $14,000, approved in principle, associated with the second and third tranches of stage I of the HPMP.

<u>Methyl bromide</u>

<u>Argentina: Methyl bromide (MB) phase-out plan</u> (UNIDO)

150. At its 30th meeting, the Executive Committee approved the project for the phase-out of MB in strawberry, protected vegetables and cut flower production in Argentina, and at its 36th meeting, approved the project for the phase-out of MB for soil fumigation in tobacco and non-protected vegetable seed-beds.

[37] Decision 80/57(e), (f) and (g)

The Agreement between the Government and the Executive Committee was subsequently modified at the 45th meeting. While the Agreement explicitly excluded quarantine and pre-shipment applications from the targets for national MB consumption, the Agreement did not include an exclusion for critical-use exemptions (CUEs) that the Parties to the Montreal Protocol may authorize, and instead specified zero national consumption of MB by 2015. The Parties authorized CUEs for Argentina at each of their meetings from 2015 (26th meeting) to 2020 (31st meeting).

151. Argentina reported MB consumption of 12.35 ODP tonnes in 2020 which was less than the authorized CUEs of 12.37 ODP tonnes for that year. Accordingly, the Secretariat considers that the level of consumption of MB for Argentina in 2020 was zero, as the maximum level specified in the Agreement, except for any CUEs approved by the Parties.

Recommendation

152. The Executive Committee may wish to note that the reported level of consumption of methyl bromide for Argentina in 2020 was zero, as per the Agreement between the Government and the Executive Committee, except for the critical-use exemptions approved by the Parties to the Montreal Protocol.

SECTION II: REPORTS ON PROJECTS WITH SPECIFIC REPORTING REQUIREMENTS FOR INDIVIDUAL CONSIDERATION

Reports related to HPMPs

Democratic People's Republic of Korea: HCFC phase-out management plan (stage I – progress report on the implementation of activities) (UNIDO)

Background

153. At its 73rd meeting, the Executive Committee approved, in principle, stage I of the HPMP for the Democratic People's Republic of Korea, with UNIDO as lead implementing agency and UNEP as cooperating implementing agency, to achieve a reduction of HCFC consumption to a sustained level of 66.30 ODP tonnes by 1 January 2018 (i.e., 15 per cent below the HCFC baseline for compliance of 78.00 ODP tonnes). The approval took place upon confirmation by the implementing agencies that stage I of the HPMP could be implemented in compliance with the resolutions of the United Nations Security Council (UNSC) Committee[38] on the Democratic People's Republic of Korea.

154. Since the approval of stage I, the Executive Committee has approved three out of four funding tranches at a total level of US $808,550 (i.e., 95.3 per cent of the total funds of US $848,550 approved in principle), as well as the transfer to UNIDO of all phase-out activities to be implemented by UNEP. In line with the Agreement between the Government and the Executive Committee, the last tranche of stage I of the HPMP, in the amount of US $40,000, was scheduled to be submitted at the 81st meeting. However, due to the UNSC resolutions UNIDO had been unable to submit the tranche request.

Progress report submitted to the 85th meeting

155. UNIDO has submitted to the 85th meeting a progress report on the implementation of stage I of the HPMP, listing the activities implemented so far, the level of disbursement achieved, the encountered challenges to a continued implementation of activities in compliance with the UNSC resolutions, and a request for guidance from the Executive Committee.

[38] The UNSC Committee established pursuant to Resolution 1718 was consulted before the submission of stage I of the HPMP to establish whether the equipment or any other services under the HPMP could be provided to the country.

156. The report indicated that despite difficulties resulting from the UNSC resolutions, the main activities performed during the first and second tranches included:

(a) Procurement of three refrigerant identifiers for the country's customs office;

(b) Purchase of one spray foaming machine for the Puhung Building Material factory upon clearance from the UNSC Committee in 2015, and preparation of a contract for and shipment of auxiliary equipment to enable the installation/commissioning of spray foaming equipment;

(c) Procurement of polyurethane (PU) foam equipment (methyl formate), cleared by the UNSC Committee in line with the procedures established in the UNSC Resolution 2270 (2016); a purchase contract to the equipment suppliers was issued; the equipment was shipped through China, as it could not be shipped directly to the Democratic People's Republic of Korea, but was rejected by the Customs authorities in China and returned to the supplier;

(d) Procurement of training equipment for refrigeration and air-conditioning (RAC) servicing technicians upon clearance by the UNSC Committee, shipped and distributed to refrigeration service technicians in June 2016;

(e) Organization of a train-the-trainers workshop for 35 RAC servicing technicians conducted in August and September 2016;

(f) Completion of an additional training session for five trainers in best practices in RAC servicing, conducted in India in December 2016; and

(g) Conducting the first train-the-trainers workshop for 40 customs officers in May 2017.

Level of fund disbursement

157. As at 30 March 2020, of the total amount of US $808,550 of funds approved, US $303,313 (38 per cent) had been disbursed, as shown in Table 6.

Table 6. Financial report of stage I of the HPMP for the Democratic People's Republic of Korea (US $)

Tranche	Approved	Disbursed	Disbursement rate (%)
First	134,003	87,386	65.2
Second	506,680	214,110	42.3
Third	167,867	1,817	1.1
Total	**808,550**	**303,313**	**37.5**

Update on the implementation plan for stage I of the HPMP

158. The activities that have not been implemented yet include:

(a) Follow-up on the training workshops for RAC servicing technicians and customs officers;

(b) Mapping of the existing reclaim and recovery centres and procurement of additional equipment; and

(c) Establishment of a project management unit once the funding transfer channel has been approved and made operational.

159. In addition, the PU foam equipment that was returned to the supplier by the Customs authorities in China, could not be re-imported as an additional resolution 2397 issued in 2017 specifically prohibits "all industrial machinery (HS codes 84 and 85), transportation vehicles (HS codes 86 through 89), and iron, steel, and other metals (HS codes 72 through 83)." Subsequent to this resolution, UNIDO was advised to submit to the UNSC a new exemption request, together with an updated list of the equipment to be imported into the country. UNIDO submitted an official exemption request on 8 May 2019 and the UNSC Committee denied the exemption on 18 June 2019. In view of the above, UNIDO has not been able to proceed with the delivery of equipment.

160. Non-investment activities have also been impacted due to the inability to transfer funds within the country, made even more difficult by the introduction of stricter sanctions following the adoption of resolution 2397 (2017).

161. In view of the above, UNIDO indicated in its report that it is not in a position to continue the implementation of the HPMP for the Democratic People's Republic of Korea and is requesting guidance from the Executive Committee.

Secretariat's comments

162. Consideration of the report submitted by UNIDO at the 85th meeting had been deferred and re-submitted at the 86th and 87th meetings in accordance with the agreed procedure of the Executive Committee for conducting those meetings. The report has been re-submitted to the 88th meeting.

163. Since the submission of the report to the 86th meeting, at their Thirty-second Meeting,[39] the Parties noted that the Democratic People's Republic of Korea was in non-compliance with the consumption and production control measures under the Protocol for HCFCs, as its annual consumption of 72.27 ODP tonnes of HCFCs exceeded the country's maximum allowable consumption of 70.2 ODP tonnes for that year, and its annual production of 26.95 ODP tonnes of HCFCs in 2019 exceeded the country's maximum allowable production of 24.8 ODP tonnes. Further, the Parties *inter alia* noted with appreciation the submission by the country of an explanation for its non-compliance and a plan of action to ensure its return to compliance with the Protocol's HCFC consumption and production control measures in 2023; further noted that, under that plan of action, without prejudice to the operation of the financial mechanism of the Protocol, the Democratic People's Republic of Korea committed to specific reductions in the production and consumption of HCFCs; urged the country to work with the relevant implementing agencies to explore options for the implementation of its plan of action to phase out the consumption and production of HCFCs subject to the application of the relevant UNSC resolutions; and invited the country to establish additional national policies facilitating HCFC phase-out that may include, but will not be limited to, bans on imports, on production or on new installations, and certification of refrigeration technicians and companies (decision XXXII/6).[40]

164. The Secretariat notes that UNIDO has continued exercising due diligence and monitoring throughout the implementation of the project. Upon the adoption of an additional UNSC resolution in 2017, it has submitted to the UNSC Committee, pursuant to resolution 1718, an exemption request, together with an updated list of equipment to be imported into the country, and has remained in close cooperation with relevant UN member states regarding the procurement and export of equipment designed to phase out the use of controlled substances in the country.

[39] 23 to 27 November 2020.

[40] The HCFC consumption and production levels reported by the Government of the Democratic People's Republic of Korea under Article 7 for the year 2020 are in line with those in the plan of action for returning to compliance contained in decision XXXII/6.

165. In preparation for the 87th meeting, upon enquiry by the Secretariat on any new development in the implementation of the HPMP for the Democratic People's Republic of Korea, UNIDO reported that there was no information additional to that provided at the 86th meeting, and that the implementation of the HPMP would only be feasible for UNIDO if UNSC sanctions were lifted or an exemption was granted. However, UNIDO was not in the position to obtain such exemption. Consequently, UNIDO reiterated that it was not in a position to continue the implementation of the HPMP for the Democratic People's Republic of Korea and requested guidance from the Executive Committee.

166. Upon request for clarification on any new development allowing the submission of the last tranche of stage I to the 88th meeting, UNIDO indicated that there was no additional information to report.

Recommendation

167. The Executive Committee may wish to consider the information on the implementation of activities under stage I of the HCFC phase-out management plan for the Democratic People's Republic of Korea, submitted by UNIDO, giving due consideration to decision XXXII/6 of the Meeting of the Parties.

SECTION III: REQUESTS FOR THE EXTENSION OF COMPLETION DATES OF STAGE I/STAGE II OF HPMPS BEYOND 31 DECEMBER 2022

Background

168. Extension requests for stage I of HPMPs for 15 countries and stage II of the HPMP for one country, with a completion date of 31 December 2021, had been submitted to the 88th meeting for requesting extension beyond 31 December 2022. The Secretariat considers that these extensions need to be reviewed on a case-by-case basis, as the delays are not all related to the COVID-19 pandemic.[41]

169. Table 7 presents a summary of the reasons for the delay in completing stage I or II of the HPMPs for the 16 Article 5 countries.

Table 7. Overview of extension requests for stage I/II of HPMPs for 16 Article 5 countries

Country	Agencies	HPMP stage I		Extension requested up to	Approval stage II/III (meeting)	Reasons for extension request
		Previous tranche (meeting)	Final tranche yet to be submitted			
Barbados (HPMP stage I)	UNDP / UNEP	84th	Yes, fourth tranche for UNEP	31-Dec-23		Delay in implementing customs training, service sector training and certification and awareness activities, and finalising verification report
Botswana (HPMP stage I)	UNEP / UNIDO	86th	No	31-Dec-23	86th	Delay in administrative approval process in the Government which resulted in delays in customs enforcement training, service sector training and procurement of equipment for centres of excellence

[41] Stage I of HPMPs that were to be completed by 31 December 2021, that require extension up to 31 December 2022 due to COVID-19 pandemic challenges are addressed in the document on the progress reports for the respective bilateral and implementing agencies; extension requests for stage I of the HPMPs where a funding tranche for stage II or stage III of HPMPs are being requested, are addressed in the respective project documents.

Country	Agencies	HPMP stage I		Extension requested up to	Approval stage II/III (meeting)	Reasons for extension request
		Previous tranche (meeting)	Final tranche yet to be submitted			
Congo, the (HPMP stage I)	UNEP / UNIDO	84th	Fifth tranche for UNEP	31-Dec-23		Delay in implementation of customs training, service sector training and awareness; internal banking issues resulted in delays in disbursement of payment
Côte d'Ivoire (HPMP stage I)	UNEP / UNIDO	84th	Fifth tranche for UNEP	31-Dec-23		Delay in implementation of customs and enforcement training, service sector training, procurement of equipment for service sector and centres of excellence, and finalising verification report
Dominica (HPMP stage I)	UNEP	84th	Third tranche for UNEP	31-Dec-23		Delays due to Hurricane Maria (2017); further delay in implementation of customs and enforcement officers training, service technicians training, awareness and outreach activities, and finalising the verification report
Grenada (HPMP stage I)	UNEP / UNIDO	77th	Third tranche for UNEP	31-Dec-23		Delay in finalisation of verification report and submission of third tranche
Haiti (HPMP stage I)	UNDP /UNEP	76th	Third and fourth tranches for UNEP	31-Dec-24		Political situation and natural disaster resulting in delays in project implementation
Jamaica (HPMP stage I)	UNDP / UNEP	85th		31-Dec-23	86th	Delay in implementation of training for customs and enforcement officers and service sector activities; fund transfer delayed due to incorrect banking details
Mali (HPMP stage I)	UNDP / UNEP	83rd	Fifth tranche for UNDP and UNEP	31-Dec-23		Political and security situation resulted in delay in project implementation
Mozambique (HPMP stage I)	UNEP / UNIDO	83rd	Fifth tranche for UNEP	31-Dec-23		COVID 19 restrictions during the years 2020 and 2021 resulting in delay in implementing remaining activities for training of technicians and customs officers, in particular those requiring in person attendance.
Saint Kitts and Nevis (HPMP stage I)	UNDP / UNEP	74th	Third tranche for UNEP	31-Dec-23		Delay in implementation due to structural changes to the national ozone unit (NOU) (February 2021) and transition to the new administration of the Montreal Protocol portfolio
South Sudan (HPMP stage I)	UNDP / UNEP	77th	Second and third tranches for UNEP and UNDP	31-Dec-24		Political and security situation resulted in delays in project implementation including verification report
South Africa (HPMP stage I)	UNIDO	83rd	Fifth tranche for UNIDO	31 Dec 23		Delay in technical inspection of foam sector conversion and training activities

Country	Agencies	HPMP stage I		Extension requested up to	Approval stage II/III (meeting)	Reasons for extension request
		Previous tranche (meeting)	Final tranche yet to be submitted			
Suriname (HPMP stage I)	UNEP / UNIDO	81st	Fourth tranche for UNEP and UNIDO	31-Dec-23		Delay in implementation of customs and enforcement training, service sector training, equipment procurement and distribution to service technicians and awareness activities
Venezuela (Bolivarian Republic of) (HPMP stage II)	UNIDO	82nd	Second and third tranches for UNIDO	Not available		Economic crisis affecting foreign currency availability for the import of raw material or finished goods, reduction of NOU staff and other institutional changes
Zambia (HPMP stage I)	UNEP / UNIDO	85th		31-Dec-23	86th	Delay in implementation of customs and service sector training and procurement of equipment.

170. Based on the information submitted, the Secretariat noted the following:

(a) During the project review process of stage II of the HPMPs for Botswana, Jamaica and Zambia that were approved in 2020, UNEP informed that the projects were expected to be completed by 31 December 2021; however, due to delays in implementation for various reasons, the date of completion of the projects would be 31 December 2023;

(b) UNEP informed that the reasons for implementation delays for stage I of the HPMPs for Barbados, Côte d'Ivoire, Congo (the), Dominica, Grenada, Mozambique, Saint Kitts and Nevis, South Africa and Suriname, include, in addition to constraints imposed by the pandemic, administrative processes relating to project approval, funds transfer due to banking related issues, and changes in NOU/administration of Montreal Protocol activities;

(c) Implementation of stage I of the HPMPs for Haiti, Mali and South Sudan, were delayed due to national political and security situation, which are beyond control of NOU and the implementing agencies; and

(d) Delays in implementation of stage II of the HPMP for Venezuela (Bolivarian Republic of) were due to the economic crisis affecting foreign currency availability for the import of raw material or finished goods, reduction of NOU staff and other institutional changes and inability to resolve issues relating to verification of HCFC consumption.

Secretariat comments

171. The Secretariat had detailed consultations with UNEP and UNIDO keeping in view that the challenges faced may be unique to each of the 16 Article 5 countries and the need for completing implementation of the stage I or II of their HPMPs at the earliest to avoid extended periods of implementation of remaining activities, noting that this would result in overlap with the ongoing activities with other stages of the HPMP and other future activities related to HFCs.

172. Based on the discussions, the following approach was agreed:

(a) For completing the activities related to the final tranche of stage I of the HPMPs for Botswana, Jamaica and Zambia, where stage II has already been approved (2020), the relevant agencies will submit a detailed implementation plan with a final completion date to the 90th meeting, noting that the outstanding activities will continue to be implemented with the aim to complete them as soon as possible;

(b) For completing the activities related to stage I of the HPMPs for Barbados, Côte d'Ivoire, Congo (the), Dominica, Grenada, Mozambique, Saint Kitts and Nevis, South Africa and Suriname, where a last tranche of stage I will be submitted in 2022 and stage II of the HPMP is under preparation, relevant implementing agencies will continue implementation of the outstanding activities and submit a comprehensive plan of action for completion of stage I to the 90th meeting;

(c) Given the uncertainties associated with the political and security situation in Haiti, Mali and South Sudan, it was agreed that UNEP will continue to closely monitor implementation of outstanding activities under stage I of the HPMPs, submit status reports on their implementation at each meeting of the Executive Committee, and that no additional funding requests for implementation of HPMP and HFC project activities would be submitted until operational completion of stage I of HPMPs; and

(d) Given the challenging economic and political situation prevailing in Venezuela (Bolivarian Republic of), UNIDO will continue implementation of the outstanding activities of stage II of the HPMP and will submit a comprehensive plan of action for their completion to the 90th meeting.

Recommendations

173. The Executive Committee may wish to:

(a) Note the request for extension of the completion date of 31 December 2021 to a period beyond 31 December 2022 for the HCFC phase-out management plans (HPMPs) for the 16 Article 5 countries listed in Table 7 of document UNEP/OzL.Pro/ExCom/88/18;

(b) Allow, on an exceptional basis, continued implementation of the outstanding activities related to stage I of the HPMPs for Barbados (UNEP), Botswana (UNEP and UNIDO), Congo (the) (UNEP), Côte d'Ivoire (UNEP and UNIDO), Dominica (UNEP), Grenada (UNEP), Mozambique (UNEP and UNIDO), Jamaica (UNEP), Saint Kitts and Nevis (UNEP), South Africa (UNIDO), Suriname (UNEP and UNIDO) and Zambia (UNEP and UNIDO), and request the relevant implementing agencies to submit a revised implementation plan including requests for the remaining tranche under stage I of HPMPs as applicable, to the 90th meeting;

(c) Allow, on an exceptional basis, UNEP to continue implementation of the outstanding activities related to stage I of the HPMPs for Haiti, Mali and South Sudan and submit a status report to each meeting of the Executive Committee on the progress of their implementation, on the understanding that no additional funding requests for implementation of HPMP and HFC project activities would be submitted until operational completion of stage I of HPMPs; and

(d) Allow, on an exceptional basis, UNIDO to continue implementation of the outstanding activities related to stage II of the HPMP for Venezuela (Bolivarian Republic of) and submit a comprehensive plan of action to the 90th meeting.

Annex I

SUMMARY OF TEST RESULTS FOR THE PROJECT TO PROMOTE LOW-GLOBAL-WARMING-POTENTIAL REFRIGERANTS FOR THE AIR-CONDITIONING INDUSTRY IN EGYPT (EGYPRA) SUBMITTED TO THE 84TH MEETING

1. Nineteen custom-built split unit prototypes with dedicated compressors provided by a number of enterprises were tested at locally available accredited labs with refrigerants provided by Arkema, Chemours, Daikin, and Honeywell. Tests were repeated for optimization.

2. The results show that there is a potential to improve the capacity and energy efficiency of the prototypes working with alternatives to HCFC-22 and R-410A (with higher improvements for R-410A alternatives). These improvements are dependent on the availability and selection of the right components for units that can deliver the required performance.

3. There is a need for capacity building to enable the manufacturers to design, optimize, and test units with flammable refrigerants in order to improve the performance and meet energy efficiency standards, and to upgrade their testing facilities both in terms of instrumentation as well as to handle flammable refrigerants. Test results show that all refrigerants used in the project are viable alternatives from a thermodynamic point of view; however, when compared to the Minimum Energy Performance Standards for Egypt, results show there are challenges for the industry to provide high efficiency AC units meeting stringent requirements in the coming years. Moreover, the viability in terms of the other criteria, like compatibility, commercial availability, safety, and cost need to be further researched.

4. Table 1 compares the design criteria, testing protocols, refrigerants tested and constraints of four testing programmes: AREP-II[1], EGYPRA, ORNL[2], and PRAHA[3]:

Table 1. Comparison of PRAHA, EGYPRA, ORNL, and AREP-II testing programmes

<table>
<tr><th colspan="2">Programme</th><th colspan="4">PRAHA</th><th colspan="4">EGYPRA</th><th colspan="2">ORNL – Phase I (Mini-split AC)</th><th>AREP-II</th></tr>
<tr><td>1</td><td>Type of test</td><td colspan="4">Custom built test prototypes, comparing with base units: HCFC-22 and R-410A</td><td colspan="4">Custom built test prototypes, comparing with base units: HCFC-22 and R-410A</td><td colspan="2">Soft optimization tests, comparing with base units: HCFC-22 and R-410A</td><td>Soft optimization or drop in of individual units tested against a base R-410A unit</td></tr>
<tr><td>2</td><td>No. of prototypes</td><td colspan="4">13 prototypes, each specific capacity and refrigerant built by one or two OEMs, compared with base refrigerants: HCFC-22 and R-410A. Total prototype and base units = 22</td><td colspan="4">28 prototypes, each specific one capacity and one refrigerant built by one OEM, compared with base refrigerants: HCFC-22 and R-410A. Total prototype and base units = 37</td><td colspan="2">2 commercially available units, soft modified to compare with base refrigerants: HCFC-22 and R-410a</td><td>22 units from different OEMs ranging from splits to water chillers</td></tr>
<tr><td rowspan="3">3</td><td rowspan="3">No. of categories</td><td colspan="2">60 Hz</td><td colspan="2">50 Hz</td><td colspan="4">50 Hz</td><td colspan="2">60 Hz</td><td>60Hz</td></tr>
<tr><td>Window</td><td>Mini Split</td><td>Ducted</td><td>Packaged</td><td>Mini Split</td><td>Mini Split</td><td>Mini Split</td><td>Central</td><td>Split unit</td><td>Split unit</td><td rowspan="2">34 MBH chiller, 2x 36 MBH split, 48 MBH packaged, 60 MBH packaged, 72 MBH packaged</td></tr>
<tr><td>18 MBH</td><td>24 MBH</td><td>36 MBH</td><td>90 MBH</td><td>12 MBH</td><td>18 MBH</td><td>24 MBH</td><td>120 MBH</td><td>18 MBH R-22 eq.</td><td>18 MBH R-410a eq.</td></tr>
<tr><td>4</td><td>Testing conditions</td><td colspan="4">ANSI/AHRI Standard 210/240 and ISO 5151 at T1, T3 and T3+</td><td colspan="4">EOS 4814 and 3795 (ISO 5151) T1, T2, and T3 conditions</td><td colspan="2">ANSI/AHRI Standard 210/240 and ISO 5153 T3 (2010) condition</td><td>ANSI/AHRI 210/240, at T1, T3, and 125 °F</td></tr>
</table>

[1] AHRI Alternative Refrigerant Evaluation Program http://www.ahrinet.org/arep
[2] Abdelaziz 2015 Abdelaziz O, Shrestha S, Munk J, Linkous R, Goetzler W, Guernsey M and Kassuga T, 2015. "Alternative Refrigerant Evaluation for High-Ambient-Temperature Environments: R-22 and R-410A Alternatives for Mini-Split Air Conditioners", ORNL/TM-2015/536. Available at: https://www.energy.gov/sites/prod/files/2015/10/f27/bto_pub59157_101515.pdf.
[3] PRAHA Project Report: https://www.unenvironment.org/resources/report/promoting-lowgwp-refrigerants-air-conditioning-sectors-high-ambient-temperature

Programme		PRAHA	EGYPRA	ORNL – Phase I (Mini-split AC)	AREP-II
		(50°C) and a continuity test for 2 hours at 52°C			
5	**Prototypes supplied and tests performed**	Prototypes built at six OEMs, test at Intertek	Prototypes built at eight OEMs, witness testing at OEM labs	ORNL, one supplier – soft optimization in situ	Individual suppliers, testing at own premises
6	**Refrigerants tested**	Eq. to HCFC-22: HC-290, R-444B (L-20), DR-3	Eq. to HCFC-22: HC-290, R-444B (L-20), DR-3, R-457A (ARM-32d)	Eq. to HCFC-22:N-20B, DR-3, ARM-20B, R-444B (L-20A), HC-290	Eq. to R-410A: HFC-32, DR-5A, DR-55, L-41-1, L-41-2, ARM-71a, HPR2A
		Eq. to R-410A: HFC-32, R-447A (L-41-1), R-454B (DR-5A)	Eq. to R-410A: HFC-32, R-447A (L-41-1), R-454B (DR-5A), ARM-71d	Eq. to R-410A: HFC-32, R-447A (L-41-1), DR-55, ARM-71d, HPR-2A	
		Final report end March 2016			
7	**Constraints**	To build new prototypes with dedicated compressors for the selected refrigerants fitting in the same box dimensions as the original design and comparing performance and efficiency to base models with HCFC-22 and R-410A units	To build new prototype with dedicated compressors for the selected refrigerants with the condition to meet same design capacities of the selected models in comparison to the HCFC-22 and R-410A units	To change some components of the two prototypes to accommodate the different refrigerants, within a “soft optimisation” process	-Drop-in; -Soft optimization by adjusting expansion device, adjusting charge amount, and changing type of oil; -One case of compressor speed adjustment using variable speed drives

*MBH = Thousand British thermal units

5. While EGYPRA is similar in design to the other projects it has the following distinctive features:

(a) EGYPRA is a programme of the HPMP designed to involve the local manufacturers in the decision making of the best refrigerant alternatives for their industry. The second phase of the programme will give manufacturers an insight of the optimization process;

(b) The programme involves more manufacturers, except for AREP, and tests more prototypes than the other three. The eight alternative refrigerants used covered the available refrigerants at the time the prototypes were built;

(c) EGYPRA was not focused only on high-ambient temperatures but across the full range of temperatures that may be prevalent in Egypt; and

(d) The test results presented are more easily to explain the relationships between refrigerant, ambient temperature, equipment application, and performance.

Annex II

TEXT TO BE INCLUDED IN THE UPDATED AGREEMENT BETWEEN THE GOVERNMENT OF MAURITANIA AND THE EXECUTIVE COMMITTEE OF THE MULTILATERAL FUND FOR THE REDUCTION IN CONSUMPTION OF HYDROCHLOROFLUOROCARBONS

(Relevant changes are in bold font for ease of reference)

9. The Country agrees to assume overall responsibility for the management and implementation of this Agreement and of all activities undertaken by it or on its behalf to fulfil the obligations under this Agreement. UNEP has agreed to be the lead implementing agency (the "Lead IA") and **UNIDO** has agreed to be the cooperating implementing agency (the "Cooperating IA") under the lead of the Lead IA in respect of the Country's activities under this Agreement. The Country agrees to evaluations, which might be carried out under the monitoring and evaluation work programmes of the Multilateral Fund or under the evaluation programme of any of the agencies taking part in this Agreement.

16. At the 88th meeting, UNDP stopped being the Cooperating IA in respect of the Country's activities under this Agreement. This updated Agreement supersedes the Agreement reached between the Government of Mauritania and the Executive Committee at the 80th meeting of the Executive Committee.

APPENDIX 2-A: THE TARGETS, AND FUNDING

Row	Particular	2017	2018-2019	2020	2021	2022	2023-2024	2025	Total
1.1	Montreal Protocol reduction schedule of Annex C, Group I substances (ODP tonnes)	18.45	18.45	13.33	13.33	13.33	13.33	6.66	n/a
1.2	Maximum allowable total consumption of Annex C, Group I substances (ODP tonnes)	6.60	6.60	5.94	5.94	5.94	5.94	2.14	n/a
2.1	Lead IA (UNEP) agreed funding (US $)	150,000	0	**0**	0	**66,750**	0	85,750	302,500
2.2	Support costs for Lead IA (US $)	19,500	0	**0**	0	**8,678**	0	11,148	39,325
2.3	Cooperating IA (**UNIDO**) agreed funding (US $)	*****105,000	0	**0**	0	**200,000**	0	0	305,000
2.4	Support costs for Cooperating IA (US $)	*****7,350	0	**0**	0	**14,000**	0	0	21,350
3.1	Total agreed funding (US $)	255,000	0	**0**	0	**266,750**	0	85,750	607,500
3.2	Total support costs (US $)	26,850	0	**0**	0	**22,678**	0	11,148	60,675
3.3	Total agreed costs (US $)	281,850	0	**0**	0	**289,428**	0	96,898	668,175
4.1.1	Total phase-out of HCFC-22 agreed to be achieved under this Agreement (ODP tonnes)								4.46
4.1.2	Phase-out of HCFC-22 to be achieved in previously approved projects (ODP tonnes)								0.0
4.1.3	Remaining eligible consumption for HCFC-22 (ODP tonnes)								2.14

*** Funds were transferred from UNDP to UNIDO at the 88th meeting**

EGYPRA – Promotion of Low-GWP Refrigerants for the Air Conditioning Industry in Egypt

2021

Report

Project supported by the Multilateral Fund of the Montreal Protocol

UNITED NATIONS ENVIRONMENT

UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANIZATION

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.

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Prof. Walid Chakroun (Kuwait)
Dr. Omar Abdel Aziz (USA/UAE)

Acknowledgement also goes to the "Technology Providers" for providing refrigerant, compressors, and components free of charge

Refrigerant Providers: Arkema, Chemours, Daikin, and Honeywell.
Compressor providers: Emerson, Highly, and GMCC.
Components: Danfoss

The project team also acknowledges the OEM manufacturers who built the split system prototypes and tested them at their own facilities.

Elaraby
Fresh
Miraco
Power
Unionaire

And the OEMs who built the central units. These units were independently tested at MIRACO.

Delta Construction Manufacturing (DCM)
Egyptian German Air Treatment Company (EGAT)
Volta

Project Team

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

The Project Management: UN Environment and UNIDO 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 Dr. Lamia Benabbas, Programme Officer – UNIDO and Mr. Ayman Eltalouny, International Partnership Coordinator, OzoneAction Programme – UN Environment

The Egyptian Organization for Standards: provided guidance on the Egyptian standards for testing as well as the minimum energy performance standards (MEPS).

The Technical Consultant, 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. The Technical Consultant witnessed-testing of all prototypes and baseline units, compiled testing data, and provided analysis of data.

The Coordination Consultant, Mr. Bassam Elassaad provided logistical support and coordination for the project and helped with writing of the final report.

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Acronyms

AHRI	Air Conditioning, Heating, and Refrigeration Institute
ANSI	American National Standards Institute
AREP	Alternative Refrigerant Evaluation Program
ASHRAE	American Society of Heating, Refrigerating, and Air Conditioning Engineers
Btu/hr	Also denoted as Btuh, BTU/h or B.t.u/hr = British Thermal Unit per Hour
BV	Burning Velocity
CAP	Capacity
CC	Cooling Capacity
CFC	Chloro Fluoro Carbon
COP	Coefficient of Performance
DB	Dry Bulb
DC	District Cooling
DX	Direct Expansion
EE	Energy Efficiency
EER	Energy Efficiency Ratio
EGYPRA	Egyptian Program for Promoting Low-GWP Refrigerant Alternatives
EN	European Norms (Standards)
EPA	Environmental Protection Agency (US)
GWP	Global Warming Potential
HAT	High Ambient Temperature
HC	Hydrocarbons
HCFC	Hydro Chloro Fluoro Carbon
HFC	Hydro Fluoro Carbon
HFO	Hydro Fluoro Olefins
HPMP	HCFC Phase-out Management Plan
HVACR	Heating, Ventilation, Air Conditioning and Refrigeration
HX	Heat Exchanger
IU	Indoor Unit
IEC	International Electrotechnical Commission
IPR	Intellectual Property Rights
ISO	International Standards Organization
Kg	Kilograms
kW	Kilowatts
LCCP	Life Cycle Climate Performance
LFL	lower Flammability Limit
MEPS	Minimum Energy Performance Standards
MOP	Meeting of Parties
MP	Montreal Protocol
NOU	National Ozone Unit
ODP	Ozone Depleting Potential
ODS	Ozone Depleting Substances
OEM	Original Equipment Manufacturer
PRAHA	Promoting Low-GWP Refrigerants for the Air Conditioning in HAT Countries
PSI	Pounds per Square Inch
RAC	Refrigeration and Air Conditioning
ROWA	UNEP Regional Office for West Africa
RTOC	Refrigeration, Air Conditioning, and Heat pump & Technical Options Committee

SCFM	Standard Cubic Foot per Minute
SHR	Sensible Heat ratio
SNAP	Significant New Alternative Policy
Tdb	Dry Bulb Temperature
Twb	Wet Bulb Temperature
TEAP	Technical & Economic Assessment Panel
TEWI	Total Equivalent Warming Impact
TF	Task Force
TWB	Wet Bulb Temperature
UNEP	United Nations Environment
UNIDO	United Nations Industrial Development Organization
USD	US Dollars
VC	Vienna Convention
VRF	Variable Refrigerant Flow
WB	Wet Bulb
WG	Working Group

Executive Summary

HCFCs are used extensively in the refrigeration and air conditioning industry, in particular in the air-conditioning industry. Parties to the Montreal Protocol, in their 21st meeting, adopted a decision concerning HCFCs and environmentally sound alternatives. The decision calls for further assessment and support work to enable parties to find the best ways of moving forward particularly for those with forthcoming compliance targets related to consumption of HCFC in the air-conditioning sector. The program called *Promotion of Low-GWP Refrigerants for the Air-Conditioning Industry in Egypt (EGYPRA)* was adopted to respond to this need.

The aim of the project is to individually manufacture custom-built AC split unit prototypes and central unit prototypes operating with alternative refrigerants to test their performance and compare against baseline units operating with HCFC-22 and R-410A. The list of refrigerants used and the units produced and tested is as per the table below.

		Split system (mini-split)			**Central 120,000 Btu/hr**	
	Replacement for	**12,000 Btu/hr**	**18,000 Btu/hr**	**24,000 Btu/hr**	**Std. coil**	**Micro channel**
HC-290	HCFC-22					
HFC-32	R-410A					
R-457C (Arkema ARM-20a)	HCFC-22					
R-459A (Arkema ARM -71a)	R-410A					
R-454C (Chemours DR-3)	HCFC-22					
R-454B (Chemours DR-5A)	R-410A					
R-444B (Honeywell L-20)	HCFC-22					
R-447A (Honeywell L-41)	R-410A					
HCFC-22 baseline						
R-410A baseline						

EGYPRA involved building and testing 19 custom built split unit prototypes with dedicated compressors provided by Emerson, GMCC, and Hitachi Highly, and 16 base units by five OEMs. The refrigerants were provided by Arkema, Chemours, Daikin, and Honeywell. All the prototypes and the base units were tested at locally available accredited labs at the time the tests were conducted and witnessed by the project's Technical Consultant who also advised the OEMs during the manufacturing stage. Tests were repeated for optimization by tweaking some of the components. A total of 140 witnessed tests were performed.

The program also involved testing three central unit prototypes with dedicated refrigerants provided by the technology providers and three HCFC-22 base units. All the prototypes and the base units were tested at an independent laboratory (the lab at MIRACO, an OEM involved in the split unit phase of the program, was used to test the central units). The tests were not witnessed by the technical consultant since they were performed at an independent lab and not at the equipment builders' labs. The tests were performed on units as received. The results from the tests were analyzed by an independent consultant. This report includes the results of the two prototypes that were tested.

The units were tested in the following conditions:

Outdoor temperature	Indoor dry bulb/wet bulb temperature	Observations
T_1 (35 °C)	27/19 °C	ISO 5151 condition
T_3 (46 °C)	29/19 °C	ISO 5151 condition
T_{High} (50 °C)	32/23 °C*	Maximum testing condition in ISO 5151
$T_{Extreme}$ (55 °C)	32/23 °C*	Max temperature in heat isles in cities

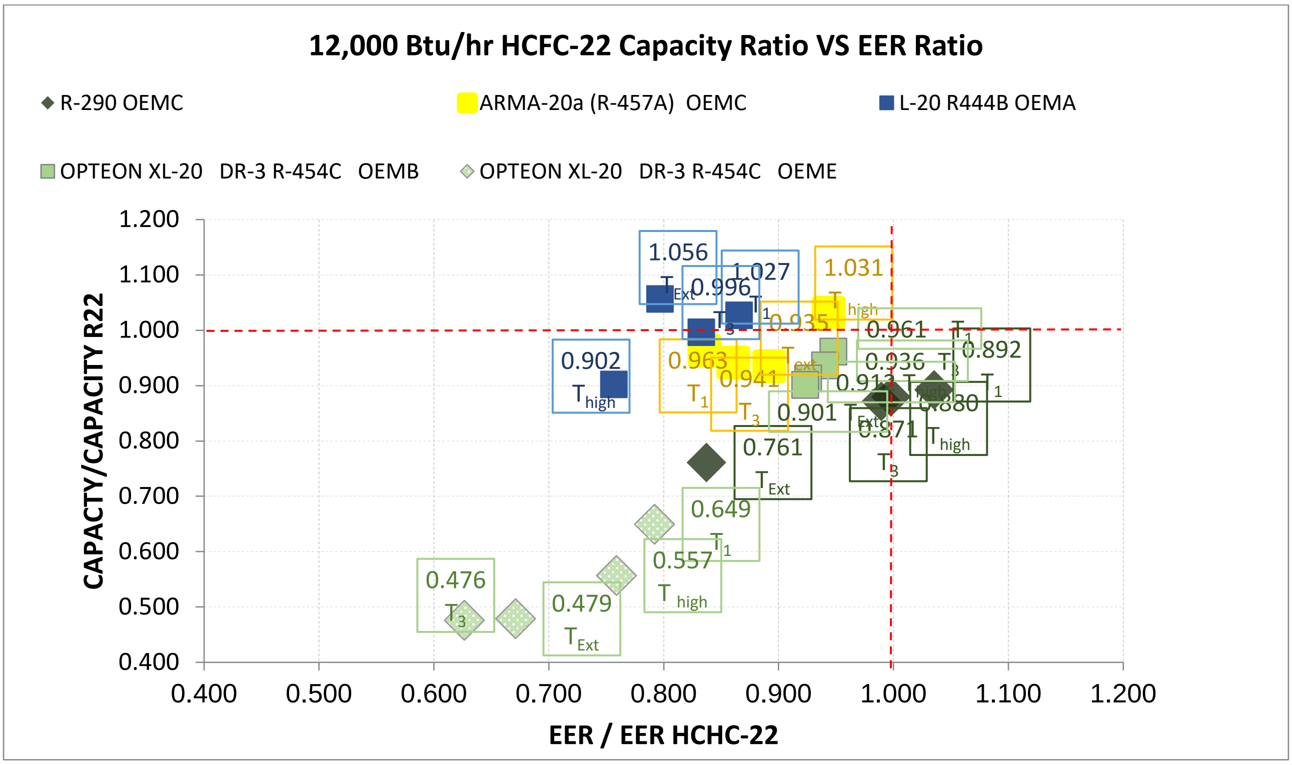
** These indoor temperatures are different from the ones used by other testing programs such as PRAHA, AREP and ORNL*

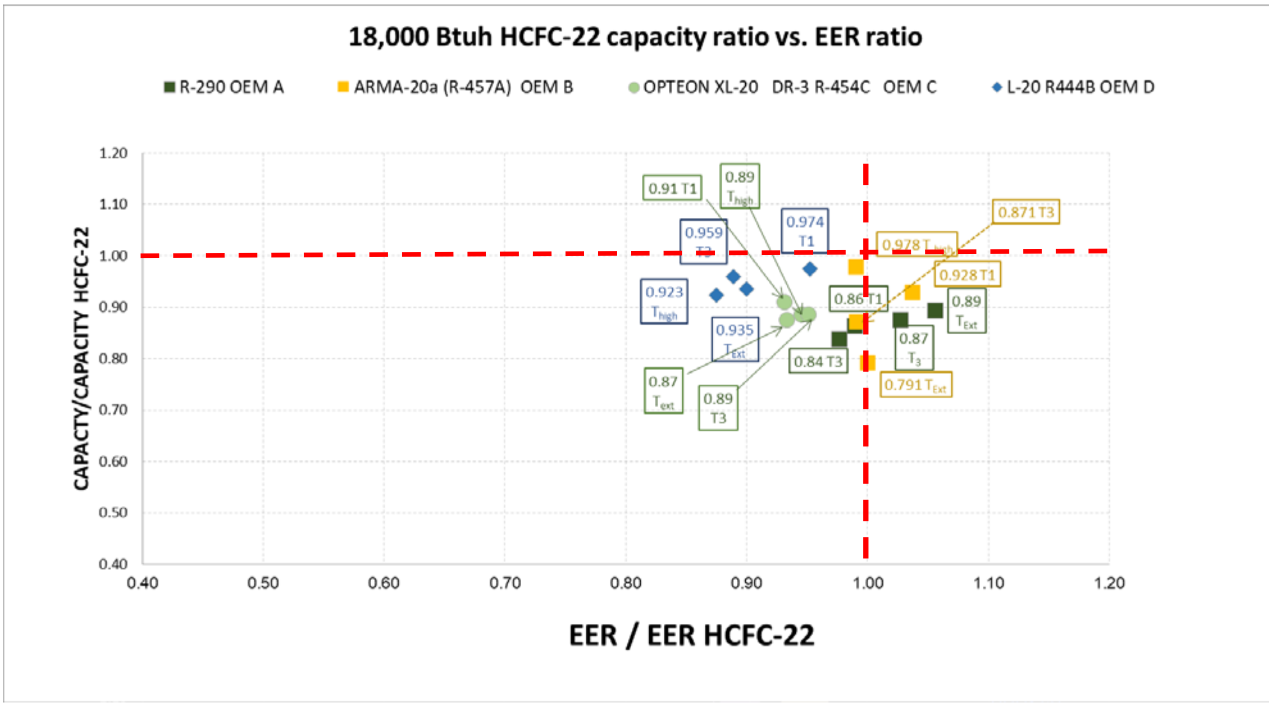
The test results gave higher capacities at T_{High} than at T_3.

The casual reading of the results may establish confusion, even among specialists, in relation to the increase in capacity and EER at T_{High} (50 ^oC) compared to T_3 (46 ^oC). This result is not witnessed in other similar research projects; however, by understanding the impact of changing the dry bulb and wet bulb indoor testing conditions i.e. T_{high} (indoor dry bulb/wet bulb 32/24 ^oC) compared to T_3 (indoor 29/19 ^oC), the results can be explained. These results were randomly double checked through a simulation exercise.

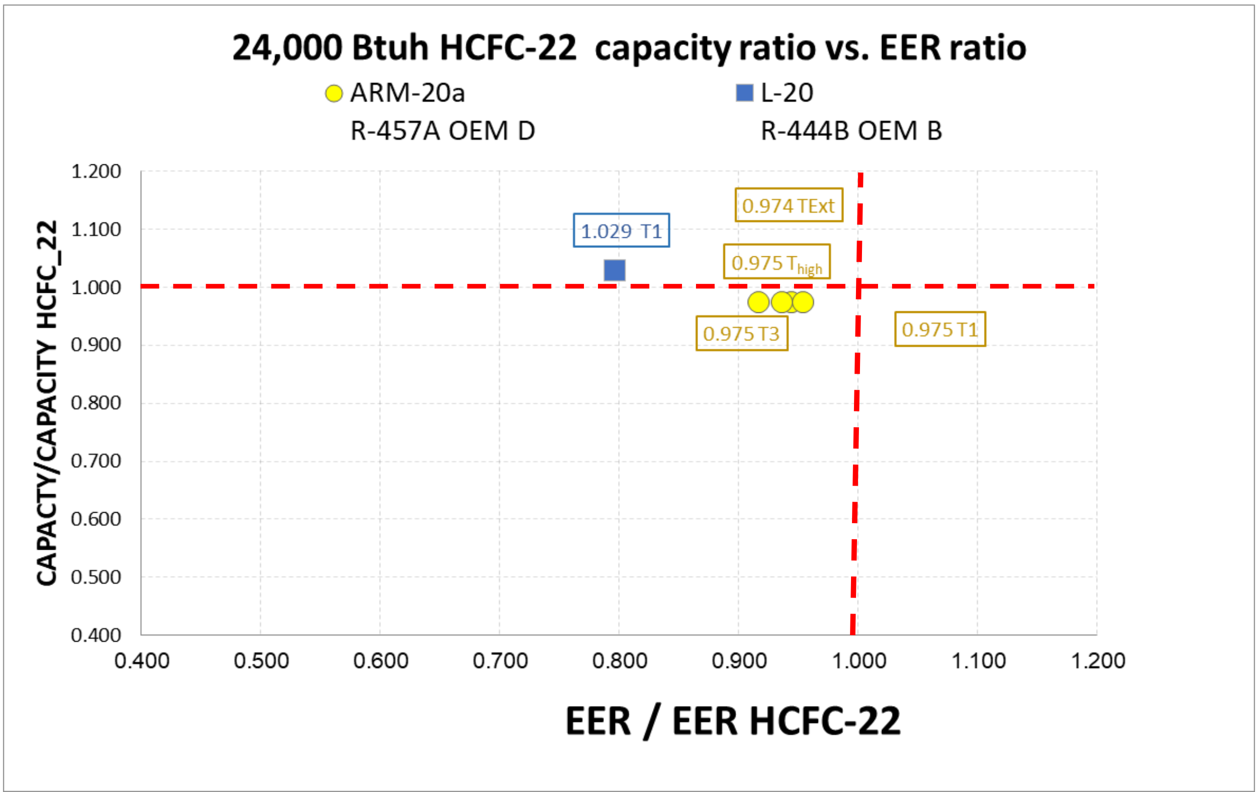
The test results are presented in comparison to the baseline units and color coded to denote the performance over or below the performance of the comparative baseline units. Scattered charts are plotted for the capacity ratio and EER ratio for the prototypes vs. the baseline units for each of the three split unit categories and for the HCFC-22 alternatives and the R-410A alternatives. The red lines denote performance comparable to the base unit

HCFC-22 alternatives



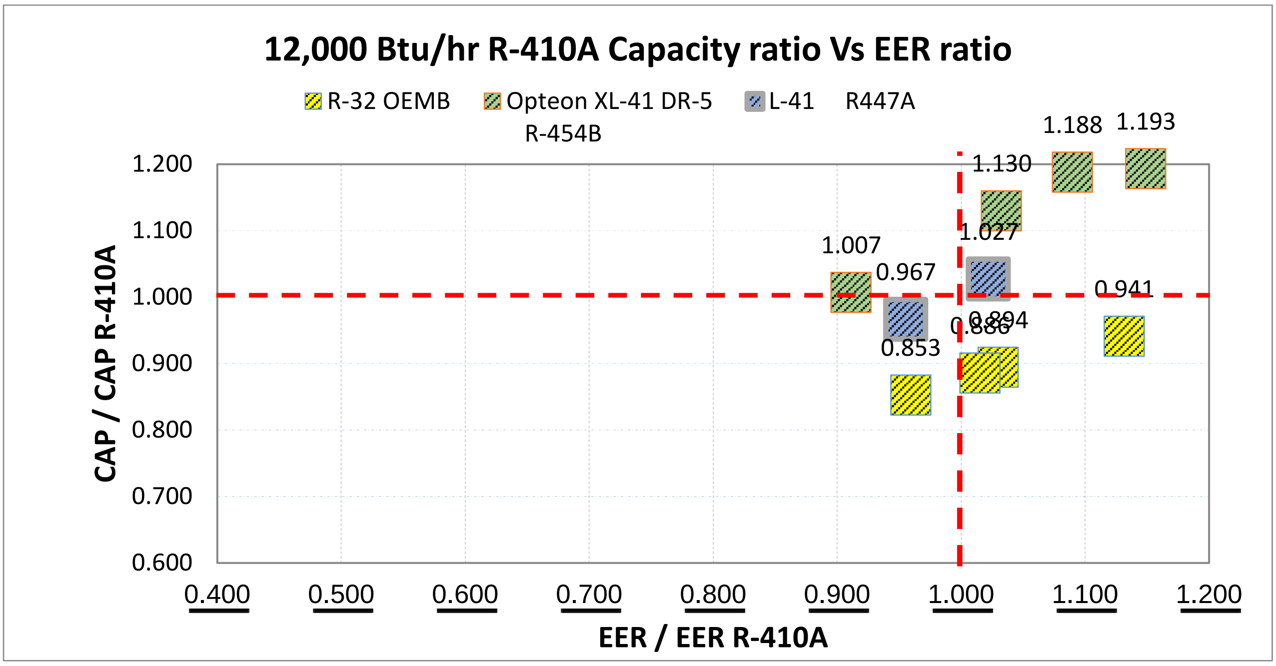


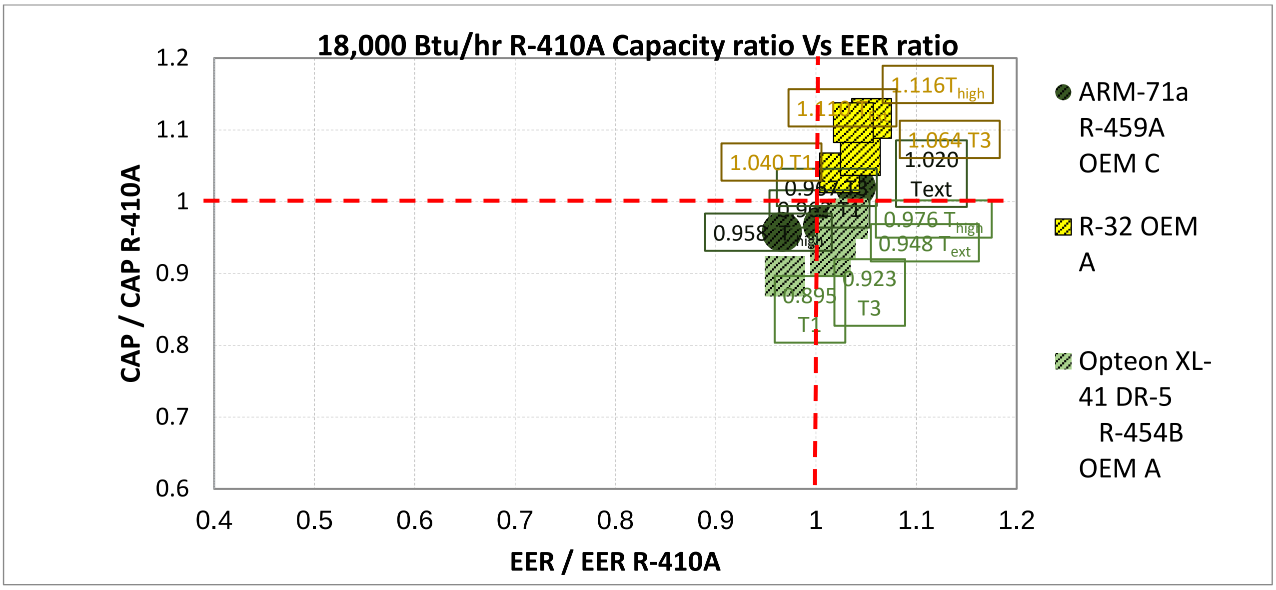
18,000 Btuh HCFC-22 capacity ratio vs. EER ratio
R-290 OEM A
ARMA-20a (R-457A) OEM B
OPTEON XL-20 DR-3 R-454C OEM C
L-20 R444B OEM D
CAPACITY/CAPACITY HCFC-22
EER / EER HCFC-22
0.91 T1
0.89 Thigh
0.974 T1
0.959 T3
0.923 Thigh
0.935 TExt
0.87 Text
0.89 T3
0.84 T3
0.86 T1
0.87 T3
0.89 TExt
0.871 T3
0.928 T1
0.791 TExt

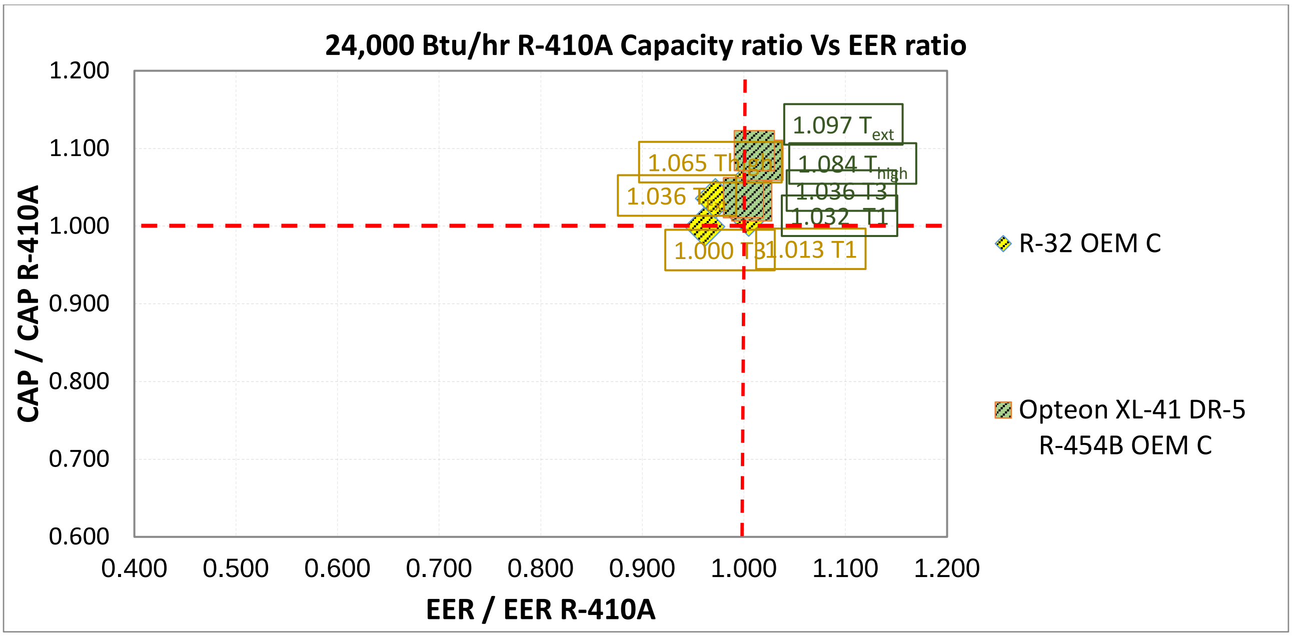


24,000 Btuh HCFC-22 capacity ratio vs. EER ratio
ARM-20a R-457A OEM D
L-20 R-444B OEM B
CAPACTIY/CAPACITY HCFC_22
EER / EER HCFC-22
1.029 T1
0.974 TExt
0.975 Thigh
0.975 T3
0.975 T1

R-410A alternatives







Test results for HCFC-22 alternatives refrigerants demonstrate that:

- Several HCFC-22 alternatives showed that in 60% of the tests, capacity matching or improvement was achieved compared to base line units across all categories and at different testing temperatures.
- Most alternatives showed that in 50% of the tests, EER improvement across all categories and at different testing temperatures is possible.

Test results for R-410A alternatives refrigerants demonstrate that:

- All refrigerants showed improvement in capacity by 25 % to 67 %
- All refrigerants showed improvement in EER by 67 % to 75 %

The results show that there is a potential to improve the capacity and energy efficiency of the prototypes working with alternatives to HCFC-22; however, the potential for improvements for the prototypes working with alternatives to R-410A is much better. This conclusion is based on the percentage of test results that were within plus or minus 10% of the baseline unit results in the same category of equipment. This improvement is dependent on the availability and selection of the right components that can deliver the required performance while still be commercially viable. This conclusion is in line with the outcome of other testing projects like PRAHA, AREP, and ORNL shown in Annex 4

The results of testing central units with HCFC-22 alternatives were less conclusive since only two prototypes of the originally planned four could be tested a couple of years after they were built. The HCFC-22 alternatives used are not among the main refrigerants adopted for air conditioning applications worldwide. As a matter of fact, one of the two alternative refrigerants tested is not currently offered by its manufacturer for commercial use.

Scattered charts plotted for the capacity and EER ratios for the prototypes vs. baseline units show a positive result for one refrigerant and a negative one for the other for all temperatures conditions tested. The analysis of the results indicated possible issues with either the baseline units or the prototypes contributing to the outcome since the units have not the refrigerant charge optimized before testing.

An outcome of the project is a need for capacity building to enable the participating OEMs to design and test units with flammable refrigerants and optimize them in order to improve the performance and meet the energy efficiency standards. There is a need to upgrade their testing facilities both in terms of instrumentation as well as to handle flammable refrigerants (refer to Annex 3 for a description of the OEM labs).

In conclusion, test results show that all refrigerants used in the project are viable alternatives for split units from a thermodynamic point of view; however, when compared to MEPS (Minimum Efficiency Performance Standards) for Egypt - see chapter 4 - results show there are challenges faced by the industry to provide high efficiency AC units meeting the upcoming stringent requirements. Moreover, the viability in terms of the other criteria like compatibility, commercial availability, safety, and cost among others needs to be further researched.

Regarding the assessment of HCFC-22 alternatives for central units, the project was not able to have a robust conclusion, due to lack of sufficient number of prototypes developed and the few alternatives used for testing

Chapter 1

1. Introduction

HCFCs are used extensively in the refrigeration and air conditioning industry, in particular in the air-conditioning industry. Parties to the Montreal Protocol, in their 21st meeting, adopted a decision concerning HCFCs and environmentally sound alternatives. The decision calls for further assessment and support work to enable parties to find the best ways of moving forward particularly for those with forthcoming compliance targets related to consumption of HCFC in the air-conditioning sector.

The PRAHA project (*Promoting Low-GWP Refrigerant Alternatives for the Air Conditioning Industry in High Ambient Temperature Countries*) was a pioneer project in testing specially built prototypes by local industries in the Middle East and West Asia region using alternatives refrigerants.

Manufacturers of residential and commercial air conditioning equipment in Egypt met with the Montreal Protocol implementing agencies in July 2014 and agreed on participating in a project to build and test prototypes using various HCFC-22 alternatives at preset conditions in order to compare the performance and efficiency of those refrigerant alternatives.

The project's key elements are to:

a) Asses available low-GWP refrigerant alternatives by building, optimizing, and testing and comparing prototypes using those alternatives;
b) Asses local Energy Efficiency (EE) standards and codes and evaluate the effect of equipment using low-GWP refrigerant alternatives on those standards;
c) Promoting technology transfer by examining and facilitating technology transfer through the HPMP.

The last two elements are part of the Egyptian HPMP and are not included in this report.

1.1. Egypt HPMP

Egypt's starting point for aggregate reductions in its HCFC consumption is the same as its HCFC baseline consumption of 386 ODP tonnes (ODPt). The analysis of the data by substance and by sector showed that HCFC-22 is used almost entirely in the RAC sector and is the most predominant ODS in metric terms. However, in terms of ODS the use of HCFC-141b is significant, being 35% of the total baseline consumption. Egypt reduced its consumption by 25% and 35% by 2018 and 2020 respectively.

The air conditioning manufacturing sub-sector accounts for about 35% of the HCFC-22 consumption. About 56% is used for servicing with RAC manufacturers accounting for the majority of this service consumption, while other service companies account for just 3% of the HCFC-22 consumption.

The significant consumption of HCFC-22 by local AC manufacturers, especially in the room air conditioning sub-sector, is the reason for adopting a project for testing locally built prototypes using low-GWP alternatives. The program has been given the name EGYPRA (*Promotion of Low-GWP Refrigerants for the Air-Conditioning Industry in Egypt)*

1.2. Project Objectives

The aim of the project is to individually test especially manufactured prototype split units and central units, to operate with alternative refrigerants and compare their performance against baseline units. Those baseline units are designed with either HCFC-22 or R-410A refrigerants.

The project objectives were decided upon in agreement with the local stakeholders and can be summarized as follows:

- Guide the Egyptian air conditioning manufacturers to lower-GWP refrigerants including those with low and high flammability;
- Support technical and policy decisions regarding long-term HCFC alternatives for the air-conditioning industry as part of the of Egypt's HPMP;
- Streamline the HCFC phase-out program with the work on Energy Efficiency in Egypt;
- Promote the introduction of relevant standards/codes that ease the adoption of alternatives needing special safety or handling considerations;
- Exchange the experience with other relevant initiatives and programs which aim at addressing long term alternatives;
- Assess the capacity building and training needs for deploying low-GWP alternatives for different groups dealing or handling refrigerants in Egypt.

The outcomes from the above objectives are not presented in this report which focuses on the results of the tests that were carried out for the various air conditioning prototypes.

1.3. Selection of Alternative Refrigerants

The selection of the alternative refrigerants was based on the following aspects which are derived from decision XXIII/9 of the Meeting of Parties (MOP):

I. Commercially available;
II. Technically proven;
III. Environmentally sound;
IV. Economically viable and cost effective;
V. Safety consideration;
VI. Easy to service and maintain.

EGYPRA took into consideration refrigerants that were still not commercially available at the time the prototype building and testing was done. The refrigerants were selected to replace either HCFC-22 or R-410A as shown in Table 1 and Table 2 below, based on availability, cost, expected performance, and ease of handling due. It is worth noting that EGYPRA is a larger testing program than PRAHA; it tested a total 39 units: 19 specially made split unit and two central prototypes and 18 baseline units,. It also witness-tested all split units at the manufacturers' labs to ensure adherence to testing standards and help in guiding technicians when particular challenges arose.

In all 156 tests were made including baseline refrigerants and eight low GWP refrigerants. Witnessing tests that were carried on at the respective OEM labs was needed to

Table 1 List of HCFC-22 alternative refrigerants

Refrigerant	ASHRAE classification	GWP (100 years) – RTOC
HC-290	A3	5
R-444B	A2L	310
R-454C	A2L	295
R-457A	A2L	251

Table 2 List of R-410A alternative refrigerants

Refrigerant	ASHRAE classification	GWP (100 years)*
HFC-32	A2L	704
R-447A	A2L	600
R-454B	A2L	510
R-459A	A2L	466

*RTOC 2018 assessment report

While not all the selected refrigerants are commercially available or cost effective at present, they have all received "R" numbers as per ASHRAE standard 34.

For testing central units, only alternatives to HCFC-22 were used since the OEMs had not built units with R-410A refrigerants when the units were produced in 2016/2017. Presently, those alternatives are not as commercially adopted as those of R-410A; however, it was decided to continue with the tests in order to accomplish the planned goals.

1.4. Selection of Capacity Categories

The selection of prototypes categories to build took into consideration that the majority of the units produced in Egypt are of the mini-split type with capacities of 12,000 Btu/hr, 18,000 Btu/hr, and 24,000 Btu/hr (equivalent to 3.5, 5.25, and 7 kW). Some of the units are still manufactured with HCFC-22 and some with HFC refrigerants which prompted building prototypes for alternatives to HCFC-22 as well as R-410A.

Manufacturers also built what is termed as Central or Packaged units. Several manufacturers produce these units in the 10 Tons (120,000 Btu/hr or 35 kW) capacity but also in larger capacities of 20 and 25 tons. A 10 Ton Central unit was added to the categories to be tested. Only HCFC-22 alternatives were used for this category. The Central category does not include a prototype with HC-290 because of the higher amount of charge needed. The stakeholders preferred to wait for the result of further risk assessment work related to the use of flammable refrigerants being done in the region.

Table 3 below shows the matrix of the prototypes that were agreed upon. Green highlighted areas are for units built, while red denotes the unused portion of the central units as mentioned above.

Table 3 Matrix of prototypes showing refrigerants selected for each equipment category

		Split units			Central Units
Central	**Replacement for**	**12,000 Btu/hr**	**18,000 Btu/hr**	**24,000 Btu/hr**	**120,000 Btu/hr**
HC-290	HCFC-22				
HFC-32	R-410A				
R-457C	HCFC-22				
R-459A	R-410A				
R-454C	HCFC-22				
R-454B	R-410A				
R-444B	HCFC-22				
R-447A	R-410A				
HCFC-22 base					
R-410A					

OEMs were asked to supply baseline units from their standard manufacturing line with equivalent capacity to each prototypes in order to compare units built by the same OEM.

1.5. Stakeholders:

The project stakeholders comprises the following entities:

The Ministry of Environmental Affairs. The following entities at the ministry provided overall supervision and monitoring of the project**:**

- **The Egyptian Environmental Affairs Agency (EEAA):** The Chief Executive Director of EEAA has direct responsibility for the supervision of the activities of the National Ozone Unit.
- **The National Ozone Unit (NOU):** The NOU as an integral part of the Ministry for Environmental Affairs may draw on the legal and technical expertise and resources of the Ministry to undertake its responsibilities. It cooperates with other relevant divisions and field offices of the Ministry and EEAA for carrying out its activities**.**

The Manufacturers (OEMs): Local manufacturers cooperated with Technology Providers to build and test agreed upon prototypes. Eight OEMs participated in the project, listed below in alphabetical order:

- **DCM: (Delta Construction Manufacturing):** a manufacturer of central air conditioning equipment;
- **EGAT (Egyptian German Air Treatment Company):** a manufacturer of ducted split and central air conditioners along with airside equipment for commercial and industrial air conditioning;
- **Elaraby Company for Air Conditioning:** a manufacturer of air conditioners and home appliances, Elaraby partners with Sharp on technology for air conditioning equipment;
- **FRESH Electric for Home Appliances:** a manufacturer of air conditioners and home appliances;
- **Miraco Carrier:** a manufacturer of residential and commercial air conditioning equipment. Miraco also partners with Midea. The lab of Miraco was used to test the central units of the three OEMs
- **Power Egypt:** a manufacturer of small and central commercial & residential air conditioning equipment;
- **Unionaire:** a manufacturer of air conditioners and home appliances;
- **Volta Egypt:** a manufacturer of central air conditioning equipment.

Note on Confidentiality: To ensure the confidentiality of results, OEMs were given random designations from A to H and the results were reported under this designation.

The Technology Providers: Provided components (refrigerants, compressors, and micro-channel coils) in addition to technical support when needed;

- **Chemours (ex-DuPont):** Provided refrigerants R-454C and R-454B;
- **Daikin:** Provided refrigerant HFC-32;
- **Danfoss:** provided components for a central unit;
- **Emerson:** provided compressors for some split systems and all central units;
- **GMCC:** Provided compressors for some of the split systems;
- **Hitachi Highly:** provided compressors for some of the split systems;
- **Honeywell:** provided refrigerants R-444B and R-447A.

1.6. Methodology

The local manufacturers volunteered to build a certain number of prototypes and provided standard units from their production line with baseline refrigerants against which the particular prototypes were compared. Baseline units are with either HCFC-22 or R-410A refrigerants.

The assignment of categories and refrigerants to each of the OEMs was based on a questionnaire in which they listed their preferences and their capabilities to take on the work. The questionnaire can be found in Annex 2. Coordination meetings were held with the OEMs in which some of the technology providers were also present. These meetings and the subsequent contacts with the OEMs facilitated the logistics of shipping both the compressors and the refrigerants to the different OEMs

The prototypes were built with the following constraints:

- Using dedicated compressors provided by the project for each type of alternative refrigerant;
- Using the same baseline-unit overall dimensions, i.e. the heat exchangers could not be oversized in order to compare with the baseline unit. The overall dimensions of the unit were hence kept the same;
- Prototypes needed to meet the MEPS as set out by the Egyptian Organization for Standards EOS 3795:2013 equivalent to ISO 5151 at T_1 conditions as a minimum.
- OEMs provided throttling devices (capillary tubes, flow controls…) according to guidance from refrigerant manufacturers for optimization.

EOS 3795:2013 stipulates for split units less than 65,000 Btu/hr capacity an EER of 9.5 equivalent to a COP of 2.78 at T_1 conditions.

The OEMs optimized the prototypes using dedicated compressors and by changing the refrigerant charge and the expansion devices. No special coil designs were made for this project. The constraint of keeping the same coils has an effect on the optimization of the prototype; however, since the purpose of the tests is to compare to a baseline unit using HCFC-22 or R-410A refrigerants with the same dimensions, this constraint was accepted by the stakeholders.

The selection of the baseline units and the categories was agreed upon with the OEMs to represent the current market landscape and trend in Egypt.

Table 4 and Table 5 below show the number and type of prototype built by each of the OEMs

Table 4 Prototypes and type of refrigerant built by the different OEMs (split systems)

Category	**12 000 Btu/hr**		**18 000 Btu/hr**		**24 000 Btu/hr**	
OEM	**HCFC-22 Alternatives**	**R-410A Alternatives**	**HCFC-22 Alternatives**	**R-410A Alternatives**	**HCFC-22 Alternatives**	**R-410A Alternatives**
A	R-444B	R-447A	R-290	HFC-32 and R-454B	-	-
B	R-454C	HFC-32	R-457A	-	R-444B	-
C	R-290 and R-457C	-	R-457A	R-459A	-	HFC-32 and R-454B
D	-	-	R-444B	-	R-457C	-
E	R-454C	R-454B	-	-	-	-

Table 5: Prototypes and refrigerants for 120,000 Btu/hr central units

OEM	Central units
X	**R-454C**
Y	**R-457C**
Z	**R-444B**

1.7. Testing Parameters and Facilities

EGYPRA testing protocol followed the following testing conditions, for both split systems and central units:

Table 6 Testing conditions for outdoor and indoor dry and wet bulb temperatures

	T_1	T_3	T_{High}	$T_{Extreme}$
Outdoor °C db/wb	35/24	46/24	50/24	55/24
Indoor °C db/wb	27/19	29/19	32/23	32/23

The indoor conditions at T_{High} and $T_{Extreme}$ are not the same as those at T_3 conditions, they were chosen in agreement with the OEMs and are in conformity with ISO 5151 which is followed in Egypt. These indoor conditions are also not the same as in the other testing projects shown in Annex 4. Since the objective of EGYPRA is to compare the performance of AC units with medium and low-GWP alternative refrigerants against units with baseline refrigerants, this comparison remains true as long as the conditions of testing are consistent.

EGYPRA testing facilities: The project managers wanted to use one independent testing lab for testing all units in order to provide a continuity and similitude of testing. The government's accredited lab was contacted for that purpose; however, the lab did not have the capability of testing flammable refrigerants. Efforts at upgrading the lab capabilities could not be finished in time for the project timeline and the project adapted the strategy of witness testing at the manufacturers' testing facilities. The Technical Consultant witnessed all the tests and verified the results. A brief description of the OEM testing facilities can be found in Annex 3.

The independent lab selected to test the central units, Miraco, is one of the OEM participants for the split units. Miraco's lab accommodates central units in both packaged and split configurations. Central units can be installed in the field either as packaged units or as split depending on the application. The units were tested in the split configuration. a.

Testing Methodology:

Testing of the units followed the Egyptian standard EOS 4814, non-ducted AC & HP testing and rating performance. The standard is derived from ISO-5151 and is followed by all manufacturers. The standard stipulates that,

> *"4.1.1.2.5 Machines manufactured for use in more than one of the climatic conditions as T_3, T_2 and T_1 shall be rated and recorded at each of the conditions for which the unit was designed."*

The Egyptian standards do not stipulate testing at temperatures higher than T_3. The T_{High} and $T_{Extreme}$ conditions were derived from ISO 5151 with the agreement of the OEMs.

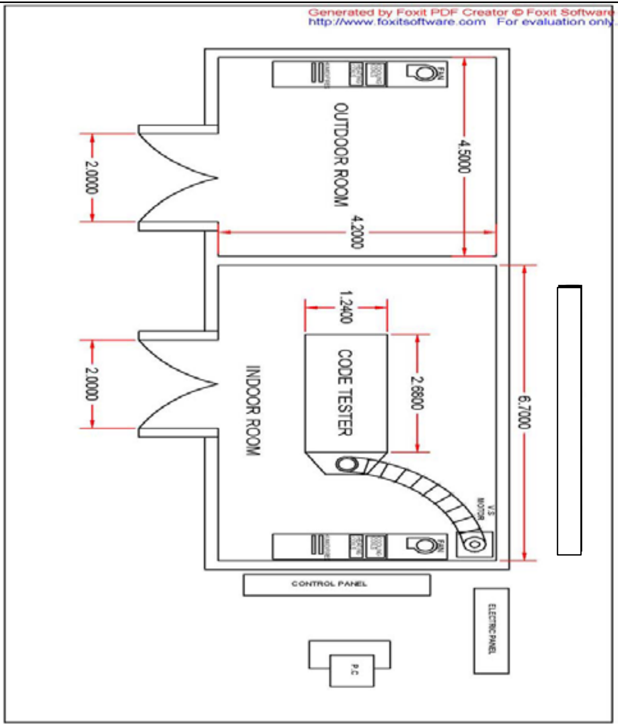
For the room splits, the tests were witnessed by the Technical Consultant. Re-testing the units was permitted when the results were inconsistent or did not meet the minimum EER stipulated in EOS 3795. In these cases, the Technical Consultant advised the OEMs on possible modifications to the design and helped them in the determination of the charge and the expansion device setting to achieve better results.

For the central units, the testing at the independent lab were not witnessed by the technical consultant as modifications could not be done at the independent lab.

Testing procedure

Table below describes the testing procedure applied by all OEMs

Table 7: Testing procedure

No.	Item	Description
1	Testing lab infrastructure: • Testing chamber description Note: (Typical testing laboratory's testing chambers schematic diagram shown. Dimensions and arrangement of equipment are for indicative purposes only.)	 I. Laboratory consists of two thermally insulated chambers (indoor and outdoor chambers). Both chamber's temperature and humidity can be controlled precisely to achieve the required required testing conditions (as per standards) using AC units, humidifiers and electric heaters. II. III. Laboratory is used for measuring capacities less than 1, 1, 1.5, 2 TR. Laboratory of the psychometric type where the air conditioner cooling capacity, heating capacity and efficiency (EER, COP) can be measured accurately. IV. Other parameters such as unit working pressure, superheat, subcooling and state point's temperature of the refrigeration cycle could also be measured. V. The accuracy of temperature control for dry and wet bulb temperatures are in the range 0.01 ^{o}C or better. VI. The indoor room to have a thermal insulated code tester to collect all outlet air from the air conditioner, measuring its dry bulb and wet bulb temperatures and volumetric flow rate.

	• Parameters measured & instrumentation used	• All temperature sensors for inlet and leaving air in indoor room as well as outdoor room air temperatures are to be measured. • Surface temperatures to be measured by sensors - accuracy 0.1 ^oC or better-for both indoor and outdoor chambers. A minimum of 15 measuring points to be used for each room at various locations on the air conditioner. • All data gathered during an experiment to be read by a computer through a specialized program with multi channels data acquisition to get the required data in a live format fashion. • Factory supplied control panel located outside the chambers space to have all necessary control switches to operate the laboratory and set the required conditions with power meters for single phase and 3 phase and all electrical data for tested units. Data to be measured and transferred to computer system.
2	Standards to be used:	All tests for cooling and heating performance to be performed according to the following standards: • EOS 4814 non-ducted AC & HP testing and rating performance • ASHRAE testing standards • ISO 5151 for non-ducted air conditioners • ISO 13253 for ducted type split • EOS 3795-1/2016 • EOS 3795-2/2017
3	Description of the testing procedures: • Description of testing method • *Method of selection of capillary tube and choosing refrigerant charge. This information was used by OEMs to help select the right expansion device* • Achieving steady state for outdoor and indoor conditions (description, time needed…)	• Psychometric testing method is used as per ISO 5151-2017 annex C, G. Nozzles were used to measure for both entering and leaving dry and wet bulb temperatures. • *Optimum selection of capillary size, length, number and refrigerant charge to achieve good matching and improved performance for the unit according to the following:* *i) Select from preliminary capillary chart size, number and length of the required capillary to match the specified load.* *ii) Accumulated experience plays an important role in determining the preliminary refrigerant charge.* *iii) Testing the unit based on pervious selections give an indication for system optimization including increasing or decreasing the charge and/or the size of the capillary.* *iv) System pressure, superheat, subcooling, power consumption, cooling capacity and refrigerant temperature at various points of the cycle give a strong indication on how the matching is proceeding.* • 2 hours' time are needed as a minimum to achieve the steady state condition for testing cooling capacity of the unit as well as EER or COP.
4	Calculating EER and capacity: • How the EER is calculated measurements used and formula • How the capacity was calculated measurements used and formula	EER= cooling capacity/ total power consumed by the system in Btu/hr/W or equivalent. As per ISO 5151 equations in annex C

Chapter 2

2. Results

The results of the various tests were combined under two major headings: results of alternatives to HCFC-22 and results of alternatives to R-410A.

The casual reading of the results may establish confusion, even among specialists, in relation to the increase in capacity at T_{High} compared to T_3. This result is not witnessed in other similar research projects; however, by understanding the impact of changing the dry bulb and wet bulb indoor testing conditions i.e. T_{high} (outdoor 50/24 ^{o}C, indoor 32/24 ^{o}C) compared to T_3 (outdoor 46/24 ^{o}C, indoor 29/19 ^{o}C), the results can be justified since the indoor temperatures both for dry and wet bulb have increased in T_{High} compared to T_3 which has a larger effect on the capacity rather than the outdoor temperature.

Modeling Using ORNL Heat Pump Design Model

Since the measurements provided by the labs were somehow limited, it was difficult to explain the hypothesis for the increase in performance under T_{High} conditions. As such, a full-scale modeling using the ORNL Flexible Heat Pump Model was performed on a sample packaged air conditioning system and the indoor and outdoor conditions were changed according to the EGYPRA conditions: T_1, T_3, T_{High}, and $T_{Extreme}$. Table 6above provides a summary of the indoor and outdoor conditions for the four simulations along with the capacity ratio (capacity/capacity at T_1), compressor mass flow rate, compressor power, sensible heat ratio (SHR), and evaporator overall area integral heat transfer for the vapor (UA_vap) and the 2 phase (UA_2-ph) portions respectively.

The T_{High} condition was selected to simulate the same ambient conditions as that tested by the OEMs but with the same indoor conditions as T_1 and T_3. The result from this simulation follows the simple intuition that as the outdoor temperature increases, the performance degrades at a rough order of magnitude of 1% point per 1°C of outdoor temperature increase. However, when examining the performance of the $T_{Extreme}$ condition; we notice a sudden increase in capacity – coupled with an increase in refrigerant mass flow rate, and reduction in SHR. The simulation results show that for T_1, T_3 and T_{High} conditions, the suction saturation temperature change was less than 1°C, while when the indoor conditions were changed to the T_{High} condition, the suction saturation temperature changed by more than 4°C. This has an impact on the compression ratio, compressor suction density, and compressor performance (volumetric and isentropic efficiencies). Furthermore, the higher humidity associated with the $T_{Extreme}$ condition induces the evaporator coil to become wetter and as such results in higher airside performance and higher SHR.

Table 8: Conditions and relevant results for the rooftop unit simulated using the ORNL Flexible HPDM simulation tool

Condition	EDB	EWB	Outdoor air	Capacity/Capacity at T1	Compressor mass flow rate	Compressor Power	SHR	Evaporator vapor UA	Evaporator 2-ph UA
	°C	°C	°C	%	g/s	W	%	W/K	W/K
T1	29	19	35	100%	379.8	14,074.9	88%	5.6	265.7
T3	29	19	46	89%	383.7	16,952.9	93%	6.7	265.1
T_{High}	29	19	50	86%	384.6	18,077.2	95%	6.7	265.2
$T_{Extreme}$	32	24	50	94%	433.9	18,693.8	78%	9.4	261.3

Hypothesis summary

When the indoor dry bulb and wet bulb temperatures are increased from the T_3 conditions to the T_{High} conditions; the sensible heat ratio of the AC system is reduced, and a large portion of the evaporator is wetted by the water vapor condensate. This results in heat transfer enhancement due to reduced free flow area and increased surface velocity and the concurrence of heat and mass transfer at the tubes and fin surfaces. From further analysis provided by the detailed study from OEM C; the evaporator log mean temperature difference is also increased due to the increased air inlet temperature. Hence on the air side, both the increase in overall heat transfer coefficient along with the increased evaporator LMTD and increased latent capacity contribute directly to the increased heat capacity between T_3 and T_3 with elevated indoor conditions (subsequently also the increased capacity at the T_{High} conditions).

At the refrigerant side, when the indoor conditions are changed from the T_3 to the T_{High} conditions – the compressor pressure ratio is reduced while the refrigerant density at the compressor inlet is increased. The refrigerant flow rate also increases which further justifies the increased cooling capacity from the refrigerant side analysis.

2.1 Presentation and Analysis of Results for Split Units

The analysis of the results is presented in table form. The complete results and comparative bar charts are found in Annex 1.

The Results for capacity in Btu/hr and energy efficiency in EER (energy efficiency ratio in Btu/hr/1,000 or MBH output/kW input) are given for the four testing temperatures. The tables show the test results and the percentage increase or decrease in capacity and EER compared to the baseline unit. As a reminder, each OEM was asked to test a baseline unit from their own standard production for each prototype built in order to compare with the prototype testing results.

The analysis uses shades of color to denote the performance comparison to the baseline unit as follows:

No shading	Performance is same as base unit – for capacity and EER
Green	**Increase** in EER or cooling capacity over baseline unit
Yellow	**Decrease** in EER or cooling capacity by **- 0.01 % to - 5 %**
Orange	**Decrease** in EER or cooling capacity from **-5 % to - 10 %**
Red	**Decrease** in EER or cooling capacity over **-10 %**

The results are then plotted on a scattered chart for the ratio of capacity of the prototype to that of the baseline unit vs. the EER ratio at the four testing temperatures. The baseline unit performance is denoted by the two red dotted lines at a ratio of one for both capacity and EER.

The analysis is presented for the alternatives of HCFC-22 and R-410A separately. Some results for inconclusive tests mentioned in the Annex were not used in the analysis.

2.1.1. Analysis of Capacity and EER Performance for HCFC-22 Alternatives

The tables in this section are for alternatives to HCFC-22 for the three categories of mini-split units: 12,000 Btu/hr, 18,000 Btu/hr, and 24,000 Btu/hr.

Results for the 12,000 Btu/hr category

Table 9 Comparison of HCFC-22 alternatives for 12,000 Btu/hr split units

HFCF-22 12,000 Btu/hr	T_1	T_3	T_{High}	$T_{Extreme}$	T_1	T_3	T_{High}	$T_{Extreme}$
	Capacity in Btu/hr				EER			
Base Units								
R-22(OEM C) R-22(OEM B) R-22(OEM A)	11,452 11,410 11,479	9,960 9,988 9,699	10,560 10,900 11,353	10,181 10,035 8,407	10.0 8.4 9.7	7.25 6.4 6.9	6.98 6.3 7.3	6.23 5.5 5.6
Prototypes								
HC-290 (OEMC)	10,219 (-10.8%)	8,677 (-12.9%)	9,289 (-12.0%)	7,747 (-23.9%)	10.4 (+3.53%)	7.17 (-1.1%)	7.0 (-0.23%)	5.2 (-16.2%)
R-457A (OEM C)	11,023 (-3.8%)	9,376 (-5.9%)	10,892 (+3.1%)	9,517 (-6.5%)	8.4 (-16.4%)	6. (-13.3%)	6.6 (-5.6%)	5.6 (-10.8%)
R-454 C (OEM B)	10,968 (-3.9%)	9,349 (-6.4%)	9,946 (-8.8%)	9,042 (-9.9%)	8.0 (-5.2%)	6.0 (-6.0%)	5.9 (-7.4%)	5.1 (-7.7%)
R-444 B (OEM A)	11,790 (+2.7%)	9,661 (-0.4%)	10,241 (-9.8%)	8,881 (+5.6%)	8.4 (-13.5%)	5.7 (-16.2%)	5.5 (-24.4%)	4.5 (-20.3%)

The table shows that for HC-290, the capacity of the prototype at all four temperatures is less than that of HCFC-22 baseline, while the EER is higher at T_1 and within 1% at T_3 and $T_{High.}$ The results for R-457A and R-454C show results for capacity up to 10% less than the baseline with R-457A showing a better capacity at Thigh which is not the case for R-454C. For R-444B, capacity is better than the baseline at both T_1 and $T_{Extreme}$ but around10% worse at T_{High} which cannot be explained. EER for R-444B is more than 10% worse than the baseline for all testing conditions. The comparison is plotted on a scattered chart as follows

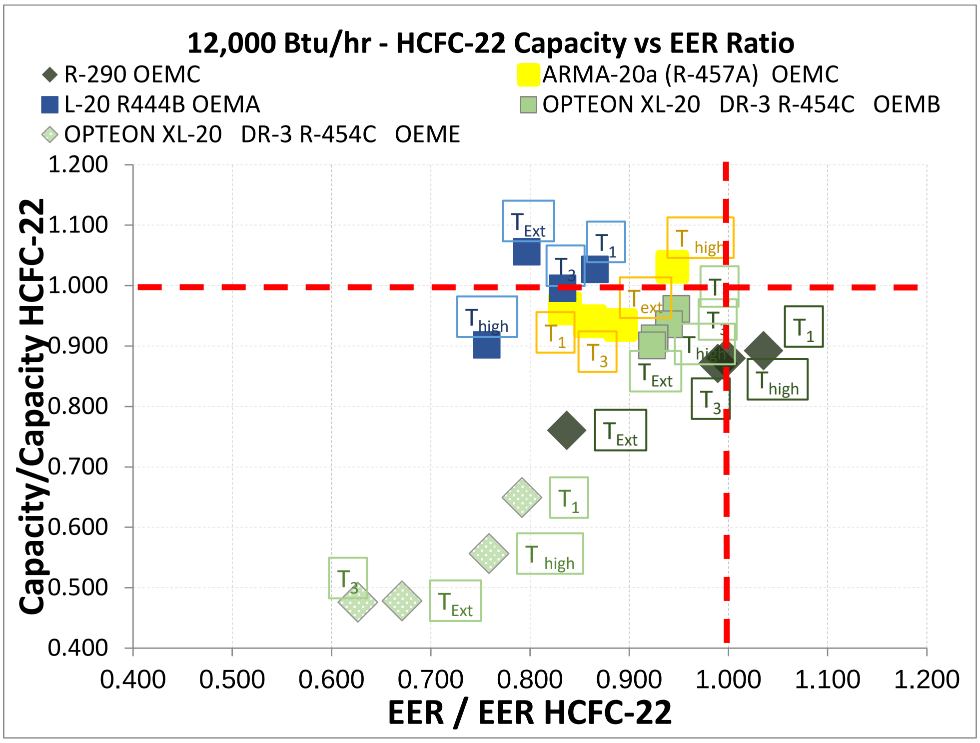


Figure 1 Capacity vs. EER ratio for HCFC-22 alternatives in 12,000 Btu/hr split units

Results for 18,000 Btu/hr Splits

Table 10 Comparison of HCFC-22 alternatives for 18,000 Btu/hr split units

18,000 Btu/hr	T_1	T_3	T_{High}	$T_{Extreme}$	T_1	T_3	T_{High}	$T_{Extreme}$
Refrigerant	Capacity				EER			
Baseline Units								
HCFC-22								
OEM A	18,659	16,799	17,543	15,046	9.4	7.2	7.0	5.6
OEM B	16,433	14,545	13,718	15,350	8.9	6.7	6.4	5.33
OEM C	18,160	16,182	17,632	16,292	10.0	7.4	7.4	6.5
OEM D	17,548	16,422	14,624	13,948	10.5	8.8	7.2	6.0
Prototypes								
R-290 (OEM A)	*16,111 (-13.66%)*	*14,067 (-16.26%)*	*15,343 (-12.54%)*	*13,442 (-10.66%)*	9.1 (-1.06%)	7.1 (-2.34%)	7.2 (+2.72%)	5.9 (+5.59%)
R-457 A (OEM B)	*15,257 (-7.2%)*	*12,672 (-13.0%)*	*13,418 (-2.2%)*	*12,149 (-20.9%)*	9.3 (+3.7%)	6.6 (-0.9%)	6.3 (-0.9%)	5.3 (0.00%)
R-454 C (OEM C)	*16,510 (-9.1%)*	*14,327 (-11.5%)*	*15,619 (-11.4%)*	*14,250 (-12.3%)*	9.3 (-6.88%)	7.0 (-5.43%)	7.0 (-4.88%)	6.0 (-6.67%)
R-444 B (OEM D)	*17,098 (-2.6%)*	*15,746 (-4.1%)*	*13,498 (-7.7%)*	*13,047 (-6.5%)*	10.0 (-4.76%)	7.8 (-11.01%)	6.3 (-12.47%)	5.4 (-10.00%)

The results for HC-290 for capacity are consistent with the results of the 12,000 Btu/hr category, while the EER shows better results than the baseline at T_{High} and $T_{Extreme}$. The results for R-457C capacity compared to the 12,000 Btu/hr category show a further degradation compared to the baseline for the 18,000 Btu/hr category, while the EER results at the four temperatures are better than the 12,00 Btu/hr category. The same can be said about R-454C, while R-444B has comparable results with the 12,000 Btu/hr category with a variation with temperature. The results of this category show higher values for both capacity and EER for T High results compared to T3 in line with the discussion at the beginning of this chapter.

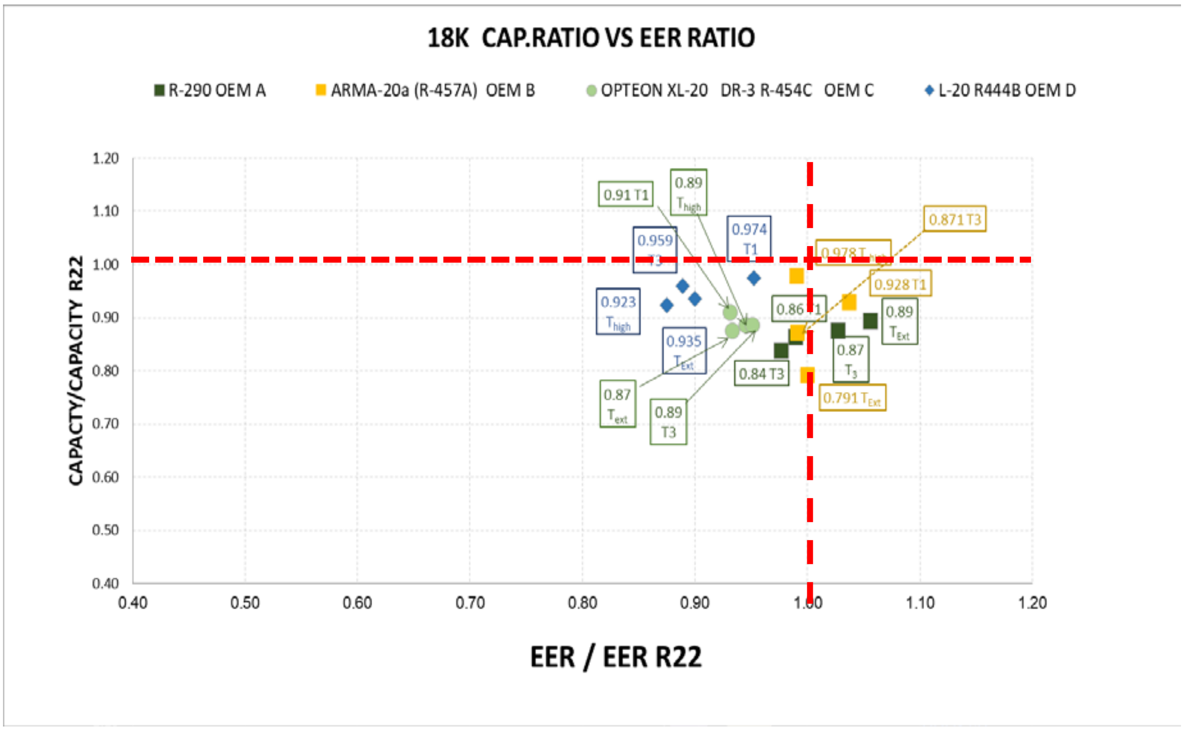


Figure 2 Capacity vs EER Ratio for HCFC-22 alternatives in 18,000 Btu/hr split units

Results for 24,000 splits

Table 11 Comparison of HCFC-22 alternatives for 24,000 Btu/hr split units

24,000 Btu/hr	T_1	T_3	T High	T Extreme	T_1	T_3	T High	T Extreme
Refrigerant	Capacity				EER			
Baseline								
HCFC-22 OEM B OEM D	 22,782 22,318	 N/A 21,202	 N/A 20,144	 N/A 19,148	 9.27 9.3	 N/A 7.3	 N/A 6.0	 N/A 5.7
Prototypes								
R-444 B (OEM B)	23,436 (+2.87%)	N/A	N/A	N/A	7.38 (-20.39%)	N/A	N/A	N/A
R-457 A (OEM D)	21,758 (-2.5%)	20,670 (-2.5%)	19,636 (-2.5%)	18,657 (-2.6%)	8.8 (-5.6%)	6.9 (-6.4%)	5.8 (-4.6%)	5.3 (-8.4%)

Unfortunately, the data for R-444B at temperatures other than T_1 were not available. Data for R-457A as a percentage of the baseline by the same OEM show a better trend than for the other two categories; however, in absolute terms the EER of the baseline of the 24,000 Btu/hr category is lower than the other two categories which explains the higher percentage.

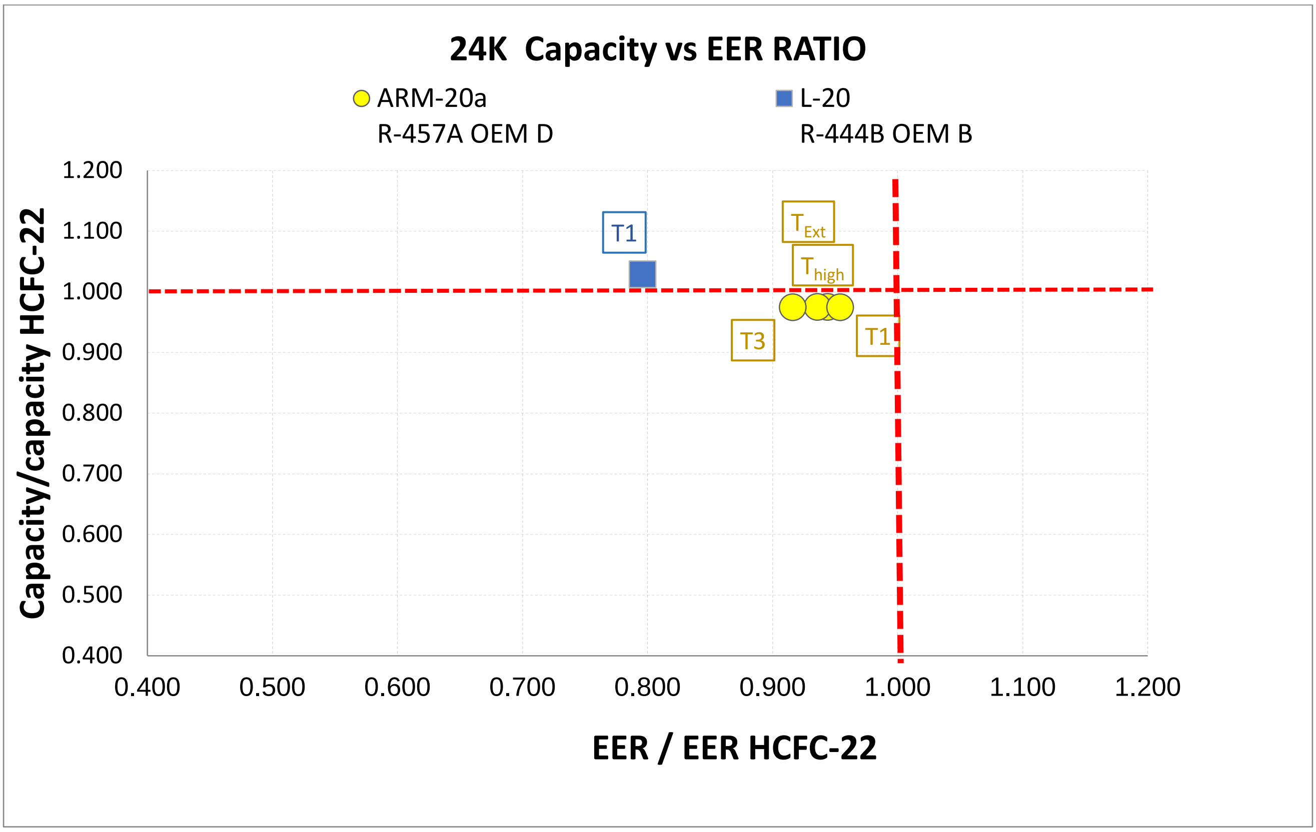


Figure 3 Capacity vs. EER ratio for HCFC-22 alternatives in 24,000 Btu/hr split units

Note that the results for the capacity for R-457A at the four temperatures are similar and hence the yellow circle label points seem almost concentric.

2.1.2. Analysis of Capacity and EER Performance for R-410A Alternatives

Results for 12,000 Btu/hr splits

Table 12 Comparison of R-410A alternatives for 12,000 Btu/hr split units

12,000	T_1	T_3	T_{High}	$T_{Extreme}$	T_1	T_3	T_{High}	$T_{Extreme}$
Refrigerant	Capacity				EER			
Baseline								
R-410A OEM A OEM B OEM E	 10,307 12,068 11,905	 N\A 10,343 9,369	 8,313 11,089 10,848	 N\A 9,968 9,299	 8.77 10.17 10.88	 N\A 7.31 7.3	 5.43 7.2 7.4	 N\A 5.9 5.9
Prototype								
HFC-32 (OEM B)	11355 (-5.9%)	9,249 (-10.9%)	9,822 (-11.4)	8,499 (-14.7%)	11.5 (+13.2%)	7.5 (+3.0%)	7.3 (+1.5%)	5.7 (-4.1%)
R-454B (OEM E)	11,987 (+0.7%)	11130 (+18.8%)	12,257 (+13.0%)	11,094 (+19.3%)	9.9 (-8.82%)	8.0 (+9.05%)	7.7 (+3.27%)	6.7 (+14.90%)
R-447A (OEM A)	9963 (-3.3%)	N\A N\A	8539 (+2.2%)	N\A N\A	8.4 (-4.4%)	N\A N\A	5.6 (+2.2%)	N\A N\A

The results for R-454B compared to the baseline is better except for the EER at T_1. Results for HFC-32 compared to the baseline show a higher performance for EER but lower for capacity.

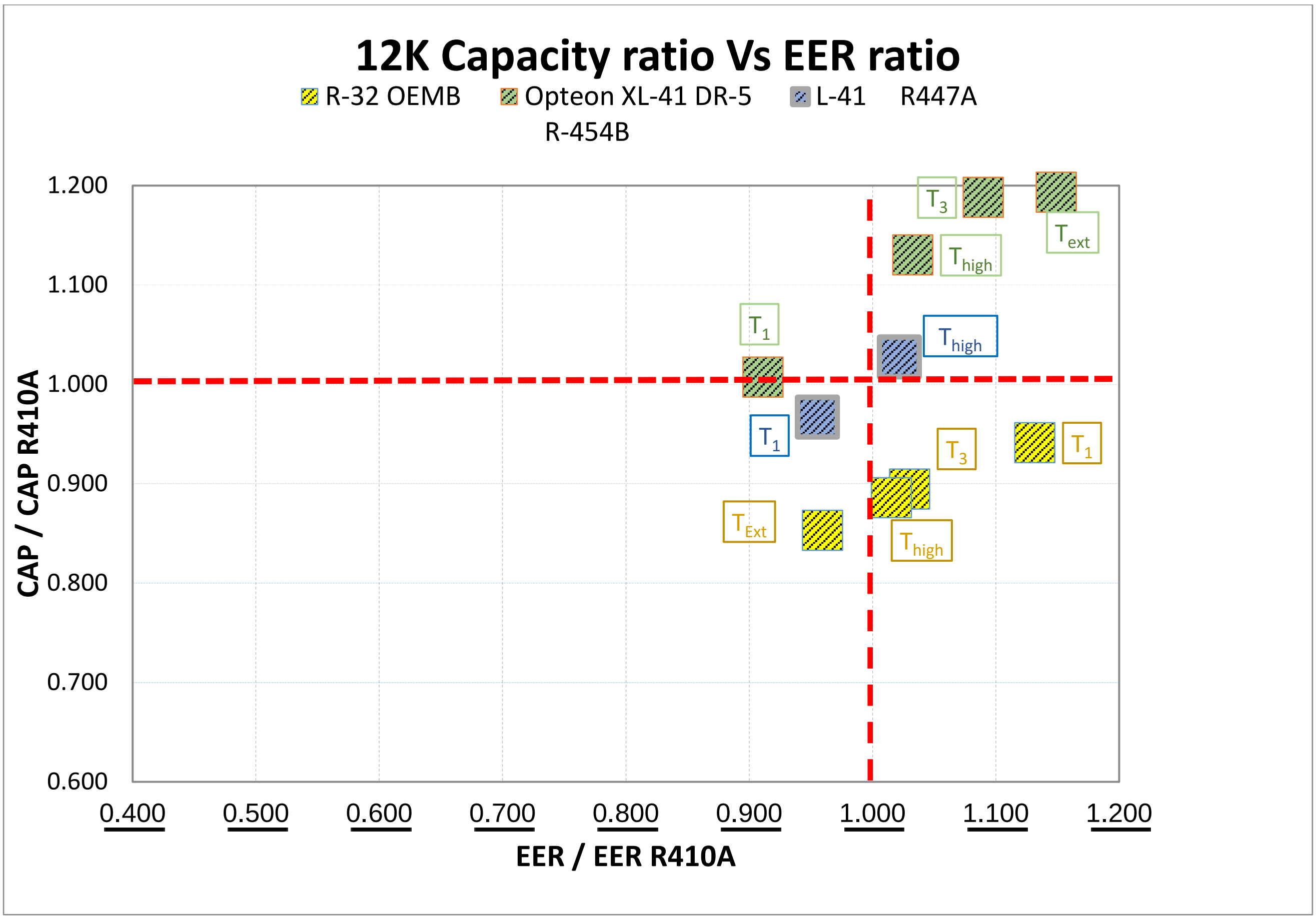


Figure 4 Capacity vs EER ratio for R-410a alternatives in 12,000 Btu/hr split units

Results for 18,000 Btu/hr

Table 13 Comparison of R-410A alternatives for 18,000 Btu/hr split units

18,000	T_1	T_3	T_{High}	$T_{Extreme}$	T_1	T_3	T_{High}	$T_{Extreme}$
Refrigerant	Capacity				EER			
Baseline								
R- 410 A OEM A OEM C	 16,938 17,800	 14,337 14,924	 14,123 16,075	 12,441 13,746	 9.8 9.2	 6.8 6.5	 6.3 6.5	 5.1 5.
Prototype								
R-459A (OEM C)	17,115 (-3.9%)	14,430 (-3.3%)	15,392 (-4.3%)	14,023 (+2.0%)	9.28 (+1.4%)	6.54 (+0.7%)	6.27 (-3.4%)	5.32 (+4.0%)
HFC-32 (OEM A)	17616 (+4.0%)	15,255 (+6.4%)	15,761 (+11.6%)	13,809 (+11.0%)	10.03 (+2.4%)	7.10 (+4.4%)	6.65 (+5.6%)	5.29 (+3.7%)
R-454B (OEM A)	15,167 (-10.5%)	13,229 (-7.7%)	13,782 (-2.4%)	11,800 (-5.2%)	9.5 (-3.1%)	6.90 (+1.5%)	6.50 (+3.2%)	5.20 (+2.0%)

The results for R-454B show a similar trend of higher values against the baseline to the 12,000 Btu/hr category for EER but lower for capacity. Results for HFC-32 are higher than the baseline for both capacity and EER, which is different from the 12,000 Btu/hr category.

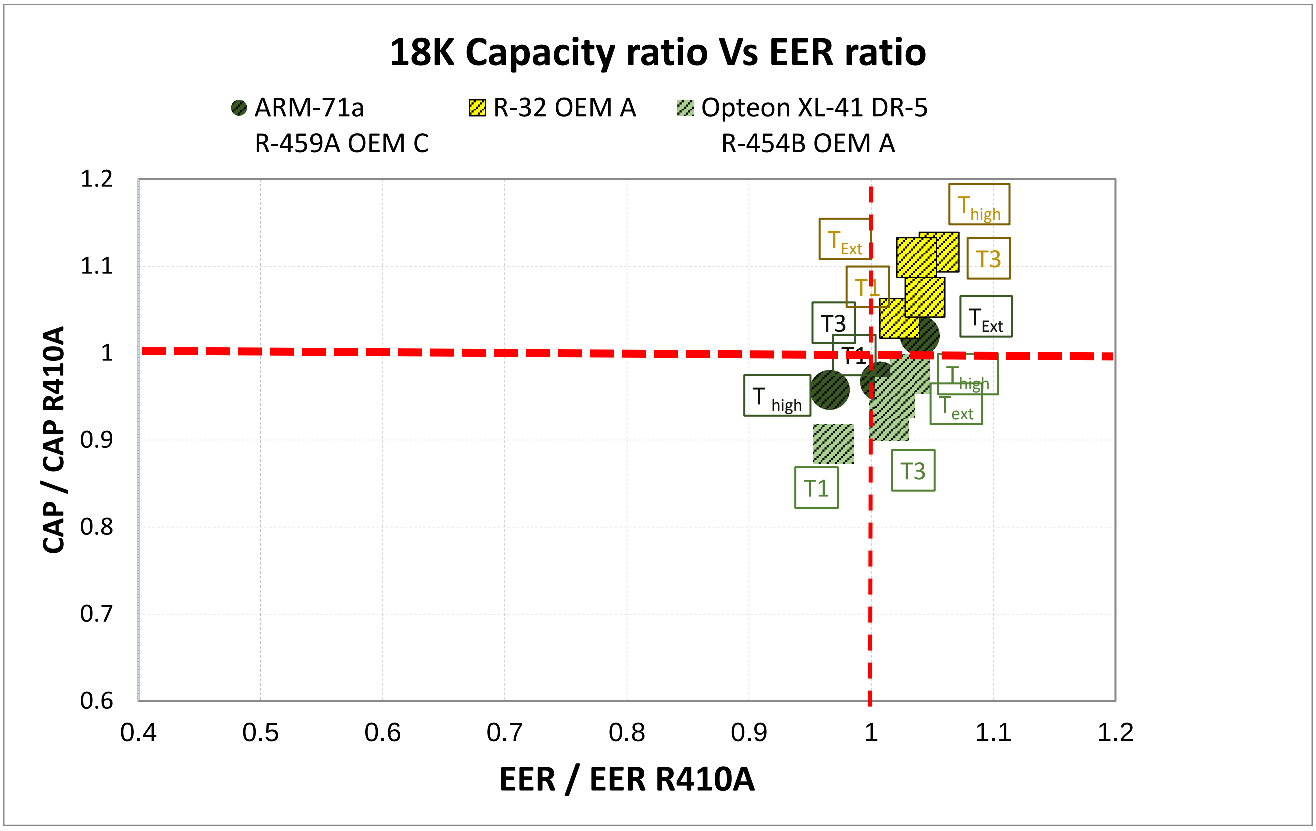


Figure 5 Capacity vs EER ratio for R-410A alternatives in 18,000 Btu/hr split units

The plot shows that most of the results are on the positive side when compared to the baseline units for EER with some results for capacity showing lower values.

Results for 24,000 Btu/hr

Table 14 Comparison of R-410A alternatives for 24,000 Btu/hr split units

24,000	T_1	T_3	T_{High}	$T_{Extreme}$	T_1	T_3	T_{High}	$T_{Extreme}$
Refrigerant	Capacity				EER			
Baseline								
R- 410 A OEM C	23022	19531	20534	18379	10.6	7.5	7.4	6.2
Prototype								
HFC-32 (OEM C)	23310 (+1.3%)	19522 (-0.1%)	21876 (+6.5%)	19035 (+3.6%)	10.62 (-0.5%)	7.228 (-3.9%)	7.459 (+1.1%)	5.988 (-2.1%)
R-454B (OEM C)	23766 (+3.2%)	20241 (+3.6%)	22268 (+8.4%)	20160 (+9.7%)	10.653 (+0.8%)	7.516 (-0.03%)	7.515 (+1.9%)	6.224 (+1.0%)

Results are mostly positive for the two refrigerants tested at this category.

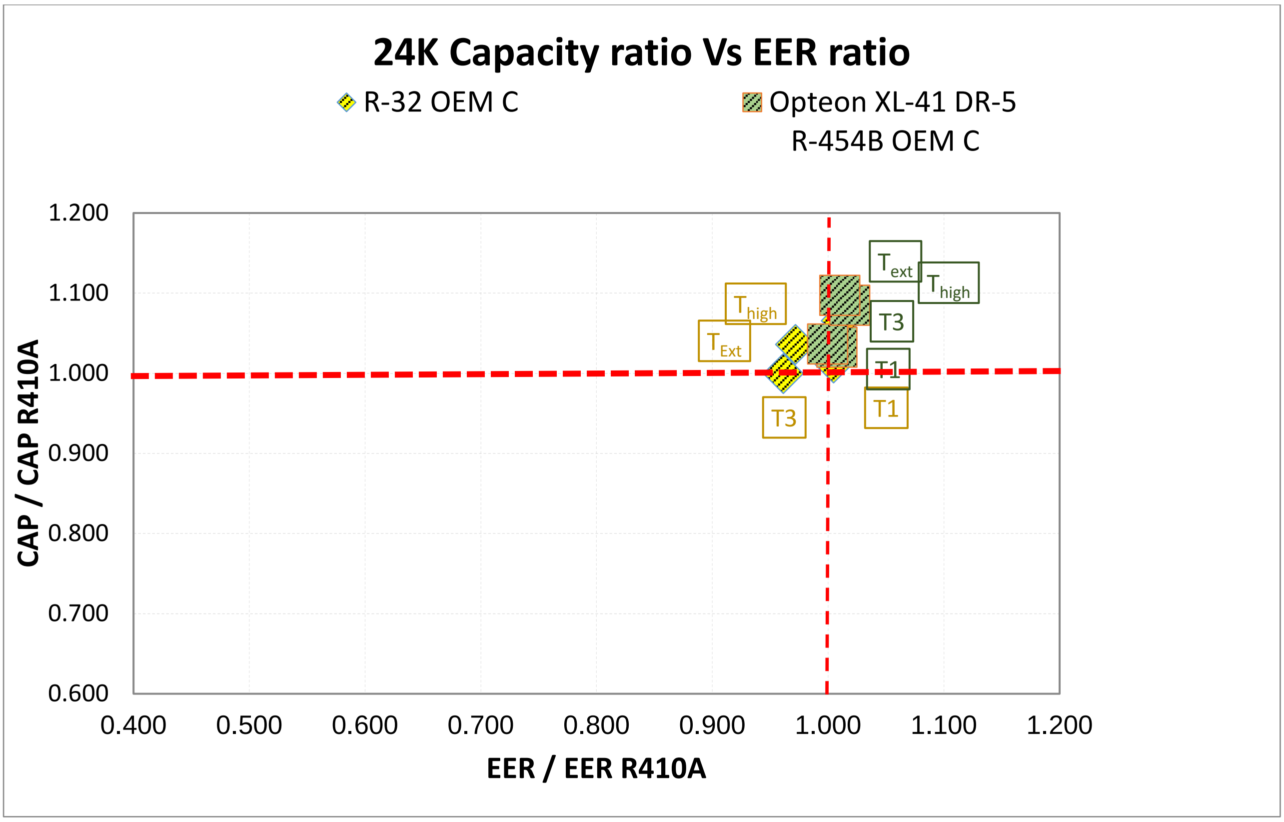


Figure 6 Capacity vs EER ratio for R-410A alternatives in 24,000 Btu/hr split units

2.2. Presentation and Analysis of Results for the central units

The central units were tested in the only commercial units accredited lab in Egypt with the OEMs' technicians attending the tests. The testing procedure was approved the technical consultant, and explained to the lab operators. Although optimization was allowed, the tests were carried on the units as received from the OEMs with no optimization at the facility, except adjusting the charge in the case of HCFC-22 baseline unit by OEM X. Optimization of refrigerant charge was the practice used for the split units at each OEM lab and witnessed by the technical consultant.

The Results for capacity in Btu/hr and energy efficiency in EER (energy efficiency ratio in MBH output/ kW input) are given for the four testing temperatures. The tables show the test results and the percentage increase or decrease in capacity and EER compared to the baseline unit. Each OEM was asked to provide a baseline unit from their own standard production in order to compare with the results. Red highlight denotes performance more than 10% below those of the baseline unit, while green is better performance as shown in the color code chart.

The results from only two prototypes were available. The third prototype working with R-444B could not be tested due to a technical problem with the prototype and the base unit that the OEM could not be solved in time. Table 15 shows the results for R-454C and R-457A.

Table 15: Presentation and comparison of results for the central units

120,000 Btu/hr	T_1	T_3	T_{HIGH}	$T_{Extreme}$	T_1	T_3	T_{High}	$T_{Extreme}$
	Capacity in BTU/h				EER in BTU/Watt.h			
Baseline								
R-22 (OEM-X)	84,330	76,030	81,860	76,430	7.0	5.4	5.6	4.6
R-22 (OEM-Y)	55,210	48,270	49,060	41,910	4.4	3.4	3.3	2.6
Prototypes								
R-454C (OEM-X)	69,010 (18.2%)	64,530 (15.1%)	66,600 (18.6%)	66,070 (13.6%)	5.36 (23.1%)	4.48 (16.9%)	4.32 (23.0%)	3.98 (13.3%)
R-457A (OEM-Y)	77,160 39.8%	63,280 31.1%	65,490 33.5%	57,670 37.6%	5.9 33.4%	4.1 21.8%	4.0 21.9%	3.3 27.8%

It is evident from the table that:

- The two baseline units do not meet the nameplate capacity at design conditions that was selected for the project. OEM X is at 70% while OEM Y is at 46% of the designated capacity at T_1 conditions;
- EER values at 7.0 and 4.4 (at T_1 conditions) also fall short of the comparative results of baseline units of split systems tested in the project;
- The prototypes' capacities are closer to each other but still around 60% of the designated capacity. It is this noteworthy that the OEM with the higher capacity baseline unit had a lower capacity prototype (OEM X), while OEM Y with the lower capacity base unit had the higher capacity prototype. The same trend was also demonstrated for EER.

Figure 7 shows the scatter graph for capacity vs. EER plotted against a reference for the baseline units at the value of one shown by the dotted lines. The results for R-457A are in the upper right hand quadrant indicating better performance than the corresponding HCFC-22 unit, while those for R-454C are in the bottom left hand quadrant indicating worse results than the base HCFC-22 unit built by the same OEM.

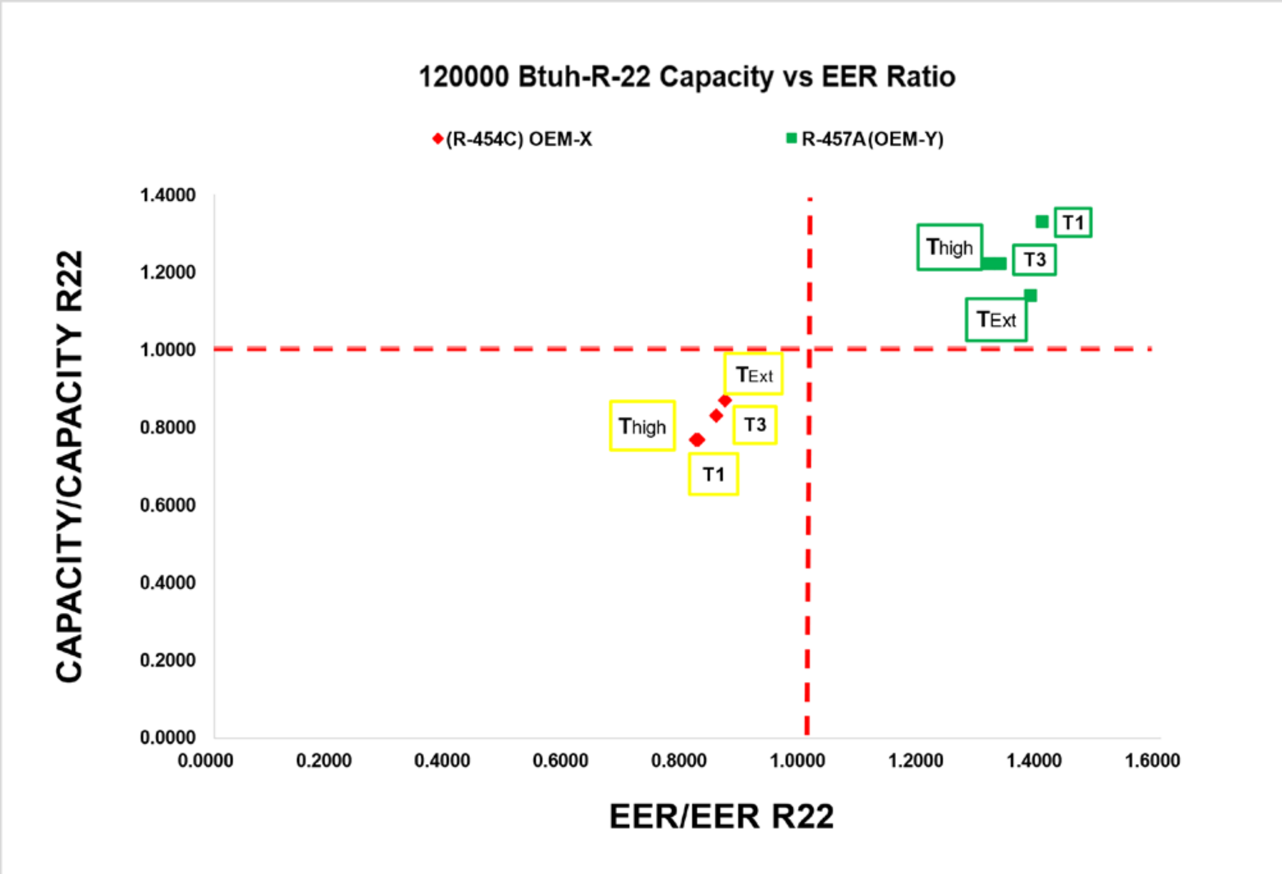


Figure 7: Capacity vs. EER ratio for HCFC-22 alternatives for the 120,000 Btu/h central units

In light of the above, it is difficult to draw a conclusion from the two set of tests since it was not possible to analyze the reason behind the performance of the baseline units which reflects on the comparison with the prototypes. On the other hand, the following facts might have a bearing on the results:

a) The prototypes were built in 2016 to 2017. The delay in testing was due to the unavailability of a test lab to test units of that capacity;
b) A lack of consistency in the production of the prototypes due to the high OEM technician rotation and lack of training in the period between 2016 to 2021;
c) In practice, units are normally optimized (charge mass) on site during installation rather than at the OEM facility. This practice is mainly due to a lack of proper well equipped labs for commercial units at the OEMs and the absence of MEPS for commercial units in Egypt;
d) The central unit can be installed in two configurations, either as a packaged unit or as a split. The unit was tested as a split unit;
e) The refrigerant charge of OEM X for the prototype unit needed further optimization;
f) R-454C is mainly used as a replacement for HCFC-22 and R-404A in refrigeration applications. Chemours advises that the refrigerant is also sometimes used for air conditioning applications;
g) R-457A has not been commercialized yet by its manufacturer.

Chapter 3

3. Analytical comparison & way forward

The purpose of the comparative analysis in this section is to determine the potential for improvement for the different alternative refrigerants at the different testing temperatures and for the three split system categories. Since there are three variables: type of refrigerants, testing temperatures, and category of equipment, the analysis fixed one of the variables and then calculated the percentage of incidence of cases where either the capacity or the EER as compared to the baseline unit falls in the five color categories defined earlier and repeated here for ease of reference.

No shading	Performance is same as base unit
Green	**Increase** in performance or cooling capacity over base unit
Yellow	**Decrease** in performance or cooling capacity by **- 0.01 % to - 5 %**
Orange	**Decrease** in performance or cooling capacity from **-5 % to - 10 %**
Red	**Decrease** in performance or cooling capacity over **-10 %**

As an example, consider the 12,000 Btu/hr category for all refrigerants and at all testing temperatures for the capacity comparison. We come up with the following table:

Table 16 Example of calculation of the comparative pie charts

12,000 Btu/hr category	**Capacity**				
Refrigerant	T_1	T_3	T_{High}	$T_{Extreme}$	
R-290	10,219	8,677	9,289	7,747	
(OEM C)	(-10.8%)	(-12.9%)	(-12.1%)	(-23.9%)	
R-457 A	1,1023	9,376	10,892	9,517	
(OEM C)	(-3.7%)	(-5.9%)	(+3.1%)	(-6.5%)	
R-454 C	10,968	9,349	9,946	9,042	
(OEM B)	(-3.9%)	(-6.4%)	(-8.7%)	(-9.9%)	
R-444 B	11,790	9,661	10,241	8,881	
(OEM A)	(+2.7%)	(-0.4%)	(-9.8%)	(+5.6%)	
	Calculation of incidence percentage				
	Green	Yellow	Orange	Red	No shading
Incidence: number of entries per color	**3**	**3**	**6**	**4**	**0**
Percentage of the 16 entries	**18.7%**	**18.7%**	**37.5%**	**25.0%**	**0%**

And the respective pie chart will look as in Figure 7 with the percentage of each incidence marked on the respective color. The pie chart indicates that when considering all the HCFC-22 refrigerant alternatives at all testing temperatures for the 12,000 category, there is

- 18.7% certainty that the result is better than the base,
- 18.7% that the result is up to 5% less compared to the base,
- 37.5% that the result between 5 and 10% less, and
- 25% that the results is over 10% less than the base.

Similar comparative analysis will be made for the different cases for HCFC-22 alternatives and R-410A alternatives. The analysis clarifies the way forward and recommendations can be made for all the cases.

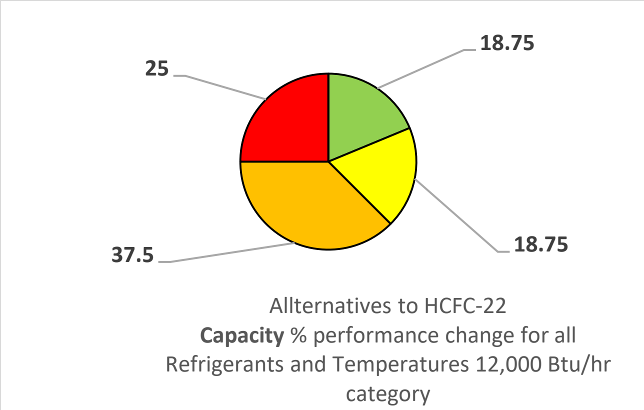


Figure 8 Example of pie chart for HCFC-22 alternatives in the 12,000 Btu/hr category

3.1. Capacity and EER behaviour of HCFC-22 Alternatives for each category across all refrigerants and testing temperatures

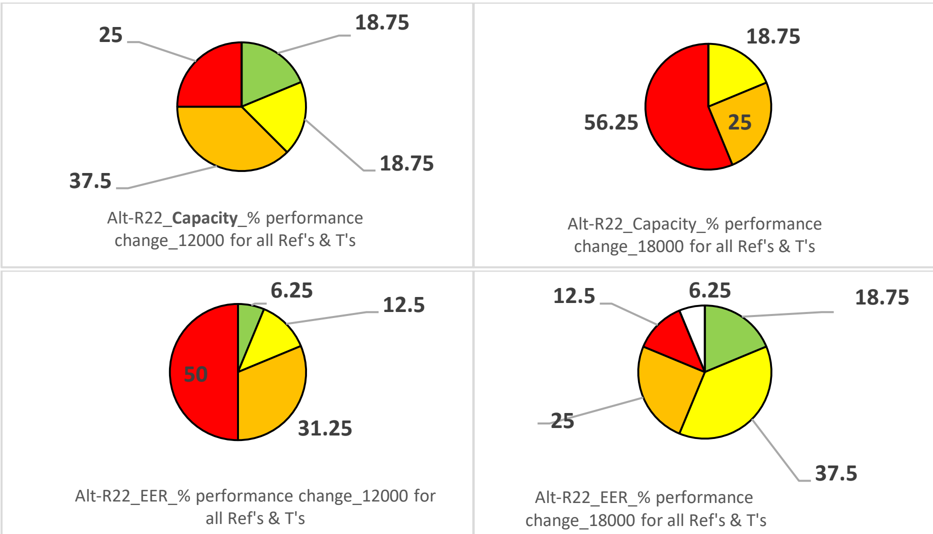


Figure 9 capacity and EER Performance of HCFC-22 alternatives for each category across all refrigerants and all testing temperatures

This analysis shows the following key observations:

For 12,000 Capacity:

- There is, certainly, potential to improve the capacity across 75% of refrigerants and at different testing temperatures
- On the EER side, the potential improvement drops down to 50%

For 18,000 Capacity:

- There is less potentiality to improve capacity across all refrigerants and at different testing temperatures compared to the 12,000 category.
- However, opportunities to improve EER is much higher reaching over 85% across all refrigerants and at different testing temperatures

The 24,000 prototypes results were disregarded, since only one OEM tested one refrigerant across all test temperatures conditions. The other OEM tested another refrigerant at only one testing temperature condition. Therefore, a comparison of the results would be misleading.

3.2. Capacity and EER behaviour of HCFC-22 Alternatives for each refrigerant across all categories and testing temperatures

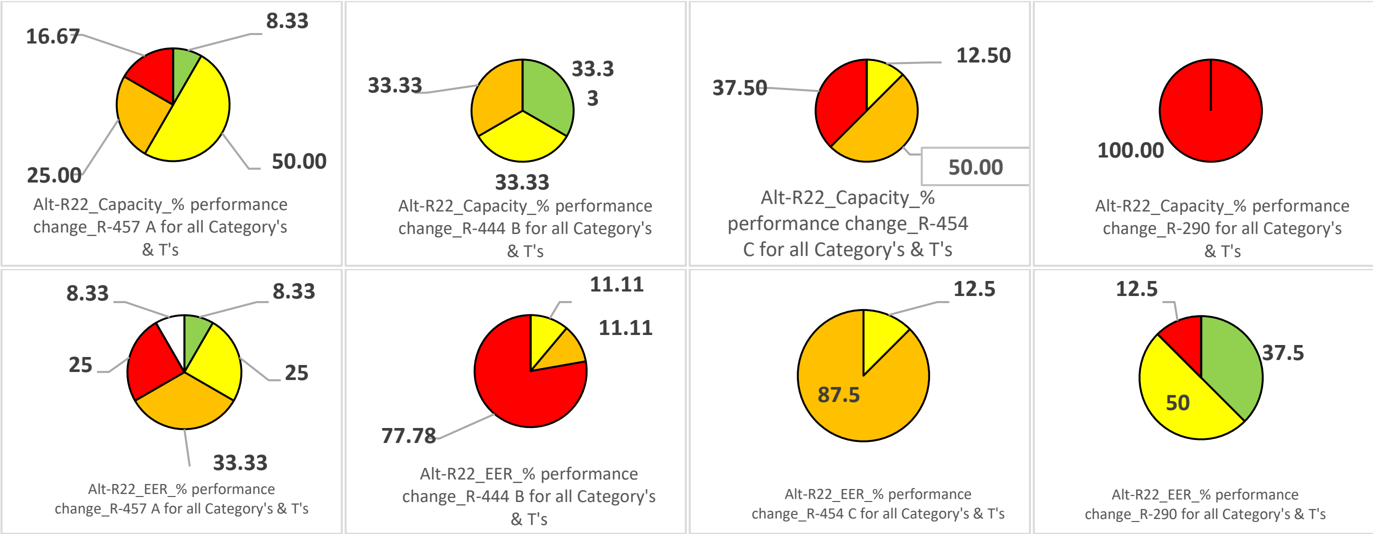


Figure 10 capacity and EER performance for HCFC-22 alternatives for each refrigerant across all categories and all testing temperatures

- Several alternatives to R-22 shows 60%, or above, chance for Capacity matching or improvement across all categories and at different testing temperatures.
- Most alternatives to R-22 shows 50%, or above, chance for EER improvement across all categories and at different testing temperatures.

3.3. Capacity and EER behaviour of HCFC-22 Alternatives for each testing temperature across all categories and refrigerants

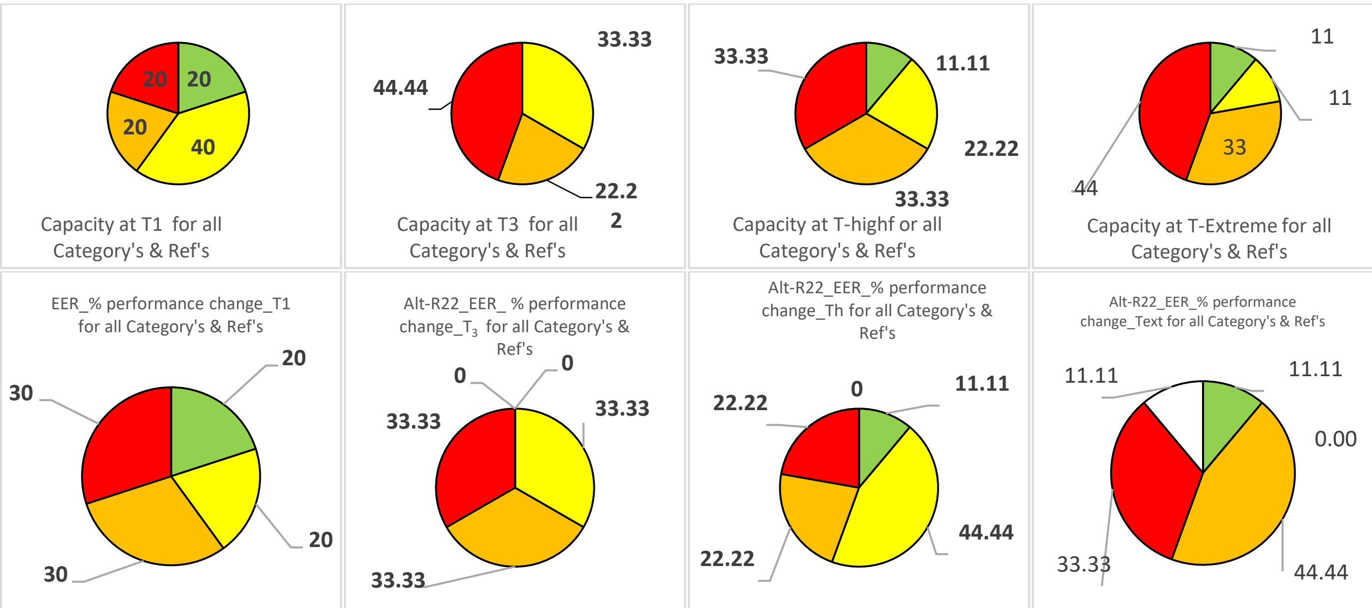


Figure 11 Capacity and EER performance of HCFC-22 alternatives for each testing temperature across all categories and all refrigerants

- As expected, moving from T1 to T3 testing temperatures, both capacity and EER deteriorate, at different levels, across all categories and refrigerants
- At T_{High}, the increased indoor wet bulb testing condition, as per EOS & ISO-5151, leads to better results for EER and capacity compared to T3

- Since T Extreme testing condition is similar to T High, with regard to indoor wet bulb testing condition, both EER and capacity re-deteriorate.
- In general, there are candidates with potential improvement, more than 50%, across all categories at all high temperature testing conditions i.e. T_3, T high & T extreme.

3.4. Capacity and EER behaviour of R-410A Alternatives for each category across all refrigerants and testing temperatures

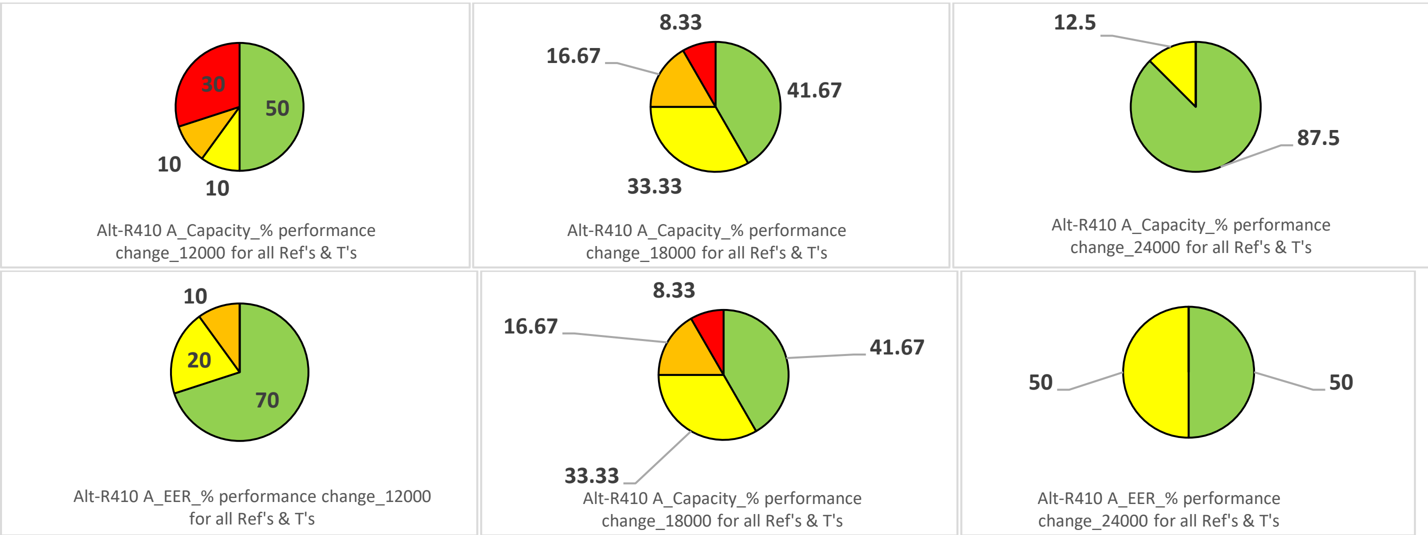
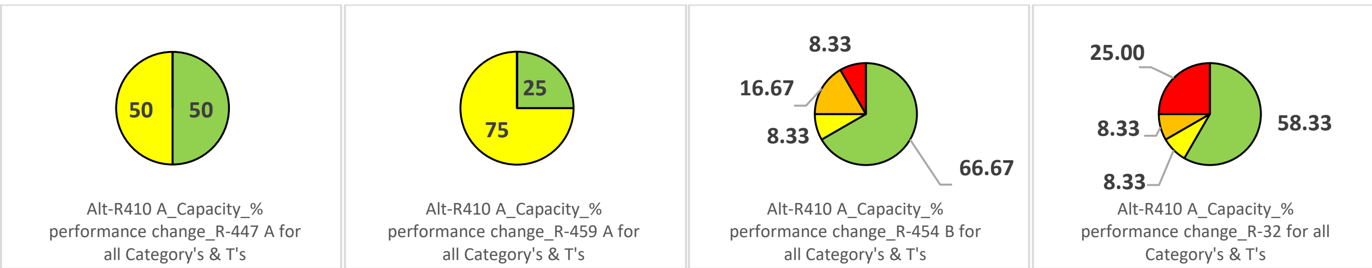


Figure 12 capacity and EER performance of R-410A alternatives for each category across all refrigerants and all testing temperatures

- Increase in capacity as category size increases, across all refrigerants and all testing temperate conditions.
- Capacity increases are from 50 % to 87.5 %.
- However, EER decreased as category size increases.
- EER improvement decreases from 70 % to 50 %.
- 18,000 showed capacity readings for all ranges similar to EER readings.
- 18,000 in the range (-0.1 % to - 5 %) readings for both capacity and EER were the same, 33.33 % instead of 10 % and 20 % in 12,000 size.
- The possibility of improving by optimization capacity and EER compared to R-410A are high

3.5. Capacity and EER behaviour of R-410A Alternatives for each refrigerant across all categories and testing temperatures



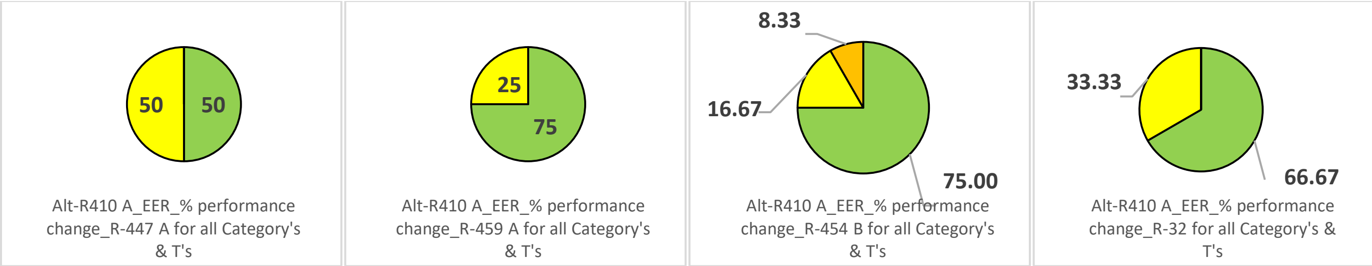


Figure 13 Capacity and EER performance of R-410A alternatives for each refrigerant across all categories and all testing temperatures

- All refrigerants showed improvement in capacity by 25% to 67 % and 50 % to 75 % in EER.
- One refrigerant was excluded from the comparison because of lack of data.
- All refrigerants have excellent chances of improvement in capacity and EER by optimization.

3.6. Capacity and EER behaviour of R-410A Alternatives for each temperature across all categories and refrigerants

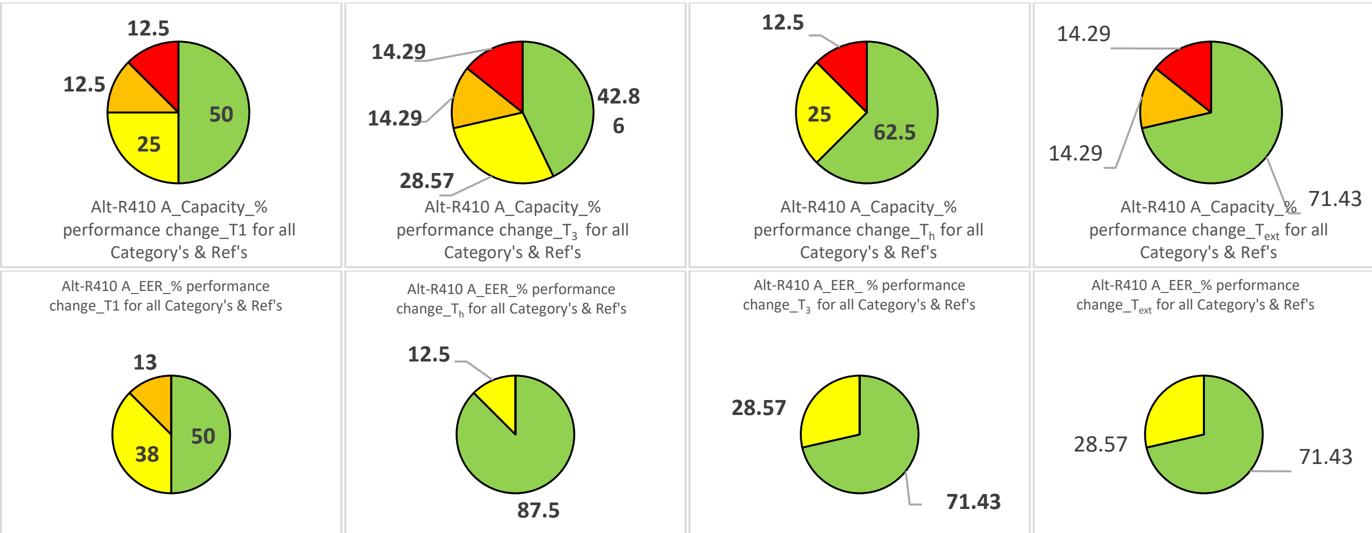


Figure 14 Capacity and EER performance of R-410A alternatives for each testing temperature across all categories and refrigerants

- At T_1: 50 % of all test readings show better capacities than R-410 A for all refrigerants and categories and 50% better EER.
- At T_3 : 42.86 % decrease in capacity improvement to 42.86% and then improvement rose to 62.5% and 71.43 % at T_h and T_{ext}.
- At T_3 : 87.5 %improvement in EER. Improvement diminished slightly to 71.43 % for both T_h and T_{ext}.

Excellent prospects for improvement in capacity and EER by optimization compared to R-410 A across all temperature testing conditions for all categories and all refrigerants.

3.7. Capacity and EER behaviour of HCFC-22 alternatives for central units

For central units, only two tests were carried out for two refrigerant alternatives; consequently, the charts for the different variables all show the same result as shown in Figure 15 where one result is better than the base unit (green) and the other is more than 10% below the base unit (red).

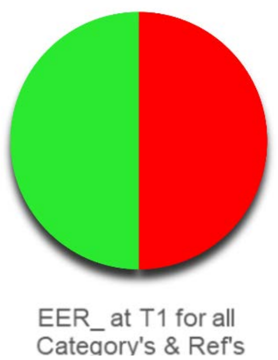


Figure 15: Chart for central units

A more significant way of analysing the result for central units is to compare with the results for split units for the same alternative refrigerants tested in the project.

Table 17 below shows the result for R454C. The table shows a consistent performance below that of HCFC-22 base units for both capacity and EER. The results for the central unit are however all in the red category, i.e., more than 10% below.

Table 17: Comparison of results for R-454C across all categories

R-454C	T_1	T_3	T_{High}	$T_{Extreme}$	T_1	T_3	T_{High}	$T_{Extreme}$
	Capacity in Btu/hr				EER			
12,000 Btu/hr	10,968 (3.9%)	9,349 (6.4%)	9,946 (8.7%)	9,042 (9.9%)	7.97 (5.2%)	6.00 (6.0%)	5.86 (7.4%)	5.05 (7.7%)
18,000 Btu/hr	16,510 (9.1%)	**14,327 (11.5%)**	**15,619 (11.4%)**	**14,250 (12.5%)**	9.31 (6.9%)	6.97 (5.4%)	7.01 (4.9%)	6.02 (6.7%)
Central unit	**69,010 (18.2%)**	**64,350 (15.1%)**	**66,600 (18.6%)**	**66,070 (13.6%)**	**5.36 (23.1%)**	**4.48 (16.9%)**	**4.32 (23.0%)**	**3.98 (13.3%)**

Table 18 below shows the results for R-457A. The extremely good results for the central unit stand out in contrast to those of the split unit which indicates a problem with the results of the central unit.

Table 18: Comparison of results for R-457C across all categories

R-457A	T_1	T_3	T_{High}	$T_{Extreme}$	T_1	T_3	T_{High}	$T_{Extreme}$
	Capacity in Btu/hr				EER			
12,000 Btu/hr	11,023 (3.7%)	9,376 (5.9%)	10,892 +3.1%)	9,517 (6.5%)	**8.36 (16.4%)**	**6.24 (13.9%)**	6.58 (5.6%)	**5.56 (10.8%)**
18,000 Btu/hr	15,257 (7.2%)	**12,672 (12.9%)**	13,418 (2.2%)	**12,149 (20.9%)**	9.3 +3.7%	6.6 (0.9%)	6.3 (0.9%)	5.3 0.00%
24,000 Btu/hr	21,758 (2.5%)	20,670 (2.5%)	19,636 (2.5%)	18,657 (2.5%)	8.78 (5.6%)	6.85 (6.4%)	5.82 (4.6%)	5.25 (8.4%)
Central unit	77,160 39.8%	63,280 31.1%	64,490 33.5%	57,670 37.6%	5.9 33.4%	4.1 21.8%	4.0 21.9%	3.3 27.8%

Chapter 4

4. Energy Efficiency and Progressive Changes in MEPS for Egypt

Egypt's MEPS (Minimum Energy Performance Standards) energy efficiency label requirement for mini split air conditioning units and window type, ES: 3795-/2013 and ES: 3795-/2016 Part 1-for constant speed compressors- define EER (BTU/W.hr) at T_1 condition (ISO 5151) across several efficiency classes, A 5+ to E as listed in the tables below according to regulation years, 2014 to 2021.

MEPS progression across the years:

The standards, starting June 2014, lists EER values for energy efficiencies that define a certain class, termed calibration level, starting from E to A^{++}, see table below.

Table 19: Egypt Energy Ratings per 2014 Standard

Calibration	Energy Efficiency ratio of a room air conditioner (Split AC)	
	Watt/ Watt	**B.T.U/ Watt/h**
A^{++}	Higher or equal to 4.1	Higher or equal to 14
A+	Higher than or equal to 3. 81 and less than 4.1	Higher or equal to 13 and less than 14
A	Higher than or equal to 3.51 and less than 3. 81	Higher or equal to 12 and less than 13
B	Higher than or equal to 3.22 and less than 3.51	Higher or equal to 11 and less than 12
C	Higher than or equal to 3.08 and less than 3.22	Higher or equal to 10.5 and less than 11
D	Higher than or equal to 2.93 and less than 3.08	Higher or equal to 10 and less than 10.5
E	Higher than or equal to 2.78 and less than 2.93	Higher or equal to 9.5 and less than 10

Those EER classes' changes to become progressively stricter, as of June 2017, see table shown below, new class created **A^{+++}** and class **E** removed:

Table 20: Egypt Energy Ratings per 2017 Standard

Calibration	Energy Efficiency ratio of a room air conditioner (Split AC)	
	Watt/ Watt	**B.T.U/ Watt/h**
A^{+++}	Higher or equal to 4.4	Higher or equal to 15
A^{++}	Higher than or equal to 4,1 and less than 4.4	Higher or equal to 14 and less than 15
A+	Higher than or equal to 3.81 and less than 4.1.	Higher or equal to 13 and less than 14
A	Higher than or equal to 3.51 and less than 3.81	Higher or equal to 12 and less than 13
B	Higher than or equal to 3.22 and less than 3.51	Higher or equal to 11 and less than 12
C	Higher than or equal to 3,08 and less than 3.22	Higher or equal to 10.5 and less than 11
D	Higher than or equal to 2,93 and less than 3.08	Higher or equal to 10 and less than 10.5

And in June 2019 as shown below, new class created **A**$^{++++}$ and class D removed:

Table 21: Egypt Energy Ratings per 2019 Standards

Calibration	**Energy Efficiency ratio of a room air conditioner (Split AC)**	
	Watt/ Watt	**B.T.U/ Watt/h**
A^{++++}	Higher or equal to 4.69	Higher or equal to 16
A^{+++}	Higher or equal to 4.4 and less than 4.69	Higher or equal to 15 and less than 16
A^{++}	Higher than or equal to 4.1 and less than 4.4	Higher or equal to 14 and less than 15
A+	Higher than or equal to 3.81 and less than 4.1	Higher or equal to 13 and less than 14
A	Higher than or equal to 3.51 and less than 3.81	Higher or equal to 12 and less than 13
B	Higher than or equal to 3. 22 and less than 3.51	Higher or equal to 11 and less than 12
C	Higher than or equal to 3. 08 and less than 3.22	Higher or equal to 10.5 and less than 11

Finally in June 2021 it becomes as shown below, new class created **A**$^{+++++}$ and class **C** removed:

Table 22: Egypt Energy ratings per 2021 Standard

Calibration	**Energy Efficiency ratio of a room air conditioner (Split AC)**	
	Watt/ Watt	**B.T.U/ Watt/h**
A^{+++++}	Higher or equal to 4.98	Higher or equal to 17
A^{++++}	Higher or equal to 4.69 and less than 4. 98	Higher or equal to 16 and less than 17
A^{+++}	Higher or equal to 4.4 and less than 4.69	Higher or equal to 15 and less than 16
A^{++}	Higher than or equal to 4.1 and less than 4.4	Higher or equal to 14 and less than 15
A+	Higher than or equal to 3. 1 and less than 4.1	Higher or equal to 13 and less than 14
A	Higher than or equal to 3.51 and less than 3.81	Higher or equal to 12 and less than 13
B	Higher than or equal to 3.22 and less than 3.51	Higher or equal to 11 and less than 12

When the EER values are tabulated according to efficiency class (calibration) versus the year(s) when standards come into operation, the below table is obtained, where the most efficient class for each year(s) is in red followed by green, violet, sky blue, orange, light blue and navy blue as the class of efficiency becomes less and less . For all years there are 7 classes of efficiency.

The highest EER in 2014-2016 was 14 for class A^{2+} while in 2021 the highest EER will be 17 and a new classis created; A^{5+}. This continuous progression to more efficient systems is reflected in the graph below, where EERs are plotted across all years from 2014 to 2021. The top line denotes the highest EER for each regulation year, while the other lines are in descending order. The colors of the rows in the table correspond to the colors of the lines of efficiency classes for each year(s) in Figure 16.

Table 23: EER Values at T1 according to the Egyptian Standard ES: 3795/2016

Eff. class /yr.	2014-2016	2017-2018	2019-2020	2021
A^{5+}				17
A^{4+}			16	16
A^{3+}		15	15	15
A^{2+}	14	14	14	14
A^{+}	13	13	13	13
A	12	12	12	12
B	11	11	11	11
C	10.5	10.5	10.5	
D	10	10		
E	9.5			

The table shows how the energy efficiency classes are increasing progressively with the years.

EER versus years:

The graph below shows the highest to lowest EER plotted against the years it came/comes into effect. The graph shows the progression to higher EER with the years. The values are taken from the table above. Seven classes are represented for each year.

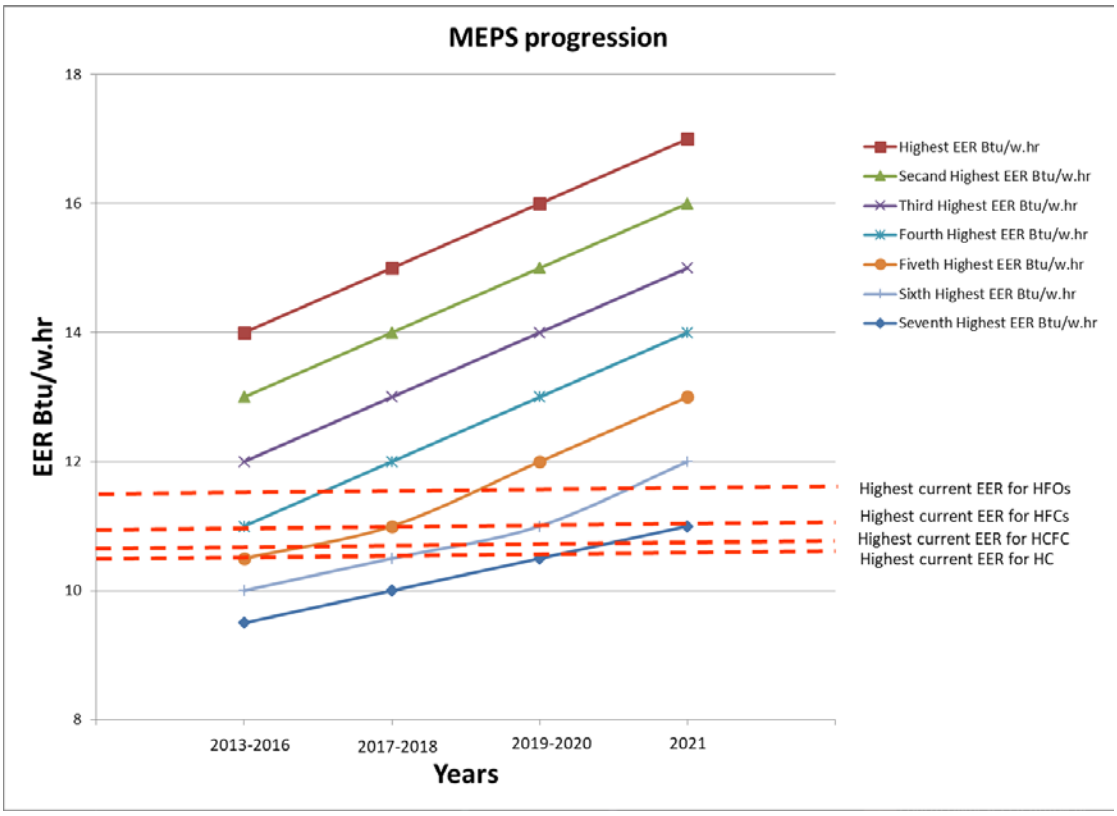


Figure 16: EER curves for the highest in each class plotted vs. the standard regulation year

When the results of the Egyptian program for testing alternative low-GWP refrigerants for the Egyptian air conditioning industry, EGYPRA, are plotted on the graph as straight lines showing the best EER achieved for HCFCs, HFCs, HC and HFO, the following is shown:

- The highest EER of prototypes using HC-290 refrigerant is 10.35

- The highest EER of tested units using HCFC refrigerant is 10.5
- The highest EER of tested units using HFC refrigerant is 10.88
- The highest EER of prototypes using HFO refrigerant is 11.5

EGYPRA prototypes, especially made for the program, were optimized by choosing an optimum refrigerant charge and suitable selection of capillary tube (expansion device). No changes were made to either evaporator or condenser.

The best EER of alterative refrigerants cannot achieve at current optimization more than class B (light blue) for MEPS 2019-2020 and class B (navy blue) for 2021.

However, there is potential for improvement. The potential for improvement is based on the fact that the prototypes were built with many constraints (size and type of heat exchangers, size if the units, etc…). In future further optimization through the selection of compressors better suited to alternative refrigerants and the selection of heat exchangers that can improve the efficiency of the units will increase EER of the systems.

it is unlikely that EER improvement can be made from the current 11.5 to 16 in 2019 and 17 in 2021. The extent of EERs improvement is related to the optimization process which requires research and development capabilities and capital cost and time. This might be beyond the capability of the majority of the manufacturers.

Further results of this correlation is as follows:

- Shifting to variable speed split units is inevitable if the higher efficiency EER standards are to be achieved by 2019 and beyond, with the resultant additional incremental costs associated with this shift, in manufacturing equipment and end product cost i.e., USD 50 to 100 (TEAP 2019)
- The introduction of Not-In-Kind cooling technology must be accelerated if energy efficiency rates are to be improved for the air conditioning sector.

Chapter 5

5. Conclusion

EGYPRA is funded from Egypt's HCFC Phase-out Management Plan (HPMP) as an enabling activity for the benefit of the Egyptian air conditioning industry to help local manufacturers experiment working with new alternative lower-GWP refrigerants.

EGYPRA tested refrigerants with medium pressure characteristics similar to HCFC-22 and others with high pressure similar to R-410A in split system units.

This conclusion is in two parts: technical and institutional regarding capacity building requirements.

5.1. Technical Conclusion

EGYPRA results lead to the following conclusions:

- As expected, and for all refrigerants, moving from T_1 to T_3 testing temperatures, both capacity and EER deteriorate, at different levels, across all categories and refrigerants;
- At T_{High}, the increased indoor wet bulb testing condition, as per EOS & ISO-5151, leads to better results for EER and capacity compared to T_3;
- Since $T_{Extreme}$ testing condition is similar to T_{High}, with regard to indoor wet bulb testing condition, both EER and capacity re-deteriorate;
- In general, there are candidates with potential for improvement; however, since high pressure refrigerants show better results vs. R-410A, the potential for improvement is higher.

Almost all of the OEMs who have participated in EGYPRA have already introduced R-410A units into the split unit market. One uncorroborated study shows that more than 10% of the units sold in 2017 were with R-410A. This might make it easier for OEMs to leap-frog solutions for HCFC-22 and pass directly to high pressure alternatives to R-410A as the possibility for performance and EER improvement is higher for those alternatives.

Split unit results also show that the potential for improvement applies also at higher ambient temperatures, an important factor for some of the regions in the south of Egypt that experience higher ambient temperatures than 35 °C. This is also important for the export market as some manufacturers export to neighboring HAT countries in the region.

Central units results do not lead to a definite conclusion. The main reason for not having a more robust conclusion on performance is the absence of enough tests involving refrigerants that are being used or considered today. The air conditioning market has adopted alternatives to R-410A rather than those equivalent to HCFC-22 used in the project. At the time the prototypes were built, the OEMs were only using HCFC-22 for their central units and hence alternative equivalent to HCFC-22 were selected. A couple of years later, when the units were going to be tested, it was not possible to rebuild new prototypes with R-410A alternatives and the decision was made to go ahead with the HCFC-22 alternatives.

Additionally, the central units were tested as received (except for baseline unit of OEM X) which affected the results since no optimization of charge was made.

5.2. Capacity Building Requirements

The conclusion from chapter 4 is clear: at the current optimization level, none of the prototypes tested will be able to meet more than class B of the 2021 MEPS values; however, the fact is that prototypes were built with many constraints

- The prototypes could be further optimized through the selection of compressors better suited to the tested refrigerants and the selection of heat exchangers that can improve the efficiency of the units, as well as the use of electronic expansion valves instead of capillary tubes for split units which has an effect on the cost of the unit;
- Variable speed technology would improve the Seasonal EER of the units where applicable;
- The optimization process requires research and development capabilities that might go beyond those available at some of the manufacturers;
- A further conclusion concerns the testing facilities of the EGYPRA OEMs. Witness testing has enabled the Technical Consultant to carefully assess the capabilities of each lab, especially for testing flammable refrigerants. For confidentiality purposes, the general description of the lab facilities given in Annex 2 does not aim to critique the individual labs or divulge where the individual labs need to be upgraded; however, the fact remains that some of the labs could benefit from an upgrade program;
- Test results show that all refrigerants used in the project are viable alternatives from a thermodynamic point of view. The viability in terms of the other criteria like commercial availability, cost, and safety – among others - needs to be further researched.

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TEAP 2019 TEAP May 2019: Decision XXX/5 Task Force Report on Cost and Availability of Low-GWP Technologies/Equipment that Maintain/Enhance Energy Efficiency (Volume 4**)** TEAP_May-2019_Task_Force_Report_on_Energy_Efficiency.pdf (unep.org)

Annex 1: Test Results

The annex includes tables and charts from the test results. All OEMs results were compiled by category, for HCFC-22 equivalent refrigerants and for R-410A equivalent refrigerants.

The tables show the results for capacity in Btu/hr and EER at the four testing temperatures. The tables are per category of 12,000 Btu/hr split units, 18,000 split units and 24,000 Btu/hr split units. They include all alternatives refrigerant tested by each OEM.

The equivalent bar charts reflect the results in the tables: one bar chart for capacity and one bar chart for EER.

The sequence in which they are presented is:

- Table and bar chart equivalents for HCFC-22 alternatives in the 12,000 Btu/hr category;
- Table and bar chart equivalents for HCFC-22 alternatives in the 18,000 Btu/hr category;
- Table and bar chart equivalents for HCFC-22 alternatives in the 24,000 Btu/hr category;
- Table and bar chart equivalents for R-410A alternatives in the 12,000 Btu/hr category;
- Table and bar chart equivalents for R-410A alternatives in the 18,000 Btu/hr category;
- Table and bar chart equivalents for R-410A alternatives in the 24,000 Btu/hr category.

Table 24 A1: Capacity and EER Results for HCFC-22 alternatives in 12,000 Btu/hr category

HCFC-22 eq. 12,000 Btu/hr		OEM A				OEM B				OEM C				OEM E			
Ambient		T_1	T_3	T_{high}	T_{Ext}	T_1	T_3	T_{high}	T_{Ext}	T_1	T_3	T_{high}	T_{Ext}	T_1	T_3	T_{high}	T_{Ext}
R-22	CAP	11479	9699	11353	8407	11410	9988	10900	10035	11452	9960	10560	10181	10753	10415	10352	9381
	EER	9.74	6.88	7.31	5.61	8.410	6.380	6.330	5.470	10.002	7.249	6.975	6.231	10.290	8.300	7.380	6.230
R-290	CAP									10219	8677	9289	7747				
	EER									10.355	7.171	6.959	5.217				
ARM-20a R-457A	CAP									11023	9376	10892	9517				
	EER									8.358	6.239	6.582	5.556				
Opteon XL-20 R-454C	CAP					10968	9349	9946	9042					6980.6	4958.27	5762.15	4489.25
	EER					7.970	6.000	5.860	5.050					8.150	5.200	5.600	4.180
L-20 R-444B	CAP	11790	9661	10241	8881												
	EER	8.43	5.73	5.53	4.47												

Figure 17 A1 - Equivalent capacity charts for HCFC-22 alternatives in 12,000 Btu/hr category plotted vs HCFC-22 results

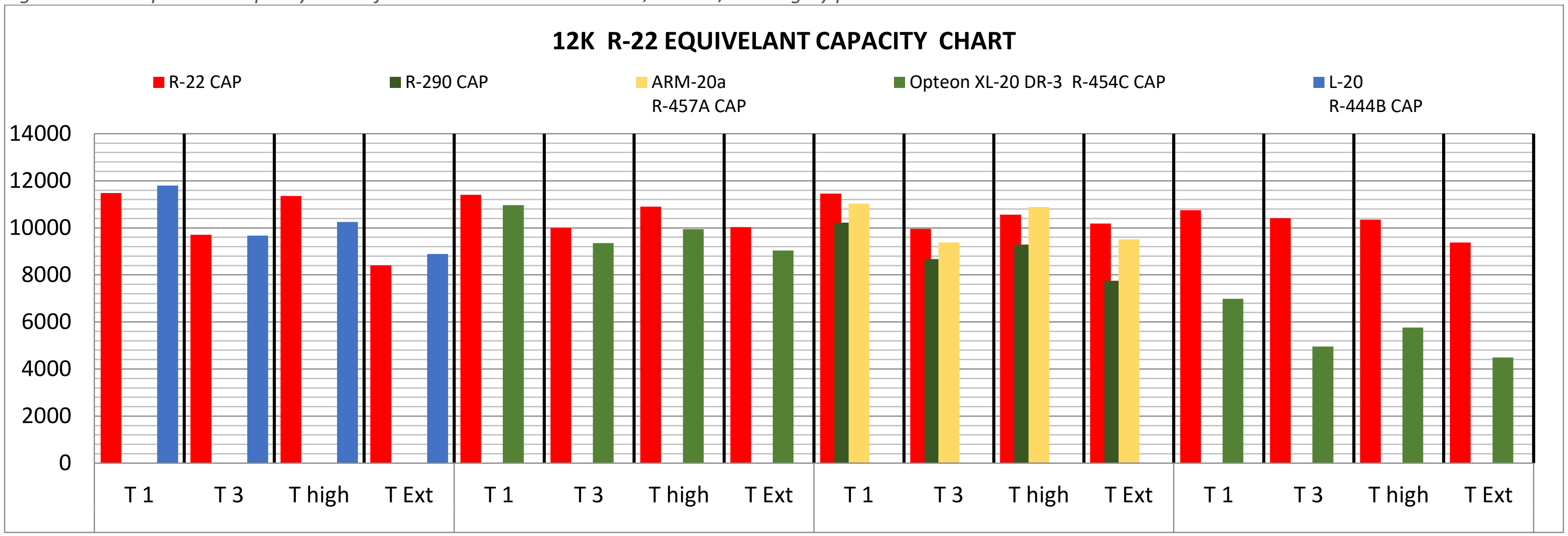


Figure 18 A1 - Equivalent EER chart for HCFC-22 alternatives in 12,000 Btu/hr category plotted vs HCFC-22 results

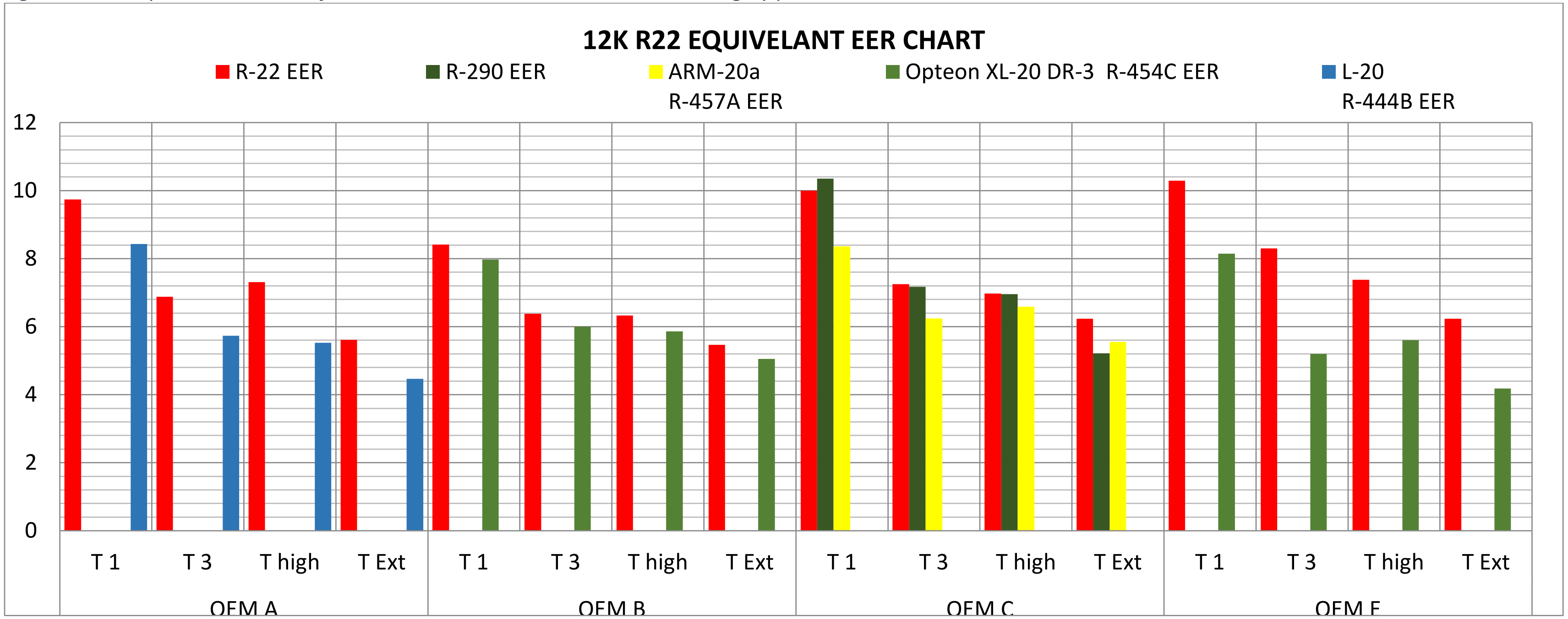


Table 25 A1- Capacity and EER results for HCFC-22 alternatives in 18,000 Btu/hr category

HCF-22 eq. 18,000 Btu/hr		OEM A				OEM B				OEM C				OEM D			
Ambient		**T 1**	**T 3**	**T high**	**T Ext**	**T 1**	**T 3**	**T high**	**T Ext**	**T 1**	**T 3**	**T high**	**T Ext**	**T 1**	**T 3**	**T high**	**T Ext**
R-22	CAP	18659	16799	17543	15046	16433	14545	13718	15350	18160	16182	17632	16292	17548	16422	14624	13948
	EER	9.410	7.260	6.980	5.550	8.930	6.650	6.370	5.330	10	7.372	7.371	6.445	10.500	8.750	7.220	6.00
R-290	CAP	16111	14067	15343	13442												
	EER	9.310	7.090	7.170	5.860												
R-457A	CAP					15257	12672	13418	12149								
	EER					9.260	6.590	6.310	5.330								
R-454C	CAP									16510	14327	15619	14250				
	EER									9.312	6.972	7.011	6.015				
R-444B	CAP													17098	15746	13498	13047
	EER													10.000	7.780	6.320	5.400

Figure 19 A1 - Equivalent capacity charts for HCFC-22 alternatives in 18,000 Btu/hr category plotted vs HCFC-22 results

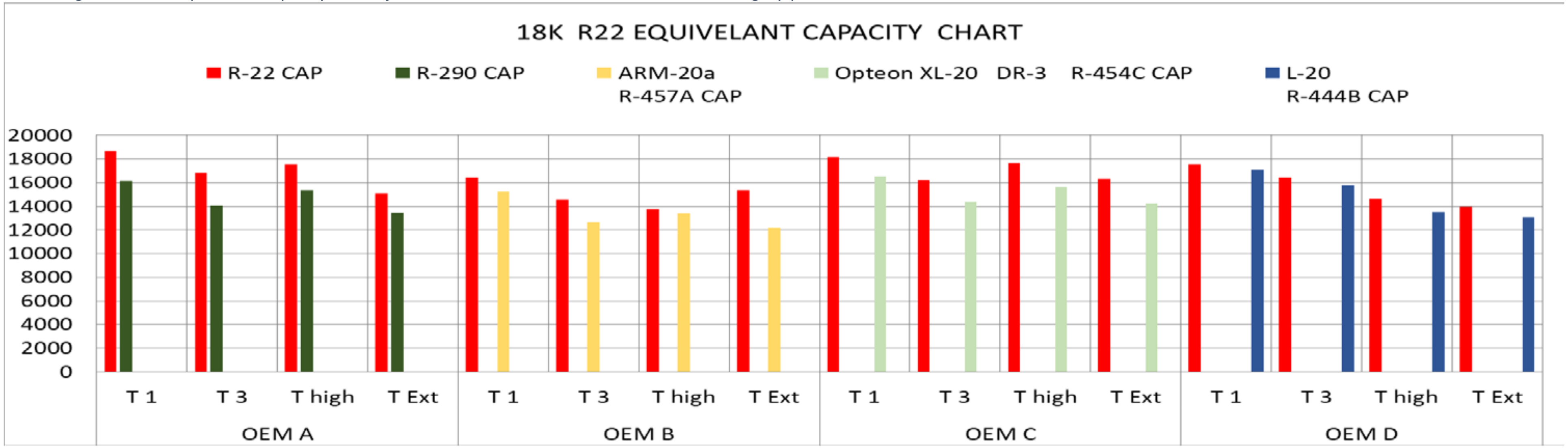


Figure 207 A1 - Equivalent EER charts for HCFC-22 alternatives in 18,000 Btu/hr category plotted vs HCFC-22 results

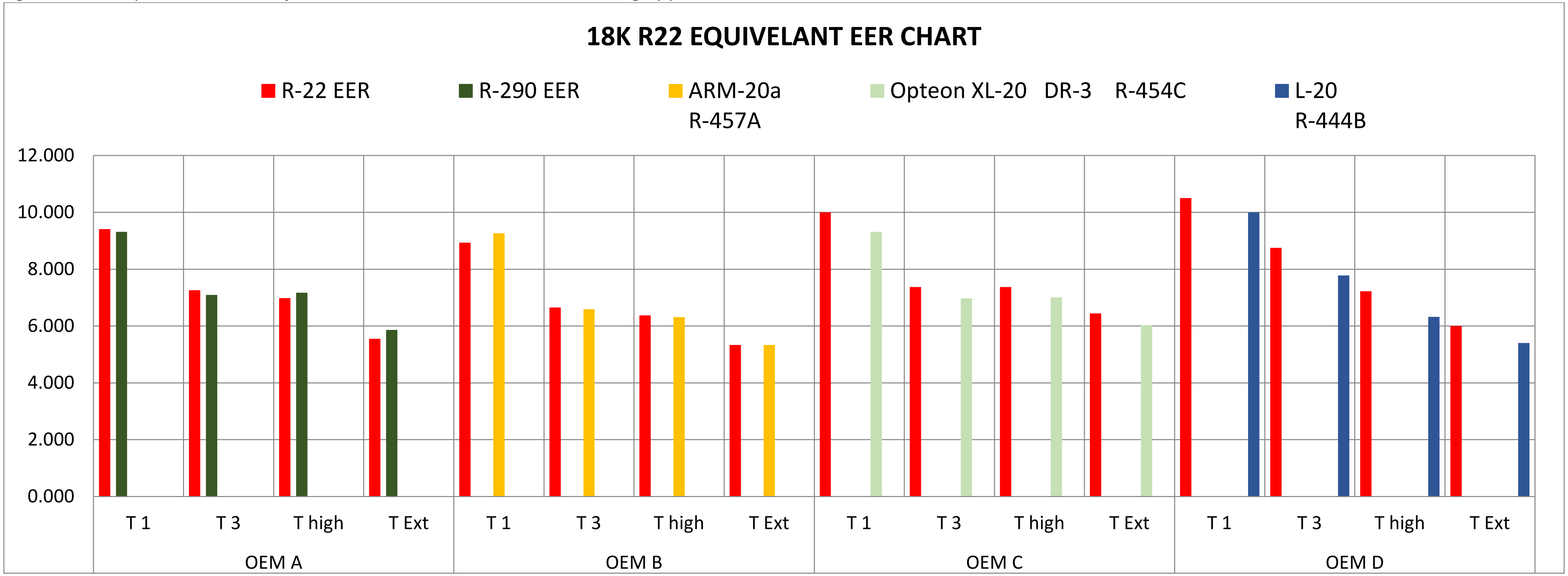


Table 26 A1 - Capacity and EER results for HCFC-22 alternatives in 24,000 Btu/hr category

HCFC-22 eq. 24,000 Btu/hr		OEM B				OEM D			
Ambient		**T 1**	**T 3**	**T high**	**T Ext**	**T 1**	**T 3**	**T high**	**T Ext**
R-22	CAP	22782				22318	21202	20144	19148
	EER	9.270				9.300	7.320	6.100	5.73
R-290	CAP								
	EER								
ARM-20a R-457A	CAP					21758	20670	19636	18657
	EER					8.78	6.85	5.82	5.25
Opteon XL-20 DR-3 R-454C	CAP								
	EER								
L-20 R-444B	CAP	23436							
	EER	7.38							

Figure 21 A1 - Equivalent capacity charts for HCFC-22 alternatives in 24,000 Btu/hr category plotted vs HCFC-22 results

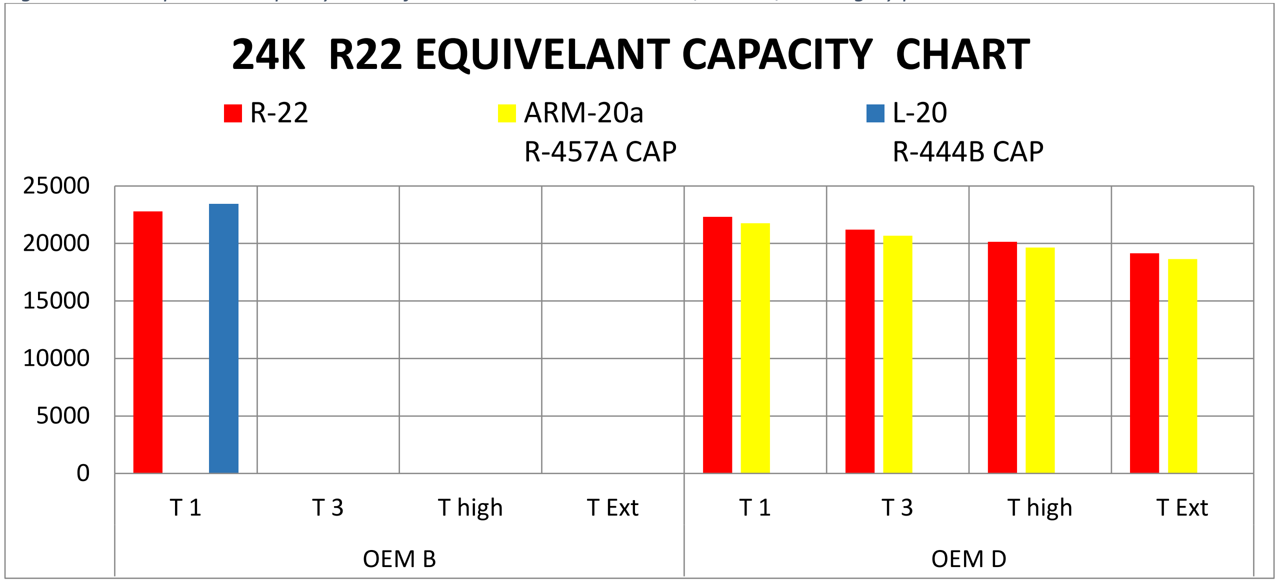


Figure 22 A1 - Equivalent EER chart for HCFC-22 alternatives in 24,000 Btu/hr category plotted vs HCFC-22 results

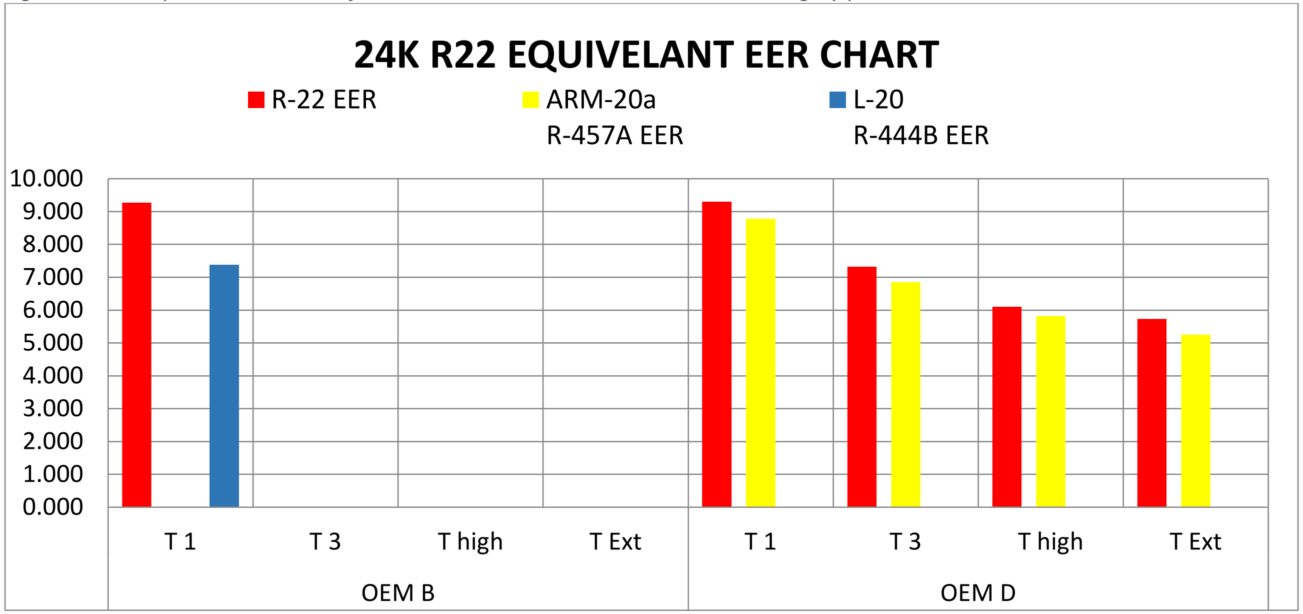


Table 27 A1 - Capacity & EER results for R-410A alternatives in 12,000 Btu/hr category

R-410 A eq.		OEM A				OEM B				OEM E			
12,000 Btu/hr Ambient		**T 1**	**T 3**	**T high**	**T Ext**	**T 1**	**T 3**	**T high**	**T Ext**	**T 1**	**T 3**	**T high**	**T Ext**
R-410A	CAP	10307	-	8313	-	12068	10343	11089	9968	11905	9369	10848	9299
	EER	8.77	-	5.43	-	10.17	7.31	7.15	5.93	10.88	7.29	7.42	5.89
ARM-71a R-459A	CAP												
	EER												
R-32	CAP					11355	9249	9822	8499				
	EER					11.51	7.53	7.26	5.69				
Opteon XL-41 DR-5 R-454B	CAP									11987	11130	12257	11094
	EER									9.92	7.95	7.66252	6.7676
L-41 R447A	CAP	9963	-	8539	-								
	EER	8.38	-	5.55	-								

Figure 23 A1 - Equivalent capacity chart for R410A alternatives in 12,000 Btu/hr category plotted vs R-410A results

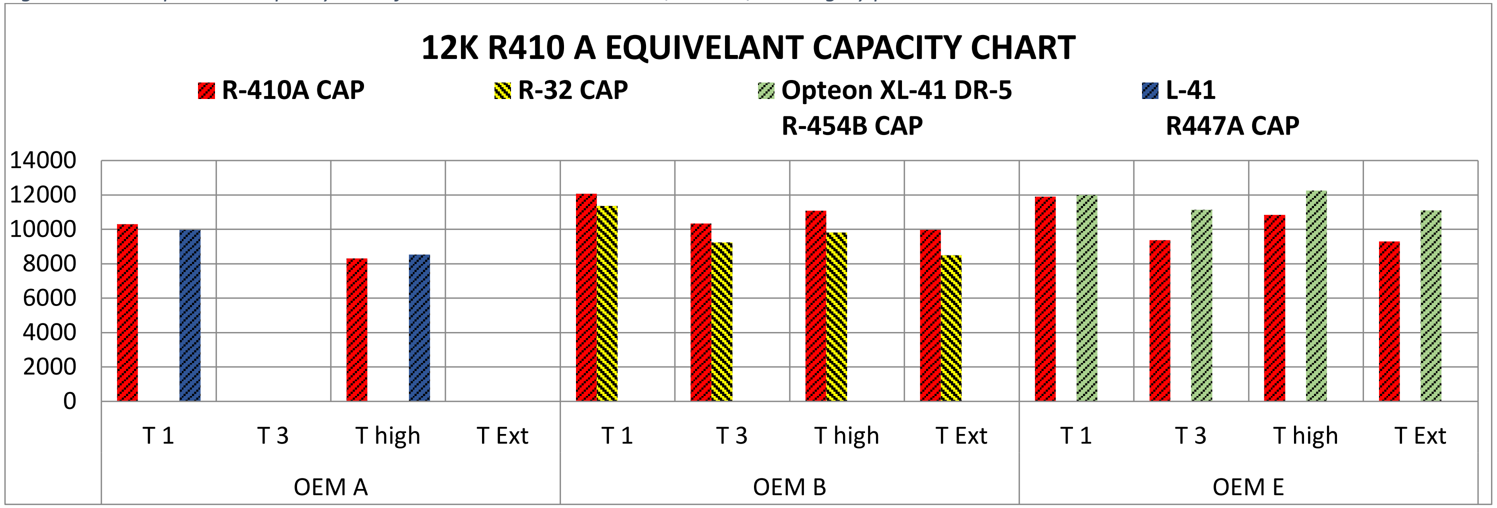


Figure 24 A1 - Equivalent EER chart for R-410A alternatives in 12,000 Btu/hr category plotted vs R-410A results

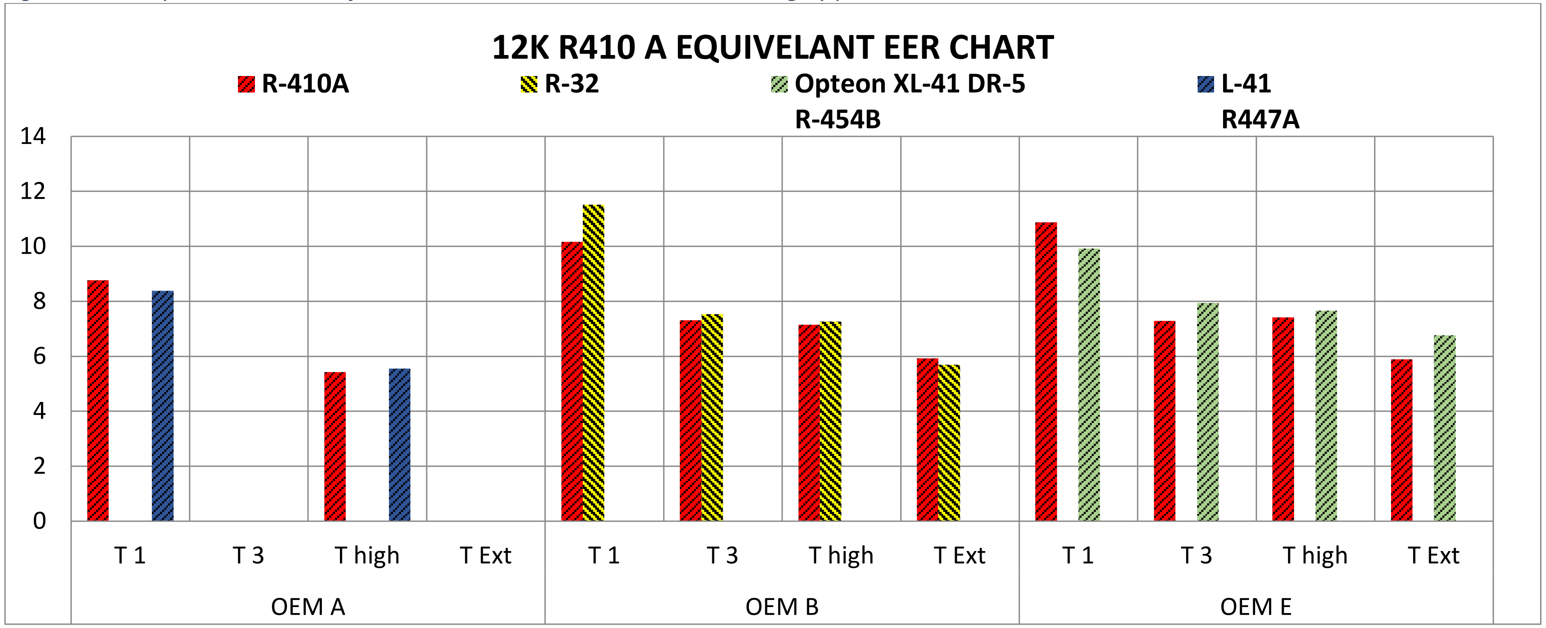


Table 28 A1 - Capacity & EER results for R-410A alternatives in 18,000 Btu/hr category

R-410 A eq. 18,000 Btu/hr		OEM A				OEM C			
Ambient		**T 1**	**T 3**	**T high**	**T Ext**	**T 1**	**T 3**	**T high**	**T Ext**
R-410A	CAP	16938	14337	14123	12441	17800	14924	16075	13746
	EER	9.8	6.8	6.3	5.1	9.152	6.497	6.485	5.116
ARM-71a R-459A	CAP					17115	14430	15392	14023
	EER					9.282	6.544	6.265	5.32
R-32	CAP	17616	15255	15761	13809				
	EER	10.03	7.1	6.65	5.29				
Opteon XL-41 DR-5 R-454B	CAP	15167	13229	13782	11800				
	EER	9.5	6.9	6.5	5.2				
L-41 R447A	CAP								
	EER								

Figure 25 A1- Equivalent capacity charts for R-410A alternatives in 18,000 Btu/hr category plotted vs R-410A results

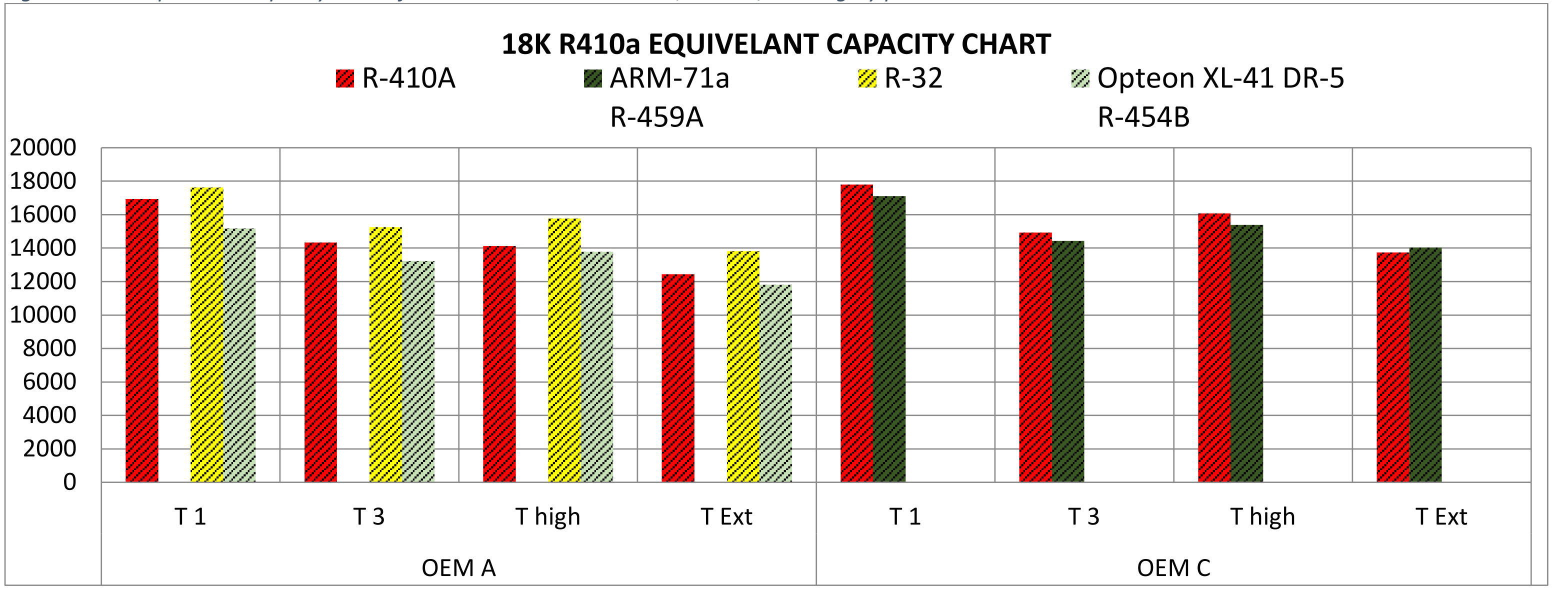


Figure 26 A1 - Equivalent EER chart for R-410A alternatives in 18,000 Btu/hr category plotted vs R-410A results

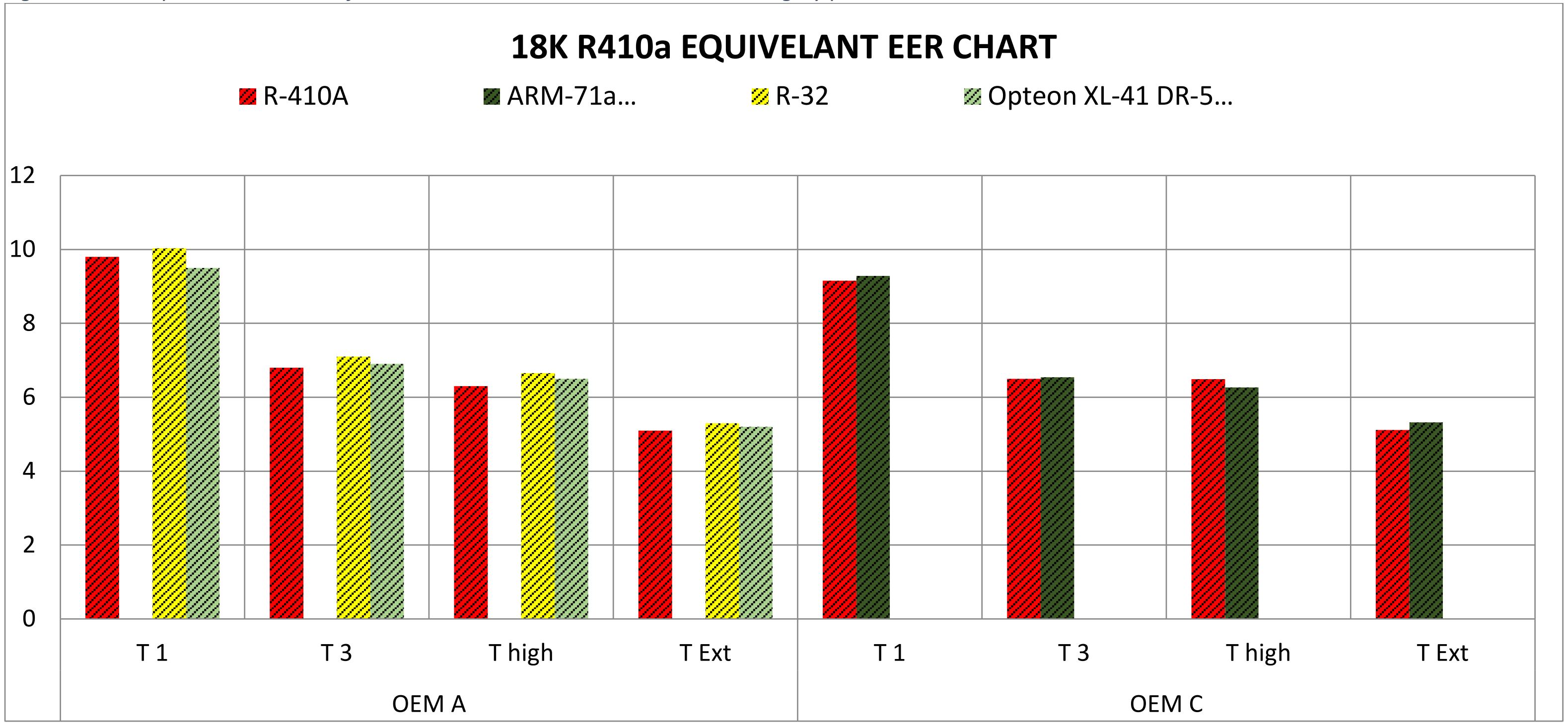


Table 29 A1 - Capacity & EER results for R-410A alternatives in 24,000 Btu/hr category

R-410 A eq. 24,000 Btu/hr		OEM C			
Ambient		**T 1**	**T 3**	**T high**	**T Ext**
R-410A	CAP	23022	19531	20534	18379
	EER	10.57	7.518	7.376	6.161
ARM-71a R-459A	CAP				
	EER				
R-32	CAP	23310	19522	21876	19035
	EER	10.62	7.228	7.459	5.988
Opteon XL-41 DR-5 R-454B	CAP	23766	20241	22268	20160
	EER	10.653	7.516	7.515	6.224
L-41 R447A	CAP				
	EER				

Figure 27 A1 - Equivalent capacity charts for R-410A alternatives in 24,000 Btu/hr category plotted vs R-410A results

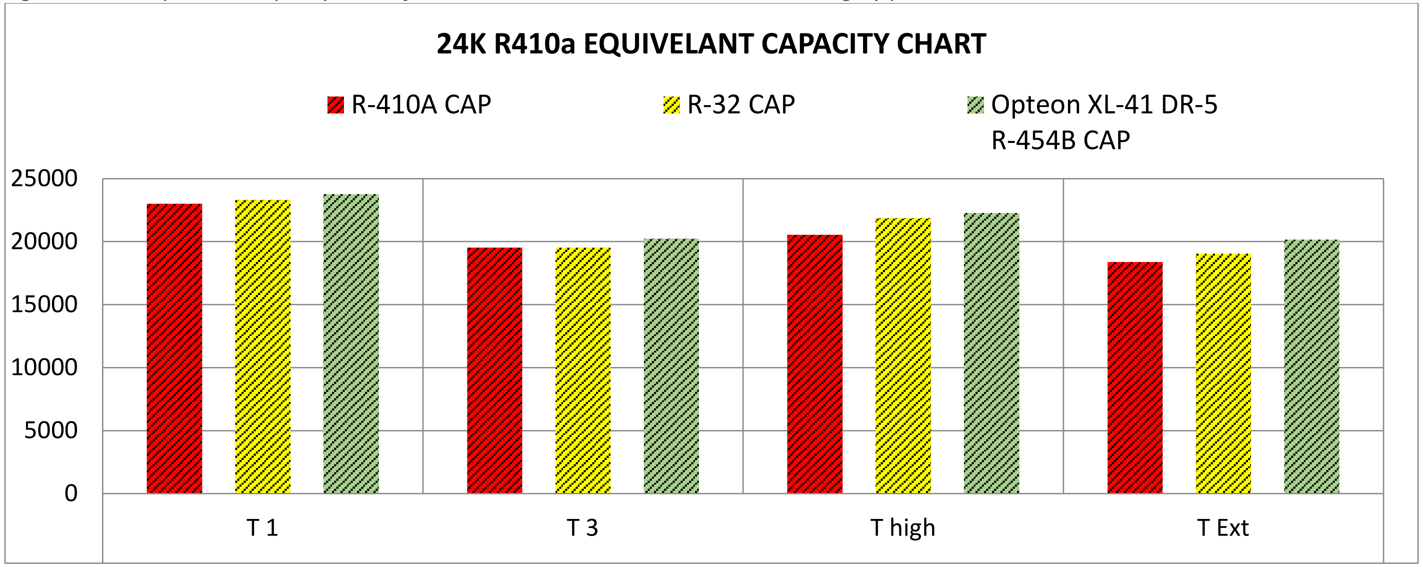
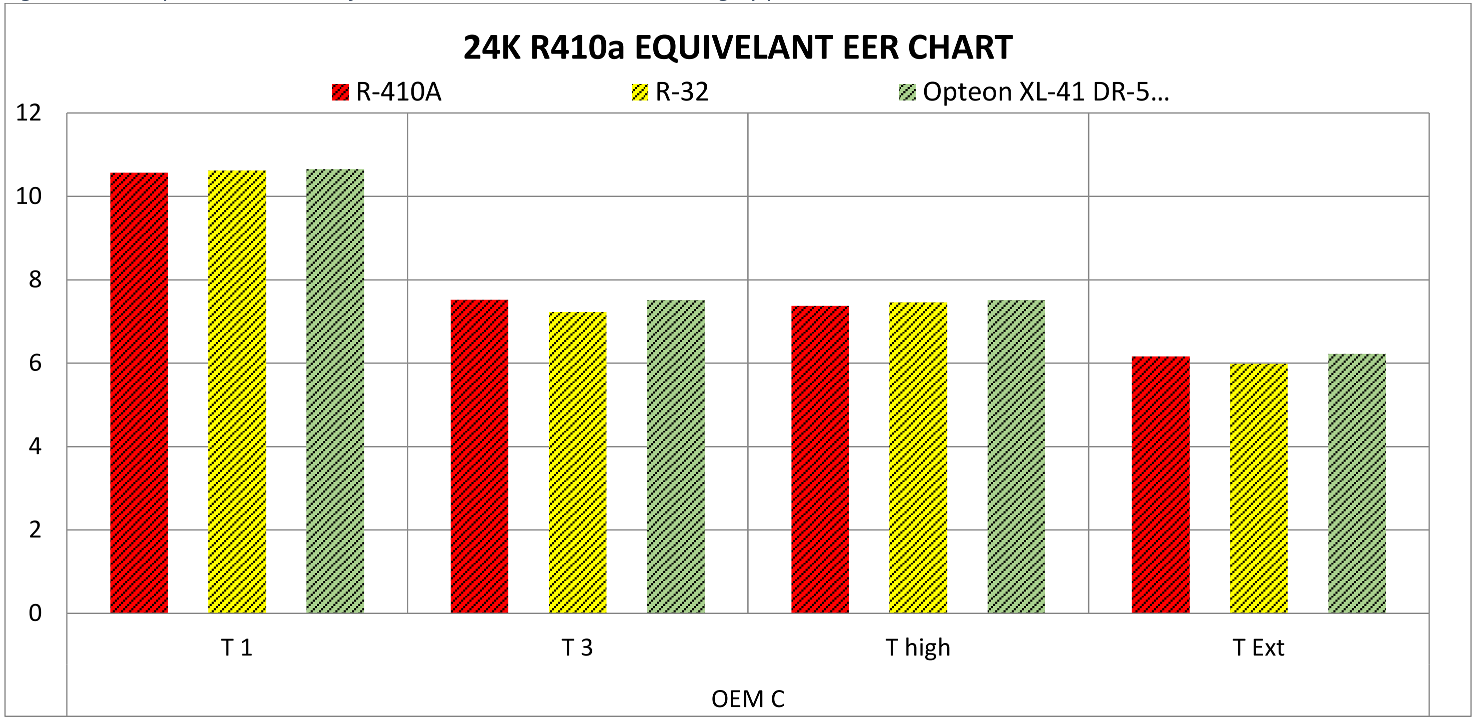


Figure 28 A1 - Equivalent EER chart for R-410A alternatives in 24,000 category plotted vs R-410A results



Annex 2: Sample Questionnaire for Local Manufacturers

Goal:

The Initiative objective is to test prototype air-conditioning units using low-GWP alternative technologies and share recommendations with manufacturers and decision makers in Egypt

Questionnaire:

This questionnaire is aimed at selected air-conditioning manufacturers in Egypt. The purpose of the questionnaire is to ask the preferences of the selected manufacturers in as far as technology selection and partnership with other stakeholders as well as getting a confirmation on their willingness to participate. All information complied of this questionnaire will be treated as confidential.

A. General Conditions	**Participant response**
My company is willing to participate in the project. If you answer YES, please proceed to rest to questionnaire.	YES NO

B. Technology Selection	**Participant response**
1. Do you have a preference for the alternative refrigerant?	YES NO
2. Alternative refrigerant choice (*you can provide more than one selection by deleting what is not applicable)*	➢ HFO Honeywell ➢ HFO DuPont ➢ R-32 ➢ Hydrocarbon
3. Do you have a preference for the compressor manufacturer?	YES NO
4. Provide name of compressor manufacturer(s)	

C. Application Selection	**Participant response**
5. Do you have a preference for the type and capacity of equipment for which you will build the prototype?	YES NO
6. My selection of equipment: (*you can provide more than one selection)*	➢ Decorative split ➢ Ducted split ➢ Rooftop package ➢ Self-contained
7. My selection of cooling capacity	➢ 1 – 5 tons ➢ 6 – 10 tons ➢ No preference

D. Building Prototypes	**Participant response**
8. My company can design and/or build prototypes	YES NO
9. How many prototypes are you willing to build?	➢ One ➢ More (*pls specify number)*

E. Testing Prototypes	**Participant response**
10. Which type of testing do you prefer?	➢ Independent 3rd party Testing ➢ Witness Testing at own premises
11. If you answered **3rd Party Testing**, are you willing to pay the cost for the test?	YES NO

12.	If you answered **Witness Testing**, is your lab certified and by whom?	YES NO Certified by:

F.	**Logistics**	**Participant response**
13.	My company will allow independent consultants appointed by UNEP/UNIDO to oversee the development of the prototypes.	YES NO
14.	If NO, pls describe what limitations you want to impose.	
15.	My company will allow independent consultants appointed by UNEP/UNIDO to oversee the testing of the prototypes.	YES NO
16.	If NO, pls describe what limitations you want to impose.	

G.	**Information about the Company**	**Participant response**
17.	Company Name	
18.	Brand names used in market	
19.	Company headquarters location	
20.	Manufacturing location where prototype will be built	
21.	Ownership percentage pertaining to the nationality where prototype is manufactured (*This information is needed to determine whether the limitations for project participation set by the Ozone Secretariat of the Montreal Protocol are applicable)*	
22.	Name and title and Contact details of designated contact person for this project	

Annex 3: Brief description of Manufacturers' testing labs

The test labs of the different OEMs had varying capabilities. The best equipped labs have the following characteristics:

- Psychrometric type laboratory in which the air enthalpy test method is used to determine the cooling and heating capacities from measurements of entering and leaving wet-and dry-bulb temperatures and the associated airflow rate;
- Air sampling devices in each room (indoor room, code tester and outdoor room) are used to measure an average temperature. The airflow induced using blower through the tree (photo on left) and insulated duct passing over the temperature instruments (photo on the right) at velocity of 4-5 m/s.

- Air flow measuring apparatus (code tester) is attached to air discharge of UUT by insulated duct. The first section (receiving chamber) delivers air from UUT and contains the static pressure measuring instrument. The air is then mixed by a mixer in next section to measure its temperature by the air sampling device installed inside the code tester.

- Nozzles section, consisting of a receiving chamber and a discharge chamber separated by a partition in which four nozzles are located (see photo below). Air passes through the nozzles and is then exhausted to the test room. The pressure drop across the nozzles is measured using differential pressure transmitter. Air flow rate is calculated according to ISO 5151:2017.

- Voltage stabilizer(photo on left) is used to adjust the applied voltage for UUT, and the Power meter device is used to measure electrical parameters for it like applied voltage, power consumption, current consumption and power factor.

- Most labs are capable of testing up to 5 TR capacity (17.5 kW of cooling) measuring unit working pressure, super-heat, sub-cooling, and various temperature points on the refrigeration cycle;
- Lab consists of two well thermally insulated rooms: indoor room and outdoor room. In both rooms, temperature and humidity can be controlled accurately to achieve the required environment, as per different standards, thru refrigeration units, humidifiers and electric heaters;
- The accuracy of temperature control for dry and wet bulb temperature is 0.01 °C;
- In the indoor room there is a thermal insulated code tester where outlet air dry bulb, wet bulb and volume are measured;
- Thermocouple sensors with accuracy of 0.1 °C are used for measuring surface temperatures at various points;
- Information gathered during the test are monitored on a computer screen, using a data acquisition screen;

The table below shows the parameters that are shown on the monitor

Table 30 A3: Typical parameters shown on a testing lab monitoring screen

Test Screen Display
Inlet DB
Inlet WB
Inlet Enthalpy
Outlet DB
Outlet WB
Outlet Enthalpy
Enthalpy Differential
Specific Density
Air velocity
Air volume
Standard air volume
Atmospheric pressure
Differential pressure
Heat Loss
Total capacity
Capacity ratio
EER
EER ratio
COMPRESSOR
FM surface temperature
high pressure
low pressure
Super-heat
Sub-cooling
ADDITIVE TEMP.
Accumulator outlet temp
Outlet air temperature
Evaporator coil sensor temp
Compressor inlet
O/D Motor surface
OUTDOOR UNIT
Inlet DB
Inlet WB
POWER
Voltage
Current
Wattage
Power Factor
Frequency

Annex 4: Other Research Programs

Research at High Ambient Temperature

The dedicated research on the performance of refrigerants at High Ambient Temperatures (HAT) was driven by the need to find low-GWP alternative refrigerants that have no or lower capacity and efficiency degradation than the commercial HFCs that are replacing HCFCs in the HAT countries. The need to meet higher Minimum Efficiency Performance Standards (MEPS) while phasing out the current production of HCFC-based units was a challenge facing both the local industry in the HAT countries and the global exporters to those markets.

Three research programs were announced and completed in the time period between 2013 and 2016. While the three programs had a common goal in testing the refrigerant alternatives at temperatures higher than the standard T1 testing conditions, they were distinct in their protocols, approach, and the entity who was behind the project.

The PRAHA program mentioned in Chapter 1 is a Multilateral Fund financed project to test custom-built prototypes in four equipment categories that built by manufacturers located in HAT countries and testing them all at one independent lab. The results were compared to base units running with HCFC-22 and R-410A refrigerants.

The AREP (Alternative Refrigerant Evaluation Program) is an industry association program by the Air Conditioning, Heating, and Refrigeration Institute (AHRI) to test various categories of equipment, by various manufacturers, at their own labs by either dropping in the refrigerant or "soft" optimizing the unit.

The Oak Ridge National Laboratory (ORNL) program by the United States Department of Energy (DoE) tested two similar capacity standard units running with HCFC-22 and R-410A and soft optimizing them for the various alternative refrigerants. All tests were carried on at ORNL labs.

In the next sections of this chapter is a resume of the test results for the three programs and a comparison of these results.

PRAHA program

Six local Original Equipment Manufacturers (OEMs) built 14 prototypes running with five refrigerant alternatives and shipped 9 other “base units’ operating with HCFC or HFC for direct comparison purposes. Testing was done at 35, 46, and 50 °C ambient temperatures with an “endurance” test at 55 °C ambient to ensure no tripping for two hours when units are run at that temperature. The indoor conditions will be kept the same for all tests; dry bulb temperature of 27 ^{0}C and a relative humidity of 50 % as per AHRI test procedures for T1 conditions (35 ^{0}C), and 29 ^{0}C and 50% for T3 (46 ^{0}C and 50 ^{0}C) conditions. A memorandum of understanding (MOU) was signed with AHRI (Air-Conditioning, Heating and Refrigerating Institute) for exchanging experience on the testing methodology benefiting of AHRI relevant research project known as AREP.

The project compares the following refrigerants: R-290, HFC-32, R-444B (herein referred to as L-20), R-447A (L-41), and DR-3 to HCFC-22 or R-410A. Prototypes operating with R-290, R-444B, and DR-3 are compared with HCFC-22 as they portray similar characteristics to HCFC-22, while HFC-32, and R-447A are compared with R-410A.

All the prototypes in every category were built to have the same cooling capacity and fit in the same box dimensions as their respective base units, and they were all required to meet the minimum energy efficiency (EER) of 7 at 46 °C. Tests were performed at an independent reputable lab for result consistency; Intertek was selected through competitive bidding. Verification for repeatability was performed to ensure that results are within the acceptable accuracy levels.

Table 31 A4 - Results for PRAHA-I program

Equipment type	Baseline refrigerant	Refrigerant tested	COP % comp to baseline @ 35°C	Capacity % comp to baseline @ 35°C	COP % comp to baseline @ 50°C	Capacity % comp to baseline @ 50°C
18,000 Btu/hr. Window Unit	HCFC-22 COP = 3.14 (35°C), 2.26 (50°C) for OEM A COP = 2.76 (35°C), 2.02 (50°C) for OEM B	L-20 (OEM A)	-11%	9%	-10%	7%
		L-20 (OEM B)	-2%	-6%	-5%	-10%
		DR-3 (OEM A)	-9%	2%	-2%	1%
24,000 Btu/hr. split system	HCFC-22 COP = 2.75 (35°C), 1.94 (50°C) for OEM C COP = 2.52 (35°C) for OEM D	HC-290 (OEM C)	4%	8%	-2%	5%
		L-20 (OEM D)	-19%	7%	-76%	-78%
		DR-3 (OEM D)	-27%	-33%	-28%	-31%
24,000 Btu/hr. split system	R-410A COP = 3.52 (35°C), 2.30 (50°C) for OEM E COP = 3.08 (35°C), 2.02 (50°C) for OEM F	HFC-32 (OEM E)	-1%	15%	-2%	16%
		HFC-32 (OEM F)	-9%	8%	-22%	-1%
		L-41 (OEM E)	-10%	20%	-7%	22%
36,000 Btu/hr. Ducted Split	HCFC-22 COP = 2.83 (35°C), 1.91 (50°C) for OEM G	L-20 (OEM G)	0%	-7%	2%	-5%
		DR-3 (OEM G)	-18%	-25%	-13%	-21%
36,000 Btu/hr. Ducted Split	R-410A COP = 2.79 (35°C), 1.84 (50°C) for OEM G	HFC-32 (OEM G)	-1%	-4%	-12%	-18%
90,000 Btu/hr. Rooftop	HCFC-22 COP = 2.95 (35°C), 2.07 (50°C) for OEM H	L-20 (OEM H)	1%	6%	-3%	5%
		DR-3 (OEM H)	-3%	-1%	-6%	-4%

AREP Program

The Alternative Refrigerant Evaluation Program (AREP) by the Air Conditioning, Heating, and Refrigeration Institute (AHRI) tested several refrigerants either as a drop-or in soft optimized units built and tested at various manufacturers who are members of AHRI (AREP 2014). Testing was done in two phases for several applications including refrigeration and at various temperatures.

Table 32 A4 - Results for the AREP program

Equipment type	Base-line refrigerant	Modifications (test-type)	Refrigerant tested	COP % compared to baseline @ 35 °C	Capacity % compared to baseline @ 35 °C	COP % compared to baseline @ 51.6 °C	Capacity % compared to baseline @ 51.6 °C
36,000 Bu/hr. Split heat pump. AREP report 52(6)	R-410A COP = 3.55 at 35C and 1.87 at 51.6C	Criteria: Drop-in. Matching superheat and sub cooling to base unit. Charge level determined by criteria and held constant for all temperatures tested.	ARM-71A	-1%	-8%	7%	-3%
			R-454A (DR-5A)	-1%	-6%	6%	-1%
			HPR2A	-4%	-11%	3%	-4%
			R-446A (L-41-1)	-2%	-10%	-1%	-3%
			R447A (L-41-2)	-1%	-7%	-1%	-4%
48,500 Btu/hr. Rooftop AREP report 56(11)	R-410A COP = 3.31 at 35C, 2.00 at 48.9C and 1.80 at 51.6C	Soft optimization. Adjustable expansion device, Variable Frequency drive matching the capacity with base unit. Varying indoor conditions.	DR-55	4%	0%	3%	0%
			HFC-32	6%	1%	NA	NA
			DR-5A	5%	1%	7%	3%
72,000 Btu/hr. Rooftop AREP report 55(10)	R-410A COP = 3.57 at 35 C and 2.06 at 51.6C	Soft Optimization. Same superheat and sub cooling as base, changing expansion devise and adjusting charge. Oil is also different.	HFC-32	2%	9%	10%	16%
34,000 Btu/hr. split AREP Report 42(5)	R-410A COP = 3.53 at 35C and 1.82 at 51.6C	Tested HFC-32 unit with POE oil and withy prototype oil for the same expansion devise and charge determined by superheat.	HFC-32 with prototype oil	3%	7%	13%	14%
60,000 Btu/hr. Rooftop AREP reports 47 & 53 (8, 9)	R-410A COP = 3.87 at 35C and 2.07 at 51.6C	Soft optimization. Matching superheat and sub cooling.	L-41-2	3%	-7%	10%	-1%
			ARM-71A	3%	-4%	10%	2%
			HPR2A	1%	-5%	8%	1%
			DR-5A	1%	-4%	2%	-3%
			HFC-32	-10%	-4%	-9%	-1%

ORNL Program

The Oak Ridge National Laboratory (ORNL) program consisted of testing alternatives of HCFC-22 and R-410A in two units of the same capacity (Abdelaziz, et al 2015). Testing was done at the ORNL labs at various temperatures. Table below shows the criteria and a comparison of the result.

Table 33 A4 - Results for the ORNL program

Equipment Type	Lab utilized	Baseline Refrigerant	Equipment Criterion	Refriger. Tested	COP % comp to baseline @ 35˚C	Capacity % comp to baseline @ 35˚C	COP % comp to baseline @ 52˚C	Capacity % comp to baseline @ 52˚C
18,000 Btu/hr. Split unit (Carrier)	ORNL	HCFC-22 COP = 3.07 at 35˚C and 1.98 at 52˚C	Same machine to test all refrigerants. Criteria: matching superheat and sub cooling to base unit. Changing expansion devise. Charge level optimized at 35C	N-20B	-13%	-14%	-11%	-15%
				DR-3	-16%	-12%	-14%	-12%
				ARM-20B	-12%	-3%	-11%	-3%
				R-444B (L-20A)	-11%	-9%	-7%	-4%
				HC-290	7%	-8%	7%	-4%
18,000 Btu/hr. split unit (Carrier)	ORNL	R-410A COP = 3.4 at 35˚C and 2.07 at 52˚C	Same machine to test all refrigerants. Criteria: matching superheat and sub cooling to base unit. Changing expansion devise. Charge level optimized at 35C	HFC-32	4%	5%	5%	11%
				DR-55	3%	-3%	3%	0%
				R-447A (L-41)	-5%	-14%	3%	-6%
				ARM-71a	-1%	-8%	2%	-4%
				HPR-2A	-2%	-9%	5%	-1%