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DESK STUDY FOR THE EVALUATION OF RECOVERY, RECYCLING AND RECLAMATION PROJECTS

[1] UNEP/OzL.Pro/ExCom/99/1

Pre-session documents of the Executive Committee of the Multilateral Fund for the Implementation of the Montreal Protocol are without prejudice to any decision that the Executive Committee might take following issuance of the document.

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ABBREVIATIONS

CFC	Chlorofluorocarbon
EPR	Extended Producer Responsibility
GIZ	Deutsche Gesellschaft für Internationale Zusammenarbeit
GWP	Global-Warming Potential
HCFC	Hydrochlorofluorocarbon
HFC	Hydrofluorocarbon
HPMP	HCFC phase-out management plan
IA	Implementing Agency
IACM	Inter Agency Coordination Meeting
KIP	Kigali HFC implementation plan
LAC	Latin America and the Caribbean
LRM	Life-cycle Refrigerant Management
LVC	Low-volume-consuming (countries)
MLF	Multilateral Fund for the Implementation of the Montreal Protocol
MYA	Multi-Year Agreement
Non-LVC	Non-low-volume-consuming (countries)
NOU	National Ozone Unit
ODS	Ozone Depleting Substance
R&R	Recovery and Recycling
RAC	Refrigeration and Air-conditioning
RRR	Recovery, Recycling, and Reclamation
SEO	Senior Evaluation Officer
SIDS	Small Island Developing States
TEAP	Technology and Economic Assessment Panel
TORs	Terms of Reference
UNDP	United Nations Development Programme
UNEP	United Nations Environment Programme
UNIDO	United Nations Industrial Development Organization
WEEE	Waste Electrical and Electronic Equipment

EXECUTIVE SUMMARY

Background and scope of study

1. At its 93rd meeting, the Executive Committee approved the monitoring and evaluation work programme for 2024 and 2025,[2] which included the preparation of the terms of reference (TORs) for a desk study for the evaluation of projects involving recovery, recycling and reclamation (RRR) (decision 93/10).[3] The evaluation aims at assessing the use of the infrastructure established in Article 5 countries for recovery, recycling and, where applicable, reclaiming controlled substances and the contribution of that infrastructure to the reduction in consumption of controlled substances.

2. The TORs for the desk study were approved by the Executive Committee at its 95th meeting[4] and provide for the evaluation to be carried out in two phases. The desk study, which constitutes the first phase, is intended to serve as a mind-mapping of the key issues and to pave the way towards a second phase which would include country visits to learn good practices from success stories and from challenges in project implementation, and to identify patterns for replication.

3. The scope of the desk study covers multi-year agreement (MYA) projects approved from 2010 to 2023, in particular HCFC phase-out management plans (HPMPs) that include at least one of the three components of recovery, recycling and reclamation, in both low-volume-consuming (LVC) and non-LVC countries (non-LVC). The analysis is structured around the evaluation questions contained in annex II to the TORs.[5]

4. The issue of RRR has been addressed in past evaluations, starting with a desk study on recovery and recycling (R&R) projects presented at the 31st meeting,[6] and subsequently as a component of other thematic evaluations, in particular on the refrigeration and air-conditioning (RAC) servicing sector.[7]

Methodology

5. The desk study was prepared by an independent international consultant, under the supervision of the Senior Evaluation Officer (SEO). It reviewed the RRR components of HPMPs in a sample of 15 countries, selected to ensure a balanced representation of regions, implementing agencies (IAs), and levels of ozone-depleting substance (ODS) consumption. In addition, 12 countries[8] in the selected sample benefited from funding under decision 91/66[9] for the preparation of national inventories of banks of used or unwanted controlled substances. While the project reports under decision 91/66 were not yet due during the time of conducting the desk study, the SEO considers that it will be beneficial to integrate the findings of these projects, when available, under the second phase of the evaluation. The countries and projects reviewed are listed in annex I to the present document.

[2] UNEP/OzL.Pro/ExCom/93/13/Rev.1.
[3] UNEP/OzL.Pro/ExCom/93/105.
[4] UNEP/OzL.Pro/ExCom/95/12.
[5] Ibid.
[6] UNEP/OzL.Pro/ExCom/31/18.
[7] UNEP/OzL.Pro/ExCom/80/10.
[8] Albania, Cambodia, Costa Rica, Egypt, Fiji, Ghana, Grenada, Malaysia, Mexico, North Macedonia, Serbia and Tunisia.
[9] UNEP/OzL.Pro/ExCom/91/72.

6. The findings of the desk study were synthesized from two streams of data:

(a) A documentary review of project proposals, tranche requests, progress reports and project completion reports submitted to the Secretariat for the selected countries, as well as relevant Executive Committee documents, chapter 3 of the 2024 report of the Technology and Economic Assessment Panel (TEAP) task force on life-cycle refrigerant management (LRM),[10] the areas of interest discussed at the Inter-Agency Coordination Meeting (IACM) held from 10 to 12 September 2024,[11] and the outcomes of the workshop on LRM held in the context of the Thirty-Sixth Meeting of the Parties;[12] and

(b) A targeted survey questionnaire designed around the evaluation questions of the TORs and sent to the national ozone units (NOUs) of the 15 selected countries, of which 14[13] submitted completed questionnaires (a response rate of 93.3 per cent).

7. In addition, feedback was requested from the IAs on their experience in delivering assistance for RRR. An advanced draft of the desk study was shared by the SEO with IAs as well as the Secretariat staff for data validation and expert review, and their comments were taken into consideration in finalizing the present document.

8. The SEO notes the following methodological limitations, which are inherent to the nature of desk reviews, and which have been taken into account in framing the second phase of the evaluation:

(a) The findings rely mainly on information reported by the NOUs and the IAs, which has not yet been triangulated through direct observation in the countries;

(b) Owing to the gaps in the monitoring of refrigerant quantities described in the summary of findings in paragraph 11 below, the desk study could not quantify the contribution of the RRR infrastructure to the reduction in consumption of controlled substances; and

(c) For the same reason, and in the absence of benchmarks, the assessment of the adequacy of the funding level remains largely qualitative.

Summary of findings

9. The summary responses to the evaluation questions contained in annex II to the TORs,[14] based on the findings of the desk study are presented below.

Adequacy of project planning, design and funding level

10. Satisfaction with the funding level varied by type of country: most LVC countries considered their funding insufficient for the establishment of R&R networks, citing the high cost of R&R equipment and insufficient support for the establishment and operation of a wider network of collection centres, while the three countries from Europe[15] expressed satisfaction with their funding level. Some non-LVC countries

[10] Decision XXXV/11 Task Force Report on Life Cycle Refrigerant Management, Report of the Technology and Economic Assessment Panel, May 2024.
[11] MLF/IACM.2024/2/2.
[12] Workshop on Life-cycle Refrigerant Management at the 36th Meeting of the Parties to the Montreal Protocol 27 October – 2 November 2024 – Bangkok, Thailand.
[13] Albania, Bahrain, Cambodia, Colombia, Costa Rica, Egypt, Fiji, Grenada, India, Malaysia, Mexico, North Macedonia, Serbia and Tunisia.
[14] UNEP/OzL.Pro/ExCom/95/12.
[15] Albania, North Macedonia and Serbia.

expressed greater confidence in their funding levels, while others highlighted needs for equipment modernization, wider geographical coverage, traceability, quality assurance and sustainable business models. The SEO considers that there is currently no adequate quantitative measure to assess the appropriateness of the funding for RRR components, especially with little information related to quantities of refrigerant available for recovery or the expected recovery volumes, and the reported satisfaction with funding levels remains largely qualitative.

Monitoring the effective implementation of recovery, recycling and reclamation projects

11. Summaries and documentation of progress in implementing RRR activities were found in all the HPMP tranche requests reviewed, entailing overall satisfactory monitoring of the progress of implementation of project activities. At the same time, countries rated their ability to monitor the quantities of recovered, recycled and reclaimed refrigerants as partial and identified various challenges. The most frequently cited reason was that RAC technicians and service workshops were not legally obliged to record and report the quantities recovered and recycled during servicing, particularly when recovered refrigerant was recharged on site. Data on refrigerants and end-of-life equipment are fragmented across customs, waste management departments, NOUs, and service providers. Monitoring issues were in some cases compounded by the activities of informal collectors. A few steps to address these gaps were reported, such as a QR code tracking system for RRR refrigerants in Egypt and mandatory annual reporting by service companies in Serbia from 1 January 2027. The desk study also notes that the quantities of recovered or reclaimed refrigerants are not required under the Article 7 data reporting formats.[16]

Mapping of relevant stakeholders

12. The countries identified servicing technicians and servicing companies, recovery and reclamation centres, training institutions, customs authorities, ministries, waste management authorities and RAC associations as relevant RRR stakeholders. However, only about half of the countries included RAC equipment supply chain actors and equipment owners, and none mentioned companies licensed to transport, treat and dispose of hazardous waste. The desk study concludes that RRR relies on two layers of stakeholders that are not yet fully integrated: direct actors in the value chain, and a peripheral layer of institutional stakeholders providing regulatory oversight that can sometimes operate in isolation from the direct actors.

Implementing agencies and national ozone units

13. All countries reported that the NOUs play a central coordinating and oversight role in RRR, including coordination with agencies and industry, policy and regulatory development, identification of equipment and training needs, and oversight of implementation and data collection. To strengthen this role, countries cited the need for, inter alia, a centralized RRR database and mandatory reporting requirements, increased financial, technical and institutional support for the NOUs, targeted capacity-building including on monitoring, reporting and verification systems, and assistance in developing comprehensive national LRM frameworks that clearly define roles and responsibilities of stakeholders throughout the refrigerant life cycle.

Customs

14. Cross-border trade in recovered or reclaimed refrigerants is not currently a significant practice in the countries reviewed, which indicates that RRR systems are primarily oriented towards domestic

[16] UNEP Ozone Secretariat, *Article 7 data reporting forms and associated instructions and guidelines*, Annex III to the report of the Thirtieth Meeting of the Parties (2018), as revised by decision XXXVI/12. Available at: https://ozone.unep.org/node/2128 and https://ozone.unep.org/node/16056

management and reuse. Customs procedures for the control of virgin refrigerants are generally well established; however, countries reported practical difficulties in distinguishing recovered or reclaimed refrigerants from virgin ones and in verifying their origin, owing to insufficient identification capacity at border points and suboptimal information-sharing between enforcement agencies. Effective measures include enforcement of import restrictions or bans on legacy ODS and non-refillable cylinders, verification of import permits and applicable quota allocations for refrigerants, as well as scrutiny of pre-charged refrigeration and air-conditioning equipment to identify potential undeclared or unauthorized imports.

15. While the feedback received from the sample demonstrates that cross-border trade in recovered and reclaimed refrigerants was negligible, the SEO considers that additional information can be sought from the reporting dashboard under the Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and their Disposal [17] on the transboundary movements of waste refrigerants and equipment containing ODS. The dashboard can provide quantifiable information reported by countries on export/import amounts and recovery and disposal operations such as reclamation or incineration. The second phase of the evaluation will include a section providing an assessment of the available data reported in the dashboard to give a better understanding on that subject.

Refrigerant containment and life management

16. Technician training and certification, venting prohibitions, provision of R&R equipment, strengthening of training centres and awareness-raising were the main measures to promote recovery. These measures improved containment and recovery practices among trained technicians and service companies, but their overall effectiveness was reported as moderate, constrained by equipment costs, by collection and transport logistics, and by insufficiently developed monitoring and enforcement. Promising approaches included a collector network supplied with recovery equipment in Egypt, strengthened regulatory frameworks (e.g., Bahrain, Cambodia and North Macedonia), and appliance replacement and extended producer responsibility (EPR) schemes (e.g., Mexico and North Macedonia).

17. Countries unanimously considered that the experience gained with RRR for HCFCs provides a strong starting point for HFC phase-down, as existing networks, infrastructure, trained technicians and licensing, reporting and quota systems can be repurposed. However, HFCs, often zeotropic blends operating at higher pressures, and flammable low-global-warming-potential (GWP) alternatives raise greater technical, safety and logistical challenges, including fractionation, cross-contamination, the need for costly testing and distillation equipment, and the revision of certification schemes and training curricula. Recovering multiple, incompatible blend types into the same cylinder ruins the entire batch, converting valuable chemical stock into contaminated hazardous waste that cannot be re-purposed and must be stored and/or exported abroad for destruction. The lack of destruction facilities in most LVC countries, together with the complexity of transboundary shipments, can result in stockpiling or venting.

Technological issues and scalability factors

18. LVC countries reported limited and uneven availability of R&R equipment and, in the case of small island developing states (SIDS), difficulties with equipment maintenance, spare parts and calibration. Non-LVC countries reported constraints related to the size and capacity of recovery and reclamation equipment and the lack of efficient reverse supply-chain networks to transport small, recovered quantities from rural/semi-urban areas to centralized reclamation plants. This is consistent with the broader life-cycle refrigerant management approach, which requires not only recovery equipment but also functioning systems for collection, storage, transport, reclamation and redistribution.

19. The scalability of RRR depends on a combination of technical capacity, enabling infrastructure, regulatory support and economic incentives. Some IAs reported positive experiences overcoming reverse

[17] BC Report Dashboard

supply-chain constraints using mobile reclamation units and phased pilot initiatives targeting high-volume end users. Establishment of models as "recovery-and-export infrastructure" implemented by Fiji can be replicated by other SIDS and geographically remote countries where supply chain challenges are prevalent.

Market factors and incentive schemes

20. There is consensus among the countries that the low market price of virgin refrigerants reduces the economic attractiveness of RRR and undermines the sustainability of RRR systems. While many countries have adopted regulatory measures (technician licensing and certification and venting prohibitions), these measures alone did not create favourable market conditions to promote RRR activities. Countries suggested a range of economic instruments, including trade-in rebates, take-back arrangements and EPR schemes, tariff and import duty concessions, subsidies for testing, and payments or credits to technicians for verified recovery. The IAs noted that import quotas or environmental taxes on virgin refrigerants widen the price gap in favour of reclaimed refrigerants.

Recovery and recycling (R&R) (re-use) networks and reclamation centres

21. Countries unanimously considered that R&R networks, by substituting virgin imports, help them remain within their Montreal Protocol consumption limits and prevent emissions, and several highlighted the importance of these networks for meeting the servicing needs of the existing HCFC-22-based equipment beyond 1 January 2030. The performance of R&R networks depends on adequate collection infrastructure, aggregation, transport, safe storage and tracking of recovered refrigerants. In many LVC countries, modest project budgets and limited national infrastructure, including the lack of certified laboratories, restrict the networks' operations.

22. The desk study distinguishes between the establishment of R&R networks and the more demanding conditions required for the operation of reclamation facilities. Reclamation requires a regular supply of suitable recovered refrigerant, adequate identification and testing capacity, segregation to avoid contamination, and a market for the reclaimed product. All non-LVC countries in the sample have operational reclamation centres, whereas the LVC countries that have taken steps to establish reclamation centres focus on activities conducive to the operationalization of their RRR schemes.

Effective implementation of reclamation schemes

23. The main constraints reported include the absence of economic incentives, insufficient regulatory provisions, the cost of equipment, low and irregular volumes, logistical costs, and low market confidence in reclaimed refrigerants. Where R&R was successfully implemented but reclamation was not, the main causes were the lack of laboratory testing and identification tools, high collection and processing costs, erratic supply and limited demand.

24. The experience of the IAs confirms that facilities may remain underutilized despite the installation of equipment and the training of operators when these supporting conditions are not in place. It also confirms that reclamation centres need viable business models up front rather than operating as project-funded facilities. Arrangements such as that reported by Bahrain, where suppliers can repurchase reclaimed refrigerant at a price below that of virgin refrigerant, illustrate the importance of examining business arrangements in conjunction with technical infrastructure.

25. Reclamation centres face challenges both in terms of quantities and quality of recovered refrigerants. Post-reclamation composition imbalances caused by unequal component loss during the recovery or distillation phases lead to limited confidence in the chemical consistency, purity, and performance reliability of the final reclaimed product, and reduce its market acceptance.

Geographical distribution

26. The study identified that RRR baseline capacities vary according to the maturity of the servicing sector, existing infrastructure, regulatory and enforcement measures, and the commercial value of recovered refrigerants rather than being part of a specific geographical region. Large and mature RAC markets generate sufficient volumes to justify reclamation commercially, while smaller or geographically spread-out countries struggle to achieve the necessary economies of scale. The desk study therefore underlines the importance of assessing the baseline RRR capacity of a country before designing assistance.

Effectiveness and sustainability of achievements

27. Nine countries rated the assistance of the Multilateral Fund and the IAs as "highly effective" or "important", and five as "moderately effective", "fair" or "adequate". LVC countries valued the provision of R&R equipment, technician training, awareness-raising and, in one case, support for a national certification scheme. Some non-LVC countries expressed reservations on the support for reclamation centres, pointing to the need to strengthen reclamation frameworks for HFCs. Sustainability requires shifting the focus from equipment procurement to long-term monitoring, technical backstopping and market-based mechanisms. RRR centres were reported to face sustainability challenges as stand-alone businesses unless integrated as a service line within an existing operational entity.

Gender dimension and women's participation

28. The initial stages of HPMPs were approved before the adoption of the operational policy on gender mainstreaming (decision 84/92(d)), lacking therefore consideration of the policy in their design. Later HPMP tranches and stages, and Kigali HFC implementation plans (KIPs), are increasingly incorporating the promotion of women's participation in projects' related activities. While most countries reported only the promotion of women's participation in training and awareness activities, a few went further with concrete actions, such as Cambodia's equal access to equipment for female-led workshops, women's involvement in the operation of the recently established RRR facility in Grenada, and female leadership in key institutions in North Macedonia.

Lessons learned and good practices

29. The desk study identified the following key lessons learned and good practices for each of the three components of RRR:

(a) Recovery: Trained technicians and accessible equipment are essential, but not sufficient unless complemented by technical support, access to spare parts and maintenance, enforced legislative systems that prohibit venting and, where possible, financial incentives for service technicians. Identified good practices included: mandatory technician licensing tied to equipment ownership alongside verified annual reporting, linking recovery to equipment replacement and retirement programmes, and shifting the burden of collection from individual technicians to organized collection networks involving large end users;

(b) Recycling: On-site recycling reduces the demand for virgin refrigerants, works best for single-refrigerant systems and requires continuous technician training to prevent cross-contamination, including practical training on flammable alternatives. The feasibility of on-site recycling is more challenging for refrigerant blends. A recycling network requires a sufficient and predictable flow of refrigerant to be economically viable;

(c) Reclamation: Reclamation requires an additional level of technical capacity (characterization, analysis, segregation, processing equipment and certification of the reclaimed product), and a reclamation facility can only be sustainable if it receives sufficient volumes, has a market for the reclaimed refrigerant, and can process different substances and blends. Investment in a facility should therefore be considered together with the recovery network serving it, collection and transport arrangements, testing and treatment costs, and market demand. As reclamation centres are rarely profitable on their own, integrating them into companies offering broader services related to products' end-of-life management, or even in some cases educational institutions, has proven effective;

(d) Across the three components, the study highlights the importance of clear institutional responsibilities, appropriate regulatory measures, cooperation among national stakeholders, and monitoring systems that can account for recovered and reclaimed quantities. It also indicates that models suited to large servicing markets may not be directly applicable to smaller markets, where volumes, geographic dispersion and access to specialized services differ; and

(e) Assessing a country's baseline RRR capacity before designing assistance would result in interventions that meet real needs and amplify benefits to countries. Baseline assessment covers, inter alia, technician and equipment coverage, the quantities available for recovery, reclamation and testing capacity, regulatory enforcement and price differentials. Phased approaches, such as pilot projects targeting high-volume end users before national scale-up, and mobile reclamation units reduce investment risks and logistics costs.

Way forward: second phase of the evaluation

30. The second phase of the evaluation will involve field visits to validate and refine the findings of the desk study, to learn good practices from success stories, to identify patterns for replication and to learn from the challenges in project implementation. Based on the findings of the desk study, the objectives of the second phase would focus on the following issues:

(a) Reconstructing, to the extent possible, and revisiting the quantitative relationship between the funding provided, the RRR infrastructure and capacity established, and its actual utilization and results;

(b) In-depth review and assessment of different RRR delivery models (e.g., centralized and decentralized approaches to collection, storage and reclamation) in different country contexts; comparing technical, institutional and financial sustainability of publicly operated, private-sector, and public-private-partnership business models;

(c) The effectiveness of RRR monitoring, focusing on traceability of refrigerants, including the extent to which recovery is measured at the technician and workshop level, whether data can be reconciled across the refrigerant life cycle and how informal servicing activities can be included;

(d) Technological and scalability factors and market incentives, including the effect of collection, transport, storage and reclamation costs on the price differential between virgin and reclaimed refrigerants, the existence of demand for reclaimed refrigerant, and the extent to which HCFC infrastructure can be repurposed for HFCs and lower-GWP refrigerants; and

(e) The roles and responsibilities of stakeholders along the refrigerant life cycle.

31. Based on the information collected, the desk study proposes field visits to develop five case studies in five countries offering contrasting RRR systems in terms of size, operational infrastructure and data collection frameworks:

(a) Bahrain, a relatively mature and compact system combining a centralized reclamation centre operated with private-sector participation and decentralized collection, with increasingly digital licensing and monitoring;

(b) Colombia, a relatively mature and geographically distributed national R&R network with multiple collection and reclamation facilities, allowing an assessment of decentralized collection, logistics and financial sustainability;

(c) Egypt, a large and diverse RAC servicing market with a reclamation centre and R&R network at significant scale and an emerging QR code traceability system;

(d) Malaysia, a mature national RRR system in a large and geographically dispersed market, operating a market-led hybrid framework that leverages private corporate networks; and

(e) North Macedonia, a relatively small RAC market with an established and documented R&R system, allowing an assessment of the minimum viable scale of R&R infrastructure and of the transition toward broader refrigerant waste management and reclamation.

32. The SEO considers that the proposed sample covers a diversity of regions and RRR delivery models. The detailed evaluation and field visits to this sample of countries would provide ample evidence and various scenarios that can be utilized by countries with variable consumption levels and with servicing sectors at different degrees of maturity.

33. The updated TORs for the second phase are contained in annex II to the present document. A budget of US $50,000 was approved at the 93rd meeting for the entire evaluation; the estimated cost of the second phase is US $30,000. Findings from both phases would be consolidated in a final evaluation report addressing achievements, effectiveness, sustainability, challenges and lessons learned, together with specific, measurable, attainable, relevant and time-bound (SMART) recommendations to facilitate the tracking of their implementation. The report will be presented to the Executive Committee at its 101st meeting.

Conclusion

34. The desk study confirms the critical importance of RRR for achieving the objectives of the Montreal Protocol and the value of the infrastructure and capacities established with the assistance of the Multilateral Fund. It also shows that the transition from project-based activities to sustainable national RRR systems depends on an integrated upstream collection network, reverse logistics, economic incentives and viable business models, enforceable regulatory frameworks, and reliable monitoring of refrigerant flows.

35. The findings also suggest that the main challenges are interrelated. Limitations in recovery equipment coverage or technician participation in recovery affect the volumes supplied to collection centres; transport and segregation arrangements affect the quality and quantity reaching reclamation facilities; and the market price of virgin refrigerants influences demand for reclaimed products. As these factors are interrelated along the refrigerant chain, the SEO considers that they warrant an integrated examination during field visits, rather than separate assessments of individual pieces of equipment or isolated activities. These findings provide valuable initial information for all stakeholders in the design and implementation of ongoing and future projects that include RRR components, including in the context of HFC phase-down, and a solid basis for the second phase of the evaluation.

RECOMMENDATION

36. The Executive Committee may wish:

(a) To take note of the desk study for the evaluation of recovery, recycling and reclamation projects contained in document UNEP/OzL.Pro/ExCom/99/11;

(b) To invite Article 5 countries, the bilateral and implementing agencies and the Secretariat to consider, where appropriate, the findings and lessons learned of the desk study referred to in subparagraph (a) above, particularly those related to tracking and monitoring systems, technical capacity, regulatory frameworks, the availability of a consistent supply of recovered refrigerants, and the economic sustainability of recovery, recycling and reclamation activities, when designing, implementing, monitoring and reporting on ongoing and future projects that include recovery, recycling and reclamation components;

(c) To approve the terms of reference for the second phase of the evaluation of recovery, recycling and reclamation projects contained in annex II to the present document; and

(d) To request the Senior Evaluation Officer to present the consolidated final report and the lessons learned and recommendations to the 101st meeting.

DESK STUDY FOR THE EVALUATION OF RECOVERY, RECYCLING AND RECLAMATION PROJECTS

I. Introduction

37. Projects on RRR and LRM are of critical importance to achieve the objectives of the Montreal Protocol and represent a significant part of the funded activities implemented in the Article 5 countries. These projects, including investment activities and associated training and capacity-building, contribute to sustainable reduction of consumption and avoidance of emissions of controlled substances.

38. At its 93rd meeting, the Executive Committee approved the monitoring and evaluation work programme for 2024 and 2025 (decision 93/10) which included preparation of the TORs for a desk study for evaluation of the projects involving RRR. The monitoring and evaluation work programme stipulated that "the evaluation would aim at assessing the use of the infrastructure established in Article 5 countries for recovering, recycling and, where applicable, reclaiming of controlled substances and that infrastructure's contribution to the reduction in their consumption". The TORs for the first phase of the evaluation were approved at the 95th Executive Committee meeting.

39. The issue of RRR has been addressed in past evaluations listed in annex I to the TORs.[18] The first dedicated evaluation on the matter was a desk study on R&R projects presented at the 31st meeting. Since then, the issue has been examined as a component of other thematic evaluations, particularly on the RAC servicing sector. These evaluations have prompted the Executive Committee to adopt several decisions on different aspects of RRR,[19] containing requests to the different stakeholders, such as the bilateral and implementing agencies and NOUs.

40. The definition of RRR within the Montreal Protocol was set by decision IV/24 of the Meeting of the Parties, as follows:

> *"Recovery: The collection and storage of controlled substances from machinery, equipment, containment vessels, etc., during servicing or prior to disposal;*
>
> *Recycling: The re-use of a recovered controlled substance following a basic cleaning process such as filtering and drying. For refrigerants, recycling normally involves recharge back into equipment and it often occurs 'on site';*
>
> *Reclamation: The re-processing and upgrading of a recovered controlled substance through such mechanisms as filtering, drying, distillation and chemical treatment in order to restore the substance to a specified standard of performance. It often involves processing 'off site' at a central facility".*

41. Since its early days, the Multilateral Fund has supported projects involving one or more of the three processes of RRR, covering a variety of substances, inter alia CFCs, halons and methyl bromide, and more recently HCFCs and HFCs. The method used to prepare this evaluation could be replicated in the future for similar evaluations of other sectors and substances, if so requested.

I.1 Objective and main issues

42. The objective of the desk study is to cover the multi-year agreement (MYA) projects with a focus

[18] UNEP/OzL.Pro/ExCom/95/12.
[19] Such as decisions 41/100, 49/6 and 58/6.

on the RAC servicing sector and set the stage for a second phase of this evaluation that will tackle the issues that the current study cannot fully address. The analysis within the desk study uses the main issues listed as the evaluation questions in annex II to the TORs to identify key challenges that occur during implementation of the projects related to RRR.

43. The findings of the desk study set the groundwork for a second phase of the evaluation that will feature country visits to identify good practices and patterns for replication, and to extract lessons learned on implementation challenges. The final report of the desk study presents updated terms of reference for the second phase reflecting the findings of the desk study as annex II to the present document.

I.2 Scope and methodology

44. The scope of the desk study covers a number of areas regarding the implementation of RRR projects, including their achievements, effectiveness, and contribution to compliance with the Montreal Protocol. The desk study considers the MYA projects approved from 2010 to 2023, in particular those of HPMPs that comprise at least one of the three components of RRR in the RAC servicing sector including domestic and commercial/industrial refrigeration, as well as residential and commercial air-conditioning subsectors.

45. The desk study reviews a sample of projects, in both LVC and non-LVC countries in selected countries, to form a balanced representation of regions, IAs and level of ODS consumption. Summary information on the selected countries is in annex I to the present document.

46. The consultant reviewed project proposals for different HPMP stages and relevant project completion reports. The consultant also reviewed relevant information provided in chapter 3 of the TEAP report on LRM, as well as the areas of interest discussed during the IACM held from 10 to 12 September 2024. The list of documents consulted for the desk study is in annex III to the present document.

47. The main limitation of the desk study arises primarily from its reliance on HPMP project proposals, completion reports, and completed survey questionnaires, which varied in scope and level of detail on planning and reporting on the RRR components. Consequently, the desk study could not independently verify the reported results, observe the practical functioning of RRR systems, or fully assess stakeholder participation, coordination, incentives and operational constraints. These limitations restricted the extent to which the adequacy and cost-effectiveness of MLF funding, the comparative performance of different RRR delivery and business models, and the sustainability of project achievements could be conclusively assessed. The second phase will therefore seek to address these evidence gaps through on-site observation, stakeholder consultations and, where available, examination of operational, technical and financial data.

II. Findings

48. This section presents the findings of the desk study, synthesized from two complementary data streams to ensure a comprehensive evaluation. The analysis of official project progress and completion reports submitted by the IAs on behalf of the selected countries to the MLF Secretariat was supplemented by primary data collected through a targeted survey questionnaire. The questionnaire was structured around the core evaluation questions set out in annex II to the TORs and was distributed directly to the NOUs of the 15 selected countries. Follow-up efforts were undertaken to ensure a robust response rate, resulting in completed questionnaires from 14 of the 15 selected countries, representing a response rate of 93.3 per cent.

49. In addition, feedback from relevant project managers from UNDP, UNIDO and GIZ implementing the RRR components of HPMPs in the selected countries was requested on experience of IAs on delivering assistance for RRR project components. The list of stakeholders targeted in the data collection is provided as annex IV to the present document.

Adequacy of project planning, design and funding level

50. The desk study found that the standardized nature of the Executive Committee HPMP project proposals and the information they contain did not provide sufficient details to assess the underlying rationale for planning of the RRR components, including how the planned activities, equipment, infrastructure and associated funding had been determined in relation to national refrigerant banks, the size and geographical distribution of the RAC servicing sector, and the quantities of refrigerants potentially available for recovery and reclamation. Consequently, although the documentation provided a basis for reviewing the planned scope and funding of RRR components, it offered limited evidence for assessing whether the proposed interventions were appropriately sized, adequately funded and likely to deliver cost-effective and sustainable results.

51. Participants of the workshop at the Thirty-Sixth Meeting of the Parties to the Montreal Protocol[20] noted the complex and cross-sectoral nature of RRR as part of the LRM frameworks and stressed the need for more investment for both capital and operational expenditures. While the MLF does not possess sufficient funding to support large-scale implementation of LRM activities, recent Executive Committee decisions lay the path for funding of LRM.[21]

52. Satisfaction with funding levels for RRR activities varied significantly by country type. Four out of the seven LVC countries[22] viewed their funding levels as inadequate for establishment of R&R networks. The most frequent concerns mentioned were high costs of recovery and recycling equipment and insufficient support for establishment and operation of wider network of collection centres. Fiji also highlighted high cost associated with transportation and logistics due to geographical dispersion of islands. Although all three countries from Europe[23] expressed satisfaction with the actual level of funding, North Macedonia called for continued and scaled-up support to upgrade the RRR network for dealing with complex refrigerant blends and mildly flammable (A2L) alternatives.

53. Whereas some non-LVC countries expressed greater confidence with their actual funding levels, few countries highlighted needs for financial and structural improvements. Mexico emphasized that improving its RRR system requires equipment modernization, wider geographical coverage to boost end-user collection, enhanced traceability, and the creation of sustainable business models. Meanwhile, Colombia noted that keeping its RRR network operational has demanded continuous financial backing from the private sector, inter-agency collaboration, and assistance from the government. Malaysia called for more funding for expansion of refrigerant collection and reclamation facilities and networks, improvement of monitoring and data management, and strengthening of quality assurance. According to India, the current funding guidelines for RRR under HPMPs are based on historical thresholds that do not reflect the actual cost of establishing a sustainable RRR infrastructure and do not consider critical systemic needs.

Monitoring the effective implementation of recovery, recycling and reclamation projects

54. Under the MLF framework, the funding and implementation of HPMPs are structured around performance-based tranche requests. To secure the next installment of funding, NOUs and IAs must submit a progress report including information on progress of the RRR component. Summaries of progress in implementing activities related to RRR were found in all reviewed HPMP tranche requests.

[20] Workshop on Life-cycle Refrigerant Management at the 36th Meeting of the Parties to the Montreal Protocol 27 October – 2 November 2024 – Bangkok, Thailand.
[21] Decisions 93/104 and 97/89.
[22] Cambodia, Costa Rica, Fiji, Grenada.
[23] Albania, North Macedonia and Serbia.

55. All 14 countries that provided responses to the survey questionnaire rated their ability to monitor quantities of RRR refrigerants partially as relevant data are collected from formal operators and reclamation facilities. Albania, Costa Rica, Fiji, Grenada, India and Malaysia highlighted the fact that RAC technicians and service workshops are not legally obliged to record and report the quantities of refrigerants recovered and recycled during servicing activities and pointed to absence of centralized databases for this purpose. Bahrain and Tunisia added that this is particularly relevant for the cases when recovered refrigerants are recharged on-site and their quantities are not recorded by the service workshops. As a result, NOUs and other relevant authorities lack reliable data to monitor refrigerant recovery and recycling practices and assess the actual volumes of refrigerants being saved from venting in the air and returned to use.

56. As an example, the key challenges reported by Bahrain include the large and diverse servicing sector, widely decentralized on-site refrigerant recovery and reuse, limited availability of historical data on refrigerants contained in installed equipment, and the practical difficulty of consolidating and verifying data from all servicing activities.

57. Moreover, data on refrigerants and end-of-life RAC equipment are fragmented across various organizations (e.g., customs, waste departments, the NOU and producer responsibility organizations), with no integrated digital platform for sharing and reconciling information. As a result, data on imports, equipment placed on the market, waste collection, refrigerant recovery and RRR activities are maintained in separate systems and cannot be readily linked or cross-checked. This limits the ability to establish a complete picture of refrigerant flows and identify gaps or discrepancies.

58. Finally, comprehensive tracking of refrigerants throughout their life cycle is lacking in all countries. As an illustrative example, North Macedonia informed that the national Waste Electrical and Electronic Equipment (WEEE) legislation does not require producers or producer responsibility organizations to report substance-level quantities of refrigerants contained in the collected end-of-life equipment. This gap is further compounded by the activities of informal collectors and unlicensed scrap yards, which dismantle refrigeration and air-conditioning equipment for scrap metal without properly recovering or reporting the refrigerants contained in the appliances.

59. Some steps were reported aimed at addressing these monitoring gaps. The NOU in Egypt successfully rolled out a QR tracking system for RRR refrigerants. However, data entries are currently restricted to reclaimers using the NOU portal, leaving a disconnection between equipment owners, maintenance providers, and reclaimers. Meanwhile, the NOU in Serbia reported that the new Air Protection Law in Serbia will mandate that service companies submit annual reports on recovered, recycled, or reclaimed refrigerant quantities to the Environmental Protection Agency, starting 1 January 2027.

60. The insufficient monitoring is compounded by the fact that quantities of recovered or reclaimed refrigerants are not required under the Article 7 reporting data forms.[24] Instead, such data are occasionally requested via separate ad-hoc decisions of the Parties (addressed to the TEAP).[25]

Mapping of relevant stakeholders

61. The countries identified as relevant RRR stakeholders service-sector technicians and companies,

[24] UNEP Ozone Secretariat, *Article 7 data reporting forms and associated instructions and guidelines*, Annex III to the report of the Thirtieth Meeting of the Parties (2018), as revised by decision XXXVI/12. Available at: https://ozone.unep.org/node/2128 and https://ozone.unep.org/node/16056

[25] For example, in paragraph 4 of decision XXX/2, parties requested the Technology and Economic Assessment Panel to provide in its quadrennial reports to be presented in 2023 and 2027 information on the availability of Annex C, Group I substances, including amounts available from recovery, recycling and reclamation, and best-available information on country-level and total known stocks.

recovery and reclamation centres, technical and vocational training institutions, customs and border control, ministries responsible for environment, waste management authorities, as well as RAC associations. However, only about half of the countries included also equipment supply chain actors (manufacturers, importers, distributors, and retailers), and commercial, industrial, and institutional equipment owners. None of the countries mentioned companies licensed to transport, treat, and dispose of hazardous waste.

62. Country responses indicate that RRR activities rely on a complex network of stakeholders. Certain actors engage directly in the value chain, including RAC servicing workshops, refrigerant importers and distributors, training institutions, industry associations, equipment end users, and reclamation facilities. In contrast, other stakeholders play a more peripheral role, such as ministries or departments overseeing environment, energy and climate change, customs and border enforcement authorities, as well as waste management authorities and companies.

63. UNDP presented experience with diverse approaches for selecting RRR operators, each with the following distinct advantages and challenges:

(a) Refrigerant importers/distributors use existing logistics networks, customer bases, and cylinder fleets. However, operators must upgrade their technical skills and receive clear economic incentives to prioritize reclaimed gas over profitable virgin imports;

(b) Universities and training centres effectively integrate RRR practices into technician certification programmes using established institutional networks. However, they generally lack the commercial infrastructure and business expertise needed to manage a viable business operation;

(c) Specialized waste management companies are well-positioned for recovering refrigerants from end-of-life equipment within circular economy frameworks. However, this model requires establishing a distinct, viable business case for reclamation separate from their primary waste-processing revenue stream.

64. The IAs highlighted importance of collaboration across the supply chain, requiring environmental authorities, refrigerant distributors, service technicians, training institutions, and waste management companies to operate as a unified network.

65. The substantive feedback submitted by the IAs assisting the countries in the desk study spanned multiple operational, technical, and strategic domains. To maintain thematic clarity and ensure a structured analysis, their diverse field experiences, institutional challenges, and best practices have been integrated directly under the specific evaluation questions detailed in annex II to the TORs.

66. All 14 countries reported that the NOUs play a central coordinating and oversight role in RRR activities. This includes coordination with IAs and industry, development and updating of relevant policies and regulations, identification of needs for RRR equipment and training, oversight of implementation of RRR activities, as well as data collection on recovered, recycled and reclaimed refrigerants. Few countries added that the NOUs also consolidate and periodically report to the government, IAs and the Ozone Secretariat.

67. For strengthening the role of NOU in RRR, Albania called for establishment of a centralized RRR database, enacting of mandatory reporting requirements, and stronger coordination with technicians, service companies, importers, customs, and waste operators. Bahrain, Fiji and Grenada stressed the need for increased financial, technical and institutional support to the NOU. Mexico added targeted capacity-building across critical operational and regulatory domains, refrigerant leak control/regulation, and

development of monitoring, reporting and verification systems. Malaysia called for development of a comprehensive national LRM framework that clearly defines responsibilities for refrigerant recovery, collection, transportation, testing, recycling, reclamation, reuse and end-of-life management.

Customs

68. Information from the countries suggests that cross-border trade in recovered and/or reclaimed refrigerants is not currently a significant practice in the countries reviewed. Only Albania mentioned cross-border trade in recycled and reclaimed refrigerants. Malaysia reported in-country (company to company) trade and North Macedonia reported that recovered refrigerants remain within national borders, where they are either stored for future use or reintroduced into servicing operations, subject to applicable technical and regulatory requirements. Costa Rica explained the absence of cross-border trade by the lack of established culture for use of recovered or reclaimed refrigerants while India explained it by lack of standard international certification and high transport costs.

69. These findings indicate that the refrigerant recovery and reclamation systems are primarily oriented towards domestic management and reuse of refrigerants rather than for regional or international markets. India highlighted the issue of “disguised trade” when contaminated, mixed, or virgin HCFCs/HFCs are falsely labelled as "reclaimed" or "recycled" to bypass import quotas or licensing controls. In this regard, countries highlighted the key role of customs authorities for preventing unauthorized trade and controlling the movement of regulated refrigerants and related equipment across national borders. This includes enforcement of import restrictions or bans on legacy ODS and non-refillable containers, verification of import permits and applicable quota allocations for bulk refrigerants, as well as scrutiny of pre-charged refrigeration and air-conditioning equipment to identify potential undeclared or unauthorized imports. These controls are particularly important where the same refrigerants may enter the country in different forms, including as bulk substances, in cylinders, or contained within imported equipment.

70. The responses indicated that customs procedures for controls on the international movement of virgin/regulated refrigerants are generally well established in the surveyed countries. Few countries stressed several challenges for control of cross-border trade with reclaimed refrigerants. Mexico mentioned difficulties with accurate identification of refrigerants and verification whether refrigerant is virgin, recovered, or reclaimed. Bahrain and Malaysia added that distinguishing recovered/reclaimed refrigerants from virgin refrigerants and verifying their origin can present practical traceability challenges. The reasons cited for these challenges were insufficient refrigerant identification capability at border points and suboptimal information sharing between relevant enforcement agencies.

Refrigerant containment and life management

71. The 2024 report of the TEAP[26] addresses the refrigerant life cycle starting from leak prevention in the design, manufacturing and assembly of RAC equipment, all the way through its operational life, until refrigerant recovery and reuse or destruction. The report further states that capacity for LRM varies with types of applications or products, the size and level of industrialization of countries, and the regions within the same country with greater accessibility in urban areas. There is an uneven accessibility in Article 5 countries to LRM technologies, particularly with regard to advanced reclaim and destruction capabilities.

72. For promotion of refrigerant recovery, most countries listed capacity-building and certification of RAC technicians, prohibition of refrigerant venting, provision of refrigerant recovery and recycling equipment under MLF supported projects, strengthening of training centres, and awareness-raising with various stakeholders. Reportedly, these measures have improved refrigerant containment and recovery

[26] TEAP May 2024: Decision XXXV/11 Task force report on life cycle refrigerant management (volume 3)

practices, particularly among trained technicians and service companies. At the same time, however, the countries also hinted that overall effectiveness of these measures remains moderate and is constrained by the high cost of R&R equipment, logistical challenges for collection and transportation to reclamation centres (if existing), limited quantities of refrigerants available for recovery, and absence of fully developed monitoring and enforcement mechanisms.

73. Egypt demonstrated a more systematic approach based on a targeted distribution of sets of refrigerant recovery equipment and tools to members/beneficiaries of a collector network. The NOU in Egypt reported that a Beneficiary Network Programme has been developed beyond simply establishing a reclamation/recycling facility through provision of equipment to a network of decentralized collectors who generate and aggregate recovered refrigerants and create an organized channel through which dispersed recovered refrigerants reach a recycling/reclamation facility.

74. Several countries also stressed importance of strengthened legislative and regulatory frameworks. Cambodia reported that its regulatory framework including sub-decrees on ODS and provisions of the Code on Environment and Natural Resources requiring proper refrigerant handling provides an important enabling condition for promotion of refrigerant recovery. Similarly, Bahrain reported that quantities of refrigerant recovered and delivered for reclamation increased since the introduction of the strengthened regulatory framework and technician training requirements. North Macedonia has introduced legal prohibition on intentional refrigerant venting under the Law on Environment and mandatory annual reporting by certified technicians through service logbooks.

75. Few countries highlighted increased relevance of appliance replacement programmes. Mexico reported progress with establishment of a programme commonly known as “Cambia tu viejo por uno nuevo”[27] through more than 100 collection and dismantling centres receiving equipment, recovering refrigerants and separating recyclable materials. Also, North Macedonia informed on implementation of extended producer responsibility (EPR) financing for e-waste collection systems. This approach proved effective in the commercial/servicing sector but less successful for end-of-life domestic equipment due to inadequate public drop-off options, household retention of obsolete units, and refrigerant leakage during handling in informal scrap yards.

76. Countries unanimously agreed that the experience from RRR activities under HCFC management projects provides a strong starting point for the HFC phase-down. The existing networks of trained technicians, infrastructures, servicing practices, and recovery equipment can be repurposed to manage HFCs, reducing both harmful emissions and the demand for virgin refrigerants. Additionally, the lessons learned from tracking HCFCs will help governments to design more effective licensing, reporting, and quota systems for stronger enforcement mechanisms, as well as a platform for better coordination of the NOUs with key stakeholders for HFC phase-down.

77. However, few countries pointed at significantly greater technical, safety, and logistical challenges for recovery of HFCs compared to HCFCs. Colombia and Tunisia stressed that the existing infrastructure must be adapted to the different characteristics of HFCs. While HCFCs were mostly single-compound, non-flammable gases, HFCs often consist of complex chemical blends operating under higher pressures that require upgrade of equipment and revised handling protocols. Mexico added the need for proper identification and segregation of refrigerant compounds and new safety requirements for certain lower-GWP refrigerants. North Macedonia called for revision of national certification schemes and upgrade of training curricula to cover mildly flammable A2L refrigerants, flammable A3 hydrocarbons and high-pressure alternative refrigerants. Egypt highlighted the need for costly multi-stage distillation units for

[27] Trade in Your Old Appliance for a New One.

separation of refrigerant mixtures while Fiji stressed importance of funding for proper storage and destruction of recovered refrigerants for the HFC RRR activities.

78. Persistent technical barriers in processing complex HFC mixtures, such as R-410A and other multi-component blends, were confirmed as a significant operational challenge also by the IAs. According to their experience, reclamation centres frequently encounter post-reclamation composition imbalances caused by unequal component loss during the recovery or distillation phases. Consequently, facility operators often express limited confidence in the chemical consistency, purity, and performance reliability of the final reclaimed product, negatively affecting its market acceptance.

79. On comparison of refrigerant blends with pure substances, the main issue cited by several countries was the zeotropic characteristics of R-410A and R-407C accounting for majority of the recovered refrigerant volumes in the servicing workshops. Such compounds are prone to fractionation during leakage that alters the component ratios and limits thus the feasibility of basic on-site recycling without sophisticated reclamation units. Also, the risk of cross-contamination further increases processing costs. These factors contribute to reduced commercial viability of reclaimed blends in comparison with purchasing virgin refrigerants.

80. Only about half of the countries indicated that refrigerant blends present greater technical and economic issues for RRR schemes compared to pure substances. North Macedonia brought attention to cross-contamination as a constant risk in on-site operations. Recovering multiple, incompatible blend types into the same cylinder ruins the entire batch, converting valuable chemical stock into contaminated hazardous waste that cannot be re-purposed and must be stored and/or exported abroad for destruction.

81. Because blends can undergo fractionation during leakage, their original component ratios may be altered, requiring specialized reclamation units capable of restoring the refrigerant to the required purity and composition standards. Several non-LVC countries[28] pointed out the need for expensive laboratory testing equipment, including gas chromatography, to verify the composition and purity of the reclaimed refrigerant before it can be safely reused in the original system or placed back on the market. Bahrain added that attention to refrigerant identification, composition and quality is required also for determining whether they are suitable for reclamation. These technical requirements, together with the costs of transportation and quality control, increase the overall cost of reclamation and make reclaimed blends less economically viable than simply buying new, virgin refrigerants.

82. As a specific example, Mexico noted that reclamation of emerging refrigerant blends requires strict identification and segregation specifications. New mixtures like R-448A, R-449A, R-452A, and R-513A demand precise tracking, while flammable alternatives like HFC-32 and R-454B require specialized tools, compatible cylinders, and strict safety protocols. This adds significant complexity to the identification, sampling, testing, and separation processes. Because of these intense technical demands, the country's national capacity to reclaim blends remains severely restricted. As a matter of fact, only a single facility in Mexico currently possesses the distillation equipment required to reclaim these blends.

83. Costa Rica does not see the need to include blends in the RRR processes as they are currently unattractive to end users. Egypt warned of impact of the technical challenges on establishment of pricing schemes for reclamation of R-400 blends due to the cost of intense processing. Tunisia reported that the above technical challenges have already been reflected in adjustment of RAC technician training programmes with focus on specialized methodologies for recovery of refrigerant blends. Bahrain stressed that to date only limited quantities of refrigerant blends have been received for reclamation. Consequently,

[28] Bahrain, Malaysia, Mexico.

requirements for capacity-building for reclamation of blends must be assessed progressively in accordance with the refrigerants entering the national market and the servicing sector's actual needs.

84. Malaysia and Tunisia stressed that interventions should be strengthened across the entire refrigerant value chain rather than focusing primarily on end-of-life recovery. The measures include preventing leakage through improved installation and servicing practices, promoting regular maintenance and early leak detection, ensuring the use of recovery equipment during servicing and decommissioning, and establishing systems for the collection, transport, testing, recycling, reclamation, and environmentally sound disposal of refrigerants. Grenada, North Macedonia and Tunisia pointed at importance of mandatory extended producer responsibility schemes where importers and suppliers of refrigerants and refrigeration equipment can contribute to the proper recovery and end-of-life management of refrigerants.

85. Bahrain highlighted a key factor in achieving a consistent flow of sufficient quantities of suitable recovered refrigerant to the reclamation centre. This perspective was fully endorsed by the IAs based on their field experience. The IAs underscored that these operational and technical barriers are systemic challenges that consistently hinder RRR project outcomes across multiple national portfolios. The integrated findings suggest that economic viability of reclamation depends on collection volumes, refrigerant quality, market demand and effective participation by servicing companies and major end users.

86. UNIDO confirmed cross-contamination of refrigerants as a persistent systemic barrier due to recovery of small quantities of refrigerants from various sources into shared recovery cylinders. Such mixtures of different chemical types of refrigerants become unsuitable for standard reclamation processes with high-temperature destruction the only technically feasible solution. Lack of local, environmentally sound destruction facilities in most LVC countries and complexities arising from transporting unwanted refrigerants for destruction in other countries result in long-term refrigerant stockpiling or illegal venting.

Technological issues and scalability factors

87. Several LVC countries[29] pointed out limited availability of essential equipment and tools, as well as uneven distribution of R&R equipment that restricts the capacity of RAC service technicians and workshops to recover refrigerants during equipment servicing and end-of-life disposal. In addition, absence of national reclamation facilities represents a major constraint in Albania and North Macedonia. This forces RAC technicians to either reuse unpurified, contaminated refrigerants or place them into long-term storage, preventing thus any circular reuse.

88. Furthermore, Grenada highlighted distinct challenges inherent to SIDS, specifically regarding the maintenance and servicing of RRR equipment. These difficulties stem from a lack of in-country technical assistance from equipment suppliers, alongside restricted access to spare parts and calibration services due to heavy reliance on international procurement for specialized components and expertise.

89. Non-LVC countries highlighted challenges with size and capacity of recovery and reclamation equipment. Mexico reported challenges with conventional recovery equipment that may be inefficient for servicing systems with large refrigerant charges owned by big end users. Malaysia currently relies mainly on small-scale mini reclamation machines and a limited number of larger reclamation systems that restrict the volume and range of refrigerants for processing. Bahrain stressed the importance of maintenance and suitability of equipment and technical capacity as the refrigerant market evolves. India highlighted lack of

[29] Albania, Cambodia, Costa Rica and Grenada.

efficient reverse supply chain[30] networks to transport small, recovered quantities from rural/semi-urban areas to centralized reclamation plants.

90. In addition, Egypt and North Macedonia pointed out lack of national destruction facilities that causes total dependence on costly cross-border exports. On the contrary, Costa Rica reported implementation of a structured system dedicated to collection, storage, testing and destruction of non-reusable refrigerants that are ultimately routed for thermal destruction in cement kilns.[31] The system, developed over several years through cooperation between the Ministry of Environment and Energy, UNDP and the country's leading cement producer Holcim, addresses the final stage of refrigerant management for safe disposal of recovered gases that are contaminated, mixed, and otherwise unsuitable for reuse, or not economically recoverable.

91. The feedback from the countries indicates that scalability of the RRR activities depends on a combination of technical capacity, enabling infrastructure, regulatory support and economic incentives. Scalability is fostered by existence of regulatory requirements and incentives encouraging refrigerant recovery, as well as mechanisms for monitoring refrigerant flows and coordinating stakeholders across the servicing and end-of-life management chain.

92. Serbia serves as a clear example, where systemic and technical hurdles keep RRR activity low. Because the local supply chain cannot reintegrate reclaimed refrigerants due to economic imbalances with cheaper virgin gases, fragmented institutional oversight, and lack of mandatory reporting for service technicians, domestic businesses are reluctant to engage. While several companies indicate they can afford purchase of RRR equipment and tools, they hold off on any investments until a functional regulatory framework and supporting infrastructures are established.

93. The IAs highlighted options for decentralization and optimization of reclamation logistics. To overcome the bottlenecks of centralized processing, the IAs supported replacing stationary reclamation machines through deployment of mobile reclamation units that deliver on-site services directly at end-user facilities. The field experience shows that such shift effectively mitigated the high logistical costs of transporting used refrigerants, minimized the risk of cross-contamination and gas mixing during transit and significantly improved both service response times and the chemical purity of the final reclaimed product.

94. UNIDO experience demonstrates that localized pilot initiatives are significantly more effective than direct national rollouts when initial project interventions target high-volume end users or specific industrial sectors[32] where substantial, predictable quantities of refrigerant can be easily mapped. Such phased approach allows NOUs and IAs to test and refine logistical collection systems, cost-sharing mechanisms, and business models in a controlled environment. By sorting out operational challenges on a smaller scale, countries can de-risk subsequent investments, build market trust in reclaimed products, and establish a proven pattern before scaling up to a comprehensive national framework.

Market factors and incentive schemes

95. Several countries highlighted that without appropriate regulatory requirements and economic incentives it is difficult to establish and upscale RRR systems on a sustainable basis. The countries expressed consensus that low market prices of virgin refrigerants reduce the economic attractiveness of

[30] The logistic process of returning recovered refrigerant for the purpose of recycling, reclamation or destruction (TEAP Report 2024).
[31] UNEP/OzL.Pro/ExCom/93/36.
[32] Such as commercial refrigeration networks, large-scale air conditioning in supermarkets, or the automotive servicing sector.

RRR activities. Consequently, servicing companies and end users have limited or no financial incentives for refrigerant recovery and reuse. This particularly weakens demand for reclaimed refrigerants as stakeholders have little interest to invest in collection, testing, storage and reclamation infrastructures. Market prices thus seriously undermine the economic sustainability and effectiveness of the RRR systems across the countries covered by the study.

96. While multiple countries have already introduced or at least initiated regulatory steps, including licensing and certification of technicians, prohibition of refrigerant venting, mandatory reporting, they have not addressed the market factors. However, Colombia has introduced an economic incentive scheme: by optimizing its operational model, it has made the cost of reclaimed refrigerant gases approximately 50 per cent cheaper than purchasing virgin refrigerants, creating a strong financial incentive for the market.

97. UNIDO stressed a profound influence of market factors on the viability of RRR initiatives. In countries with high virgin refrigerant prices, strict import caps, or foreign exchange controls, reclaimed refrigerants command a high market value. This economic reality creates natural, self-sustaining incentives for technicians and end users to prioritize recovery and reclamation. Conversely, in open markets where virgin refrigerants are cheap and abundantly supplied, establishing a competitive scheme for reclaimed alternatives becomes highly difficult, as the economic driver for market actors disappears.

98. Several countries suggested economic instruments aimed at improving the financial attractiveness of the RRR for key actors in the refrigerant supply chain. These included trade-in/old-for-new rebates or disposal credits for equipment owners and take-back arrangements as part of extended producer responsibility of manufacturers and distributors of RAC equipment. Return of equipment through authorized channels avoids informal disposal and ensures that refrigerants contained in the equipment enter the formal recovery chain.

99. To secure the long-term sustainability of its RRR system, Tunisia is pursuing new regulations targeting the life-cycle management of refrigerants and associated equipment. A key component of this strategy includes introducing an EPR framework for refrigerant and equipment importers. The drafted regulations have already been finalized and submitted to the Ministry of the Environment for formal review and potential adoption.

100. Cambodia, Grenada, Egypt and Malaysia suggested various financial incentives such as tariff exemptions on recovery tools, import duty concessions, subsidies for reclamation testing, and buy-back and deposit-refund schemes, to make RRR financially attractive for local servicing centres. Yet another proposed incentive was introduction of payments or credits to service technicians for verified recovery and return of refrigerant, potentially linked to technician certification, in order to make refrigerant recovery financially attractive compared with venting or disposal and encourage technicians to become active participants in the formal RRR systems.

101. North Macedonia is institutionalizing an EPR financing model to fund the equipment collection, transport, and disposal infrastructure. This system establishes a product fee managed directly by producer responsibility organizations. For enhanced sustainability of capacity-building, the country integrates service technicians' training into permanent vocational school curricula.

102. According to UNDP experience, countries implementing strict import quotas or environmental taxes on virgin refrigerants deliberately constrict the supply of new refrigerants broadening the price gap between virgin refrigerants and reclaimed alternatives. By establishing these fiscal barriers, regulations guarantee a predictable market demand for lower-cost reclaimed products. Servicing companies, technicians, and end users are effectively forced by market economics to adopt circular practices,

transforming reclamation from a subsidized environmental initiative into a self-sustaining, commercially viable business model.

Recovery and recycling (R&R) (re-use) networks and reclamation centres

103. Information provided by the countries shows unanimous consensus that substituting virgin imports by effect of established R&R networks helps countries to remain within their consumption limits set by the Montreal Protocol and prevent uncontrolled refrigerant emissions. Grenada, Malaysia, Mexico, North Macedonia and Tunisia highlighted the importance of recovery, reuse and reclamation of HCFC-22 in relation to the "servicing tail" of HCFC-22 beyond 1 January 2030 when import of the latter will no longer be permitted but the substance will still be required for the continued servicing needs of the existing HCFC-22 legacy equipment stock. Tunisia and India added that meeting the ongoing servicing demand of the existing RAC fleet with reclaimed/recycled gases will extend the useful life of the existing legacy equipment and thus prevents economic losses until the legacy equipment stock is fully phased out.

104. For improvement of performance of R&R networks and reclamation centres, several countries stressed importance of adequate collection infrastructure, aggregation, transport, safe storage and tracking of recovered refrigerants for the overall efficiency and traceability. They pointed out that lack of dedicated collection points, shortage of appropriate recovery cylinders, and absence of central storage facilities and digital tracking systems can result in fragmented handling practices, refrigerant losses through prolonged storage and uncertainties regarding the quantities, origin, composition and final destination of recovered substances. Collectively, technological challenges and infrastructure gaps limit the development of integrated and economically viable RRR systems.

105. Bahrain reported that companies supplying certain refrigerants to its National Refrigerant Reclamation Centre, operated by a private sector company, can purchase the reclaimed refrigerant back at a significantly lower price than virgin refrigerant available in the local market, encouraging thus recovery of refrigerants while supporting the financial sustainability of the RRR scheme.

106. UNIDO field experience shows that modest MLF project budgets and limited national infrastructure restrict many LVC countries to basic refrigerant R&R operations. Progressing to reclamation is rarely feasible because these countries lack the certified laboratories and quality-control systems required to verify refrigerant purity. Without this technical backing, creating a sustainable reclamation system in LVC countries remains highly challenging.

Effective implementation of reclamation schemes

107. The study reveals significant variation of responses across the surveyed countries according to their ODS consumption status. The diversity is primarily driven by the countries' differing levels of practical experience with reclamation schemes. All non-LVC countries in the study have already established and operational reclamation centres hence they have accumulated experience with implementation of refrigerant reclamation schemes.

108. Egypt has singled out absence of economic incentives as the only important factor and Tunisia highlighted absence of regulatory provisions for the RRR system and delayed certification of technicians. Colombia highlighted a combination of economic, market and technical capacity factors.[33]

[33] Cost of machines and tools and cost of refrigerant gas analytical equipment, low confidence in reclaimed refrigerants in the market, and lack of good practices in the service sector.

109. Mexico recognized as the main issues quantity and quality of recovered refrigerants (low and irregular recovery volumes, contamination and mixing of refrigerants), logistical challenges (high transportation costs due to long distances to collection points, lack of connectivity among actors throughout the recovered refrigerants supply chain, lack of analytical laboratory equipment) and economic factors (limited formal market due to low demand for reclaimed refrigerants and absence of a sufficiently robust business model).

110. Similarly, Malaysia pointed to several challenges, including limited number and geographical location of collection points, concerns over the quality and acceptance of reclaimed refrigerants, and absence of an integrated collection, tracking and return system that constrain the development of an effective reclamation network.

111. The LVC countries in the sample currently do not have fully operational reclamation schemes. Therefore, responses from the LVC countries focus more on factors for creation rather than operation of reclamation schemes. The countries highlighted several factors impacting establishment of reclamation centres and schemes, including shortage of financial resources for reclamation equipment and cylinders, limited quantities of refrigerants available for reclamation hindering achievement of economies of scale, gaps in technical expertise for effective operation of reclamation equipment.

112. Fiji highlighted importance of links to regional reclamation facilities for SIDS. Reportedly, the technical expertise and support to Fiji on refrigerant recovery and reclamation, and on promotion of best practices in refrigerant management provided by Refrigerant Reclaim Australia[34] has helped to build understanding of refrigerant reclamation and its role in sustainable refrigerant management. Establishment of such recovery-and-export infrastructure can serve as a model for replication by other SIDS in the Pacific region.

113. The above findings are consistent with the conclusions previously provided by the Refrigeration, Air-Conditioning and Heat Pumps Technical Options Committee[35] that the mere existence of recovery equipment and trained technicians does not automatically translate into a reliable feedstock for reclamation centres. Particularly important is the pricing relationship between recovered, reclaimed and virgin refrigerant. If virgin refrigerant is relatively inexpensive or readily available, service technicians have little financial incentive to recover refrigerant, transport to a reclamation centre and pay reclamation fees. Conversely, if reclaimed refrigerant is competitively priced and recognized as a reliable substitute for virgin product, the reclamation centre can create a market incentive for technicians and distributors to bring recovered gas.

114. The above experience demonstrates that logistics of the reverse supply chain should be treated as integral part of the RRR system build-up. The 2024 TEAP report highlighted the need to improve transportation between refrigerant recovery collection points and recycling centres and to develop an economic model that includes incentives for sustainable operation. This is consistent with the broader life-cycle refrigerant management approach, which requires not only recovery equipment but also functioning systems for collection, storage, transport, reclamation and redistribution.

115. UNIDO has documented another institutional experience on this issue. Its publication on servicing-sector refrigerant management[36] states that existing reclamation centres in developing countries are often underutilized because of lack of predefined business modalities. It explicitly links development of

[34] A non-profit organization dedicated to safeguarding the environment by recovering and responsibly managing ODS and synthetic greenhouse gases.
[35] Report of the Refrigeration, Air-Conditioning and Heat Pumps Technical Options Committee, 2010 Assessment.
[36] Fixing Fridges Helps Save The Planet, Department of Environment, UNIDO (2023).

sustainable business models with motivating technicians to recover refrigerants and maintain the reuse cycle. The publication also describes centralized, decentralized and semi-centralized models for organizing refrigerant reuse, with central reclamation considered the preferred option where feasible. UNIDO also stressed that successful reclamation requires appropriate legislation, awareness and private-sector participation, because the reclamation centre ultimately needs to operate as a viable service rather than simply as a project-funded facility.

116. UNIDO has subsequently moved towards more explicit network-and-business-model approaches. For example, in Egypt, UNIDO supported a pilot reclamation centre managed by a local refrigerant supplier and its client network.[37] The project specifically aimed to demonstrate the logistical, business and technical aspects of operating the centre. Importantly, UNIDO is also establishing R&R network teams equipped to recover and collect controlled refrigerants for delivery to the reclamation centre.

117. UNDP-supported projects similarly demonstrate the value of linking reclamation infrastructure with certified service companies, technician networks and dedicated collection logistics, including mobile recovery capacity or establishment of a network of reclamation centres distributed among several institutions. This approach combines institutional/training capacity with service-sector infrastructure and in cases where geography, transport costs or market size make a single central reclamation facility difficult to sustain, uses a distributed network of smaller collection, recovery, reclamation facilities.

118. Data collected from countries revealed that the lack of laboratory testing and identification tools, high costs of collection, transportation and reclamation, erratic material flow from individual servicing activities, and limited demand for reclaimed refrigerants severely hinder reclamation efforts in all non-LVC countries in the sample. In particular, these countries hinted at insufficient supply of portable analysers and lack of analytical laboratory instruments. Without these tools, they cannot accurately measure refrigerant purity or contamination. This constraint directly impacts the reclamation of refrigerant blends, where exact identification is critical to guarantee safe processing and meet formal quality standards for reuse.

119. UNIDO highlighted importance of refillable cylinders for shift from basic recovery to reclamation. However, its field experience suggests that although countries generally show strong interest in introducing refillable cylinders, their deployment can face resistance from the informal technicians, viewing this as an advantage for large distributors with the capital to buy and manage refillable cylinders' infrastructure.

Geographical distribution

120. The desk study revealed that baseline capacities for RRR vary substantially across the selected sample of countries, reflecting disparate levels of servicing-sector maturity, existing R&R networks and reclamation infrastructure, regulatory frameworks and enforcement capabilities, alongside the commercial value of recovered refrigerants. Countries characterized by large and relatively mature RAC servicing markets generate sufficient refrigerant volumes to commercially justify reclamation services; conversely, smaller or geographically dispersed countries struggle to achieve the economies of scale necessary for the viable operation of reclamation facilities.

Effectiveness and sustainability of achievements

121. Nine countries[38] rated the assistance of the MLF and its IAs as "highly effective", "important" or

[37] UNEP/OzL.Pro/ExCom/88/47.
[38] Albania, Bahrain, Cambodia, Egypt, Fiji, Malaysia, North Macedonia, Serbia and Tunisia.

"crucial", while another five countries[39] summarized it as "moderately effective", "fair" or "adequate".

122. Amongst the successful interventions under the MLF assistance, LVC countries listed provision of R&R equipment, training of service technicians, and awareness-raising of stakeholders involved in the value chain. North Macedonia also highlighted support for establishment of a national certification scheme. These countries see the strengthened national R&R infrastructures and technical capacities as an important milestone in the transition towards establishment of national refrigerant reclamation systems. Fiji and Grenada identified areas for further assistance, such as expanding recovery equipment coverage, improving refrigerant tracking and reporting systems, strengthening refrigerant collection and storage infrastructure.

123. Few non-LVC countries expressed some reservations regarding the effectiveness of the MLF support for establishing refrigerant reclamation centres and highlighted critical systemic gaps. Colombia emphasized the necessity of strengthening refrigerant reclamation frameworks, particularly concerning HFCs, and together with Egypt highlighted a lack of support for infrastructure for destroying unwanted ODS. Although Mexico praised assistance for destruction of some quantities of unwanted ODS through a demonstration project of plasma and cement-kiln technologies, it underscored insufficient follow-up support to initial investments in recovery centres, identifying irregular material flows and the absence of sustainable economic models as primary risks to achieving commercially viable operations.

124. Bahrain summarized that continued awareness activities, stakeholder engagement, technician training, inspections and integration of RRR requirements into national licensing and monitoring systems, support the continued operation and sustainability of the scheme.

125. Mexico pointed out that initial investments through pilot projects alone are not sufficient to ensure sustainability of operations beyond the project funding. Currently, only seven of the 14 established historical centres have been operational, but face persisting challenges regarding material flows, costs, geographical coverage, business models and follow-up. Therefore, the country suggests that transition from subsidized schemes toward commercially sustainable operations require strengthening post-investment follow-up, elaborating long-term economic models, and introducing certification mechanisms or quality seals for recycled and reclaimed refrigerants.

126. UNIDO stressed that stand-alone RRR centres are rarely sustainable as independent, for-profit business schemes because operational costs exceed the revenues generated solely from selling reclaimed refrigerants. According to experience from the countries, RRR initiatives achieve long-term financial sustainability almost exclusively when integrated as a secondary service line within a pre-existing entity whose core business does not rely on reclamation. This model allows the parent entity to absorb the operational overhead while leveraging its existing customer base and logistics networks to secure a steady pipeline of refrigerant supply.

Gender dimension

127. Mainstreaming of gender into MLF-funded RRR projects must be seen in relation to the Operational Policy on Gender Mainstreaming for MLF-supported projects. Originally approved by the Executive Committee at its 84th meeting in 2019[40] and further strengthened in 2023,[41] the policy mandates integration of gender equality and women's empowerment throughout the entire life cycle of MLF-funded

[39] Colombia, Costa Rica, Grenada, Mexico and India.
[40] Decision 84/92(d).
[41] Decision 92/40.

projects, starting with projects submitted from the 85th Executive Committee meeting onwards. In addition, the IAs have their own policies on gender mainstreaming.

128. Executive Committee decision 90/48 subsequently requested bilateral and IAs to report key gender-mainstreaming results as part of annual progress reports from 2023 onward. It also called for project proposals to include specific gender-related outputs, outcomes and performance indicators. The above facts imply that gender focus had not been included in the design of HPMPs approved before decision 84/92(d) and was introduced to limited extent in several countries in HPMP tranches approved after the above decision. HPMP stage II project proposals submitted after 2020 include a short paragraph on gender policy implementation. HPMP stage-III and KIP are beginning to incorporate more concrete gender mainstreaming and training targets for women.

129. Mexico informed about the development of a gender action plan used for all projects supported by the MLF, including late tranches for stage II and entire stage III of the HPMP and the KIP. Its stage III of HPMP includes quite comprehensive gender programme with several different activities, including insertion of gender sessions to all trainings on ozone issues, updated instructional videos and video clips with female technicians, dissemination campaign on gender issues in enterprises in the RAC sector, facilitation of a collaboration network of women in the sector, focused on developing training days, mentoring schemes, networking and competency-based certification, as well as systematization of lessons learned on gender perspective.

130. Concrete implementation of the gender policy differs from country to country. While majority of countries report only promotion of women's participation in capacity-building and awareness-raising activities, few countries go beyond that. Cambodia reported that female-led servicing workshops and female trainees received equal access to MLF-funded recovery equipment and toolkits, and that women actively participated in decision-making, monitoring, and coordination roles within the NOU and partner environmental agencies. Grenada reported involvement of women in operation and maintenance of the recently established RRR facility.

131. North Macedonia reported that in addition to the basic participation in technical training, the country considered gender mainstreaming in the selection of consultants, implementation and project monitoring teams, and incorporated the gender dimension through female leadership and active representation across key institutional bodies, including the NOU and relevant division of the Ministry for development of broader national environmental policy frameworks.

Challenges, good practices and lessons learned

Recovery

132. Several LVC countries[42] stressed that the main lesson learned is that trained technicians and accessible equipment are essential to increase refrigerant recovery during service and at end-of-life. However, the countries added that providing recovery tools and training is not enough on its own if not complemented with technical support and access to spare parts and equipment maintenance services, strictly enforced rules against gas venting and eventual financial incentives to technicians.

133. Experience from North Macedonia proves that mandatory technician licensing is highly effective when tied directly to equipment ownership and verified annual reporting. This combined approach serves as the strongest driver for recovering controlled substances during both servicing and decommissioning.

[42] Albania, Cambodia, Fiji, and Grenada.

134. From the non-LVC countries, Mexico highlighted the good practice to link refrigerant recovery with equipment replacement and retirement programmes, together with technician training and the provision of suitable equipment and cylinders. However, it added it must be complemented by an accessible and economically viable pathway for delivering recovered refrigerant, particularly in case of large end users.

135. The key lesson for Malaysia is that refrigerant recovery becomes a routine part of servicing and equipment decommissioning, supported by clear procedures, suitable equipment and stronger responsibility among technicians to prevent venting.

136. UNIDO presented a good practice for maximizing collection efficiency through a shift in responsibility of primary actors in refrigerant collection. Evidence from successful initiatives in the Latin America and the Caribbean (LAC) region demonstrates that shifting the logistical burden of collection from fragmented field technicians to large-scale institutional end users stabilizes the feedstock pipeline. Co-location of reclamation centres adjacent to high-priority industrial hubs guaranteed a direct, high-volume, and reliable supply of recovered refrigerants.

Recycling

137. Experience in the LVC countries has shown that on-site refrigerant recovery reduces refrigerant emissions and such circular economy approach reduces demand for virgin refrigerants. However, it requires continuous technician training to prevent cross-contamination between different refrigerant types. It works best for single-refrigerant systems while on-site recycling of refrigerant blends is not a common practice as it requires advanced techniques for refrigerant quality control to ensure the recycled blends meet relevant standards for reuse. However, Cambodia brought attention to the fact that where wall-mounted air-conditioners are installed at high elevations, it is difficult and dangerous for technicians to transport heavy recovery machines for performing on-site refrigerant recovery.

138. Insights from North Macedonia indicate that practical training on mildly flammable A2L refrigerants, such as HFC-32 or other flammable natural alternatives is critical. Such training ensures that field servicing capabilities remain aligned with the ongoing market transition away from legacy HCFCs.

139. Mexico added that a recycling network needs a sufficient and predictable flow of refrigerant to make the recycling services economically accessible to all levels of the refrigerant value chain.

Reclamation

140. All countries in the sample agreed that reclamation requires an additional level of technical capacity, including refrigerant characterization, analysis, segregation, appropriate processing equipment and certification that the resulting product meets applicable quality specifications. Experience from non-LVC countries shows that a reclamation facility can only be sustainable if it receives sufficient volumes, has a market for reclaimed refrigerant and has the capacity to process different substances and blends. Malaysia suggested that RRR activities should gradually move from project-supported activities towards a more viable industry-supported systems.

141. UNIDO highlighted successful cases where RRR centres operate within a university framework. This model successfully blends reclamation activities with formal academic programmes, providing valuable hands-on learning opportunities for both engineering students and Heating, Ventilation and Air Conditioning servicing technicians while fostering collaboration with industry. The high level of public and corporate trust inherently associated with academic institutions, combined with formalized university agreements, has provided a stable, transparent, and credible operational framework for refrigerant reclamation.

142. Overall, Mexico's main lesson is that physical infrastructure alone does not guarantee an effective RRR system. Field refrigerant recovery must be connected with aggregation, analysis, recycling/reclamation and final disposal through clear rules, traceability, economic incentives, participation of large end users and a sustainable business model. Colombia added that refrigerant reclamation and recovery centres are rarely profitable on their own and often fail to cover their operating expenses. Consequently, these facilities are best integrated into educational institutions or companies that offer broader, revenue-generating services.

143. Bahrain mentioned as good example across RRR combining regulatory requirements with technician certification and training, availability of recovery equipment and refillable cylinders, refrigerant segregation, inspections, and the establishment of a national reclamation facility operated with private-sector participation. The experience also demonstrates the value of linking recovery and reclamation with practical economic incentives. The experience further shows that RRR systems should remain practical and responsive to national market conditions and should evolve progressively as refrigerant technologies and servicing-sector needs change. India suggested considering RRR as an environmental service that requires initial policy protection for sustainability.[43]

144. North Macedonia suggests effectiveness gains of a centralized approach for establishment of the necessary economies of scale. This strategy is based on establishing a single facility in Skopje equipped to manage the nation's entire multi-gas mix, including HCFC-22, HFC-134a, R-404A, R-410A and HFC-32. Furthermore, it offers a compelling rationale for linking conventional bulk refrigerant management directly to mechanical foam-extraction infrastructure. This approach addresses the fact that insulation foams contain more than 80 per cent of the national ozone-depletion potential, representing thus a risk category that standard gas-recovery technology is unequipped to extract from retired appliances.

145. On the contrary, Malaysia highlighted its experience with small-scale mini machines as the first step towards refrigerant reclamation. The overall lessons learned for Malaysia and Tunisia is that RRR should be integrated into a national LRM system covering servicing, recovery, collection, transport, testing, recycling, reclamation, reuse and end-of-life management.

III. Conclusions

On adequacy of project planning, design and funding level

146. Assessment of funding level appears to be a matter of personal judgment due to the lack of options for more objective evaluation. Currently, there are no indicative criteria for assessing adequacy of the funding for RRR components that would establish a link between the quantity of refrigerants available for recovery, expected refrigerant recovery volumes, or number of R&R training centres in a country on one side and resources required for meaningful RRR operations on the other side.

147. Adequacy of funding for RRR components should be assessed against the resources required to establish and operate a functional RRR system, including institutional coordination by the NOU, technicians training, refrigerant recovery, recycling, storage and transport, intended reclamation capacity, regulatory/enforcement arrangements, and monitoring of actual amounts of recovered and reclaimed refrigerants.

148. The above conclusion also explains why funding adequacy can be difficult to determine retrospectively, unless an HPMP establishes explicit cost norms, targets or benchmarks such as number of technicians and equipment units per RAC servicing population, quantities of HCFC to be recovered,

[43] Such as tax on virgin refrigerants, mandatory recycling quotas.

required reclamation capacity, or cost per tonne of refrigerant recovered, there is no objective denominator against which the funding allocation for RRR can be judged.

149. The issue of funding adequacy could be explored in more detail in the second phase of the RRR through visits to a sample of countries that received support for RRR activities. In this way, in-country data collection and assessment could transfer the funding adequacy from a largely qualitative judgement into a more evidence-based assessment. For RRR components of HPMPs, the key issue would be to establish the actual national RRR capacity and the necessary geographical coverage.

On monitoring of effective implementation of RRR projects

150. There are systemic vulnerabilities in the ability to accurately monitor, track, and reconcile the quantities of recovered, recycled, and reclaimed refrigerants. Lack of statutory obligations for RAC technicians and service workshops to record and report recovered refrigerant quantities particularly during on-site recharges, creates a significant data vacuum. Consequently, NOUs lack the reliable baseline data necessary for a comprehensive quantitative verification of actual recovery rates and determine effectiveness of the RRR components of the HPMPs.

151. Data sets remain fragmented across disparate entities, including customs authorities, waste management departments, NOUs, and producer responsibility organizations. In the absence of an integrated digital data-sharing platform, information on imports, market placement, waste collection, and RRR activities cannot be cross-checked, preventing the establishment of an accurate overview of refrigerant flows and identify gaps or discrepancies.

152. Establishing full data transparency and accountability will require uniform reporting mandates, integrated digital tracking platforms, and stricter oversight of the informal recycling sector.

On mapping of relevant stakeholders

153. The operational architecture of RRR networks relies on two distinct layers of stakeholders that are not yet fully integrated. The immediate value chain is driven by direct actors, such as servicing workshops, refrigerant collection centres, and reclamation facilities, who handle the physical life cycle of the refrigerants. A peripheral layer of institutional stakeholders, including customs authorities and waste departments of environmental ministries, provides regulatory oversight but often operates in isolation from the direct actors. Despite their role in reprocessing RAC equipment, waste management and recycling companies are often overlooked as stakeholders in RRR.

154. Transitioning from isolated RRR projects to nationwide RRR systems will require that countries broaden the mapping of relevant stakeholders and ensure their roles are legally integrated within the national refrigerant management frameworks.

On customs

155. National customs authorities constitute a critical enforcement link in the national systems for managing trade in refrigerants, particularly in preventing illegal imports and unauthorized cross-border movements. Strengthening coordination between NOUs, customs authorities, environmental regulators and servicing-sector stakeholders could help ensure that customs controls are better aligned with national licensing and quota systems, while also establishing appropriate procedures for potential expansion of cross-border trade in recovered or reclaimed refrigerants.

156. The fact that no significant cross-border trade in recovered or reclaimed refrigerants has been reported may reflect both limited market demand and the relatively early stage of development of formal

reclamation systems. As national reclamation capacity and markets for reclaimed refrigerants develop, customs authorities may increasingly need clear procedures for identification of recovered/reclaimed substances from virgin refrigerants and for verifying their origin, quality, intended use and regulatory status.

On refrigerant containment and life management

157. Feedback from the countries indicates that while the MLF-funded projects successfully established the necessary infrastructure and demonstrated the technical feasibility of refrigerant recovery and reuse, they achieved limited success in creating systematic, nationwide R&R systems. Notably, the responses did not indicate a systematic pattern of potential cost savings derived from refrigerant reuse for service workshops and equipment users. To effectively upscale recovery efforts, more attention is required to decentralization of collection points for improved accessibility, direct connection of technicians and end users with R&R centres, and economic viability of the entire R&R framework.

158. The study established that while the prior experience with HCFC management offers a valuable foundation for RRR activities, transitioning to HFC phase-down introduces some technical, safety, and regulatory complexities. Institutional experience gained from HCFC phase-out can be directly applied to refine national licensing, reporting, and quota systems. Repurposing physical assets for HFC management when technically feasible can represent a cost-effective strategy to curb emissions and decrease reliance on virgin chemical inputs. However, RRR of HFCs requires equipment upgrades, rigorous substance segregation protocols, and sophisticated identification technologies to prevent cross-contamination.

159. Integration of low-GWP alternatives brings heightened safety concerns, specifically regarding mildly flammable (A2L) HFC refrigerants. Addressing these risks demands an overhaul of national technician certification schemes, updated vocational training curricula, and dedicated international funding streams to establish secure long-term storage and destruction options for hazardous end-of-life substances.

160. Also, reclaimed HFC blends may be less commercially competitive than readily available virgin refrigerants, particularly where prices of virgin refrigerant blends are relatively low, thereby constraining the economic viability and wider uptake of RRR schemes for HFC refrigerants.

On technological issues and scalability factors

161. While efforts have been made to provide support through MLF-funded projects, further expansion requires wider geographical coverage of recovery and collection facilities, reliable storage facilities for recovered refrigerants, access to refrigerant identification and testing, and sufficient reclamation capacity. Without these supporting conditions, RRR activities tend to remain project-based and limited in scale rather than developing into sustainable national systems.

On market factors and incentive schemes

162. Incentive schemes could play an important role in leveraging stakeholder participation and sustaining the existing RRR achievements. Rather than focusing on a single stakeholder, incentives should target several actors along the chain. Furthermore, financial incentives should be complemented by certification, tracking and verification mechanisms led by the NOU and relevant regulatory authorities. Such an integrated approach would help create both the supply of recovered refrigerant and sustained demand for reclaimed products, thereby reducing dependence on public funding and improving the long-term commercial viability of RRR systems.

On R&R networks and reclamation centres

163. The overall conclusion on this topic is that proper performance of a reclamation centre is not guaranteed only by the type and capacity of the reclamation equipment, but also by the strength of the upstream R&R network supplying recovered refrigerants. A technically well-equipped reclamation centre may remain underutilized if RAC service workshops lack recovery equipment, collection points are geographically inaccessible, transport arrangements are weak, or there are insufficient incentives to supply recovered refrigerant.

On effective implementation of reclamation schemes

164. For effective implementation, reclamation centres cannot be considered as stand-alone technical facilities. Their effectiveness depends on the establishment of an upstream R&R network capable of consistently collecting, aggregating and delivering recovered refrigerant, and availability of a viable commercial model that gives technicians and service companies an incentive to participate. Performance of a reclamation scheme depends as much on the economics and logistics of collecting recovered refrigerant as on the technical capacity of the centre itself.

165. Economic incentives should also be considered in the above process. When individual technicians are required to absorb the entire financial burden of transporting small quantities of recovered refrigerant, economic disincentives inherently suppress participation rates. This lack of incentive frequently also contributes to reclamation centres suffering from an insufficient, highly irregular, and unpredictable supply of refrigerant feedstock. Absence of mechanism to offset these logistical expenses undermines the operational efficiency and long-term sustainability of the centralized recovery networks.

On geographical distribution

166. Differences in baseline capacities and development needs appear to be driven primarily by country-specific characteristics, including the maturity and size of RAC servicing markets, the availability of established recovery and recycling networks and reclamation infrastructure, the strength of regulatory frameworks and enforcement capacities, and the commercial value of recovered refrigerants. These differences are evident across continents, with no consistent regional patterns emerging that would justify differentiated assistance modalities based on geographical location alone.

167. The desk study findings pinpoint the importance of assessment of the baseline capacity for RRR before design of the assistance from MLF. A variety of indicators can be used in such assessment including number and geographical distribution of trained technicians, recovery equipment per servicing population, quantity of refrigerant recovered, existing reclamation capacity, distance to reclamation facilities, availability of equipment for testing, regulatory enforcement and the price differential between virgin and reclaimed refrigerant.

On effectiveness and sustainability of achievements

168. Sustainability of R&R networks and reclamation centres requires shifting the focus from front-end equipment procurement to long-term monitoring, technical backstopping, and continuous operational support. Physical tools are only effective if backed by a reliable and transparent tracking of material flows, specialized technical assistance for equipment calibration services, and spare parts, and institutionalized market-based mechanisms, such as fee-for-service reclamation models, EPR, compliance revenues, and end-user savings from buying certified recycled refrigerants.

On gender dimension

169. The desk study observed that while HPMP project proposals submitted after the adoption of the gender policy systematically contain provisions for gender mainstreaming, there is less systematic focus on gender issues in implementation and reporting. This shows a tendency for formal compliance with the gender policy (gender mentioned in the project proposal) with gaps in substantive mainstreaming in implementation and reporting of measurable results.

IV. Plan for second phase of the evaluation

IV.1 Proposed focus of second phase

170. As outlined in the TORs, the desk study serves as the first phase of the overall evaluation of RRR activities. Its primary purpose is to map out and highlight the core issues that require a more rigorous, in-depth analysis during the second phase of the evaluation. The insights and results of this desk study provide essential foundation for effective planning and implementing the second phase. Specifically, these findings establish a rationale for defining the scope of the second phase and offer guidance for the selection of specific countries to be targeted for field visits.

171. The country visits should present a comparative sample covering different levels of RRR infrastructure, scale of the RAC servicing markets, and maturity of the RRR value chain. This would allow the evaluation to test whether the funding provided for RRR components was proportionate to the actual system that the countries wanted to establish and operate.

172. The fieldwork should assess the cost-effectiveness of funding provided for the RRR components by examining whether the level and allocation of MLF funding were proportionate to the national RRR opportunities, the capacity required, and the systems that the funding was intended to establish. The assessment should reconstruct, to the extent possible, the relationship between funding provided, RRR infrastructure and capacity established, and its actual utilization and results. The above focus will thus allow to make a more evidence-based assessment, verify actual achievements and thus move beyond a qualitative judgement of funding adequacy.

173. The assessment should also examine the cost-effectiveness of different RRR delivery models. It is suggested to select a purposive sample of countries with contrasting RRR systems, including centralized and decentralized approaches to refrigerant collection, storage and reclamation, different sizes of RAC servicing markets and contrasting levels of existing RRR capacities and geographical characteristics. The fieldwork will thus help determine which RRR funding and delivery model is cost-effective and appropriate for different country contexts, taking into account market size, geographical coverage, available refrigerant quantities, infrastructure requirements and expected utilization.

174. With regard to effectiveness of RRR monitoring, the fieldwork will focus on end-to-end traceability of refrigerants through the recovery, recycling, reclamation and reuse chain and identify gaps arising from fragmented reporting by relevant stakeholders. In this way, the country visits should suggest practical measures for strengthening the traceability, such as reporting requirements, unique identification of refrigerant containers, digital recording systems, data sharing between responsible institutions, and verification mechanisms.

175. This will be examined in countries representing different models of data generation, verification and reconciliation. Information should be collected on existence of legal basis for reporting, entities responsible for generating and verifying the data, the interconnection of various databases, and ability of the NOUs to reconcile the data on recovered and reclaimed refrigerants in possession of various national stakeholders.

176. For refrigerant containment and life-cycle management, the fieldwork will be guided by outcomes of the 2024 workshop on LRM[44] that stressed several requirements for effective LRM financing, including robust data collection on refrigerants, operational costs and financial needs, strong regulatory frameworks defining stakeholders' roles and ensuring transparency and accountability, private sector engagement; as well as circular business models adaptable to market changes and regulatory shifts.

177. In this regard, the fieldwork will test the following issues identified in the desk study:

(i) To what extent refrigerant recovery is measured at technician/workshop level;

(ii) Whether the collected data can be reconciled across the refrigerant life cycle; and

(iii) What actions have been done or could be done to include informal servicing activities.

178. Technological and scalability factors will be examined in countries representing different approaches to expanding RRR systems beyond their initial project-supported limitations. The fieldwork should test both the technical bottlenecks and the incentives needed to make the infrastructure operational at scale. Attention should be given to establish the effect of recovery, collection, transport, storage and reclamation costs on the price differential between virgin and reclaimed refrigerants.

179. The assessment should examine to what extent certification, tracking and verification mechanisms reinforce financial incentives and whether sufficient demand exists for reclaimed refrigerant. Also, the exercise should establish economic benefits to service workshops and end users from refrigerant reuse and availability of incentives for technicians to return recovered refrigerants to the formal RRR system. This would help identify scalable combinations of technological infrastructure, regulatory requirements and economic incentives capable of sustaining RRR systems beyond the period of MLF financing. This is particularly relevant because the 2024 TEAP assessment identifies logistics, business models, economies of scale, refrigerant prices and supporting policies as determinants of functionality and usability of reclamation equipment. The visits should also assess the extent to which the historical HCFC technological infrastructure can be repurposed for HFCs and eventually newer low-GWP refrigerants.

180. Sustainability of R&R networks and reclamation centres will be examined in terms of technical, institutional and financial sustainability. In particular, the fieldwork will assess the different business models used to operate reclamation centres and their implications for effectiveness, financial viability and long-term sustainability. This should include comparison of publicly operated, private-sector, public–private partnership and service-based models, and assessment of sustainability of reclamation financing through fee-for-service reclamation, sales of certified reclaimed refrigerant, EPR or compliance revenues, producer/importer contributions.

181. The assessment should provide insight on appropriateness of different business models under different country contexts and market conditions and the institutional, regulatory and financial factors required for their successful operation. It will collect information on the extent to which various models have moved from a project-financed installation to a functional and institutionally sustainable service and determine which elements are most critical to sustaining the achievements after termination of MLF financing.

[44] Annex II in UNEP/OzL.Pro/ExCom/97/87.

182. On the issue of stakeholders, the visits should map stakeholders legally responsible for each stage of the refrigerant life cycle and connections between institutional and physical responsibilities.

183. Country visits should examine whether promoting women's participation in RRR projects has progressed beyond formal inclusion in project documents and data collection on training participation towards substantive changes in women's access to certification, employment, entrepreneurship and decision-making within the RAC/RRR sector. Data and information should be collected on women's participation as technicians, service-company owners, trainers and operators of collection and reclamation facilities, as well as their access to MLF-funded equipment and economic opportunities generated by refrigerant recovery and reclamation. The fieldwork should also assess to what extent promoting women's participation and empowerment responsive measures have been institutionalized to ensure sustainability.

IV.2 Proposed selection of countries for field missions

184. It is proposed that the second phase of the evaluation framework for refrigerant RRR expand to include field assessments across five distinct regulatory and climatic environments: Bahrain, Colombia, Egypt, Malaysia and North Macedonia. By incorporating countries from West Asia, Latin America and the Caribbean, Africa, Asia and the Pacific, and Europe and Central Asia, the second phase of the evaluation will collect information and data for comparative analysis in terms of RRR system size, operational infrastructure, and data collection frameworks.

185. Bahrain is proposed for the fieldwork because it provides an example of a relatively mature and compact RRR system. Its HPMP-supported interventions combined regulation, technician and company certification, recovery and reclamation infrastructure, training, and increasingly digital licensing and monitoring. The country utilizes a centralized reclamation framework paired with a decentralized collection infrastructure. Therefore, it offers an opportunity to assess whether RRR investments have been effectively institutionalized, whether recovered refrigerants are reaching reclamation facilities, and what regulatory, logistical and economic factors determine the sustainability of the system.

186. Colombia represents a relatively mature and geographically distributed R&R network. It is proposed as a field-visit country because it provides an established national RRR network and multiple collection and reclamation facilities, through which the evaluation can examine the complete chain from refrigerant recovery and collection to reclamation. The country is particularly relevant for assessing decentralized collection, logistics, feedstock supply to reclamation facilities, institutionalization of RRR arrangements and their financial sustainability.

187. Egypt is an example of a complex system with large and diverse RAC servicing market, allowing assessment of RRR systems with a reclamation centre and recovery/reclamation network at significant scale. It provides an emerging example of use of QR codes to test to what extent digital traceability can address the limitations of conventional reporting. Egypt is particularly useful for testing whether substantial investment and relatively high volumes of refrigerants can translate into high utilization, effective collection/reclamation flows and sustainable RRR services beyond the period of MLF project support.

188. Malaysia is a model of a mature, well-supported national RRR system operating within a large, geographically dispersed RAC servicing market. Transitioning from initial HPMP investments in recovery equipment and technician training, the country now utilizes a market-led, hybrid RRR framework. This system leverages major private corporate networks to capture decentralized data. The fieldwork would offer an opportunity to assess whether such hybrid model facilitates adequate equipment utilization and achieves long-term economic viability.

189. North Macedonia is proposed for the fieldwork because it represents a relatively small RAC market with an established, documented recovery and recycling system supported through the HPMP. The country provides a useful case for assessing the minimum viable scale and sustainability of R&R infrastructure, the effectiveness of technician/service-shop reporting, and the extent of reuse of the recovered refrigerants. The visit could also examine the transition from the HCFC-focused R&R system towards broader refrigerant-waste management and reclamation, including the links between servicing-sector refrigerant recovery, collection and end-of-life management.

Annex I

LIST OF COUNTRIES

No.	Country	Project Title	Project Code	Implementing Agencies
1.	Albania	HCFC Phase-Out Plan (Stage I & II & III)	ALB/PHA/75/INV/30 ALB/PHA/81/INV/34 ALB/PHA/81/TAS/35 ALB/PHA/64/INV/22 ALB/PHA/70/INV/25 ALB/PHA/85/INV/41 ALB/PHA/75/TAS/31	UNIDO/UNEP
2.	Bahrain	HCFC Phase-Out Plan (Stage I & II)	BAH/PHA/88/TAS/41 BAH/PHA/88/TAS/40 BAH/PHA/93/TAS/45 BAH/PHA/68/TAS/26	UNEP/UNIDO
3.	Cambodia	HCFC Phase-Out Plan (Stage I)	KAM/PHA/70/INV/28 KAM/PHA/76/INV/33 KAM/PHA/61/INV/24 KAM/PHA/83/INV/36	UNEP/UNDP
4.	Colombia	HCFC Phase-Out Plan (Stage I & II & III)	COL/PHA/84/TAS/108 COL/PHA/88/INV/111 COL/PHA/88/INV/114 COL/PHA/62/INV/77 COL/PHA/72/INV/89 COL/PHA/66/INV/81 COL/PHA/75/INV/96 COL/PHA/75/TAS/94 COL/PHA/81/TAS/104	UNDP
5.	Costa Rica	HCFC Phase-Out Plan (Stage I & II)	COS/PHA/64/INV/46 COS/PHA/70/INV/48 COS/PHA/90/INV/65 COS/PHA/84/INV/61	UNDP
6.	Egypt	HCFC Phase-Out Plan (Stage I & II)	EGY/PHA/84/INV/142 EGY/PHA/68/TAS/116 EGY/PHA/79/INV/136 EGY/PHA/84/INV/141 EGY/PHA/65/TAS/114	UNIDO/UNDP/Germany
7.	Fiji	HCFC Phase-Out Plan (Stage I)	FIJ/PHA/65/INV/23 FIJ/PHA/73/INV/27 FIJ/PHA/77/INV/31 FIJ/PHA/86/INV/38	UNDP/UNEP
8.	Ghana	HCFC Phase-Out Plan (Stage I & II)	GHA/PHA/81/TAS/45 GHA/PHA/67/INV/34 GHA/PHA/61/INV/30 GHA/PHA/76/INV/42 GHA/PHA/72/INV/39 GHA/PHA/84/INV/48 GHA/PHA/87/INV/50	UNDP/Italy

No.	Country	Project Title	Project Code	Implementing Agencies
9.	Grenada	HCFC Phase-Out Plan (Stage I & II)	GRN/PHA/62/TAS/18 GRN/PHA/90/INV/30	UNEP/UNIDO
10.	India	HCFC Phase-Out Plan (Stage I)	IND/PHA/66/INV/442	UNDP/UNEP/Germany
11.	Malaysia	HCFC Phase-Out Plan (Stage I)	MAL/PHA/77/INV/184 MAL/PHA/65/TAS/168	UNDP
12.	Mexico	HCFC Phase-Out Plan (Stage I & II)	MEX/PHA/77/INV/185 MEX/PHA/64/INV/160 MEX/PHA/64/TAS/158 MEX/PHA/77/INV/183 MEX/PHA/81/INV/189 MEX/PHA/73/INV/171	UNIDO/UNEP/UNDP/Germany/Italy/Spain
13.	North Macedonia	HCFC Phase-Out Plan (Stage I & II)	MDN/PHA/64/INV/31 MDN/PHA/67/INV/33 MDN/PHA/70/INV/34 MDN/PHA/60/INV/29 MDN/PHA/72/INV/35 MDN/PHA/93/INV/50	UNIDO
14.	Serbia	HCFC Phase-Out Plan (Stage I & II)	YUG/PHA/62/INV/38 YUG/PHA/91/INV/60 YUG/PHA/71/INV/41 YUG/PHA/85/INV/54	UNIDO/UNEP
15.	Tunisia	HCFC Phase-Out Plan (Stage I & II)	TUN/PHA/72/INV/58 TUN/PHA/92/INV/82 TUN/PHA/84/INV/73 TUN/PHA/92/TAS/81	UNIDO/UNEP

Annex II

TERMS OF REFERENCE FOR THE SECOND PHASE OF THE EVALUATION OF RECOVERY, RECYCLING AND RECLAMATION PROJECTS

Introduction

1. At its 93rd meeting, the Executive Committee approved the monitoring and evaluation work programme for 2024 and 2025 (decision 93/10), which included an evaluation of projects involving recovery, recycling and reclamation (RRR). At its 95th meeting, the Executive Committee approved the terms of reference (TORs) for the desk study (UNEP/OzL.Pro/ExCom/95/12), which provided for the evaluation to be carried out in two phases, with updated TORs for the second phase to be presented on the basis of the findings of the desk study.

2. The desk study covering 15 selected countries was undertaken as the first phase of the evaluation of recovery, recycling and reclamation (RRR) projects funded by the Multilateral Fund. The desk study served as a mind-mapping of the key issues such as project design and funding, implementation arrangements, R&R and reclamation infrastructure, monitoring and reporting systems, technological and logistical arrangements, sustainability, and promoting women's participation. It identified common achievements, implementation challenges, systemic gaps and emerging good practices across the countries reviewed.

Objective and scope

3. The objective of the second phase is to complement and validate the findings of the desk study through country visits. The second phase of the evaluation will involve field visits to a purposively selected group of countries. The country visits will assess, validate, and explain in more detail the desk study findings through direct consultation with national stakeholders and observation of a variety of RRR facilities and operations. The visits will provide an opportunity to examine how project-supported RRR systems function in practice and assess the extent to which the infrastructure, institutional arrangements and capacities established through Multilateral Fund support have translated into enhancing national RRR capacities and contributed to compliance.

4. The country visits will focus on issues where the desk study identified limitations in available information or where country-level evidence is required to draw more robust conclusions. Countries for the second phase have therefore been selected as case studies to provide examples and complementary evidence. The countries will collectively represent sufficient diversity to test how the findings of the desk study apply across different national contexts and to identify factors that explain differences in the performance and sustainability of various types of RRR systems.

5. The fieldwork will focus on selected issues requiring further investigation, including the adequacy of project planning, design and funding; the effectiveness of monitoring and tracking of recovered, recycled and reclaimed refrigerants; the functioning and geographical coverage of refrigerant recovery and collection systems; technological and logistical options for scaling up RRR activities; the effectiveness and economic viability of different reclamation schemes; market factors and incentive schemes; the role of customs and of legislative and regulatory frameworks; the management of unwanted and cross-contaminated refrigerants at the end of the life cycle; institutional arrangements and the sustainability of project-supported infrastructures.

6. The country visits will also seek to identify good practices and innovative approaches that may have potential for replication, including decentralized collection, the applicability of digital tools for refrigerant tracking and traceability, options for aggregation and transport of recovered refrigerants, the functionality of various reclamation business models, the availability of financial incentives, and the impact of market-based mechanisms on the sustainability of RRR operations. At the same time, the visits will document implementation challenges and unintended constraints, such as underutilization of equipment, insufficient feedstock for reclamation, high collection and transport costs, fragmented data systems, inadequate financial incentives for refrigerant recovery and reuse, and difficulties in adapting the existing infrastructures and capacities to the recovery and reclamation of new refrigerants.

7. Where feasible, the fieldwork will identify and portray the relationship between the RRR project component inputs and actually achieved outputs and outcomes, for example: between the equipment and training provided; the number and geographical coverage of participating technicians and collection points; quantities of refrigerant recovered and delivered for recycling or reclamation; the utilization of reclamation capacity; and the financial and institutional arrangements supporting continued operation.

8. On this basis, and to the extent that the available records permit, the fieldwork will assess in a quantitative manner the extent to which recovered, recycled and reclaimed refrigerants have been returned to use in place of virgin refrigerants, thus contributing to the reduction in consumption of controlled substances and the avoidance of emissions.

Methodology

9. A sample of countries was selected to ensure balanced geographical representation and implementing agency presence. In addition, the proposed sample ensures a diverse range of information related to project results, level of RRR infrastructure, size of the RAC servicing market, and maturity of the RRR operation. The countries selected are:

(a) Bahrain: a compact, relatively mature, and integrated R&R system pairing a centralized reclamation framework with a decentralized collection infrastructure, allowing an examination of how recovered refrigerants are reaching reclamation facilities, and what regulatory, logistical and economic factors determine sustainability;

(b) Colombia: a mature and geographically distributed R&R network with multiple reclamation facilities, through which the evaluation can examine the complete chain from refrigerant recovery and collection to reclamation;

(c) Egypt: a large and diverse RAC servicing market, allowing assessment of RRR systems with a reclamation centre and recovery/reclamation network at significant scale;

(d) Malaysia: a large, geographically dispersed RAC servicing market with a market-led, hybrid RRR framework involving private corporate networks offering an opportunity to assess whether such a model facilitates adequate equipment utilization and achieves long-term economic viability; and

(e) North Macedonia: a relatively small RAC market with an established recovery and recycling system which provides a useful case for assessing the minimum viable scale and sustainability of R&R infrastructure.

10. The evaluation will be undertaken by an independent consultant (lead expert) under the supervision of the SEO and in line with applicable evaluation norms and standards. In addition, a team of five national experts will be recruited to conduct the country visits, collect information related to monitoring of quantities of recovered, recycled and reclaimed refrigerants, modalities of operation of refrigerant collection networks, and reclamation facilities. The experts will engage in discussions with key actors in the refrigerant value chain, including refrigerant importers/distributors, RAC service workshops, technical training institutions, operators of refrigerant reclamation centres, and specialized waste management companies.

11. Prior to the country visits, the experts will prepare, under the supervision of the lead expert and the guidance of the SEO, a mission plan setting out the methodology and assumptions, the data collection tools (e.g., questionnaires, interview guides and checklists for the observation of facilities) and the schedule of visits.

12. The analysis will combine quantitative and qualitative methods. The information and findings of the desk study will be triangulated against records maintained at the country level (e.g., records of service workshops, collection points and reclamation centres, and licensing and customs data) and through direct observation of equipment and facilities. To the extent available, quantitative data will be collected on the quantities of refrigerants recovered, recycled, reclaimed and returned to use; the utilization of equipment and reclamation capacity; the costs of collection, transport, testing and reclamation; and the prices of reclaimed and virgin refrigerants. In addition, supportive information will be collected from external sources (e.g. Basel Convention dashboard on the transboundary movement of waste refrigerants and equipment containing ODS). All supporting evidence collected during the country visits (e.g., questionnaires, interview guides, minutes of meetings and data collected) will form part of the outputs submitted to the evaluation unit.

Expected result

13. A final comprehensive report will be prepared providing an assessment of the operational models of RRR systems in different country settings and conditions. More specifically, the following issues will be examined in detail:

- Effectiveness of RRR interventions;
- Better understanding of the quantitative contribution of RRR activities to the reduction in consumption of controlled substances, to the extent that data permit;
- Adequacy of project planning, design and funding;
- Stakeholder mapping, roles and participation;
- Role of customs and of legislative and regulatory frameworks in supporting RRR;
- Effectiveness of monitoring of RRR operations and refrigerants traceability;
- Functioning and scalability of refrigerant recovery and collection systems;
- Where available, national plans for the collection, transport and disposal under decision 91/66 including consideration of recycling, reclamation and cost-effective destruction;
- Economic viability of different reclamation business models;
- Market factors and incentive schemes;
- Sustainability of established RRR frameworks;
- Applicability of the RRR systems for use in the HFC phase-down and refrigerant blends;
- Existing practices in the management of unwanted and cross-contaminated refrigerants at the end of the life cycle.

14. The second phase of the evaluation will provide country-level evidence that complements, and where appropriate, validates the findings of the desk study. The country visits will generate sufficiently detailed and reliable information to assess how RRR interventions have functioned in practice, identify the factors influencing their effectiveness and sustainability, and draw lessons applicable to future Multilateral Fund-supported interventions.

15. The country visits will also identify good practices that have contributed to the effective implementation, scalability or sustainability of RRR systems and document them together with the conditions that enabled them to work.

16. To the extent possible, the fieldwork will examine actions promoting women's participation in RRR implementation, in particular whether and how considerations have been integrated into the implementation of RRR components beyond formal references in the project documents and progress reports.

17. The findings of the country visits and of the desk study will be consolidated in a final evaluation report including specific, measurable, attainable, relevant and time-bound (SMART) recommendations to facilitate the tracking of their implementation. The country reports will be presented as annexes to the final evaluation report.

Budget and schedule

18. A team of consultants will be recruited to conduct field visits and to collect information from existing RRR facilities. Each visit will yield a country report, and a comprehensive synthesis report will summarize the findings and formulate lessons learned, which will be submitted to the 101st meeting.

19. The cost of the second phase is US $30,000 as per the approved budget, as detailed in table 1 below.

Table 1: Budget for the second phase of RRR evaluation (in US $)

Budget item	Consultant	Unit cost	Number of units	Total
Professional fee	Lead expert	500	25	12,500
Professional fee	Country experts	350	50*	17,500
TOTAL				**30,000**

*10 days for five experts in five countries

EVALUATION QUESTIONS

I. Design, planning and results of recovery, recycling and reclamation interventions

(a) *Results and contribution to compliance:* To what extent have the equipment, training and facilities provided translated into operational results, such as the utilization of equipment and reclamation capacity and the quantities of refrigerant recovered, recycled, reclaimed and returned to use? To the extent that data permit, what has been their contribution to reducing the consumption of controlled substances and to compliance with the Montreal Protocol?

(b) *Planning, design and funding:* To what extent were the design, scale and funding of RRR interventions commensurate with national needs (refrigerant bank, RAC servicing sector, geographical coverage and expected recovery and reclamation requirements)? Which indicators could be used to assess funding adequacy and a country's baseline RRR capacity when designing future assistance (e.g., technician and equipment coverage, quantities available for recovery, testing and reclamation capacity, regulatory enforcement and price differentials)?

II. Institutional framework and monitoring

(c) *Stakeholders, regulatory measures and customs:* Which stakeholders are involved across the RRR value chain, and what are their roles? How can coordination among them, and the role of the NOUs and of the bilateral and implementing agencies, be strengthened? To what extent have regulatory measures (e.g., venting prohibitions, technician licensing and certification, mandatory reporting) been enforced, and how have they influenced RRR practices?

(d) *Monitoring and traceability:* To what extent can national systems monitor, verify and reconcile the quantities of refrigerant recovered, recycled and reclaimed along the RRR chain, including informal servicing and dismantling activities? What institutional, regulatory or technological changes are needed to fill the existing data gaps?

III. Functioning and viability of recovery, recycling and reclamation

(e) *Recovery and collection networks:* To what extent are networks accessible, geographically adequate and scalable? Which technological and logistical factors (e.g., availability and maintenance of equipment, refillable cylinders, transport and storage) constrain their coverage, participation and expansion?

(f) *Reclamation and market factors:* Which business models and arrangements for collection, financing, testing and certification have ensured a regular feedstock, market confidence and the economic viability of reclamation facilities? How do centralized and decentralized approaches compare in cost-effectiveness? Which regulatory and economic instruments have encouraged the return of recovered refrigerant to the formal system? How can this experience, including links with regional reclamation facilities, support reclamation in LVC countries?

IV. Sustainability and life-cycle management

(g) *Sustainability:* Which technical, institutional and financial factors, challenges and risks determine whether RRR operations can continue beyond Multilateral Fund financing? What are the support instruments utilized to ensure sustainability?

(h) *Transition to HFCs and end-of-life management:* To what extent have HCFC RRR infrastructure, equipment and capacity been repurposed for HFCs, refrigerant blends and lower-GWP refrigerants, and what additional technological, safety, training and regulatory investments are required? How are ODS banks, unwanted and cross-contaminated refrigerants managed (storage, export or destruction)? What measures along the life cycle (e.g., equipment replacement programmes, extended producer responsibility) could reduce the burden at the end of the cycle?

V. Lessons learned and future programming

(i) *Lessons learned and future programming:* What were the main implementation constraints and how were they addressed? Which good practices, lessons learned and changes to the design, implementation and monitoring of project interventions would improve the effectiveness, scalability and sustainability of future RRR interventions?

(j) *Promoting women's participation and empowerment:* To what extent have implemented activities contributed to the promotion of women's participation and resulted in substantive changes in women's participation in RRR training, certification, employment, entrepreneurship and decision-making?

Annex III

SOURCES OF INFORMATION AND REFERENCES

Country	Multilateral Fund Documents
Albania	UNEP/OzL.Pro/ExCom/64/23; UNEP/OzL.Pro/ExCom/70/23; UNEP/OzL.Pro/ExCom/75/35; UNEP/OzL.Pro/ExCom/81/21; UNEP/OzL.Pro/ExCom/85/19; UNEP/OzL.Pro/ExCom/91/36; UNEP/OzL.Pro/ExCom/98/17
	Project completion report HPMP Stage I (UNIDO/UNEP, November 2022)
Bahrain	UNEP/OzL.Pro/ExCom/68/22; UNEP/OzL.Pro/ExCom/75/37; UNEP/OzL.Pro/ExCom/88/38; UNEP/OzL.Pro/ExCom/93/41; UNEP/OzL.Pro/ExCom/95/41; UNEP/OzL.Pro/ExCom/98/22
	Project completion report HPMP Stage I (UNEP/ UNIDO, April 2022)
Cambodia	UNEP/OzL.Pro/ExCom/61/30; UNEP/OzL.Pro/ExCom/70/27; UNEP/OzL.Pro/ExCom/76/21; UNEP/OzL.Pro/ExCom/83/21; UNEP/OzL.Pro/ExCom/90/22
Colombia	UNEP/OzL.Pro/ExCom/62/27; UNEP/OzL.Pro/ExCom/66/33; UNEP/OzL.Pro/ExCom/72/25; UNEP/OzL.Pro/ExCom/75/42; UNEP/OzL.Pro/ExCom/81/30; UNEP/OzL.Pro/ExCom/84/43 UNEP/OzL.Pro/ExCom/88/44; UNEP/OzL.Pro/ExCom/93/48
	Project completion report HPMP Stage I (UNDP/UNEP, July 2018)
	Project completion report HPMP Stage II (UNDP/Germany/UNEP, October 2023)
Costa Rica	UNEP/OzL.Pro/ExCom/64/31; UNEP/OzL.Pro/ExCom/70/31; UNEP/OzL.Pro/ExCom/74/26; UNEP/OzL.Pro/ExCom/80/39; UNEP/OzL.Pro/ExCom/83/24; UNEP/OzL.Pro/ExCom/84/45; UNEP/OzL.Pro/ExCom/90/24; UNEP/OzL.Pro/ExCom/93/36; UNEP/OzL.Pro/ExCom/95/50
	Project completion report HPMP Stage I (UNDP, May 2022)
Egypt	UNEP/OzL.Pro/ExCom/65/32; UNEP/OzL.Pro/ExCom/68/27; UNEP/OzL.Pro/ExCom/79/32; UNEP/OzL.Pro/ExCom/84/49; UNEP/OzL.Pro/ExCom/88/47; UNEP/OzL.Pro/ExCom/94/33; UNEP/OzL.Pro/ExCom/96/32; UNEP/OzL.Pro/ExCom/97/49
	Project completion report HPMP Stage I (UNIDO/UNDP, December 2021)
Fiji	UNEP/OzL.Pro/ExCom/65/35; UNEP/OzL.Pro/ExCom/73/38; UNEP/OzL.Pro/ExCom/77/45; UNEP/OzL.Pro/ExCom/86/50; UNEP/OzL.Pro/ExCom/88/49
	Project completion report HPMP Stage I (UNDP/UNEP, April 2023)
Ghana	UNEP/OzL.Pro/ExCom/61/39; UNEP/OzL.Pro/ExCom/67/25; UNEP/OzL.Pro/ExCom/72/27; UNEP/OzL.Pro/ExCom/76/32; UNEP/OzL.Pro/ExCom/81/35; UNEP/OzL.Pro/ExCom/87/28; UNEP/OzL.Pro/ExCom/95/54
	Project completion report HPMP Stage I (UNDP, December 2024)
Grenada	UNEP/OzL.Pro/ExCom/62/33; UNEP/OzL.Pro/ExCom/77/47; UNEP/OzL.Pro/ExCom/90/27
	Project completion report HPMP Stage I (UNEP/UNIDO, April-June 2024)
India	UNEP/OzL.Pro/ExCom/66/38; UNEP/OzL.Pro/ExCom/71/35; UNEP/OzL.Pro/ExCom/75/48; UNEP/OzL.Pro/ExCom/77/49; UNEP/OzL.Pro/ExCom/82/52; UNEP/OzL.Pro/ExCom/86/54 UNEP/OzL.Pro/ExCom/91/42; UNEP/OzL.Pro/ExCom/95/58
	Project completion report HPMP Stage I (UNDP, Germany, UNEP, September 2018)
Malaysia	UNEP/OzL.Pro/ExCom/65/41; UNEP/OzL.Pro/ExCom/71/38; UNEP/OzL.Pro/ExCom/75/54; UNEP/OzL.Pro/ExCom/77/54; UNEP/OzL.Pro/ExCom/84/54; UNEP/OzL.Pro/ExCom/88/53; UNEP/OzL.Pro/ExCom/94/43
	Project completion report HPMP Stage I (UNDP, October 2018)
Mexico	UNEP/OzL.Pro/ExCom/64/39; UNEP/OzL.Pro/ExCom/68/33; UNEP/OzL.Pro/ExCom/71/40; UNEP/OzL.Pro/ExCom/73/43; UNEP/OzL.Pro/ExCom/75/56; UNEP/OzL.Pro/ExCom/77/55; UNEP/OzL.Pro/ExCom/81/45; UNEP/OzL.Pro/ExCom/90/32; UNEP/OzL.Pro/ExCom/92/34; UNEP/OzL.Pro/ExCom/95/66
	Project completion report HPMP Stage I (UNIDO/UNDP, June 2020)
	Project completion report HPMP Stage II (UNIDO/Germany/Italy/Spain/UNEP, March 2025)
North Macedonia	UNEP/OzL.Pro/ExCom/60/40; UNEP/OzL.Pro/ExCom/64/45; UNEP/OzL.Pro/ExCom/67/31; UNEP/OzL.Pro/ExCom/70/47; UNEP/OzL.Pro/ExCom/72/35; UNEP/OzL.Pro/ExCom/75/69; UNEP/OzL.Pro/ExCom/79/41; UNEP/OzL.Pro/ExCom/82/60; UNEP/OzL.Pro/ExCom/84/56; UNEP/OzL.Pro/ExCom/88/57; UNEP/OzL.Pro/ExCom/93/78
	Project completion report HPMP Stage I (UNIDO, April 2024)
Serbia	UNEP/OzL.Pro/ExCom/62/47; UNEP/OzL.Pro/ExCom/71/46; UNEP/OzL.Pro/ExCom/79/40; UNEP/OzL.Pro/ExCom/84/59; UNEP/OzL.Pro/ExCom/85/46; UNEP/OzL.Pro/ExCom/91/50

Country	Multilateral Fund Documents
	UNEP/OzL.Pro/ExCom/97/74
	Project completion report HPMP Stage I (UNIDO/UNEP, October-November 2022)
Tunisia	UNEP/OzL.Pro/ExCom/72/36; UNEP/OzL.Pro/ExCom/76/51; UNEP/OzL.Pro/ExCom/84/60; UNEP/OzL.Pro/ExCom/92/40; UNEP/OzL.Pro/ExCom/97/80; UNEP/OzL.Pro/ExCom/98/51
	Project completion report HPMP Stage I (UNIDO/France/UNEP, April 2022)
Previous related evaluation studies and additional resources	
UNEP/OzL.Pro/ExCom/31/18: Desk Study on Recovery and Recycling Projects	
UNEP/OzL.Pro/ExCom/52/8: Extended Desk Study on Incentive Programmes for Retrofits	
UNEP/OzL.Pro/ExCom/75/10: Desk Study on the Evaluation of the Pilot Demonstration Projects on ODS Disposal and Destruction	
UNEP/OzL.Pro/ExCom/80/10: Desk Study for the Evaluation of the HCFC Phase-Out in the Refrigeration Servicing Sector	
UNEP/OzL.Pro/ExCom/97/87: Report pursuant to Decision 93/104 on Life-Cycle Refrigerant Management with a View to Considering the Establishment of a Funding Window in Line with Decision XXXV/11 of the Thirty-Fifth Meeting of the Parties	
UNEP/OzL.Pro/ExCom/97/87 Annex II: Key takeaways from the workshop on life-cycle refrigerant management convened pursuant to decision XXXV/11	
TEAP: Decision XXXV/11 Task force report on life cycle refrigerant management (May 2024)	
MLF/IACM.2024/2/2	
Life-cycle Refrigerant Management at the 36th Meeting of the Parties to the Montreal Protocol, Carbon Containment Lab, November 2024	

Annex IV

LIST OF STAKEHOLDERS

National Ozone Officers (through a survey questionnaire)

Country	Organization/Institution
Albania	National Ozone Unit Coordinator
Bahrain	Head of Hazardous Chemical Management Unit & National Ozone Officer
Cambodia	Under Secretary of State
Colombia	Unidad Técnica de Ozono de Colombia
Costa Rica	Dirección de Gestión de Calidad Ambiental - Oficina Técnica del Ozono
Egypt	Director, Ozone Unit
Fiji	Acting Principal Environment Officer, Ozone Depleting Substances Unit
Ghana	National Ozone Officer
Grenada	Permanent Secretary
India	Additional Director, Ozone Cell
Malaysia	Senior Principal Assistant Director
Mexico	Oficial de Ozono
North Macedonia	Manager of the Ozone Unit
Serbia	Head of Ozone Layer Protection Group
Tunisia	Coordinateur du Bureau Ozone

Implementing Agencies (through e-mail communication)

Agency	Contact Person
UNDP	Global Programme Specialist, UNDP Chemicals & Waste Hub, New York
	Senior Technical Advisor and Regional Coordinator for Cooling, Circularity and Pollution Prevention, Bangkok
	Regional Coordinator, Panamá City
	Regional Technical Specialist, Panamá City
	National Programme Manager, New Delhi
UNIDO	Chief, Montreal Protocol Unit, Vienna
	Industrial Development Officer, Vienna
	Industrial Development Officer, Vienna
GIZ	Advisor Proklima, Eschborn