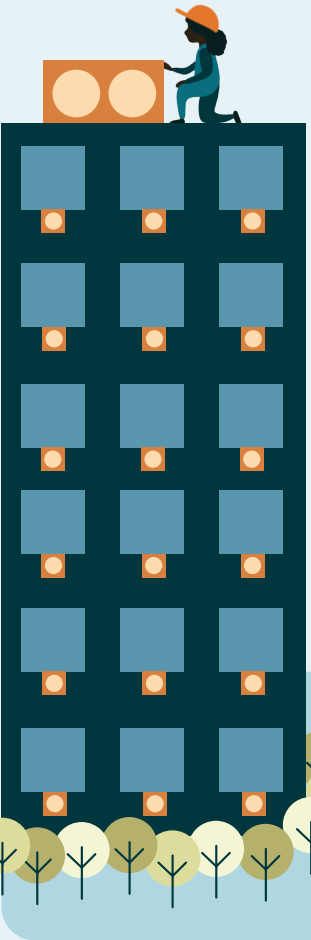
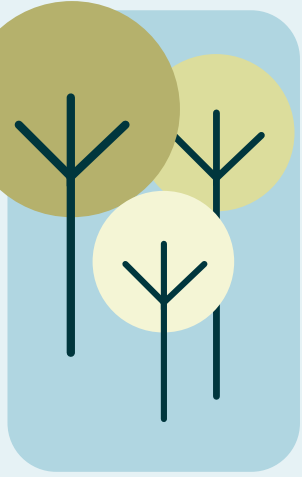




THE 90 BILLION TON OPPORTUNITY



LIFECYCLE REFRIGERANT MANAGEMENT (LRM)

How minimizing leaks and maximizing reclaim can avoid up to 91 billion metric tons CO₂-eq emissions

Executive Summary

Today, built into each cooling appliance and insulating foam in nearly every household, building, and car in America and across most of the world, there sits a type of fluorinated gas called a hydrochlorofluorocarbon (HCFC) and/or a hydrofluorocarbon (HFC).

When leaked out into the atmosphere, HCFCs cause depletion of Earth's ozone layer and both HCFCs and HFCs are extremely potent climate warmers. Pound for pound, these chemicals warm the climate several thousands of times as much as carbon dioxide.ⁱ In total, the U.S. installed base of HCFCs and HFCs is equivalent to 3.6 billion CO₂-equivalent metric tons today, mostly in use as refrigerants. Globally, it is approximately 24 billion.ⁱⁱ

The primary global environmental policy on fluorocarbons is implementation of the Montreal Protocol, which focuses on gradual reductions in the production, import, and use of these gases in the future. To date, however, the policies have not gone to sufficient lengths to prevent emissions, and thus environmental harm, from the HCFCs and HFCs of the past, i.e., those already out in the world.

A global phasedown of HFCs has recently begun under the Kigali Amendment to the Montreal Protocol. The American Innovation and Manufacturing (AIM) Act, enacted by Congress in December 2020, implements it in the United States.

But barebones implementation of the Kigali Amendment and other Montreal Protocol requirements doesn't go far enough, neither in the United States nor the rest of the world. For example, by 2050 the prescribed HFC reduction schedule will have allowed 3.6 billion CO₂-equivalent metric tons to be sold into the U.S. market, effectively doubling from today's levels the potential climate harm requiring mitigation.ⁱⁱⁱ The HCFCs and HFCs of the past, and the HFCs that have yet to enter the market, must not leak into the atmosphere. **If we meet this opportunity to prevent emissions from existing equipment, we'll avert as much warming as two years of President Biden's economy-wide greenhouse gas annual emissions target for 2030.** The numbers are even greater globally, where these transitions are earlier in their processes: 61 billion CO₂e metric tons by mid-century and 91 by century's end (cumulatively).

There is a huge opportunity for chemical producers, equipment manufacturers, federal and state policymakers, major corporations, and maintenance professionals to come together to prevent as much of these potent chemicals as possible from making it into the atmosphere. This report makes a first attempt at laying out the starting point for an approach, referred to here as **Lifecycle Refrigerant Management (LRM)**.

“**In total, the U.S. installed base of HCFCs and HFCs is equivalent to 3.6 billion CO₂-equivalent metric tons today, mostly in use as refrigerants. Globally, it is approximately 24 billion.**”

LRM focuses on avoiding and reducing refrigerant leaks, promoting refrigerant recovery, and increasing reclamation rates to mitigate unnecessary refrigerant use and emissions. The U.S. Environmental Protection Agency (EPA) has ample authority under the AIM Act to successfully pursue many aspects of LRM. The recently passed Infrastructure Reduction Act (IRA) also provides significant additional funding to implement and operationalize the AIM Act and other opportunities to advance LRM including through green bank programs, heat pump and efficiency incentives and rebates, and more. Many of the measures described herein should be considered for adoption by EPA as the AIM Act and the IRA are operationalized.

EPA cannot do it alone, however. Successful LRM will rely on a variety of stakeholders each playing distinct roles: regulators setting mandates, legislatures and other well-resourced entities offering financial incentives, and industry members adapting their practices in favor of the types of interventions we recommend in this paper.

Nor can the U.S. alone collectively meet the 91 billion metric ton opportunity – not even close. Global leadership on LRM is badly needed, and for the U.S. to serve that role, action must start at home.



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We identify six pillars to the LRM approach described in brief here.

- 1 ENHANCE PRODUCT STEWARDSHIP.** Most LRM best practices – leak repair, refrigerant recovery and proper disposal – must be ultimately carried out by the entity least responsible for introducing those materials into the economy: service professionals. Government or private entities can set up programs to help increase the responsibility of those higher up the supply chain, such as chemical producers and equipment manufacturers, to provide for economically and technically feasible LRM. This may be arranged voluntarily at first, or mandatorily, and is a good candidate for a pilot state program.
- 2 INCREASE REFRIGERANT RECOVERY, RECLAMATION AND REUSE.** At the end of an appliance's life, the refrigerant should be recovered and sent to a company that cleans and resells it, a process called reclamation. Reclamation relies on refrigerant recovery for a steady supply of refrigerant so emphasis must be placed on making recovery of old refrigerant at end of life economical and enforceable. The reclamation industry itself needs investment and expansion to meet growing demand. Companies and regulators should require that certain equipment use only reclaimed refrigerant, whether by voluntary commitment or mandate, to increase demand for reclaimed refrigerant.
- 3 LEAK REDUCTION.** If they are not well maintained, cooling appliances leak refrigerant slowly but continuously. Targeting low leak rates is an extremely high priority for LRM because they can lead to large climate benefits at low cost. Companies should pursue operational emission reductions as voluntary targets, and regulatory requirements should ensure that systems meet minimum standards. In some cases, leak reduction incentives by electric utilities may be appropriate. Operators and technicians should also adopt best practice leak monitoring and repair practices.
- 4 REPORTING AND ENFORCEMENT.** Stakeholders frequently report that a lack of enforcement aids and abets improper LRM practices in the field, including violations of existing law regarding refrigerant management. Redoubled effort to monitor and enforce LRM provisions, with modernized technologies and approaches, is needed to ensure fair play and an even playing field for all.
- 5 WORKFORCE DEVELOPMENT.** A well-trained, specialized workforce is the bedrock of LRM. Technicians that handle refrigerants should be recertified by EPA based on the latest standards of practice, with ongoing learning and development opportunities to follow. LRM is also a critical cornerstone of efforts to reduce the emissions footprint of buildings, an opportunity that calls for a concerted approach to recruiting and retaining talent.
- 6 INSTALLATION AND SERVICING.** Installation is the starting point of HVACR equipment's life, and LRM cannot be achieved without proper installation and verification. Servicing practices, such as the widespread technique of topping up leaky systems without repairing the underlying leaks, should be discouraged and avoided whenever possible.

Policies and Actions

Within these six pillars, myriad policies and actions are available to advance LRM through regulatory actions, financial incentives, and voluntary action by the private sector. Each system category calls for a different mix of these approaches. In brief, installation, leak reduction, and recovery all need to be improved for residential systems, commercial system owners and operators should focus on reducing operational leaks, and the vehicle industry should focus on limiting use of small refrigerant cans and emissions upon vehicle disposal.

In each sector, much greater use of reclaimed refrigerant is needed. It is also of first and foremost importance that stakeholders in every sector adopt climate-friendly new equipment whenever a product is being replaced; this report, however, focuses on reducing emissions from older equipment prior to replacement, so this issue is not discussed at length here.

Each of these outcomes should be pursued through a mix of regulatory, incentives-based, and voluntary leadership programs. The extent to which these approaches are regulatory in nature, for example, EPA or state agencies should take the lead in implementing them. EPA has clear authority to promulgate regulations addressing LRM under the AIM Act in addition to expanding existing and new voluntary partnership programs.

Simultaneously, state agencies can lead on innovative approaches to LRM that may eventually pave the way for new federal policies. Similarly, companies have a role to play in piloting beneficial approaches to help build the evidence base of achievable and practical refrigerant management interventions. Some of the following concepts are also well suited to corporate commitments and should become a pillar of corporate sustainability programs.

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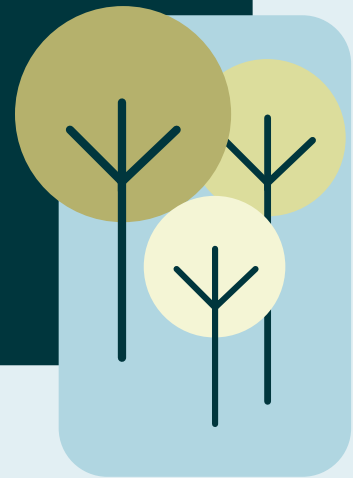
The following policies and actions are presented in the full report:

LRM PILLAR	RECOMMENDED POLICIES & ACTIONS
Enhance Product Stewardship	<ul style="list-style-type: none"> ● Extended producer responsibility schemes; ideally requiring mandatory participation by a range of industry stakeholders to create a level playing field; ● Voluntary industry initiatives and take-back programs; ● Incentives for recovery such as deposit/refund schemes for refrigerant; ● Retailer-led product stewardship awareness raising for consumer appliances; ● QR code database of disposal practices & contacts for consumers; ● Expand existing voluntary programs, such as the EPA Green Chill Partnership, to recognize excellence in end of life refrigerant management and maximizing reclamation, including through partnership with reclaimers, manufacturers, technicians, & retailers.
Increase Refrigerant Recovery, Reclamation, & Reuse	<ul style="list-style-type: none"> ● Bolstering data on current levels of recovery, reclamation, and reuse, such as through a NODA (Notice of Data Availability); ● Required use of reclaimed refrigerant in new equipment; ● Restrictions on virgin refrigerant use to service existing equipment; ● Voluntary procurement standards for reclaimed refrigerant and equipment; ● Reclamation ratio or maximum cap on use of virgin material in rebalancing blends; ● Fees on appliances to cover disposal and recovery costs; ● Utility programs providing incentives for replacement of inefficient equipment include proper recovery and reclamation or refrigerant; ● Expansion of fractional distillation capacity, including through financial and technical assistance such as loan guarantees, low interest financing, or tax credits.
Leak Reduction	<ul style="list-style-type: none"> ● Mandatory and voluntary leak rate targets, periodic leak checks, installation of automatic leak detection; ● Improved recordkeeping & reporting requirements, including electronic registration and reporting for commercial systems; ● Emissions warranties for equipment to cover costs of leak inspection and repair, could be made mandatory; ● Leak-tight equipment design standards and requirements including better fittings, hoses, connections, compressor shaft seals & heat exchanger designs; ● Restrictions on “topping off” refrigerants during servicing without repairing leaks, especially for residential systems; ● Mandatory disclosure of servicing options to customers, including cost of leak check and repair, potential CO₂e emissions or energy impacts.

LRM PILLAR	RECOMMENDED POLICIES & ACTIONS
Reporting & Enforcement	<ul style="list-style-type: none"> ● Collection and publication of data on current levels of recovery, reclamation, and sectoral use of reclaimed refrigerants; ● Targeted investigations to enforce venting prohibition and other requirements based on differences between expected recovery and reported levels of recovery/reclamation; ● Expanded reporting requirements, including for refrigerant wholesalers may support this approach.
Workforce Development	<ul style="list-style-type: none"> ● Updated and expanded training courses to ensure safety and best LRM practices; ● Revised certification requirements for technicians, including recertification and/or continuing education; ● Subsidized or reduced cost training opportunities and programs.
Installation & Servicing	<ul style="list-style-type: none"> ● Minimum quality standards for installation/commissioning new systems including practices such as pressure testing and minimum refrigeration circuit tightness value, evaluation of system parameters; ● IOT-platforms for reporting to track and enforce practices and standards around installation and maintenance; ● Reporting on bad installations; ● Voluntary/utility programs to encourage leak tight/IOT enabled equipment design and reward best practice installation, particularly for VRFs.



The climate benefits associated with LRM – which globally are expected to approach 91 GtCO₂e based on our calculations – hinge on prompt action by governments and in the private sector to send clear and unambiguous signals to refrigerant markets that minimizing leaks and maximizing reclamation should be a policy priority and a central tenet of corporate ESG initiatives.



Endnotes

- i IPCC Fourth Assessment Report: Climate Change 2007. https://archive.ipcc.ch/publications_and_data/ar4/wg1/en/ch2s2-10-2.html
- ii Based on authors calculations. See “Essential Background”
- iii Source: author calculations. The sum of estimated U.S. consumption for 2019-2021, and for the period 2022-2050 the Kigali Amendment control schedule multiplied by EPA’s HFC baseline of 304 MMT of CO₂e. EPA Regulatory Impact Analysis for Phasing Down Production and Consumption of Hydrofluorocarbons (June 2022) at: <https://www.epa.gov/system/files/documents/2022-07/RIA%20for%20Phasing%20Down%20Production%20and%20Consumption%20of%20Hydrofluorocarbons%20%28HFCs%29.pdf>



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