Yale Carbon Containment Lab

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To:
U.S. Environmental Protection Agency
Stratospheric Protection Division

From:
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Comments on the Phasedown of Hydrofluorocarbons: Management of Certain Hydrofluorocarbons and Substitutes Under Subsection (h) of the American Innovation and Manufacturing Act of 2020

To Whom It May Concern,

We appreciate the opportunity to provide comment on the EPA's proposed rule under Subsection (h) of the American Innovation and Manufacturing (AIM) Act. We strongly support the EPA's proposed requirements and expect that, if implemented as written, they will lead to significant expected climate and economic benefits. The implementation of Subsection (h) could generate $353 million in annual net benefits between 2025 and 2050 and mitigate 142 million metric tons CO_2e of hydrochlorofluorocarbon (HCFC) and hydrofluorocarbon (HFC) emissions domestically by 2050.[1]

The Yale Carbon Containment Lab (CC Lab) has been a champion of lifecycle refrigerant management (LRM), a climate change mitigation strategy aimed at detecting and repairing refrigerant leaks; recovering, reclaiming, and destroying refrigerant; and designing and installing equipment with high energy efficiency and lower-Global Warming Potential (GWP) refrigerants. LRM can have a profound climate impact, with the potential to mitigate 91 gigatons CO_2e globally by 2100, with a tenth of those emissions reductions happening in the United States.[2]

The United States can do much more to implement LRM, including scaling HFC reclamation and reducing HFC leakage and venting. Currently, refrigerant leakage in sectors such as commercial refrigeration can be as high as 25 percent per year, and very little refrigerant is being recovered at equipment end-of-life, especially in the residential cooling sector and for small commercial equipment.[3,4] We therefore applaud EPA's efforts to implement leak detection and repair, reclamation, disposable cylinder recovery, and container tracking requirements.

[1] Office of Atmospheric Programs, "Draft Regulatory Impact Analysis Addendum: Analysis of the Economic Impact and Benefits of the Proposed Rule: American Innovation and Manufacturing (AIM) Act Subsection H Management of Regulated Substances," Draft Regulatory Impact Analysis (Environmental Protection Agency, September 2023), https://www.epa.gov/system/files/documents/2023-10/subsection-h-proposed-rule-ria-addendum.pdf.
[2] Christina Theodoridi et al., "The 90 Billion Ton Opportunity" (EIA, NRDC, IGSD, 2022), https://us.eia.org/wp-content/uploads/2022/10/Refrigerant-Lifecycle-FullReport-6Spreads-PRINT.pdf.
[3] EPA GreenChill, "Profile of an Average U.S. Supermarket's Greenhouse Gas Impacts from Refrigeration Leaks Compared to Electricity Consumption" (Environmental Protection Agency, June 2011), https://www.epa.gov/sites/default/files/documents/gc_averagestoreprofile_final_june_2011_revised_1.pdf.
[4] Energy and Environmental Economics, "Refrigerant Avoided Cost Calculator" (California Public Utilities Commission, 2022), https://www.cpuc.ca.gov/industries-and-topics/electrical-energy/demand-side-management/energy-efficiency/idsm.

In March 2023, the CC Lab hosted a policy workshop at the Yale School of the Environment with two dozen experts in refrigerant management, climate policy, and energy efficiency.[5] This workshop focused on developing a policy roadmap to maximize the climate benefits of the AIM Act and Kigali Amendment to the Montreal Protocol. Two of the policy recommendations from the workshop relate directly to this proposed rule. First, participants emphasized the need to enhance refrigerant recovery, reclamation, and destruction, including scaling up private and public procurement of reclaimed and low-GWP refrigerant. Second, participants called for the expansion of requirements to detect and repair refrigerant leaks, and to fully account for and report leaks in emissions data. We are pleased that EPA's proposed rule is aligned with these recommendations.

I) Leak Detection and Repair

We support EPA's proposed leak detection and repair requirements (Proposed Rule Section IV.C), which build logically upon EPA's existing requirements for large HFC-containing equipment and equipment using ozone-depleting substances (ODS) under Section 608 of the Clean Air Act. These proposed requirements will have positive benefits for the atmosphere and climate and will help ease demand for servicing gas.

On Yale's campus, the use of automatic leak detection (ALD) systems on equipment with very high refrigerant charge sizes is already common practice. Yale currently operates several systems with charge sizes at or above the proposed 1,500-pound charge threshold for ALD systems. Our refrigerant managers have found that these ALD systems are useful not only in reducing fugitive refrigerant emissions, but also for maximizing equipment performance and energy efficiency. Using ALD systems for large equipment is good for the environment and a tenet of good building and facility management.

We also believe that EPA's extension of leak repair to appliances with charge sizes as small as 15 pounds is reasonable and necessary. Starting in 2021, members of our team began conducting an inventory of Yale's refrigerant-containing equipment, including small- to medium-sized equipment with charge sizes less than 50 pounds. To our knowledge, this was one of the first refrigerant inventories at an institution of our size. Largely because of EPA's preexisting recordkeeping requirements for equipment above 50 pounds, most of our refrigerant management efforts had been allocated to large equipment. Surprisingly, we discovered that small- to medium-sized equipment contributed an unexpectedly large portion of our campus refrigerant emissions. Collectively, these leaks were larger than leaks from large equipment such as our power plant chillers.[6] Using this knowledge, we began to regularly survey some equipment with charge sizes lower than 50 pounds for leaks. These surveys successfully identified leaky equipment, which we then flagged for repair. Without such requirements for leak detection and repair, facility managers and building owners would likely not allocate sufficient resources to reducing leaks from smaller equipment. These leaks, as we have found, can account for considerable emissions in aggregate.

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[5] "Maximizing the Climate Benefits of the HFC Transition: Fast Action for Short-Lived Climate Pollutants & Clean Technology Investment," Workshop Report (Yale Carbon Containment Lab, March 14, 2023), https://carboncontainmentlab.yale.edu/documents/yale-workshop-report---maximizing-the-climate-benefits-of-the-hfc-transition_may-1.pdf.

[6] Data from this inventory have not yet been peer-reviewed or vetted by the Yale Office of Sustainability. However, collected data suggest that in 2021, power plant chillers accounted for 1,297 metric tons CO_2e in fugitive HFC emissions, compared with 435 metric tons CO_2e from cafeterias and 1,002 metric tons CO_2e from split air conditioners and heat pumps.

Lastly, we acknowledge that ALD systems are also commercially available for medium-sized cooling equipment such as compressor racks. This equipment typically has charge sizes well below 1,500 pounds. Yale University is exploring potential pilots of ALD systems on campus food preparation facilities with similar refrigerant charge requirements to a small supermarket. Use of ALD systems even for equipment below the 1,500-pound threshold is quickly becoming best practice and should be encouraged where possible.

II) Scaling up the Supply and Use of Reclaimed Refrigerant

We support EPA's proposed requirements for the use of recovered and reclaimed HFCs (Proposed Rule Section IV.D). Scaling up the supply of reclaimed refrigerant is critical to facilitating the phasedown of HFCs. First, reclaimed gas ensures supply of regulated substances to service existing equipment and helps ensure compliance with the HFC phasedown. Second, reclaiming refrigerant creates end markets for recovered refrigerants, helping to finance refrigerant recovery and the infrastructure to recover refrigerant at scale. Third, high enough volumes of reclaimed gas may help reduce demand for new, virgin fluorocarbon production and consumption, which is more emissive than the reclamation process.[7]

Many large-scale purchasers, including the federal government, are already supporting the proposed rule by purchasing reclaimed refrigerants. In 2021, for example, the Biden Administration announced that the General Services Administration (GSA) will review contracts to support the use of reclaimed refrigerant in its facilities.[8] We encourage GSA and other federal agencies to continue sending market signals in favor of refrigerant recovery.

In the last several years, refrigerant reclaimers in the United States have made significant progress in investing in and installing the technology that will be required to reclaim HFCs. HFCs are typically more complex chemicals than previous-generation hydrochlorofluorocarbons (HCFCs) and chlorofluorocarbons (CFCs), and in many cases, require fractional distillation technology to be cost-effectively reclaimed. Several companies have made large, deliberate investments in recent years to expand HFC reclamation capacity.

We understand that there are concerns among other stakeholders about the feasibility of Proposed Rule Section IV.D, specifically for original equipment manufacturers (OEMs) in meeting requirements for initial charge. These concerns center around future supply of reclaimed R-32, which is used as (or a component in) lower-GWP refrigerants compliant with EPA's technology transitions rules under Subsection (i). R-32 itself is not currently a significant portion of the American installed refrigerant bank.[9]

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[7] Office of Atmospheric Programs, "Draft Regulatory Impact Analysis Addendum: Analysis of the Economic Impact and Benefits of the Proposed Rule: American Innovation and Manufacturing (AIM) Act Subsection H Management of Regulated Substances."

[8] The White House, "FACT SHEET: Biden Administration Combats Super-Pollutants and Bolsters Domestic Manufacturing with New Programs and Historic Commitments," The White House, September 23, 2021, https://www.whitehouse.gov/briefing-room/statements-releases/2021/09/23/fact-sheet-biden-administration-combats-super-pollutants-and-bolsters-domestic-manufacturing-with-new-programs-and-historic-commitments/.

[9] Environmental Protection Agency, "Updated Draft Report - Analysis of the U.S. Hydrofluorocarbon Reclamation Market: Stakeholders, Drivers, and Practices" (Docket: Environmental Protection Agency, September 2023), https://www.regulations.gov/document/EPA-HQ-OAR-2022-0606-0021.

Our modeling, however, suggests that EPA's proposed requirement is not only ambitious, but also attainable. Given EPA's previous regulatory actions Subsection (i), we anticipate that much of the reclaimed gas entering new equipment – particularly in the air conditioning and heat pump sectors – will be R-32 and R-454B. R-454B is a zeotropic blend of 68.9 percent R-32 and 31.1 percent R-1234yf. Demand for reclaimed R-32 will likely lean on recovery volumes of R-410A, which is composed of equal parts of R-32 and R-125. Refrigerant reclaimers can separate R-410A into its constituents, thus creating a potential supply stream of R-32. In 2022, EPA reported 3.6 million pounds of recovered R-410A.

Based on our own modeling and data from EPA's 2023 Analysis of the U.S. Hydrofluorocarbon Market, demand for reclaimed R-32 for use in initial charge will be approximately 36 million pounds in 2028.[10] Although this number is significantly higher than current volumes of R-32 coming back to reclaimers, it is much smaller than the total amount of R-32 that could be reclaimed via recoverable R-410A. We estimate that today, about 63 million pounds of R-410A is possible to be recovered *annually* from equipment in the United States alone.[11] These estimates imply that if recovery volumes for R-410A rose to only a fraction of the total recoverable opportunity, reclaimers would be able to meet R-32 demand from domestically available refrigerant alone. If reclaimers indeed meet R-32 demand by splitting R-410A, we encourage EPA to mandate the destruction of any R-125 in excess of market demand.

Several additional factors also support the feasibility of initial charge requirements. First, EPA also does not stipulate that reclaimed gases must be sourced from the United States, enabling additional potential supply from overseas if needed. Our understanding is that foreign markets, especially in Asia, have much higher proportions of R-32 in their installed refrigerant banks compared with the United States. Second, R-410A is used primarily in air conditioning and heat pump applications, which are covered under initial charge but not servicing requirements proposed in Section IV.D. Therefore, the servicing sector is unlikely to compete with OEMs for supply of recovered R-410A, since the volumes of reclaimed R-410A in the servicing sector are small.[12]

To grow reclaimed refrigerant volumes at the pace necessary to hit 2028 requirements, however, EPA must help industry gradually build capacity. We recommend that EPA add interim targets between 2024 and 2028 to help set benchmarks for industry to meet the proposed reclamation requirements. EPA should consult refrigerant reclaimers when crafting these benchmarks. We anticipate that volumes of reclaimed gas must increase at least nine-fold (on a weight basis) by 2028 compared with today's levels, suggesting a tremendous expansion in recovery volumes and reclamation capacity. This growth in volumes implies that the reclamation industry must grow faster than historical rates between today and 2028 to meet market demand. In 2022, reclamation volumes increased 38 percent with 2021 levels, but in the absence of any regulatory mandate or a major market push toward reclaimed gas. Annual or biannual targets for recovery volumes can help

[10] Environmental Protection Agency.

[11] In this calculation, we use EPA's estimates for the installed stock of refrigerant and the percentage of the stock that is R-410A. We assumed that there is yearly turnover in this stock – specifically with equipment retiring on average every 15 years, making the remaining refrigerant charge "recoverable." From our research and in interviews with technicians and reclaimers, equipment commonly contains close to the full nameplate charge, even at end-of-life.

[12] Environmental Protection Agency, "Updated Draft Report - Analysis of the U.S. Hydrofluorocarbon Reclamation Market: Stakeholders, Drivers, and Practices."

industry make necessary investments in distillation technology, refillable cylinders, recovery machines, and other critical components of the refrigerant recovery and reclamation value chain.

EPA should also consider creating more flexibility in how OEMs meet requirements to use reclaimed gas. This flexibility could emulate California's R4 Program, which allows some OEMs to meet reclaimed refrigerant requirements by using reclaimed gas for the initial charge, field charge of new equipment, servicing of existing equipment, or using lower-Global Warming Potential refrigerants.[13] If EPA does allow more flexibility for OEMs, however, it should be *additional* to all of EPA's existing proposed requirements. For example, OEMs could meet their requirements by purchasing reclaimed gas in a RACHP sector not subject to the servicing requirements for reclaimed gas. OEMs should purchase an equivalent amount (in *pounds*, not CO_2e) to the amount of virgin gas used for initial charge. We believe that OEMs can demonstrate compliance with their obligation by showing proof of purchase of reclaimed refrigerant equal in mass to the volume of virgin refrigerant used for first charge. This flexibility could lower compliance burdens for OEMs while achieving the same overall results as the proposed rule as written. Once again, we believe that EPA's current level of ambition in Proposed Rule Section IV.D is attainable.

We also recommend that EPA develop a way of verifying that imported, pre-charged equipment is using reclaimed gas. Currently, EPA is proposing that all new equipment use reclaimed refrigerant, regardless of whether it is pre-charged and imported. Since imported equipment would almost certainly use reclaimed gases sourced outside of the United States, we are concerned that EPA would have less ability to verify the initial charge as coming from a reclaimed source. EPA could therefore consider limiting geographies from which reclaimed gas is sourced or requiring additional recordkeeping from entities seeking to import pre-charged equipment covered by reclamation requirements. The proposed rule as currently designed could create an unintentional loophole for virgin refrigerant (posing as reclaimed gas) to enter the United States with little ability to trace the gas back to its initial sources.

EPA's reclaimed refrigerant mandates for initial charge and for servicing must be accompanied by a standard for reclaimed refrigerant. Without such a standard, there will be tremendous incentive to label virgin (or primarily virgin) material as reclaimed, and very little ability to trace its origin. We believe that EPA's proposed 15 percent limit on virgin composition of reclaimed material is reasonable and ensures the continued existence of smaller reclaimers who must sometimes bulk up reclaimed gases to meet AHRI-700 purity standards. Reclaimers also use virgin refrigerant to adjust the composition of reclaimed refrigerant blends. However, we would note that the United States' largest reclaimers can already achieve AHRI-700 purity standards without blending in virgin refrigerant. Blending in virgin gas is not a technical requirement to reclaim refrigerant. Therefore, EPA could consider ramping down the acceptable proportion of virgin gas over time, to incentivize investment in better reclamation technology.

Reclamation plays a key role in facilitating the HFC phasedown, keeping existing equipment operational, moderating prices for HFCs and other regulated substances, and temporarily preventing the emission of refrigerant into the atmosphere. Moreover, if refrigerant reclamation volumes grow sufficiently large, they may decrease the need for emission-intensive production and

[13] Stratospheric Protection Division, "Draft Report - Analysis of the U.S. Hydrofluorocarbon Reclamation Market: Stakeholders, Drivers, and Practices" (U.S. Environmental Protection Agency, October 2022), https://www.epa.gov/system/files/documents/2022-10/Draft_HFC-Reclamation-Report_10-13-22%20sxf%20v3.pdf.

consumption of virgin gases. If this occurs, EPA should accelerate the phasedown schedule to reduce excess allowance allocation, using their authority under Subsection (f) of the AIM Act.

III) Requiring Refrigerant Recovery from Disposable Cylinders

We support EPA's proposed requirement to send disposable cylinders to certified refrigerant reclaimers to ensure refrigerant recovery. In our understanding, empty disposable cylinders commonly contain residual vapor, known as a "refrigerant heel," which are usually around 1 to 2 percent (and up to 10 percent) of the cylinder's total charge. In business-as-usual practice, these cylinders are punctured when disposed, leading to the emission of the refrigerant heel. Emissions from heels could account for as much as 5 million $MTCO_2e$ annually.[14]

Currently, we know of several refrigerant reclaimers who recover refrigerant from disposable cylinders that they aggregate from their technician networks. Although volumes of recovered gas are low compared with recovery volumes from equipment, these reclaimers have told us that recovering heels is a low-effort activity that protects the ozone layer and prevents unnecessary emissions. This gas can also easily be reclaimed since it is at or very close to AHRI-700 purity standard. Recovering heels should be part of any program to maximize reclaimed refrigerant and minimize refrigerant emissions.

We are concerned that a mandate to recover heels from disposable cylinders will be impossible to enforce unless such cylinders have adequate tracking identifiers. Ideally, these identifiers – feasibly implemented via technology such as QR codes – would store information about the certified person who purchased the refrigerant, subsequent owners of the cylinder (if transferred or resold), and confirmation from a certified reclaimer that the cylinder was collected for heel recovery. Improper handling of empty disposable cylinders, then, can be traced back to the individuals who handled or purchased them. This information is reasonable to ensure compliance with this component of the proposed rule.

IV) Container ("Cylinder") Tracking and Data Collection

Cylinder tracking and data collection are important steps in implementing the HFC phasedown and ensuring compliance with this proposed rule. Cylinder tracking, including for disposable cylinders, is a necessary and reasonable compliance requirement for participants in the refrigerant value chain. We therefore support EPA's proposed requirements for cylinder and container tracking (Proposed Rule Section IV.F). These measures are well within EPA's authority under Subsection (h).

Today, cylinder tracking and data collection are features of other countries' phasedown policies, including in the European Union.[15] The European Union has also taken the additional step of prohibiting the use of disposable (non-refillable) cylinders, which has been European law since 2007.[16] Tracking and data collection are already common practices among companies handling large volumes of equipment and refrigerant. We are aware of both small refrigerant services companies and large OEMs that have developed their own cylinder tracking systems to help

[14] David Doniger et al., "Comments from the NRDC to the US EPA on the Phasedown of Hydrofluorocarbons," Public Comment (NRDC, July 2021), https://www.nrdc.org/sites/default/files/comments-epa-hfc-allocation-rule-20210706.pdf.
[15] Neil Everitt, "F-Gas Revision to Ensure Cylinder Return," Cooling Post, March 19, 2023, https://www.coolingpost.com/world-news/f-gas-revision-to-ensure-cylinder-return/.
[16] Neil Everitt, "New Rules to Tackle 'Refillable' Cylinder Loophole," Cooling Post, October 29, 2023, https://www.coolingpost.com/world-news/new-rules-to-tackle-refillable-cylinder-loophole/.

increase refrigerant recovery volumes and monitor technician compliance. If tracking and data collection were burdensome to technicians, these companies would not have voluntarily adopted these practices.

Tracking systems are commonly implemented via QR code stickers or labels applied to cylinders. Each QR code can contain large amounts of stored data and include redundancies to ensure readability even if the code is cosmetically damaged. QR codes are now commonplace in a variety of applications in the American economy, from restaurant menus to rentable bikes, and are proven to be well-suited to refrigerant container tracking. We also would welcome other suitable tracking technology, if it ensures the same or better traceability, durability, and data storage as a QR code.

Data collection will also play an important role in maximizing refrigerant recovery and reclamation volumes. Across the country, refrigerant recovery is not happening at the levels required to meet EPA's reclamation requirements in this proposed rule. Instead of recovery, current business-as-usual practice, especially at the residential level, is the illegal venting (i.e., release) of the gas when equipment is decommissioned, or the recycling of recovered gas. EPA prohibits recycling of refrigerant in the stationary sector across equipment with different owner-operators under Section 608 of the Clean Air Act. However, because refrigerant is colorless and odorless, it has been historically difficult for EPA to monitor and enforce instances of noncompliance, especially at the residential equipment level.

In lieu of full enforcement of the venting prohibition and limitations on refrigerant recycling, the private sector has played a role in incentivizing refrigerant recovery. Refrigerant reclaimers, for example, have paid technicians for clean recovered gases, and, more recently, also paid for recovered gas regardless of its species or contamination level. We expect that reclaimers will continue these incentive payments in the future. Nonetheless, incentive payments have not yet been successful in dramatically increasing recovery volumes and cannot be the only way to increase regulatory compliance. Tracking cylinders and collecting more data along a refrigerant's lifecycle is a reasonable step toward ensuring regulatory compliance.

Since recovered HFCs are often blends, segregating recovered refrigerant by species is an important step in being able to cost-effectively reclaim the gas. Commingled gases may need to be destroyed or, at the very least, are less profitably reclaimed. Information stored in QR codes about the type of refrigerant contained in the cylinder, as well as about past refrigerant recoveries, can help technicians and reclaimers separate gas and ensure that it can be easily reclaimed. Data collection and cylinder tracking are therefore an important component of scaling up refrigerant reclamation volumes.

Lastly, cylinder tracking and data collection are important measures to prevent the illegal import, manufacture, and trade of HFCs in the United States. The European Union's prohibition on disposable cylinders, for example, has been *the* key instrument in identifying contraband fluorocarbons. In the absence of a disposable cylinder ban in the United States, more robust tracking of disposable cylinders can aid EPA identifying and preventing illegal trade and be a strong deterrent for non-compliance. We encourage EPA to refer to the usefulness of cylinder tracking in

published materials from the Environmental Investigation Agency on proven methods of mitigating illegal trade.[17]

V) Further Engagement

We are grateful to EPA for the opportunity to comment on the proposed rule. We look forward to engaging further with EPA and other stakeholders on these topics.

Respectfully submitted,

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About the Yale Carbon Containment Lab:

The Yale Carbon Containment Lab (CC Lab) is a 501(c)(3) nonprofit housed within the Yale School of the Environment. The CC Lab develops, implements, and scales novel and neglected climate solutions, focusing on carbon removal and containment. The CC Lab's Anthropogenic Program includes a project on refrigerant emissions, focusing on implementing and financing lifecycle refrigerant management. In addition to working on domestic policy in the United States, the CC Lab is also active internationally in the Montreal Protocol. The CC Lab is gift-funded.

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[17] US Environmental Investigation Agency, "Next Generation Monitoring and Enforcement to Prevent Illegal Trade Under the Montreal Protocol" (Environmental Investigation Agency, October 2022), https://us.eia.org/wp-content/uploads/2022/10/AIM-Act-Fact-Sheet-5.4.pdf.

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