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EVALUATING OPTIONS FOR SUSTAINABLY FINANCED ACTION ON ODS AND HFC BANKS

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EXECUTIVE SUMMARY

This report provides a practical assessment of potential financing mechanisms, together with associated policy instruments, for the environmentally sound management, including destruction, of banks of ozone-depleting substances (ODS) and hydrofluorocarbons (HFCs).

The findings aim to inform advocacy and implementation under the Montreal Protocol on Substances that Deplete the Ozone Layer and complementary international frameworks, strengthening global action on ODS and HFC bank management through robust and sustainable funding models.

Banks of ODS and HFCs contained in existing equipment, products, foams and infrastructure are a major source of greenhouse gas (GHG) emissions and a threat to the future success of the Montreal Protocol. Estimates of the total volumes currently held in global banks range from 13 gigatonnes CO₂-equivalent (GtCO₂e) to 24 GtCO₂e, and these figures will of course grow in the future. Annual emissions currently amount to an estimated 1.5 GtCO₂e per year, almost three per cent of total global greenhouse gas emissions (it should be noted that estimates of total bank volumes are subject to considerable uncertainty and may not fully capture stocks in all countries and equipment types; the figures cited here should therefore be treated as indicative rather than definitive).

Many of these emissions could be prevented through systematic recovery and destruction programmes. Based on estimates of existing and future banks, a sustainable approach to lifecycle refrigerant management (LRM), encompassing leak prevention, end-of-life recovery, reclamation and eventual destruction, could potentially avoid a cumulative 91 GtCO₂e of emissions released globally by the end of the century.

However, a significant proportion of the total global refrigerant stock is located in developing countries, where collection, recovery and end-of-life management systems are still developing at the same time as air-conditioning use, and therefore fluorocarbon consumption, is growing rapidly. Effective management of banks is costly and needs reliable financing to support the sustained implementation of projects and activities. This report examines a range of possible options for the sustainable management and financing of banks.

The best option is to prevent the growth of banks in the first place. LRM represents a comprehensive framework specifically designed to address the environmental threats posed by existing banks of ODS and HFCs while preventing future accumulation. It covers leak reduction and prevention, refrigerant recovery and reuse and destruction. Effective LRM strategies require investment in supporting infrastructure, regulatory and institutional systems. Accelerating the transition to non-fluorinated alternatives can also avoid continued accumulation of these climate-critical gases.

The costs of LRM, including destruction, vary with the type of refrigerant, the scale of the operation, the local regulatory framework, the technology employed and the end use of the refrigerant. Current global cost estimates include \$675 million to \$6.7 billion a year just for destruction (Montreal Protocol Technology and Economic Assessment Panel) or about \$7 billion a year for all stages of LRM, including destruction (Climate and Ozone Protection Alliance, COPA). However, these studies appear to be based on old or incomplete data and may not be wholly reliable.

Nevertheless, it is clear that substantial upfront capital investment will be required for activities that do not generate obvious revenue streams. This has led some stakeholders, especially smaller developing countries lacking disposal or destruction facilities, to explore voluntary carbon markets as a funding source for the disposal of material already collected in their country. This option faces fundamental challenges, including difficulties in establishing credible baselines, the risks of non-additional activities being credited, verification and accounting complexities, the likelihood of project developers targeting only the substances with the highest global warming potential (GWP) for destruction (leaving the rest for the host country to deal with) and the potential for offset purchases to undermine rather than supplement direct emissions reductions.

The international compliance carbon markets established under Article 6 of the Paris Agreement are at least linked to national emissions reduction targets (unlike voluntary markets), but these are also at risk of serious problems of over-crediting, non-additionality and leakage, as displayed in the Kyoto Protocol-era equivalent mechanisms.

This report concludes that neither voluntary nor compliance carbon markets can provide the reliable, sustainable finance necessary to establish effective, long-term LRM and bank management strategies. In particular, in light of their pervasive weaknesses, voluntary carbon markets should play no part in financing LRM or bank management.

If countries do seek to engage in international compliance markets, they should do so only in limited circumstances and subject to strict oversight and additional constraints; for example: funding is provided only for destruction, not reclamation; substances to be destroyed are determined by the host country; volumes destroyed are not excluded from the calculations of production and consumption under the Montreal Protocol; and resources spent by the investor country must contribute to permanent destruction capacity.



This report examines three major alternative sources of funding.

Multilateral and bilateral support could be provided most obviously from the Montreal Protocol's own Multilateral Fund, which has already provided support for projects related to LRM, including technical assistance for the recovery and reclamation of refrigerants, demonstration pilot projects covering ODS disposal and destruction and, most recently, inventories of used or unwanted controlled substances and plans for their collection and disposal. Other potential multilateral sources of support include the Green Climate Fund and Global Environment Facility. Bilateral support may be available from some Montreal Protocol donors.

A wide range of national financing options are available to governments seeking to support LRM, including simple loans, grants or subsidies. These can be used to finance LRM-related projects, such as technician training, or to invest in collection and destruction infrastructure. Taxation of ODS and/or HFCs has been used in some countries, including Denmark and Norway, based on the GWP value of the refrigerant. Some emissions trading systems, such as New Zealand's, include HFCs. In New Zealand's system, businesses importing, manufacturing or using HFCs must surrender emissions units according to their GWP-weighted emissions; units can be generated by exporting or destroying HFCs.

Extended producer responsibility programmes have been introduced by several countries, making producers responsible for their products along the entire lifecycle, including at the post-consumer stage. The simplest version is a take-back scheme, requiring producers to collect and dispose of end-of-life products; examples include those in Germany (e-waste; EU regulations also require the collection and disposal of the ODS and HFCs they contain), Japan (home appliances and vehicles) and Canada (refrigerants). These systems include various fees and charges to fund the costs of collection and disposal, paid either by the manufacturer or importer or the purchaser. A variant of a take-back scheme is a deposit-refund scheme, whereby a levy or fee is charged for the sale of virgin substances and/or products or equipment containing them and refunds or payments are provided when the substances are returned for recovery.

Refrigerant Reclaim Australia is a development of these approaches; a national product stewardship scheme established by the industry, it is now backed by regulation requiring end-of-life arrangements and financed by a levy charged on imports. New Zealand's Cool-Safe product stewardship scheme uses revenue generated from the country's emissions trading system to fund buy-back programmes for destruction and includes a bounty programme, rewarding companies and technicians for returning used refrigerants.

These extended producer responsibility programmes demonstrate that industry-led stewardship can achieve high recovery rates when combined with regulatory requirements, stable funding mechanisms and clear governance structures. Unlike voluntary corporate initiatives, these programmes benefit from mandatory participation embedded in licensing or regulatory frameworks, ensuring comprehensive coverage and predictable financing independent of market fluctuations.

The economic viability of bank management depends, most obviously, on assumptions about the costs of the various elements of LRM programmes. A plausible global estimate is \$0.7-3 billion a year to manage and destroy 37,500–100,000 tonnes annually (this assumes a recovery rate of 15-25 per cent from decommissioned equipment, which is in line with recent experience). This equates to a cost per tonne of CO₂-equivalent emissions avoided ranging from \$2.50 for substances with GWP of 10,000 (common for many CFCs) to \$16.67 for substances with GWP of 1,500 (typical for some HFCs). These compare very favourably with the costs of other climate mitigation options, e.g., carbon capture and storage (\$50-100 per tonne CO₂-equivalent) or energy efficiency improvements and renewable energy deployment (\$30-50 per tonne); in December 2025, the average EU ETS carbon price was about €75 (\$88) per tonne CO₂-equivalent.

However, this underplays the many challenges faced by developing countries with often weak regulatory capacity and small volumes of substances needing to be collected and disposed of, as well as barriers facing service technicians such as limited training, low wages and lack of incentives to support recovery and proper handling practices. A cost-benefit analysis yields several implications for the design of economically viable programmes:

- prioritise high-value interventions, especially recovery from applications offering the highest cost-effectiveness ratios such as commercial and industrial systems or old systems containing high-GWP CFCs
- phase implementation to match capacity and scale, starting with urban commercial sectors, progressing to industrial applications and eventually extending to residential and rural areas
- design financing mechanisms for long-term sustainability, including front-loading costs through initial grants while establishing levy systems that mature to cover operating costs
- invest in cost reduction through infrastructure and standardisation, including standardised collection protocols and technology transfer
- establish regional destruction facilities, especially for small developing countries.



Against this background, options for sustainable management and financing include:

- international and bilateral sources of funding to support the initial investment and establishment of systems, focused on low-income and small developing countries, primarily from the Multilateral Fund but also from the Green Climate Fund and, for middle-income countries, concessional loans from regional development banks
- simple levy systems focused on the largest importers bringing in refrigerants in bulk, at the point of entry, integrated with existing customs licensing systems and using mobile money or direct bank transfers rather than cash
- for larger developing countries with greater regulatory and enforcement capacity, more complex taxes or fees may be an option, applying taxes to refrigerants at point of sale proportional to their GWP
- deposit-refund mechanisms, including fees charged when purchasing equipment containing refrigerants; the fees are refunded upon proper disposal, creating direct financial incentives for recovery while also ensuring funding availability
- high-value bounty programmes, paying technicians for recovered substances and thereby incentivising recovery
- combining extended producer responsibility requirements with centralised fund mechanisms can address both manufacturer accountability and resource availability. Producers contribute to centralised funds based on their products sold, ensuring adequate resources regardless of individual company operations.

Alongside sustainable financing, robust regulatory frameworks are essential. Critical elements include:

- strengthened regulatory frameworks – restrictions on the use and import of substances and equipment, accompanied by mandatory leak prevention and recovery requirements
- monitoring and reporting systems and standards to track waste substances and where they end up are critical. This includes the establishment of national databases of refrigerants tracking production, imports, sales and recovery
- industry-led stewardship with regulatory backing – industry governance of extended producer responsibility programmes backed by statutory requirements and stable levy-based funding
- effective training and capacity-building of technicians, including certification and registration programmes
- comprehensive national planning – integrated strategies coordinating policy development, infrastructure investment and stakeholder engagement
- building regional cooperation frameworks for shared facilities and knowledge exchange
- integration with other development priorities, such as food security, health and waste management, can help to ensure programme sustainability beyond donor cycles.

1. INTRODUCTION

Ozone-depleting substances (ODS) and hydrofluorocarbons (HFCs) contained in existing equipment, products, foams and infrastructure, known collectively as 'banks', are a major source of ODS and greenhouse gas emissions, contributing to climate change and threatening the recovery of the ozone layer and the goals of the Montreal Protocol on Substances that Deplete the Ozone Layer.

Annual emissions from improperly managed banks currently amount to an estimated 1.5 billion tonnes of carbon dioxide-equivalent (GtCO₂e) per year, almost three per cent of total global greenhouse gas emissions. Even with full compliance with the Montreal Protocol, this volume will rise in the future, as appliances containing ODS and, especially, HFCs, reach the end of their lives. Comprehensive strategies for lifecycle refrigerant management (LRM) could minimise the build-up of banks and avoid leakage from existing equipment. This is a global challenge facing all countries, requiring coordinated international action, sustained financing and strengthened regulatory frameworks world-wide.

The challenge is particularly acute in developing countries, where a significant proportion of the total global refrigerant stock is located and where collection, recovery and end-of-life management systems are still developing at the same time as air-conditioning use, and therefore fluorocarbon consumption, is growing rapidly.¹ Banks are diffuse and dispersed; small refrigerant charges are distributed across millions of household and commercial units, while larger facilities may retain cylinders of obsolete substances awaiting final disposal. In some cases, confiscated



material remains in prolonged storage at customs facilities, increasing the risk of leaks from sub-optimal storage conditions.

Effective management of ODS and HFC banks is costly; it requires reliable financing that will support the sustained implementation of projects and activities. Investment is required across the lifecycle of refrigerants, including establishing collection networks, equipping technicians, recovering and reclaiming refrigerants and safely destroying gases that cannot be reused, together with monitoring and verifying the destroyed gases to ensure the integrity of the process. In many developing countries, high up-front costs, unclear responsibilities, lack of a clear market for recovered substances and the absence of destruction facilities all inhibit action, despite the obvious climate and ozone benefits.

Financing models for the management of these banks have so far not delivered at the necessary scale. In many cases, developing countries have relied on voluntary carbon markets, selling volumes of collected substances to companies that destroy them, generating carbon credits which are then sold on to other companies to offset their own emissions. At best, this has no overall impact on global emissions and, at worst, problems of additionality, leakage and baseline-setting can inflate credited volumes without ensuring real recovery and destruction. Offsets may also create perverse incentives to stockpile substances or delay action, potentially undermining the Montreal Protocol's achievements in phasing out the production and consumption of ODS and HFCs.

It is therefore an urgent priority to explore alternative options for financing the management and eventual destruction of banks. This report provides a practical assessment of potential financing mechanisms, together with associated policy instruments, for the environmentally sound management, including destruction, of ODS and HFC banks. The findings aim to inform advocacy and implementation under the Montreal Protocol and complementary international frameworks, strengthening global action on ODS and HFC bank management through robust and sustainable funding models.

The study is based on a desk review of available literature and interviews with country representatives to capture national experiences, together with the discussions at a side meeting held at the 37th Meeting of the Parties to the Montreal Protocol in November 2025. It is organised as follows:

Chapter 2 provides context and background on the climate and environmental threat of ODS and HFC banks, establishing the rationale for action.

Chapter 3 describes the key steps in lifecycle refrigerant management (LRM) and their role in effective bank management, together with the scale of the financing needed.

Chapter 4 describes the option of generating financing for destruction through carbon markets and summarises the potential drawbacks.

Chapter 5 analyses alternative potential sources of financing for LRM and bank management, including international funds, national financing mechanisms and extended producer responsibility programmes.

Chapter 6 examines the economic viability of bank management, including cost-effectiveness relative to mitigation potential, gaps in current cost assessments and implications for programme design and financing.

Chapter 7 puts forward for discussion a series of options for managing and financing banks of ODS and HFCs, including the essential need for robust regulatory frameworks.

2. THE CLIMATE AND ENVIRONMENTAL THREAT OF ODS AND HFC BANKS

The 1987 Montreal Protocol on Substances that Deplete the Ozone Layer is widely considered to be one of the most successful international environmental agreements to date.² Under the Protocol, the production and consumption of synthetic ODS for controlled uses has been almost completely phased out and the phase-down of HFCs under the Kigali Amendment to the Protocol is under way.

Despite these remarkable achievements, the Protocol has not comprehensively addressed the critical issue of managing these substances during or at their end of life. This oversight has created a growing and time-sensitive challenge – the accumulation of banks of ODS and HFCs contained in stockpiles, old equipment, infrastructure and products such as foams that, if continued to be left to grow unchecked, pose significant threats to both the ozone layer and the climate system.³



The term 'banks' refers to the total volumes of controlled substances, both ODS and HFCs, in existing equipment, products, infrastructure and stockpiles that would eventually be released to the atmosphere unless properly managed through recovery, recycling and eventual destruction.⁴ This includes substances still in active use in operating equipment as well as volumes already at or approaching end of life. This report focuses specifically on the latter – substances in end-of-life equipment and other unwanted or stored volumes, rather than those still providing a useful service in functioning systems. Unless properly managed, these substances will leak naturally over time or are sometimes even vented deliberately.

Successful management of these banks offers a rapidly closing window of opportunity – an opportunity which, if not seized, will undermine the legacy of the Montreal Protocol and contribute significantly to climate change. It represents a critical blind spot in the Montreal Protocol and in global environmental governance.

2.1 THE SCALE AND URGENCY OF THE BANK CHALLENGE

The climate risks associated with ODS and HFC banks are substantial, though volumes are difficult to measure precisely. The Climate and Ozone Protection Alliance (COPA) estimated that, in 2022, global banks of ODS and HFCs contained approximately 7,680 kilotonnes (kt) of controlled substances, equivalent to roughly 13.4 GtCO₂ (see Figures 2.1 – 2.4).⁵ To put this in perspective, the impact on the climate of the substances contained in these banks, if they were all released, would be more than one-third of global energy-related CO₂ emissions in 2022.⁶

The COPA analysis also shows the changing composition of these banks. Banks of ODS peaked around 2002, at approximately 18.6 GtCO₂e, and have been declining since due to equipment replacement and recovery efforts together with natural leakage.⁷ Banks of HFCs, however – which also have high global warming potential (GWP) values (averaging around 1,800 for HFCs phased down to date, though varying considerably by substance) – are continuing to grow and are projected to peak near 2030 before beginning to decline, as activities under the Kigali Amendment's phase-down schedules are implemented.⁸

Figure 2.1: Global ODS and HFC banks by volume (kt). HCFC consumption is interpolated between 2023-30 (deadline for the phase-out in Article 5 countries)

Source: Climate and Ozone Protection Alliance (2025). *Global Banks of ODS and HFCs: A Country-Level Estimate*

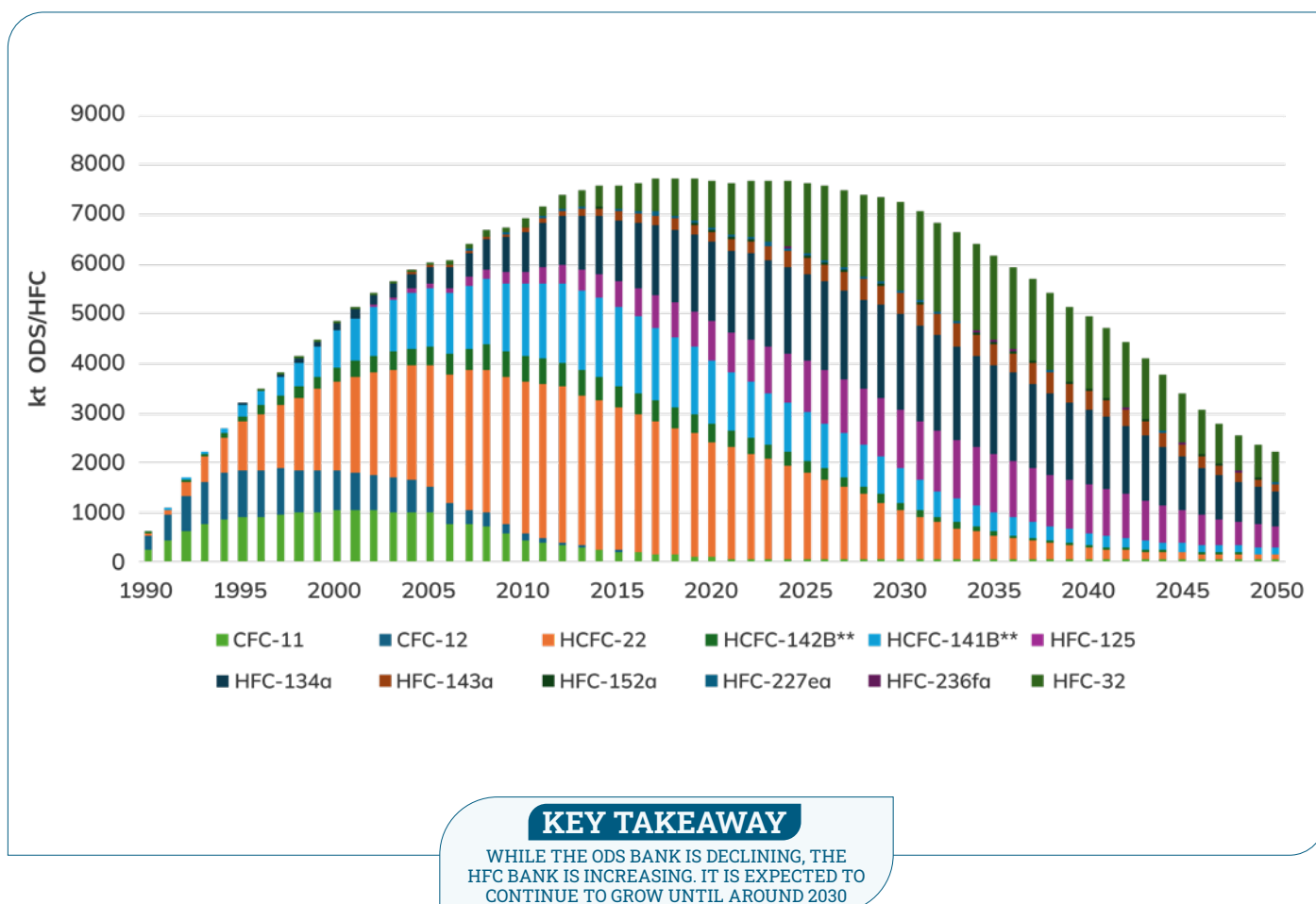


Figure 2.2: Global ODS and HFC banks by volume (kt), disaggregated for non-Article 5 and Article 5 countries
Source: Climate and Ozone Protection Alliance (2025). Global Banks of ODS and HFCs: A Country-Level Estimate

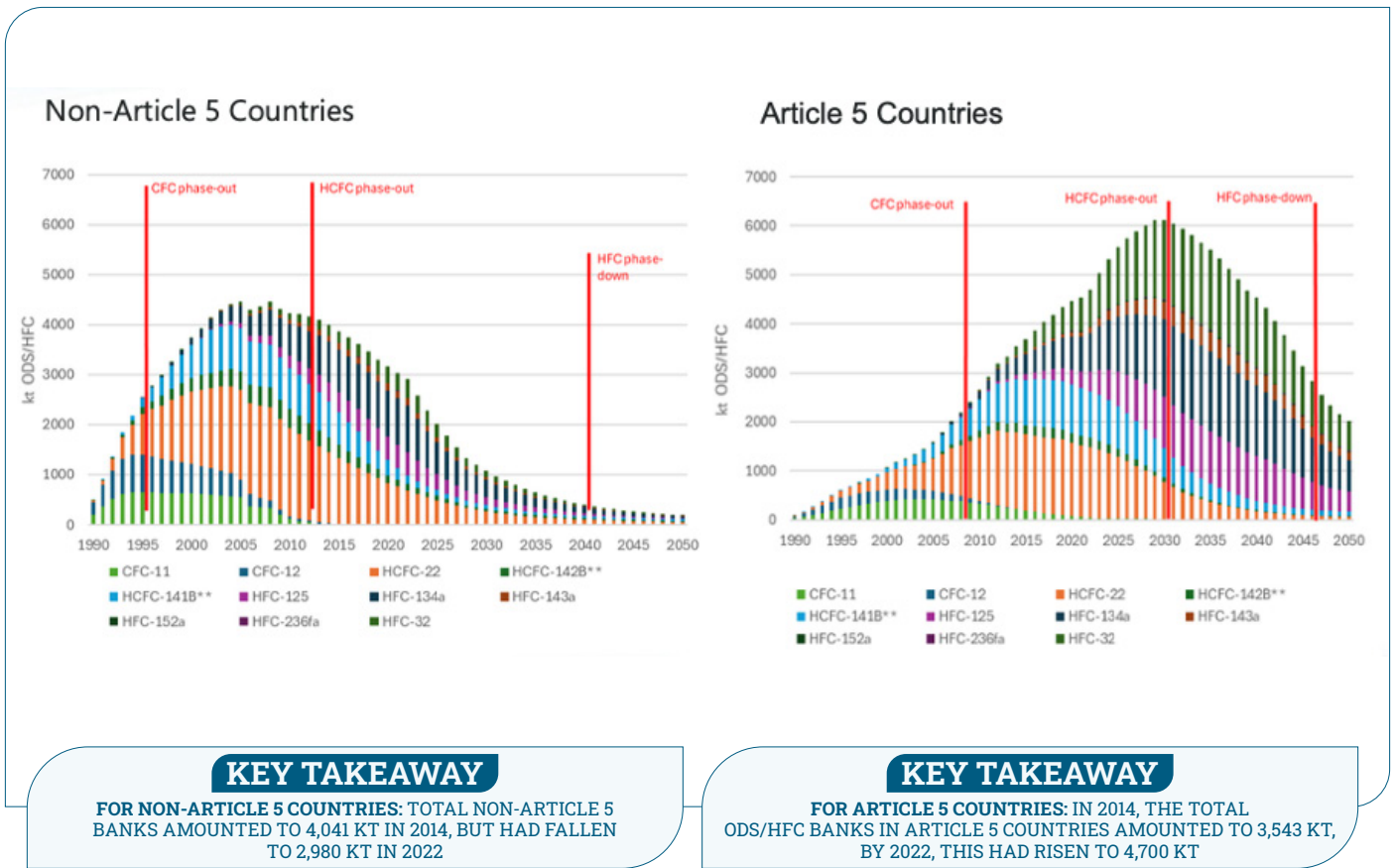


Figure 2.3: Global ODS and HFC banks by equivalent emissions potential (GtCO₂e). HCFC consumption is interpolated between 2023-30 (deadline for the phase-out in Article 5 countries)
Source: Climate and Ozone Protection Alliance (2025). Global Banks of ODS and HFCs: A Country-Level Estimate

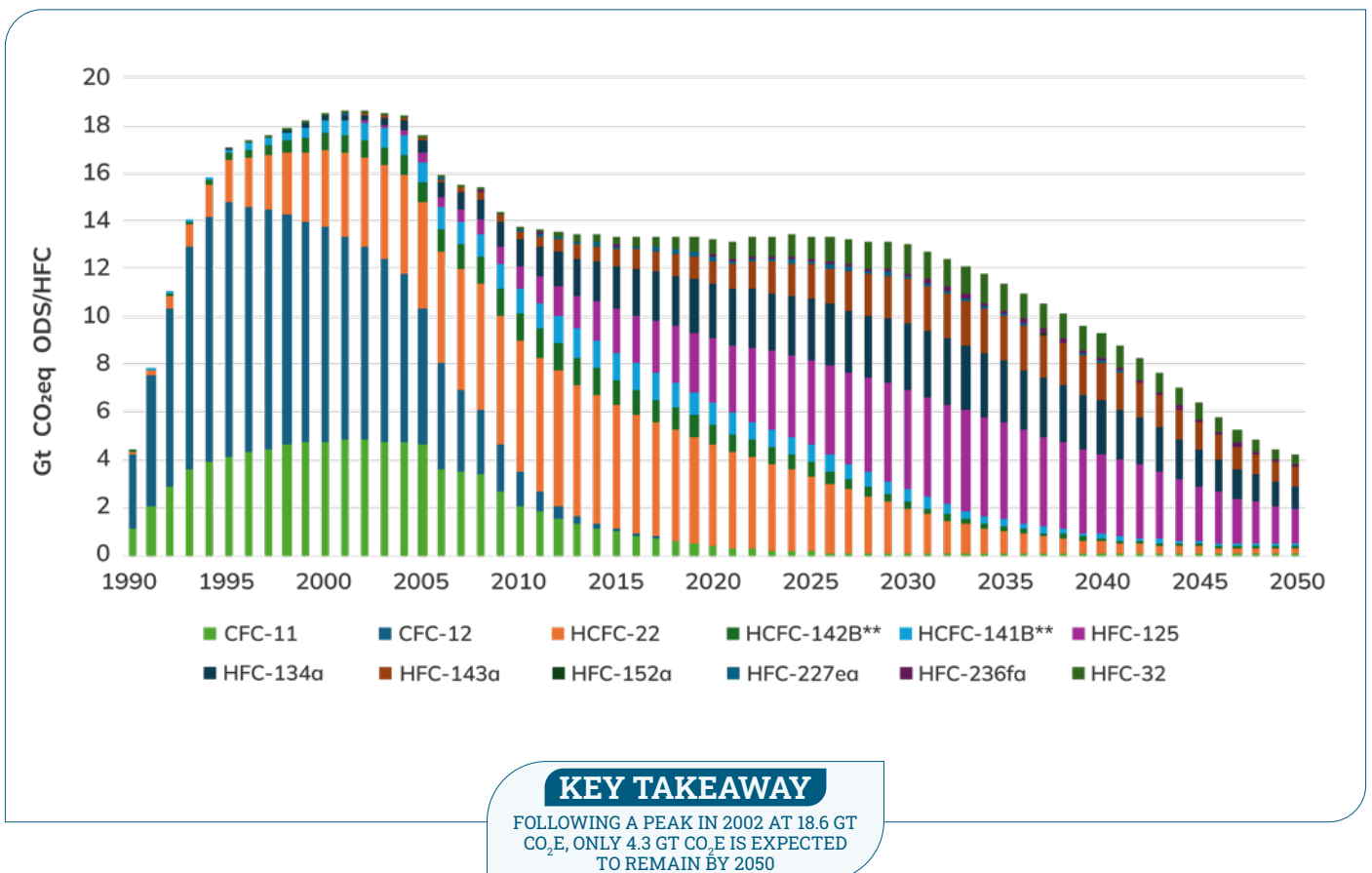
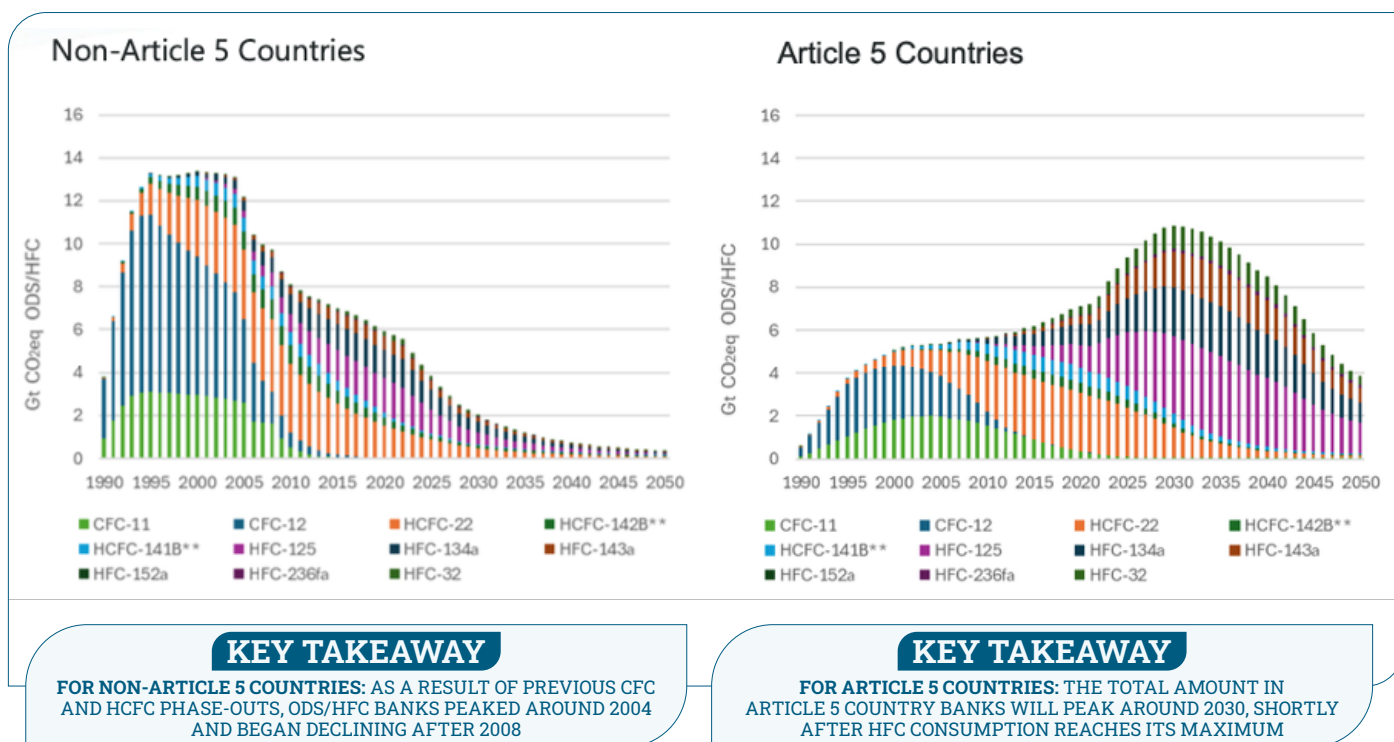


Figure 2.4: Global ODS and HFC banks by equivalent emissions potential (GtCO₂e), disaggregated for non-Article 5 and Article 5 countries

Source: Climate and Ozone Protection Alliance (2025). *Global Banks of ODS and HFCs: A Country-Level Estimate*



Other estimates of bank volumes are even higher. The Medical and Chemical Technical Options Committee (MCTOC) of the Protocol's Technology and Economic Assessment Panel (TEAP), estimated a slightly smaller bank in terms of volume of substances – approximately 6,000kt of ODS and HFCs in 2022 – but a higher potential impact on the climate of 16 GtCO₂e.⁹ A report published in 2022 by EIA, Natural Resources Defense Council and Institute for Governance & Sustainable Development estimated the current global bank to be equivalent to 24 GtCO₂e.¹⁰

The environmental consequences of inaction are measured not just in total bank size but also in ongoing daily emissions. COPA estimates that approximately one megatonne of CO₂-equivalent is released from banks every day, representing annual emissions of 1.5 GtCO₂e per year, almost three per cent of total global greenhouse gas emissions.¹¹ The Intergovernmental Panel on Climate Change (IPCC) has warned that if left unmanaged, emissions from banks could rise to 2.1 GtCO₂e annually by 2030.¹² Future growth beyond these levels can be expected.

Many of these emissions could be prevented through systematic recovery and destruction programmes. A sustainable approach to lifecycle refrigerant management (LRM), encompassing leak prevention, end-of-life recovery, reclamation and eventual destruction, could potentially avoid a very significant volume of emissions by the end of the century. The EIA/NRDC/IGSD report referred to above projected the emissions equivalent of banks to reach a cumulative 61 GtCO₂e by 2050 and 91 GtCO₂e by 2100, based on stocks of 24 GtCO₂e in 2022, and estimated future ODS and HFC production.¹³ This massive mitigation potential represents one of the most cost-effective climate actions available, with associated benefits for ozone layer protection.

However, the geographic distribution of these banks complicates the challenge. As can be seen in Figures 2.2 and 2.4, COPA's analysis, which is based on country-level calculations from annual data reports to the Montreal Protocol, shows that a substantial share of banks sit in Article 5 countries, where collection and destruction infrastructure remain under-developed.¹⁴ While some larger developing countries with high bank inventories may have the technical and financial capacity to implement LRM and reduce the size of their banks, smaller countries have limited technical and financial capacity to address them systematically.

2.2 EMERGING POLICY RESPONSES

Recognition of this challenge has prompted several countries to adopt LRM policies. The European Union's F-Gas and ODS Regulations, both updated in 2024, expand the obligations on businesses for recovery, reclamation and destruction of HFCs and ODS, with mandatory recovery, stronger enforcement and market incentives for reclaimed refrigerants.¹⁵

The US, through Environmental Protection Agency (EPA) rules under the Clean Air Act, sets reclamation obligations, leak repair standards and mandatory recovery requirements, reinforcing circular economy principles.¹⁶



Japan's Fluorocarbon Emissions Control Act mandates recovery during maintenance and disposal, requires certified handlers with reporting obligations and integrates appliance take-back systems, creating a national chain for recovery and destruction.¹⁷

At the national level, especially in developing countries, operators and dealers often face compliance challenges in the collection, transport and treatment of recovered ODS and HFCs, especially when regulatory frameworks are not aligned with waste management legislation. These waste substances are typically classified as hazardous substances and require specialised infrastructure and permits for handling. Updates to national ODS and HFC regulations should be consistent with waste management regulations, within a comprehensive framework which allows for the full consideration of the lifecycle of these substances.

Pilot projects in developing countries have shown technical feasibility but have also revealed major financial and institutional barriers.¹⁸ Under the Montreal Protocol, in 2022, the Multilateral Fund established a window to support Article 5 countries in developing inventories and plans for bank management (Decision 91/66).¹⁹ By the time the window closed in December 2025, the Fund had approved funding for 128 countries and one regional project, leaving only 16 Article 5 countries that had not submitted requests. At its December 2025 meeting, the Executive Committee decided not to extend the funding window (Decision 97/31) and to consider in 2027 a decision on the establishment of a new funding window to support the implementation of the plans developed as a result of these projects (Decision 97/89).²⁰

Since bank accumulation and natural release unfold over time, there is a narrow window for decisive action on ODS and HFC bank management. With HFC banks expected to peak around 2030, each year of delay in action increases the risks of avoidable emissions and higher costs. Article 5 countries that have completed or begun preparing national inventories of banks through Multilateral Fund support have taken the first step towards establishing comprehensive national systems that make containment, recovery, reclamation and, when necessary, destruction, routine and enforceable. As they are further developed and implemented, these systems should be integrated with existing national waste management infrastructure, appliance recycling programmes and refrigeration servicing networks, capitalising on key opportunities for efficiency gains and cost sharing.

Acting now and determining the best financing options for bank management will secure substantial climate and ozone co-benefits while protecting the credibility and long-term effectiveness of the Montreal Protocol.

3. KEY ELEMENTS OF LIFECYCLE REFRIGERANT MANAGEMENT AND ITS ROLE IN EFFECTIVE MANAGEMENT OF BANKS

Although this report focuses primarily on financing options for end-of-life bank management, the most effective approach to managing ODS and HFC banks is to prevent their growth in the first place.

Recent analyses by the Technology and Economic Assessment Panel (TEAP),²¹ the Climate and Clean Air Coalition (CCAC),²² EIA, NRDC and IGSD²³ and several peer-reviewed studies collectively describe **lifecycle refrigerant management** (LRM) as a comprehensive framework designed to address the environmental threats posed by existing banks of ODS and HFCs, while preventing the accumulation of future stocks.

This chapter examines how each element of LRM, from leak prevention and recovery to reclamation and destruction, contributes to effective bank management within the time-sensitive window of opportunity that exists before natural leakage and deliberate venting further diminish these high-value yet environmentally harmful substances.

3.1 LEAK REDUCTION AND PREVENTION

The best approach to avoiding future emissions from banks of ODS and HFCs is to avoid creating them in the first place by accelerating the transition to non-fluorinated alternatives.

Where fluorocarbon-based equipment remains in use, however, preventing leakage is the single most effective means of avoiding emissions. Each refrigerant molecule that escapes through equipment leaks represents both an environmental emission and a reduction in the recoverable bank that could otherwise be captured for reuse or destruction.²⁴

Advanced leak detection technologies, including electronic sensors and infrared imaging, enable the early identification of losses before they become significant atmospheric releases. Regulatory frameworks such as the EU's F-Gas Regulation demonstrate how mandatory leak checking requirements can systematically preserve bank integrity while reducing emissions.²⁵ These approaches are particularly valuable for large commercial and industrial



systems which contain substantial refrigerant banks, where early leak detection can preserve thousands of kilos of controlled substances for eventual recovery and proper management.

The economic case for leak prevention is compelling. For example, supermarkets which employ best practices to prevent, detect and repair leaks can reduce their leak rates from the sector average of 25 per cent to less than 10 per cent, saving tens of thousands of dollars in replacement, repair and lost-asset costs.²⁶

If US supermarkets reduced leakage to the level achieved by the partner stores of the EPA's GreenChill Programme, it is estimated the industry could save about \$108 million per year in refrigerant replacement costs.²⁷

For equipment containing obsolete or high-GWP refrigerants that will eventually require bank recovery, leak prevention extends the operational window for planned bank management interventions and reduces emissions to the atmosphere before these substances can be recovered and destroyed. Maintaining the correct refrigerant charge also delivers operational co-benefits – properly charged systems run more efficiently, reducing energy consumption and operating costs for equipment owners and thereby strengthening the economic case for regular leak checking and maintenance.²⁸

3.2 REFRIGERANT RECOVERY DURING SERVICING

Recovery operations during equipment servicing represent the primary mechanism for capturing substances before they escape to the atmosphere through normal equipment operation or emergency venting. Professional recovery practices require specialised equipment, trained technicians and appropriate storage infrastructure to ensure that the removed refrigerants are properly contained for subsequent processing decisions.

The US EPA's Section 608 regulations exemplify how mandatory recovery requirements can systematically capture banks during routine servicing activities, requiring technicians to recover refrigerants before servicing or disposing of equipment.²⁹ Similar requirements under the EU F-Gas Regulation prohibit intentional release and mandate recovery during maintenance activities, effectively transforming routine service events into capture opportunities.³⁰

Countries with comprehensive technician certification programmes, such as the Australian Refrigeration Council's system, demonstrate significantly higher bank recovery rates compared to jurisdictions with voluntary approaches.³¹ These systems ensure that service technicians possess the knowledge and equipment necessary to recognise recovery opportunities and execute proper procedures that preserve material quality for subsequent reuse or destruction.

3.3 REUSE THROUGH RECYCLING AND RECLAMATION

Recycling and reclamation processes extend the useful life of recovered materials, reducing demand for virgin production while maximising value extraction from existing banks.

The economic viability of bank material reclamation depends critically on the type and purity of recovered refrigerants, with single-component refrigerants generally offering superior reclamation prospects compared to complex blends that present technical challenges in separation and purification.³² This creates important considerations for bank management strategies, as equipment containing easily reclaimable refrigerants may justify more intensive recovery efforts compared to systems containing complex blends. This also reinforces the case for the transition to non-fluorinated alternatives, such as carbon dioxide, ammonia or hydrocarbons, in preference to the increasingly common lower-GWP HFC and hydrofluoroolefin (HFO) blends.

Reverse supply chain logistics play an important role in successful recovery, recycling and reclamation efforts in order to aggregate small refrigerant quantities from dispersed locations for centralised processing. Article 5 countries face challenges that make comprehensive bank management systems costly to establish, including limited economies of scale, long transport distances, inadequate storage infrastructure, informal servicing sectors and regulatory gaps. Regional reclamation facilities can potentially provide cost-effective processing for materials from multiple countries. However, a lack of infrastructure, the high cost of sophisticated reclamation equipment, limited technical expertise, weak regulatory support and the absence of a market for reclaimed refrigerants in the face of cheaper, high-GWP virgin refrigerants can make it difficult to establish these regional facilities in developing countries.

In December 2024, the Executive Committee of the Multilateral Fund commissioned a desk study for the evaluation of recovery, recycling and reclamation projects, including their achievements, effectiveness and contribution to compliance with the Montreal Protocol (Decision 95/12). The results, expected at the end of 2026, will provide a comprehensive assessment of how these projects have supported the phase-out and phase-down of controlled substances, identifying key success factors, challenges and lessons learnt. The findings are expected to inform future project design and policy decisions, ensuring ongoing and upcoming initiatives under the Multilateral Fund continue to deliver tangible environmental benefits and sustainable capacity at the national level.



While reuse through recycling and reclamation remain an essential component of effective bank management, its environmental benefits depend on how reclaimed refrigerants are subsequently used. Care must be taken to ensure that reuse pathways do not unintentionally prolong the operation of older, high-leakage equipment nor delay the transition to available lower-GWP alternatives, both of which could defer or reduce potential emission reductions.

Such considerations are important where viable lower-GWP replacements or retrofit options are already available in the market. This challenge emphasises the need for carefully designed reclamation and reuse strategies that support near-term compliance while remaining aligned with longer term phase-out and phase-down objectives.

3.4 COLLECTION OF UNUSABLE REFRIGERANTS

The systematic collection of materials that cannot be economically recycled or reclaimed requires coordinated infrastructure specifically designed to handle contaminated substances from diverse sources. This includes refrigerants from deteriorating equipment banks, degraded materials from failed reclamation attempts and contaminated substances that are environmentally hazardous and cannot be reused.

Collection infrastructure must accommodate the diverse characteristics of unusable bank materials, from small residential units containing minimal quantities to large industrial installations holding substantial contaminated volumes. Mobile collection units can serve to collect dispersed sources in rural areas, while fixed collection points in major cities can consolidate larger volumes more efficiently for transport to destruction facilities.³³

Studies show that digital tracking tools, such as RFID (radio frequency identification) tags connected to blockchain-based registries, can help countries keep clear track of refrigerant banks from collection to destruction while ensuring environmental integrity throughout collection and processing activities.

For example, a pilot by SNCF in France used blockchain-linked identifiers to record transfers of waste, creating a reliable audit trail that prevented errors and confirmed final handling. Similar approaches could help countries verify that recovered refrigerants delivered for destruction are actually processed and not diverted to alternative, possibly illegal, uses.³⁴

3.5 DESTRUCTION OPTIONS

Destruction technologies provide the final solution for bank materials that cannot be reused or reclaimed, achieving complete elimination of ozone-depleting and climate-warming emissions through thermal or chemical processes. Technologies approved by meetings of the parties to the Montreal Protocol, such as high-temperature incineration, plasma arc destruction and other thermal processes can achieve destruction efficiencies exceeding 99.99 per cent (as required by the Protocol), ensuring that collected bank materials are permanently eliminated.³⁵

Cement kilns offer a particularly attractive destruction option in many developing countries. Already found in almost all countries, cement kilns have the capacity to handle both pure substances and polyurethane foams, achieving complete destruction through high-temperature combustion while allowing waste materials to be used as supplementary fuel.³⁶ The co-benefits of waste heat recovery and fuel substitution can improve the economic viability of bank destruction programmes while also reducing overall environmental impacts through reducing fossil fuel consumption.

Regional cooperation frameworks can help smaller countries access appropriate destruction capacity for their bank materials while sharing infrastructure costs across multiple jurisdictions. This approach is particularly important for countries with limited bank quantities that cannot justify dedicated destruction facilities.

However, significant barriers remain, including complex transboundary transport procedures, permitting requirements and high compliance costs. Clear timelines for planning, licensing and operationalising a regional destruction facility are essential to understand when it could realistically begin accepting materials.

3.6 SUPPORTING INFRASTRUCTURE AND CAPACITY-BUILDING

Supporting infrastructure encompasses the physical, regulatory and institutional systems necessary to implement effective bank management programmes. This includes specialised collection and storage facilities designed for controlled substances, transport networks capable of handling hazardous materials and processing equipment scaled appropriately for anticipated bank volumes.

Investment in training and certification programmes helps to build a well-trained and specialised workforce that is the foundation for LRM and sustainable refrigerant bank management. Technical training centres, mobile training units and partnerships with educational institutions can support the development of the skilled workforce needed to identify, recover, process and document bank management activities across diverse equipment types and operational contexts.



In many Article 5 countries, this capacity is built through activities for the servicing sector included in their HCFC Phase-out Management Plans (HPMPs) and Kigali HFC Implementation Plans (KIPs).

While some support is available, many small and medium-sized countries require additional financing to enable more comprehensive interventions to build a solid LRM infrastructure.

3.7 REGULATORY AND POLICY FRAMEWORK

Strong regulatory frameworks provide the foundation for effective LRM by establishing clear requirements for bank identification, recovery and disposal, while creating enforcement mechanisms that ensure compliance with bank management objectives. Comprehensive policies must address multiple aspects of bank management, from venting and mandatory inventory requirements to end-of-life management obligations that prevent uncontrolled releases. Where the implementation of regulations on venting and other related policies are monitored, associated reporting and enforcement can significantly strengthen LRM practices.

Integration with existing environmental and trade regulatory systems can improve bank management efficiency while reducing the administrative burden on regulated entities. Alignment with Montreal Protocol compliance systems ensures that bank management activities support rather than complicate international obligations while maximising the environmental benefits from investments in bank management.

3.8 COSTS

The costs of LRM, including destruction, vary substantially with the type of refrigerant, the scale of the operation, the local regulatory framework, the technology employed and the end use for the refrigerant, i.e., whether it is to be reused or destroyed.

This end-use, in turn, varies significantly with market conditions – the higher the cost of new substances, the greater the return on recovery and reuse. There are also benefits to offset against the costs – investment in leak detection and control and in recovery and reuse leads to lower levels of consumption of newly produced refrigerant and higher energy efficiency, resulting in lower levels of energy consumption.

The TEAP Task Force study published in 2024 broke down the costs of LRM into a number of elements:³⁷

- **capital expenditure** – the costs associated with acquiring and maintaining fixed assets such as equipment, tools and infrastructure. This includes leak detection and repair equipment, refrigerant recovery equipment and technologies for the reuse (including recycling and reclamation) and destruction of refrigerants. There may also be capital expenditure required for supporting equipment, such as refrigerant recovery cylinders and equipment for refrigerant purity testing, as well as quality control laboratory costs (chromatography, etc.)
- **operational expenditure** – the costs associated with equipment maintenance, labour, energy consumption, quality control and administrative costs such as reporting and regulatory compliance
- **centralised handling, storage and other logistical costs** – the costs of transporting recovered refrigerants from the point of extraction to storage or destruction facilities (including the costs of fuel, coordination and logistics), secure handling and storage infrastructure and regulatory costs
- **training and education costs** – technician training for refrigerant life-cycle management involves comprehensive education on various aspects of handling refrigerants, focussing on leak prevention, recovery, recycling and reclamation, alongside health and safety and environmental regulations. Training also requires investment in facilities such as laboratories
- **compliance costs** – arising from adherence to regulatory requirements and standards, including training materials, instructor fees, certification programmes, reporting requirements, documentation for refrigerant transaction fees and licenses and consulting for regulatory compliance
- **destruction costs** – of all the LRM components, destruction of end-of-life ODS or HFCs is generally the highest in terms of unit cost. Costs can fluctuate based on the local accessibility of the technology and the quantity of materials to be destroyed:
 - commercial rotary kilns applied to moderate/large volumes – \$2-3/kg; smaller demonstration quantities: \$5-8/kg
 - commercial scale plasma arc destruction – S\$8/kg, with smaller units over \$20/kg
 - cement kilns – about \$8/kg.



The Task Force estimated the total global cost for the destruction of substances accessible in banks between 2024-30 – 225kt – to be approximately \$675 million a year, primarily in non-Article 5 countries if a unit cost of \$3/kg could be achieved; this included only the costs of destruction, not the other elements of LRM. From 2030-50, estimated destruction costs rose along with volumes – 350kt – to reach about \$1 billion per year, at a unit cost of \$3/kg.

The Task Force believed that \$3/kg was achievable, but only if significant economies of scale could be realised. If the cost was \$20/kg – the top of the range for plasma arc destruction – total costs for the 2024-30 period would reach \$4.5 billion a year. The true figure will lie somewhere in between these estimates, although demonstration projects funded by the Multilateral Fund support the assumption that costs will be at the higher end – see Table 3.1.

Table 3.1: ODS/HFC destruction costs from Multilateral Fund-funded demonstration projects

Source: COPA. 2023. COPA Financing and Fundraising Mechanism: A Review and Concept. Data collected from the Multilateral Fund Secretariat's Synthesis report describing best practices and ways for the Executive Committee to consider operationalizing paragraph 24 of decision XXVIII/2 (decision 84/87(b)) (UNEP/OzL.Pro/ExCom/89/9)

COUNTRY	AMOUNT (t)	METHOD	DESTRUCTION COSTS (\$/kg)	APPROVED FUNDS (\$)	
				Project preparation	Project implementation
MLF-funded projects that received funding directly from UNIDO, UNDP, IBRD or a country					
China	194.8	RKI	8-12.50	85,000	2,127,885
Colombia	15.1	MSW/HTI	5.20	40,000	1,195,000
			5.98		
			6.20		
Georgia*	1.5	Exported to France – HTI	5.99**	30,000	55,264
Ghana*	1.3	Exported to Poland – HTI		30,000	198,000
	1.0	Exported to US – HTI			
Mexico	74.1	Argon plasma arc	7.50	100,000	1,427,915
	39.1	Cement kiln	8.00**		
Nepal*	9.1	Exported to US			157,200
Nigeria	1.5	RKI	29.82	60,000	911,724
Türkiye	9.2	Exported to Poland – RKI	1.87-2.45	60,000	1,076,250
UNIDO projects					
Reclamation centre in Santiago de Chile					195,000
HFC destruction in a chemical plant in Mexico					537,752

HTI = high-temperature incineration; MSW = municipal solid waste; RKI = rotary kiln incineration

** LVC countries ** Handling and transport costs included*



Estimates for the total cost of LRM, including all the stages outlined above, including destruction, were published by COPA in 2023.³⁸ These ranged from \$18-40/kg for 'low-effort' densely populated urban areas, where collection was relatively easy, to \$34-48/kg for 'medium-effort' rural and small settlement areas. The costs were based on TEAP studies published in 2009 and 2010. Although the figures were adjusted to reflect 2022 prices, they will not reflect changes in technology, market dynamics, developing economies of scale and regional variations in the intervening period, so it is possible the data is too outdated to be reliable.

Nevertheless, these figures were used to calculate the total global costs for LRM leading to destruction for three Article 5 country groups: China (Type 1); medium-volume consuming countries, such as Mexico, South Africa, Chile or Malaysia (Type 2); and low-volume consuming (LVC) countries such as Nepal, Costa Rica, Montenegro or Lesotho (Type 3), which were assumed to export collected waste substances for destruction abroad. See Table 3.2.

Table 3.2: Total costs for ODS/HFC collection, transportation and destruction for each country type in the year 2022
Source: COPA, COPA Financing and Fundraising Mechanism: A Review and Concept (2023)

CATEGORY	ODS/HFC ANNUAL WASTE PER CAPITA (KG)	EFFORT LEVEL	POPULATION PER EFFORT LEVEL	ESTIMATED ANNUAL COST OF DESTRUCTION FOR AN AVERAGE SIZE COUNTRY (\$)	TOTAL ANNUAL COST ESTIMATE FOR DESTRUCTION IN WHOLE COUNTRY GROUP (\$)
Type 1	0.067	Low	65%	1.9 billion	1.9 billion
		Medium	35%	1.6 billion	1.6 billion
Type 2	0.019	Low	52%	23 million	1.2 billion
		Medium	48%	33 million	1.8 billion
Type 3	0.014	Low	39%	1.6 million	135 million
		Medium	61%	3.8 million	340 million

'Low effort' represents the lower costs of collection and transport in urban areas, 'medium effort' the higher costs in rural and small settlement areas.

This gives a total cost of about \$7 billion per year, an order of magnitude higher than the lower bound of the TEAP study estimate (based on \$3/kg destruction costs) and more than 50 per cent higher than the upper bound (based on \$20/kg destruction costs), although the TEAP costs only included destruction. The COPA study assumed, however, that all the substances collected were destroyed, whereas in reality some would be reused. Some capital costs, such as building infrastructure, collection centres or destruction facilities, were not included.

Given the very wide variation in estimated costs, more detailed and more up-to-date studies are required.

4. FINANCING OPTIONS FOR ADDRESSING BANKS: CARBON MARKETS

It should be clear from Chapter 3 that managing ODS and HFC banks requires substantial upfront capital investment for activities which do not generate obvious revenue streams. These include preparing detailed inventories to map bank locations and compositions, implementing leak prevention programmes to minimise emissions, establishing collection and transport networks and funding the environmentally sound destruction of recovered materials.

Results from pilot projects funded by the Multilateral Fund confirm that while the management of banks is technically feasible, having been demonstrated in various contexts, significant barriers remain in terms of cash-flow management and transaction costs. Project design, verification tools, transport logistics and destruction processes often involve complex coordination among multiple stakeholders, creating high transaction costs that inhibit the scaling-up of these activities, especially in Article 5 countries.³⁹ These financial challenges are compounded by the fact that there is so far no business model for Article 5 countries to incentivise the sustainable management of these banks.

This financing gap has led some stakeholders, especially smaller developing countries, to explore carbon markets as a potential funding source for the disposal of material already collected. But this option faces fundamental



challenges, including difficulties in establishing credible baselines, the risks of non-additional activities being credited, verification and accounting complexities and the potential for offset purchases to undermine rather than supplement direct emissions reductions. These issues are explored below, while alternative options for financing bank management in Article 5 countries are covered in Chapter 5.

Carbon markets enable purchasing entities to offset their greenhouse gas emissions by purchasing carbon credits generated by projects avoiding, reducing or removing emissions (including, potentially, destruction of ODS or HFCs), carried out by other entities. In theory, they are a means of directing investment to the most cost-effective opportunities to reduce greenhouse gas emissions. Carbon markets can be divided into compliance markets and voluntary markets (see box below).

TYPES OF CARBON MARKETS

Compliance markets are created in response to legally binding emissions reduction targets set by, or in response to, regional, national and international agreements, such as the 1997 Kyoto Protocol and the 2015 Paris Agreement. They often function at a national level, where they are usually called emissions trading systems, and are typically mandatory for entities participating in specified activities and/or sectors. See Section 4.1.

International carbon trading systems have also been established, under both the Kyoto Protocol and the Paris Agreement (where they are still in the process of finalisation). Participation is voluntary, but they are usually classified as compliance markets as they are linked to mandatory emissions targets. See Section 4.2.

Voluntary carbon markets operate outside legal obligations and are driven by corporate climate commitments and consumer demand. See Section 4.3.

4.1 COMPLIANCE MARKETS: EMISSIONS TRADING SYSTEMS

Compliance markets are tied to targets for reducing greenhouse gas emissions, whether national or sub-national. From their beginnings under the 1997 Kyoto Protocol, compliance carbon markets have evolved to cover roughly 23 per cent of global greenhouse gas emissions, mostly through national emissions trading systems.⁴⁰

The EU Emissions Trading System, launched in 2005, was the first, and is still the largest, regional implementation of emissions trading. This requires large emitters of greenhouse gases – power stations, industrial plants and airlines (for flights within the European Economic Area) and, since 2024, maritime transport – to buy allowances to cover their emissions every year.

The system currently covers over 10,000 installations and approximately 1,600 aircraft operators. If an operator reduces its emissions sufficiently to generate a surplus, it can sell the unneeded allowances to installations that have not. The system thereby incentivises the most cost-effective emissions reductions, and – since the total of allowances is reduced each year – ensures a steady reduction in total emissions over time.

HFC emissions are included in the EU ETS (though ODS are not), but the generation of allowances from the destruction of HFCs was banned in 2013 in the light of evidence that it created a perverse incentive to manufacture HFC-23 as a by-product of HCFC-22 production (see below). The main EU instrument for controlling production and consumption of HFCs is the F-Gas Regulation, which sets steadily reducing caps. In contrast, in New Zealand's ETS, credits can be generated from the export or destruction of HFCs, as discussed below in Section 5.2.

In the US, two states have enacted cap-and-trade (California) and cap-and-invest (Washington) programmes, capping carbon emissions state-wide at thresholds which are ratcheted down over time.⁴¹ Under each programme, companies in the state must lower their emissions in line with the cap or purchase offset credits.

In both programmes, compliance offset credits are available for projects related to the destruction of ODS from eligible sources; this includes refrigerants, but the types of refrigerants eligible are limited and periodically updated. Currently, in California, six CFC refrigerants are eligible for generating ODS destruction credits, although only if the refrigerants originate from the US and the destruction takes place within the US. Protocols used for ODS destruction credits on the California and Washington compliance markets are modelled after existing methodologies on the voluntary carbon market and are subject to strict scrutiny and oversight.

4.2 COMPLIANCE MARKETS: INTERNATIONAL INITIATIVES

International carbon offsets took off in the mid-2000s, with the establishment of the Clean Development Mechanism (CDM) under which developed countries were helped to meet their emission reduction goals under the Kyoto Protocol by investing in offset projects in developing countries (which had no targets). The projects generated Certified Emission Reductions (CERs) to offset against the targets. Joint Implementation (JI) was a similar mechanism,



allowing the generation and transfer of Emission Reduction Units between countries which did have emission caps under the Kyoto Protocol.

Although the CDM had a more rigorous system of oversight, screening and monitoring than any other offset programme at the time, it still suffered from significant flaws. A 2016 analysis found that 85 per cent of projects had a low likelihood of ensuring environmental integrity (i.e., ensuring that emission reductions were additional and not overestimated), while only two per cent had a high likelihood.⁴² JI was similarly flawed – one analysis concluded that about 75 per cent of JI projects were unlikely to be additional – i.e., they would have happened anyway.⁴³ Most notoriously, the CDM and JI both created perverse incentives to manufacture HFC-23 as a by-product of HCFC-22 production and to then claim credits for its destruction (with a similar incentive to manufacture and then destroy sulphur hexafluoride, SF₆, another potent greenhouse gas).⁴⁴

These developments helped to undermine the credibility of international compliance markets (and led, among other responses, to the EU excluding all international offsets from activities outside the EU from its own ETS) until the 2015 Paris Agreement renewed the momentum. The Paris Agreement's Article 6.2 allows bilateral or multilateral transfers of emission reductions (Internationally Transferred Mitigation Outcomes, or ITMOs), replacing JI. Article 6.4 establishes a new global crediting mechanism (the Paris Agreement Crediting Mechanism) to replace the CDM, through which developed countries may invest in emission reduction projects in developing countries in return for emissions credits. The intention was to establish systems with stronger oversight and alignment with national targets, avoiding the problems of non-additionality, leakage and permanence that had dogged the Kyoto mechanisms.

The detailed procedures to operationalise Article 6 took many years to agree, but significant progress was made at the climate conferences in 2021 (CoP26) and 2022 (CoP27). Following CoP27, several countries began building the infrastructure for reporting, authorisation and registry systems. A handful of bilateral deals have been announced to date under Article 6.2; these are mostly pilot projects, but they signal the beginning of a formal global carbon trading system. Japan's Joint Crediting Mechanism, originally set up to support the implementation of the Kyoto Protocol, has supported HFC destruction projects in Thailand, Vietnam and the Philippines.⁴⁵

The UN Supervisory Body for the Article 6.4 Paris Agreement Crediting Mechanism has worked since 2023 on operational details, including methodologies, baseline setting and removals. Final rules were agreed at CoP29 in 2024, although CoP30 in 2025 saw some attempts to reopen the decisions and continued discussions over implementation.

By early 2026, well over a thousand projects and programmes had notified their intention to transition from the CDM to the new Mechanism, with more expected; at CoP30, the deadline for transitioning was extended from the end of 2025 to mid-2026, and the CDM will close completely at the end of 2026.⁴⁶ NGOs and others have raised concerns that the weaker CDM crediting methodologies, which have led to significant excess generation of credits, have in effect been transferred without corrective measures into the new system.⁴⁷ More broadly, the emerging rules governing both the Article 6 mechanisms have been criticised as lacking sufficient levels of quality, transparency, accountability and equity.

Three HFC project activities previously under the CDM can transition to the Paris Agreement Crediting Mechanism – the HFC Decomposition Project in Republic of Korea, the Quimobásicos HFC Recovery and Decomposition Project in Mexico and the Avoidance of HFC-134a emissions in rigid Poly Urethane Foam (PUF) project in India.⁴⁸

To date, only the Quimobásicos project, with a potential reduction of 3.43 million tonnes CO₂e (MtCO₂e), has requested the transition. Quimobásicos has also received funding from the Multilateral Fund for the destruction of HFC-23 by-product from HCFC-22 production.⁴⁹ Since one of the conditions of this financial support was that no additional funding streams (including, specifically, from carbon credits) should be pursued, it is not clear why this request was made.

4.3 VOLUNTARY CARBON MARKETS

Voluntary carbon markets (VCMs) are not linked to national emissions reductions targets and are driven primarily by corporate responsibility programmes. They emerged in the 1990s and grew alongside compliance markets under the Kyoto Protocol. Like them, growth stagnated until the 2015 Paris Agreement revived interest by establishing a global framework for climate action. This led to increased private sector ambition from companies wanting to go beyond regulatory requirements and offsets began to play a larger role in corporate net zero strategies. By 2021, VCMs were valued at more than \$2 billion worldwide and covered more than 500 million tonnes of greenhouse gas emissions. However, by 2023 this had fallen to \$755 million and in 2024 to \$535 million in the wake of a number of high-profile investigations revealing substantial over-crediting in voluntary (and compliance) markets.⁵⁰

The financing gap for ODS and HFC bank management has led some countries, especially smaller developing countries, to turn to the voluntary market as a funding source for waste substances already in their country. Since many ODS and HFCs have extremely high GWP values, destroying even small amounts can avoid large CO₂e emissions, generating significant volume of credits relative to effort.



Tradewater, one of the most prominent project developers involved, collects refrigerant gases and destroys them, issuing credits based on the avoided emissions. It has run projects in Chile, Dominican Republic, Ghana, Honduras, Saudi Arabia and Thailand, among others. One of the biggest Tradewater projects was its partnership with Thailand's Customs Department to collect more than 10,000 cylinders of illegal ODS which had been seized and stockpiled; the destruction was estimated to avoid about 1.1 million tonnes CO₂e emissions.

More typical was Ghana's partnership with Tradewater, which destroyed more than 15 tonnes of CFC-12 from old refrigerators, generating more than 150,000 carbon credits.⁵¹

By 2025, Tradewater claimed to have eliminated more than 10.5 million tonnes of CO₂e emissions since its foundation in 2012, although this includes an unspecified volume from preventing methane leaks.⁵²

Another prominent developer, the A-Gas Group, also sells recovery, reclamation and destruction services, generating carbon credits from both reclamation and destruction of ODS and HFCs for both voluntary markets and the California cap and trade system (see above). A-Gas was reclaiming HFCs before it started generating credits from it and still carries out reclamation in other jurisdictions, outside the US, without generating credits. A-Gas claims to have abated 10.8 MtCO₂e emissions in 2024, although this includes recovery and reclamation activities; no separate figure appears to be available for destruction.⁵³

Although the voluntary carbon market has been an important source of revenue for some projects in some countries, overall, it is not a major source of finance on a global scale. The total value of carbon credits in the chemical processes/industrial manufacturing sector reported by Ecosystem Marketplace – which includes ODS and HFCs, but also nitrous oxide destruction, fugitive emissions capture and destruction and direct air capture and other engineered removals – reached \$50.2 million in 2023 and just \$20.8 million in 2024.⁵⁴

4.4 PROBLEMS WITH CARBON MARKETS

Carbon markets, both voluntary and compliance, suffer from serious underlying flaws:

- **over-crediting** – as noted above, a clear majority of CDM and JI projects overestimated the volume of emissions offset, sometimes very significantly. In practice, it can be very difficult to estimate in advance the emissions offset from a project. This is particularly true for forestry-related projects but also affects technology transfer, such as replacing inefficient cookstoves. For ODS and HFCs, estimates of volumes stored in banks are not likely to be precise (note the wide ranges for global totals included in Chapter 2), leading to potential over-crediting
- **additionality** – as also noted above, many CDM and JI projects were found not to be additional – i.e., the activities would have taken place anyway. The carbon credits generated from these offset schemes did not, therefore, represent any reduction in emissions and instead led to a net increase as they allowed the buyer of the credits to avoid taking action to reduce their own emissions. As one former offset developer said in 2021, when offset rules are written they often "ignore the fact that there are 1,000 smart people next door that will try to game them".⁵⁵ This is reflected in the findings of a 2024 analysis of CDM projects which observed that "project developers have been able to define exaggerated baseline scenarios and to register nonadditional projects".⁵⁶ In reality, it is impossible for regulators to know with certainty what companies would have done in the absence of carbon markets and, in voluntary markets, companies may choose certifiers which ignore such issues altogether
- **leakage** – this occurs when emissions which are reduced, avoided or removed within a project boundary are shifted, either wholly or partially, outside that boundary. This is a particular problem for forestry projects, but also potentially for ODS and HFC banks. Since volumes of substances destroyed are deducted from the calculation of 'production' (and therefore 'consumption') under the terms of the Montreal Protocol, destruction for credit-generation potentially allows additional production to take place
- **double-counting** – as noted above, claiming credits for the reclamation of ODS or HFCs clearly risks double-counting since the substances will eventually be emitted or destroyed in any case and there is no guarantee that an equivalent quantity of virgin gas production will have been offset (this being the premise of the credit generation). Article 6 of the Paris Agreement aims to prevent double-counting through 'corresponding adjustments', requiring the country selling a carbon credit to deduct that reduction from its own emissions inventory; this does not, however, apply to credits sold on the voluntary market
- **perverse incentives** – as seen, for example, in the CDM and JI, under which incentives were created to manufacture HFC-23 as by-product, purely to gain revenue from destroying it. Another example is the potential incentive created by ODS and HFC credits to delay the phase-out of substances in order to continue generating credits from their reclamation and ultimate destruction.

Reliance on VCM offsets raises particular concerns for ODS- and HFC-based credits because of significant weakness in oversight and the lack of connection to national emissions reductions targets.⁵⁷ Research shows very high non-



compliance rates – between 25-70 per cent – in voluntary offset programmes, largely due to information asymmetries and ‘greenwashing’. Indeed, estimates suggest at least 25 per cent of VCM offsets lack integrity.⁵⁸

While refrigerant destruction is permanent, reliance on continuous credit sales creates market vulnerability as the system will only work if the carbon price is high enough to generate sufficient profits for the company generating the credits. As future refrigerant banks are likely to be increasingly composed of refrigerants with lower GWPs and/or difficult-to-recover blends, this risks the project developer simply abandoning recovery in due course. Developing countries will then be left with higher-cost options for reducing their own emissions after private developers (or developed countries, in the case of compliance markets) have skimmed off the cheapest emissions reductions. This behaviour has already been observed in current programmes, with operators tending to focus only on the highest-GWP substances.

VCM stakeholders have attempted to meet some of these concerns through the development of defined methodologies, such as Verra’s VM0016 standard (Recovery and Destruction of Ozone-Depleting Substances (ODS) from Products). Verra has recently revised this standard in order to, it claims, align with the Kigali Amendment. In practice, the revision has been used to expand the scope of credit-generating activities to allow for the destruction of previously excluded substances, including HCFCs held in stockpiles, certain HFCs, intact foams, fire suppressants and propellants.

NGO responses to these developments have included criticisms of the proposed eligibility conditions as too easy to meet and the increased risk that diversion or continued production of HCFCs is incentivised so that project developers and/or other stakeholders can benefit from destruction revenues. Furthermore, the proposed methodology does not prevent destroyed quantities of HCFCs being deducted from a party’s allowed production or consumption levels under the Montreal Protocol, potentially enabling additional production or consumption, along with associated emissions.

Finally, the methodology contains no requirement for benefit-sharing or disclosure of what proportion of the revenue is contributing to climate action versus private profit.

Even if higher standards can be achieved, many jurisdictions, particularly in developing countries, lack regulations mandating proper recovery. This makes baseline determination difficult and may create perverse incentives to delay regulatory development so as to maintain high baselines for credit generation. TEAP reports emphasise that destruction succeeds only when driven by regulation – yet offset mechanisms create financial disincentives for this.

Since VCMs are not tied to national targets agreed under the Paris Agreement framework, there is no guarantee that the emissions reductions that result would be additional to what would have happened anyway.

The Montreal Protocol succeeded by establishing binding obligations and predictable compliance schedules backed by financial assistance and supported by universal participation. By contrast, voluntary offset markets create unstable incentives dependent on corporate commitments and credit prices, creating fragmented systems where bank management depends on voluntary buyers rather than legal mandates. This results in slower technology transfer, inadequate infrastructure investment and reduced compliance certainty.

The system is also not equitable, since the profits from the sales of credits accrue to companies based, most often, in non-Article 5 countries, with no profit-sharing or long-term investment in the Article 5 countries where the recovered substances are located.

In theory, compliance markets should be more robust since they are tied to national or sub-national programmes for reducing emissions. But the problems outlined above continue to affect the development of international systems for trading emissions. As one recent academic review concluded, “many of the problems plaguing the [carbon] market are likely intractable. Put differently, the present market failures are not due to a few bad apples but rather to systematic, deep-seated problems, which will not be resolved by incremental changes.”⁵⁹

This report therefore concludes that neither voluntary nor compliance carbon markets can provide the reliable, sustainable finance necessary to establish effective, long-term LRM and bank management strategies. In particular, in light of the pervasive weaknesses outlined in this chapter, voluntary carbon markets should play no part in financing LRM and bank management.

Compliance markets, including those under Article 6 of the Paris Agreement, do possess a theoretically sounder footing, but pervasive risks remain unaddressed. The serious weaknesses of the CDM should serve as a warning against climate finance predicated on carbon market mechanisms. As such, this report cautions countries against financing LRM and bank management activities through either Article 6 or any other international compliance markets.



If countries do seek to engage in these markets, they should do so only in limited circumstances and subject to strict oversight and additional constraints – such as, for example:

- funding is provided only for destruction, not reclamation
- substances to be destroyed are determined by the host country (i.e., no cream-skimming, where the project developer accepts only the highest-GWP substances for destruction)
- volumes destroyed are not excluded from the calculations of production and consumption under the Montreal Protocol (they will be excluded for reporting purposes under the Protocol, but this should not be allowed to affect actual production or consumption in the country)
- resources spent by the investor country must contribute to permanent destruction capacity – e.g., investment in destruction facilities in the host country or a neighbour, as part of a regional scheme, and/or in collection and transport facilities.

5. ALTERNATIVE FINANCING OPTIONS FOR ADDRESSING BANKS

The drawbacks of relying on financing from carbon markets explored in the last chapter highlight the need to explore alternative options for financing bank management in Article 5 countries.

This chapter discusses potential options for multilateral and bilateral support (Section 5.1), national support (5.2) and corporate responsibility programmes, including extended producer responsibility (5.3).

5.1 MULTILATERAL AND BILATERAL SUPPORT

Funding for bank management in Article 5 countries could be derived from a range of external sources of support.

MULTILATERAL FUND FOR THE IMPLEMENTATION OF THE MONTREAL PROTOCOL

With respect to Article 5 countries, perhaps the most obvious is the main existing source of financial assistance – the **Multilateral Fund for the Implementation of the Montreal Protocol (the MLF)**.

As noted in Chapter 2, the Fund has already provided support for projects related to LRM, including technical assistance for the recovery and reclamation of refrigerants, demonstration pilot projects covering ODS disposal and destruction and, most recently, the development of inventories of used or unwanted controlled substances and plans for their collection and disposal. Between 2009-14, the Fund supported pilot ODS disposal demonstration projects for nine countries (including those listed in Table 3.1, above) leading to 392.15 tonnes of ODS destroyed (largely CFC-11 and CFC-12), representing a reduction of 2.23 MtCO₂e in greenhouse gas emissions.

No further projects were supported until December 2022 when, in Decision 91/66, the Executive Committee agreed to open a funding window for drawing up national inventories of used or unwanted controlled substances and developing plans for their collection and disposal. Projects could be submitted from December 2023 to December 2025, with project completion expected between 2025-27. By December 2025, \$12.04 million had been approved for projects in 128 countries and one region (Asia Pacific).⁶⁰

At the 35th Meeting of the Parties to the Montreal Protocol in 2023, the Executive Committee was requested to consider providing funding to those parties which had completed bank inventories and management plans for collection and disposal to enable them to implement these plans.⁶¹

At its meeting in December 2025, the Executive Committee decided it would consider a new document on funding modalities, including elements for draft cost guidelines to implement plans developed in accordance with decision 91/66 at its first meeting in 2027 (Decision 97/89).⁶²

Despite this delay, many recently approved HPMPs and KIPs have included, as part of the activities for the servicing sector, the provision of equipment to support the establishment of recovery and reclamation centres. As noted above, in December 2024 the Executive Committee had also decided to commission a desk study for the evaluation of recovery, recycling and reclamation projects.

The 37th Meeting of the Parties in November 2025 saw the adoption of a decision requesting the TEAP to conduct a global study of used and unwanted refrigerants containing controlled substances; the identification of existing



destruction and reclamation facilities that could accept used refrigerants from other countries; and estimates of the potential benefits in terms of avoided ozone depletion and global warming associated with the reclamation and destruction of the substances. The study is to be presented to the 39th Meeting of the Parties in 2027.

The Multilateral Fund remains the primary and preferred mechanism for financing bank management activities in Article 5 countries, particularly for low-income countries and small developing states.

The alternative and complementary options discussed below should be seen as supplementary to Multilateral Fund support, not as substitutes for it.

OTHER MULTILATERAL FUNDS

Other multilateral funds could potentially provide additional support for LRM activities, including capacity-building, infrastructure development and technology transfer for refrigerant recovery, reclamation and destruction. As well as multilateral development banks such as the Asian Development Bank or African Development Bank, two institutions, the Green Climate Fund and the Global Environment Facility, are major sources of environmental project funding.

Established in 2010, the **Green Climate Fund (GCF)** acts as the main financial mechanism of the UN Framework Convention on Climate Change (UNFCCC) and Paris Agreement. By the end of 2024, the Fund had financed 285 projects with a total value of \$60 billion, mostly through concessional loans and grants, but also with some equity investment, results-based finance and guarantees.⁶³

In 2021, the GCF provided \$157 million to the World Bank's Clean Cooling Facility, which supports the adoption of sustainable cooling technologies across different sectors (health, buildings and agriculture/rural communities) in nine developing countries.⁶⁴ This includes funding for policy, regulatory and enabling environment support as well as investment. It does not currently cover end-of-life management.

The **Global Environment Facility (GEF)** was established in 1991, ahead of the 1992 Earth Summit in Rio de Janeiro, to support country-driven sustainable development initiatives in developing countries that generate global environmental benefits. To date, the GEF has provided more than \$22 billion in grants and mobilised another \$120 billion in co-financing for more than 5,200 projects and programmes. In June 2022, donors to the GEF pledged a record \$5.33 billion in support for its latest four-year replenishment cycle, which runs until June 2026.

Within the topic of chemicals and waste (one of the GEF's five focus areas), the Facility has provided support for the phase-out of ODS, especially for countries which do not qualify as Article 5 parties under the Montreal Protocol but nevertheless need assistance.

In 2017 it approved \$18 million for the Regional Demonstration Project for Coordinated Management of ODS and POPs Disposal in Ukraine, Belarus, Kazakhstan and Armenia.⁶⁵ Including co-financing, the total amount available came to \$74.5 million. By 2023, an estimated 418 tonnes of ODS (plus 11,700 tonnes of persistent organic pollutants) were due to be destroyed.

BILATERAL FUNDING

Up to 20 per cent of donor countries' contributions to supporting Article 5 countries to meet their obligations under the Montreal Protocol can be made through bilateral cooperation projects instead of through direct payment to the Multilateral Fund.

A number of countries, including Australia, France, Germany and Italy, regularly use this route. Between 2013-25, for example, the German Federal Ministry of Economic Affairs and Climate Action provided €9.5 million for the development of inventories, plans and pilot plants for the recycling and disposal of old stocks of refrigerants and foams in China, Colombia, Dominican Republic, Ecuador, Ghana, Iran, Malawi and Tunisia.⁶⁶

From 2021, some of this funding was used to launch the **Climate and Ozone Protection Alliance (COPA)** to accelerate the global shift to sustainable refrigerant management and accelerate the mitigation measures needed to address ODS and HFCs.⁶⁷

COPA aims to increase knowledge, raise awareness and secure sustainable financing solutions; it has published several studies, referenced throughout this report. Current members include the Ozone Secretariat, two of the four implementing agencies of the Multilateral Fund (UNDP and UNIDO), several NGOs, a wide range of businesses and industry associations and 27 developing countries.

Initial activities have focused on mitigation actions in metropolitan regions in five countries – China, Ecuador, Ghana, Mexico and Tunisia. COPA has also financed studies of possible actions in other countries, e.g., the potential for EPR in Pakistan (*see below*, Section 5.3).



5.2 NATIONAL FINANCING MECHANISMS

A wide range of options is available to national governments seeking to provide finance to support LRM, including simple loans, grants or subsidies for LRM-related projects such as technician training and investment in collection and destruction infrastructure. These could be delivered via green banks or technology accelerators, as well as directly from government.

Blended finance aims to combine different outcomes – including financial return, environmental impact and social benefit – into one vehicle, enabling a project with multiple outcomes to achieve funding; it has been the main development and climate finance collaboration approach to date, incentivising commercial capital to flow to projects that contribute to sustainable development while also providing financial returns to investors. Much of the international finance discussed in Section 5.1 has in practice been delivered through such vehicles. Results-based finance aims to tie financial support directly to the fulfilment of agreed goals, such as emissions avoided.

Governments can also introduce measures designed to raise additional finance for LRM activities. In some countries, taxes, levies, import duties or emissions trading systems have been used both to generate revenue for the public sector – some of which may be dedicated to funding LRM activities – and to raise the price of virgin substances, increasing the incentives to recover and reuse used substances and to adopt alternative, lower-GWP refrigerants.

Environmental taxation of this kind has been widely used in the Nordic countries. In 2000, **Denmark** adopted an HFC tax initially set at DKK150 (\$21.60) per tonne of CO₂e, applied to substances according to their GWP.⁶⁸ The tax rate was raised in 2020 and by 2023 had reached DKK181 (about \$28) per tonne of CO₂e.

The tax is believed to have contributed to a significantly more rapid fall in the import and use of HFCs in Denmark than in the rest of the EU, although this was also partly due to a ban of HFCs in new equipment introduced in 2006. By 2020, the combined effect was estimated at avoided emissions of approximately 5.3 MtCO₂e.

In 2003, **Norway** introduced excise taxes on the import and production of HFCs (and perfluorocarbons, PFCs), with rates graduated according to the GWP of the gases.⁶⁹ In 2021, the tax was NOK591 (about \$60) per tonne of CO₂ equivalent. Recovered HFCs are exempt from the tax and the tax is reimbursed to those who dispose of HFCs for destruction.

Since 2013, **New Zealand's** Emissions Trading System (ETS) has included HFCs, applying import taxes to new (virgin) refrigerant by GWP and to importers of goods containing HFCs, including motor vehicles and pre-charged equipment.⁷⁰ The ETS does not apply to ODS.

In 2024, the carbon price was set at NZ\$71.97 (about \$42) per tonne CO₂e. Companies regulated under the ETS gain credits (New Zealand Emissions Units) for exporting or destroying HFCs. Until 2026, the country did not possess domestic destruction facilities, so HFCs for destruction were exported to Australia, although the country's first destruction plant was officially opened in March 2026. The ETS provides funding for the country's EPR system (see Section 5.3) and has helped increase refrigerant recovery rates from end-of-life equipment to 11 per cent.

Overall, national mechanisms for raising LRM funding are relatively uncommon. In most countries, including the EU (which has its own ETS), regulations rather than taxation limits businesses' use of ODS and HFCs. The extension of such national approaches to producer responsibility schemes, covering the post-consumer stage, is considered in the next section.

5.3 EXTENDED PRODUCER RESPONSIBILITY

Extended producer responsibility (EPR) is a policy approach which makes producers responsible for their products along the entire lifecycle, including at the post-consumer stage. This can be voluntary, adopted as part of a business' corporate responsibility programme, or mandatory, required through regulation.

EPR schemes increase the collection and recycling rates of end-of-life products, thereby saving costs. They also shift financial responsibility from the public sector to producers, which then have an incentive to produce more easily recoverable and less hazardous products; for example, for refrigerants, end-of-life treatment of natural refrigerants is less costly than waste treatment of appliances containing ODS or HFCs.

EPR schemes are sometimes supported through public funding and sometimes by manufacturers, which typically pass on the costs to end users. Studies of the impacts of EPR schemes generally show good results, although this varies with national circumstances and implementation factors.⁷¹

The simplest version is a take-back scheme, requiring producers to collect and dispose of end-of-life products. For example, the **EU's Waste Electrical and Electronic Equipment (WEEE) Directive**, originally adopted in 2002 and subsequently amended, mandates the separate collection and responsible recycling of electronic waste in order to



reduce landfill, recover valuable resources and protect the environment. It establishes producer responsibility for costs and promotes eco-design to facilitate the easier dismantling, reuse and recycling of electronics, supporting the EU's transition to a circular economy.

The Directive includes refrigerators and air-conditioning appliances and it is complemented in this regard by the **EU's F-Gas Regulation**, which requires the financing of the collection, treatment, recovery, environmentally sound disposal, recycling, reclamation or destruction of fluorinated greenhouse gases contained in the appliances.

In **Germany**, the implementation of the WEEE Directive led to the establishment of the Waste Electrical Equipment Register Foundation (Stiftung Elektro-Altgeräte Register) by manufacturers and associations in the electrical and electronics industry; this is now backed by law. Manufacturers or their representatives with electrical equipment on the market in Germany are required to register with the Foundation and to contribute to collection and recycling costs in proportion to their market share. The Foundation ensures that all manufacturers register, records the quantities of electrical appliances placed on the market and coordinates the provision of collection containers for handover points and the collection of old appliances from public waste disposal authorities, charging manufacturers a fee for its services.⁷²

In **Italy**, legislation governs the take-back of halons.⁷³ Under agreements between the Ministry of the Environment, the Ministry of Industry and private companies, the costs of destroying ODS are covered by the companies selling the new, non-ODS alternatives. This incentivised equipment owners to switch to sustainable alternatives. The strategy was highly successful, recovering 90 per cent of the stock, and although the law provided for at least 70 per cent of the destruction costs to be borne by the companies, in practice they covered the entire costs of destruction.

In **Japan**, the Home Appliance Recycling Law, enacted in April 2001, mandates manufacturers, retailers and consumers to recycle specified home appliances, including air-conditioners and refrigerators.⁷⁴ Consumers pay a collection, transport and recycling fee to the retailer when discarding their appliance and the retailer then collects the appliance and transports it to a manufacturer for recycling, which includes recovering the coolant from air conditioners and refrigerators. A manifest system is used to track the flow of discarded appliances from consumers to retailers to manufacturers to ensure proper disposal and recycling, thus creating a closed-loop system with high recovery rates.

Similarly, Japan's Law for the Recycling of End-of-Life Vehicles, adopted in 2002, requires the vehicle manufacturer or importer to collect, process and recycle the refrigerants contained in end-of-life vehicles, along with airbags, shredder residues and other wastes. The purchaser of the vehicle pays a recycling fee at the point of sale and this is claimed by the manufacturer against the costs incurred; the rate is agreed jointly by the industry and government.⁷⁵ From 2026, the law will be extended to incentivise the recovery and reuse of other components including plastics, aluminium, copper and glass.⁷⁶

Refrigerant Management Canada (RMC), which was launched in 2000, provides another successful industry-led example.⁷⁷ Established by the Heating, Refrigeration and Air Conditioning Institute of Canada in partnership with industry stakeholders, RMC operates as a self-sustaining programme funded by environmental levies on refrigerant manufacturers, importers and reclaimers. It operates through a network of collection service providers across Canada, using hazardous waste protocols and destruction facilities in Alberta and Texas. Since its inception, RMC has destroyed more than 4,700 tonnes of refrigerants representing 8.7 MtCO₂e emissions.

In the US, **New York City's Refrigerant Equipment Safe Handling Act** of 2014 required manufacturers to collect refrigerant-containing appliances.⁷⁸ Manufacturers have so far collected more than 90,000 products, saving the city in excess of \$1.3 million.⁷⁹

A variant of a take-back scheme is a deposit-refund scheme, where a levy or fee is charged for the sale of virgin substances and/or products or equipment containing them and refunds or payments are provided when the substances are returned for recovery. Several countries have implemented deposit-refund systems for reusable drinks containers such as glass bottles and some have introduced them for single-use containers. A few have applied them to refrigerants.

For example, **New Zealand's** Cool-Safe product stewardship scheme, funded by the Trust for the Destruction of Synthetic Refrigerants, with revenue from the country's ETS (see Chapter 4), is responsible for collecting and destroying HFCs and other synthetic refrigerants across New Zealand.⁸⁰ In October 2022, Cool-Safe introduced two buy-back programmes to reward those companies and technicians sending refrigerants for destruction; in May 2024, the payment was increased from NZ\$25/kg to NZ\$40/kg, with higher rates for collections of 200kg or more. The programme has funded the destruction of an average of 35 tonnes a year of refrigerants and has provided funding for the construction of a plasma arc destruction facility, which opened in March 2026.⁸¹ Currently a voluntary scheme, Cool-Safe is intended to become mandatory.

Australia's system is run by **Refrigerant Reclaim Australia (RRA)**, a national product stewardship scheme established in 1993 by the refrigeration and air-conditioning industry to manage the collection and destruction of ODS and other



refrigerants. A non-profit organisation, RRA plays a key role in a nationally coordinated system which brings together government, importers, wholesalers, technicians and consumers to ensure refrigerants are recovered, reclaimed or destroyed in a safe and environmentally sound manner.

The scheme functions within the regulatory framework controlling import, use and disposal of ODS and HFCs. Importers of refrigerants and pre-charged equipment are required by their licence conditions to participate in an approved product stewardship programme to manage refrigerants at the end of their life; almost all meet this obligation by contributing to RRA. Funding for the system is provided through a levy on imported refrigerants, which supports the costs of collection, transport, testing, destruction and financial incentives for recovered refrigerant.

Refrigerant recovered from servicing or end-of-life disposal is returned to participating wholesalers or collection points where recovered refrigerant is consolidated and, where suitable, retained for reclamation. RRA then pays rebates to technicians and wholesalers for every kilogram of refrigerant returned.

By 2024, the RRA programme had collected and disposed of more than 10,000 tonnes of refrigerant gases. The scheme is widely seen as a success, with regulatory backing ensuring comprehensive industry participation, while retaining industry-led governance. The combination of import levies and recovery rebates has created a closed-loop system in which all actors, from manufacturers and importers to service technicians, have a clear role and a tangible reason to comply.

RRA also invests in education and outreach, encouraging safe disposal and research into recovery from smaller split refrigeration and air-conditioning systems and the development of improved storage and transport solutions.

These EPR programmes demonstrate that **industry-led stewardship can achieve high recovery rates when combined with regulatory requirements, stable funding mechanisms and clear governance structures**. Unlike voluntary corporate initiatives, these programmes benefit from mandatory participation embedded in licensing or regulatory frameworks, ensuring comprehensive coverage and predictable financing independent of market fluctuations.

It is important to note, however, that developing countries are likely to face challenges in establishing such systems, including competition from the informal sector and inadequate enforcement. Research on e-waste EPR in China and Thailand revealed 'subsidy gaming', where collectors over-reported the quantities collected.

In addition, given the economic returns, informal markets prioritised metal extraction over proper refrigerant handling.⁸³ Suggestions made by the study's authors to meet these challenges included: tracking systems with multi-party verification; conducting random third-party audits of recycling facilities; creating online, real-time reporting systems for better transparency; cross-checking claimed capacity against actual processing capability; and requiring photographic and weighbridge evidence with timestamps. All of these, of course, require investment in control systems and enforcement.

6. ECONOMIC VIABILITY OF BANK MANAGEMENT

The substantial disparity between the cost estimates presented in Chapter 3, ranging from under \$1 billion to more than \$7 billion annually for global bank management, reflects fundamental uncertainties about the scope, efficiency and comprehensiveness of LRM programmes.

This chapter analyses these estimates, evaluates cost-effectiveness relative to climate mitigation potential and identifies critical factors determining economic viability.

6.1 RECONCILING DIVERGENT COST ESTIMATES

As noted in Section 3.8, the TEAP Task Force lower-bound estimate of \$675 million to \$1 billion annually for the destruction of accessible banks between 2024-50 assumed a unit cost of \$3/kg, which was assumed to be potentially achievable if significant economies of scale and optimal efficiencies could be accomplished – a scenario rarely realised in developing countries, where limited volumes, dispersed sources and inadequate infrastructure generally drive up unit costs.

At the upper end of the estimate range, costs could be between \$4.5 billion to \$6.7 billion. Additionally, these figures did not include the costs of collection, transport, storage and monitoring, which represent significant components of real-world programmes.

The COPA estimate of approximately \$7 billion annually includes comprehensive LRM costs across all stages, from leak prevention to final destruction. This estimate, however, relies on data from 2009-10 studies (adjusted for inflation), raising questions about relevance to current conditions. The assumption that all recovered substances would be destroyed rather than reclaimed also inflates costs, as reclamation typically costs \$5-15/kg less than destruction and



also generates revenue through the resale of purified refrigerants (although this is highly dependent on the market cost of virgin refrigerants – where this is low, revenue from sales of reclaimed refrigerants will fall).

A realistic estimate probably falls somewhere between these extremes. Based on international recovery programmes and industry data, and assuming that 40-60 per cent of recovered substances are successfully reclaimed to purity standards, with the remainder requiring destruction due to contamination or mixed refrigerants, and average collection and transport costs of \$10-15/kg and destruction costs of \$6-10/kg for substances that cannot be reclaimed, total unit costs would range from \$20-30/kg for comprehensive programmes.⁸⁴

TEAP's Medical and Chemical Technical Options Committee (MCTOC) estimates that 250,000-400,000 tonnes of controlled ODS and HFCs are decommissioned annually from the RACHP and foams sectors globally.⁸⁵ However, not all decommissioned refrigerant is realistically accessible for recovery. Factors including informal disposal practices, equipment abandonment, venting (whether legal or otherwise) and infrastructure gaps, particularly in developing countries, substantially reduce recoverable volumes.

Data from mature recovery programmes in Australia, Japan and the EU suggest that even well-functioning systems capture only 20-30 per cent of end-of-life refrigerant.⁸⁶ Assuming a global average recovery rate of 15-25 per cent as comprehensive programmes scale up, this implies 37,500-100,000 tonnes annually accessible for recovery, yielding programme costs of \$0.75 billion – 3.0 billion per year. This range falls between TEAP's lower estimate and COPA's higher figure, reflecting both more realistic unit costs and the practical constraints on recovery rates.

But none of these estimates adequately account for the substantial variation in costs across different contexts. The demonstration projects in Table 3.1 illustrate this – Türkiye achieved destruction costs of \$1.87-2.45/kg through economies of scale, while Ghana's export-based approach cost \$5.99/kg and Nigeria's small-scale rotary kiln incineration \$29.82/kg.

Granted that these costs were results only from pilot projects and may not reflect realistic situations on the ground, country size, infrastructure availability, regulatory maturity and proximity to destruction facilities all significantly affect viability.

6.2 COST-EFFECTIVENESS RELATIVE TO MITIGATION POTENTIAL

Despite uncertainties about absolute costs, cost-effectiveness analysis demonstrates that LRM ranks among the most economically attractive climate mitigation options.

Using the conservative midpoint estimate of \$25/kg for comprehensive LRM and typical refrigerant GWP values, the cost per tonne in CO₂e emissions avoided ranges from \$2.50 for substances with GWP of 10,000 (common for many CFCs) to \$16.67 for substances with GWP of 1,500 (typical for some HFCs).

These abatement costs compare exceptionally favourably to alternatives. The IPCC's Sixth Assessment Report identifies few mitigation options with abatement costs below \$20 per tonne CO₂e.⁸⁷ Carbon capture and storage typically costs \$50-100 per tonne CO₂e. Even highly cost-effective options such as energy efficiency improvements and renewable energy deployment often exceed \$30-50 per tonne when full system costs are included. In December 2025, the average EU ETS carbon price was about €75 (\$88) per tonne CO₂e.

The 91 GtCO₂e total global mitigation potential cited in Chapter 2 takes on greater significance in this context. At \$25/kg average cost and assuming an average molecular weight and GWP yielding 1,000 kg CO₂-equivalent per kg of refrigerant, the cost of comprehensive global LRM to 2100 would be approximately \$2.25 trillion, spread over 75 years, i.e., roughly \$30 billion annually. This represents less than 0.03 per cent of current global GDP and would result in emissions reductions equivalent to more than two years' worth of total current global greenhouse gas emissions.

Nevertheless, this cost-effectiveness calculation masks important distributional and temporal challenges. The climate benefits accrue globally over decades, while costs fall predominantly on the developing countries where banks are concentrated. As noted above, these countries face many challenges, with often weak regulatory capacity and small volumes of substances needing to be collected and disposed of, as well as barriers to service technicians such as limited training, low wages and lack of incentives to support recovery and proper handling practices. The benefits of avoided emissions occur gradually, as prevented releases would have occurred over equipment lifetimes of 10-20 years, while costs are front-loaded in terms of infrastructure establishment and programme initiation.

6.3 ECONOMIC VIABILITY DETERMINANTS

The wide cost range in Table 3.1 reveals that programme design and context determine viability more than the inherent characteristics of destruction technologies. Three factors emerge as particularly critical:



Scale and aggregation efficiency: Türkiye's low unit costs (\$1.87-2.45/kg) resulted from aggregating 9.2 tonnes for destruction, achieving a sufficient volume to justify dedicated destruction infrastructure and negotiate favourable pricing. In contrast, Ghana's 2.8 tonnes and Nepal's 9.1 tonnes required export to distant facilities, adding \$1-2/kg in transport costs. Nigeria's 1.5 tonnes resulted in very high per-unit costs despite using the same technology (rotary kiln incineration) as in Türkiye.

This suggests that economic viability in most Article 5 countries requires either regional aggregation (as discussed in Chapter 3) or accumulation of sufficient volumes over time before destruction. The financial models in Chapter 5 largely overlook this temporal dimension – deposit-refund and levy systems may collect revenue steadily, but destruction costs concentrate in periodic campaigns when sufficient quantities justify facility mobilisation.

Technology selection and local availability: The cement kiln option noted in Chapter 3 offers particular advantages for developing countries. Nearly all countries have cement production facilities, eliminating the need for long-distance transport costs, and the technology requires minimal adaptation of existing infrastructure, reducing capital costs. Cement kilns can handle both pure refrigerants and foam applications, providing flexibility. However, TEAP's \$8/kg estimate for cement kiln destruction may not reflect developing country realities, where regulatory approvals, monitoring requirements and lack of precedent can substantially increase costs.

Integration versus stand-alone approaches: The most successful national programmes described in Chapter 5 – Japan's Home Appliance Recycling Law, Refrigerant Reclaim Australia and Refrigerant Management Canada – achieve viability through integration with broader waste management or product stewardship systems. This allows the fixed costs of governance, monitoring and administration to be shared across multiple waste streams. Stand-alone refrigerant programmes face the full burden of establishing parallel systems.

The COPA country cost estimates in Table 3.2 implicitly recognise this through the 'effort level' categories. Low-effort urban areas leverage existing waste collection infrastructure and technician networks, achieving unit costs of \$18-40/kg. Medium-effort rural areas require dedicated outreach and collection systems, driving costs up to \$34-48/kg. The 60-90 per cent cost differential between these categories exceeds the cost variation between different destruction technologies, confirming that upstream system design matters more than downstream processing choices.

6.4 GAPS IN CURRENT COST ASSESSMENTS

Existing cost studies exhibit several important limitations that constrain their utility for programme design and financing decisions:

Incomplete accounting of transaction costs: The Multilateral Fund demonstration projects in Table 3.1 include direct costs for collection, transport and destruction, but largely exclude the substantial transaction costs of programme coordination, stakeholder engagement, regulatory approvals, customs clearance for transboundary movement and verification. These transaction costs can equal or exceed direct costs in developing-country contexts, particularly for first-mover programmes establishing precedents.

Inadequate treatment of capacity-building costs: Chapter 3 identified training and education as essential LRM components, but neither the TEAP nor COPA estimates provide suggested global figures. Japan's decades-long investment in technician certification and consumer education underpins its high recovery rates, but similar investments would require sustained funding beyond the typical 3 to 5 year project horizons assumed in most cost estimates. Analysis of the extent to which the capacity-building elements of HPMPs (and, in due course, KIPs) have succeeded or failed to meet the needs of LRM would be of value.

Neglect of opportunity costs and benefits: The estimates focus exclusively on direct programme costs without considering the opportunity costs of delayed action or economic benefits beyond avoided climate damages. The leak prevention programmes discussed in Chapter 3 reduce energy consumption and extend equipment lifespans (benefits that accrue to equipment owners), offsetting programme costs. Similarly, investment in training builds general technical capacity with spillover benefits to other sectors.

Limited analysis of cost dynamics over time: The estimates present static snapshots rather than analysing how costs evolve as programmes mature. Initial programmes face high per-unit costs due to limited scale, steep learning curves and infrastructure establishment. As volumes grow and systems become routine, unit costs should decline, but no studies quantify this trajectory or identify the volume thresholds at which programmes achieve sustainability.

Insufficient disaggregation by substance type and application: Both ODS and HFCs encompass diverse substances with radically different handling requirements, GWP values and market dynamics. A tonne of pure CFC-12 from commercial refrigeration (must be destroyed, high-GWP) faces very different economics than a tonne of mixed HFC blend from residential air-conditioning foam (difficult to reclaim, lower GWP). Aggregated cost estimates mask these differences and provide limited guidance for prioritising interventions.



6.5 IMPLICATIONS FOR PROGRAMME DESIGN AND FINANCING

This cost-benefit analysis yields several implications for designing economically viable programmes:

Prioritise high-value interventions: Given the wide variance in costs and benefits, programmes should prioritise recovery from applications offering the highest cost-effectiveness ratios. Commercial and industrial systems with large refrigerant charges, professional servicing and concentrated locations offer substantially better economics than dispersed residential applications. High-GWP substances justify more intensive (and costly) recovery efforts than lower-GWP alternatives, as do old systems containing high-GWP CFCs. Destruction of stored substances can also free up cylinders and collection centre capacity that otherwise remains unavailable for LRM activities.

Phase implementation to match capacity and scale: The attempt to implement comprehensive national programmes immediately faces prohibitively high costs in countries with limited existing infrastructure and small refrigerant banks. A phased approach starting with urban commercial sectors, progressing to industrial applications and eventually extending to residential and rural areas, would allow the gradual development of capacity while accumulating sufficient volumes for cost-effective destruction.

Design financing mechanisms for long-term sustainability: The levy systems discussed in Chapter 4 offer sustainability advantages over grant funding but must be calibrated to actual cost structures, including temporal patterns. Front-loading costs through initial grants while establishing levy systems that mature to cover operating costs offers a possible transition pathway. The Australian and Canadian examples demonstrate that well-designed levy systems can achieve financial self-sufficiency within five to 10 years.

Invest in cost reduction through infrastructure and standardisation: The large gap between best-case destruction costs (Türkiye, \$1.87/kg) and worst-case (Nigeria, \$29.82/kg) in Table 3.1 suggests that strategic infrastructure investments could substantially reduce long-term costs. Regional destruction facilities, standardised collection protocols and technology transfer can shift countries from high-cost to low-cost positions on the cost curve.

Recognise further carbon market limitations, in light of cost structures: The discussion in Chapter 4 of carbon markets takes on additional significance when analysed against actual cost structures. With carbon prices of \$20–30 per tonne of CO₂e and destruction costs of \$6–10/kg, carbon market revenue could potentially cover destruction costs for high-GWP substances (GWP >2,000) but falls far short of what is needed for collection, transport, training and programme administration costs. Coupled with the many serious challenges to carbon markets discussed in Chapter 4, this reinforces the conclusion that voluntary carbon markets should not play any role in funding LRM, and that compliance markets should do so only to a limited degree.

Comprehensive cost-benefit analysis confirms that LRM offers exceptional climate mitigation value, but its economic viability depends critically on programme design choices, scale achievements and integration with existing systems. The wide variation in empirical costs demonstrates that generic cost estimates provide limited guidance; context-specific analysis considering local infrastructure, regulatory capacity, bank characteristics and implementation phasing is essential for realistic planning and financing decisions.

7. OPTIONS FOR BANK MANAGEMENT AND FINANCING

The previous four chapters have outlined options for dealing with the different components of LRM and discussed their costs and cost-effectiveness.

Developing countries face several challenges to their implementation – the prevalence of the informal sector (typically, 60–80 per cent of technicians are uncertified), limited environmental and customs enforcement capacity, a lack of domestic destruction facilities, weak data systems, competing fiscal priorities and vulnerability to external shocks.

Policy and financing options must address these realities rather than replicate developed-country models requiring sophisticated infrastructure and stable institutions, such as the emissions trading systems described in Chapter 4.

Although this report focuses primarily on financing options for bank management, the most effective approach to managing ODS and HFC banks is to prevent their growth in the first place, which implies implementing all the stages of LRM programmes described in Chapter 3.

In turn, this requires robust regulatory frameworks, innovative financing mechanisms and extended producer responsibility systems. Accelerating the transition to non-fluorinated alternatives will also efficiently avoid continued accumulation of climate-damaging ODS and HFCs.



7.1 SUSTAINABLE FINANCING

It should be clear that the discussion above in Chapters 4 and 5 that there are three main options for sustainable financing of the management of banks of ODS and HFCs: international sources, national sources from taxation or levies and extended producer responsibility.

All three, or blends of them, can be used to provide predictable and sustainable flows of finance. This section outlines a range of different solutions and financing options potentially applicable to developing countries.

A) MULTI-LAYERED GRANT AND CONCESSIONAL FINANCING

The international and bilateral sources of funding discussed in Section 5.1 could play a major role in supporting LRM programmes, particularly in their initial phases. The critical principle is to establish sustainable financing through predictable public sources plus industry contributions, rather than volatile carbon market mechanisms.

Once the systems are established, industry levies can provide a larger proportion of stable, long-term revenue directly linked to refrigerant consumption, while creating accountability within the sector. Below are some illustrative examples of the potential of this type of financing. The viability of each project will depend on how it is designed and how the financing sources are mobilised.

Low-volume consuming countries: The Multilateral Fund will need to provide seed funding. Depending on the funding windows available and the guidelines of the Executive Committee, a suggested 60-70 per cent of the total funding for eligible costs should be provided under the Fund (all as grants), with bilateral technical assistance providing 20-30 per cent and the host country government co-financing 5-10 per cent in kind. Revenue from industry levies (see Option B, below) should gradually replace grant dependency by years six to eight.

Medium-volume consuming countries: Here, a wider range of international sources should be available. A suggested blend could be the Multilateral Fund providing 30-40 per cent, Green Climate Fund or Global Environment Facility 25-35 per cent, regional development bank 15-20 per cent (as concessional loans) and industry levies 15-25 per cent. Multilateral Fund grants could leverage Green Climate Fund co-financing, addressing the typical 25-50 per cent co-financing barrier that excludes many developing countries.

B) SIMPLE LEVY SYSTEMS

Complex levy structures can fail in developing countries with weak customs capacity. Rather, successful models should use more streamlined approaches; for example:

- levy applied only to bulk refrigerant imports at point of entry, with pre-charged equipment initially exempted due to its complexity to manage
- focus on top 5-10 importers, aiming to capture 80-90 per cent of the market, achieving manageable enforcement
- single flat rate per kilo of substance (perhaps \$1-2/kg) rather than GWP-differentiated rates, for the sake of administrative simplicity
- integration with existing customs licensing systems, piggybacking on established infrastructure
- use of mobile money or direct bank transfers, avoiding cash and thereby reducing the risk of corruption.

The revenue expectations from such a programme would need to be estimated depending on the substances and applications where the levy is imposed. While this may not be sufficient to cover all the costs of LRM, it would represent a first step and demonstrate country commitment, which would help to leverage funding from other sources.

As in many approaches, some revenues from the levy will probably not be collected, for example from informal imports. Such gaps can be tackled by prioritising commercial and industrial refrigerants (where formal imports dominate); phasing enforcement gradually; offering amnesty programmes; and using bounties ('rewards' for returned refrigerants – see option D, below), thereby creating incentives for informal sector participation without requiring formalisation.

C) GWP-BASED TAXATION AND DEPOSIT-REFUND SYSTEMS

For larger developing countries with greater regulatory and enforcement capacity, more complex taxes or fees may be an option. As discussed in Chapter 5, several countries already apply taxes to refrigerants at the point of sale proportional to their GWP, generating revenue for end-of-life infrastructure while incentivising low-GWP



alternatives.⁸⁸ Unlike disposal fees, taxes generate funding upfront, ensuring resources are available when needed.

Deposit-refund mechanisms include fees charged when purchasing equipment containing refrigerants; the fees are refunded upon proper disposal, creating direct financial incentives for recovery while also ensuring funding availability.

D) HIGH-VALUE BOUNTY PROGRAMMES

New Zealand's Cool-Safe programme, discussed in Chapter 5, demonstrates that paying technicians for returning recovered substances directly incentivises recovery. Cool-Safe, for example, offers bounties of NZ\$25/kg.

In developing countries with prevalent informal sectors and limited enforcement capacity, financial incentives are likely to outperform regulatory mandates. A possible approach suitable for developing countries could include:

- competitive rates: \$15-30/kg for high-GWP refrigerants, \$25-40/kg for ODS refrigerants.
- mobile money payments, eliminating cash handling and corruption
- no certification requirements initially, maximising participation in the programme's early years
- wholesalers as payment points, leveraging existing commercial relationships. The financial transfers to the wholesalers needed to pay for the bounties would form the basis of the necessary monitoring and verification system
- initial funding would be necessary to set up the system, potentially from international sources, for an estimated annual cost of \$0.5-2 million, depending on country size. After initial set-up, industry levies would ensure financial sustainability.

E) HYBRID EXTENDED PRODUCER RESPONSIBILITY – FUND MODELS

Combining EPR requirements, as discussed in Section 5.3, with centralised fund mechanisms addresses both manufacturer accountability and resource availability.

Producers contribute to centralised funds based on products sold, ensuring adequate resources regardless of individual company operations. Systems such as these have been used in Germany for e-waste (see Section 5.3) and Republic of Korea for packaging, where recycling rates increased by 70 per cent between 2003-17 because of well-designed producer responsibility combined with Government coordination.⁸⁹ These can generate sustainable financing while incentivising low-GWP alternatives and proper disposal behaviour.

F) REGIONAL DESTRUCTION FACILITIES

Most developing countries lack domestic destruction capacity and cannot justify the substantial capital costs of investment, which can exceed several million dollars for dedicated facilities serving only domestic needs. Even larger countries may use facilities abroad, as discussed in Chapter 5, with Canada's programme sending substances for destruction to facilities in Texas (as well as domestically in Alberta) and New Zealand's sending collected substances to Australia.

Providing an example of cost, Ghana's rotary kiln incinerator (currently under construction) required an investment of more than \$3 million, while the cost of a superheated-steam unit suitable for small-scale applications has been estimated at around \$500,000. In contrast, modifying existing industrial infrastructure, such as cement kilns, has proven to be a significantly more economical option; Japan's Ministry of the Environment reported a cost of approximately \$50,000 for adapting a cement kiln in Indonesia to handle ODS destruction.⁹⁰

Illustrative cost ranges:

- **dedicated facility** – Capital costs of \$3-25 million, with annual operating expenditures typically of \$1-3 million, depending on throughput and technology type.⁹¹
- **regional facility shared by multiple countries** – Consolidating destruction capacity across 10 or more participating countries can reduce per-country cost burdens to roughly \$150,000-500,000 annually when operating at scale, although this does add transport cost.
- **verification** – All destruction operations require stringent monitoring, reporting and verification, including certificates of destruction issued by facilities, periodic third-party audits and, increasingly, video documentation of destruction events.



Possible regional models for developing countries are therefore:

- **Sub-Saharan Africa** – Establishment of two to three regional facilities using upgraded cement kilns or co-processing units, each serving 15-25 countries and operating at an estimated \$2-5 million per facility. Ghana's rotary kiln incinerator provides a reference point for capital and operational feasibility
- **Caribbean and Pacific small island developing states (SIDS)** – Single regional facilities supported by mobile collection units or interim storage arrangements, enabling aggregation of small volumes for periodic destruction. Grenada is currently establishing a national refrigerant recovery and reclamation centre, the first of its kind in the Caribbean region, through a collaboration between the National Ozone Unit, GIZ and the Grenada Solid Waste Management Authority. The facility will support improved recovery, handling and reuse of refrigerants under the Kigali Amendment and may be used as a regional hub for the Caribbean⁹²
- **South and South-East Asia** – Sub-regional hubs can leverage existing cement kilns retrofitted for ODS/HFC destruction, as demonstrated by PT Holcim Indonesia's Narogong plant in Jakarta. With technical assistance from Japan's Ministry of the Environment, the kiln was modified in 2006-07 to inject and destroy fluorocarbons; by 2009, it had destroyed more than 16 tonnes of ODS (mainly CFC-11) at roughly eight tonnes a year, illustrating a practical, lower-cost alternative to building dedicated units. This approach – using industrial co-processing capacity – is specifically identified by the World Bank, Japan Ministry of Environment and the US EPA as a feasible model for Article 5 countries and can be replicated as sub-regional hubs serving 5-8 countries where suitable kilns exist.⁹³

Initial seed funding could be provided by the Multilateral Fund, with shared operating costs met through country levy contributions proportional to refrigerant consumption. This ensures permanent capacity rather than project-based approaches.

Regional cooperation such as this would require several administrative measures, including harmonised import and export permits, shared monitoring, reporting and verification standards, equitable cost-sharing formulas and regional coordination, potentially through regional bodies such as the African Union, CARICOM, ASEAN or the Pacific Islands Forum.

It would also require agreements under the 1989 Basel Convention on Transboundary Movements of Hazardous Waste, which aims to reduce the export and import of hazardous wastes, minimise their total amount and assist developing countries in their environmentally sound management, with a specific focus on preventing the dumping of hazardous waste from developed countries on to developing countries. Through strict requirements for 'Prior Informed Consent', hazardous waste – which includes used ODS and HFCs – cannot be exported without written permission from the receiving country, as well as any transit countries (though recycled ODS meeting purity specifications are not considered to be waste for these purposes).

7.2 REGULATORY AND GOVERNANCE FRAMEWORKS

As discussed in Chapters 3 and 5, preventing the future growth of ODS and HFC banks, and managing substances in existing and future banks, requires robust regulatory frameworks alongside sustainable financing. Critical elements include:

Strengthened regulatory frameworks – Restrictions on the use and import of substances and equipment, accompanied by mandatory leak prevention and recovery requirements, provide the foundation for bank prevention and management independent of market conditions. This includes sanctions for breaches of the regulations, coupled with effective enforcement.

Monitoring and reporting – Systems and standards to track waste substances and where they end up are critical. This includes the establishment of national databases, tracking refrigerant production, import, sale, use (including requiring equipment owners to report the volume of substances installed) and recovery, creating transparency and enabling monitoring of compliance. Systems can help to track substance flows and identify patterns of non-compliance, supporting data-driven policy decisions. Implementation requires coordination across customs agencies, environmental regulators and industry associations.

Industry-led stewardship with regulatory backing – Programmes such as Refrigerant Recovery Australia and Refrigerant Management Canada demonstrate how industry governance of extended producer responsibility programmes, backed by statutory requirements mandating participation and stable levy-based funding, can achieve comprehensive recovery while maintaining industry leadership and operational efficiency.

Effective training and capacity-building of technicians – including certification and registration programmes.

Comprehensive national planning – Integrated strategies coordinating policy development, infrastructure investment and stakeholder engagement ensure coordinated action across government ministries and sectors.



National plans for environmentally sustainable management of waste substances, including refrigerant recovery targets backed by regulatory enforcement, are necessary elements. A good example is provided by Colombia's national strategy for environmentally sound management of waste substances. Developed with the assistance of GIZ, this defined six strategic lines through to 2030 combining hazardous waste regulations, institutional capacity and financial mechanisms.⁹⁴ The installation in 2019 of degassing machines enabled safer refrigerant recovery, demonstrating the importance of technology transfer alongside policy development.

An illustrative example of phased sectoral implementation matching capacity could be:

- **Phase 1 (Years 1-3):** Commercial refrigeration in urban centres – supermarkets, hotels, restaurants. Large charges (10-100kg), professional technicians, concentrated locations.
Recovery: 20-80 tonnes annually.
Funding: Multilateral Fund grants and bilateral assistance
- **Phase 2 (Years 4-6):** Industrial cooling plus foam banks. Expand to 10-20 cities with levy revenues operational.
Recovery: 100-300 tonnes annually.
Funding: Multilateral Fund, Green Climate Fund and levy revenue
- **Phase 3 (Years 7-10):** Residential appliances and mobile air-conditioning integrated with e-waste systems. National coverage with self-sustaining financing.
Recovery: 300-600 tonnes annually.
Funding: Levies plus Green Climate Fund plus reduced Multilateral Fund dependence.

Building regional cooperation frameworks for shared facilities and knowledge exchange – as discussed in the previous section, where destruction facilities are shared, formal frameworks of cooperation need to be agreed. These can be useful even in the absence of shared facilities.

Integration with other development priorities – finally, it can also be valuable to connect the activities and investments involved in LRM and bank management with broader development priorities, building support and generating possible additional sources of finance. Relevant links include:

- **food security** – Frame as 'Sustainable Cold Chain Development', accessing World Bank agricultural lending and Food and Agriculture Organisation (FAO) assistance
- **health infrastructure** – Link to vaccine cold chain (World Health Organisation (WHO), Global Alliance for Vaccines and Immunization (Gavi), funding) and hospital refrigeration. The COVID-19 pandemic elevated cold chain visibility
- **e-waste management** – Integrate refrigerant recovery into comprehensive e-waste systems, accessing Basel Convention support and existing infrastructure.

This strategic integration can help to ensure programme survival beyond donor cycles through alignment with permanent development priorities rather than, for example, temporary carbon market trends.

7.3 CONCLUSIONS

The management of ODS and HFC banks is both a technical and an institutional challenge requiring sustained commitment, integrated policy design and predictable financing.

As discussed throughout this report, effective bank management cannot rely on any single mechanism; rather, it must combine regulatory, financial and institutional measures tailored to national circumstances. Developing countries face constraints – limited enforcement capacity, informality in the servicing sector and insufficient infrastructure – but these can be overcome through pragmatic, phased approaches anchored in sustainable financing and strong governance.

Among the options reviewed, a multi-layered financing structure offers the most viable path forward. Blending international support with domestic levies, industry contributions and extended producer responsibility can ensure long-term financial stability while promoting accountability within the sector. Simplified levy schemes, bounty systems and hybrid producer responsibility funds can generate consistent revenues and incentivise participation, particularly in countries with large informal sectors. Regional cooperation over destruction facilities provides additional cost-effective opportunities, especially for small and low-volume-consuming countries.

Ultimately, the sustainable management of ODS and HFC banks depends on embedding these financial models within coherent regulatory frameworks that mandate recovery, reporting and safe disposal. Integrating bank management into broader development priorities – such as food security, health infrastructure and e-waste systems – can further enhance policy alignment and access to finance.



The Montreal Protocol has demonstrated that binding international obligations backed by assured financial support can solve global environmental challenges. Maintaining this legacy in the field of LRM requires resisting any reliance on carbon market mechanisms, especially voluntary carbon markets, that lack the permanence, predictability and universal participation necessary for managing banks of refrigerants.

Only through comprehensive regulatory approaches – accelerating the transition to non-fluorinated alternatives while managing existing banks through mandated recovery and destruction – can continued accumulation of these climate-damaging substances be prevented.

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