UN environment programme

National Action Plans for Lifecycle Refrigerant Management

A Practical Guide for Developing Countries

CLIMATE & CLEAN AIR COALITION
TO REDUCE SHORT-LIVED CLIMATE POLLUTANTS
a UNEP convened initiative

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Foreword

From production and use to recovery and end-of-life treatment, countries around the world are stepping up efforts to manage refrigerants more responsibly across their full lifecycle – as a pillar of climate action, ozone protection, and sustainable cooling.

The transition to lifecycle refrigerant management reflects both a responsibility and an opportunity: responsibility to prevent emissions from the existing stock, the large volumes of ozone-depleting substances and hydrofluorocarbons already contained in existing equipment and products, and an opportunity to create decent jobs, advance circular economy and strengthen national systems.

The need could not be more urgent: Demand for cooling is rising sharply in response to urbanization, economic development, and intensifying heat. At the same time, millions of air conditioners, refrigerators, and other cooling systems are approaching the end of their useful life. Many contain high-global-warming-potential refrigerants that, if not properly recovered and treated, will be released into the atmosphere. Without effective recovery, reclamation, and destruction systems, these emissions risk undermining the Montreal Protocol and its Kigali Amendment and contribute significantly to near-term warming.

Yet, experience from countries across regions shows that we can change this vicious circle. With clear policies, reliable data, trained technicians, and practical incentives, refrigerants at the end of equipment life can be safely recovered, reused to certified standards, or destroyed in an environmentally sound manner. What once contributed to unmanaged emissions can become a well-managed resource stream that delivers compliance, reduces emissions, and strengthens domestic capacity.

National Action Plans for Lifecycle Refrigerant Management: A Practical Guide for Developing Countries is designed to help governments move from inventories to implementation. Building on work supported by the Multilateral Fund and informed by assessments of the Technology and Economic Assessment Panel, it shows how to translate national data into operational, costed National Action Plans. It connects recovery, recycling, reclamation, and destruction systems with existing frameworks such as Hydrochlorofluorocarbon Phase-out Management Plans, Kigali Implementation Plans, National Cooling Action Plans, and Nationally Determined Contributions. In doing so, it supports countries in embedding lifecycle refrigerant management within broader waste, energy, and climate strategies.

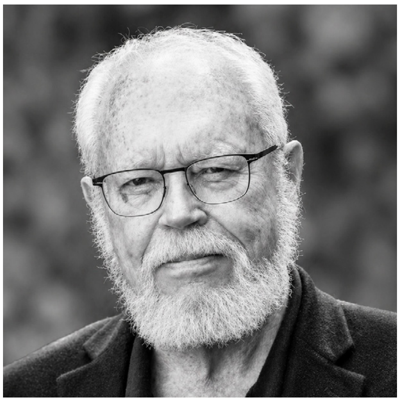
Effective lifecycle refrigerant management is not a one-off — it is a system anchored in regulatory clarity, reliable data, technical expertise, and sustained financing. When these elements come together, countries can prevent avoidable emissions, strengthen international commitments, and achieve measurable climate benefits at relatively low cost.

This Guide is a practical roadmap and a call to action. With clear plans, strong institutions, and sustained cooperation, responsible refrigerant management can protect the ozone layer, speed-up climate action, and deliver lasting benefits for people and planet.

Martina Otto
Head of Secretariat
Climate and Clean Air Coalition (CCAC), United Nations Environment Programme (UNEP)

Message

This publication of the United Nations Environment Programme is a road map for Article 5 developing country Parties seeking finance for lifecycle refrigerant management (LRM) from the Multilateral Fund for the Implementation of the Montreal Protocol (MLF). It demonstrates the necessary steps for refrigerant recovery, recycling, remanufacturing, and leakage reduction.



The Institute for Governance & Sustainable Development is grateful for this collaboration with the Climate & Clean Air Coalition and its Cooling Hub. The Practical Guide for Developing National Action Plans for Lifecycle Refrigerant Management is a critical step towards reducing emissions of ozone-depleting and greenhouse gas refrigerants.

Special thanks to author Cecilia Mercado and the many contributors, including Denise San Valentin and Ana Petričić-Tinto, as well as IGSD's Stephen O. Andersen, Tad Ferris, and Sean Dennis, who together bring a wealth of experience and wisdom to the fast action kick-started by this publication.

The cooling sector has a critical role to play in keeping us safe and productive at home, at school, and at work. This publication presents win-win solutions for ensuring the most efficient lifecycle management of refrigerants. It will permit refrigerant manufacturers to pledge responsible use and towards a circular economy. Equipment manufacturers will be led to make affordable cooling with higher reliability, fewer service requirements, and proper refrigerant charges. Governments will be able to demonstrate to citizens the benefits of funds spent on healthy communities. Finally, citizens will learn exactly how to be a part of the solution, with product choice, service, and proper recycling and reuse at the end of the product lifecycle, resulting in a more just and sustainable Earth.

Durwood Zaelke
Founder and President, IGSD

Message from the CCAC Cooling Hub Co-Leads

In 2026, the world will celebrate the 10th anniversary of the Kigali Amendment, and in 2027, the 40th anniversary of the Montreal Protocol on Substances that Deplete the Ozone Layer, which has been recognised for decades as one of the most successful multilateral environmental agreements in history, phasing out almost 99% of controlled substances that deplete the ozone layer.

What we have been realizing in the last few years is that there is much more we can do in addition to compliance to Montreal Protocol phase-out obligations for the production and international trade of these ozone-depleting and climate-harming chemicals – including lifecycle refrigerant management or LRM. According to the Montreal Protocol Technology and Economic Assessment Panel (TEAP) Task Force Report on Lifecycle Refrigerant Management (May 2024), implementing LRM practices can cut an estimated additional 39 Gt CO_2e of HFC and HCFC emissions between 2025 and 2050 and up to 67 Gt CO_2e emissions by 2100. The 67 Gt benefit is roughly equivalent to 26.7 years of the European Union's (EU) total carbon dioxide (CO_2) emissions!

The Montreal Protocol has, for decades, addressed many aspects of LRM: specifically, Multilateral Fund for the Implementation of the Montreal Protocol (MLF) has supported capacity building in Article 5 countries to prevent leaks, promote recovery and recycling, and ensure safe handling of refrigerants. Refrigeration and air-conditioning (RAC) training schools and servicing technicians worldwide have benefited from MLF with training and granted refrigerant identifiers and recovery/recycling machines. The TEAP has often highlighted the value of recovery, recycling and reclamation, while many governments have put in place policies like venting bans and mandatory recovery. The MLF has even funded pilot ODS destruction projects.
But now is the time to do more!

Climate and Clean Air Coalition (CCAC), through the leadership of Japan as a state partner, began promoting LRM in 2019 with the launch of the Initiative on Fluorocarbon Lifecycle Management (IFL) and advocacy on the issue with the IFL Secretariat through awareness raising activities since then. In December 2022, the MLF Executive Committee, through Decision 91/66, opened a funding window for Article 5 countries to prepare national inventories of banks of controlled substances and management plans. Currently, 127 Article 5 countries are receiving this support and are developing their action plans on LRM.

CCAC Cooling Hub sees this as an amazing opportunity to work together to make the most out of these inventories and national action plans, looking at the future of MLF support as well as exploring other opportunities for integrating these plans into national climate strategies and NDCs, which will maximise benefits for the countries on ozone layer protection, climate change mitigation, energy efficiency, food security, green job creation, and circular economy.

We hope that this Practical Guide will be helpful to policymakers, implementing agencies as well as other stakeholders such as industry and service providers as we navigate this new world of LRM.

We must move from commitment to action now!

Co-Leads of the CCAC Cooling Hub,

Ms. Miruza Mohamed
Maldives

Mr. Makoto Kato
Japan

Executive Summary

National Action Plans for Lifecycle Refrigerant Management: A Practical Guide for Developing Countries provides a structured approach to help governments translate national inventories of ozone-depleting substances (ODS) and hydrofluorocarbon (HFC) banks into practical and costed National Action Plans (NAPs). The Guide supports Article 5 Parties in preventing emissions from existing refrigerant banks while aligning national actions with obligations under the Montreal Protocol and its Kigali Amendment. By promoting the recovery, recycling, reclamation and environmentally sound disposal of refrigerants already in circulation, the Guide highlights the significant ozone and climate benefits that can be achieved through effective lifecycle management.

The Guide is intended as a practical resource for national ozone units (NOUs), environmental ministries and implementing agencies responsible for managing refrigerants throughout their lifecycle. It explains how countries can move from understanding which refrigerants exist and where they are located, to identifying the actions required to recover, reclaim, reuse and dispose of them safely. It consolidates experience from Multilateral Fund (MLF) projects, Technology and Economic Assessment Panel (TEAP) reports, and national examples to present feasible policy, technical, and institutional models. It also shows how lifecycle refrigerant management can be integrated within existing national policy frameworks, including HCFC Phase-out Management Plans (HPMPs), Kigali HFC Implementation Plans (KIPs), and National Cooling Action Plans (NCAPs), while strengthening coordination, data systems and transparent reporting.

The Guide is structured to help countries move from inventories of refrigerant banks toward practical national action plans for LRM. It begins by setting out the policy context and environmental importance of LRM and explaining why refrigerant banks represent a significant source of potential emissions if not properly managed. The Guide then presents the LRM framework and explains how recovery, recycling, reclamation and destruction fit within existing Montreal Protocol implementation plans and national cooling strategies. Selected case studies illustrate practical approaches and highlight lessons learned from countries that have implemented key elements of LRM systems. Subsequent sections describe methodologies for developing national inventories of ODS and HFC banks and provide a step-by-step approach for preparing LRM-aligned National Action Plans. Technical options for recovery, recycling, reclamation and destruction are reviewed, and a model template is provided to help countries structure and prepare their national plans.

This Guide also presents the key components of LRM. Effective LRM depends on a set of interrelated policy, technical and institutional elements that together enable countries to prevent emissions from refrigerant banks. A sound policy and legal framework provides the foundation by mandating refrigerant recovery, prohibiting venting, establishing quality standards for reclaimed refrigerants and integrating refrigerant waste within hazardous waste and extended producer responsibility regimes. Reliable inventories are equally important, combining equipment-based and consumption-based data to quantify refrigerant banks and provide the evidence base for costed national action plans. Recovery during servicing and decommissioning forms the basis for recycling and reclamation, which extend the usable life of refrigerants and reduce demand for virgin substances. Where reuse is no longer possible, environmentally sound destruction provides the final safeguard against emissions. Effective LRM systems also depend on strong institutional coordination, sustained financing and transparent monitoring, reporting and verification systems that allow countries to track recovered, reclaimed and destroyed refrigerants and demonstrate measurable climate benefits.

To support practical implementation, a model National Action Plan (NAP) template is provided that countries can adapt to their own circumstances. The template organises the key elements of LRM, including policy frameworks, institutional roles, infrastructure needs, financing arrangements and monitoring indicators, into a structure consistent with Multilateral Fund project preparation requirements. Guidance notes suggested indicators and data requirements are included to help governments prepare costed and prioritised national action plans.

Experience from existing initiatives demonstrates that LRM systems can be implemented successfully in a variety of national contexts. Case studies included in the Guide illustrate how regulatory frameworks, technician certification systems, reclamation infrastructure and public–private cooperation can create functioning circular systems for refrigerants. For example, Bahrain's integrated reclamation system demonstrates how mandatory recovery requirements, technician licensing and certification, and cooperation between government and industry can support the development of a national reclamation programme. Other examples show how regional cooperation and mobile reclamation models can reduce costs and expand access in low-volume consuming countries. Across these experiences, a common lesson emerges: successful systems depend on the combination of clear regulation, reliable data, trained technicians and predictable financing.

The Guide also identifies several priority actions that governments can undertake in the near term. These include embedding LRM objectives within ongoing HPMPs, KIPs and national cooling strategies; establishing regulatory requirements for refrigerant recovery and technician certification; developing collection and reclamation systems or partnerships with industry; assessing national or regional options for refrigerant destruction; strengthening digital tracking and monitoring systems; and preparing costed NAPs that can access implementation funding.

When implemented effectively, LRM systems can significantly reduce emissions from existing and future refrigerant banks while strengthening compliance with the Montreal Protocol and the Kigali Amendment. Even partial recovery, reclamation, reuse and destruction of refrigerants can achieve substantial and verifiable emissions reductions while supporting skills development and circular economy opportunities in the refrigeration servicing sector.

This Practical Guide equips Article 5 countries with the technical, institutional, and financial tools to convert refrigerant-bank inventories into operational, costed NAPs. By embedding LRM within national frameworks, countries can transform what was previously waste or emitted into the atmosphere into an opportunity for strengthened Montreal Protocol compliance, environmental integrity, sustainable development, and accelerated climate action.

Abbreviations and Acronyms

AHRI	The Air-Conditioning, Heating, and Refrigeration Institute
AIM	American Innovation and Manufacturing (AIM) Act
CCAC	Climate and Clean Air Coalition
CO_2	Carbon dioxide
COPA	Climate and Ozone Protection Alliance
DRE	destruction/removal efficiency
EE	Energy efficiency
EIA	Environmental Investigation Agency
EOL	End-of-life
EPR	Extended Producer Responsibility
EU	European Union
GHG	Greenhouse gas
HCFC	Hydrochlorofluorocarbon
HFC	Hydrofluorocarbon
HPMP	HCFC Phase-out Management Plan
IGSD	Institute for Governance & Sustainable Development
KIP	Kigali HFC Implementation Plan
LRM	Lifecycle Refrigerant Management
LVC	Low-Volume Consuming countries
MLF	Multilateral Fund for the Implementation of the Montreal Protocol
MRV	Monitoring (including measurement), reporting and verification
MSWI	Municipal Solid Waste Incineration
NAP	National Action Plan
NDC	Nationally Determined Contribution
NOAA	National Oceanographic and Atmospheric Administration
NOU	National Ozone Unit
NRDC	Natural Resources Defense Council
ODS	Ozone-depleting substance
PFAS	Per- and polyfluoroalkyl substances
POP	Persistent Organic Pollutant
PPP	public–private partnership
RAC	refrigeration and air-conditioning
RACHP	Refrigeration, Air Conditioning and Heat Pumps
RRA	Australia Refrigerant Reclaim Scheme
RRR	recovery, recycling, and reclamation
SAP	Scientific Assessment Panel of the Montreal Protocol
TFA	trifluoroacetic acid
TEAP	Technology and Economic Assessment Panel of the Montreal Protocol
UNDP	United Nations Development Programme
UNEP	United Nations Environment Programme
UNIDO	United Nations Industrial Development Organization

Glossary of Terms Unique to Montreal Protocol and Associated Agreements

A2L	Refrigerants that are classified as mildly flammable, have low toxicity, and exhibit a low global warming potential (GWP). The "A" indicates lower toxicity, the "2" signifies flammability, and the "L" indicates low burning velocity
Article 5 Party	Any Party that is a developing country and whose annual calculated level of consumption of the controlled substances in Annex A is less than 0.3 kilograms per capita
Non-Article 5 Party	Other parties not belonging to the list of Article 5 countries, which are mostly developed countries.
ODS/HFC Bank	The total amount of substances contained in existing equipment, chemical stockpiles, foams and other products not yet released to the atmosphere.
LRM	Lifecycle refrigerant management (LRM) is a comprehensive approach to avoid and reduce refrigerant leaks across the refrigeration, air conditioning, and heat pump (RACHP) lifecycle, which encompasses: the production, storage, and transportation of refrigerants; the design, manufacturing and installation; operation and maintenance; and the recovery, reuse, and environmentally sound disposal of refrigerants.
MRV (Monitoring [including measurement], reporting and verification)	The integrated processes, tools, and systems through which countries collect data on refrigerant flows, quantify emissions and emission reductions across the LRM chain, report progress against national objectives, and verify the accuracy of reported outcomes. MRV operates at distinct and interconnected levels: at the ground level, developing and applying the tools, protocols, and data systems that enable technicians, service enterprises, and recovery operators to track and measure their domestic actions; and at the national level through aggregated inventories and compliance reporting. These functions demonstrate the climate and ozone benefits of LRM and can directly contribute to national GHG inventories and NDC reporting.
NDC	A country's Nationally Determined Contribution (NDC) outlines and communicates its post-2020 domestic mitigation measures that are prepared and communicated as required for Parties under the Paris Agreement (Article 4, paragraph 2)[1] adopted at COP21 of the United Nations Framework Convention on Climate Change.
Virgin production	Process of creating products using 100% raw, natural materials that have never been used, or recycled, etc., before.

1 United Nations Framework Convention on Climate Change. (2015) Paris Agreement, Art. 4, 2-3, ("2. Each Party shall prepare, communicate and maintain successive nationally determined contributions that it intends to achieve. Parties shall pursue domestic mitigation measures, with the aim of achieving the objectives of such contributions. 3. Each Party's successive nationally determined contribution will represent a progression beyond the Party's then current nationally determined contribution and reflect its highest possible ambition, reflecting its common but differentiated responsibilities and respective capabilities, in the light of different national circumstances.").

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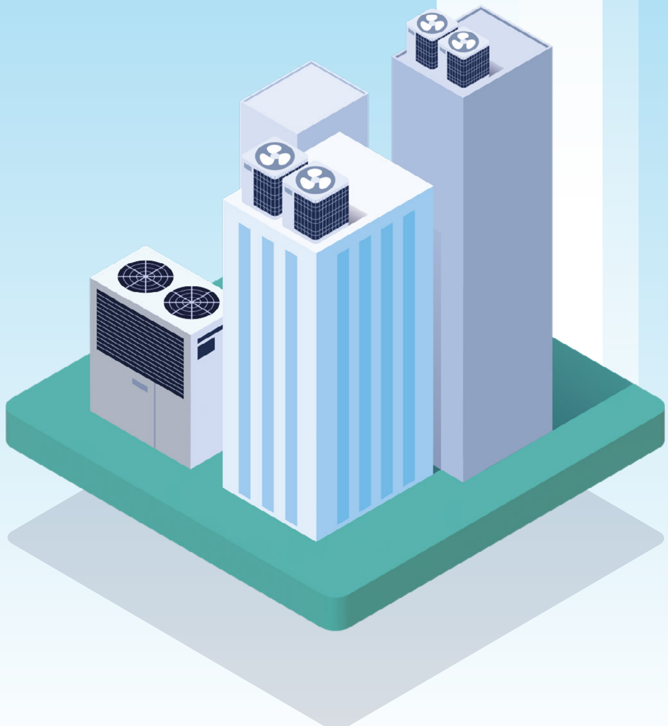

01 Introduction and purpose of this Guide

As a result of climate change, the Earth is getting hotter and entering an era of sustained heat, with more frequent, longer heatwaves. The year 2024 was the warmest on record, with global mean temperatures reaching 1.29 degrees C, an increase of 0.10 degrees C from 2023.[2] The UN Secretary-General's Call to Action on Extreme Heat warns that this crisis causes approximately 489,000 heat-related deaths annually and calls for urgent measures, including preventing the dumping of new but inefficient cooling equipment that uses obsolete refrigerants.[3]

Such actions can help reduce the resources needed to address obsolete refrigerants and associated equipment by implementing lifecycle refrigerant management (LRM) programs in developing countries. 2025 was the first year to surpass 1.5°C target of the Paris Agreement and later decisions while greenhouse gas emission concentrations continue to rise.

Demand for cooling is rising — even in regions and communities that did not historically need it. UNEP's Global Cooling Watch 2025 report warns that global cooling capacity could more than triple by 2050, nearly doubling cooling-related emissions and putting energy systems under major strain. This challenge also presents a great opportunity. Taking sustainable approaches to reduce emissions in the cooling sector could cut emissions by 64% by 2050, with an estimated US $17 trillion in cumulative energy savings, while delivering life-saving access to cooling.[4]

Recent research further highlights the climate implications of rising cooling demand. A 2026 study in Nature Communications estimates that emissions from air-conditioning use could reach about 113 $GtCO_2$-eq between 2010 and 2050, contributing up to 0.07°C of global warming, with refrigerant leakage projected to account for a large share of these emissions.[5]

While new equipment is rapidly deployed worldwide, there are also large stocks of old, inefficient equipment nearing EOL that contain harmful "banks" of ozone-depleting substances (ODS) and hydrofluorocarbon (HFC) greenhouse gases (GHGs). Although the Montreal Protocol on Substances that Deplete the Ozone Layer (Montreal Protocol) currently does not require Parties to contain or destroy these banks of refrigerants, some Parties have regulations and technology to do so. Most do not. When the gases in these banks eventually reach the atmosphere, the impacts are profound: depletion of the stratospheric ozone layer, increased global warming, and the atmospheric degradation of some refrigerants into trifluoroacetic acid (TFA), a persistent substance in the environment that is sometimes classified as a per- and polyfluoroalkyl substance (PFAS), commonly called "everywhere and forever chemicals". Technologies and opportunities exist throughout the lifecycle of cooling equipment that can prevent these gases from ever reaching the atmosphere.

LRM is a comprehensive approach to managing refrigerants to minimise their environmental impact throughout their lifecycle, including chemical production; cooling equipment manufacture, delivery, and installation; operation and service; and recycling, reuse, or destruction at the end of cooling equipment life. LRM focuses on minimizing refrigerant charge, avoiding and reducing refrigerant leaks,

2 National Oceanographic and Atmospheric Administration (NOAA) (2024). The year 2024 was the warmest year in the modern temperature record. https://www.noaa.gov/news/2024-was-worlds-warmest-year-on-record#:~:text=Earth's%20average%20land%20and%20ocean,ranked%20by%20other%20scientific%20organizations

3 United Nations Secretary-General (2024). Call to Action on Extreme Heat. United Nations. https://www.un.org/sites/un2.un.org/files/unsg_call_to_action_on_extreme_heat_for_release.pdf

4 United Nations Environment Programme (UNEP) (2025). Global Cooling Watch (2025): Tracking Sustainable Cooling Progress. Nairobi: UNEP.

5 H. Zhang et al., "Rising Air-Conditioning Use Intensifies Global Warming," Nature Communications (2026).

and promoting refrigerant recovery at service and end-of-life (EOL). Proactive LRM is therefore a frontline climate and environmental protection measure, complementary to energy-efficiency improvements in the cooling sector.

The Scientific Assessment Panel (SAP) of the Montreal Protocol underscores the urgency of avoiding near-term climate tipping points through fast action to reduce emissions of ODS and Hydrofluorocarbons (HFCs), including: continuing the phaseout of ODSs, accelerating the HFC phasedown, controlling nitrous oxide, destroying existing ODS/HFC banks, and reaching net-zero for carbon dioxide (CO_2) and methane (CH_4) while also removing legacy greenhouse gases already in the atmosphere.[6] In parallel, Parties to the Montreal Protocol are sharpening their focus on banked refrigerants through careful consideration and decision-making. Following key decisions at Meetings of the Parties, the Technology and Economic Assessment Panel (TEAP) Task Force on LRM produced a detailed report on the subject, and the Protocol Secretariat hosted an in-depth workshop showcasing opportunities and best practices from around the world. The recent report analyzed and compiled scenarios for ODS and HFC banks and identified persistent barriers to recovery, reclamation, and destruction, especially in developing countries. The Task Force's report highlights the need for coherent national systems that make collection and EOL treatment routine, economical, and verifiable, underscoring the urgency for LRM.[7]

Recent international legal actions encourage momentum with respect to LRM. On 23 July 2025, the International Court of Justice delivered a unanimous Advisory Opinion[8] clarifying that States have binding obligations under international law to prevent significant climate harm through due diligence, cooperation, and concrete mitigation actions. The Court also underscored that failure to act, including inadequate regulation of private emissions, may constitute an internationally wrongful act, particularly where harm to vulnerable States or future generations can be linked. This reinforces the urgent need for concrete national measures such as National Action Plans (NAPs) for LRM, which directly address a key source of climate pollutants.

International and national policies are similarly converging on EOL controls. The European Union's updated F-gas Regulation (EU) 2024/573[9] broadens recovery obligations across sectors and mandates recovery, recycling, and destruction of F-gases at the end of equipment life. The United States, under the American Innovation and Manufacturing (AIM) Act, now pairs the HFC phasedown with measures to maximise reclamation and minimise releases (e.g., leak repair, disposal/servicing requirements) through the Emissions Reduction and Reclamation (ER&R) Programme.[10] Japan's Fluorocarbon Emissions Control framework mandates recovery and sets operator responsibilities throughout the refrigerant lifecycle. These are useful models for Article 5 Parties choosing policy instruments. Other countries are also following suit.

1.1 How this practical guide helps

The Multilateral Fund for the Implementation of the Montreal Protocol (MLF) has now assisted 127 Article 5 (A5) countries[11] in developing national inventories of ODS and HFC banks. These inventories are a first step toward the sustainable management of those substances and could help identify future actions, including disposal. It is expected that these inventories would be harmonised into NAPs for the environmentally sound management of waste-controlled substances in developing countries, and eventually into NAPs for LRM.

6 World Meteorological Organization (WMO) (2022). Scientific Assessment of the Ozone Layer Depletion. GAW Report No. 278. https://csl.noaa.gov/assessments/ozone/2022/downloads/2022OzoneAssessment.pdf
7 Technology and Economic Assessment Panel (TEAP), United Nations Environment Programme (UNEP) (2024). Task Force Report on Lifecycle Refrigerant Management (LRM)
8 International Court of Justice (2025, July 23). Advisory Opinion on Obligations of States in respect of Climate Change. https://www.icj-cij.org/sites/default/files/case-related/187/187-20250723-pre-01-00-en.pdf
9 https://eur-lex.europa.eu/eli/reg/2024/573/oj/eng
10 https://www.epa.gov/system/files/documents/2024-09/err-fact-sheet.pdf
11 Article 5 countries are developing nations with a low consumption of ozone-depleting substances (ODS), as defined by the Montreal Protocol. This classification allows them a delayed timeline for phasing out these chemicals compared to developed countries and makes them eligible for financial and technical assistance from the Multilateral Fund to help transition to ODS-free technologies.

This Practical Guide is a hands-on companion for national ozone units (NOUs) and their ministries, as well as other stakeholders and market actors that are designing and implementing NAPs for LRM. It is structured to give countries the opportunity to:

Translate A5 inventory results into action. The Guide explains how to move from "how much is there, where, and in what form" to an operational plan that identifies specific actions the country can take to reclaim refrigerants where feasible and to destroy unusable or unwanted ODS stocks identified in the inventory.

Integrate LRM into national waste management strategies and regulations. LRM is not a stand-alone initiative. The Guide shows how to integrate actions with Montreal Protocol Hydrofluorocarbon Phase-out Management Plan (HPMP)/Kigali HFC Implementation Plan (KIP) servicing strategies, National Cooling Action Plans (NCAPs), other national cooling strategies, Paris Agreement NDC implementation, waste management and hazardous-waste regimes, customs/market surveillance, and product stewardship schemes to ensure that the LRM financing, enforcement, and data systems to be developed are complementary to these plans, initiatives, and obligations.

Learn from past projects on ODS waste management. Lessons from MLF-funded ODS disposal pilots and other demonstrations show what worked (e.g., cement kilns as accessible local destruction options, synchronised cooling appliance replacement and recovery programs) and what projects were not economically viable (e.g., one-off projects lacking consistent waste streams and payment-on-delivery models). The Guide distills these lessons into potentially replicable tools that countries can adapt when developing their NAPs for LRM.

Develop their NAPs for LRM from a model template and tools. To assist countries in developing their NAPs, this Guide offers a model template that can serve as a starting point for elaborating on the priorities they aim to pursue in their LRM journeys. The NAP will provide reporting indicators compatible with the requirements of the Multilateral Fund and other potential donors and funding sources and ensure that identified actions are consistent with the country's HPMP/KIP and other cooling initiatives.

1.2 From inventories to action

Inventories are the essential first step, but they are useful only if they can be converted into prioritised strategic activities that support the overall LRM objective. LRM encompasses the full refrigerant lifecycle, including prevention and containment; recovery during servicing; reuse and recycling to reduce the use of virgin substances; reclamation to certified purity; and eventual destruction when no other options are available, using best available techniques. The Guide will clarify when each route applies. It also explains how to set performance-based incentives and ensure that reuse and reclamation do not undermine the Montreal Protocol's compliance objectives and control schedule, or lock in obsolete substances. Further, it addresses the supporting infrastructure requirements to ensure that the selected option meets the country's needs.

The Guide also shows how to use inventory outputs to design an institutional structure that builds on the inventory methodology and sets realistic targets for each step of the LRM value chain. Additionally, the Guide will describe how much refrigerant can be realistically collected, how it can be aggregated, who will be responsible for each step of the process, and what needs to be done for substances that have already been collected and those that will be collected in the future.

The Guide explains the advantages and methods of public procurement and buyers' clubs, electric utility energy efficiency (EE) financing for equipment replacement, carbon and/or chlorine credits for mandatory recovery and verified destruction, extended refrigerant-supplier chemical responsibility, revenues from recovered materials (metals, plastics), and other options to co-finance logistics.

The Guide also explores whether and how low volume consuming countries (LVC) countries can cooperate regionally to pool destruction volumes, share accredited labs, and standardise tracking and reporting to meet both national and MLF expectations.

1.3 Enabling conditions and funding sources

Sustainable LRM is not a one-time project; it requires capital, often on a large scale, depending on which step of the LRM cycle the country chooses to invest in. In many developing countries, funding is needed across the refrigerant lifecycle. This includes funding for technician training and specialised tools to enable good servicing practices that reduce emissions, for establishing collection and aggregation networks, for purchasing equipment like cylinders that facilitate collection and aggregation of unused substances, for purchasing recovery and recycling equipment, and for implementing NAPs for LRM, to name a few activities that typically need financial resources. While the Guide does not go into detail on financing options, it provides information on identifying the best approach to obtaining financing for certain activities. For instance, it gives advice on how initial MLF funding can be leveraged to optimise the use of development finance and domestic sources to make the LRM business model sustainable.

The Guide also provides guidance on ensuring that the supporting policy and its enabling framework are in place to support the actions required in the plan. Policy clarity is crucial because it guides users and producers in implementing LRM. Clear recovery mandates, quality standards for reclaimed refrigerant, producer/importer obligations, and enforceable EOL rules lower risk and attract private investment. Recent regulatory moves in the EU, US, and Japan demonstrate how combining phase-down with recovery/reclamation rules and market surveillance fosters reclaim markets, curbs illegal trade, and reduces venting.

1.4 Monitoring (including measurement), reporting and verification (MRV)

Robust MRV underpins the successful implementation of the NAPs and LRM. The Guide proposes systems and tools, as well as verification protocols, for the various steps in the LRM chain to develop a national MRV system. It outlines how to align this national MRV with MLF reporting, customs data, hazardous-waste manifests, and climate inventories, thereby enabling the credible aggregation of outcomes (kg recovered/reclaimed/destroyed; CO_2-eq avoided) for domestic accountability and to support international financial and logistical support.

1.5 How to use this guide

The rest of the Guide is structured as follows:

CHAPTER	
02	lays out the LRM framework, definitions, and interfaces with HPMPs/KIPs and cooling/energy policy.
03	presents case studies and synthesises lessons from ODS-disposal pilot projects and other bank-management initiatives to identify scalable models.
04	explains inventory methodologies and how to translate results into an action plan.
05	provides a step-by-step method for designing a NAP for LRM, with policy, institutional, infrastructure, financing, and MRV building blocks.
06	summarises technical options for recovery, reuse/recycling, reclamation, and destruction, and includes selection criteria to determine the course best suited to national contexts.
07	sets out challenges and priority recommendations for near-term action.

The Guide will help countries define what can be done now, what can be scaled tomorrow, and what can be sustained over time. It will assist Article 5 Parties in translating their inventories and intentions into a practical NAP that prevents refrigerant emissions, strengthens compliance with the Montreal Protocol and its Kigali Amendment, promotes LRM, and delivers rapid verifiable climate and ozone benefits.

02 The National Action Plans for LRM framework

Managing refrigerants across their full lifecycle is essential to address "banks" — the gases contained in existing equipment, chemical stockpiles, and other products.[12] Because many refrigerants contained in banks are ozone-depleting substances (ODS) or high-global warming potential (GWP) hydrofluorocarbons (HFCs), their release can result in significant ozone and climate impacts, undermining ozone protection and climate mitigation goals.

There are several definitions of LRM. For this Guide, LRM refers to the approach that focuses on avoiding and reducing refrigerant leaks, promoting refrigerant recovery, and increasing reclamation rates to mitigate unnecessary refrigerant use and emissions.[13]

Additionally, this Chapter defines the terms used when describing LRM, and details each step across the refrigerant value chain, including prevention and leak minimisation; recovery, reuse, and recycling; reclamation; and, where necessary, destruction. It also explains how these activities should align with existing policy instruments and programmes that Article 5 countries are already implementing: the HCFC Phase-out Management Plans (HPMPs), Kigali HFC Implementation Plans (KIPs), national cooling strategies, and the preparation of Paris Agreement NDCs. It draws on the ongoing country inventories of banks of used or unwanted controlled substances funded by the Multilateral Fund (MLF) to illustrate why timely, structured national plans for managing waste-controlled substances are urgently needed.

This Guide frames LRM within a broader circular-economy perspective: prioritising prevention and leak avoidance, promoting recovery and high-quality reclamation to displace virgin production where permitted, and reserving destruction for non-reusable or obsolete gases. This is crucial as LRM aims to reduce direct emissions from refrigeration, air-conditioning, and heat pump (RACHP) systems, thereby expanding the availability of recovered and reclaimed refrigerant, especially for servicing-only Parties and other operators with limited flexibility in phasing out or phasing down consumption of refrigerants.

Throughout the development of national plans, compliance with control measures and phase-out/phase-down schedules under the Montreal Protocol and its Kigali Amendment is paramount. Where increased availability of recovered and reclaimed refrigerants could mean their continued use beyond the compliance period of the Montreal Protocol, the national plans should consider LRM as a structured pathway to reduce emissions from in-use equipment and legacy banks as countries transition to compliant alternatives.

2.1 Key components of LRM and why action is urgent

In practice, LRM should be seen as a comprehensive set of strategies that manage refrigerants and equipment throughout their lifecycle: product design; installation and in-use operation; maintenance and repair; EOL collection and environmentally sound disposal; and final fates (reuse, recycling, reclamation, or destruction) to reduce emissions from the installed refrigerant bank. It should integrate technical practices, such as leak prevention, with existing policy efforts and institutional frameworks that support the implementation of this approach, and with the infrastructure that enables the practical handling and treatment of refrigerants.

LRM practices can be broadly grouped into several components, which are described in this Guide as follows:

12 United Nations Environment Programme, Ozone Secretariat (2024). Briefing Note: Introduction to life-cycle refrigerant management.
13 EIA, NRDC and IGSD (2022). The 90 Billion Ton Opportunity: Lifecycle Refrigerant Management.

- Containment and leak prevention during design, manufacturing, installation, and operation
- Recovery, recycling, and reclamation during servicing and EOL
- Reuse of recovered and/or reclaimed refrigerant
- Destruction and environmentally sound disposal
- Environmentally sound management of used and waste equipment

2.1.1 Containment and leak prevention during design, manufacturing, installation, and operation

Reliable equipment design is the cornerstone of leak prevention. Selecting high-quality, leak-tight components, minimising refrigerant charge, using compatible materials with the selected refrigerant — especially for flammable refrigerants — and designing easy-to-reach connection joints reduce failure points and the likelihood of refrigerant loss throughout the equipment's operational life. Proper design also includes correct testing, from pressure tests and vacuum checks to factory leak tests. Quality control is needed across the production process. International and national design standards[14] should be followed to ensure quality control in the manufacturing of RACHP equipment.

Only licensed[15] technicians should install equipment to ensure that evacuation and pressure-test protocols are followed, and that initial charge and serial numbers are recorded. During operation, only certified service technicians should perform regular maintenance, and tightness checks to prevent leaks.

In many developing countries, equipment is imported both with and without refrigerant. The practices outlined above should also be followed when the initial charge of refrigerant is performed in-country, after import. When equipment containing refrigerant is imported, extreme care should be taken to ensure that refrigerant does not leak during transport.

Ensuring robust equipment design can result in lower annual leak rates, longer equipment life, and potentially less demand for virgin refrigerants, avoiding refrigerant emissions before they occur, and helping ensure the energy-efficient operation of the equipment.

2.1.2 Recovery, recycling and reclamation during servicing and EOL

The Montreal Protocol Parties have defined recovery, recycling, and reclamation (collectively RRR).[16] Recovery involves collecting controlled substances from machinery, equipment, and containment vessels during servicing or before disposal. Recycling is the reuse of controlled substances after basic on-site cleaning (e.g., filtering, drying, oil separation) and then recharging back into equipment. Reclamation refers to reprocessing and upgrading a recovered substance (typically off-site) using methods such as filtering, drying, distillation, and chemical treatment to meet a specified performance standard, which is typically verified by analysis.

Refrigerant recovery should be the default whenever a system is opened, during servicing or repair, and during decommissioning or replacement. Refrigerant recovery requires special equipment (e.g., recovery machines, certified cylinders, and scales). In many Article 5 countries, this equipment may already have been provided through MLF projects under the HPMP and the KIP. Once the refrigerant is recovered, it can be recycled, reclaimed, or destroyed if found to be unusable. Recovered refrigerants require storage in specialised cylinders and tanks, which are not readily available in developing countries.

Recycling (basic cleaning) can support reuse for servicing the same equipment, while reclamation restores gas to recognised specifications through testing, segregation, and certification. This also applies to mildly flammable (A2L) and flammable (A3) refrigerants, which can be recycled and reclaimed provided specialised, certified equipment is used; however, because they are flammable, they must never be vented and require strict safety measures, including the use of approved recovery machines, non-sparking tools, proper grounding, and adequate ventilation.

14 ISO, ISO 5149-1:2014 – *Refrigerating systems and heat pumps — Safety and environmental requirements — Part 1: Definitions, classification and selection criteria;* ISO, ISO 14903:2017 – *Refrigerating systems and heat pumps — Qualification of tightness of components and joints.*

15 Many developing countries currently operate a single-tier technician qualification system in which the same certification covers both installation and servicing tasks, thus do not differentiate between licensed and certified technicians. Where this is the case, national programmes should ensure that training curricula explicitly cover installation protocols (including evacuation, pressure testing, and charge recording) as well as routine maintenance and leak-checking. Countries building new qualification frameworks may wish to consider a tiered structure as their servicing sector matures.

16 Decision IV/24: Recovery, reclamation and recycling of controlled substances

To successfully implement RRR, the regulatory framework should, at a minimum, include prohibitions on venting, mandates for refrigerant recovery, inspections of service shops, and the professionalisation of the servicing sector.

All RRR actions, while already practiced and promoted in Article 5 countries, face challenges due to the need for increased capacity in the servicing sector, the cost of equipment and tools, the lack of available technologies, the supporting infrastructure and policy framework, and the need for stronger enforcement capacity.

The MLF, through its evaluation function, is preparing a desk study to identify challenges in implementing RRR projects, analyse the effectiveness of RRR infrastructure developed through the HPMPs in Article 5 countries, and assess its impact on reducing refrigerant consumption. This desk study will cover projects approved between 2010 and 2023 and is due in 2027.

Also, reverse supply-chain logistics are essential for EOL refrigerant management and for more complex reclamation practices beyond simple on-site recovery and recycling. This organised system of refrigerant collection, transport, storage, processing, and eventual destruction is not easy to establish in many developing countries. Difficulties include limited economies of scale arising from the small quantities of substances collected, varying distances between collection points, the lack of storage cylinders and storage areas, the use of informal servicing, inadequate reclaim/destruction facilities, and limited regulatory measures. While necessary, the LRM logistics system is costly for developing countries.

2.1.3 Reuse of recovered and/or reclaimed refrigerant

Refrigerant reuse can minimise emissions and reduce demand for virgin refrigerant, provided it complies with safety and legal requirements. Determining whether a refrigerant is suitable for reuse and where it is suitable (i.e., in the same RACHP system, a comparable system, or a different system) usually requires confirmation of its composition through chemical analysis. This testing can be performed on-site using portable refrigerant identifiers or off-site at qualified laboratories that can perform full specification analysis to verify compliance with Air-Conditioning, Heating, and Refrigeration Institute (AHRI) Standard 700 or other standards.

While reusing HFCs is possible, challenges arise when the refrigerant is an HFC-blend. Portable refrigerant identifiers may not distinguish similar blends or detect all contaminants. Hence, confirming the exact refrigerant composition typically requires full lab analysis using a gas chromatograph before reuse, which may not be readily available in developing countries. Ensuring that the refrigerant meets the purity requirements for reuse becomes more complex, as off-site reclamation is required rather than simple on-site recycling. In addition, there is a high risk of contamination, which means that returning the gas to the required specification will be costly.

It is recommended to limit direct reuse of recovered gas to the same system or to controlled fleets where contamination risk is low and national rules permit. When quality is uncertain, prioritise reclamation to certified specifications so the product can legally substitute for virgin refrigerant. Where possible, all refrigerant reuse should be tracked through a registry to preserve traceability and ensure alignment with phase-out/phase-down schedules.

Quick Tips for Reusing Refrigerant Blends (HFC/A2L)

- Best option: return to the same system after repair.
- For other systems: verify composition (screen on site; confirm by lab if needed).
- Only transfer/sell if reclaimed to AHRI 700 standard with documentation.
- Recover/charge as liquid; never top-off with a different or unknown blend.
- Keep cylinders separate and clearly labeled; record source and date.
- Check for contaminants; replace filter-driers after each use.
- Confirm oil/material compatibility and account for glide.
- For A2L blends: follow codes, ventilation, leak detection, and training.
- When unsure, send to a certified reclaimer.

2.1.4 Destruction and Environmentally Sound Disposal

LRM treats the destruction and environmentally sound disposal of substances as the final option, to be used when refrigerants are unrecoverable,[17] unreclaimable, or legally/technically obsolete (e.g., contaminated mixtures, unknown blends, or degraded stocks). These contaminated substances should be permanently eliminated using approved technologies that meet destruction efficiency and emissions-control requirements.

Operationally, environmentally sound disposal starts with efficient collection and consolidation of unwanted material, verified recovery by certified technicians, oil separation and basic filtration where feasible, and accurate identification/labeling (including all components, where possible). Then, these aggregated volumes are packaged to transport standards and moved under a documented chain of custody to qualified destruction facilities, selected based on availability, throughput, and compliance.

Various technologies and approaches can be used to destroy these unusable substances. Options include high-temperature incineration, plasma technologies with high destruction efficiency, cement-kiln co-processing, and other chemical transformation technologies. These are described in more detail in Chapter 6.

The most sophisticated and typically more expensive destruction capacity facilities are mostly concentrated in non-Article 5 Parties and in a few larger Article 5 Parties. These facilities can achieve up to 99.99% destruction efficiency[18] at high temperatures, with alkaline environments neutralising acidic by-products.[19] However, properly managed and permitted local cement kiln destruction by developing countries can achieve high destruction efficiency at far lower cost, thereby encouraging greater recovery and destruction. The lower cost comes from less shipping and storage, fewer permitting delays and costs, and fewer brokers and traders driving up costs.[20] Therefore, cement kilns represent the most cost-effective and readily available destruction technology for unwanted refrigerants in small and medium-sized Article 5 Parties under the Montreal Protocol. The primary advantage lies in infrastructure availability: high-temperature cement kilns are widely available in most countries and provide an affordable, environmentally sound, and sustainable treatment option for hazardous chemicals when adequate procedures are implemented.

MRV is also important in this process as it confirms what was destroyed, in what quantities, and at what level of destruction/removal efficiency (DRE), ensuring actual emissions reductions. MRV methodologies provide frameworks for monitoring (including measurement), reporting, and verifying GHG emission reductions associated with ODS destruction,[21] enabling accurate estimates of emissions prevented through exhaust gas sampling and comprehensive documentation.[22]

2.1.5 Environmentally sound management of used and waste equipment

When refrigeration and air-conditioning equipment reach EOL, after the remaining refrigerant is removed from the system, other usable materials remain. These components must be disposed of in compliance with environmental regulations. These materials, especially recyclable ones, could also be treated as a managed materials stream and a potential income source. If properly segregated and aggregated, these materials could generate a modest revenue that can help finance LRM activities and reduce operational cost. For instance, metals such as steel and aluminium, and plastics, are fully recyclable, and their safe collection and recycling would be consistent with circular economy principles.

LRM should be embedded in national waste management frameworks to ensure that hazardous components and recyclable materials are handled correctly.

17 Some materials that cannot be used by law include contaminated or mixed refrigerants that cannot be reclaimed to AHRI 700 purity; unknown blends identified in EPA guidance as destined for destruction; legally obsolete stocks such as R-22 for EU servicing, R-404A/R-507A in U.S. SNAP-prohibited end-uses, or halon agents in EU aviation after 31 Dec 2025

18 The Montreal Protocol requires a minimum destruction and removal efficiency (DRE) of 99.99% for concentrated sources of ozone-depleting substances (ODS). A slightly lower DRE of 95% is permitted for dilute sources, such as ODS contained in foams.

19 Eco News (2025). From Cylinder to Cement Kiln: Tracking the Final Journey of Refrigerants.

20 *See* Andersen, Stephen O., Richard 'Tad' Ferris, and Marco Gonzalez (2025). Destruction of Surplus Refrigerants in Local Cement Kilns. Global Environmental Research, Vol. 29, No. 2. Association of International Research Initiatives for Environmental Studies (AIRIES).

21 American Carbon Registry (2024). Ozone Depleting Substances. Retrieved from https://acrcarbon.org/resources/ozone-depleting-substances/

22 U.S. Environmental Protection Agency (2018). ODS Destruction in the United States and Abroad. EPA 430-R-18-001.

2.2 Connecting LRM to HPMPs, KIPs, NCAPs, and NDCs

For most Article 5 Parties, the servicing sector is the primary source of refrigerants that require lifecycle management. This sector encompasses installation, maintenance, repair, and EOL handling of refrigeration and air-conditioning (RAC) equipment across residential, commercial, and industrial applications. Strategies for this critical sector are defined through HPMPs for HCFC phase-out and KIPs for HFC phase-down, both prepared under the MLF.

These plans share common servicing sector interventions: establishing technician training programmes, promoting good servicing practices, building recovery and recycling capacity, and professionalising the sector through certification. HPMPs and KIPs typically also include an allocation for providing technicians with essential tools and equipment, including recovery machines where requested.

Beyond the Montreal Protocol, many developing countries are implementing NCAPs or other cooling strategies, comprehensive policy frameworks that address growing cooling needs while minimising environmental and climate impacts, ensuring equitable access, and improving energy efficiency. These strategies offer additional LRM integration opportunities, particularly through activities such as recycling and disposal schemes with take-back programs, which achieve higher capture rates when coupled with energy-efficiency incentives and comprehensive EOL requirements. It is important to note that the NCAP is distinct from this NAP LRM which focuses mostly on environmentally sound management of refrigerants and banks.

From a climate policy perspective, LRM also delivers measurable, near-term mitigation outcomes that can significantly strengthen Paris Agreement NDCs by explicitly including refrigerant management. Given the high GWP of HFCs and other refrigerants, incorporating these substances into national climate plans is crucial for meaningful emissions reductions. NDCs should establish clear methodologies for calculating avoided emissions based on documented quantities of recovered and destroyed refrigerants by gas type, with particular attention to HFC management, plus verified leak reductions from improved servicing practices. This approach ensures transparent NDC reporting while maximising climate benefits and capturing the substantial mitigation potential of refrigerant management in national commitments.

To maximise effectiveness and avoid duplication, these diverse national strategies must be carefully coordinated. Aligning HPMPs, KIPs, cooling strategies, and NDC commitments ensures that LRM actions build synergies rather than compete for limited resources or create conflicting servicing sector requirements.

03 **Case studies:** Examples of effective LRM initiatives

CASE STUDY 1:

Bahrain: Establishing a comprehensive regulatory model for a national reclamation system

Overview

As part of its HPMP, the Kingdom of Bahrain developed an integrated regulatory framework to manage refrigerants in its servicing sector. A central objective of this initiative was to establish a sustainable reclamation system to recover, reclaim, and reuse refrigerants. In this way, the initiative reduced dependence on new imports, prevented the venting of refrigerants to the atmosphere, and ensured compliance with the Montreal Protocol's HCFC and HFC control measures. The Kingdom's Supreme Council for Environment (SCE), through its National Ozone Unit (NOU), implemented a coordinated approach that links regulation, recovery, and reclamation, transforming policy commitments into a functioning circular system for refrigerant management.

Key regulatory measures

Ministerial Decree No. 1/2020 on the Management of Refrigerants and refrigeration and air-conditioning (RAC) equipment establishes mandatory recovery and refill practices, prohibits the use of disposable cylinders, and requires registration of refrigerants, equipment, and servicing enterprises. Licensing of RAC technicians ensures that only qualified personnel manage recovery and reclamation. This regulatory backbone enables Bahrain to build and sustain a national reclamation system within a controlled, traceable framework.

Development of the reclamation system

With support from the MLF, UNEP, and UNIDO, the Government of Bahrain established a National Refrigerant Reclamation Facility, currently operated by Aztec Services, through a competitive process to reclaim and refill refrigerants collected from the market. This facility operates four collection centres supervised by the NOU. The NOU also partnered with Centro Studi Galileo, the Italian Association of Technicians (ATF), and Tamkeen, a semi-autonomous government agency, to develop a national certification and licensing scheme for RAC technicians and to co-finance training of local specialists.

Results and lessons learned

The transition to refillable cylinders and the systematic reclamation of refrigerants have reduced refrigerant waste, which the NOU previously estimated at 200 mt annually. The system also strengthened the import and quota systems and mitigated price volatility caused by market disruptions, especially during the COVID-19 pandemic. A broad technician-licensing and inspection campaign ensured compliance with recovery and reuse requirements. The combination of legal enforcement, financial support, and training created a closed-loop system for refrigerant management, demonstrating how integrated regulation and reclamation infrastructure can reinforce each other to deliver sustained environmental benefits.

Lessons for national action planning

Bahrain's experience highlights that reclamation — when mandated, regulated, and financed — is essential to the core of LRM. To ensure sustainability and overcome the challenges of operating the facility, future priorities include establishing a national laboratory for refrigerant analysis, improving data systems for monitoring reclaimed volumes, and embedding these measures within the NAP with clear institutional roles, performance indicators, and financing strategies.

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Key takeaways

- Regulation is the enabler of effective reclamation.
- Reclamation links recovery, reuse, and emissions reduction in LRM.
- Any reclamation activities need to be integrated within a national action plan for LRM that formalises mandates, monitoring systems, and financing.

Map to LRM policy pillars

Regulatory framework: A Ministerial Decree establishes mandatory recovery and refill practices, prohibits the use of disposable cylinders, and requires registration of refrigerants, equipment, and servicing enterprises.

Sustainable financing: Government, MLF and others supported the establishment of the facility.

Recycling and destruction infrastructure: Planned expansion of recycling, reclamation, and destruction capacity.

CASE STUDY 2:

Ghana: National Strategy for Lifecycle Management of ODS Banks

The Government of Ghana, with support from GIZ, developed a roadmap on ODS bank management. Published in May 2025, the roadmap is supported by four policy pillars for good practice in ODS bank management: (1) a coherent and enforceable regulatory framework, (2) a sustainable and predictable financing mechanism, (3) an operational recycling and destruction infrastructure, and (4) an efficient and effective nationwide collection system.

During consultations, the National Ozone Unit and other relevant stakeholders identified the following priority actions for ODS bank management:

1. **Collect and safely process ODS-containing refrigerators.** Ensure the systematic collection and environmentally sound management of EOL refrigerators, including the recovery and treatment of both refrigerants (e.g., CFC-12 and HFC-134a) and blowing agents (e.g. CFC-11 and HCFC-141b).

2. **Optimise the recovery and reuse of existing HCFCs.** Reduce leakage rates and expand recycling and reclamation infrastructure to support the continued, but controlled, use of reclaimed Hydrochlorofluorocarbons (HCFCs), with priority for unitary air-conditioning, which has the highest consumption.

3. **Prevent the creation of future refrigerant banks.** Accelerate the transition to low-GWP, zero-ODP alternatives where possible and support technician training and safety standards, with priority for the unitary air-conditioning sector.

The roadmap also prioritised actions by subsector, including an implementation timeline, defining short-, medium-, and long-term actions across key RAC subsectors to guide the various actions and determine resource allocation.

More information: https://www.copalliance.org/imglib/publications/2025_COPA_Ghana_ODS%20Roadmap.pdf

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Key takeaways

- National roadmaps can align policy, infrastructure planning, and financing for ODS bank management.
- Sequencing actions by subsector and clearly defined timeframes improve feasibility and resource allocation.
- Accelerating transition to low-GWP, zero-ODP alternatives prevents the creation of refrigerant banks.
- Early integration with waste and energy efficiency policies strengthens sustainability of LRM initiatives.

Map to LRM policy pillars

Regulatory framework: ODS bank management roadmap is anchored in national ODS and waste policies.

Sustainable financing: Roadmap provides basis for mobilizing MLF and other sources of financing.

Recycling and destruction infrastructure: Planned expansion of recycling, reclamation, and destruction capacity.

Collection systems: Priority actions focus on systematic collection of EOL equipment and substances.

CASE STUDY 3:

Grenada: From analysis to action on LRM

Grenada's work on LRM began in response to limited national data on ozone-depleting substances (ODS) banks and their EOL management. With support from GIZ, a detailed analysis of ODS and refrigerants stored in equipment and cylinders was conducted, resulting in a 2021 study.[23] The study provided the first comprehensive overview of ODS banks in Grenada and assessed feasible options for their EOL management.

By combining data from this report with the country's 2020 greenhouse gas inventory, the analysis showed that very little refrigerant is recovered and stored in cylinders and that a significant share of these banks is released as emissions. This highlighted the need to move beyond service-based practices towards a more systematic, EOL-focused approach

Grenada has an established recovery and recycling programme in the servicing sector spearheaded by the National Ozone Unit (NOU). More than 20 workshops were equipped with recovery machines, and while participation was voluntary, compliance in the formal sector was high.

The roadmap recommended developing a structured national system for collecting and treating refrigerant banks at the EOL to be integrated into existing ODS control and waste management legislation. This would build on existing tools such as a code of practice that defines procedures for refrigerant recovery, handling and storage, and could then be expanded to address EOL equipment more clearly.

Proposed solutions include introducing an extended-producer responsibility take-back scheme for EOL equipment, establishing a national reclamation centre to incentivise recovery by compensating technicians and companies, and exporting refrigerants that cannot be reclaimed for environmentally sound destruction abroad. These recommended solutions were developed through extensive consultations led by the NOU, the Grenada Solid Waste Management Authority, and private sector representatives.

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Key takeaways

- Data driven inventories are essential to design feasible LRM systems in small island countries.
- Existing servicing sector capacity can be leveraged to address EOL management of equipment and substances.
- Regional or export for destruction can be a practical interim solution for small countries without destruction facilities.

Map to LRM policy pillars

Regulatory framework: Integration of LRM into ODS control and waste legislation.

Sustainable financing: Incentive-based recovery and compensation mechanism can be proposed.

Recycling and destruction infrastructure: National reclamation centre and interim export for destruction.

Collection systems: Proposed take-back schemes for EOL equipment.

23 Elassaad & Associates (2021, June). Analysis of ozone-depleting substances (ODS)/refrigerants stored in equipment and cylinders and feasible technologies for their End-of-Life (EOL) treatment in Grenada.

CASE STUDY 4:

Mexico: Consolidating national systems for refrigerant recovery, recycling, and destruction

Mexico has developed an increasingly comprehensive national framework for LRM, integrating recovery, recycling, and destruction activities into its broader environmental and circular-economy policies. Building on decades of implementation under the Montreal Protocol and its Kigali Amendment, the Government of Mexico, through the Secretariat of Environment and Natural Resources (SEMARNAT) and the National Ozone Unit, has strengthened its national refrigerant management planning to address emissions from existing stocks of ODSs and HFCs. This approach reflects a shift from pilot interventions toward scaled, system-wide management of refrigerants across the equipment lifecycle.

An important element of Mexico's approach is the operational network of refrigerant recovery and recycling centres established with support from the MLF. These centres provide technicians and enterprises with accessible tools to recover and process refrigerants during servicing and equipment decommissioning. This is complemented by authorised destruction facilities capable of treating controlled substances using industrial co-processing technologies for refrigerants that cannot be reclaimed.

Recent efforts have focused on strengthening data on refrigerant banks through national inventories, improving collection and coverage and increasing traceability of substances, aligning refrigerant management with energy efficiency and waste management policies. Training programmes and stakeholder engagement have also been used to progressively integrate informal practices into regulated formal systems to increase compliance.

Mexico's experience illustrates how mature regulatory frameworks, operational infrastructure, and continuous data improvement can be combined within national LRM plans to move from compliance-driven actions toward long-term emissions mitigation and circular refrigerant management.

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Key takeaways

- Mature regulatory frameworks support transition from pilot projects to national scale LRM.
- Domestic destruction capacity reduces reliance on temporary storage or export for destruction.
- Integrating the informal servicing sector with existing frameworks improves recovery rates and compliance.

Map to LRM policy pillars

Regulatory framework: Alignment of refrigerant management policies with environmental and waste policy.

Sustainable financing: MLF-supported infrastructure provides a framework for leveraging national resources.

Recycling and destruction infrastructure: Nationwide recovery centres and co-processing facilities support efficient LRM implementation.

CASE STUDY 5:

Togo: Using public–private partnership (PPP) to advance lifecycle refrigerant management

Togo is laying the groundwork for LRM by combining policy reform, institutional coordination, and innovative financing mechanisms in the early stages of development. The country has chosen to anchor its approach in the creation of a nationally coordinated recycling system supported by a public-private partnership (PPP).

Through the Froid Vert Togo initiative, led by the Ministry of Environment and Forest Resources and the National Ozone Office, Togo is developing a PPP model to establish a national refrigerant recycling facility. The initiative is designed to reduce and prevent emissions from obsolete refrigeration and air-conditioning (RAC) equipment, reduce emissions of fluorinated gases, and support compliance with the Montreal Protocol by embedding recovery and recycling within a structured national framework.

A distinctive feature of Togo's approach is its reliance on a strengthened legal framework for public procurement and PPPs. This framework defines institutional roles, risk-sharing arrangements, and performance oversight, while enabling private sector participation in the delivery of environmental services.

Preparatory actions have focused on building enabling conditions for implementation. These include developing a national F-gas management strategy (2025–2029), preparing sector-specific PPP guidelines, and building capacity among both public authorities and private partners. At the same time, Togo has initiated work on fluorocarbon bank inventories to generate the data needed to guide future recovery and recycling, and potential investment actions.

Togo's experience demonstrates how early integration of inventory development, regulatory clarity, and financing models within national action plans can support the phased establishment of sustainable refrigerant management systems tailored to national capacity and market.

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Key takeaways

- Early use of PPP models can accelerate the establishment of recovery and recycling systems.
- Timely and updated inventories of banks help to ensure that recycling capacity and financing models are based on national capacity.
- Clear legal frameworks for procurement and PPP enable sustainable financing and implementation.

Map to LRM policy pillars

Regulatory framework: Strengthened public procurement and PPP legislation supports LRM.

Sustainable financing mechanisms: PPP with public payment can support financial viability limiting reliance on short-term or donor-driven financing.

Recycling and destruction infrastructure: Development of a national refrigerant recycling facility under the Froid Vert Togo initiative.

Collection systems: Parallel inventories and stakeholder engagement support the foundation for a systematic collection mechanism.

CASE STUDY 6:

Viet Nam: Institutionalising LRM through governance

Viet Nam's approach to LRM[24] illustrates how a strong legal and institutional framework can support long-term and systemic change. LRM in Viet Nam has been progressively embedded through a hierarchy of national laws, regulations and other implementing instruments that clarify responsibilities of various stakeholders across the refrigerant lifecycle.

This process was significantly strengthened and supported by the revised Law on Environmental Protection (Law No. 72/2020/QH14) adopted by the National Assembly in 2020. The revised law introduced the concept of lifecycle refrigerant management for industrial and commercial cooling equipment. Importantly, the law empowered the Ministry of Natural Resources and Environment (later reorganised as the Ministry of Agriculture and Environment (MAE)) to elaborate detailed implementation rules, technical regulations, and standards, providing the legal basis for adopting lifecycle approaches.

Following the adoption of the LEP, the Government issued a series of decrees, while MAE promulgated implementing circulars and national technical regulations to operationalise the law. This regulatory approach enabled the introduction of LRM approaches in a structured and coordinated manner with clear guidance for stakeholders on their roles and obligations at each stage of refrigerant management from import to use, to recovery, recycling, and EOL handling. National technical regulations further supported compliance.

Beyond developing legal instruments, the Government of Viet Nam has also actively partnered with bilateral and international organisations to strengthen their implementation. In collaboration with the Climate & Clean Air Coalition, the Overseas Environmental Cooperation Center - Japan and Environment and Ecology Institute – Viet Nam, MAE has piloted electronic refrigerant-tracking systems using digital logbooks. These systems are designed to link servicing-level data with compliance to government regulations and reporting for controlled substances under the Montreal Protocol.

These measures demonstrate how Viet Nam has moved beyond individual project interventions toward institutionalisation of LRM as part of mainstream environmental governance, highlighting the importance of legal initiatives, regulatory actions and digital tools in supporting compliance and the long-term sustainability of refrigerant management.

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Key takeaways

- Strong legal frameworks can institutionalise LRM without large upfront infrastructure.
- Regulatory sequencing clarifies stakeholder roles across the refrigerant lifecycle.
- Digital tracking strengthens compliance and transparency.

Map to LRM policy pillars

Regulatory framework: Law on Environmental Protection and its supporting implementing decrees.

Sustainable financing: Regulatory compliance embedded in national regulations.

Recycling and destruction infrastructure: The current framework enables potential future infrastructure investments.

Collection systems: Tracking systems link recovery to reporting obligations.

24 Quoc Trinh Dung and Makoto Kato (2025). Institutionalizing Life Cycle Refrigerant Management by Development of the Legal Framework in Viet Nam. Global Environmental Research, Vol. 29, No. 2. Association of International Research Initiatives for Environmental Studies (AIRIES). Available at: https://www.airies.or.jp/journal_GlobalEnvironmentalResearch_29-2eng.html

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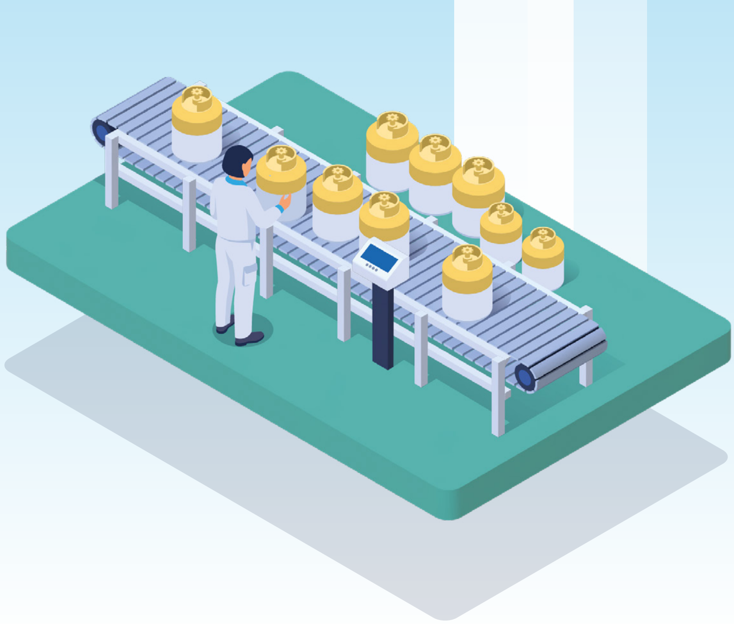

04 Building the baseline: National inventories of banks of refrigerants

Between 2009 and 2014, the MLF funded pilot demonstration projects on ODS disposal for 11 Article 5 countries.[25] One of the main barriers identified in the analysis of the project results was the lack of a national inventory of the targeted waste substances.[26] This fundamental gap has consistently undermined refrigerant waste management initiatives across Article 5 countries, highlighting the critical need for comprehensive baseline data. While substantive data gathering occurs during the preparation of the HPMPs and the KIPs, there are no dedicated data-collection exercises focused on banks of ODS and HFCs.

Since ODS and HFCs from banks can be released to the atmosphere over time through slow leakage, catastrophic leaks, and venting, unless they are recovered and adequately treated, a sound understanding of ODS and HFC banks at the country level is the basis for any action and policy decisions. This understanding includes assessing the general need for action, potential environmental benefits, potential destruction capacities, and appropriate policy measures.[27] Preparing national inventories is a critical first step in transitioning from ad-hoc disposal activities to systematic, nationally coordinated programs that maximise environmental benefits while ensuring cost-effectiveness and regulatory compliance. This will eventually serve as the framework for developing a NAP for the environmentally sound management of ODS and HFC banks and for overall LRM.

While MLF guidelines for national inventories focus specifically on used or unwanted substances, this Guide addresses inventories of all ODS and HFC banks and their contribution to LRM.

4.1 Methodological framework for national inventories

There are several existing methodologies for preparing ODS and HFC Bank inventories. This Chapter will briefly summarise an approach that builds on these processes and provides practical guidance on conducting inventories efficiently. The steps outlined are likely the best fit for LRM.

4.1.1 Preliminary desk study and stakeholder identification

A preliminary desk study involves reviewing available literature and existing information in the country to make the data collection exercise more efficient. This will simultaneously build upon data already gathered from existing plans and programs, such as HPMPs and KIPs, to identify the responsibilities and roles of all relevant actors in the ODS/HFC value chain. Identifying interested parties and other stakeholders is also important at this step, as they will be the primary respondents for the data collection activities that follow.

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25 The Executive Committee, at its 57th meeting in 2009 decided to look at pilot ODS disposal projects that would respond to decision XX/7 of the Meeting of the Parties to the Montreal Protocol. This decision specified that pilot projects could cover the collection, transportation, storage and destruction of ODS, with a focus on assembled stocks with high global warming potential (GWP) in a representative sample of regionally diverse Article 5 countries. The decision also postulated that ODS disposal demonstration projects should be feasible and include methods of leveraging co-funding

26 Paragraph 16, UNEP/OzL.Pro/ExCom/91/66. Criteria for a funding window to provide Article 5 countries with assistance to prepare an inventory of banks of used or unwanted controlled substances and to develop a plan for the collection, transport, and disposal (including consideration of recycling, reclamation, and cost-effective destruction) of such substances (decision 90/49(c)). UNEP Multilateral Fund Secretariat

27 Preventing the Dumping of Inefficient Cooling Equipment with High Global-Warming-Potential Refrigerants | Climate & Clean Air Coalition

To understand the available data landscape, a review of existing data from previous studies is required. Identify potential data sources from manufacturers, associations, customs departments, and national statistical databases. An initial analysis of available data from national surveys on HCFC consumption undertaken in the preparation of HPMPs, ODS alternatives surveys, equipment importers, recovery and recycling activities from waste management operators, and the collection, dismantling, and recovery of waste refrigerants and other substances from EOL equipment and cylinders should be undertaken during this step. This establishes an initial understanding of data availability and the regulatory context while identifying critical gaps.

Stakeholders should be identified to clarify the roles and responsibilities of all relevant actors in the ODS/HFC value chain. This process should consider gender-differentiated roles, including the participation of women in formal and informal servicing, waste handling, customs, retail, training institutions, and community-based collection activities, where applicable.

The roles of the various stakeholders should also be mapped, explaining where they are in the supply chain, what their interests are in the sector, and how to best communicate with them. Where feasible, stakeholder mapping and consultation processes should ensure balanced representation of women and men. Understanding these relationships and gaps will help design an effective consultation strategy for the final inventory.

4.1.2 Analysis of the national regulatory framework and initial consultation

A country's legislative and regulatory framework forms the backbone that supports LRM. To support the preliminary regulatory and policy context mapping, a country should assess its current regulatory framework; existing programmes supporting refrigerant recovery, recycling, and reuse; and policies on waste collection initiatives, including Extended Producer Responsibility (EPR). A review of the links between the overall ODS and HFC national policy and existing waste and hazardous waste management policies and regulations will guide the inventory approach.

An initial stakeholder consultation must be held to present the preliminary findings from the desk study and the methodology for further data collection and analysis. This critical step ensures their buy-in to the process, validation of the inventory preparation approach, and an open communication channel for data access. These stakeholders are also the sources of additional data that may be required.

4.1.3 Data collection and survey

This comprehensive phase includes conducting additional data collection and surveys to complete the inventory of ODS/HFC banks. Countries will define their data collection methodology based on national circumstances and initial information from the desk study, with the primary objective of validating and updating existing data. This will include a more comprehensive policy analysis and an understanding of the country's collection, treatment, and waste-management practices. It will also identify the sources of banks and establish a data-collection methodology to update the inventory in the future.

For this purpose, the Climate and Ozone Protection Alliance's (COPA's)[28] data collection methodology using the equipment-based and chemical consumption analysis approaches is described below. These are described along with a hybrid approach that Article 5 countries may wish to use in their inventory.

4.1.3.1 Equipment-based (Bottom-up approach)

The bottom-up methodology involves detailed sector-by-sector analysis to quantify refrigerant banks across all applications. This approach uses equipment-based data collection, following a step-by-step process: first, estimate the number of existing systems, considering key characteristics such as initial charge; second, determine how consumption is calculated using equipment stock figures and the share of refrigerant used; and third, compile data from all sources on equipment stock figures, the initial charge, and refrigerant market share. This data will then be processed using tools like Excel, focusing on a specific time series, to understand what can be managed and what can be left for future banks.

28 Papst, I., & Heubes, J. (2023). *Guideline to conduct an inventory of used or unwanted controlled substances: ODS and HFC banks.* Climate and Ozone Protection Alliance (COPA). Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH. https://www.copalliance.org/imglib/downloads/2023_COPA_Guideline%20Inventory%20for%20ODS_HFC_Banks.pdf

4.1.3.2 Chemical consumption analysis (Top-Down Approach)

The chemical consumption approach, or the use of import/export/production data, is considered a faster option because it relies on historical consumption data from existing national plans, including annual reporting through national licensing systems under Article 7 of the Montreal Protocol. It uses demographic indicators to estimate the total number of refrigerant banks. The objective of this approach is to extrapolate actual consumption from imports of different refrigerants rather than from equipment. This approach provides only a rough initial estimate of consumption, which can be cross-checked against the equipment approach.

4.1.3.3 Hybrid methodologies

The most effective data collection approach often combines the two described above, using top-down data to validate bottom-up estimates and identify data gaps. This hybrid approach provides cross-verification, improves overall accuracy, and optimises resource allocation during data collection.

4.1.3.4 Surveys

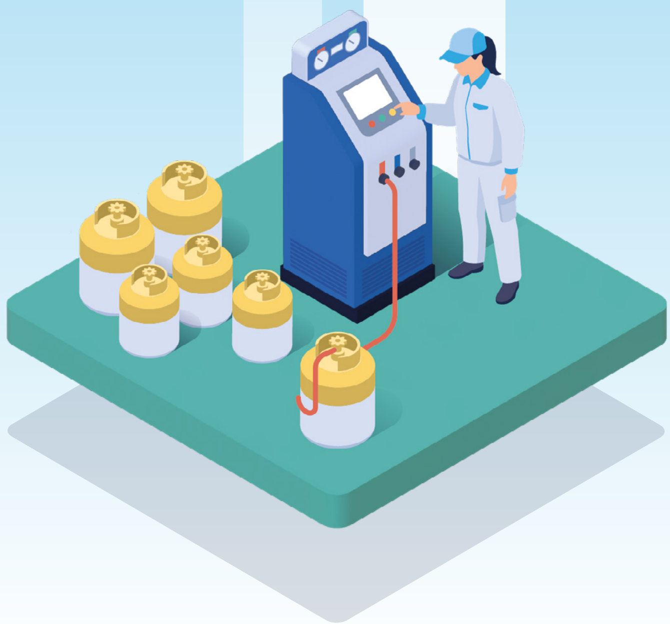
Surveys are an important step in the data collection process. Questionnaires are developed for service technicians on recovery equipment, service and recycling practices, and barriers to collecting used refrigerants. Information from collection centres is also needed to understand how the collection process works, how waste substances are transported, what storage methods are used, what testing procedures are implemented, and whether the centres have treatment facilities. An analysis of waste sources and quality will also determine recovery rates and collection effectiveness. The information collected will reveal any policy gaps, helping determine specific recommendations.

4.1.4 Finalisation of the Inventory Report

After data collection and analysis are complete, the national inventory report is prepared and presented for consultation with government and private-sector stakeholders, including waste management operators, collection centres, retailers, and refrigeration associations, to obtain validation and feedback. These consultations help build consensus on technical solutions and identify additional support requirements. The finalised report incorporates stakeholder input, addresses identified gaps, and provides comprehensive documentation of assumptions, data sources, and methodologies to ensure transparency and replicability. It consolidates validated data, actionable recommendations, and formal commitments to guide future waste management efforts.

4.1.5 Development of the National Action Plan

The final national inventory of banks is expected to provide the framework for Article 5 Parties to develop a NAP for the collection, transport, and disposal of these waste-controlled substances. This is detailed in the following chapter (Chapter 5).



05 Step-by-step guide to preparing an LRM-aligned National Action Plan

This Chapter provides guidance on the next crucial step: developing the LRM-aligned NAP. This NAP will integrate inventory findings, stakeholder input, and policy analysis into a comprehensive roadmap for managing waste-controlled substances and provide a solid basis for an LRM strategy. The inventory can be viewed as a map showing the locations of the refrigerant banks, and the NAP serves as the overarching strategy for addressing them systematically.

At the same time, a NAP cannot realistically be based solely on the inventory as it captures only a snapshot of banks of used or unwanted substances at a single point in time. Refrigerant banks are dynamic, and quantities change as equipment is installed and serviced, retired, or replaced. Effective NAP planning, therefore, requires an understanding of overall refrigerant flows, including imports, servicing demand, recovery rates, and EOL trends, and how these will evolve. This forward-looking perspective will allow developing countries to design NAPs that include the appropriate business models and financing arrangements to ensure the long-term sustainability of LRM implementation.

It is also important to recognise that countries are at varying stages of readiness. The approach to developing a NAP will depend on the comprehensiveness of the country's national inventory and the state of its knowledge and understanding of refrigerant banks and their supporting policies and regulations. A key principle to consider during this process is that the NAP should be integrated with the country's existing national phase-out plans, such as the HPMP and the KIP, and, where possible, with the NCAP or other cooling strategies.

NAPs should also include a description of a potential business model that details arrangements with various stakeholders and the private sector's commitment and involvement in activities ranging from waste collection to final destruction.

To assist countries in developing their NAP, a model NAP template is presented in the following chapter (Annex 1).

5.1 Defining the scope

Before developing the NAP for LRM, several guiding questions need to be addressed at the country level. These decisions will shape the direction and scope of the plan:

a. **Substances to be Recovered**
Should the NAP focus only on recovering ODS and HFC refrigerants, or also include recovering blowing agents contained in foams?

b. **Applications to be Included**
Which equipment types should be covered? For example, the NAP may limit activities to the RACHP sector, recognising that not all equipment types allow for cost-effective refrigerant recovery.

c. **Integration with existing national plans**
How will this NAP consider activities in the servicing sector that are already included in the HPMPs and KIPs? Do the HPMPs and KIPs adequately support the country's requirements for refrigerant management (i.e., are the right tools and equipment being provided to technicians, is assistance sufficient to professionalise the servicing sector, and are regulations in place to support LRM)?

d. **EOL Management Options**
How is the country's recovery, recycling, and reclamation infrastructure contributing to LRM? Should national capacity be developed for reclamation and/or destruction of collected non-usable substances, or should the country pursue alternative arrangements, such as regional cooperation or export to approved destruction facilities abroad?

5.2 Essential elements of the NAP

The NAP should address eight key elements. Each element is described below, along with practical steps on what to include. These could form the Chapters of your NAP.

ELEMENT 1

UNDERSTANDING SOURCES AND BANKS

An National Action Plan for LRM begins with a clear understanding of what is being managed. Refrigerant banks are not merely "stockpiles in cylinders." They are distributed across the economy: in split air-conditioners, supermarket refrigeration systems, transport vehicles, cold storage warehouses, and insulating foams. Each source presents distinct challenges for recovery.

By mapping these banks, countries can identify where to make interventions that yield greater gains. For example, large supermarkets may be concentrated sources of high-GWP HFCs, while the informal servicing sector may account for slow but continuous releases. Quantifying amounts and locations enables countries to plan targeted interventions, design collection networks, and anticipate storage needs.

Understanding sources also means distinguishing between what remains usable (i.e., what can be reclaimed and reused) and what has become waste (i.e., contaminated substances). Recognising this difference helps structure financial and technical strategies from the start.

This section will provide a clear picture of the types, locations, and volumes of refrigerant banks. The information and data for this section should come from the completed detailed inventory.

If the inventory is incomplete or not yet prepared, **Chapter 4** provides steps for preparing a national inventory of banks.

ELEMENT 2

POLICY AND REGULATORY FRAMEWORK

LRM and its elements (recovery, recycling, and reclamation (RRR), as well as destruction) work well only when backed by a solid policy and regulatory framework that covers the entire refrigerant lifecycle. Good regulations set the stage for containment during design and servicing, require recovery and reclamation when equipment reaches EOL, and provide oversight for safe destruction or export. Without this foundation, efforts become sporadic, optional, and hard to sustain. Ensuring that adequate laws and regulations, along with their enforcement, are in place to support the safe management of refrigerants is an important element of the NAP.

To complete this section, the following key activities should be completed:

- Review existing laws and international conventions[29] to which the country is a Party, including those regulating controlled substances, waste management, hazardous materials, and trade.
- Identify which laws and regulations already cover recovery, recycling, and reclamation, and highlight any overlaps or gaps, such as the absence of requirements for waste tracking.
- Identify which domestic laws and regulations correspond with provisions in international conventions and highlight gaps, such as the absence of regulations at the national level.
- After the review develop, or amend regulations that cover:
  - Certification of technicians and recovery facilities.
  - Standards for recovery and recycling equipment and for recovered and/or reclaimed refrigerants.
  - Tracking systems for waste refrigerants.
  - Import/export controls aligned with the requirements of the Basel Convention.
  - Safety and environmental standards for transport and storage.

A well-aligned framework avoids duplication, strengthens enforcement, and provides clarity for private sector actors.

ELEMENT 3

COLLECTION, TRANSPORT, AND STORAGE INFRASTRUCTURE

The NAP must define the specific activities required to establish an effective system for the safe handling of waste refrigerants. This is where the plan becomes operational. Without collection centres, proper recovery cylinders, and secure storage, refrigerants remain scattered across thousands of pieces of equipment and facilities. A well-designed system ensures a fully functional recovery, recycling, and reclamation infrastructure that secures these substances at each stage, preventing inadvertent venting.

When designing the system, it is important to build on the recovery and recycling activities already established under the country's HPMP or KIP. This ensures that the new setup does not duplicate efforts but instead creates a seamless process that reinforces existing practices, uses trained technicians and available infrastructure, and strengthens national capacity for long-term sustainability. The key actions to take are as follows:

- **Collection:** Link recovery to equipment replacement programmes and to servicing activities in the HPMPs and KIPs. Identify service workshops and retailers that can serve as collection hubs and explore connecting them into an in-country network to make it convenient for technicians and end-users to collect and recover refrigerants during servicing.

29 Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and Their Disposal

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- **Transport:** Moving recovered refrigerants from collection points to storage or reclamation/destruction facilities is the next important step in this process, unless these substances can be recycled or reclaimed on-site with the same equipment. The NAP should describe how this will work, including defining transport routes, specifying approved containers, and training personnel in the safe handling of these refrigerants.

- **Storage:** Most developing countries lack appropriate storage facilities for recovered refrigerants. It is important to consider whether it is financially viable to set up storage facilities — possibly through local refrigeration associations, or national or regional excellence or training centres. When designing these facilities, meeting safety and environmental standards should be a priority, and each facility should have sufficient capacity to handle projected volumes. Segregating refrigerants by type ensures the usability of reclaimed gases and prevents contamination.

  For smaller countries that may not have a waste stream large enough to require a storage facility, consider using local servicing associations.

- It is also important to establish a **tracking system**. A tracking system ties these steps together, ensuring that refrigerants are traceable from recovery through destruction or reclamation. Traceability builds confidence and ensures accurate reporting.

Refrigerant tracking systems at work

The tracking system that a country establishes should be tailored to its own unique circumstances and capacities. These examples have certain elements which can be considered in the NAP.

The **EU F-gas Regulation** requires electronic logbooks and reporting of quantities recovered, placed on the market, and destroyed (European Parliament and Council, 2024).

Japan's Act on Rational Use and Proper Management of Fluorocarbons mandates designated end-users to report leakage amount, based on logbook keeping. Also, it mandates recovery operators to record and report refrigerant flows to the government. Non-compliance can trigger strict penalties. (Government of Japan, adopted as the Fluorocarbon Recovery and Destruction Act in 2001, revised in 2015 and updated in 2020).

The **United States EPA** has established tracking requirements under Section 608 of the Clean Air Act, requiring technicians to maintain records of refrigerant sales and service and to document recovery and reclamation (U.S. EPA, 2017).

The **Australia Refrigerant Reclaim Scheme (RRA)** has built a nationwide voluntary-but-mandatory return system with detailed tracking of cylinders and recovered gases (RRA, Updated 2020).

ELEMENT 4

ROLES AND RESPONSIBILITIES OF STAKEHOLDERS

Managing refrigerant banks involves many institutions and stakeholders. Each relevant actor, including government agencies, customs officials, service technicians, waste operators, collectors and consolidators, and private companies, plays a distinct role. Defining the roles of these stakeholders across the refrigerant management chain is essential to a NAP.

The NAP should spell out who does what at each stage. While the overall responsibility might initially lie with the NOU as the agency responsible for putting together the Plan, other partners need to know their place in the framework.

During the preparation of the NAP, the following steps must be undertaken:

- Identify all relevant actors, contact them, and bring them together for coordination meetings
- Define the roles and responsibilities of each partner and establish a coordination mechanism, and
- Create a matrix to illustrate who does what, ensuring clarity at every step of LRM.

When defining roles and responsibilities, the NAP should assess whether women and men have equitable opportunities to participate in different functions along the refrigerant lifecycle, including decision-making, technical operations, and service delivery. Measures to promote inclusive participation, such as gender-responsive procurement, training quotas, or partnerships with vocational institutions should be considered where appropriate.

The NOU often leads coordination and reporting; environment ministries oversee regulations; customs enforce import/export controls; technicians recover refrigerants; collection centres verify and store; transporters move materials safely; and destruction or reclamation facilities provide final treatment.

ELEMENT 5

TECHNOLOGY OPTIONS FOR DISPOSAL

Disposal is the last resort for refrigerants that cannot be reused or reclaimed, and it involves destruction. It is the final safeguard against releasing these harmful substances into the atmosphere. Choosing how to do this is one of the most strategic decisions in a NAP, because disposal determines both environmental effectiveness and financial feasibility.

Prior to preparing the NAP, the country may have had experience with the disposal of unwanted substances, perhaps through domestic destruction or export for destruction. The lessons learned from these experiences, or the lack thereof, are important considerations when expanding this section of the NAP.

This element should assess the technology options for disposing of waste refrigerants, including destruction options. The practical steps for doing this include:

- **Research existing destruction technologies**

    - Survey and understand the approved destruction technologies under the Montreal Protocol (e.g., plasma arc, cement kilns, incineration).[30, 31, 32, 33]
    - Determine which technologies would fit within the country's conditions and capacity.
    - Include an analysis of the environmental performance, cost, and technical requirements of each option.

- **Evaluate domestic capacity**

    - Find out whether existing domestic facilities, such as hazardous waste incinerators or cement kilns, can destroy these refrigerants. Document these and describe how they can be used.
    - Assess whether these facilities meet the Montreal Protocol standards for destruction, and whether they can accept refrigerants.
    - Consider the feasibility and costs of establishing new domestic destruction capacity, and determine whether it is required; and understand the business model that will make this facility economically viable.

- **Explore co-disposal options**

    For countries with small waste streams and limited disposal or destruction facilities, it is important to consider combining the disposal of refrigerants with that of other hazardous wastes, such as Persistent Organic Pollutants (POPs). This approach can reduce costs by sharing destruction capacity.

- **Export for destruction**

    Pilot ODS disposal demonstration projects have shown that, in the absence of local destruction facilities or cement kilns that can be adapted for safe disposal, the more cost-effective option for many Article 5 Parties is to aggregate waste and export it to non-Article 5 Parties for destruction. While this option may still be considered under specific circumstances, NAPs should clearly acknowledge the broader concerns it raises.

    Exporting waste refrigerants for destruction entails additional transaction and transport costs that may be prohibitive for developing countries. Additionally, Party compliance with Basel Convention obligations, or the obligations of similar or related national laws, poses another layer of complexity to the process and may even result in unwanted emissions during the transport process. Where export for destruction is linked to carbon credits, there is concern that these may raise integrity issues, referencing earlier carbon market experience in which crediting for

30 The U.S. EPA's updated report ODS Destruction in the United States and Abroad (2021) reviews destruction technologies, grouping them into incineration, plasma, and non-incineration methods, including cement kilns, and provides practical case studies of application in Article 5 and non-Article 5 Parties.

31 The Climate and Ozone Protection Alliance (COPA), in collaboration with UNIDO, UNDP, and GIZ, published a 2023 report on ODS/HFC Reclamation and Destruction, outlining the state of approved destruction technologies and identifying barriers to their adoption in developing countries.

32 The Montreal Protocol Technology and Economic Assessment Panel (TEAP) response to Decision XXXVI-3 (2025) reaffirms plasma arc, incineration, and cement kilns as established destruction technologies under the Protocol, while noting implementation challenges in some regions.

33 Recent guidance under COPA (2023) and TEAP (2025) highlights cement kilns as a practical option for ODS/HFC destruction, noting their high operating temperatures (1,000–1,600°C) and long residence times, if acid gas scrubbing systems are in place to manage by-products.

HFC-23 destruction created unintended incentives related to HCFC-22 production.[34] These experiences emphasise the need for safeguards to ensure that destruction activities do not inadvertently result in unintended consequences, or undermine the environmental gains achieved under the Montreal Protocol.

For these reasons, export could be regarded only as a measure of last resort, pursued solely where no safe, technically sound, and economically feasible domestic option exists, and always under strict controls consistent with applicable international and national laws.

ELEMENT 6

IMPEDIMENTS AND BARRIERS TO MANAGING REFRIGERANT BANKS

Every country will face obstacles in setting up systems for refrigerant bank management. Some are technical, others financial or institutional, and some stem from international law. Recognising these barriers early makes the NAP more realistic and avoids costly delays. A transparent assessment also helps determine whether domestic destruction is viable or whether export must be considered.

- **Domestic challenges** are often the most immediate. Many countries lack facilities for destruction or the expertise to operate them safely. Waste volumes may be too small to justify investment, or capital costs too high. Skilled technicians and inspectors may be scarce, weakening enforcement of recovery rules. Even where facilities exist, gaps in permitting, monitoring, or safety standards can limit credibility. Any potential facility (especially cement kilns for Article 5 Parties) must be identified and assessed to determine its suitability for use as a destruction facility.

- **Exporting for destruction** is not simple. Aggregating waste into viable volumes and securing contracts agreed with companies are challenges for many developing countries. The Basel Convention[35] also requires permits and strict procedures for hazardous waste shipments, and not all Parties have the necessary legal frameworks or administrative capacity to comply. Paperwork, coordination between governments, and costs for packaging, shipping, insurance, and destruction fees can quickly become burdensome. Exporting these wastes for carbon credits also needs to be examined thoroughly.

- **Institutional barriers** also play a role. Coordination among various national entities is frequently a challenge, and these barriers must be identified in the plan. This will ensure that responsibilities are clearly defined. In many Article 5 countries, recovery and recycling remain largely informal, making oversight difficult and making it hard to ensure that gases are collected and processed through a system. The plan should endeavour to address most, if not all, of the institutional barriers.

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34 Romm, J., Lezak, S. and Alshamsi, A (2025). *Are Carbon Offsets Fixable?* Annual Review of Environment and Resources, 50. Discusses integrity risks in carbon offset markets, including non-additionality and perverse incentives in earlier mechanisms such as HFC-23 destruction under the Clean Development Mechanism. See also VCMI (2023), *Ensuring High-Integrity Carbon Market Activities.* https://vcmintegrity.org/wp-content/uploads/2023/05/VCMI-decision-sheet-5.pdf

35 In the African region, the Bamako Convention, a regional treaty of African nations prohibiting the import into Africa of any hazardous (including radioactive) waste, is enforced for signatories. For Pacific Island countries, a similar regional treaty exists, the Waigani Convention which also bans the import into the region of hazardous wastes. In contrast with the Basel Convention which allows transboundary movement of hazardous wastes under strict consent and environmentally sound management, both the Bamako and the Waigani Convention prohibit imports of hazardous waste into Africa and the Pacific islands and add stricter controls. In a sense, these regional conventions strengthen obligations under the Basel Convention for these two regions.

- **Financial constraints** affect all aspects of refrigerant management. Collection, transport, and storage require sustained resources, yet programs often fade when donor support ends. The plan should detail the costs and how they can be funded.
  Mapping these obstacles in the NAP enables countries to set realistic timelines, design targeted solutions, and make the case for international support. Anticipating barriers is key to building systems that endure.

ELEMENT 7

ESTABLISH THE INSTITUTIONAL FRAMEWORK

Technical systems can be designed and financed, but without strong institutions to anchor them, they rarely last. A refrigerant management system needs more than equipment and rules — it needs institutions that provide leadership, coordination, and continuity over time.

- **Clear leadership** is essential. One agency must be designated as the lead, usually the NOU or the Ministry of Environment or equivalent body. This agency coordinates activities, ensures alignment with Montreal Protocol obligations, and reports progress. Clear leadership prevents duplication and provides stakeholders with a single point of reference.

- **Interagency coordination** is equally important. Refrigerant management spans ministries and other executive agencies in trade, energy, environment, finance, and customs, among others. If each ministry or agency works in isolation, the result is inefficiency, inconsistent program implementation, and gaps in enforcement. Coordination mechanisms, such as inter-ministerial committees, technical working groups, or joint reporting platforms, ensure that intragovernmental responsibilities are shared, and that actions are harmonised.

- **MRV systems** provide credibility. Collection centres should submit regular reports on recovered quantities; destruction facilities should provide certificates; and customs should track imports and exports. These systems enable countries to measure progress against targets, identify leaks or weaknesses, and demonstrate compliance with the Montreal Protocol.

- **Capacity building** is a core part of the institutional framework. Activities required for technician capacity building — technician training in recovery and recycling techniques, inspector and customs officer training to recognise controlled substances, and facility operator training in the safe handling, storage, and destruction of refrigerants — must be clearly listed and outlined. Certification and accreditation programmes should be established to improve quality and build professional pride and accountability.

- **Sustainability** must also be addressed from the planning stage. Important questions include: Will collection and destruction systems be operated by public authorities, private companies, or a combination of both? How will operations continue when donor funding ends? Institutional arrangements should clarify how systems will be financed, managed, and adapted as technologies and market conditions evolve.

Why MRV matters for LRM

A strong MRV system is the foundation on which a credible NAP for LRM implementation rests. Systematic tracking and verification make it possible to demonstrate that refrigerants have been recovered, reclaimed, or destroyed, and to quantify the resulting climate and ozone benefits. Reliable MRV data strengthens confidence among governments, donors, and financiers, facilitating access to sustained financing and enabling evidence-based policy decisions.

MRV operates at distinct but interconnected levels. At the ground level, it develops systems and tools to capture the actions of technicians, service enterprises, and recovery operators, generating the primary data on which other analysis depends. At the national level, this data is aggregated into inventories and compliance reports that demonstrate progress relative to countries' international obligations and climate commitments. The integrity of the national level reporting depends entirely on the quality of data collected at the ground level, making investment in ground-level MRV tools and capacity an essential foundation for the entire system.

Countries should invest in MRV capacity early to better access performance-based financing and demonstrate progress toward and achievement of national objectives over time.

ELEMENT 8

COSTED AND PRIORITISED IMPLEMENTATION PLAN

Once all elements and their corresponding actions are identified, it is important to build a prioritised, costed implementation strategy that will form the operational core of the NAP, ensuring the identified activities are feasible, cost-effective, and ready for implementation.

When making the implementation strategy and budget, consider the following actions and questions:

- Identify and list all specific activities that need to be funded under the NAP. Use information gathered from the previous seven elements to develop a comprehensive list of activities required to implement the NAP. Group these activities under the relevant components of the LRM framework, where possible (e.g., policy and regulatory framework, recovery, reclamation, technology transfer, and institutional capacity).
- Estimate the funding required for the activities listed above, identify which of these activities already have funding (i.e., from the HPMP or KIP), and then make a prioritised list.
- What are the additional funding requirements, and how would they be coordinated with current activities?
- What funding sources are currently available in the country to help finance the NAP, and how can they be approached?
- Include a description of a potential business model that details arrangements with various stakeholders and the private-sector commitment and involvement in activities, from responsible equipment servicing and waste collection to eventual destruction.

Cost elements that may be included:

- Recycling/reclamation: additional recovery machines and tools, storage cylinders (non-disposable), training and other equipment, and capacity building/training
- Collection infrastructure: equipment, facilities, personnel
- Transportation: vehicles, containers, fuel
- Storage: Facility rental or construction; security and maintenance
- MRV: establishing digital systems, managing inspection costs, coordination, and reporting
- Institutional support: allowances for stakeholders; coordination meeting costs

It might also be helpful, when analysing and developing the cost of the NAP, to create scenarios for handling waste refrigerants. Some scenarios are presented below:

- Strengthening the country's recovery and recycling infrastructure to reduce banks
- Domestic destruction with one or more new facilities or mobile destruction equipment
- Export to an established destruction facility through private refrigerant management companies
- Regional or South-South cooperation/destruction options with neighbouring countries
- Co-disposal with other hazardous wastes

The cost of these scenarios will vary based on how well established the country's refrigerant management system is and whether there is already a way to collect waste refrigerant gases. It is essential to use inventory data to provide an overall picture of how costs can be estimated for the plan, considering the parameters outlined above.

It is also important to identify potential financing sources while developing a budget. Some potential financing sources may include the following:

- The **Multilateral Fund,**[36] through its Executive Committee, as the main source of international support, considers funding of activities consistent with HPMPs, KIPs, funding windows, and other projects, including technical assistance, capacity building, and pilot demonstrations that strengthen national LRM systems.

- **National budgets** should allocate co-financing to demonstrate government ownership, sustain institutional structures, and ensure the long-term continuity of LRM actions beyond project cycles, particularly for enforcement, data management, and training programmes.

- **Private sector contributions**, through levies on imported equipment, refrigerants, or servicing licenses, can create a sustainable national funding stream that links producers, importers, and end users to the costs of proper RRR. Public-private partnerships (PPPs) and Extended Producer Responsibility (EPR) approaches can also be explored.

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36 The Multilateral Fund for the Implementation of the Montreal Protocol was established in 1991 to assist developing countries in meeting their Montreal Protocol obligations through strategic project investments, technical guidance and capacity building; funding is provided to Article 5 countries through project proposals submitted and approved by the MLF's Executive Committee following the MLF Policies, Guidelines and Procedures

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- **Donor or climate finance programmes**, such as the GEF, GCF, or bilateral assistance, can be mobilised when LRM activities align with mitigation, circular economy, or energy-efficiency goals, supporting complementary investment in technology and infrastructure.

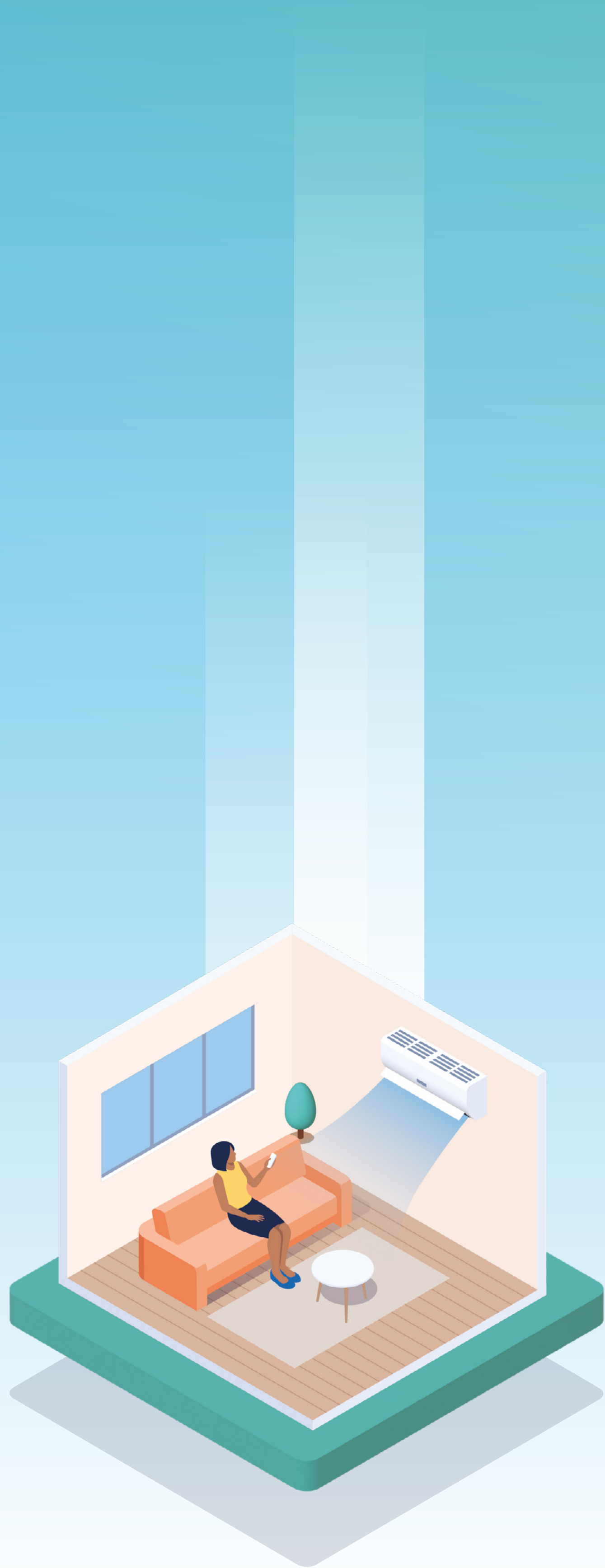
- **Revenues from reclaimed refrigerants and recycled materials** can help offset the operational costs of reclamation centres, incentivise collection and return, and foster a self-sustaining market mechanism that rewards environmentally responsible recovery and reuse practices.

The main outputs of this section are:

- A costed and prioritised implementation plan aligned with MLF and national frameworks
- Defined institutional responsibilities, financing mechanisms, and timelines
- A ready-to-use framework for preparing project proposals and coordinating with donors
- A monitoring and reporting mechanism linking financial inputs to environmental outcomes
- A business plan model for LRM that is responsive to the country's requirements and waste stream.

LRM business models that deliver

When developing an LRM business model, countries should define clear roles and financial arrangements among stakeholders from collection and transport to reclamation or destruction. The model should outline responsibilities, cost-sharing mechanisms, and revenue flows, ensuring private sector participation through incentives, contracts, or public-private partnerships that promote accountability and long-term sustainability.



06 Technical options for recovery, recycling, reuse, and destruction

This Chapter builds on the concepts and guidance presented in Chapters 2 and 5, which described the LRM approach and the step-by-step process for developing a NAP. The technologies and practices outlined here are designed to help Article 5 countries determine how to recover, treat, and dispose of controlled substances in an environmentally sound and economically viable manner. They are intended as a reference, as each country may choose the options that meet its domestic requirements, and these technologies and practices should be consistent with its NAP.

6.1 Recovery and collection options

As described in Chapter 2, recovery is the foundation for all subsequent LRM actions. It must be performed whenever refrigeration or air-conditioning systems are serviced, repaired, or decommissioned.

Recovery requires the use of both portable and larger recovery units, vacuum pumps, scales, and approved storage cylinders. In large commercial or industrial systems, high-capacity recovery units and dedicated transfer lines improve efficiency. Technicians should be certified (as discussed in Chapter 5, Element 7) and ensure that recovery occurs under vacuum to minimise losses.

Recovered gases must be transferred into reusable, non-disposable cylinders that are clearly labelled by type and source. Mixing gases should be avoided because it reduces reuse potential and increases destruction costs. Transport must comply with national hazardous-materials regulations and international safety standards.

For LVC countries, aggregating recovered gases through servicing networks or regional hubs is essential because it can reduce logistical costs.

6.2 Recycling and reclamation options

6.2.1 Recycling

Recycling involves on-site cleaning of used refrigerant through processes such as filtering, drying, and oil separation to remove particulates, moisture, and acid contaminants. This is typically performed at the workshop or service centre level using portable or semi-portable recycling units, which can be shared among service technicians or integrated into recovery-and-recycling (R&R) centres.

Basic recycling units often consist of:

- Moisture and acid filters to remove contaminants
- Oil separators to eliminate compressor lubricants
- Dryers and purifiers using molecular sieves or desiccants
- Vacuum pumps and cylinders for recharging the refrigerant into the same or similar equipment

This equipment is often already provided through the HPMP and the KIP, and, if not, is readily affordable and suitable for technician cooperatives, vocational training centres, or national recovery programs, especially when linked to mandatory recovery and reuse regulations.

Although recycled refrigerant does not meet the certified purity levels of virgin or reclaimed gas, it may be sufficient for recharging similar systems in a controlled environment, reducing demand for new imports and minimising emissions.

To ensure quality and safety, countries can include the following in their NAPs:

- **Training modules** on proper recycling and identification of refrigerant types
- **Guidelines** restricting use to "like-for-like" applications to prevent cross-contamination
- **Labelling and documentation systems** to trace recycled refrigerants within servicing networks

6.2.2 Reclamation

Reclamation is a more advanced process that restores recovered refrigerant to virgin-equivalent quality, meeting international purity standards such as AHRI 700. The process typically includes several steps:

1. **Pre-filtering and drying** to remove large particulates and moisture
2. **Fractional distillation or molecular** filtration to separate refrigerant mixtures and contaminants
3. **Chemical treatment** to neutralise acids or react with impurities
4. **Gas chromatography (GC) analysis** to verify composition and purity

In practice, many developing countries may lack the required infrastructure for an advanced reclamation facility. However, the options presented below will allow each country to design its own approach based on the available resources.

- **Basic reclamation units** equipped with advanced filtration and dehydration can be installed at existing HPMP training centres or recovery hubs. These units require limited investment and can handle smaller volumes of common refrigerants (R-22, R-134a, R-410A), and may be funded under the HPMPs and KIPs.

- **Mobile reclamation units** can be used between major cities or servicing clusters, providing periodic collection and purification services. This model has been successfully used in several Article 5 countries[37] and offers flexibility when volumes are dispersed. These examples demonstrate that mobile systems are a scalable, low-investment approach for developing countries, especially when paired with national recovery mandates and technician training programs.

- **Regionally accessible reclamation facilities**[38] can serve multiple countries with low refrigerant demand, through cost-sharing arrangements or public-private partnerships. Such facilities can leverage existing gas or chemical plants, minimising the need for new infrastructure. This underscores the practical model: smaller/LVC countries can outsource reclamation to facilities in regional or neighbouring countries, while considering regulations governing the transport of these substances.

In their study of ODS/HFC reclamation and destruction technologies, COPA listed the following technical reclamation options:

Distillation: Separates refrigerants from impurities by heating them to boiling temperatures. Effective for single-gas refrigerants but less effective for blends.

Adsorption: Uses materials like activated carbon, membranes, or metal-organic frameworks (MOFs) to capture and clean specific refrigerants. Effective but requires advanced technology.

Subcooling: Condenses refrigerants into a liquid, filters impurities, and removes non-condensable gases. Effective but costly and energy intensive.

6.3 Destruction technologies

Destruction is the final stage in the LRM hierarchy and should be used only when refrigerants are contaminated, mixed, or legally and technically obsolete. Chapter 5 (Element 5) identified destruction as a policy option; this section provides technical details to assist developing countries in deciding which option to select.

Under the Montreal Protocol (including Montreal Protocol TEAP guidance), the selected destruction technologies must meet the required destruction and removal efficiency (DRE ≥ 99.99%) and emission-control standards.

37 To name a few, under its HPMP, India deployed mobile R&R units managed by the National Productivity Council and GIZ Proklima to serve multiple cities and training centres, especially for R-22 recovery and reuse; Indonesia's HPMP used mini reclaim units, and mobile reclamation equipment was used to support training and demonstration of good practices in major islands beyond Java.

38 Bahrain has a national reclamation facility that can serve the GCC region; Grenada has a project underway to establish a refrigerant recovery and reclaim centre that can be used by Caribbean countries.

39 ODS/HFC Reclamation and Destruction Technologies: A Review for Article 5 Countries. Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH, September 2023. Available at: https://www.copalliance.org.

The table below describes four destruction technologies included in the COPA study that may be used in developing countries:

Technology	Description	Advantages	Disadvantages
Cement Kilns	High-temperature kilns used for cement production can be adapted to destroy ODS/HFCs. Gases are injected into the hottest part of the kiln (up to 1600°C), ensuring destruction and binding reaction by-products into the cement clinker.	Widely available in Article 5 countries. Relatively low cost for adaptation. Effective destruction with minimal by-products when properly managed.	Requires infrastructure adjustments (e.g., gas injection systems, storage facilities). Emissions (e.g., dioxins, furans, acid gases) need monitoring and control.
Municipal Solid Waste Incineration (MSWI)	Large-scale incineration plants used for city waste can destroy ODS/HFCs, including foams containing these substances.	Useful if existing MSWI plants are available. Can destroy foams containing ODS/HFCs.	High investment and operational costs for new plants. Risk of incomplete destruction and high emissions if temperatures are not maintained.
Rotary Kiln Incineration	Uses a rotary kiln furnace with high temperatures (1200°C) and a post-combustion chamber for hazardous waste destruction.	Effective for destroying ODS/HFCs and other hazardous substances. Can be installed near industries and serve multiple purposes.	High building and operational costs. Requires advanced emission control systems.
Argon Plasma Arc	Uses electricity to create a high-temperature plasma (up to 20,000°C) that destroys ODS/HFCs through pyrolysis (anoxic thermal degradation).	Highly effective destruction with minimal emissions (low dioxins and by-products). Compact technology (24 m^2) that can be installed in chemical facilities.	High costs Requires pretreatment of ODS/HFCs to remove oils and ensure low emissions. Limited availability due to patent restrictions.

The study also recommended cement kilns as the most suitable destruction technology for Article 5 countries due to their availability and adaptability.

Effective management of refrigerants at EOL requires a practical balance among environmental soundness, technical feasibility, and economic efficiency. The recovery, recycling, reclamation, and destruction options outlined in this Chapter demonstrate a phased approach that can be adapted to national circumstances: start with systematic recovery and basic recycling, then progress to reclamation, and ultimately to destruction where unavoidable. Developing countries can build on existing HPMP and KIP investments, strengthen technician training and certification, and establish partnerships with regional or private facilities to scale up these activities in a cost-effective way. Integrating these technical options into the broader framework of national policies and financing mechanisms described in earlier chapters will help countries achieve the objectives of their NAPs for LRM, minimise emissions, and move toward a sustainable, circular management of refrigerants consistent with the goals of the Montreal Protocol.

Guidance checklist: Preparing an LRM-aligned NAP

Use this checklist to ensure all essential elements are addressed when preparing the NAP. Each step should be tailored to the national context and build on inventory results, existing policies, and available capacities.

1. **Define the Scope**

   - ☐ Decide which substances to include (ODS, HFCs, foams).
   - ☐ Identify sectors and equipment types to be covered (RACHP, foams, transport).
   - ☐ Align with HPMPs, KIPs, and cooling strategies.

2. **Review Policy and Regulatory Framework**

   - ☐ Assess existing laws on controlled substances, waste, and trade.
   - ☐ Identify gaps (e.g., certification, tracking, safety standards).
   - ☐ Develop or amend regulations to cover recovery, recycling, destruction, and import/export controls.

3. **Collection, Transport, and Storage Infrastructure**

   - ☐ Build on existing HPMP/KIP activities.
   - ☐ Identify collection hubs (workshops, retailers).
   - ☐ Define safe transport routes, approved containers, and training.
   - ☐ Plan for safe storage facilities (segregation, safety standards).
   - ☐ Establish a tracking system from recovery to final treatment.

4. **Define Roles and Responsibilities**

   - ☐ Map all stakeholders (NOUs, ministries, customs, technicians, private sector).
   - ☐ Clarify responsibilities through coordination mechanisms.
   - ☐ Develop a stakeholder matrix.

5. **Technology Options for Disposal**

- ☐ Review approved destruction technologies (municipal solid waste or rotary kiln incineration, cement kilns, plasma arc).
- ☐ Assess domestic capacity and compliance with Protocol standards.
- ☐ Consider co-disposal with hazardous wastes.
- ☐ Evaluate costs, environmental performance, and feasibility.
- ☐ Export only as a last resort, under strict controls.

6. **Identify Barriers and Impediments**

- ☐ Technical: lack of facilities, small waste volumes.
- ☐ Institutional: weak coordination, informal recovery systems.
- ☐ Financial: collection, transport, storage costs.
- ☐ Legal: Basel Convention procedures and permits.

7. Establish Institutional Framework

- ☐ Designate a lead agency (e.g., NOU/Ministry of Environment).
- ☐ Set up cross-agency coordination mechanisms.
- ☐ Develop monitoring and verification systems.
- ☐ Build capacity (training, certification, accreditation).
- ☐ Define sustainable institutional arrangements beyond donor support.

8. Costs and Financing

- ☐ Identify all cost elements (infrastructure, training, monitoring, institutional support).
- ☐ Map existing vs. additional funding needs.
- ☐ Explore sources: MLF, national budgets, private sector, donors, reclaimed refrigerant sales.
- ☐ Develop long-term financing strategies (levies, service fees, responsibility schemes).
- ☐ Describe a business plan for implementing the NAP.

07 Priority actions and recommendations for near-term implementation

The development of NAPs for LRM presents a critical opportunity for Article 5 countries to transform inventory results and pilot initiatives into long-term, institutionalised systems. Drawing on the lessons and analyses throughout this Guide, the following recommendations aim to help governments, implementing agencies, and partners design coherent, enforceable, and financially sustainable national frameworks that deliver verifiable ozone and climate benefits.

1. Strengthen national policy and regulatory frameworks

A coherent legal foundation is the cornerstone of LRM. Countries should, within their HPMPs, KIPs, NCAPs, and other cooling strategies, review and amend existing environmental, trade, and waste-management legislation to explicitly cover the entire refrigerant lifecycle, from import and use through recovery and destruction. The following key actions should be prioritised:

- Mandate recovery and prohibit venting.
- Define quality and safety standards for reclaimed refrigerant.
- Require licensing and certification.
- Integrate refrigerant waste into hazardous-waste and extended producer responsibility (EPR) regimes.
- Adopt a national regulatory framework to comply with international conventions on waste management to which the country is a Party (e.g., Basel Convention).

2. Build national capacity and coordination mechanisms

Developing a clear framework and institutional structure is essential to sustained LRM implementation. Countries should:

- Designate a national lead agency (typically the NOU).
- Establish inter-ministerial committees or technical working groups.
- Create stakeholder platforms with servicing associations, importers, and financial institutions.

3. Develop comprehensive collection, storage, and tracking systems

Effective LRM depends on safe, traceable movement of refrigerants. Governments should prioritise:

- Nationwide recovery networks linked to servicing workshops and replacement programmes.
- Approved storage facilities and aggregation hubs.
- Transport regulations specifying approved cylinders and documentation.
- Digital tracking systems for transparency and performance monitoring.

4. Prioritise reclamation and local destruction capacity

The hierarchy of LRM interventions should favour recovery, reuse, and reclamation (RRR) before destruction. Policy frameworks should:

- Promote domestic reclamation facilities through concessional loans or public-private partnerships.
- Incentivise reclaimed refrigerant use via import-quota credits or tax incentives.
- Use existing infrastructure such as cement kilns for cost-effective destruction.
- Treat export for destruction as a last resort.

5. Integrate LRM with existing HPMPs, KIPs and national cooling sector strategies

Countries may consider mandating the integration of LRM with ongoing HPMPs, KIPs, and NCAPs as a cross-cutting policy approach. This ensures strategic alignment of refrigerant management with energy efficiency, sustainable cooling, and climate objectives. Governments should establish interagency coordination mechanisms, harmonise data and reporting frameworks, and link LRM interventions with NDCs. Utilising existing institutional structures and financing channels, including the Multilateral Fund and national green finance programmes, will enhance implementation efficiency, reduce duplication, and deliver greater environmental and socioeconomic impact.

6. Establish robust MRV systems

Robust MRV systems are essential to ensure the accuracy, consistency, and credibility of refrigerant management data. They enable governments to track progress toward national and international commitments, assess environmental benefits, and demonstrate compliance. Reliable MRV frameworks also build investor and donor confidence, facilitating access to sustainable financing and performance-based incentives. National MRV frameworks should be established to do the following:

- Define standardised metrics (quantities recovered, reclaimed, destroyed, CO_2-equivalent avoided).
- Align data across HPMP/KIP reporting, customs, and national GHG inventories.
- Require verification by accredited laboratories and third-party auditors.
- Applying electronic data tracking system to facilitate data recording on the ground and increase transparency, if available

7. Continue capacity building across stakeholders for LRM

Successful LRM relies on the sustained development of human and institutional capacities across all actors in the refrigerant value chain, from technicians and service companies to policymakers, inspectors, and end users. Continuous capacity building ensures that good practices introduced through HPMPs, KIPs, and NAPs are not one-off initiatives, but part of an ongoing system of professional standards and national ownership. The following should be prioritised:

- Certification and refresher training for technicians, inspectors, and customs officers.
- Establishment of centres of excellence for recovery and reclamation.
- Awareness campaigns targeting equipment owners and service enterprises.

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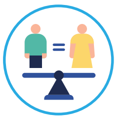
8. Promote regional cooperation and approaches

Regional cooperation should be promoted as a strategic policy measure to enhance the effectiveness and cost-efficiency of LRM, particularly for LVC countries. Joint approaches can enable shared use of destruction and reclamation facilities, harmonised data and reporting protocols, and pooled training resources, while complying with Basel Convention requirements. Governments and regional organisations should facilitate South-South cooperation, technology transfer, and peer learning through regional networks, twinning programmes, and centres of excellence, thereby strengthening institutional capacity and promoting consistent implementation of LRM measures across borders.

9. Set clear targets and timelines

The NAPs for LRM should establish clear, measurable targets and timelines to guide implementation and track progress. These targets provide accountability, enable performance monitoring, and attract sustained financing. Countries should:

- Define specific, time-bound goals for recovery, reclamation, reuse, and destruction aligned with HPMP, KIP, and NDC commitments.
- Set interim milestones to assess progress and adjust actions as needed.
- Link targets to MRV systems to ensure data consistency and transparency.
- Integrate performance indicators into national reporting frameworks to support evidence-based policy decisions and funding mobilisation.



10. Promote gender equality and inclusive participation in LRM systems

Governments and implementing agencies should integrate gender-responsive approaches across policy design, capacity building, financing, and monitoring, in line with national gender policies and international commitments, ensuring that LRM contributes to inclusive green job creation and just transitions in the cooling sector.

Conclusion

The priority actions and recommendations outlined in this Chapter provide a practical roadmap for countries to transition from fragmented initiatives to integrated national systems for LRM. By embedding LRM within existing policy and financing frameworks, building institutional and human capacity, and fostering regional collaboration, countries can achieve measurable reductions in emissions of ODS and HFCs while improving energy efficiency and compliance with the Montreal Protocol and its Kigali Amendment. Clear targets, robust MRV systems, and sustained coordination among stakeholders will be essential to transform NAPs from planning tools into operational mechanisms that meet Parties' Montreal Protocol compliance obligations and promote LRM.

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Annex 1: Model National Action Plan (NAP) template and performance indicators

Chapter 5 of this Practical Guide outlined the core elements required for the environmentally sound management of waste-controlled substances throughout their lifecycle. These elements form the foundation for developing a coherent and effective strategy. This section presents these elements in a practical implementation framework through a model NAP template.

The template provides simplified instructions to help Article 5 countries transform the conceptual framework presented in Chapter 5 into an actionable, country-specific plan that integrates policy, technical, institutional, and financing dimensions. It serves as both a design and reporting tool, ensuring that each country's proposed actions align with MLF project submission requirements and reflect measurable progress toward compliance and sustainability.

Each section of the template corresponds to one of the eight core elements of Chapter 5 and provides a structured outline for national teams to document current conditions, identify priorities, and plan interventions. Guidance boxes are provided in each Chapter that expand on these elements, explaining the data to be collected, the institutional arrangements to be clarified, and the indicators to be tracked.

The inclusion of performance indicators in each section allows NOUs, implementing agencies, and other partners to set quantifiable targets, monitor implementation, and report results that are initially aligned with MLF performance frameworks. These same indicators can also be used to report to other potential funding partners on specific elements of the NAP that may not be eligible for MLF funding. When fully completed, the NAP will form a comprehensive, strategic national plan that links regulatory action, technical systems, and financing options into a coherent strategy for lifecycle refrigerant management.

How to use this template: Complete each section by entering the required information in the boxes and tables. Add space as needed. Instructions can be deleted once the specific section is completed.

COVER PAGE

National Action Plan for Refrigerant Banks	
Country	[add country name]
Implementing agency	[add implementing agency or other partners]
Funding requested	[insert funding requested and funding source]
Date	[insert date]

MODEL TEMPLATE OUTLINE

Executive Summary

*[**Instructions:** Summarise the overall goal, objectives, scope and expected outcomes of the NAP, and highlight collaboration with HPMPs and KIPs. Include a summary of the data and information from the preceding sections (i.e., refrigerant volumes, waste quantities identified, main collection approaches, and expected environmental benefits in reduction of megatonnes of carbon dioxide equivalent (MT CO_2-eq) emissions). Include information on activities and cost in a summary table.]*

1. Defining the Scope and understanding the sources of banks

*[**Instructions:** Outline which substances, applications, and sectors are covered, and clarify how the NAP aligns with the HPMP, KIP, and waste-management frameworks.]*

[Insert text here]

Inventory of refrigerant banks

[*From Element 1 of the Guide, summarise the inventory findings in a table like the one provided below.*]

Substance	Application	Current quantity (MT)	Location/sector	Annual waste (MT/ year)
TOTAL				

[Add other relevant tables from the Inventory that will demonstrate a clear understanding of the banks, their locations and the quantities determined.]

2. Policy and regulatory framework

*[**Instructions:** From Element 2, summarise existing and planned legal instruments that support LRM. Identify gaps (e.g., lack of mandatory recovery, tracking systems, or technician certification).]*

[Insert text here]

Additional Guidance

Provide a detailed description of existing and required policies and regulations supporting the management of waste-controlled substances, including recovery, recycling and, where applicable, reclamation. Identify gaps in the institutional and regulatory framework and propose measures for strengthening enforcement, technician certification, and tracking systems.

Data to be gathered:

- *Existing laws on controlled substances, waste management, and import/export control*
- *Institutional responsibilities*
- *Existing licensing and quota systems*

Sample performance indicators:

- *Updated regulation on refrigerant recovery enacted by Year 2*
- *Technician certification program operational by Year 1*

3. Description of the collection, transport and storage infrastructure

*[**Instructions:** From Element 3 describe the current operational system for collecting refrigerants, including where collection occurs, how refrigerants are transported, where they are stored, and how this process is tracked.]*

Additional Guidance

Define the activities being undertaken in the country for effective collection, transportation, and storage mechanisms, including the country's recovery, reclamation, and recycling infrastructure. Where available, include information on the tracking system being used for recovered refrigerants.

Data to be gathered:

- *List of collection centres*
- *Storage facilities and reclamation units*
- *Transport logistics*

Sample performance indicators:

- *Establish [target #] of operational collection centres by Year 2*
- *National refrigerant tracking system established by Year 3*

3.1 Collection approach

[Describe coordination with service shops, regional excellence centres, equipment replacement and recovery programmes, and other initiatives that allow for the collection of refrigerants, either for reclamation or for destruction.]

[insert text]

Table of key collection points

Location	Description (service shop/ aggregator, etc.)	Date when operations began

3.2 Transportation

[Describe the type of containers used for transport, the safety procedures, the routes, and the challenges.]

3.3 Storage facilities

[Describe the approach for storage, including where the storage facilities are located, their capacity, and the security measures in place.]

3.4 Tracking system

[Describe the type of tracking system in place (i.e., paper-based or electronic), who is responsible for tracking, and any challenges with the existing system](security measures in place.)]

4. Roles and responsibilities of stakeholders

*[**Instructions:** From Element 4 of the Guide, define institutional arrangements and coordination mechanisms. Include a simple matrix showing who does what (NOU, customs, technicians, reclaimers, waste operators).]*

Additional Guidance

Clearly describe the responsible actors and their roles in the collection, storage, transport, and disposal processes. Include government entities, private sector operators, customs, and training institutions. Define coordination mechanisms and accountability structures to ensure effective collaboration.

Data to be gathered:

- *Institutional mandates*
- *List and roles of stakeholders*
- *Coordination arrangements*

Sample performance indicators:

- *Inter-agency coordination mechanism operational by Year 1*
- *Stakeholder responsibility matrix approved and published*

5. Technology options for disposal and destruction

*[**Instructions:** From Element 5 of the Guide, describe the approach that your country wants to take for LRM and eventual disposal. Include a clear justification for selecting the specific approach, especially for disposal options.]*

Additional Guidance

Assess available technology options for disposal and destruction, noting best practices and opportunities for co-disposal of waste-controlled substances with other hazardous wastes (e.g., POPs). For countries with small ODS waste streams, explore potential regional approaches for destruction or shared treatment capacity.

Data to be gathered:

- *Inventory of existing facilities (cement kilns, incinerators)*
- *Estimated destruction capacity/reclamation figures*
- *Feasibility of regional cooperation*

Sample performance indicators:

- *Technology assessment completed by Year 1*
- *Destruction facility achieving ≥99.99% DRE by Year 3*

Selected disposal approach (check one or more)

- ☐ Domestic destruction (specify technology)
- ☐ Export for destruction
- ☐ Co-disposal with POPs or other chemical wastes
- ☐ Combination

Explain why this approach was selected:

[insert text]

Technology Assessment (fill in table below)

Technology option	Estimated cost	Capacity	Selected (Y/N)

If export for destruction was selected, specify the following:

Destination country: ____

Name of destruction facility: ________________________________

Permits required? Y/N (list permits and schedule for getting it)

If domestic destruction was selected, provide the following:

Facility type: ____

Capacity: ____

Compliance standards required: ____________________________

6. Barriers and solutions

*[**Instructions:** From Element 6: List technical, financial, institutional, and regulatory barriers identified through stakeholder consultations. Link each to a mitigation measure and the responsible entity.]*

Additional Guidance

List technical, financial, institutional, and regulatory barriers identified through stakeholder consultations. Link each to a mitigation measure and responsible entity.

Data to be gathered:

- *Stakeholder consultations and the results*
- *Cost analyses*
- *Basel Convention export documentation requirements*

7. Institutional framework and monitoring

[From Element 7 of the Guide, describe governance arrangements, reporting lines, and capacity building needs. Include how plan implementation will be sustained once funding is allocated and spent.]

Additional Guidance

Address the institutional framework needed to support the sustainable management of waste-controlled substances. While this should build upon the roles and responsibilities described in Element 4, this Element will focus more on the implementation and reporting aspects. Describe MRV procedures and how institutions will ensure continuity of operations beyond the project period. Include training, certification, and data management systems.

Data to be gathered:

- *Lead and supporting agency roles*
- *MRV system design*
- *Capacity building and reporting structures*

8. Costed and prioritised implementation plan

*[**Instructions:** From Element 8, identify and prioritise activities, including costs to develop the implementation plan for the NAP, and determine the financial resources required. Sources of financing should also be identified.]*

Additional Guidance

Additional Guidance:

Countries should do the following:

Identify the activities needed

- *List all activities required for the NAP using information from Elements 1–7 and group these under the specific LRM components.*
- *Describe the potential business model, detailing the arrangements with the various stakeholders and the private sector commitment and involvement in the activities, from waste collection to eventual destruction.*

Estimate costs and develop a budget

- *Estimate the cost of each activity, identifying capital, operational, and other recurring costs.*
- *List those activities that have funding from HPMP or KIP, specify which ones need additional resources and why, and list those that need new funding.*
- *Cost components could include the following:*
  - *Recycling/reclamation: equipment, tools, cylinders, training, and capacity building*
  - *Collection infrastructure: facilities, personnel, equipment*
  - *Transportation: vehicles, containers, fuel*
  - *Storage: rental or construction of storage facilities, maintenance, and security*
  - *MRV: establishment of digital systems, inspection, reporting*
  - *Institutional support: coordination costs, allowances, stakeholder engagement*
  -

While this activity is optional, it might be helpful to create scenarios based on different options for managing waste refrigerants using data from the refrigerant inventory. This can assist in prioritisation of activities and quantifying costs. Some options include:

- *Strengthening national recovery/recycling systems*
- *Developing domestic destruction capacity*
- *Exporting waste refrigerants through licensed companies*
- *Establishing regional destruction partnerships*
- *Co-disposal with hazardous waste*

Identify and list financing sources. *See examples provided in Element 8.*

Data to be gathered:

- *Inventory data on refrigerant banks and projected recovery volumes*
- *Estimated cost of equipment, training, and facilities*
- *List of existing funding commitments (HPMP/KIP or national sources)*
- *Estimates of financial gaps and potential co-financing*
- *Institutional arrangements and responsible entities*

9. Implementation schedule

*[**Instructions:** Once the NAP is completed, provide a timeline (i.e., Gantt Chart) for the activities listed in Element 8 and include possible funding sources for each. The timeline should include indicators. The table below may be used as a reference and adapted to national requirements.]*

Implementation Plan

Component	Activity description	Agency responsible	Approved funding (US$)	Expected outcomes/ indicators	Implementation target date

10. Annexes – the list of annexes below is indicative and will depend on the final NAP document

A. Stakeholder roles and coordination matrix

B. Inventory data summary tables

C. Legal and policy gap analysis

D. Destruction/reclamation facility profiles

E. Activity prioritisation matrix

F. MRV tools and project indicators

Special thanks to UNEP's funding partners. For more than 50 years, UNEP has served as the leading global authority on the environment, mobilizing action through scientific evidence, raising awareness, building capacity and convening stakeholders. UNEP's core programme of work is made possible by flexible contributions from Member States and other partners to the Environment Fund and UNEP Planetary Funds. These funds enable agile, innovative solutions for climate change, nature and biodiversity loss, and pollution and waste.

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