# Stopping Leaks, Keeping it Cool – Findings to help small and independent grocery stores maintain efficiency and reduce costs through refrigerant management.

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## ABSTRACT

Unlike most national and regional supermarket chains, small and independent grocers are often unaware of refrigerant leaks until they're a major issue. Small and independent grocers are also largely unaware of EPA requirements to track and repair leaks, in part because EPA enforcement historically only targets larger chains. Annual refrigerant leaks in existing grocery refrigeration systems often exceed 20% of the full charge and are increasingly costly to repair. Such leaks have a disproportionate carbon footprint, increase peak cooling demand, and can cause loss of both refrigerated products and loyal customers. Simultaneously, the provisions in the American Innovation and Manufacturing Act are spiking the cost and limiting the availability of the high-GWP refrigerants that these systems are leaking.

While national and regional chains often dedicate resources to proactively repairing and replacing high-GWP refrigerant equipment, small and independent grocers often do not know which refrigerants their systems use. A 2025 Grocery Store Refrigerant Baseline Practices Study found that these smaller grocery stores are heavily dependent on their over-extended refrigeration service providers for guidance on repairing and replacing their systems.

To help address these gaps, our paper presents findings and recommendations from the 2025 Study and highlights how grocery store refrigerant measures can expand conventional energy efficiency models into a new territory with outsized GHG benefits. Program Administrators can use these findings to help expand energy efficiency program scope and effectiveness, help small and independent grocers stay competitive, reduce GHG emissions, and reduce energy and repair costs in an ever-changing market.

## Introduction

Integrating refrigerant management measures into energy efficiency programs can provide significant climate, energy, and operational benefits. While grocery retail refrigeration has long been a significant source of electricity use within the building sector, it is also an outsized source of direct greenhouse gas (GHG) emissions. The 2018 Commercial Buildings Energy Consumption Survey (CBECS) reports that the food sales building category has the second highest energy use intensity at 232 kBtu/foot,[2] with refrigeration accounting for 38% of the overall food sales consumption (EIA 2022). In a typical supermarket using high-global warming potential (GWP) refrigerants, about 70% of the total climate impact comes from direct refrigerant emissions (leaks), versus only ~30% from energy use (DTE 2023).

Beyond emissions, uncontrolled leaks harm grocery businesses. Refrigerant losses reduce cooling capacity and force equipment to run longer or at full output to maintain safe temperatures, especially during hot summer peaks. This not only wastes energy but can stress equipment and increase peak demand on the grid. Leaks also lead to higher operating costs:

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supermarkets must routinely replace lost refrigerant (an expense that is rising as high-GWP refrigerant supplies tighten) and may incur costly emergency repairs when a major leak causes equipment failure. Food spoilage resulting from refrigeration downtime adds further expense and can lead to long-term customer loss if shoppers must turn to other retailers.

Larger supermarket chains are often proactively addressing these concerns by dedicating resources to refrigerant management—monitoring and repairing leaks as well as replacing outdated, high-GWP systems. However, many small and independent grocers are commonly unaware of the system's refrigerant types and of leak repair requirements, relying heavily on over-extended refrigeration service contractors for system upkeep. A 2025 Grocery Store Refrigerant Baseline Practices Study in Massachusetts found that none of the interviewed independent store owners or managers was aware of impending 2026 EPA leak repair regulations (Mass Save PAs and EEAC 2026). This was partly because past enforcement focused on large retail chains and partly because these stores don't have the resources to proactively monitor leaks or plan for system retrofits and replacement.

To help address these gaps, our paper presents key findings and recommendations from the 2025 MA Study and highlights how grocery store refrigerant measures allow conventional energy efficiency program models to expand into a new territory with outsized GHG benefits. Throughout, we focus on pathways for reducing emissions and improving performance and reliability in grocery stores. We examine the five primary measure strategies:

- **Leak inspection, detection, and repair** – to find and fix refrigerant leaks, thereby cutting GHG emissions and improving reliability and often efficiency.
- **Refrigerant-only system retrofits** – retrofitting legacy high-GWP refrigerant systems to operate on lower-GWP refrigerant replacements (retro-commissioning is recommended to achieve maximum benefits).
- **Partial system replacements** – e.g., replacing or converting portions of a system (<100% of compressors, <75% of condensers, and not increasing overall system capacity) to lower-GWP refrigerants.
- **Full system replacements** – installing new refrigeration systems (ideally with ultra-low GWP natural refrigerants like $CO_2$, ammonia, or hydrocarbons like propane and isobutane).
- **High-GWP charge reduction** – redesigning existing systems to significantly reduce the total charge of hydrofluorocarbon (HFC) refrigerant required (for example, using distributed micro-booster systems or secondary loop configurations)

Program Administrators can use these findings to expand energy efficiency programs, target best-case projects, and help all grocers—especially small and independent ones—stay competitive, reduce GHG emissions, and lower energy and repair costs in an ever-changing market.

## Methodology

This conference whitepaper was developed through secondary research, 15 in-depth interviews with refrigeration market actors, and data analysis.

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**Secondary Research**: We reviewed federal regulations (and emerging state policies, as well as existing refrigerant management programs and pilot studies across the U.S. This provided context on how laws and market trends affect grocery store refrigerant practices.

**Primary Research**: Researchers knowledgeable in both refrigerant regulations and refrigeration systems conducted 15 in-depth interviews with knowledgeable market actors across seven segments in the commercial refrigeration sector. These included:

- **General refrigeration experts** (industry consultants and organizations)
- **Small/Independent grocers** (owners or financial decision-makers from grocers operating <15 stores)
- **Large chain grocers** (facility or energy managers from chains with 15+ stores)
- **Refrigeration service providers** (who service small/independent grocery stores)
- **EPA-licensed refrigerant reclaimers**
- **In-house refrigeration/facility specialists** (at 15+ store chains)
- **Refrigerant tracking and compliance organizations**

**Data Analysis**: We synthesized findings from secondary research and refrigerant and leak rate responses from interviews to quantify typical refrigerant leak rates, characterize system configurations (e.g., central rack, remote condensers, transcritical $CO_2$), and help inform the potential impacts of various mitigation measures. The team developed baseline estimates and used case studies to project potential energy and emissions savings from leak repairs, refrigerant "retrofits" (replacing refrigerant gas), partial system upgrades, and full system replacements.

## Refrigerant GWP and Regulatory Context Background and Influence

This section explores the current and pending refrigerant types used in grocery store refrigeration systems. Refrigerants play an indispensable role in transferring heat in commercial refrigeration systems, but their environmental impacts vary immensely. Most grocery cooling systems use chemical refrigerants with extremely high GWP—typically in the thousands of pounds of $CO_2$ equivalent. Some modern alternatives have lower GWP; for instance, R-448A has a 100-year GWP of 1,387, while natural refrigerants like $CO_2$ (R-744) have a GWP of 1.

One medium-sized grocery store can contain 1,000+ pounds of refrigerant in its cooling systems. At a typical 20% annual leak rate, that store will emit 200 pounds of refrigerant per year. If that refrigerant is the commonly used R-404A (GWP 3,920), this equates to roughly 360 metric tons of $CO_2$ equivalent ($CO_2$e) emissions annually, or 83 gas combustion passenger vehicles driven in a year. A North American Sustainable Refrigeration Council study estimated that annual refrigerant leaks from supermarkets and grocery stores emit 55 million metric tons of $CO_2$e (2022). Another significant concern is the potential for negative health impacts from long-term environmental exposure to synthetic refrigerants. Many refrigerants can break down into per- and polyfluoroalkyl substances (PFAS) or "forever" chemicals," which are persistently damaging to all organisms (Salierno 2025).

### Natural refrigerants

By contrast, natural refrigerants contain no PFAS, have GWPs below 4, and contain no ozone-depleting properties. When safety, design, and skilled workforce challenges are addressed, natural refrigerants can deliver equal or better performance than synthetic options. For example,

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transcritical $CO_2$ systems have matured to reliably cool large supermarkets, and hydrocarbon refrigerants are now standard in many self-contained units like beverage coolers due to their efficiency and ultra-low GWP (Mass Save PAs and EEAC). Table 1 shows the primary barriers preventing the adoption of natural refrigerants are safety and design.

Table 1. Natural refrigerant primary barriers to adoption

| Natural Refrigerants | Barriers |
|---|---|
| Hydrocarbons: Propane (R-290) Isobutane (R-600a) | Safety: High flammability. Current 300-500 gram charge size restrictions in the U.S. limit effective hydrocarbon use to residential and smaller self-contained commercial refrigeration equipment. |
| Ammonia (R-717) | Safety: Toxic, mildly flammable. Limited use outside of industrial refrigeration. |
| Carbon dioxide (R-744) | Design: Higher system pressures due to gas properties increase system component costs, and design requirements compared to synthetic higher-GWP HFC alternatives. |

The American Society of Heating, Refrigeration, and Air-Conditioning Engineers (ASHRAE) classifies R-717 (ammonia) as a B2L (toxic, mildly flammable) refrigerant. $CO_2$ (R-744) is classified as an A1 (non-toxic, non-flammable) refrigerant; however, $CO_2$ does not mechanically behave like a traditional refrigerant. $CO_2$ has much greater heat transfer efficiency, which can lead to smaller heat exchangers with lower temperature differentials compared to a traditional system. The biggest downside to $CO_2$ is that the pressures of the refrigerant are much higher than traditional systems, leading to increased system component, piping, design, and controls costs.

**Laws, regulations, and market forces.** A confluence of new regulations is pushing the grocery industry toward improved refrigerant management, retrofitting with lower-GWP alternatives, and replacing existing high-GWP systems with natural refrigerant systems. The American Innovation and Manufacturing (AIM) Act of 2020 gave the Environmental Protection Agency (EPA) authority to phase down HFC production/consumption by 85% by 2036 (from a baseline) and to implement rules on minimizing HFC release and facilitating the transition to next-generation refrigerants. Under the AIM Act's HFC phasedown schedule, HFC supply quotas are tightening, driving up prices of many traditional refrigerants. These regulations and market impacts create additional incentives for grocers to fix leaks and transition away from high-GWP refrigerants.

In addition, state climate policies are accelerating the transition. Twenty-three U.S. states (plus Washington, D.C.) have enacted climate action policies that often include refrigerant reduction strategies (Climate 2025). For an increasing number of states and regions, key performance indicators of energy efficiency programs are expanding to include GHG metrics alongside kWh, kW, and therm savings. Refrigerant-focused measures directly support these climate metrics, helping states and utilities meet their emissions targets while also producing energy benefits. Figure 1 summarizes key regulatory events driving the ongoing grocery refrigerant transition.

| | |
|---|---|
| Jan 2020: R-22 Phase-Out Completed | • The U.S. bans production/import of R-22 (an HCFC refrigerant with ozone depleting properties), driving up costs for legacy systems and prompting grocers to plan for replacements. |
| Dec 2020: AIM Act Enacted | • The American Innovation & Manufacturing Act becomes law, setting the course for an 85% phasedown of HFC refrigerant production and consumption by 2036 and new rules to curb HFC leaks and promote reclamation. |
| Jan 2024: HFC Supply Cut 40% | • Per AIM Act, national HFC production/consumption capped at 60% of baseline levels, spurring higher prices for high-GWP refrigerants. |
| Sep 2024: EPA Subsection (h) Leak Reduction Rule | • AIM Act subsection (h) (ammendment to 2020 AIM Act): 15+ lb systems must repair >20% leaks by 2026; largest systems (≥1,500 lb) must install ALD by 2026/27; reclaimed refrigerant required for supermarket service by 2029. |
| 2025: State Level Climate Actions | • 24 states and DC enforce GHG targets, prompting utility programs to value GHG cuts (e.g. MA adds grocery refrigerant measures to EE portfolio). |
| Jan 2026: New EPA Leak Repair and Monitoring Rules | • 40 CFR Part 84: Commercial refrigeration appliances (≥15 lb HFC charge) must repair leaks if annual leaks >20%. New systems (≥1,500 lb) must install automatic leak detection (ALD) |
| Jan 2027 – Leak Detection in Existing Systems | • Existing large refrigeration systems (installed 2017–2025 with ≥1,500 lb HFC charge) must be retrofitted with ALD systems by this date to comply with EPA rules. |
| 2032 – HFC GWP Limit for New Systems | • EPA's proposed rule (Sept 2025) extends deadlines: allowing up to GWP ~1,400 in new supermarket systems until Jan 1, 2032, when a 150/300 GWP limit would then take effect. |

Figure 1. Timeline of Key Policies Affecting Grocery Refrigerants

Market dynamics (beyond formal regulations) are also at play. Many national grocery chains have voluntary sustainability goals and participate in programs like EPA GreenChill, tracking and publicizing their leak rates and retrofitting systems with natural refrigerants. Equipment manufacturers are innovating lower-charge systems and "plug-and-play" natural refrigerant cases, slowly making it easier to adopt climate-friendly options. Table 2 presents a timeline of refrigerant regulations for retail refrigeration equipment. The table includes equipment specific GWP limits and acceptable refrigerant types for new installed systems over the next six years.

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Table 2. Federal approved refrigerant GWP regulation timeline by end-use type

| | | | | | | |
|---|---|---|---|---|---|---|
| Retail refrigeration – products[1] | Retail refrigeration - standalone units | GWP ≤150 | | | | |
| | Refrigerated food processing and dispensing equipment (≤500 g) | No regulation | GWP≤150 | | | |
| | Refrigerated food processing and dispensing equipment (>500 g) | No regulation | Prohibited list C[5] | | | |
| | Ice cream makers | No regulation | | EPA SNAP approved list[5] | | |
| Retail refrigeration – systems[2] | Remote condensing units (≥200 lb., high-temp. side cascade systems) | GWP≤1,400 | | | | GWP≤150 |
| | Remote condensing units (<200 lb.) | GWP≤1,400 | | | | GWP≤300 |
| | Remote condensing units (high-temp. side cascade systems) | GWP≤1,400 | | | | GWP≤300 |
| | Supermarket refrigeration systems (≥200 lb., excl. high-temp. side cascade systems) | EPA SNAP approved list[3, 4] | GWP≤1,400 | | | GWP ≤150 |
| | Supermarket refrigeration systems (<200 lb.) | EPA SNAP approved list | GWP≤1,400 | | | GWP ≤300 |
| | Supermarket refrigeration systems (high-temp. side cascade systems) | EPA SNAP approved list[3, 4] | GWP≤1,400 | | | GWP ≤300 |
| | Remote refrigerated food processing and dispensing equipment. | No regulation | EPA SNAP approved list[5] | | | |

**1. Products:** factory-charged and functional upon leaving factory.
**2. Systems** = assembled and charged in the field using multiple components.
**3. Prohibited refrigerants (A), for new systems:** HFC-227ea, R-404A, R-407B, R-421B, R-422A, R-422C, R-422D, R-428A, R-434A, R-507A
**4. Prohibited refrigerants (B), for retrofit systems:** R-404A, R-407B, R-421B, R-422A, R-422C, R-422D, R428A, R-434A, R-507A
**5. Prohibited refrigerants (C):** R-402A, R-402B, R-404A, R-407A, R-407B, R-407C, R-407F, R-407H, R-408A, R-410A, R-410B, R-411A, R-411B, R-417A, R-417C, R-420A, R-421A, R-421B, R-422A, R-422B, R-422C, R-422D, R-424A, R-426A, R-427A, R-428A, R-434A, R-437A, R-438A, R-507A, HFC-134a, HFC-227ea, R-125/290/134a/600a (55/1/42.5/1.5), RB-276, RS-24 (2002 formulation), RS-44 (2003 formulation), GHG-X5, Freeze 12

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**Published Leakage Rates and Baseline Leakage Rate Assumptions.** Publicly reported refrigerant leakage rates for all application types, including grocery store refrigeration systems, vary considerably, both quantitatively and how equipment types are defined. Table 3 shows a comparison of retail refrigeration end-use categories and their corresponding leakage rates as reported by the two U.S. organizations that have historically tracked and published emission inventory estimates, the U.S. EPA and the California Air Resources Board (CARB). It should be noted that the annual leakage rate values for both the EPA and CARB estimates in Table 3 have not changed in over four years. Given the regulatory actions that impacted both the leak monitoring of HCFCs in 2020 and refrigerant prices, it's reasonable to expect that operational leakage rates have decreased since these numbers were first published.

Table 3. Published refrigerant leakage rates

| End use | Annual leakage rate (percent) | End-of-life leakage rate (percent) | Equipment EUL (years) | Charge size (lb.) |
|---|---|---|---|---|
| **EPA** | | | | |
| Small Retail Food | 1% | 19-65% | 10 | 0.9 to 1.1 |
| Condensing Units (Medium Retail Food) | 7.8%–14.8% | 10-20% | 20 | 5.7 to 55 |
| Large Retail Food | 17%–33% | 10% | 18 | 900 to 3,968 |
| **CARB** | | | | |
| Stand-alone (self-contained) Refrigeration | 1% | 99% | 20 | 1.2 |
| Retail Food Refrigeration, Small | 15% | 34% | 14 | ≤50 |
| Retail Food Refrigeration, Medium | 15.6% | 20% | 15 | >50 to <200 |
| Retail Food Refrigeration, Large | 22.9% | 20% | 15 | ≥200 to <2,000 |
| Retail Food Refrigeration, Very Large | 24.2% | 20% | 15 | ≥2,000 |

## Grocery Store Refrigerant Practices and Measure Opportunities

### Large chains vs small and independent grocers and the low-GWP transition

The 2025 Grocery Refrigerant Baseline Practices Study revealed that the existing stock of grocery store refrigeration systems operates with a wide range of refrigerant types with 100-year GWPs spanning 0 to 3,985. When asked in interviews what actions are being taken to navigate the low-GWP refrigerant transition and rising refrigerant prices, market actors across all grocery sectors agreed that their biggest priority is to replace or retrofit any remaining legacy systems still operating on the HCFC refrigerant R-22. Grocery financial decision-makers and service providers often referred to R-22 as a "banned" refrigerant because of laws prohibiting the production and import of virgin R-22 refrigerant. These factors are quickly escalating the cost of servicing legacy equipment containing R-22 and, in turn, making R-22 systems untenable for most stores. Secondary research findings show that several national and regional grocery store chains are actively transitioning their systems to operate on natural refrigerants or a combination of natural refrigerants and synthetics (Mass Save PAs and EEAC).

Market actor interviews also revealed that a large portion of the grocery stores (both chains and independents) are reluctant to retrofit or replace existing high-GWP HFC systems, except as part of a larger renovation being planned for the store. Grocery store refrigeration system retrofits (and especially replacements) are expensive and create significant logistical challenges that impact everyone in the store. The same cohort of market actors also acknowledged that rising prices for high-GWP refrigerants could alter that position and accelerate their plans to transition legacy high-GWP systems in the future. Some of the 15+ store chains we spoke with shared that they are primarily installing $CO_2$ systems in new stores and in full system retrofits while the smaller and independent stores did not have specific retrofit plans. The regional and national chain market actors with stores in states with state-level regulations exceeding federal ones—like NY and CA—said they are prioritizing full system retrofits and replacements in those states over states like Massachusetts, where regulations largely align with federal regulations.

**Regular leak inspection, detection, and repair**

**Approaches to leak monitoring**. Our research confirms a significant contrast in refrigerant management practices between large supermarket chains and small or independent grocers. The large chain supermarkets we spoke with all oversee medium to large supermarkets and operate central refrigeration systems. The smaller and independent stores we spoke with vary more and operate a mix of central systems and remote condensing units, depending on the size of the store. The smaller stores only operate remote condensing units. All the larger chain stores we interviewed have formal leak inspection or detection procedures, with most tracking refrigerant usage and leak rates. Interviewees from national/regional chains in the 2025 study reported average leak rates around 15–16% per year.

In contrast, smaller and independent grocers (<15 stores) typically operate with a reactive approach to refrigerant-related issues. According to multiple independent store owners and the contractors who service them, most small grocers do not actively track annual leak rates; instead, leaks are usually only discovered when a case loses cooling capacity and triggers a temperature alarm or experiences noticeable product warming. None of the independent store owners we interviewed were aware of the upcoming 2026 EPA leak repair and tracking requirements, underscoring a significant knowledge gap in this segment. Small stores also commonly lack on-site technical staff and therefore rely heavily on external refrigeration service providers to diagnose and fix leaks during emergency service calls. These service contractors noted that in many small stores, leakage issues are essentially unmanaged and can persist for years, especially in older equipment, until a major failure forces equipment replacement.

This gap is aggravated by resource constraints: the fewer the stores and the smaller the business, the less likely it is to invest in robust leak monitoring or to have preventive maintenance contracts in place. The research suggests that smaller grocery retailers merit special attention in program design, as they stand to gain the most from leak reduction efforts (in terms of percentage GHG savings and avoided costly failures), yet are currently the least likely to manage refrigerant leaks on their own.

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**Automatic Leak Detection (ALD) and Monitoring**. One tool for improving leak management is Automatic Leak Detection (ALD) technology, which encompasses both direct monitoring (fixed sensors that detect refrigerant concentrations in the air) and indirect monitoring (software analytics that detect leaks by analyzing refrigeration system performance data). ALD systems continuously monitor refrigerant leaks and alert owners or technicians as soon as a leak is detected—far sooner than a periodic manual inspection or a warm case alert would. Large chains have already invested in these systems and/or conduct routine leak inspections, helping them to catch leaks well before they escalate. Smaller grocers, however, rarely install ALD systems due to cost and limited awareness, meaning leaks may go undetected for extended periods.

Upcoming regulations give new importance to ALDs: EPA's AIM Act Section (h) will require larger commercial refrigeration systems (with a full charge size of 1,500 pounds or more) to incorporate ALD capabilities or adhere to rigorous leak inspection and reporting schedules (EPA 2024). The benefits of ALD systems are substantial for grocers of all sizes: by catching leaks early, ALDs can reduce annual leak rates, prevent large refrigerant losses, improve energy efficiency (by maintaining optimal charge), and extend equipment life. They also help stores stay in compliance with leak reporting rules.

Program Administrators can achieve significant GHG reductions by incentivizing ALD system installations or service contracts in small and independent groceries. Such support could include offsetting the cost of EPA-certified ALD equipment and providing technical training, since proper installation, calibration, and attention to ALD alerts are critical for effectiveness. By making ALDs more accessible, programs can empower small retailers to monitor and manage leaks proactively, bridging the gap between large and small chain practices.

**Energy Impacts of Leak Repair.** While the primary driver for refrigerant leak repair measures is GHG reduction and reliability, there are also modest energy efficiency benefits. When a refrigeration system loses refrigerant, it often operates less efficiently (e.g., compressors may run longer, and cooling capacity drops). Restoring a system's proper refrigerant charge and fixing leaks can reduce energy use. Efficiency Vermont's technical reference assumes roughly 7.5–8% efficiency improvement for leak repairs in small systems and allows a 3-year measure life, recognizing that leakage reduction can yield sustained (if modest) energy savings for smaller systems (Vermont TRM 2024).

In larger supermarket rack systems, however, interviews and research indicate the efficiency gains from repairing leaks alone are often negligible (<1%) (Mass Save PAs and EEAC 2025). Large racks typically have receiver tanks that help maintain liquid refrigerant supply in the system even after some leaks occur. Because of these receivers, performance isn't significantly impacted until leaks deplete a significant portion (>30%) of full system charge. When properly maintained, larger stores will detect and top up leaks before efficiency is impacted. All the smaller grocers interviewed agreed that refrigeration performance suffers as leaks increase – cases struggle to keep temperature, especially in hot summer months. Thus, a leak repair program focused on small retailers with distributed or standalone systems can save energy and reduce peak loads by restoring equipment efficiency, in addition to preventing major failures. Notably, Efficiency Vermont's leak repair incentive was deliberately targeted at small groceries, convenience stores, dairies, and similar facilities with total compressor capacity under 100 HP.

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**Baseline and Savings Estimates for Leak Repair.** The 2025 Baseline Practices Study developed estimated values for use in program planning for leak repair measures. Table 4 summarizes recommended baseline leak rates, post-repair leak rates, efficiency impacts, and measure life for refrigerant leak inspection & repair initiatives in grocery stores, segmented by market type (large chains vs. small/independent stores). Note that these estimates were not developed for use in regions with state-level refrigerant regulations that exceed federal levels.

Table 4. Recommended baselines for refrigerant leakage management practices at grocery stores

| Grocery store market segment | 2026 maximum leakage rate (EPA) | Baseline practices annual system leakage rate | Post leak inspection & repair system leakage rate% | Leak repair energy impact* | Leak repair measure life |
|---|---|---|---|---|---|
| 15+ store grocery chain | < 20% | 16% | 6% | <1% efficiency improvement | 6 months |
| <15 store grocery chains | < 20% | 20% | 10% | 2+% efficiency improvement | 6 months |

When asked how long a store or system can expect to remain tight after a leak repair, market actors universally responded with some variation of "it depends." The location of the repaired leak was a common theme for qualifying the longevity of the repair. A leak repair on a compressor rack was identified as having the shortest efficacy period, and a leak repair in a refrigerated case could potentially last a year or more. Additionally, with larger systems, market actors shared that no matter how vigilant they are, the tightest they can maintain a system is around 6%. This also assumes that they have regularly scheduled leak detection or ALD systems in place, with staff readily available to repair leaks when detected.

- Leak repair measure life or efficacy periods ranging from two weeks to two years were shared.
- The larger the system, the shorter the measure life.
- The quality with which a system is being maintained is another major driver for both leakage rates and leak repair measure life.

Refrigeration service providers in smaller markets also shared that the season in which the leak repair occurs impacts the longevity of the repair. During the summer, refrigeration service providers are extremely busy and inevitably don't have time to conduct a thorough leak inspection and repair at a single store when they are getting urgent service call requests from other stores they support. Instead, they may need to perform a partial test and repair that has the potential to fail that same summer.

**Refrigerant GWP reduction pathways**

While fixing leaks reduces emissions from current systems, a more permanent GHG opportunity lies in transitioning existing high-GWP refrigerants out of the market entirely.

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Market actors we spoke with shared numerous strategies currently being deployed in grocery stores to achieve refrigerant GWP reduction. They also shared that retailers installing new grocery store refrigeration systems are using refrigerant GWPs ranging from 0 to 1,400. Our study explored some of the main pathways for existing grocery stores to achieve refrigerant GWP reductions:

1. **Partial system replacement**
    a. Partial system upgrades that replace some but not all components of the existing refrigeration system. This could include replacing 80% of the compressor racks and shifting to a $CO_2$ system for low-temperature cases while retaining some of the old equipment for medium-temperature areas.
    b. Refrigerant charge reductions involve existing system redesigns that reduce the overall high-GWP refrigerant charge of the system. Examples include satellite rack or protocol systems
2. **Full system replacement** (installing an entirely new refrigeration system, typically during a major store remodel or end-of-life equipment cycle).

Each pathway has different applicability depending on store size, system age/condition, and financial considerations. For baseline condition definition purposes, the distinction between partial and full system replacement is critical. In October 2023, the EPA defined the distinction between maintenance or partial retrofit of an HVAC or refrigeration system and installation of a new system (2023). The following actions constitute what the EPA defines as a new installation:

1. Assembling a system for the first time from used or new components
2. Increasing the cooling capacity, in Btu per hour, of an existing system; or
3. Replacing 75 percent or more of evaporators (by number) and 100 percent of the compressor racks, condensers, and connected evaporator loads of an existing system.

**Examples of partial and full replacement projects**

**Conventional or "one-on-one" condensing unit replacement.** This retrofit involves replacing existing condensers that serve individual loads with low-GWP or natural refrigeration condensing unit systems. The units are rooftop-mounted and use air-cooled or adiabatic gas coolers. This approach is well-suited for smaller stores, convenience stores, or dedicated loads in larger retail stores. This type of project can be used for both partial and full-system retrofits.

**Secondary loop R-744 ($CO_2$) systems.** In this configuration, the existing high-GWP system is used to cool liquid $CO_2$, which then circulates to serve the refrigeration loads via liquid recirculation or thermal siphon. If $CO_2$ is used as the secondary loop fluid, the $CO_2$ does not need to operate at the high pressures seen by full system transcritical $CO_2$ rack systems. This type of system can be installed as a partial- or full-system replacement.

**Distributed R-290 (propane) systems.** These systems place small, dedicated refrigeration circuits with two to three compressors dedicated to each display case by using a small amount of R-290, typically 150 to 500 g. Heat is rejected to the outside through either an air-cooled water loop or chilled water loop. These systems are best suited for small stores since the high compressor count that would be needed for larger stores would drive up maintenance costs.

**Transcritical $CO_2$ rack.** This retrofit option—probably better described as a full replacement—involves a complete overhaul of the refrigeration system to replace all fixtures and machinery with one to four transcritical[1] $CO_2$ racks and multiple remote condensers or gas coolers. This retrofit is most appropriate for large-scale remodels at supermarkets over 15,000 square feet. One advantage of this option is that it's considered "future-proof" due to its use of natural refrigerants.

**Partial replacement baseline criteria.** Partial system or GWP reduction projects that do not meet the EPA-defined criteria for a new installation should be subject to existing condition baselines. The key baseline practice findings specific to partial replacement GWP reduction projects from the 2025 Grocery Refrigerant Baseline Practices Study are presented in Table 5.

Table 5. Baselines for refrigerant GWP reduction and partial system replacement measures

| Grocery store market segment | Existing system GWP | Baseline system annual leakage rate | Energy impact | Eligible system age | Measure life |
|---|---|---|---|---|---|
| 15+ store grocery chains | 0 to 3,985 | 16% | Highly variable depending on measure | ≤ 2/3 of existing system life | 1/3 of existing system life |
| <15 store grocery chains | 0 to 3,985 | 20% | Highly variable depending on measure | ≤ 2/3 of existing system life | 1/3 of existing system life |

**Full system replacement baseline criteria.** Projects that meet the EPA definition of a new system installation should be subject to current new installation refrigerant GWP ISP values. Both market actor interviews and research findings also indicate that, over the last ten years, much of the new system market has transitioned to using natural refrigerants, with CO2 (GWP 1) being the most common in larger systems, and propane and isobutane (GWP 4 and GWP 2, respectively) being common in smaller self-contained systems. Additionally, on September 30th 2025, EPA announced delays to pending new system GWP limits of 150 and 300 GWP that were previously set to go into effect starting in 2026 and 2027.

**End-of-life decommissioning and recovered refrigerant opportunities.** EPA and California Air Resources Board (CARB) emissions data shows that, when decommissioning existing refrigerant-containing equipment, refrigerant is often released to the atmosphere. This runs counter to EPA Section 608, which has very clear guidelines for maintaining, servicing, repairing, and disposing of refrigeration equipment to reduce emissions of ozone-depleting substances (ODS) and their substitutes, such as non-exempt HFCs. The regulation prohibits technicians from intentionally venting refrigerants and requires only EPA-certified technicians to handle non-exempt refrigerants. Technicians must use EPA-approved recovery equipment,

[1] Transcritical $CO_2$ racks are refrigeration systems that use $CO_2$ as the refrigerant but never condense it to a liquid; the $CO_2$ remains in a gaseous state throughout the refrigeration cycle.

follow proper evacuation procedures, and keep detailed records of refrigerant recovery and disposal.

Reclamation of high-GWP refrigerants also has benefits over destruction. With the phasedown of the consumption and import of high-GWP refrigerants, it is expected that there will be a shortage of refrigerants available to service the existing stock of grocery store refrigeration equipment. The growing shortage will only increase the need to continue reclaiming refrigerants that are still being manufactured and used in existing grocery store systems. Reclamation also has emissions benefits over virgin refrigerants, with 75%–82% lower production emissions for reclaimed refrigerants compared to virgin refrigerants (RMI 2024).

## Conclusions and Recommended Strategies for Program Administrators

**Conclusions**. Key performance indicators of energy efficiency programs are continually expanding to include GHG metrics alongside traditional energy savings. Refrigerant-focused measures provide an outsized new area of measure opportunity that directly support these climate metrics. By embracing the strategies discussed below, energy efficiency programs can accelerate the adoption of refrigerant management best practices and ultra-low-GWP technologies across the entire grocery and retail refrigeration sectors. Directing these strategies toward small and independent grocers and stores will maximize program opportunities, including substantial greenhouse gas emission reductions, improved energy performance, and strengthened resiliency for grocers in underserved communities. With adequate attention and persistence, refrigerant-focused initiatives can become a cornerstone of next-generation energy efficiency and climate programs.

**Focus on small and independent grocers.** Direct program outreach and incentives toward small and independent grocers first. Research findings show that larger supermarket chains are already dedicating resources to manage their refrigerant leaks and are being pushed by regulatory and market forces to transition away from high-GWP refrigerants. Smaller chains and independent operators, however, often do not act until a major leak or system failure occurs. By focusing on the underserved segment, PAs will acquire more "net" emissions reductions (i.e., addressing leaks and retrofits before substantial environment, financial, and community losses occur) and provide tangible benefits to businesses that are least aware and can least afford refrigeration upgrades. This focus also supports equity goals: smaller and independent grocers serve many rural and low-income communities. By helping these stores reduce costs and increase reliability, programs will provide social equity benefits alongside environmental gains.

**Prioritize natural refrigerants.** Program administrators should consider prioritizing grocery store measure offerings for partial or full-system replacement of existing high-GWP with natural refrigerant systems. The three most common natural refrigerant categories—hydrocarbons, CO2, and ammonia—all have zero ozone-depleting properties, have GWP levels below 4, contain no "forever" chemicals (e.g., PFAS), and are proven to have equal or superior performance capabilities when safety, design, flammability, and toxicity barriers are addressed.

**Bundle leak inspection with other measures.** Combining refrigerant leak inspection and repair visits with other measure-potential assessments could help improve outreach and program cost-effectiveness. A program could offer a "Refrigeration Performance Tune-Up" package that includes leak inspection/repair, Automatic Leak Detection system assessment, condenser coil cleaning, and possible system retrofit/replacement assessments for older systems.

**Prioritize high-GWP refrigerant charge reduction.** Program Administrators should consider providing grocery store measure offerings for existing system redesigns that reduce the overall high-GWP refrigerant charge of the system. Examples include satellite rack or protocol systems, which have the potential to reduce the overall refrigerant charge of the system by over 50% and average system leakage rates by even more. One knowledgeable market actor oversaw these retrofits and said they typically cost three times as much as a refrigerant-only retrofit project but provide both GHG and energy savings benefits that far exceed the refrigerant-only retrofits.

**Avoid summer leak inspection and repairs.** Plan program cycles to conduct leak inspection and repair initiatives outside of peak cooling months. Refrigeration technicians report that leaks are most frequent in summer (when systems are under greatest stress) and that refrigeration service providers are operating at max capacity just keeping systems operational in those months. By contrast, in fall, winter, or early spring, refrigeration loads are lighter, and service providers tend to have time to perform more thorough leak inspections and repairs. This timing can also help by preparing systems before summer peak load conditions or helping a store consider retrofit or replacement alternatives before catastrophic failures occur. Additionally, by not offering incentives during summer, programs reduce the chance of free-ridership, i.e., paying for leak repairs that would have happened anyway due to urgent necessity.

**Launch a refrigerant recovery pilot**. Program Administrators should consider launching a refrigerant recovery and reclamation pilot in combination with other refrigeration and even HVAC programs that retire existing equipment with high-GWP refrigerants. Market actors in both Massachusetts and California have all shared that it's very common for technicians to forgo responsible recovery and reclamation when decommissioning systems, especially those with less than 50 lb. of refrigerant. Added time, lack of enforcement, and lack of financial incentives are the biggest reasons given for this. District of Columbia Sustainable Energy Utility (DCSEU) is partnering with Hudson Technologies to pilot a utility-sponsored GHG emissions reduction pilot incentivizing refrigerant reclamation and recycling by contractors participating in DCSEU programs. This pilot endeavors to avoid 7 million metric tons of GHG release. Program Administrators should consider providing monetary incentives, recovery training, and best-in-class recovery equipment support to market actors who provide documentation that demonstrates that responsible, EPA-compliant recovery and reclamation has occurred, with the removal of existing high-GWP refrigerant found in retrofitted or replaced equipment.

**Extended leak and energy monitoring and data tracking**: Program Administrators should consider conducting extended pre- and post-energy and refrigerant leak detection monitoring of future leak inspection and leak repair projects to better inform and potentially update the parameters found in Table 4. Program design should strictly follow leak rate guidelines defined in the Code of Federal Regulations. 40 CFR 82.152 – Definitions when calculating leak rates.

**Collect leakage data**. Program Administrators should consider collecting facility refrigerant leak repair, leak charge adjustment, and refrigerant purchase data from grocers who participate in refrigerant-related projects. With all the changing regulations and various market factors impacting refrigerant and maintenance costs, the leakage rate values presented in Table 3 will not remain static. Through gathering maintenance and refrigerant purchase data from participating grocers, the Program Administrators will better understand if and how the leakage values are changing and if updates to current estimates are warranted.

**References**


California Air Resources Board. 2024. Quantification Methodology and User Guide for the CARB FRIP. p. 12. https://ww2.arb.ca.gov/sites/default/files/auction-proceeds/carb_frip_qm_userguide_2024.pdf

California Public Utilities Commission (CPUC). 2024. Forward-Looking Low-Global Warming Potential Refrigerant Transition Study. San Francisco, CA: California Public Utilities Commission. calmac.org/publications/CPUC_Forward-Looking_Low-GWP_Refrigerant_Transition_Study.pdf

Climate XChange. 2025. "Climate Action Plans." State Climate Policy Dashboard. Updated July 21, 2025. climatepolicydashboard.org/policies/climate-governance-equity/climate-action-plans

DTE Energy Co. (DTE). 2023. C&I Refrigeration Pilot: EWR Collaborative Meeting. Detroit, MI: DTE. www.michigan.gov/mpsc/-/media/Project/Websites/mpsc/workgroups/EWR_Collaborative/2023/DTE-CI-Refridgeration-Pilot-032023-Final.pdf

Massachusetts Program Administrators and Massachusetts Energy Efficiency Advisory Council (Mass Save PAs and EEAC). 2025. Massachusetts Refrigerant Leak Repair and Refrigerant Global Warming Potential Reduction: Baseline Practices Research. Boston, MA: Massachusetts Program Administrators and Massachusetts Energy Efficiency Advisory Council. ma-eeac.org/wp-content/uploads/MA24C09-E-ISPREFR-Grocery-Store-Refrigerant-Baseline-Practices-Memo_Final.pdf

North American Sustainable Refrigeration Council (NASRC). 2022. Leak Reduction Initiative: A Proactive Approach to Reducing Leaks Over the Lifetime of Commercial Refrigeration Systems. Mill Valley, CA: North American Sustainable Refrigeration Council. nasrc.org/wp-content/uploads/2024/08/NASRC_LeakReduction_Final_b.pdf

North American Sustainable Refrigeration Council (NASRC). 2026. Case Study: Berryvale Grocery $CO_2$ Refrigeration System. Mill Valley, CA: North American Sustainable Refrigeration Council. nasrc.org/wp-content/uploads/2026/03/FRIP_Case-Study_Berryvale-Grocery.pdf

Rasmussen, L. and Lou, Y. 2025. "*Clean Energy 101: Solid-State Cooling: Why revolutionary technologies are key to solving the cooling challenge." Rocky Mountain Institute* rmi.org/clean-energy-101-solid-state-cooling/

Rocky Mountain Institute (RMI), Buildings. September 2024. *Refrigerant Reclamation: Assessing Potential Emissions Impact of R-410A Refrigerant Reclamation in the United*

*States' Residential HVAC Sector*. https://www.hudsontech.com/pdfs/RMI-Buildings-Refrigerant-Reclamation-Report.pdf

Salierno, Gabriel. 2025. Assessment of Available Low-GWP Alternatives to F-Gas Refrigerants. Toxics Use Reduction Institute of Massachusetts, Lowell, MA. https://www.turi.org/wp-content/uploads/2025/11/2025-Refrigerant-Report-102225-fixed-1.pdf

U.S. Energy Information Administration (EIA), (2022). 2018 Commercial Buildings Energy Consumption Survey (CBECS). Washington, DC: U.S. Energy Information Administration. https://www.eia.gov/consumption/commercial/data/2018/pdf/CBECS_2018_Building_Characteristics_Flipbook.pdf

U.S. Environmental Protection Agency, Office of Air and Radiation. (December 2023). Restrictions on the Use of Certain HFCs under Subsection (i) of the AIM Act. Washington, DC: U.S. Environmental Protection Agency. https://www.epa.gov/system/files/documents/2023-10/technology-transitions-final-rule-fact-sheet-2023.pdf.

U.S. Environmental Protection Agency (EPA). 2023. US GHG Inventory 2023 Annexes Table A-116: Refrigeration and Air Conditioning Lifetime Assumptions. Washington, DC: U.S. Environmental Protection Agency. https://www.epa.gov/system/files/documents/2023-04/US-GHG-Inventory-2023-Annexes.pdf

U.S. Environmental Protection Agency (EPA). 2024. Final Rule – Phasedown of Hydrofluorocarbons: Management of Certain Hydrofluorocarbons and Substitutes under Subsection (h) of the American Innovation and Manufacturing Act. Washington, DC: U.S. Environmental Protection Agency. epa.gov/system/files/documents/2024-09/err-fact-sheet.pdf

U.S. Environmental Protection Agency (EPA). 2025. Proposed Rule: Phasedown of Hydrofluorocarbons – Reconsideration of Certain Regulatory Requirements Promulgated Under the Technology Transitions Provisions of the American Innovation and Manufacturing Act of 2020 (2023 Technology Transitions Rule). Washington, DC: U.S. Environmental Protection Agency. epa.gov/system/files/documents/2025-09/sept-2025-technology-transitions-reconsideration-proposal-fact-sheet.pdf

Efficiency Vermont. Technical Reference Manual (TRM), Program Year 2024. p. 102. https://publicservice.vermont.gov/document/2024-technical-reference-manual

## Disclosure

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