Analysis of the U.S. Hydrofluorocarbon Reclamation Market: Stakeholders, Drivers, and Practices

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Contents

List of Tables

List of Figures

List of Abbreviations and Acronyms

AHRI	Air-Conditioning, Heating, and Refrigeration Institute
AIM	American Innovation and Manufacturing Act of 2020
ASHRAE	American Society of Heating, Refrigerating and Air-Conditioning Engineers
CAA	Clean Air Act
CARB	California Air Resources Board
CFC	Chlorofluorocarbon
CFR	Code of Federal Regulations
CO_2e	Carbon dioxide equivalent
DOE	Department of Ecology
EIA	Environmental Investigation Agency
eNGO	Environmental non-governmental organization
ER&R	Emissions Reduction and Reclamation
EPA	Environmental Protection Agency
GC	Gas chromatograph
GHG	Greenhouse gas
GWP	Global warming potential
HCFC	Hydrochlorofluorocarbon
HFC	Hydrofluorocarbon
HFO	Hydrofluoroolefin
IPR	Industrial process refrigeration
lbs	pounds
$MMTCO_2e$	Million metric tons of carbon dioxide equivalent
MVAC	Motor vehicle air conditioning
NODA	Notice of Data Availability
NRDC	Natural Resources Defense Council
NYSDEC	New York State Department of Environmental Conservation
ODP	Ozone depletion potential
ODS	Ozone-depleting substances
OEM	Original equipment manufacturer
PTAC	Packaged terminal air conditioner
PTHP	Packaged terminal heat pump
R4 Program	Refrigerant Recovery, Reclaim, and Reuse Requirements (CARB Program)
RACHP	Refrigeration, air conditioning, and heat pumps
RMP	Refrigerant management program
RRA	Refrigerant Reclaim Australia
TEAP	Technology and Economic Assessment Panel to the Montreal Protocol
U.S.	United States
VM	Vintaging Model
VRF	Variable refrigerant flow

Executive Summary

Background

Subsection (h) of the American Innovation and Manufacturing (AIM) Act of 2020, titled "Management of Regulated Substances," directs the United States (U.S.) Environmental Protection Agency (EPA) to establish certain regulations for regulated substances[1] and their substitutes for the purposes of maximizing reclaiming and minimizing releases of regulated substances (used interchangeably with hydrofluorocarbons (HFCs) in this document) from equipment and ensuring the safety of technicians and consumers.

More specifically, subsection (h) directs EPA to promulgate regulations to control, where appropriate, any practice, process, or activity regarding the servicing, repair, disposal, or installation of equipment that involves: a regulated substance, a substitute for a regulated substance, the reclaiming of a regulated substance used as a refrigerant, or the reclaiming of a substitute for a regulated substance used as a refrigerant.

Subsection (h) also provides for the Agency to consider options to increase opportunities for reclaiming HFCs used as refrigerants and potential approaches to coordinate regulations carrying out subsection (h) of the AIM Act with other EPA regulations that involve the same or a similar practice, process, or activity regarding the servicing, repair, disposal, or installation of equipment, or reclaiming.

As part of implementing subsection (h), EPA is finalizing certain regulatory requirements[2] related to maximizing reclamation of regulated substances. This document, prepared for the purposes of subsection (h), provides background information on the refrigerant reclamation market in the United States and use of HFCs in the refrigeration, air conditioning, and heat pumps (RACHP) sector.

Report Contents and Organization

This report summarizes available information on the reclamation of refrigerants, including information on the processes and methods used, the stakeholders involved, and the key barriers to increasing refrigerant reclamation in the United States. The report is organized as follows:

- Section 1 provides an introduction and context of the AIM Act and reclamation.
- Section 2 provides background information on reclamation and EPA's regulatory authority over refrigerant reclamation as well as information on state actions pertaining to reclamation.
- Section 3 identifies key stakeholders in the reclamation industry and describes their roles and responsibilities.

[1] The AIM Act lists 18 saturated HFCs, and by reference any of their isomers not so listed, that are covered by the statute's provisions, referred to as "regulated substances" under the Act (42 U.S.C. 7675(c)(1)).
[2] See final rule in Docket EPA-HQ-OAR-2022-0606 at www.regulations.gov.

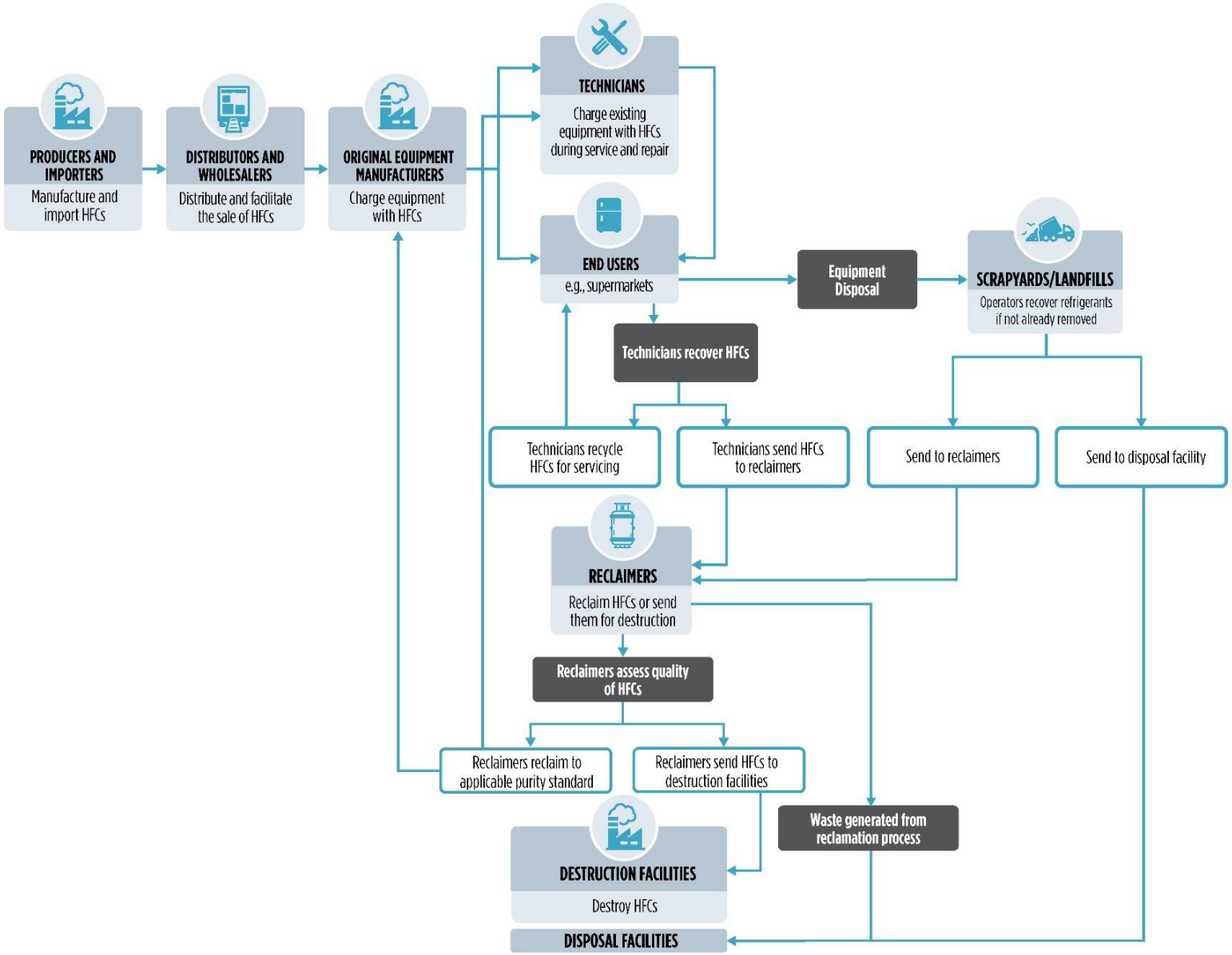
- Section 4 provides details on HFCs as refrigerants in the RACHP sector and particular subsectors within the RACHP sector.
- Section 5 describes the U.S. reclamation market and includes a description of reclamation methods and processes, cost drivers, and incentives.
- Section 6 describes safety considerations for technicians and consumers.
- Section 7 discusses the barriers and key challenges to increasing refrigerant reclamation.

Key Findings

Reclamation Process and Stakeholders

A diverse group of industry stakeholders engage in the sale and reclamation of HFCs. Figure ES-1 illustrates the general flow of HFCs through each of the key stakeholders, including producers and importers, wholesalers (including distributors), technicians, end users, reclaimers, destruction facilities, and scrap recyclers and landfills. In general, technicians recover HFCs and either recycle them for use in existing equipment, send them for reclamation, or send them for destruction. Depending on the quality of the recovered refrigerant, reclaimers decide whether to reclaim the HFCs to the required purity standard (*e.g.*, based on Air-Conditioning, Heating, and Refrigeration Institute (AHRI) Standard 700-2016) or send them to destruction facilities. Reclaimers may choose to send recovered refrigerants for destruction if they are too contaminated, making the reclamation process cost-prohibitive or infeasible from a technological standpoint. As stated, Figure ES-1 intends to depict a general movement of HFCs in the supply chain, and does not capture all possibilities or intricacies of certain transactions. Additional information on other pathways of the movement of HFC refrigerants and equipment is discussed in section 3 of this report.

Figure ES-1. General Flow Chart of HFCs Through Industry, Including Recovery and Reclamation



Reclamation Market

Since 2017, EPA has required that certified reclaimers report data on HFC reclamation activity in accordance with regulations promulgated under section 608 of the Clean Air Act (CAA). These requirements are analogous to the longstanding requirements for ozone-depleting refrigerants. As shown in Table ES-1,[3] the amount of reclaimed HFCs has remained relatively constant from 2017 to 2021 and showed a notable increase in 2022. From 2021 to 2022, the total amount of reclaimed HFCs increased by approximately 40 percent. EPA also saw an increase in the reclamation data reported from 2022 to 2023 with the total amount of reclaimed HFCs increasing by approximately 20 percent. From 2017-2023, the HFC refrigerants with the highest reclamation totals were R-134a (14.79 million pounds (lbs)) and R-410A (19.84 million lbs).. From 2022-2023, R-407A and R-404A had the highest percent increase in reported reclamation volume, increasing by nearly 360 percent and 98 percent, respectively.

Table ES-1. HFC Refrigerant Reclamation Reported from 2017 to 2023 (lbs)

Refrigerant	2017	2018	2019	2020	2021	2022	2023
R-134a	1,858,132	1,910,240	2,399,952	1,956,644	1,844,793	2,313,639	2,505,902
R-404A	486,719	506,639	485,338	478,556	416,352	443,977	880,502
R-407A	111,255	143,254	105,435	87,162	60,580	22,874	105,497
R-407C	167,445	167,248	213,668	315,424	366,521	473,155	342,904
R-410A	2,103,404	2,043,667	2,596,861	2,347,000	2,550,164	3,569,249	4,625,948
Other HFCs	363,311	479,261	258,486	206,029	173,022	757,818	611,611
Total	**5,090,266**	**5,250,309**	**6,059,479**	**5,390,816**	**5,411,433**	**7,580,672**	**9,072,364**

Table ES-2 presents data on reclaimed HFCs in terms of million metric tons of carbon dioxide equivalent ($MMTCO_2e$), a measure used to to compare the relative warming effects of greenhouse gases (GHGs) in the atmosphere based on their global warming potentials (GWPs) For context, the total consumption of HFCs in 2022 was 254 $MMTCO_2e$ (U.S. EPA, 2024). It is expected that the HFC reclamation market will increase in future years as more refrigeration and air conditioning equipment using HFC refrigerants reach their end-of-life and virgin HFC supplies are restricted consistent with the AIM Act. One estimate predicts that under the HFC phasedown, reclaimed HFCs will increase in sales by $0.8 billion and add almost 4,000 jobs (Inforum et al., 2019).

[3] Refrigerant reclamation data as reported to EPA per requirements under section 608 of the CAA are current as of July 22, 2024.

Table ES-2. HFC Refrigerant Reclamation Reported Totals by Year ($MMTCO_2e$)

Refrigerant	2017	2018	2019	2020	2021	2022	2023
R-134a	1.21	1.24	1.56	1.27	1.20	1.50	1.63
R-404A	0.87	0.90	0.86	0.85	0.74	0.78	1.57
R-407A	0.11	0.14	0.10	0.08	0.06	0.02	0.10
R-407C	0.13	0.13	0.17	0.25	0.29	0.38	0.27
R-410A	1.99	1.94	2.46	2.22	2.41	3.38	4.38
Other HFCs[a]	0.59	0.77	0.37	0.31	0.28	1.19	0.89
Total	**4.89**	**5.11**	**5.52**	**4.99**	**4.99**	**7.25**	**8.84**

[a] Other HFCs were calculated in $MMTCO_2e$ using aggregated totals of each HFC reclaimed as reported during annual reporting per 40 CFR 82.164(d) and using their respective GWPs

Key Barriers to Increasing Reclamation

The report identifies some key barriers to increasing refrigerant recovery and reclamation:

- **Contamination, Blends, and Mixed Cylinders.** When cylinders contain refrigerant blends or different types of refrigerants, it is more difficult and time-consuming for reclaimers to process and reclaim the refrigerants.
- **Costs of Reclamation.** The cost of recovering and reclaiming refrigerant is increasing primarily due to new blends requiring new technologies. In addition, market fluctuations affect the relative price of reclaimed refrigerant to virgin refrigerant. Further, logistical costs, such as transporting recovered materials to the relatively few reclamation factilities nationwide and who bears that cost, also may factor in to the overall economics of reclaim.
- **Refrigerant Release Limits Recovery Potential.** When refrigerant is released from equipment, it results in less refrigerant available for recovery and reclamation. Accidental release and leakage rates vary depending on application and charge size, and may occur at different points throughout the lifetime of equipment, including during installation, servicing and maintenance, and at end-of-life. Intentional release, such as venting, may also occur.

1. Introduction

Subsection (h) of the American Innovation and Manufacturing (AIM) Act of 2020, titled "Management of Regulated Substances," directs the U.S. Environmental Protection Agency (EPA) to establish certain regulations for regulated substances[4] and their substitutes for the purposes of maximizing reclaiming and minimizing releases of regulated substances (used interchangeably with hydrofluorocarbons (HFCs) in this document) from equipment and ensuring the safety of technicians and consumers.

More specifically, subsection (h) directs EPA to promulgate regulations to control, where appropriate, any practice, process, or activity regarding the servicing, repair, disposal, or installation of equipment that involves: a regulated substance, a substitute for a regulated substance, the reclaiming of a regulated substance used as a refrigerant, or the reclaiming of a substitute for a regulated substance used as a refrigerant.

Subsection (h) also provides for the Agency to consider options to increase opportunities for reclaiming HFCs used as refrigerants and potential approaches to coordinate regulations carrying out subsection (h) of the AIM Act with other EPA regulations that involve the same or a similar practice, process, or activity regarding the servicing, repair, disposal, or installation of equipment, or reclaiming.

As part of implementing subsection (h), EPA is finalizing certain regulatory requirements[5] related to maximizing reclamation of regulated substances. This document, prepared for the purposes of subsection (h), provides background information on the refrigerant reclamation market in the United States and use of HFCs in the refrigeration, air conditioning, and heat pumps (RACHP) sector.

While this report focuses on the recovery and reclamation of regulated HFCs being used as refrigerants, subsection (h) of the AIM Act does not limit activities identified in subsection (h) only to refrigerants.[6] Although not a focus of this report, EPA understands that regulated HFCs and their substitutes recovered from other equipment, such as fire suppression systems, may be reprocessed and reused as well.[7]

This report provides background information on the reclamation for refrigerants in stationary equipment in the RACHP sector. This report is organized as follows:

- Section 1 provides an introduction and context of the AIM Act and reclamation.
- Section 2 provides background information on reclamation and EPA's regulatory authority over refrigerant reclamation as well as information on state actions pertaining to reclamation.
- Section 3 identifies key stakeholders in the reclamation industry and describes their roles and responsibilities.

[4] The AIM Act lists 18 saturated HFCs, and by reference any of their isomers not so listed, that are covered by the statute's provisions, referred to as "regulated substances" under the Act (42 U.S.C. 7675(c)(1)).

[5] See final rule in Docket EPA-HQ-OAR-2022-0606 at www.regulations.gov.

[6] Subsection (h)(4), however, states that: "No regulation promulgated pursuant to this subsection shall apply to a regulated substance or a substitute for a regulated substance that is contained in a foam."

[7] See TSD titled "American Innovation and Manufacturing Act of 2020 – Subsection (h): Fire Suppression Sector" available in the docket in Docket EPA-HQ-OAR-2022-0606 at www.regulations.gov.

- Section 4 provides the details on HFCs as refrigerants in the RACHP sector and particular subsectors within the RACHP sector.
- Section 5 describes the U.S. reclamation market and includes a description of reclamation methods and processes, cost drivers, and incentives.
- Section 6 describes safety considerations for technicians and consumers.
- Section 7 discusses the barriers and key challenges to increasing refrigerant reclamation.
- Section 8 includes references cited in the text.
- Appendix A includes the statutory text of subsection (h) of the AIM Act.

2. Background

Under the multilateral environment treaty known as *The Montreal Protocol on Substances that Deplete the Ozone Layer* (Montreal Protocol), all countries are phasing out the production and consumption of ozone-depleting substances (ODS).[8] Domestically, under title VI of the Clean Air Act (CAA), EPA is phasing out production and consumption of ODS consistent with the Montreal Protocol. In addition, title VI includes complementary measures, such as identifying safer substitutes and regulating use and disposal of ODS.

In the United States, ODS are regulated as class I or class II controlled substances. Class I substances, such as chlorofluorocarbons (CFCs) and halons, have higher ozone depletion potentials (ODPs), and their production and consumption were phased out in the United States with few exceptions. This means no one can produce or import virgin (newly produced) class I substances.

Class II substances are all hydrochlorofluorocarbons (HCFCs), which are transitional substitutes for many class I substances. Section 605 of the CAA establishes the U.S. phaseout targets for class II substances. EPA established the class II phaseout framework with a "worst-first" approach, which focused first on HCFC-141b, HCFC-142b, and HCFC-22 because they have the highest ODPs of all HCFCs. Since January 1, 2020, production and import of all HCFCs in the United States must be less than 0.5 percent of the HCFC baseline. Further, newly produced or imported HCFCs are limited to HCFC-123 and HCFC-124 and can only be used to service RACHP and fire suppression equipment that was manufactured before January 1, 2020.

The Montreal Protocol has successfully reduced the production and consumption of ODS; however, it resulted in a shift toward greater use of HFCs, which are potent GHGs that have GWPs that can be hundreds to thousands of times greater than carbon dioxide (CO_2). In 2016, in Kigali, Rwanda, countries agreed to an amendment to the Montreal Protocol, known as the Kigali Amendment, which provides for a global phasedown of the production and consumption of HFCs.

[8] See *The Montreal Protocol on Substances That Deplete the Ozone Layer* at https://www.state.gov/key-topics-office-of-environmental-quality-and-transboundary-issues/the-montreal-protocol-on-substances-that-deplete-the-ozone-layer/#:~:text=The%20Montreal%20Protocol%2C%20finalized%20in,%2C%20fire%20extinguishers%2C%20and%20aerosols.

In 2020, Congress enacted the AIM Act, which directs EPA to phase down HFC production and consumption by 85 percent below historic baseline levels by 2036 and also includes other provisions for EPA to regulate HFCs. The AIM Act lists 18 saturated HFCs, and by reference any of their isomers not so listed, that are covered by the statute's provisions, referred to as “regulated substances” under the Act. Congress also assigned an “exchange value” to each regulated substance, which is numerically equivalent to the 100-year GWPs listed in the 2007 Intergovernmental Panel on Climate Change (IPCC) Fourth Assessment Report.

The AIM Act authorizes EPA to address HFCs in three main ways: phasing down HFC production and consumption through an allowance allocation program; issuing certain regulations for purposes of maximizing reclamation and minimizing releases of HFCs and their substitutes from equipment; and facilitating sector-based transitions to next-generation technologies. The phasedown provisions are consistent with the Kigali Amendment to the Montreal Protocol. On October 31, 2022, the United States ratified the Kigali Amendment.[9]

This report focuses on the recovery and reclamation of regulated substances. Reclamation has played a key role in maintaining the supply of ODS during their phaseout, so that appliances and equipment can be used for their full useful lifetime and not retired prematurely. For example, reclaimed HCFC-22 may continue to be used for as long as it is available to service existing HCFC-22 systems (U.S. EPA, 2020). Reclamation is also expected to help ease the impacts of the phasedown of production and consumption of HFCs in accordance with the AIM Act.

2.1 What is Reclamation?

In this context, reclamation refers to the reprocessing of a recovered substance to an established specification for purity as verified using a prescribed analytical methodology. Reclamation can play an important role as the United States phases down HFC production and consumption. The reclamation process involves reprocessing and upgrading recovered substances through such mechanisms as filtering, drying, distillation, and chemical treatment to restore the substance to industry specifications (Stratus Consulting 2010). The AIM Act defines both reclaim and reclamation as follows (42 U.S.C. 7675(b)(9)):

> *(A) the reprocessing of a recovered regulated substance to at least the purity described in standard 700–2016 of the Air-Conditioning, Heating, and Refrigeration Institute (or an appropriate successor standard adopted by the Administrator); and*
>
> *(B) the verification of the purity of that regulated substance using, at a minimum, the analytical methodology described in the standard referred to in subparagraph (A).*

[9] More information is available at: https://www.state.gov/u-s-ratification-of-the-kigali-amendment/

The Air-Conditioning, Heating, and Refrigeration Institute (AHRI) Standard 700-2016 (AHRI Standard 700) establishes purity specifications and methods of testing to verify the composition of refrigerants regardless of source (new, reclaimed, and/or repackaged) for use in new and existing refrigeration and air conditioning products (AHRI, 2019a).

By bolstering the current supply of HFCs with refrigerants from existing systems, reclamation supports a smooth transition to alternatives. In addition, reclamation can minimize disruption of the current capital stock of equipment by allowing its continued use with existing refrigerant supplies (U.S. EPA, 2016a).

Reclamation can also help avoid supply shortages of virgin refrigerants and can insulate the industry against price spikes that could affect the servicing of existing systems using HFCs. Refrigerant reclamation creates value for used refrigerants recovered from equipment, for example, during routine servicing, and helps embed good practices in refrigerant management throughout the supply chain.

A key example of the benefits of reclamation or recycling is the use of reclaimed or recycled ODS whose production has been phased out. This sector has a long history of using recycled ODS for both servicing and new equipment. For example, HCFC-123 can be recovered from chillers and reprocessed for reuse in fire suppression application where there is continued need.

Recycled halons are also important for use in fire suppression systems. EPA phased out the production and importation of virgin halons in the United States in 1994. Since that time, there has been continued demand for halons in both newly manufactured fire suppression equipment and servicing of existing equipment. Recycled halons have been the only supply in the United States for specialty fire suppression applications. Sources of recycled halons include stockpiles and recovered halons from cylinders both in the United States and abroad.[10]

The management of halons in the United States over the last several decades demonstrates a model of collaboration between industry, government, and key users, effective regulations to reduce emissions, a smooth transition to safer alternatives through revisions to industry standards, voluntary industry codes of practice, maintenance of halon banking, and government halon reserves. Existing halon stocks are purchased by commercial recyclers from decommissioned equipment, reprocessed to industry specifications, and sold back into the market. Similar to the handling of refrigerants under section 608 of the CAA, EPA's regulations addressing halons, at 40 Code of Federal Regulations (CFR) part 82, subpart H, include certain prohibitions on intentional release (venting) of halons and requirements for technicians to be trained regarding halon emission reduction.

Ultimately, demand for halons have been satisfied with recycled halons, ensuring equipment can be serviced and investments are not stranded. Recycled halons have been used for over 25 years to charge new fire suppression equipment and more

[10] For additional information on the halons program, please visit https://www.epa.gov/ozone-layer-protection/halons-program.

recently recycled HCFCs have similarly been used in a fire suppression blend (U.S. EPA, 2020). Similar to the importance of recycled halons for use in new and existing equipment, reclaimed HFCs are and will continue to be important to help to meet demands for uses of HFCs in RACHP equipment.

2.2 Federal Statutory and Regulatory Provisions

Two sections in title VI of the CAA that are particularly relevant to reclamation are sections 608 and 609. EPA's current regulations under these sections of the CAA require certain refrigerant management practices by reclaimers, those who buy or sell refrigerant, technicians, owners and operators of air conditioning and refrigeration systems, and others. The refrigerant management regulations are at 40 CFR part 82, subpart F (subpart F). These requirements generally apply to the management of ODS and substitutes for ODS, such as HFCs, used as refrigerants.[11] As ODS production and import have been phased out under title VI of the CAA, refrigerant reclamation has provided an important source of ODS refrigerants to service existing equipment. Refrigerant recovery, recycling, and reclamation occur primarily in stationary and mobile air conditioning and refrigeration applications.

CAA Section 608: National Recycling and Emission Reduction Program

Section 608 of the CAA, titled "National Recycling and Emission Reduction Program," has three main components. First, section 608(a) requires EPA to establish standards and requirements regarding the use and disposal of class I and class II substances. The second component, section 608(b), requires that the regulations issued pursuant to subsection (a) contain requirements for the safe disposal of class I and class II substances. The third component, section 608(c), prohibits the knowing venting, release, or disposal of ODS refrigerants and their substitutes in the course of maintaining, servicing, repairing, or disposing of appliances or industrial process refrigeration (IPR).

Section 608 regulations under Title 40 CFR part 82, subpart F define reclaim to mean to "reprocess recovered refrigerant to all of the specifications in appendix A of this subpart (based on AHRI Standard 700-2016, *Specifications for Refrigerants*) that are applicable to that refrigerant and to verify that the refrigerant meets these specifications using the analytical methodology prescribed in section 5 of appendix A of this subpart" (40 CFR 82.152 (definition of "reclaim")).

Under subpart F, recovery involves removing refrigerant in any condition from an appliance and storing it in an external container without necessarily testing or processing it in any way (40 CFR 82.152 (definition of "recover")).

Similarly, under subpart F, recycling a refrigerant involves extracting it from an appliance and cleaning the refrigerant for reuse in equipment of the same owner without meeting all of the requirements for reclamation. In general, recycled refrigerant is refrigerant that is cleaned using oil separation and single or multiple passes through

[11] One exception to this general rule is 40 CFR 82.157, which relates to appliance maintenance and leak repair, and which only applies to appliances containing an ODS as of April 10, 2020.

devices, such as replaceable core filter-driers, which reduce moisture, acidity, and particulate matter (40 CFR 82.152 (definition of "recycle")).

Furthermore, EPA regulations under section 608 of the CAA address the handling and recycling of refrigerants used in stationary refrigeration and air conditioning systems. Several of these requirements are particularly relevant to reclamation, including:

- Venting Prohibition: consistent with the venting prohibition under section 608(c) of the CAA, EPA's subpart F regulations at 40 CFR 82.154(a) prohibit individuals from knowingly venting or otherwise releasing into the environment ODS refrigerants and their substitutes (such as HFCs), while maintaining, servicing, repairing, or disposing of air conditioning or refrigeration equipment, while also providing for certain limited exceptions from this prohibition.
- Recovery: With certain limited exceptions, under 40 CFR 82.156, before opening (*e.g.*, for servicing) or disposing of an appliance, technicians must ensure refrigerant is evacuated from air conditioning or refrigeration equipment to established vacuum levels. Similar requirements apply to persons opening or disposing of a small appliance, motor vehicle air conditioner (MVAC), or MVAC-like appliances.[12]
- Reclamation: Under 40 CFR 82.154(d)(1), the sale of used refrigerant is prohibited, with certain limited exceptions. Under one of those exceptions, used refrigerant may be resold if it has been reclaimed by an EPA-certified reclaimer. Under 40 CFR 82.164, reclaimers must also follow certain practices[13] when reclaiming such refrigerants for sale to a new owner, such as:
    - Not releasing more than 1.5 percent of the refrigerant during the reclamation process;

[12] EPA's subpart F regulations at 40 CFR 82.152 define "MVAC-like appliance" to mean "a mechanical vapor compression, open-drive compressor appliance with a full charge of 20 lbs or less of refrigerant used to cool the driver's or passenger's compartment of off-road vehicles or equipment. This includes, but is not limited to, the air-conditioning equipment found on agricultural or construction vehicles. This definition is not intended to cover appliances using R-22 refrigerant." By contrast, EPA's subpart F regulations at 40 CFR 82.152 define "Motor vehicle air conditioner (MVAC)" as "any appliance that is a motor vehicle air conditioner as defined in 40 CFR part 82, subpart B." The subpart B regulations at 40 CFR 82.32 provide that: "Motor vehicle air conditioners means mechanical vapor compression refrigeration equipment used to cool the driver's or passenger's compartment of any motor vehicle. This definition is not intended to encompass the hermetically sealed refrigeration systems used on motor vehicles for refrigerated cargo and the air conditioning systems on passenger buses using HCFC-22 refrigerant." Further, the subpart B regulations at 40 CFR 82.32 provide that: "Motor vehicle as used in this subpart means any vehicle which is self-propelled and designed for transporting persons or property on a street or highway, including but not limited to passenger cars, light duty vehicles, and heavy-duty vehicles. This definition does not include a vehicle where final assembly of the vehicle has not been completed by the original equipment manufacturer."

[13] A complete list of requirements is available at 40 CFR 82.164, and they are briefly described in an EPA fact sheet for reclaimers, available at https://www.epa.gov/sites/default/files/2016-09/documents/608_fact_sheet_reclaimers_0.pdf.

- Reclaiming refrigerant such that it meets all the required specifications (based on AHRI Standard 700-2016, Specifications for Refrigerants) that are applicable to that refrigerant; and
- Verifying that each batch of refrigerant reclaimed meets these specifications using the required analytical methodology.

CAA Section 609: Servicing of Motor Vehicle Air Conditioners

Section 609 of the CAA specifically addresses the servicing of MVACs and require EPA to promulgate regulations establishing standards and requirements regarding the servicing of MVACs. EPA's regulations under section 609 are at 40 CFR part 82, subpart B. Under those regulations, any person repairing or servicing an MVAC system for consideration (*i.e.*, payment in any form) involving the use of refrigerant[14] must use approved refrigerant recycling equipment and be properly trained and certified. These regulations also require recovered refrigerant to be either recycled or reclaimed, consistent with certain regulatory requirements, before it can be charged or recharged into an MVAC system. This requirement applies even if the refrigerant is being returned to the system from which it was removed.

AIM Act: Recovery and Reclamation

Under the AIM Act, the terms reclaim and reclamation are both defined to mean "(A) the reprocessing of a recovered regulated substance to at least the purity described in standard 700-2016 of the Air-Conditioning, Heating, and Refrigeration Institute (or an appropriate successor standard adopted by the Administrator); and (B) the verification of the purity of that regulated substance using, at a minimum, the analytical methodology described in the standard referred to in subparagraph (A)" (42 U.S.C. 7675(b)(9)). The term **recover** is defined in the AIM Act to mean "the process by which a regulated substance is (A) removed, in any condition, from equipment; and (B) stored in an external container, with or without testing or processing the regulated substance" (42 U.S.C. 7675(b)(10)). These are similar but not identical to EPA's existing definitions in the refrigerant management regulations.

Subsection (h) of the AIM Act includes provisions related to the management of regulated HFCs and their substitutes. Subsection (h)(1) provides that "[f]or purposes of maximizing reclaiming and minimizing the release of a regulated substance from equipment and ensuring the safety of technicians and consumers," EPA "shall promulgate regulations to control, where appropriate, any practice, process, or activity regarding the servicing, repair, disposal, or installation of equipment … that involves (A) a regulated substance; (B) a substitute for a regulated substance; (C) the reclaiming of a regulated substance used as a refrigerant; or (D) the reclaiming of a substitute for a regulated substance used as a refrigerant." Subsection (h) also provides that "[i]n carrying out this section, the Administrator shall consider the use of authority available to the Administrator under this section to increase opportunities for the reclaiming of regulated substances used as refrigerants" (subsection (h)(2)(A)) and authorizes EPA in

[14] The term "refrigerant" as used in CAA Section 609 has included class I or class II substances and substitutes since November 15, 1995.

promulgating regulations carrying out subsection (h) of the AIM Act to "coordinate those regulations with any other [EPA] regulations" involving "the same or a similar practice, process, or activity regarding the servicing, repair, disposal, or installation of equipment," or reclaiming (subsection (h)(3)). Such regulations could potentially include the refrigerant management program established under title VI of the CAA.

2.3 State Statutory and Regulatory Provisions

California

In December 2021, the California Air Resources Board (CARB) finalized amendments to its regulation on prohibitions on the use of certain HFCs in stationary refrigeration, stationary air conditioning, and other end uses. Section 95376 of this regulation established the Refrigerant Recovery, Reclaim, and Reuse Requirements (R4 Program), which requires that manufacturers of two types of air conditioning end-uses, *other air conditioning (new) equipment, residential and non-residential*;[15] and *variable refrigerant flow (VRF) equipment*, must use a minimum amount of reclaimed refrigerant[16], starting in 2023.

For other new air conditioning equipment, residential and non-residential, the regulations require that manufacturers utilize a volume of reclaimed refrigerant in 2023 and 2024 that is approximately 10 percent of the total HFCs entered into California in the equipment in the baseline years. For VRF equipment, the regulations require that manufacturers utilize a volume of reclaimed refrigerant in 2023 and 2024 that is approximately 15 percent of the total HFCs entered into California in this equipment in the baseline years, and then increases to a 25 percent reclaim requirement in 2025. The reclaimed refrigerant requirement can be met using the reclaimed refrigerant for factory charge of new equipment, field charge of new equipment, or servicing of existing equipment. The requirement may also be met by using a refrigerant with a GWP of less than 750 during these activities. The reclaimed refrigerant does not need to be sourced from inside the state and can be reclaimed from recovered refrigerant from any geographic location. Furthermore, CARB defines "certified reclaimed refrigerant" for the purposes of this requirement as not containing more than 15 percent virgin refrigerant by weight (17 CCR § 95371-95379 2021).

Although similar reclamation programs have been discussed in proposed rulemakings for other states, California is the first state to implement such a reclaim program in the United States. As the requirements under the R4 Program did not begin until 2023, information is not available about the effect this program may have on reclamation rates. Additionally, CARB recently approved an update to the Small Containers of

[15] "Other Air-conditioning" or "Other Air-conditioning Equipment" is defined in California's regulation as any residential or non-residential air-conditioning equipment or air-conditioning system not otherwise defined as "room air conditioner," "wall air conditioner," "window air conditioner," "packaged terminal air conditioner (PTAC)," "packaged terminal heat pump (PTHP)," "portable air conditioner," "residential dehumidifier," or "variable refrigerant flow (VRF) system." (17 CCR section 95373 2021).

[16] The minimum amount is calculated according to a baseline which uses the average number of pounds of refrigerant in equipment that entered California in 2018 and 2019. For manufacturers with no shipments into California in those years, the requirement for using certified reclaimed refrigerant will be based on the current year the refrigerant enters California.

Automotive Refrigerant regulation, which will require refrigerant sold in these containers in California to be 100 percent reclaimed by 2027 (CARB, 2023).

Washington

In 2021, the State of Washington finalized House Bill 1050, which expanded HFC restrictions. The new law set a maximum GWP for HFCs used in new stationary air conditioning equipment, new and existing stationary refrigeration equipment, and ice rinks. House Bill 1050 also directed the Washington State Department of Ecology (DOE) to establish and implement a refrigerant management program to address refrigerant emissions from air conditioning and refrigeration equipment with charge sizes of 50 lbs or more (Washington DOE, 2022). Lastly, House Bill 1050 mandated the Washington DOE to prepare a report summarizing approaches for state regulators to manage the end-of-life and disposal of refrigerants. Washington's report found an "incentive-based approach incorporating extended producer responsibility may maximize the recovery and disposal of refrigerants" and that a "fee-based program that provides incentives to consumers and businesses for proper refrigerant disposal, recovery, reclaim, and reuse would significantly reduce HFC emissions" (Drumheller et al., 2021).

Washington adopted its HFC rule in November 2023 and became effective on December 31, 2023, further implementing House Bill 1050. Washington's refrigerant management program (RMP) requires specific leak detection and monitoring requirements for systems with a full charge of 50 lbs or more of a refrigerant with a GWP of 150 or more. Leak repair and recordkeeping requirements began on January 1, 2024, for all sizes of refrigeration and air conditioning systems that are subject to the RMP. Systems with a full charge greater than or equal to 1,500 lbs must install an automatic leak detection system for their system(s) by January 1, 2025. Systems with charge sizes of 50–1,499 lbs must have either annual or quarterly leak inspection requirements depending on the charge size of the system. Leak inspections would also be required any time an amount of refrigerant equal or greater to 1 percent of full charge is added to a system. Washington's proposed RMP has strict leak rate thresholds which system owner/operators must adhere to. Leak rates must be reported to Washington DOE each time a leak inspection is completed. A 12-month rolling average leak rate is calculated for each system. If a threshold is breached, the owner/operator must repair the system. If the system cannot be repaired within the time allotted in Washington's rule proposal, the owner/operator must work with Washington DOE to create and implement a retrofit or retirement plan for the system. The rule also establishes certain registration, recordkeeping, and reporting requirements for wholesalers, distributors, and reclaimers. Specifically, these entities would have requirements related to the amount of GWP greater than 150 HFCs they wholesale, distribute, or reclaim (Washington DOE, 2023a & 2023b).

On February 9, 2024, the Washington State Legislature introduced House Bill 2401 which would require producers of HFCs to register with the state and participate in a refrigerant stewardship organization. Other entities in the supply chain, including reclaimers, must register report information to the organization (Washington State Legislature, 2024a & 2024b).

New York

In September 2020, the New York Department of Environmental Conservation (NYDEC) finalized *Part 494 Hydrofluorocarbon Standards and Reporting* establishing prohibitions for certain HFCs in air conditioning and refrigeration equipment, aerosol propellants, and foam end-uses. These prohibitions went into effect starting in 2021 (NYDEC 2024). In December 2023, NYDEC proposed amendments to its Part 494 HFC regulations proposing additional prohibitions for certain HFCs in specific end uses, limiting the amount of virgin HFCs allowable in reclaimed refrigerants to 15% by weight, requiring specific labeling and disclosure requirements for reclaimed refrigerants, requiring registration and reporting for reclaimers operating in the state of New York, and establishing a refrigerant management program for stationary refrigeration and air conditioning equipment with a refrigerant charge size greater than 50 pounds. One notable difference between NYDEC's proposal and other state and Federal HFC regulations is the use of 20-year GWP values instead of 100-year GWP values; the department defines regulated substances under the proposal as any chemical intended for use in specific sectors that has a 20-year GWP value greater than 10. Starting January 1, 2025, the proposal's labeling and disclosure provision requires manufacturers of specific equipment to state, in part, if the regulated substances used in equipment are of reclaim in origin. Under the proposal, reclaimers are required to register with the department by January 1, 2025, and are subject to annual reporting beginning calendar year 2026 (NYDEC, 2023).

NYDEC's proposed refrigerant management program for refrigeration and air conditioning equipment with a full charge of 50 pounds or more begins January 1, 2025. The proposal requires owners or operators to meet specific labeling and equipment registration requirements depending on charge size starting as early as June 1, 2025. The RMP would require the installation of an ALD system for large refrigeration equipment with a charge size capacity of 1,500 pounds or more and establish monthly, quarterly, or annual leak inspections for equipment depending on charge size. The proposed RMP also establishes leak repair requirements for owners or operators to fix any detected leak within 14-days. Finally, the proposal's RMP would require owners or operators of specific equipment to submit annual reports to the Department (NYDEC, 2023).

Other States

While California, Washington, and New York have enacted comprehensive refrigerant management regulations in addition to prohibitions for the use of certain HFCs in specific end-uses nine additional states have adopted similar prohibitions for HFCs. Colorado, Delaware, Massachusetts, Maryland, Maine, New Jersey, New York, Rhode Island, Virginia, and Vermont have enacted legislation and/or adopted regulations that prohibit the use of certain HFCs in specific end-uses such aerosols, refrigerated appliances, and foams. Additionally, since late 2022, the New York State Department of Environmental Conservation (NYSDEC) has conducted outreach to local governments and stakeholders to solicit feedback on their intended updates to their HFC regulations.

2.4 EPA Outreach

EPA has performed various outreach activities in preparing this updated report on the status of reclamation in the United States. In October 2021, EPA released a draft version of this report accompanying a Notice of Data Availability (NODA) (87 FR 62843, October 17, 2022). EPA solicited stakeholder feedback and held a public stakeholder meeting shortly after the NODA was published on November 9, 2022. EPA received eleven comments in response to the NODA from stakeholders, including reclaimers, environmental non-governmental organizations (eNGOs), original equipment manufacturers (OEMs), industry organizations, and a private citizen.[17] Commenters provided input on a variety of topics. They noted the importance of tackling certain barriers to increased reclamation and availability of reclaimed HFCs on the market. Such barriers included increasing recovery of refrigerants, handling mixed refrigerants returned to reclaimers, and reclaiming certain patented blends. Commenters also provided input on consideration for a clear standard of what constitutes reclaimed HFCs, as well as improved tracking of HFCs in the supply chain. Further, some commenters noted opportunities for requiring the use of reclaimed materials in certain uses (*e.g.*, first charge of certain equipment).

EPA also held additional public stakeholder meetings to solicit feedback. On March 16, 2023, EPA held a public stakeholder meeting with a focus on reclamation. The webinar was attended by reclaimers, state and local governments, eNGOs, industry organizations, and OEMs. Stakeholders provided feedback on similar topics, including the barrier of increasing recovery to then increase reclamation of HFCs. EPA also held a public webinar via EPA's GreenChill Partnership Program on April 12, 2023, and heard similar feedback. On October 19, 2023, EPA published the proposed rule, "Phasedown of Hydrofluorocarbons: Management of Certain Regulated Substances under Subsection (h) of the American Innovation and Manufacturing Act of 2020" and accepted public comments through December 18, 2023 (U.S. EPA 2023a).

3. Reclamation Stakeholders

3.1 Overview

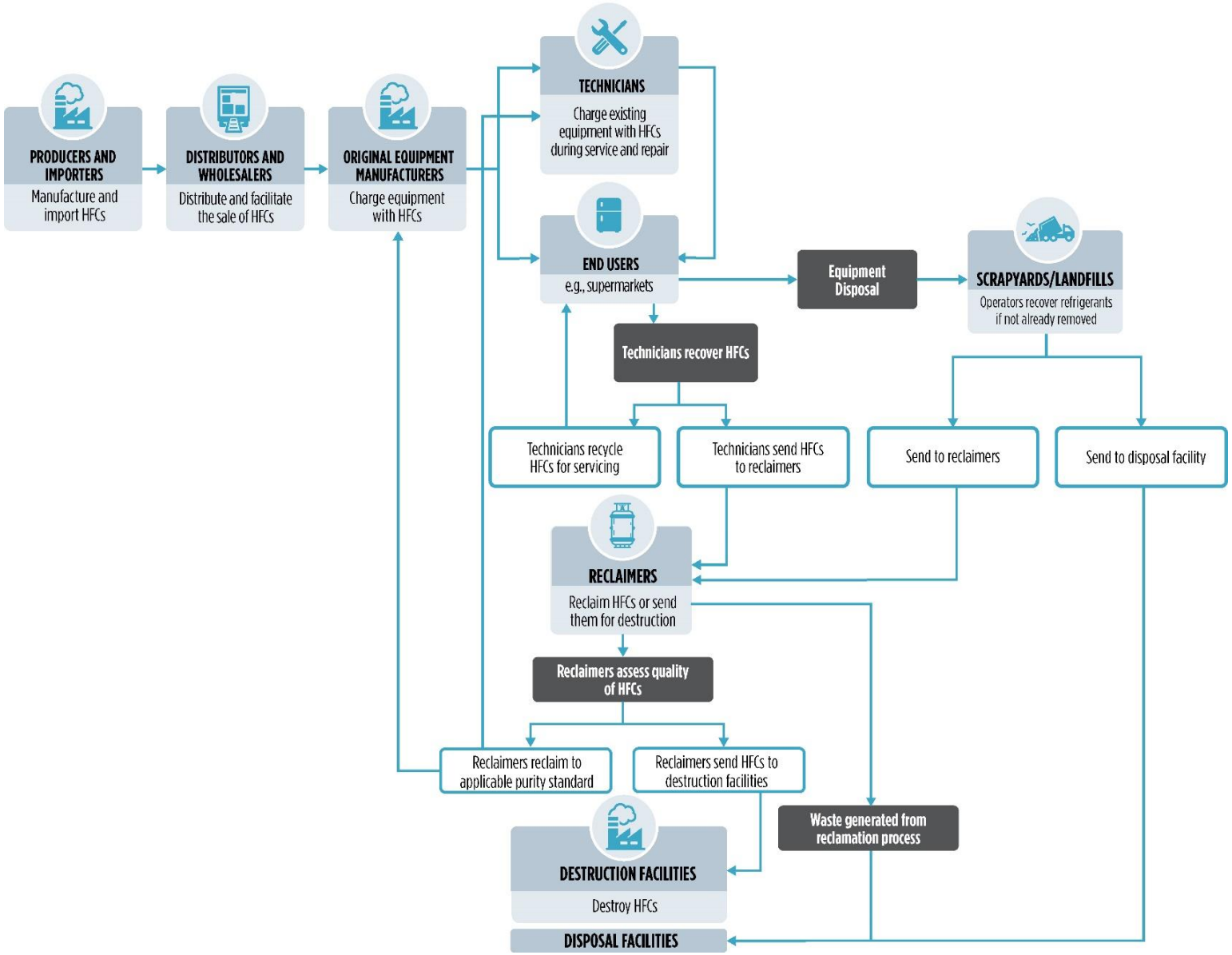
A diverse mix of industry stakeholders engage in the sale and reclamation of HFCs. Figure 1 illustrates the general flow of HFCs through each of the key stakeholders, including producers and importers, wholesalers (including distributors), end users, reclaimers, destruction facilities, and scrap recyclers and landfills. In general, technicians may recover HFCs and either recycle them for use in existing equipment, send them for reclamation, or send them for destruction. Depending on factors including the quality of the recovered refrigerant, reclaimers decide whether to process the HFCs to the applicable purity standard (*e.g.*, based on AHRI Standard 700-2016) or send them for destruction. For example, the market price of the refrigerant, among other factors, may influence whether a reclaimer will choose to reclaim lower quality recovered refrigerant or send it offsite for destruction. Reclaimers may choose to send

[17] See docket ID EPA-HQ-OAR-2022-0606.

recovered refrigerants for destruction if they are too contaminated and reclamation is deemed not technologically and/or economically feasible.

As EPA understands, and based on comments received in response to the NODA published in October 2022, there are other pathways for the movement of HFCs (virgin, reclaimed, or recovered) and equipment that use refrigerants that contain HFCs. As noted in the previous paragraph, Figure 1 is provided as an example of the general movement of HFCs and equipment in the supply chain. In some cases, OEMs may have agreements with producers to purchase directly from them to use in equipment that is charged by an OEM before being sold. Further, OEMs typically distribute their equipment to a wholesaler or distributor rather than sell directly to an end user. Service technicians who recover refrigerant may return the refrigerant to wholesalers or distributors who collect the recovered refrigerant and then send to a reclaimer when a sufficient amount is collected. After reclaimers have reclaimed refrigerants to the applicable purity standard, they may either distribute the reclaimed refrigerant through wholesalers or distributors or sell directly to OEMs. Typically, contractors or technicians would obtain refrigerants (virgin or reclaimed) by way of a wholesaler or distributor that are needed to perform servicing, repair, or installation jobs.

Figure 1. General Flow Chart of HFCs through Industry, including Recovery and Reclamation



3.2 Reclaimers

EPA certifies refrigerant reclaimers and publishes a list of their names and contact information. As of April 2024, there are over 60 EPA-certified refrigerant reclaimers.[18] Reclaimers receive refrigerant recovered from existing RACHP equipment and process the refrigerant through various means to achieve a targeted purity and blend composition. Reclaimers typically inspect the recovered refrigerant that they receive to determine whether the refrigerant is technologically and/or economically feasible to reclaim or should be destroyed. At least one reclaimer has capacity to destroy refrigerant themselves, while some may pay destruction companies or facilities with the capability to destroy the refrigerant (U.S. EPA, 2018). Reclaimers may pay wholesalers and technicians for the recovered refrigerant or may charge a fee for the recovered refrigerant, especially if the recovered refrigerants must be destroyed.

For quantities that can be reclaimed, reclaimers sell the refrigerant back into the supply chain through equipment or refrigerant-specific wholesalers or directly to RACHP technicians or RACHP original equipment manufacturers (OEMs). EPA is aware of at least one reclaimer that offers a line of products that are marketed as reclaimed.[19] In interviews with reclaimers in 2018 and 2019,[20] EPA learned about the various ways in which reclaimers sell refrigerant back into the supply chain. From those interviews, EPA understands that reclaimers may sell exclusively to wholesalers, directly to technicians and contractors, directly to OEMs, or through a third-party agent.

3.3 Wholesalers and Distributors

Wholesalers include distribution companies that provide a full range of RACHP equipment, components, and refrigerants, as well as those that focus exclusively on refrigerants. The wholesalers sell virgin or reclaimed refrigerant to RACHP technicians, who then use the refrigerant to charge customer equipment. Currently, refrigerant is not typically marketed or sold by wholesalers or distributors as “reclaimed refrigerant.”

Wholesalers may sell or otherwise provide empty recovery cylinders to technicians so they can recover refrigerant from existing RACHP equipment and return the full cylinders with recovered refrigerant to the wholesalers. Wholesalers then provide the recovered refrigerant to reclaimers for processing and may facilitate any credits or fees for the refrigerant recovered by technicians.

3.4 Technicians

EPA certifies technicians per the regulations under sections 608 and 609 of the CAA (40 CFR 82.161, 40 CFR 82.40). Technicians include contractors that install and service RACHP systems for residential, commercial, and industrial customers, independent operators, and in-house technicians employed by larger commercial and industrial

[18] For a list of EPA-certified reclaimers, please see https://www.epa.gov/section608/epa-certified-refrigerant-reclaimers.

[19] Hudson Technologies, Emerald Refrigerants. More information available at: https://www.hudsontech.com/refrigerants/emerald-refrigerants/

[20] Between 2018 and 2019, EPA conducted interviews with eight reclaimers to obtain more information on the industry, including reclamation technologies and equipment and potential challenges and barriers.

facilities (*e.g.*, food retailers), as well as those repairing or servicing MVACs for consideration (*i.e.*, payment of any form). Technicians may purchase virgin or reclaimed refrigerant from wholesalers, and sometimes directly from reclaimers. Similarly, some technicians may return recovered refrigerant to wholesalers or reclaimers in smaller quantities on a daily or weekly basis, whereas others may store refrigerant for less-frequent returns. Many technicians will handle refrigerant recovery and processing themselves, although some use subcontractors who specialize in equipment disposal and refrigerant recovery so they can focus on installations and servicing.

3.5 Landfill Operators, Scrap Metal Recyclers, and Disposal Facilities

Final processors, including but not limited to landfill operators, scrap metal recyclers, and disposal facilities, are responsible for ensuring that refrigerant is recovered from equipment before the equipment's final disposal. Equipment that typically enters the waste stream with its refrigerant charge intact (e.g., MVACs, household refrigerators and freezers, and window unit air conditioners) must be disposed of in accordance with the disposal requirements under 40 CFR 82.155(b). These requirements include recovering refrigerant from equipment, verifying using a signed statement that refrigerant that had not leaked previously has been recovered (or that the refrigerant has leaked out of the appliance), and keeping on-site records of all signed statements or contracts for three years.

3.6 Destruction Facilities

Reclaimers may send contaminated or less valuable HFCs or ODS that they choose not to reclaim to a destruction facility, an entity which is responsible for the destruction of ODS and HFCs. Destruction involves the near complete extermination of a chemical using biological, chemical, thermal, or other means, as described under the alternative treatment standards of Table 1 to 40 CFR 268.45. As of July 2024, 40 CFR 84.29 has designated twelve approved technologies for the destruction of HFCs (excluding HFC-23) and eight technologies approved for the destruction of HFC-23. The destruction of HFCs prevents the emissions of these high GWP substances into the atmosphere, at the cost of these chemicals no longer being available for reclamation and reuse.

4. Current Subsectors and Applications using Refrigerants

In general, refrigerants are selected based on their use in equipment in specific subsectors and applications within the RACHP sector. For the purposes of this report, EPA assessed the refrigerants used in the RACHP subsectors. While there are many ways to categorize subsectors and applications, we are using the general categories as established in EPA's Vintaging Model (VM)[21] (U.S. EPA, 2023b). As such, the categories that the VM uses may include a group of subsectors. For example, the commercial refrigeration category in the VM would include various subsectors, such as supermarket systems, self-contained equipment for food retail, and more. Refrigerants

[21] EPA's Vintaging Model of ODS Substitutes - *https://www.epa.gov/ozone-layer-protection/epas-vintaging-model-ods-substitutes*.

that are currently in use may be available for recovery and possible reclamation when the equipment using the refrigerant reach their end-of-life or cease operation.

EPA's VM estimates the annual emissions from sectors that have used ODS and alternatives, in particular HFCs. The VM estimates the use and emissions of each of the substances separately for each of the ages or "vintages" of equipment. The VM is used to produce the estimates of GHG emissions in the official U.S. GHG Inventory and is updated and enhanced annually. Information on the version of the model used to support the finalized ER&R rulemaking under subsection (h) of the AIM Act, the various assumptions used, and HFC emissions may be found in EPA's *Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990–2014* (U.S. EPA, 2016c).

The peer-reviewed VM utilizes detailed information on more than 60 end uses across the five major industrial sectors that previously relied on ODS and have more recently used HFCs (*i.e.*, refrigeration and air conditioning, foams, aerosols, solvents, and fire suppression) (U.S. EPA, 2018b). Each end use is modeled differently based on its characteristics such as pieces of equipment in operation, the number added or removed annually, the average amount of HFC used and emitted over time from each item, typical lifetime of operation, and growth/decline rate in the U.S. market. As each end use transitions from an ODS to one or more HFC(s) and possibly other options, the model tracks annual vintages and calculates the amount of each chemical in use, emitted, and the consumption needed to both support new products and service existing products (*e.g.*, to "top-off" leaks from air conditioners). The VM estimates the use and emissions of ODS substitutes—including HFCs and other substitutes—by taking the following steps:

1. Gather historical emission data. The VM is populated with information on each end use, taken from published and confidential sources and industry experts.

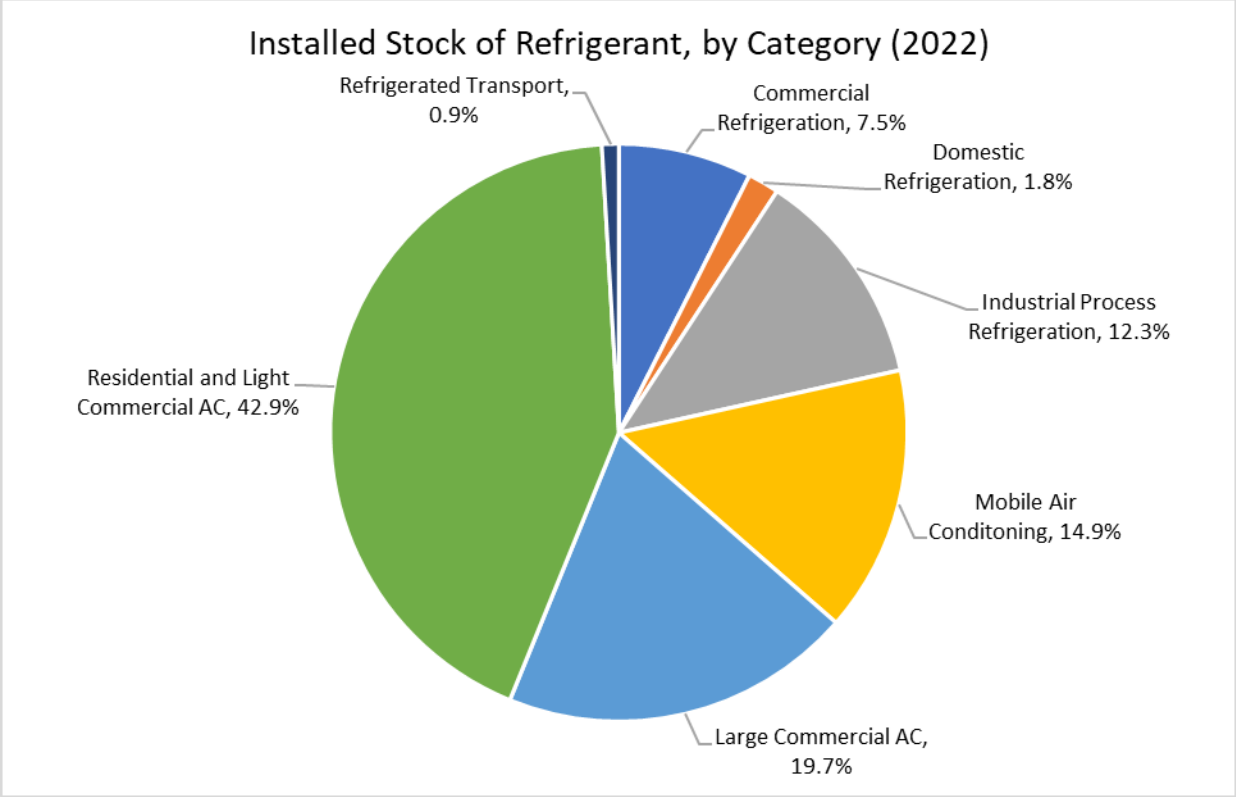
2. Simulate the implementation of new, non-ODS and HFC replacement technologies. The VM uses detailed characterizations of the historical and current uses of HFCs to simulate the implementation of new technologies. This step can be expanded to include secondary transitions from HFCs to other technologies as a means to estimate the HFC reductions achievable with such actions.

3. Estimate emissions of the ODS substitutes and HFC substitutes. The chemical use is estimated from the amount of substitutes that are required each year for the manufacture, installation, use, or servicing of products. The emissions are estimated from the emission profile for each vintage of equipment or product in each end use. By aggregating the emissions from each vintage, a time profile of emissions from each end use is developed.

To project into the future, each end use is assigned a growth rate based on the overall growth seen from the past several years. In some cases, other data are used to estimate growth rates: for instance, the U.S. Energy Information Administration's Annual Energy Outlook projections for automobile sales and new single-family housing starts are used to estimate future growth in the MVAC and residential split system air conditioning end-uses, respectively (EIA, 2009).

Figure 2 shows the estimated stock of refrigerants in 2022 in various RACHP subsectors.[22] The total installed stock of refrigerants is 1.1 million metric tons. Specifically, the air conditioning subsectors account for approximately 77.5 percent of the installed stock, with the greatest amount in residential and light commercial air conditioning (42.9 percent). The refrigeration subsectors account for approximately 22.5 percent of the installed stock of refrigerants.

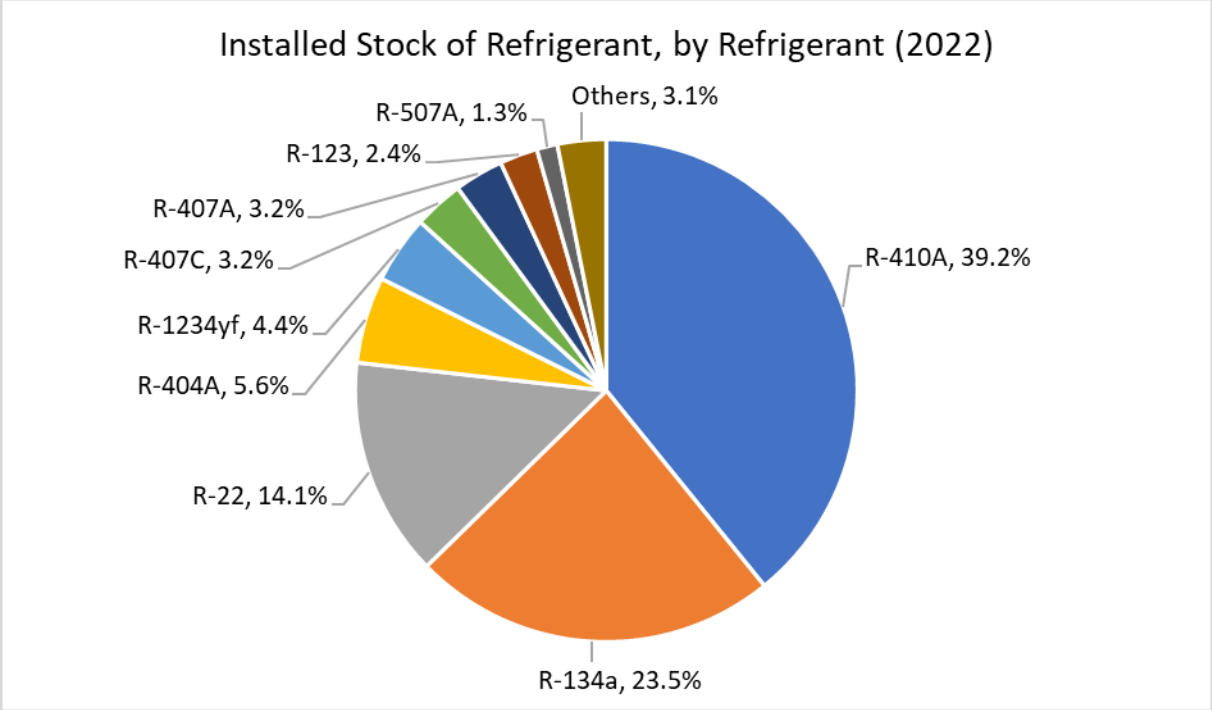
Figure 2. Installed stock of ODS and substitute refrigerants by category, by mass



The VM also provides estimates on the types of refrigerants (ODS and substitutes) that are in installed stock both within the RACHP sector and across the sector. Figure 3 shows the breakdown of installed stock of the most abundant refrigerants. The top three refrigerants in installed stock are R-410A (39 percent), R-134a (24 percent), and R-22 (14 percent). The following sections of this report provide additional, high-level information on each of the subsectors within the RACHP sector, including typical refrigerants used within these subsectors.

[22] Data pulled from VM IO file_v5.1_03.23.2022.

Figure 3. Installed stock of ODS and substitute refrigerants by refrigerant, by mass



4.1 Refrigeration Categories

There are four main refrigeration categories with estimates of installed refrigerant stock from the VM: IPR, domestic refrigeration, commercial refrigeration, and refrigerated transport.

4.1.1 Industrial Process Refrigeration

IPR accounts for the greatest amount of installed stock of ODS and substitute refrigerants among refrigeration categories. As the name implies, this category encompasses refrigerant use in the IPR subsector, but also tracks stocks of refrigerants in other subsectors, like cold storage warehouses. It accounts for 12.3 percent of the total installed stock across all RACHP categories, and over half (54.7 percent) among refrigeration categories. IPR systems are used to cool process streams in industrial applications and may involve complex and customized systems for a given application. Typically, the equipment and systems used in IPR have a large refrigerant charge size to accommodate for the significant cooling demands at a facility.

IPR equipment may use different refrigerants depending on the application (*e.g.*, the cooling demand needed). The most common ODS and substitutes used as refrigerants in the IPR category in the VM are R-22, R-134a, and R-404A, making up about three quarters of the installed ODS and substitutes. Beyond HFCs and ODS, other refrigerants such as ammonia (R-717) is also used in the IPR subsector (AHRI, 2019b).

4.1.2 Commercial Refrigeration

Commercial refrigeration accounts for 7.5 percent of the installed stock of ODS and substitute refrigerants among all RACHP categories. Among only refrigeration

categories, commercial refrigeration accounts for about one third of the installed stock of ODS and substitute refrigerants. Commercial refrigeration includes a wide range of subsectors that depends on the specific uses of the equipment. Such subsectors may include stand-alone retail food refrigeration, supermarket systems, refrigerated display cases, refrigerated food processing and dispensing equipment, vending machines, automatic commercial ice makers, and more. Within these subsectors, there may be a variety of different types of equipment used. For example, equipment used in supermarket systems may be large and complex depending on the layout of the store and its geographic location. Refrigerated dispensing equipment may include products such as soft-serve ice cream machines.

Along with the variety of subsectors within commercial refrigeration, the amount of refrigerant charged in the equipment and the type of refrigerant used vary by application and use. The most common ODS and substitute refrigerants in installed stock in the commercial refrigeration subsector are R-407A, R-404A, and R-22 (collectively accounting for 87 percent of the installed stock of refrigerants in this subsector). As the industry transitions to lower-GWP refrigerants, there are many suitable substitutes depending on the subsector or application within commercial refrigeration. For example, some types of equipment in supermarket systems are using CO_2 (R-744) as a refrigerant (U.S. EPA, 2022).

4.1.3 Domestic Refrigeration

Domestic refrigeration accounts for less than 2 percent of the total installed stock of ODS and substitute refrigerants among all RACHP categories. Of the refrigeration categories, domestic refrigeration accounts for nearly 8 percent. The domestic refrigeration category covers the subsector of residential applications of refrigeration equipment, including household refrigerators, freezers, and combination refrigerator/freezers. These types of equipment are intended for residential use but may be used outside of the home. Products with both a refrigerator and freezer (*i.e.*, combination refrigerator/freezer) are the most common. Other products included in this subsector may include chilled kitchen drawers and wine coolers.

Among ODS and substitutes, the most common refrigerant in installed stocks in domestic refrigeration in the United States is R-134a, accounting for about 89 percent of the subsector. Prior to the Montreal Protocol, R-12 was commonly used before most of the industry transitioned to HFC-134a for domestic refrigeration applications. According to the 2022 progress report from the Technology and Economic Assessment Panel (TEAP) to the Montreal Protocol, isobutane (R-600a) is now used in 75 percent of all new units globally, with the remainder being R-134a.[23]

4.1.4 Refrigerated Transport

Refrigerated transport accounts for just under one percent of the total installed stock of ODS and substitute refrigerants among all RACHP categories and accounts for 4.2

[23] The Technology and Economic Assessment Panel is an advisory body to the parties to the Montreal Protocol and is recognized as a premier global technical body; reports available at: https://ozone.unep.org/science/assessment/teap.

percent of the total installed stock of ODS and substitute refrigerants in the refrigeration categories. The refrigerated transport category essentially is comprised of the refrigerated transport subsector, which generally includes the movement of perishable goods (*e.g.*, food) and pharmaceuticals at low temperatures (between -22 °F and 61 °F). Various modes of transportation take place within this subsector, including road, ships, and intermodal containers. The most common mode of refrigerated transport is via roads, which includes refrigerated vans, trucks, and trailer-mounted systems. Refrigerated transport via ship, or marine, includes transport of perishable goods via refrigerated ship and marine branches (*e.g.*, merchant, naval, fishing, cruise-shipping). Intermodal containers in refrigerated transport are refrigerated containers that allow uninterrupted storage during transport on different mobile platforms, including railways, trucks, and ships.

The most common ODS and substitute refrigerants in installed stock for refrigerated transport are R-404A (50 percent), R-134a (20 percent), R-507A (16 percent), and R-22 (10 percent). Recently, manufacturers have been designing equipment to use other substitute refrigerants, including R-744, R-513A, and R-452A. The type of refrigerant selected may depend on the application or mode of refrigerated transport. For example, a particular refrigerant may be selected depending on its cooling capacity or other properties, such as non-flammability.

4.2 Air conditioning Categories

There are three main air conditioning categories with estimates of installed refrigerant stock from the VM: residential and light commercial air conditioning; large commercial air conditioning; and MVAC.

4.2.1 Residential and Light Commercial Air Conditioning

Residential and light commercial air conditioning has the greatest estimated installed stock of ODS and substitute refrigerants among all RACHP categories at about 40 percent of the total. Among air conditioning categories, the residential and light commercial air conditioning subsector accounts for 55.3 percent. The category shares the same name of the subsector, and equipment used within this subsector include those for cooling individual rooms and single-family homes, small commercial unitary air conditioning systems, and packaged terminal air conditioners (PTAC). The equipment may contain self-contained or split systems. Self-contained systems may include window air conditioning units, portable air conditioning units, and wall-mounted self-contained units. Split systems may include ducted and non-ducted mini-splits, VRF systems, and ducted unitary split systems.

R-410A accounts for the majority (85 percent) of the installed stock of ODS and substitute refrigerants in the residential and light commercial air conditioning subsector. The remaining installed stock in this subsector is primarily R-22 at 13 percent of the total. R-454B and R-32 have been emerging as possible substitutes for equipment using R-410A as industry is transitioning to lower-GWP refrigerants (Turpin, 2020).

4.2.2 Large Commercial Air Conditioning

Large commercial air conditioning accounts for 19.7 percent of the total installed stock of ODS and substitute refrigerants in the RACHP sector. Among air conditioning categories, large commercial air conditioning accounts for 25.5 percent of the installed stock of refrigerants. Large commercial air conditioning applications for stationary air conditioning include comfort cooling for larger buildings, such as offices, hotels, arenas, and more. Comfort cooling in these applications is often achieved using a chiller (*e.g.*, centrifugal or positive displacement). In commercial applications, centrifugal chillers may more often be used for higher cooling demands, while positive displacement chillers tend to be used for smaller capacity needs, like mid- and low-rise buildings.

The most common ODS and substitute refrigerants in installed stock in stationary air conditioning – large commercial are R-134a (38 percent), R-22 (21 percent), R-407C (16 percent), R-123 (9 percent), and R-410A (8 percent). The VM also shows estimates of installed stock of some lower-GWP refrigerants, including R-450A (4 percent) and R-513A (4 percent).

4.2.3 Mobile Air Conditioning

Mobile air conditioning accounts for 14.9 percent of the installed stock of ODS and substitute refrigerants in the overall RACHP sector. Among air conditioning categories, mobile air conditioning accounts for 19.2 percent of the installed stock of refrigerants. The mobile air conditioning category essentially comprises of the MVAC subsector and it includes systems that are used to cool the passenger compartment of light-duty vehicles, light-duty trucks, heavy-duty vehicles, school and tour buses, transit buses, and passenger rail vehicles.

There are two refrigerants that make up essentially all of the installed stock of ODS and substitutes in mobile air conditioning: R-134a (71 percent) and R-1234yf (29 percent). All of the estimated installed stock of R-1234yf are in the mobile air conditioning subsector. Much of the MVAC subsector is transitioning to using R-1234yf, particularly for light-duty vehicles. According to the 2023 EPA Automotive Trends Report, approximately 97 percent of model year 2022 light-duty vehicles sold used R-1234yf and some manufacturers have implemented R-1234yf across their entire vehicle brands (U.S. EPA, 2023c).

5. Reclamation Market for HFCs

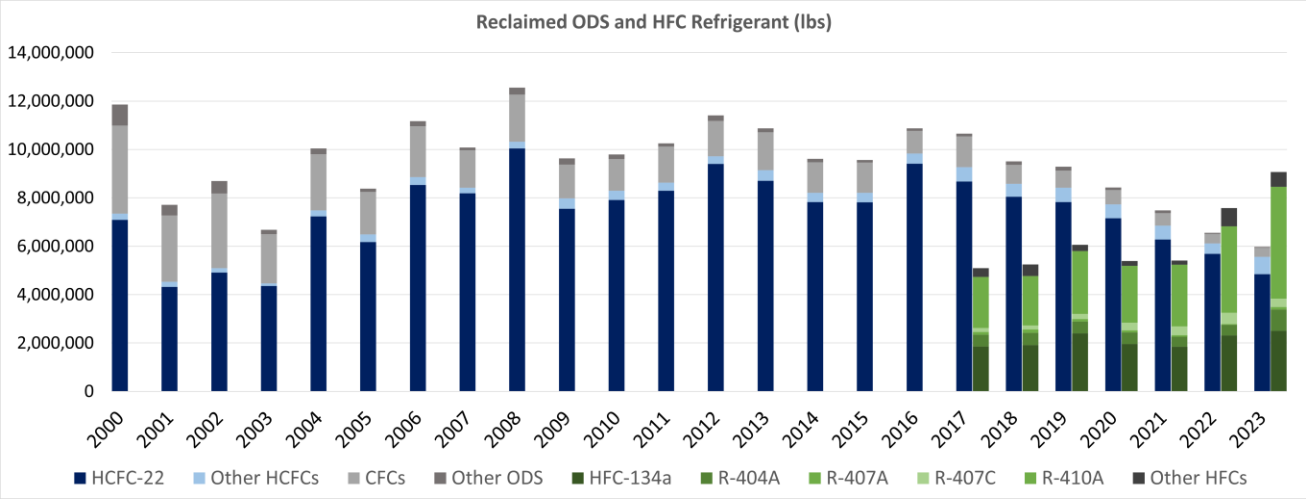
This section provides information on the reclamation market in the United States, beginning with a section on trends of the HFC reclamation market in the recent past and present, followed by an assessment of the anticipated demand of reclaimed HFCs in certain RACHP subsectors (Section 5.1). Section 5.2 describes the processes and methods of reclamation, including sources, equipment, and other aspects. Section 5.3 then presents cost drivers of reclaimed HFCs. Section 5.4 provides information on examples of incentives to recover and reclaim refrigerants.

5.1 HFC Reclamation Market

5.1.1 Past HFC Reclamation Trends

Figure 4 provides the total quantities of reclaimed substances since 2000, as reported annually to EPA by reclaimers per 40 CFR 82.164(d).[24] The figure shows data for certain ODS (*e.g.*, HCFCs, CFCs) and HFCs. ODS are shown in the stacked grey and blue columns and HFCs are shown in the stacked green columns. Reclaimers were not required to include HFC refrigerant in reports to EPA until 2017 (U.S. EPA, 2016b).

Figure 4. Reclaimed ODS and HFC Refrigerants from 2000 to 2023



After a relatively consistent upward trend between 2001 and 2008, reaching a peak of 12.55 million lbs, ODS reclamation was reasonably stable between 2009 and 2017, ranging between 8.39-11.32 million lbs per year. Since 2016, ODS reclamation quantities have decreased steadily by an average of 6.4 percent each year. HFC reclamation had remained relatively constant, between 5.09 and 6.06 million lbs from 2017 to 2021. In 2022, HFC reclamation had a notable increase to 7.58 million lbs, which is approximately 40 percent more than HFC reclamation in 2021. Further, 2022 is the first year that HFC reclamation totals exceeded ODS reclamation totals.Reclamation activity in 2023 continued the upward trend of HFC reclamtion, resulting in a further 20 percent increase from 2022 to 2023. The most common refrigerants containing HFCs reclaimed from 2017-2023 were R-410A (totaling 19.84 million lbs) and HFC-134a (totaling 14.79 million lbs) (Table 1).. From 2022 to 2023, R-407A and R-404A had the highest percent increases in reported reclamation volume, increasing by nearly 360 percent and 98 percent, respectively.

[24] Refrigerant reclamation data as reported to EPA per requirements under section 608 of the CAA are current as of July 2024.

Table 1. HFC Refrigerant Reclamation Reported Totals by Year (lbs)

Refrigerant	2017	2018	2019	2020	2021	2022	2023
R-134a	1,858,132	1,910,240	2,399,952	1,956,644	1,844,793	2,313,639	2,505,902
R-404A	486,719	506,639	485,338	478,556	416,352	443,977	880,502
R-407A	111,255	143,254	105,435	87,162	60,580	22,874	105,497
R-407C	167,445	167,248	213,668	315,424	366,521	473,115	342,904
R-410A	2,103,404	2,043,667	2,596,861	2,347,000	2,550,164	3,569,249	4,625,948
Other HFCs	363,311	479,261	258,486	206,029	173,022	757,818	611,611
Total	**5,090,266**	**5,250,309**	**6,059,740**	**5,390,816**	**5,411,433**	**7,580,672**	**9,072,364**

As noted in section 2 of this report, the AIM Act assigns each regulated HFC with an exchange value. HFCs are potent GHGs that have a capacity to trap hundreds to thousands of times the amount of heat in the atmosphere relative to CO_2, as presented by each individual chemical's GWP.[25] GWPs can be used to compare relative warming effects of GHGs in the atmosphere using a common unit, carbon dioxide equivalent (CO_2e), and often is presented in million metric tons CO_2e ($MMTCO_2e$).

To present the data in Table 1 in $MMTCO_2e$, the totals for each refrigerant were converted from lbs using GWPs that range from 1,430 (HFC-134a) to 14,800 (HFC-23). Subsection I of the AIM Act currently provides the full list of exchange values for regulated HFCs. Multiplying the respective GWP by the number of lbs of each HFC yields the exchange value in lbs. To obtain $MMTCO_2e$, the total exchange value in lbs was first divided by 2,204.6 (the number of lbs in a metric ton) and then divided by one million. Table 2 presents the total estimated reclaimed HFC refrigerants in $MMTCO_2e$.

As a reference for the size of the HFC reclamation market, EPA compared the annual amount of HFC reclamation total to the total annual consumption of HFCs in 2022. The total consumption[26] is calculated as the sum of the annual production and imports of HFCs minus the total HFCs destroyed and transformed. This total includes HFCs produced or imported for any use in any sector, including for RACHP equipment, foams, aerosol, or others, or could even have been imported by reclaimers for the purposes of rebalancing blends of reclaimed HFCs. The total consumption of HFCs in 2022 was 254 $MMTCO_2e$ (U.S. EPA 2024). When comparing to annual HFC reclamation, the total amount of HFCs reclaimed in 2022 is equal to an amount that is approximately 2.9 percent of the total annual consumption in 2022, and when comparing to the total amount of HFCs reclaimed in 2023, the total amount reclaimed is equal to approximately 3.5 percent of the total consumption in 2022.

[25] See 42 U.S.C. 7675(c); see also Appendix A to Part 84 - Regulated Substances. As explained in the Allocation Framework Rule (86 FR 55116), EPA has determined these are the same as the 100-year GWPs listed in the 2007 Intergovernmental Panel on Climate Change (IPCC) Fourth Assessment Report.

[26] For additional detail, see https://www.epa.gov/climate-hfcs-reduction/hfc-data-hub..

Table 2. HFC Refrigerant Reclamation (in $MMTCO_2e$)

Refrigerant	2017	2018	2019	2020	2021	2022	2023
R-134a	1.21	1.24	1.56	1.27	1.20	1.50	1.63
R-404A	0.87	0.90	0.86	0.85	0.74	0.78	1.57
R-407A	0.11	0.14	0.10	0.08	0.06	0.02	0.10
R-407C	0.13	0.13	0.17	0.25	0.29	0.38	0.27
R-410A	1.99	1.94	2.46	2.22	2.41	3.38	4.38
Other HFCs[a]	0.59	0.77	0.37	0.32	0.28	1.19	0.89
Total	**4.89**	**5.11**	**5.52**	**4.99**	**4.99**	**7.25**	**8.84**

[a] Other HFCs were calculated in $MMTCO_2e$ using aggregated totals of each HFC reclaimed as reported during annual reporting per 40 CFR 82.164(d) and using their respective GWPs

It is expected that the HFC reclamation market will increase in future years as more RACHP equipment using HFC refrigerants reach their end-of-life, and more HFCs are potentially available for recovery and reclamation. In addition, virgin HFC supplies are restricted consistent with the AIM Act, and industry may look to reclaimed materials for servicing existing equipment.

5.1.2 Anticipated Demand for Reclaimed HFCs in Equipment in Certain RACHP Sectors

Under subsection (h) of the AIM Act, EPA is finalizing certain regulatory requirements[27] to address HFC management for RACHP equipment. For certain RACHP subsectors EPA is finalizing requirements for the servicing/repair of refrigerant-containing equipment to be done with reclaimed HFCs. In particular, these subsectors and requirements are as follows:

- supermarket systems;
- refrigerated transport; and
- automatic commercial ice makers.

EPA reviewed the estimated demand for HFCs for the servicing/repair of existing equipment in certain subsectors of the RACHP sector. Specifically, EPA reviewed the estimated demand for the covered subsectors with requirements for servicing and/or repair of refrigerant-containing equipment with reclaimed HFCs as finalized under the ER&R rulemaking under subsection (h) of the AIM Act using the VM. The model was assessed for estimated demand in 2029, as the compliance date for the Agency's requirements for using reclaimed HFCs would be January 1, 2029. Table 3 shows the anticipated demand for reclaimed HFCs in the covered subsectors for servicing and/or repair, respectively, that would be required to be met with reclaimed HFCs. The baseline demand for this analysis assumes that the ER&R rule and its associated provisions have gone into effect.

Table 3 provides estimates of the demand for the servicing and/or repair of existing equipment in the covered subsectors in 2029, by refrigerant type for selected refrigerants that contain HFCs (whether neat or in a blend). Again, the selected

[27] See docket EPA-HQ-OAR-2022-0606.

refrigerants are those, in general, commonly used today in the covered subsectors in the RACHP sector. As Table 3 shows, however, the estimated demand for the supermarket systems and refrigerated transport subsectors is greater. These subsectors will have a greater need for reclaimed refrigerants containing HFCs for use in existing equipment so they can be used throughout their remaining useful life. Compared with existing equipment, new equipment is more likely to be transitioning to other refrigerants, whether that be other HFCs or blends containing HFCs (not included in Table 3), or substitute refrigerants that do not contain HFCs (*e.g.*, hydrofluoroolefins (HFOs), ammonia, hydrocarbons).

The subsector with the greatest anticipated demand of HFCs for servicing and/or repair in existing equipment in 2029 is supermarket systems. Supermarket systems account for approximately 69 percent of the total anticipated demand of HFCs for servicing and/or repair in 2029. This is likely a result of a few factors assumed in the Vintaging Model for this subsector, including a high average leak rate for equipment and large charge sizes of equipment. The refrigerant blend containing HFCs with the highest anticipated demand for servicing and/or repair in 2029 is R-407A (all anticipated use in supermarket systems) followed by R-404A (anticipated use in supermarket system, refrigerated transport, and automatic commercial ice makers).

Table 3. Estimated demand for servicing and/or repair (lb) for the covered RACHP subsectors in 2029

Service Demand (lbs)	HFC-134a	R-404A	R-410A	R-507A	R-407A	R-407C	R-450A/R-513A	R-448A/R-449A	R-452A	Total
Supermarket Systems	-	5,017,210	-	132,386	13,942,072	-	-	-	-	19,091,668
Refrigerated Transport	1,479,666	3,073,125	134,301	1,344,265	-	35,124	17,461	-	2,134,922	8,218,863
Automatic Commercial Icemakers	22,862	68,564	-	-	-	-	-	99,473	-	190,898
Total	**1,502,528**	**8,158,899**	**134,301**	**1,476,651**	**13,942,072**	**35,124**	**17,461**	**99,473**	**2,134,922**	**27,501,429**

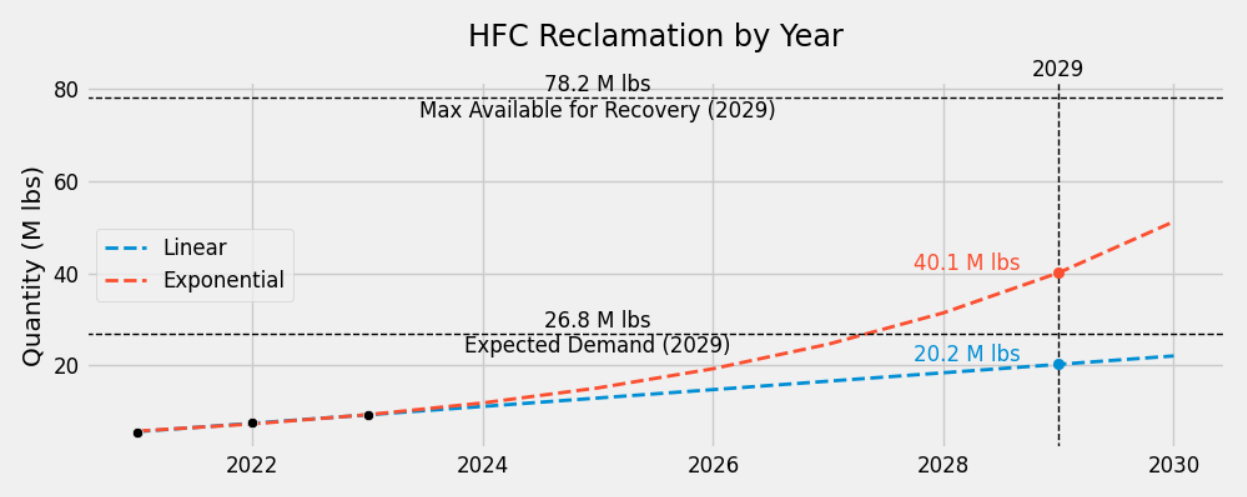
The estimated demands for servicing and/or repair of equipment in Table 3 for common reclaimed HFC refrigerants (neat or in blends) can be compared to the totals of reclaimed HFC refrigerants in Table 1. For clarification, Table 3 provides the total amount of blends that also contain non-HFC substitutes. The requirements for servicing and/or repair of certain refrigerant-containing equipment with reclaimed material do not apply to reclaimed substitutes for HFCs. The total estimated demand for reclaimed HFCs in 2029 is 26.8 million pounds.[28] As can be seen, the anticipated demand for reclaimed HFCs in 2029 is generally greater than the total amount of HFCs reclaimed in

[28] See Technical Support Document: *Analysis of the Economic Impact and Benefits of the Final Rule* in the rulemaking docket (EPA-HQ-OAR-2022-0606).

any year where reclaimed HFC data have been reported to-date. Additional reclaimed capacity will be required to meet the anticipated demands for using reclaimed refrigerants containing HFCs (neat or in a blend).

EPA estimated supply of reclaimed HFCs available in 2029 based on an analysis of recent trends in reclamation totals from 2021 to 2023, as these data points capture effects on growth in the reclamation industry as a result of the phasedown (as observed in 2022 and 2023). Figure 5 below illustrates projected supply and demand for reclaimed refrigerants for covered subsectors in 2029. Both linear and exponential growth projections (relative to recently reported totals from 2021, 2022, and 2023) are shown, illustrating reasonable patterns of growth for the reclamation market. As shown, a linear trajectory would yield approximately 20 million lbs of refrigerant in 2029 (slightly below required demand), while an exponential trajectory would yield approximately 40 million pounds of refrigerant in 2029 (above required demand). EPA expects growth to be more exponential than linear due to various factors, such as the regulatory drivers from the rule, the overall HFC phasedown, and announcements from reclaimers for building additional facilities to significantly increase reclamation capacity.[29] Notably, both results are far below total achievable recovery and reclaim in 2029 of 78 million lbs, based on EPA modeling. While reclamation would need to increase substantially from current levels to meet expected demand in 2029, it would only require recovery of approximately 35% of the total recoverable HFCs in that year. Furthermore, while the lines in this figure illustrate supply and demand in a given year, EPA understands that it is common practice for reclaimers to stockpile recovered refrigerants and reclaim them when most efficient or opportune, a factor which may lead to further shoring up of supply of reclaimed HFCs in anticipation of 2029.

Figure 5. Projected HFC Reclamation by Year



[29] A-Gas (2023). A-Gas Breaks Ground on Additional Market-Leading Refrigerant Separation Technology. Available at: *https://www.agas.com/news-insights/a-gas-breaks-ground-on-additional-market-leading-refrigerant-separation-technology/*.

5.2 Reclamation Methods and Processes

In 2010, EPA commissioned an analysis of the state of the reclamation industry (Stratus Consulting 2010). For the study, several reclaimers, one industry organization, one laboratory, and four air conditioning and refrigeration equipment manufacturers were interviewed.

Additionally, EPA interviewed reclaimers between 2018 and 2019 on the reclamation industry as a whole, their role in the reclamation industry, and the reclamation methods and processes they performed. EPA hosted a public reclamation workshop in 2021 to provide general information on the AIM Act and reclamation, as well as open discussion on preliminary questions. Further, EPA held stakeholder meetings in November 2022, March 2023, and April 2023. These stakeholder meetings sought feedback related to the development of the proposed rule under subsection (h) of the AIM Act, while also providing focus on specific topics related to reclamation. EPA heard feedback on potential barriers to reclamation, as well as technical capabilities that were detailed in the draft version of this report that was issued with the NODA in October 2022.

EPA is also aware of a report produced in 2022 by a group of eNGOs that provides information and research on "Life Cycle Refrigerant Management," which includes increasing opportunities for reclamation of HFCs (NRDC et al., 2022). The report highlights the importance of reclamation of HFCs to supporting the overall phasedown of HFCs under the AIM Act, since some HFCs will continue to be needed to support the servicing of existing equipment. Further, HFCs are being phased *down*, not phased *out* like ODS, indicating the recognized need for HFCs for certain uses. The report also describes the reality that the reclamation of HFCs currently does and will continue to require more sophisticated separation technologies to purify complex mixtures of refrigerant gases that are returned to reclaimers. Other challenges and opportunities for increasing reclamation are described in the report, such as the need to increase the amount of refrigerant recovered and returned to reclaimers and exploring options for requiring the use of reclaimed HFC refrigerant in certain new or existing equipment.

The 2010 study found that the reclaimers mix-and-match quantities of refrigerant from different cylinders to produce bulk batches that meet or exceed a given overall purity level. The objective is to maximize the amount of recovered refrigerant while minimizing the energy required to return each batch to the required purity level (*e.g.*, 99.5 percent). The study also found that reclaimers' business operations determined their reclamation methods. A small reclaimer that only processes small batches of almost pure HCFC-22 might use different processes than a large reclaimer that processes large batches of refrigerant with a higher proportion of mixed gas. For example, smaller reclaimers may rely more on "off-the-shelf" systems that have limited technical capacity and throughput. A larger reclaimer may have the ability to process a greater capacity of recovered materials and may use a more complex and/or customized system to reclaim (*e.g.*, via distillation).

Based on information available to EPA, including those listed above, the following sections of this report discuss the sources of recovered refrigerant (Section 5.2.1), equipment used in reclamation (Section 5.2.2), the use of virgin gas by reclaimers

(Section 5.2.3), how much refrigerant they stockpile at any given time (Section 5.2.4), and the reclamation of HCFC-22, specifically (Section 5.2.5).

5.2.1 Sources of Recovered Refrigerant

Reclaimers obtain recovered HFCs for reclamation through a number of means:

- Refrigerant wholesalers or distributors that collect recovered refrigerant as a service to contractors,
- Contractors/technicians who recover refrigerants and send materials to reclaimers,
- Scrap metal recycling yards that recover refrigerant from small appliances and MVACs before shredding, and
- Owner/operators of large appliances such as chillers and supermarkets. (U.S. EPA 2021a)

The 2010 study found that recovered refrigerant comes from numerous sources. Most often, reclaimers received recovered refrigerant indirectly from wholesalers who accepted cylinders as a service to technicians. Less frequently, the refrigerant came directly from technicians who dropped it off at reclaimers' facilities (Stratus Consulting, 2010).

Similarly, from past interviews in 2018 and 2019, EPA understands that reclaimers may receive recovered refrigerant from a variety of locations. Based on these interviews, EPA understands that some reclaimers receive recovered refrigerant primarily from RACHP contractors and technicians (both small and large), while others primarily work with wholesalers. EPA learned that one reclaimer receives recovered HFCs from supermarkets, chillers, and ice rinks, and that another reclaimer provides reclamation/recycling as a side service for their customers.

Additionally, EPA understands that reclaimers that primarily work with wholesalers may be less aware of the original application of the recovered refrigerant. Those that recover their own materials or work closely with contractors and technicians may have more information on the original application in which the recovered refrigerant was used. For example, based on the interviews in 2018 and 2019, EPA understands that a common source of recovered HFC-134a for some reclaimers is from residential refrigerators. EPA also learned that one reclaimer that does on-site recovery maintains a database for the source of all of their recovered refrigerant.

5.2.2 Equipment Used in Reclamation

Based on the 2010 study, reclaimers first weighed the cylinder (to determine the volume of refrigerant inside) and determined the contents of each cylinder, generally using a hand-held gas analyzer (*e.g.*, a Neutronics refrigerant analyzer). If the contents appeared to be mixed, the reclaimer sometimes used a gas chromatograph (GC) to determine the container's contents in more detail. The study found distillation to be the most common primary separation method for reclamation systems. Other methods may include adsorption/desorption, cryogenic subcooling, and other processes used to address the different specifications established in appendix A to 40 CFR part 82, subpart F (Stratus Consulting, 2010).

According to the 2010 study, the typical reclamation process uses one of three pieces of equipment/technologies: a compressor for distillation, adsorbent beds for adsorption/desorption separation, or cryogenic filters to cool the refrigerant (Stratus Consulting, 2010). Among these separations, distillation is the most common primary separation method for reclamation systems, and larger reclaimers are more likely to have this capability.

- In a compressor-based distillation system, a compressor is used to increase the pressure of the refrigerant to use ambient air to condense the refrigerant.
- In an adsorption/desorption system, the contaminated refrigerant enters an initial adsorption chamber where the refrigerant is adsorbed to an adsorbent bed; impurities are not adsorbed in this chamber and continue to a second chamber, from which they are discharged. After the impurities have been isolated, the refrigerant can be desorbed from the adsorption bed and collected from the system.
- In a cryogenic subcooling system, dirty refrigerant is cooled in three stages. The refrigerant is then sent through cryogenic filtration with coalescent filters to remove most small particles. In the last step, a microprocessor-controlled purge device releases the non-condensable substances.

The type of equipment used in the industry can vary considerably and may depend on factors such as the size of the reclaiming operation and the amount of refrigerant that the reclaimers are handling. Smaller operations typically use “off-the-shelf” equipment, while larger operations purchase or manufacture custom equipment. Off-the-shelf equipment are pre-designed systems that are sold to be used for the reclamation of recovered refrigerants. These off-the-shelf models were limited in terms of capacity and speed (2-5 lbs per minute). EPA further learned from interviews in 2018 and 2019 that refrigerants may require multiple cycles through off-the-shelf equipment to get a clean result with an acceptable refrigerant purity and may have difficulties when processing recovered refrigerants that were mixed. Off-the-shelf equipment are likely more applicable to the reclamation of ODS, where recovered gases are not typically in complex mixtures with other types of refrigerants, which is more common for refrigerants containing HFCs.

Large-scale operations typically do not use off-the-shelf equipment because they are not capable of handling larger volumes of refrigerants. Larger reclaimers use customized equipment that can handle more refrigerants and provide a higher degree of accuracy when processing refrigerant blends. Among the reclaimers interviewed by EPA in 2018 and 2019, many used custom-built equipment and a GC. At least two reclaimers who were interviewed have separation towers and at least two used fractional distillation to separate mixed gas. In comments submitted on the ER&R rule, one reclaimer stated that they “currently use fractional distillation to separate R-32 from recovered refrigerant blends, most notably R-410A and R-407 variants. This ensures a level of purity that meets or exceeds the AHRI-700 standard for the product” (A-Gas, Inc 2023).

Additional analytics first test the refrigerant that has been recovered in addition to testing for purity specification after processing. Mixed refrigerants and multi-component

blends may require complex fractional distillation, where the recovery of single-component refrigerants (more common with ODS) could be a simpler separation process. The increase in mixed refrigerants returned for reclamation and the use of refrigerant blends have led to more complex reclamation systems. The U.S. reclamation industry is transitioning from simpler ODS reclamation technologies to more sophisticated fractional distillation for HFCs (NRDC et al., 2022). One reclaimer noted that, as a technical matter, "no mix of gases is so mixed as to be beyond the ability of fractional distillation equipment to separate."[30] While this may be the technical case, refrigerant gases that are highly mixed could require more complex processing and the decision to reclaim or destroy the mixed refrigerant would likely consider costs.

There is some new and ongoing research into techniques for separating HFC refrigerant mixtures into their constituent refrigerants. Some of these new techniques include (Shiflett Research Group, n.d.):

- Ionic liquids: the unique properties of ionic liquids (no measurable vapor pressure, dissolution of many organic and inorganic compounds, variable solubility of gases and liquids, and high thermal, chemical, and electrochemical stability) can be used in many separation and purification processes, such as HFC separations.
- Membranes: membranes are a barrier that selectively allows the passage of some species while preventing the passage of others. It is possible to design membranes capable of separating difficult HFC blends while potentially requiring less energy and capital.
- Porous media: porous media include nano- to micro-sized materials that can be exploited for their molecular sieve capabilities and chemical properties to conduct difficult separations of HFC mixtures.

5.2.3 Use of Virgin Gas

As noted in section 5.2.2 of this report, companies may use separation processes (*e.g.*, fractional distillation) to separate out impurities and other components (*e.g.*, oils, contaminants) from the recovered refrigerant to ensure that the refrigerant meets purity specifications, such as AHRI Standard 700-2016. Based on conversations with reclaimers, fractional distillation and other technologies allow companies to separate refrigerant blends without the use of virgin gas. However, some reclaimers note that these technologies are less economical and more energy intensive than blending (Hudson Technologies Company, 2021). Although entities can meet the purity standards through distillation by separating out other components from the desired final material, EPA's reclamation requirements under CAA section 608 do not require entities to have any particular purification technology. As the HFC phasedown progresses, access to virgin material to facilitate reclamation through blending will likely decrease. This increases the importance of separation and distillation technologies, as well as better practices during maintenance and recovery to avoid refrigerants being mixed.

[30] See https://www.regulations.gov/comment/EPA-HQ-OAR-2022-0606-0009.

Several refrigerant reclaimers submitted comments[31] to EPA during the public comment period for the Allocation Framework Rule (86 FR 27150) and additional comments were submitted in response to the NODA[32], indicating that virgin stock was necessary to meet AHRI Standard 700-2016, particularly if blending processes were used (*e.g.*, A-Gas, Inc. 2021, Hudson Technologies Company 2021). In their public comments, reclaimers noted that the reclamation of HFC blends may also require balancing, which necessitates the addition of one or more virgin refrigerants to the process (*e.g.*, Golden Refrigerant 2021, Hudson Technologies Company 2021). EPA responded to these public comments in finalizing the Allocation Framework Rule in 2021 (86 FR 55116). EPA noted that virgin HFCs are important during the reclamation process for rebalancing particular blends of HFC refrigerants. The 2022 report by the group of eNGOs states that virgin or otherwise pure (*e.g.*, other reclaimed HFCs) are generally used to rebalance specific ratios, but should not be used to dilute out impurities to reach the required purity standard (NRDC et al., 2022)

CARB finalized a regulation effective January 1, 2022, that defines “certified reclaimed refrigerant” as containing no more than 15 percent virgin refrigerant by weight and the certified reclaimer must provide supporting documentation showing as such (17 CCR § 95371-95379 2021). CARB arrived at a maximum allowable amount of virgin HFCs of 15 percent by weight in “certified reclaimed refrigerant” based on feedback from multiple stakeholders (including reclaimers, OEMs, and industry trade groups) who commented that having an allowable amount of virgin HFCs in reclaimed HFCs would be necessary for rebalancing out-of-ratio recovered HFCs and HFC blends (CARB, 2021).

For reclaimers who do not have distillation capacity, or for which distillation is not cost-effective, the throughput of refrigerant reclamation may be proportional to the amount of virgin materials they can access and the purity of the recovered refrigerants they receive. Under the Allocation Framework Rule, reclaimers that historically imported HFCs received allowances from the general pool. EPA also established a process under which eligible entities, including but not limited to reclaimers, could receive allowances, even if they did not historically import HFCs (*i.e.*, new market entrants). Some reclaimers received HFC consumption allowances in 2022 and 2023 as a result of either being previous importers of HFCs or through the new market entrant process.

From interviews with reclaimers in 2018 and 2019, EPA understands that some of the larger refrigerant reclaimers may also operate a refrigerant “banking” system, where they establish a price market for reclaimed refrigerant sold under their own brand name. In these cases, it is possible that an HFC producer or importer would be in direct competition with a reclaimer, although it is unclear the prevalence of this scenario or whether there are significant price disparities between virgin and reclaimed products for different refrigerants. For smaller refrigerant reclaimers, who function as a pass-through cost and may not directly sell their reclaimed refrigerant back to the market, there may be less likelihood of direct competition with HFC importers or producers.

[31] Docket ID No. EPA-HQ-OAR-2021-0044.
[32] See https://www.regulations.gov/comment/EPA-HQ-OAR-2022-0606-0003.

5.2.4 Refrigerant Stockpile

Information on the amount and type of refrigerants stockpiled by reclaimers is limited. In the 2010 study, reclaimers noted that they did not believe stockpiling refrigerants was common.[33] Per recordkeeping and reporting requirements under AIM Act regulations (40 CFR 84.31), reclaimers are required to maintain records of the names and addresses of the persons sending them material for reclamation; however, they are only required to report the total mass of material received for reclamation. Thus, reclaimers are not required to report whether the reclaimed refrigerant came from a stockpile or from a recent field recovery. In interviews EPA had with reclaimers between 2018 and 2019, one reclaimer stated that they store some R-410A until prices are at the level at which it can profitably be reclaimed. As described in section 2 of this report, with the exception of a small allocation of allowances for R-123 and R-124, whose use is limited to servicing certain equipment, production and consumption of virgin ODS, including ODS refrigerants, have been phased out in the United States. Reclamation of HCFC refrigerant does not offset the production of HCFCs but provides another way for HCFC refrigerant to enter the market. EPA's intent has always been to facilitate a smooth transition to substitutes, which includes avoiding stranding equipment that has not yet reached the end of its useful life. For example, although certain restrictions apply to the use of class II substances under section 605(a) of the CAA, used R-22 that is recovered and reclaimed, or virgin material produced before the 2020 phaseout, may continue to be used for as long as it is available to service refrigeration and air-conditioning equipment existing as of January 1, 2020. In this example, the availability of reclaimed R-22 refrigerant may lower the market price of R-22 refrigerant because reclaimed refrigerant helps supplement a limited supply of virgin refrigerant that can no longer be produced. This would reduce the perceived notion of a shortage and reduce the incentive for largescale stockpiling. EPA learned in interviews in 2018 and 2019 that some reclaimers use a "refrigerant bank" model that allows users to return recovered refrigerant and be guaranteed a similar quantity of refrigerant for a set price. This provides security to consumers on the availability of ODS refrigerant, which can reduce the need to stockpile it.

In the public comments to the Allocation Framework Rule, one reclaimer stated that there are limited data on virgin HFC stockpiling, including the size of such stockpiles (A-Gas, Inc., 2021). Additionally, other stakeholders asserted that although there are surplus HFC stockpiles in the marketplace, they saw no evidence of this in the market data. They said that if there were actual HFC stockpiles, they would expect companies to sell them at an incentivized price to make a large profit, which is not happening (FluoroFusion Specialty Chemicals, Inc., 2021, Kivlan and Company, Inc., 2021).

Data on imports of HFCs in 2021 suggests an increase in stockpiling across those with consumption allowances, which includes some reclaimers (as noted in section 5.2.3 of this report). Imports increased by over double from 2020 to 2021 (U.S. EPA, 2024). It is expected that imports may have seen increases as significant steps begin to draw near in the phasedown schedule as required by the AIM Act (for example, a 40 percent

[33] Reclaimers contacted for that study were running smaller operations and may not have been able to afford to keep a large inventory of refrigerants.

reduction in 2024). While not all importers are reclaimers, reclaimers that do import may also be using their consumption allowances to stockpile virgin HFCs for future use in rebalancing reclaimed HFC refrigerants. Stockpiling may also occur related to the current market price of particular HFC refrigerants. Reclaimers may hold recovered material until the market is favorable to reclaim and sell the HFCs.

5.2.5 Reclamation of R-22

As a result of a variety of restrictions on R-22 under title VI of the CAA, including restrictions on HCFC production, consumption, and use, stockpiles of virgin R-22 refrigerant have been shrinking over the past few years. R-22 that is recovered and reclaimed, along with R-22 produced prior to 2020, will help meet the needs of owners of existing R-22 systems. To return recovered R-22 refrigerant to purity specifications, reclaimers often blend reclaimed HCFC-22 with virgin R-22. In some cases, R-22 that cannot be reclaimed onsite may be sent to other reclaimers that have the necessary technology to improve the purity (*e.g.*, distillation). In interviews with reclaimers in 2018 and 2019, one reclaimer noted that in the last few years, the price has become too expensive to use virgin R-22 to return the recovered R-22 to specifications through blending. According to reclaimers, some refrigerant in the market that is being reclaimed is not pure enough to process without separation. With no additional production or import, remaining stocks of virgin HCFC-22 are not available in sufficiently large quantities to blend with recovered gas, so R-22 outflows are now exclusively from reclaimed refrigerant. R-22 is still being reclaimed and is still expected to be reclaimed for the foreseeable future as long as there is eligible R-22 equipment in the field needing refrigerant for servicing.

5.3 Reclamation Cost Drivers

Proper refrigerant reclamation incurs a variety of costs borne by various parties throughout the refrigerant value chain. The overall reclamation cost may include cleaning the refrigerant, mixed gas separation, laboratory testing, and repackaging, in addition to sales and overhead expenses. The following sections of this report qualitatively describe costs borne throughout each stage of the reclamation process.

5.3.1 Recovery at End-of-Equipment Life

The reclamation process begins with contractors dispatched to site locations who recover refrigerant from decommissioned equipment. Contractors incur upfront costs for refrigerant recovery equipment, including recovery machines, refrigerant recovery cylinders, and field tests for moisture and contamination. As refrigerant recovery takes time, there can be an opportunity cost for contractors to properly recover all refrigerants (per EPA’s regulations under CAA section 608) as opposed to illegally venting refrigerant. It is unclear whether any such opportunity costs are significant compared to the overall cost of a typical installation, and whether contractors typically pass along those costs to consumers in the form of hourly rates. Contractors also often bear any costs associated with transporting refrigerants to a distributor or reclaimer site. These costs may be more pronounced in rural areas or areas with low concentrations of refrigerant-containing equipment, as more travel is required per volume of refrigerant.

In other cases, small appliances and MVAC may be disposed of by an end user and may ultimately end up for final processing at a scrap recycler or landfill. Per regulations in 40 CFR 82.155, the final processor must properly recover any remaining refrigerant from appliances, or the final processor must receive a signed verification that the refrigerant in the appliance has been properly recovered prior to delivery. In the case where the refrigerant is not recovered prior to delivery, operators at landfills or scrap yards may encounter challenges in recovering the refrigerant due to limited training. Further, these entities may not have direct relationships with other steps of the reclamation supply chain. While the collective amount of refrigerant able to be recovered from small appliances and MVACs is significant, each individual scrap recycler or landfill operator likely recovers small quantities of refrigerant, limiting the economic benefit to the individual business of recovering the refrigerants.

5.3.2 Handling before Reclamation

Typically, contractors who recover used refrigerant will return the refrigerant to a distributor or wholesaler, who in turn will aggregate the refrigerant and interact with reclaimers. In these cases, the costs for storage and management may fall on the distributor or wholesaler. Larger contractors with the capability to store and catalogue volumes of refrigerants may work directly with a refrigerant reclaimer to return recovered refrigerants and to buy back reclaimed refrigerants. In these circumstances, the contractor bears the costs associated with storage and management. As the variety of different refrigerants being reclaimed increases, it is expected that storage and management costs will also increase. These anticipated cost increases account for additional refrigerant cylinders, more complex labeling and tracking, and any special equipment or handling required for processing flammable refrigerants.

5.3.3 Reclamation Costs

Refrigerant reclaimers must make significant capital expenditures to purchase the equipment required for testing refrigerant composition, removing impurities and waste products to meet the necessary purity standards, and altering blend compositions to be within required specifications. Section 5.2.2 of this report describes the equipment used for refrigerant reclamation in greater detail. These capital expenditures are typically amortized across the lifetime of the equipment. For higher-complexity refrigerant blends, it is likely that equipment costs are higher as there are more steps required for component separation, mixing, and testing. For example, fractional distillation requires both distillation expertise and capital investment (NRDC et al., 2022).

There are also various operational costs for refrigerant reclamation, including electricity to the reclamation equipment as well as labor costs to run the reclamation equipment and perform quality assurance checks. Some portion of the recovered refrigerant may be lost during the reclamation process; refrigerant reclaimers may purchase quantities of virgin refrigerants for the purpose of rebalancing reclaimed HFCs to achieve proper compositions. The cost of these purchases will vary depending on the quantity required and the price of the virgin refrigerant. Some refrigerant reclaimers also directly re-sell reclaimed refrigerant, in which case they assume marketing and administrative costs. In many cases, reclaimers will simply collect a pass-through toll from wholesalers to

reclaim their refrigerants. In this scenario, the wholesaler will bear the costs associated with resale of the reclaimed refrigerant to equipment manufacturers and/or contractors.

Other logistical costs may also be considered as factors to reclamation, such as transporting recovered materials. It may not always be the case that when technicians recover refrigerants that they are located near a reclamation facility. The costs and time required to transport materials may be significant and possibly prohibitive depending on who in the supply chain bears the costs. Some reclaimers offer services to recover refrigerant on-site and may even offer buy-back incentives for certain types of refrigerants (*e.g.*, Hudson Technologies Company n.d., A-Gas, n.d.). Even still, ready access to these services may be geographically dependent.

5.4 Reclamation Incentives

At the time of the 2010 study, many reclaimers established incentive programs to encourage technicians and wholesalers to turn in recovered HCFC-22. Some reclaimers noted that EPA could maximize the amount of refrigerant entering the market by requiring technicians to report additional information on the amount of refrigerant that the technicians recover and where the recovered refrigerant goes after it leaves the technicians (Stratus Consulting, 2010).

During interviews EPA conducted with reclaimers between 2018 and 2019, the Agency learned about different incentives for HCFC-22 reclamation. EPA understands from these interviews that some reclaimers offer financial incentives and at least one does not. EPA also learned that one reclaimer offers financial incentives to wholesalers and strongly encourages them to share the incentive with their contractors. Another reclaimer has incentives that may shift over time based on prices. Further, EPA learned that reclaimers use various business models for the reclamation process. Some reclaimers operate as a “tolling” system (*i.e.*, the entity bringing in the recovered refrigerant pays a pass-through fee to account for reclamation and disposal, and then receives a matching volume of reclaimed refrigerant available for reuse on the market). Other reclaimers operate as a “banking” system, where contractors and wholesalers deposit recovered refrigerant and retain the title to a matching volume of reclaimed refrigerant that can be withdrawn later. Reclaimers who typically sell the banked refrigerant on the open market will use their own branding, excluding patented blends.

Beyond those programs discussed and known buyback programs from some reclaimers as discussed in section 5.3.3 of this report, EPA heard feedback to the NODA and in stakeholder meetings hosted for development of the proposed rule under subsection (h). Stakeholders expressed interest in the development of a type of incentive program to encourage additional recovery of HFC refrigerants to support the need for increased reclaim capacity. In general, some reclaimers have noted that they tend to pay for refrigerant returned to them for reclamation as refrigerant (both virgin and reclaimed) prices tend to increase with the progression of the phasedown of virgin HFCs.

5.4.1 Differences in Reclamation Incentive/Credit Programs

Several countries have set up refrigerant recovery and reclamation programs that establish prices and policies for incentives and credits. For example, in Australia, the industry-funded organization Reclaim Refrigerant Australia (RRA) recovers, reclaims,

and destroys ODS and synthetic GHG refrigerants by placing a shared responsibility for end-of-life product management on producers or other entities in the supply chain. RRA establishes a levy system on imports for which the levies are then used to pay for rebates to refrigerant wholesalers, technicians, and contractors for recovering, handling, and returning refrigerants (RRA, 2019).

The United States currently does not have a national incentive or credit-based recovery and reclamation program, such as a national refrigerant bank or specific crediting scheme for reclamation. Individual wholesalers and reclaimers that wish to offer such incentives would need to develop their own credit programs to incentivize the return of recovered refrigerant, as they may see fit. As the RACHP sector transitions to lower-GWP substitute refrigerants, it may become more difficult for individual wholesalers and reclaimers to accurately forecast prices for various refrigerants, which may reduce the feasibility of establishing incentive/credit programs for refrigerant recovery.

6. Safety of Technicians and Consumers

RACHP technicians are typically trained and, at minimum, required to have the appropriate certification under 40 CFR 82.161 for the equipment that they maintain, service, repair, or dispose of. While the process for recovering lower-GWP refrigerants will be similar to those in wide use today, technicians must be mindful of substitute refrigerants that carry flammability risks. As described in this section, the RACHP sector is currently preparing technicians to be knowledgeable of safe procedures to handle flammable refrigerants, which presents a change in historical refrigerant recovery and handling practices. Consumers are generally not involved in the refrigerant recovery process and should not experience any safety issues if technicians follow industry guidance and EPA requirements per 40 CFR part 82 on proper recovery procedures.

Under EPA's regulations implementing CAA section 608, all persons who could reasonably be anticipated to violate the integrity of the refrigerant circuit during maintenance, service, repair, or disposal of appliances that contain ODS, as well as those containing non-exempt substitute refrigerants, such as HFCs, are required to meet certification requirements (40 CFR 82.161). Under regulations per CAA section 609, no person who repairs or services a MVAC or MVAC-like appliance may perform any service involving the refrigerant for the MVAC or MVAC-like appliance unless they properly use approved equipment and are trained and certified by an EPA-approved organization (40 CFR part 82, subpart B).

Certain substitutes to HFC refrigerants, including higher flammability (*e.g.*, A3; R-600a), lower flammability (*e.g.*, A2L; R-454A), and higher toxicity (*e.g.*, B2L; R-717) refrigerants, are likely to enter the market as the transition to lower-GWP refrigerants progresses. See Table 4 for the American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) classification of refrigerant flammability and toxicity (ASHRAE, 2019). Widespread use of A2L, A3, and B2L refrigerants may require additional training for service technicians to ensure safe handling when equipment using those refrigerants need servicing or require end-of-life recovery.

There may be other safety considerations when dealing with flammable refrigerants. EPA heard in our public workshop in 2021 that there should be considerations for the safe transport of flammable refrigerants like A2L refrigerants and treatment of these refrigerants under other regulation. EPA further heard in the stakeholder meeting in November 2022 of the importance of continuing to train technicians as new refrigerants are entering the market and becoming more common. For example, refrigerants that exhibit the hazardous waste characteristic of ignitibility per 40 CFR 261.21 may need to be managed as hazardous waste under the Resource Conservation and Recovery Act (RCRA).

Table 4. ASHRAE Refrigerant Designations

Higher Flammability	A3	B3
Lower Flammability	A2	B2
	A2L	B2L
No Flame Propagation	A1	B1
	Lower Toxicity	**Higher Toxicity**

Source: ASHRAE (2019)

7. Barriers and Key Challenges to Greater Refrigerant Recovery and Reclamation

There are barriers and key challenges that technicians, wholesalers, reclaimers, and other market actors have raised for consideration in order to increase the amount of refrigerant that is recovered and reclaimed for refrigeration and air conditioning systems. Barriers and challenges such as rising costs of reclaiming, market fluctuations, increased blends and mixed gases, and increased technological demands have led to a lack of incentivization to reclaim refrigerants. However, more recent price dynamics for HFCs may be changing historic trends.

7.1 Contamination and Accommodating Blends and Mixed Cylinders

From interviews with reclaimers in 2018 and 2019 and comments received in response to the NODA in October 2022, EPA understands that one of the biggest challenges in the reclamation industry is dealing with mixed refrigerants or a recovery cylinder containing multiple types of refrigerants, an issue that may become more common with the increase in the variety of refrigerants being used. EPA understands that with the RACHP sector's transition to lower-GWP substitutes, there will be a greater variety of refrigerants on the market. For example, technicians recovering refrigerant may inadvertently recover R-410A in a cylinder containing R-22 or may knowingly do so if there is no other recovery cylinder available. RACHP technicians servicing residential and light-commercial air conditioning equipment may need to carry multiple cylinders for the refrigerant used to service equipment (*e.g.*, new) or any refrigerant that is recovered, including R-22, R-410A, R-134a, R-32, and R-454B. Additionally, many lower-GWP refrigerants consist of multi-component HFC/HFO blends, which require

additional steps to reach purity specifications and proper refrigerant compositions and are more difficult to separate than blends with only two components. Other lower-GWP refrigerants also carry flammability risks, which may increase costs and safety processes. To ensure the maximum value for recovered refrigerants, technicians would likely have to increase the number of cylinders they carry to prevent mixing refrigerants.

During interviews in 2018 and 2019, EPA learned of potential issues with mixed gases from the residential air conditioning sector, specifically the lack of proper maintenance or the reuse of gas from one job to the next, which leads to contamination. Further, EPA understands from these interviews that "topping-off" systems occurs when original refrigerants have not first been evacuated, which contributes to contaminated refrigerants that would be available for recovery.

Reclaiming mixed-refrigerant cylinders may incur increased time and difficulty to determine the precise composition of gases in the cylinder, separate the various component gases, and then return each component to the specified composition. From EPA's public workshop in 2021, the Agency understands that blends and mixed refrigerants can be problematic, and that reclaimers who are unable to perform the required processing may decide to destroy the returned refrigerant rather than incurring additional costs. As noted in previous sections of this report, sophisticated fractional distillation is required to separate and reclaim highly mixed refrigerants, which requires technical expertise and high capital costs.

Some reclaimers will blend virgin refrigerant, which can be combined with mixed recovered refrigerant, to increase the purity as a cost-effective option over the process of using a fractional distillation column. As the phasedown of virgin HFCs progresses, however, this will become a less feasible option. Further, EPA understands the need for virgin HFCs to rebalance reclaimed HFCs to achieve appropriate ratios of blends of HFCs. Blending up as the sole method of achieving the purity standard for reclaimed HFCs would be counterintuitive to maximizing reclamation.

7.2 Price of Refrigerant

The costs associated with reclamation have historically been considered a barrier, with the price of refrigerants being a major factor. From interviews in 2018 and 2019, EPA learned that customers might not buy refrigerant marketed as reclaimed gas when there is virgin gas available for the same cost. However, as the phasedown of virgin HFCs progresses, prices for refrigerants containing HFCs are expected to rise as virgin HFCs become scarcer. Reclaimed refrigerants containing HFCs are also expected to rise in price, since they will be needed for similar uses as their virgin counterparts.

Based on interviews in 2018 and 2019, EPA understands that other factors may affect the price of refrigerants as well. For example, EPA heard the view that the price of R-410A may be low because of supply from overseas (*i.e.*, "dumping"). Dumping is "when a foreign producer sells a product in the United States at a price that is below that producer's sales price in the country of origin ("home market"), or at a price that is lower than the cost of production" (U.S. EPA 2021b). Between 2016 and 2021, the U.S. Department of Commerce and the U.S. International Trade Commission have taken various actions to impose antidumping duty orders related to certain cases of imports of

HFCs and blends containing HFCs. EPA also heard that market fluctuations in the price makes it difficult for reclaimers to operate profitably, and such fluctuations may be a result of various effects, including the import of refrigerants manufactured overseas into the U.S. market, court rulings, and allocation changes. As the HFC phasedown progresses, this price dynamic is expected to change, especially for high-GWP HFCs, which will likely become scarcer and/or more expensive over time. During EPA's public workshop in 2021, EPA heard anecdotical information that the price of HFC-134a has increased by as much as 77 percent.

7.3 Market Demand for Reclaimed Refrigerant

In general, EPA understands that reclaimers process recovered refrigerant that they can profitably sell back into the market. As reclaimed refrigerants are required to meet the same purity standards as their virgin counterparts, there is no difference between virgin and reclaimed refrigerants for sale in the market. Reclaimed refrigerants are able to meet the same functionality as virgin refrigerants when used in RACHP equipment. Technicians and other consumers have historically purchased refrigerant based on the lowest cost and/or availability and have not sought out reclaimed refrigerant specifically.

It is expected that the demand for reclaimed refrigerant will increase with the progression of the HFC phasedown. Virgin refrigerants that contain HFCs will decrease; however, many existing equipment will still need these refrigerants for servicing and/or repair to reach their useful life. Reclaimed refrigerants that contain HFCs will be critical for servicing these types of existing equipment that will continue to need refrigerants that contain HFCs. Thus, the demand for reclaimed refrigerants that contain HFCs will increase and likely provide more favorable market dynamics for reclamation.

7.4 Release Events over Useful Life and Disposal of Equipment

Although there are statutory and regulatory requirements under title VI of the CAA designed to restrict certain releases of refrigerants, refrigerant release continues to pose a challenge to greater refrigerant recovery as it results in less refrigerant that can be recovered from equipment. Refrigerant release for refrigeration and air conditioning equipment can occur at several points throughout the useful life of the equipment, including installation, servicing, operation, and end-of-life disposal. The types of release may vary by equipment type, operating environments, and site-specific situations. Leak rates in refrigeration systems may vary depending on a variety of factors, including the application of the equipment and the charge size of refrigerant in the equipment. For example in commercial refrigeration equipment, leak rates may vary between 15.624.2 percent (CARB, 2020).

7.4.1 End-of-Life Leakage

Refrigeration and air conditioning equipment eventually reach the end of their useful life through either gradual or catastrophic failure of key components. The full refrigerant charge could be released if the system is physically damaged or if the system is not properly disposed of at the end of its useful life. Self-contained systems can be transported to off-site recyclers that will then recover the remaining refrigerant before disposal of the appliance. Split-system and remote condensing products as well as

larger self-contained systems (*e.g.*, chillers) will generally have the refrigerant recovered on-site by technicians before equipment disposal. Regulations under CAA sections 608 and 609 require proper refrigerant recovery either on- or off-site. Feedback from industry is that refrigerant recovery at the end of life, while legally required, is not always practiced in the field, and that variance in actual practice could result in additional releases to the atmosphere at equipment end-of-life. Anecdotal feedback is that recovery is less common from residential and light commercial air conditioning equipment than from commercial refrigeration and larger air conditioning equipment.

7.5 Technician Outreach and Cost Penalty for Returning Refrigerant

Per EPA regulations under section 608 of the CAA at 40 CFR 82.156, with certain limited exceptions, before opening or disposing of an appliance technicians must ensure refrigerant is evacuated from air conditioning or refrigeration equipment to established vacuum levels. Similar requirements apply to persons opening or disposing of small appliances. These recovery requirements may cause technicians to spend time to achieve compliance. As technicians who recover refrigerant are often servicing many systems each day, the recovered refrigerant can be exposed to a range of contaminants on a daily basis. The refrigerant recovered from a given system may be contaminated or mixed with other refrigerants from previous servicing and maintenance by other technicians.

Although some technicians may use different recovery cylinders for different types of refrigerants, there is still the potential for cross-contamination from using the same cylinder to service different refrigerants or using the same hose to hook up to different cylinders. In EPA's interviews with reclaimers in 2018 and 2019, reclaimers noted that there are technology solutions on the horizon, including digital gauges and gauges built into systems, but it could take decades for these to become widely adopted. In conversations with smaller reclaiming operations, it was found that most reclaimers emphasized the importance of outreach to technicians as the fastest way to increase the amount of refrigerant reclaimed, reduce emissions, and reduce contamination (Stratus Consulting, 2010).

Technicians are often not made aware when RACHP equipment has been converted to a new refrigerant, which can lead to contamination. In interviews in 2018 and 2019, EPA learned that, if a contractor is consistently returning mixed gas for reclamation, the reclaimers test it each time and some may start charging costs for disposal, if needed. EPA understands that it may be difficult to pass these costs on to customers since one cylinder can come from multiple jobs and it is not always easy to locate the technician for additional information. If technicians return a contaminated cylinder to a wholesaler or reclaimer, they may be charged a penalty for destruction. In addition, as refrigerants transition, technicians may need to purchase new recovery machines or equipment. For example, recovery machines or equipment that are rated for A2L refrigerants that carry flammability risks may be needed.

7.6 Destruction of HFCs

Based on interviews in 2018 and 2019, EPA understands that reclaimers often contract out destruction of waste oils, contaminants, and impurities to a waste management

company. When determining whether the material can be reclaimed, reclaimers may look at the laboratory data to see what the make-up of the mixed gas is, the level of contamination, and what it would take to separate it to determine whether it is worth the energy and time to reclaim. When determining what can be reclaimed, the contamination or the number of gases are important but these are not the only considerations. Some gases are much harder to separate because of their boiling points, among other factors. Mixed gases that cannot be reclaimed may be sent for destruction.

According to some reclaimers, if highly mixed refrigerants are sent for destruction, the destruction facility may charge a fee and the reclaimer may pass that fee on to the wholesaler or technician. Fees vary based on the refrigerant blend. For example, a refrigerant such as R-410A requires a small fee for disposal, while highly mixed refrigerants with unique compositions typically require a much higher fee. For example, a blend with mixed HCFC-22 could have a buy back offered for which the customer would be paid for the portion of the blend that is HCFC-22 to offset some of the disposal cost of the other contents.

8. Bibliography

17 CCR section 95371-95379. 2021. California Code of Regulations, Title 17, Division 3, Chapter 1, Subchapter 10 Climate Change, Article 4, Subarticle 5. Prohibitions on Use of Certain Hydrofluorocarbons in Stationary Refrigeration, Stationary Air-Conditioning, and Other End-Uses. Available: https://ww2.arb.ca.gov/sites/default/files/barcu/regact/2020/hfc2020/frorevised.pdf. Accessed April 25, 2024.

A-Gas, Inc. 2023. "Re: Phasedown of Hydrofluorocarbons: Management of Certain Hydrofluorocarbons and Substitutes Under Subsection (h) of the American Innovation and Manufacturing Act of 2020; EPA–HQ–OAR–2022–0606." Available: https://www.regulations.gov/comment/EPA-HQ-OAR-2022-0606-0109. Accessed April 25, 2024.

A-Gas, Inc. 2021. "Public Comments to the Phasedown of Hydrofluorocarbons: Establishing the Allowance Allocation and Trading Program under the American Innovation and Manufacturing Act Proposed Rulemaking." Available: https://www.regulations.gov/comment/EPA-HQ-OAR-2021-0044-0154. Accessed April 25, 2024.

A-Gas, Inc. n.d. "Our Services." Available: https://www.agas.com/us/products-services/refrigerant-services/rapid-recovery/. Accessed April 25, 2024.

Air-Conditioning, Heating, and Refrigeration Institute (AHRI). 2019a. "AHRI Standard 700. 2019 Standard for Specifications for Refrigerants." Available: https://www.ahrinet.org/system/files/2023-06/AHRI_Standard_700_2019.pdf. April 25, 2024.

Air-Conditioning, Heating, & Refrigeration Institute (AHRI). 2019b. "AHRI Letter Responding to CARB's Request for Input and Clarifications Following the August 6, 2019, Public Meeting for Industrial Process Refrigeration and Transport Refrigeration Equipment."

American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE). 2019. "Standard 34-2019 – Designation and Safety Classification of Refrigerants." Available: https://www.techstreet.com/ashrae/standards/ashrae-15-2019-packaged-w-34-2 019?product_id=2046531. Accessed Apirl 25, 2024.

California Air Resources Board (CARB). 2020. "Public hearing to consider the proposed amendments to the prohibitions on use of certain hydrofluorocarbons in stationary refrigeration, chillers, aerosols-propellants, and foam end-uses regulation; Staff Report: Initial State of Reasons." Available: https://ww2.arb.ca.gov/sites/default/files/barcu/regact/2020/hfc2020/notice.pdf?_ga=2.175449314.1762832053.1714055882-2118068492.1708029924. Accessed April 25, 2024

CARB. 2021. "Final Statement of Reasons for Rulemaking, Including Summary of Comments and Agency Response." Available:

https://ww2.arb.ca.gov/sites/default/files/barcu/regact/2020/hfc2020/fsorrevised.pdf. Accessed April 25, 2024.

CARB. 2023. "Phasedown of Hydrofluorocarbons: Management of Certain Hydrofluorocarbons and Substitutes under Subsection (h) of the American Innovation and Manufacturing Act of 2020; Docket: EPA-HQ-OAR-2022-0606; FRL-10105-01-OAR." December 18, 2023. Docket Number: EPA-HQ-OAR-2022-0606-0139-A1.pdf. Available: https://www.regulations.gov/comment/EPA-HQ-OAR-2022-0606-0139. Accessed April 25, 2024.

Drumheller, B., A. Brown, and E. Bruns. 2021. "Report to the Legislature: The Hydrofluorocarbon Transition Background and Recommendations for Incentive-Based Policies and Programs." Washington Department of Ecology. Available: https://apps.ecology.wa.gov/publications/documents/2102004.pdf. Accessed April 24, 2024.

Environmental Investigation Administration (EIA). 2009. "Annual Energy Outlook. Annual Energy Outlook 2009 with Projections to 2030." March 2009. U.S. Department of Energy. DOE/EIA report DOE/EIA-0383(2009). Available: https://www.eia.gov/outlooks/archive/aeo09/pdf/0383(2009).pdf. Accessed April 24, 2024.

FluoroFusion Specialty Chemicals, Inc. and Kivlan and Company, Inc. 2021. "Public Comments to the Phasedown of Hydrofluorocarbons: Establishing the Allowance Allocation and Trading Program under the American Innovation and Manufacturing Act Proposed Rulemaking." Available: https://www.regulations.gov/comment/EPA-HQ-OAR-2021-0044-0106. Accessed April 25, 2024.

Golden Refrigerant. 2021. "Public Comments to the Phasedown of Hydrofluorocarbons: Establishing the Allowance Allocation and Trading Program under the American Innovation and Manufacturing Act Proposed Rulemaking." Available: https://www.regulations.gov/comment/EPA-HQ-OAR-2021-0044-0118. Accessed April 25, 2024.

Hudson Technologies Company. 2021. "Public Comments to the Phasedown of Hydrofluorocarbons: Establishing the Allowance Allocation and Trading Program under the American Innovation and Manufacturing Act Proposed Rulemaking." Available: https://www.regulations.gov/comment/EPA-HQ-OAR-2021-0044-0166. Accessed April 25, 2024.

Hudson Technologies Company. N.d. "Refrigerant Recovery and System Conversions." Available: https://www.hudsontech.com/on-site-refrigerant-services/refrigerant-recovery/. Accessed: April 25, 2024.

INFORUM, JMS Consulting, Alliance for Responsible Atmostpheric Policy, and AHRI. 2019. "Economic & Consumer Impacts of HFC Phasedown." December 12, 2019. Available:

https://www.congress.gov/116/meeting/house/110388/documents/HHRG-116-IF18-20200114-SD003.pdf. Accessed April 25, 2024.

International Panel on Climate Change (IPCC). 2007. "Climate Change 2007: The Physical Science Basis." Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change, S. Solomon, D. Qin, M. Manning, Z. Chen, M. Marquis, K.B. Averyt, M. Tignor, and H.L. Miller (Eds.). Cambridge University Press, Cambridge, UK and New York. September. Available: http://www.ipcc.ch/publications_and_data/ar4/wg1/en/contents.html. Accessed April 25, 2024.

Natural Resources Defense Council, Envrinmental Investigation Agency, and Institute for Governance and Sustainable Development, 2019. "The 90 Billion Ton Opportunity – Lifecycle Refrigerant Management (LRM)." Available: https://www.nrdc.org/sites/default/files/lrm-90-billion-ton-opportunity-report-20221020.pdf. Accessed April 25, 2024.

North American Sustainable Refrigeration Council. N.d. "HFC Policies & Refrigerant Regulations by State." Available: https://nasrc.org/hfc-policy. Accessed May 17, 2022.

New York Department of Environmental Conservation. 2023. Part 494 Express Terms Public 2023. Available: https://dec.ny.gov/sites/default/files/2023-12/part494expressterms2023public.pdf. Accessed April 25, 2024.

New York Department of Environmental Conservation. 2024. "Climate Change Regulatory Revisions." Available: https://dec.ny.gov/regulatory/regulations/proposed-emergency-recently-adopted-regulations/climate-change. Accessed April 25, 2024

Refrigerant Reclaim Australia (RRA). 2019. "Annual Report." Available: https://refrigerantreclaim.com.au/wp-content/uploads/2021/08/RRA-2019-20-Annual-Report.pdf. Accessed April 25, 2024.

Shiflett Research Group. N.d. "Project EARTH (Environmentally Applied Research Toward Hydrofluorocarbons)." Kansas University School of Engineering. Available: https://shiflettresearch.com/projects/#:~:text=Project%20EARTH%20(Environmentally%20Applied%20Research,refrigerant%20mixtures%20in%20use%20worldwide. Accessed April 25, 2024.

Stratus Consulting. 2010. "Analysis of Equipment and Practices in the Reclamation Industry, Draft Report." Available: https://www.epa.gov/sites/default/files/2015-08/documents/analysis_of_equipment_and_practices_in_the_reclamation_industry.pdf. Accessed April 25, 2024.

Turpin, J. 2020. "R-454B Emerges as a Replacement for R-410A, ACHR News." August 2020. Available: https://www.achrnews.com/articles/143548-r-454b-emerges-as-a-replacement-for-r-410a. Accessed April 25, 2024.

U.S. EPA. 2016a. “Protection of Stratospheric Ozone: Update to the Refrigerant Management Requirements under the Clean Air Act.” Final Rule. 81 Fed. Reg. 82,272 (Nov 18, 2016) (to be codified at 40 C.F.R. pt. 82). Avalable: https://www.regulations.gov/document/EPA-HQ-OAR-2015-0453-0125. Accessed April 25, 2024.

U.S. EPA. 2016b. “The EPA’s Updated Refrigerant Management Requirements.” Available: https://19january2017snapshot.epa.gov/sites/production/files/2016-09/documents/608_fact_sheet_reclaimers_0.pdf. Accessed April 25, 2024.

U.S. EPA. 2016c. “Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990–2014.” April 2016. EPA Report EPA-430-R-16-002. Available: https://www.epa.gov/ghgemissions/inventory-us-greenhouse-gas-emissions-and-sinks-1990-2014. Accessed April 25, 2024.

U.S. EPA. 2018. “ODS Destruction in the United States and Abroad.” Available: https://www.epa.gov/sites/default/files/2018-03/documents/ods-destruction-in-the-us-and-abroad_feb2018.pdf. Accessed April 25, 2024.

U.S. EPA. 2018b. “EPA’s Vintaging Model of ODS Substitutes.” September 2018. EPA Report EPA-400-F-18-001. Available: https://www.epa.gov/sites/default/files/2018-09/documents/epas-vintaging-model-of-ods-substitutes-peer-review-factsheet.pdf.

U.S. EPA. 2020. “Protection of Stratospheric Ozone: Adjustments to the Allowance System for Controlling HCFC Production and Import, 2020–2029; and Other Updates.” Final Rule. 85 Fed. Reg. 15,258 (Mar. 17, 2020) (to be codified at 40 C.F.R. pt. 82). Available: https://www.govinfo.gov/content/pkg/FR-2020-03-17/pdf/2019-28020.pdf. Accessed April 25, 2024.

U.S. EPA. 2021a. “ Overview of Supply Chains for Selected Hydrofluorocarbon (HFC) Product Types.” Available: https://www.regulations.gov/document/EPA-HQ-OAR-2021-0044-0227. Accessed April 25, 2024.

U.S. EPA. 2021b. “Summary of Antidumping and Countervailing Subsidy Duties Concerning Hydrofluorocarbon (HFC) Imports to the United States.” Available: https://www.regulations.gov/document/EPA-HQ-OAR-2021-0044-0046. Accessed April 25, 2024.

U.S. EPA. 2022. “GreenChill Partner Spotlight: Hannaford, February 2022.” Available: https://www.epa.gov/system/files/documents/2022-02/greenchill-partner-spotlight-hannaford-feb-2022.pdf. Accessed April 25, 2024.

U.S. EPA. 2023a. “Phasedown of Hydrofluorocarbons : Management of Certain Regulated Substances under Subsection (h) of the American Innovation and Manufacturing Act of 2020.” Available : https://www.regulations.gov/document/EPA-HQ-OAR-2022-0606-0014. Accessed April 25, 2024.

U.S. EPA. 2023b. "EPA's Vintaging Model of ODS Substitutes." October 24, 2023. Available: https://www.epa.gov/ozone-layer-protection/epas-vintaging-model-ods-substitutes. Accessed April 25, 2024.

U.S. EPA. 2023c. "The 2023 EPA Automotive Trends Report." pg. 96-97. Available: https://www.epa.gov/system/files/documents/2023-12/420r23033.pdf. Accessed April 25, 2024.

U.S. EPA. 2024. "HFC Data Hub." June 12, 2024. Available: https://www.epa.gov/climate-hfcs-reduction/hfc-data-hub. Accessed July 24, 2024.

Washington Department of Ecology. 2022. "Hydrofluorocarbon Transition." Available: https://ecology.wa.gov/Air-Climate/Climate-change/Reducing-greenhouse-gases/Hydrofluorocarbons. Accessed April 25, 2024.

Washington Department of Ecology. 2023a. "Hydrofluorocarbons (HFCs) and Other Fluorinated Greenhouse Gases." Available: https://ecology.wa.gov/getattachment/47b1efc8-486e-44fa-bbac-27caf42053f8/OTS-4615-4-For-Filing.pdf. Accessed April 25, 2024.

Washington Department of Ecology. 2023b. "Concise Explanatory Statement Chapter 173-443 WAC, Hydrofluorocarbons (HFCs) and Other Fluorinated Greenhouse Gases and Chapter 173-455, WAC Air Quality Fee Rule." November 2023. Available: https://apps.ecology.wa.gov/publications/documents/2302109.pdf. Accessed April 25, 2024.

Washington Department of Ecology. 2024. Chapters 173-443 and 173-455 WAC – Hydrofluorocarbons (HFCs). Available: https://ecology.wa.gov/regulations-permits/laws-rules-rulemaking/closed-rulemaking/wac-173-443-455. Accessed April 25, 2024.

Washington State Legislature. 2024a. "HB 2401 - 2023-24." Available: https://apps.leg.wa.gov/billsummary/?BillNumber=2401&Year=2024&Initiative=false#documentSection. Accessed April 25, 2024.

Washington State Legislature. 2024b. "HOUSE BILL 2401." Available: https://lawfilesext.leg.wa.gov/biennium/2023-24/Pdf/Bills/House%20Bills/2401.pdf?q=20240328060412. Accessed April 25, 2024.

Appendix A: Subsection (h) of the AIM Act

42 U.S.C. 7675: American innovation and manufacturing

(h) Management of regulated substances

(1) In general

For purposes of maximizing reclaiming and minimizing the release of a regulated substance from equipment and ensuring the safety of technicians and consumers, the Administrator shall promulgate regulations to control, where appropriate, any practice, process, or activity regarding the servicing, repair, disposal, or installation of equipment (including requiring, where appropriate, that any such servicing, repair, disposal, or installation be performed by a trained technician meeting minimum standards, as determined by the Administrator) that involves-

(A) a regulated substance;

(B) a substitute for a regulated substance;

(C) the reclaiming of a regulated substance used as a refrigerant; or

(D) the reclaiming of a substitute for a regulated substance used as a refrigerant.

(2) Reclaiming

(A) In general

In carrying out this section, the Administrator shall consider the use of authority available to the Administrator under this section to increase opportunities for the reclaiming of regulated substances used as refrigerants.

(B) Recovery

A regulated substance used as a refrigerant that is recovered shall be reclaimed before the regulated substance is sold or transferred to a new owner, except where the recovered regulated substance is sold or transferred to a new owner solely for the purposes of being reclaimed or destroyed.

(3) Coordination

In promulgating regulations to carry out this subsection, the Administrator may coordinate those regulations with any other regulations promulgated by the Administrator that involve-

(A) the same or a similar practice, process, or activity regarding the servicing, repair, disposal, or installation of equipment; or

(B) reclaiming.

(4) Inapplicability

No regulation promulgated pursuant to this subsection shall apply to a regulated substance or a substitute for a regulated substance that is contained in a foam.

(5) Small business grants

(A) Definition of small business concern

In this paragraph, the term "small business concern" has the same meaning as in section 632 of title 15.

(B) Establishment

Subject to the availability of appropriations, the Administrator shall establish a grant program to award grants to small business concerns for the purchase of new specialized equipment for the recycling, recovery, or reclamation of a substitute for a regulated substance, including the purchase of approved refrigerant recycling equipment (as defined in section 609(b) of the Clean Air Act (42 U.S.C. 7671h(b))) for recycling, recovery, or reclamation in the service or repair of motor vehicle air conditioning systems.

(C) Matching funds

The non-Federal share of a project carried out with a grant under this paragraph shall be not less than 25 percent.

(D) Authorization of appropriations

There is authorized to be appropriated to carry out this paragraph $5,000,000 for each of fiscal years 2021 through 2023.