Federal Policy to Manage Refrigerant Banks

Prepared for the Natural Resources Defense Council

By the HFC Management Workshop Team of the MPA in Environmental Science and Policy of Columbia University

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Preface

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Acronyms

AIM	American Innovation and Manufacturing Act
CARB	California Air Resources Board
CFC	Chlorofluorocarbon
CO_2	Carbon Dioxide
CO_2e	Carbon Dioxide Equivalent
EPA	Environmental Protection Agency
EU	European Union
GHG	Greenhouse Gas
GWP	Global Warming Potential
HCFC	Hydrochlorofluorocarbon
HFC	Hydrofluorocarbon
HFO	Hydrofluoroolefin
HVACR	Heating, Ventilation, Air Conditioning, and Refrigeration
ODS	Ozone-Depleting Substances
US	United States

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Executive Summary

Hydrofluorocarbons (HFCs) are a class of synthetic fluorinated gases that are most commonly used as refrigerants. They came into widespread use worldwide following the agreement to phase out ozone-depleting refrigerants, chlorofluorocarbons (CFCs), under the Montreal Protocol. HFCs do not deplete ozone, but they are potent greenhouse gases, with hundreds to thousands of times the global warming potential (GWP) of carbon dioxide. If left unchecked, HFC emissions could contribute up to 0.5°C of additional global warming by 2100.[1]

HFCs are released into the atmosphere at many points during their life cycle. They leak out of equipment at installation, during servicing, and over the course of regular use. At the end of their life cycle, HFCs are often improperly disposed of and vented into the atmosphere. Regulation on appropriate management is vital to avoid the climate impact of existing HFCs. Effective management will also reduce reliance on virgin HFCs. In turn, it will help accelerate the phasedown of their production and consumption.

The recent passage of the American Innovation and Manufacturing (AIM) Act gives the Environmental Protection Agency (EPA) explicit authorization to promulgate regulations to control HFCs during installation, servicing, repair, and disposal. These regulations will need to address the practices undertaken by several entities, including HFC producers, equipment manufacturers, equipment operators, service technicians, and entities responsible for end-of-life waste disposal. Regulators should consider all of these stakeholders as well as their interactions. Importantly, a large portion of the US heating, ventilation, air conditioning, and refrigeration (HVACR) industry supported the AIM Act and is expected to be amenable to bank management regulations.

Regulators should seek to promote consistency and transparency whenever possible. This means developing an up-to-date, centralized repository with information on the quantities, types, and transaction histories of HFCs. Regulators should also consider creating labeling standards that record HFC quantities in a common unit of carbon dioxide equivalent (CO_2e).

Supporting the burgeoning reclamation industry is another important action to manage HFC emissions. Increasing the use of reclaimed HFCs will reduce the demand for virgin HFCs, thus creating an opportunity for an accelerated phasedown schedule. Therefore, regulators should require operators to use only reclaimed HFCs to service equipment. Efforts should be made to ensure that the price of reclaimed HFCs achieves parity with that of virgin HFCs: not only to speed the phasedown process, but also to ensure that

1 Y. Xu, "The Role of HFCs in Mitigating 21st Century Climate Change," *Atmospheric Chemistry and Physics*, 13, no. 12 (2013): 6083–89, https://doi.org/10.5194/acp-13-6083-2013.

the regulatory process does not result in price spikes that may disproportionately harm small businesses that are less capable of absorbing large price changes.

Operators should bear responsibility for emissions while equipment is under their management. Leak checks and lowered detection thresholds, along with financial incentives, would greatly reduce unintentional leakage. Federal policy should also reflect the critical role of service technicians in HFC management and implement training requirements that encourage climate-friendly practices in the workforce.

The recommendations in this report seek to advise on the appropriate management of HFCs in commercial HVACR equipment. While some recommendations are applicable to all uses of HFCs, additional analysis would be necessary to address important sources of emissions such as mobile and residential air conditioning. Some sources of HFC emissions, such as foam, are intentionally omitted for lack of a mandate from Congress.

This report examines best HFC regulatory practices from jurisdictions around the world and incorporates EPA's regulatory history and legislative authority to provide effective recommendations. Deploying these recommendations in tandem would accelerate the creation of a comprehensive, nationwide management framework for HFCs. These policies are not without their challenges. Potential barriers include the lack of reclamation infrastructure, stockpiling of virgin refrigerants, and transition costs. However, regulatory successes in the European Union (EU), Japan, Australia, and California, among others, provide guidance. It is well within EPA's capabilities and legislative mandate to promulgate rules that effectively manage the refrigerant bank and accelerate the phasedown of these potent greenhouse gases.

Recommendations for EPA in Brief

Facilitate Life Cycle Management

1. EPA should develop a **central registry and comprehensive tracking system** to improve the implementation of all other HFC regulations found below.

2. EPA should **use carbon dioxide equivalent** as the measurement for all refrigerant management regulations.

Transfer Responsibility to Producers and Manufacturers

3. EPA should implement an **extended producer responsibility** scheme that would make HFC producers ultimately responsible for proper reclamation or destruction and incentivize reductions in leakage and venting at all stages of life cycle management through fees or regulatory requirements.

4. EPA should **standardize labeling requirements** on produced HFCs as well as on HFC-containing equipment. Labeling should include tonnage in terms of CO_2e.

5. EPA should **ban the use of disposable cylinders** for transport to reduce leakage and improve tracking. If transport cylinders are not banned, EPA should **ensure that residual refrigerant is properly recovered**.

6. EPA should require **automatic HFC leak detection systems** to be installed on all new HFC-containing commercial equipment.

Make Equipment Operators Responsible

7. EPA should require that **only reclaimed or recycled chemicals are used** to recharge existing equipment.

8. To encourage a transition to more efficient HFC-containing equipment, policymakers should **establish a trade-in program** under which operators could trade in leak-prone or high-GWP equipment to receive rebates for the purchase of more efficient replacements.

9. EPA should **require frequent leak inspections** (e.g. every one to eight months) to reduce inadvertent emissions.

10 Along with mandatory leak detection systems, EPA should **require a leak detection threshold** for automatic leak detectors to be set at a level that can reliably detect leaks that occur away from the monitor. This should be at most 25 ppm and, ideally, 5 ppm.

11 EPA should continue to **support and expand voluntary compliance programs**, such as GreenChill, because they can be used to further push the bounds of climate-friendly refrigeration and heat pump dissemination as well as expand technical skills in the field.

Address Service Technicians' Role in the Phasedown

12 EPA should expand upon and provide additional access to job **training and certification programs** that will require all technicians to be trained in leak minimization and climate-friendly refrigerants.

Study and Create Incentives for Proper Destruction When Needed

13 Once the phasedown process has progressed to the point where HFCs can be phased out of the refrigerant bank without encouraging unproductive destruction, EPA should **design a tax incentive or other monetary rebate** for the proper and verified destruction of HFCs, potentially similar to the route found in the 45Q tax credit.

Introduction

Hydrofluorocarbons (HFCs) are a class of man-made fluorinated gases made up of hydrogen, fluorine, and carbon. While HFCs have diverse applications, they are primarily used in heating, ventilation, air conditioning, and refrigeration (HVACR) systems. Fluorinated gas regulation began with the ratification of the Montreal Protocol in 1988, which called for phasing out ozone-depleting chlorofluorocarbons (CFCs). HFCs are a non-ozone depleting refrigerant successor. However, HFCs themselves are potent greenhouse gases (GHGs) with high global warming potentials (GWP).[2] Carbon dioxide (CO_2) has a GWP of 1, whereas the most abundant HFC has a GWP of 3,790.[3] This means that a given mass of this particular HFC can contribute up to 3,790 times more to global warming over a set period than would that same mass of CO_2.

There are two main ways to mitigate HFC emissions: refrigerant bank management and a phasedown of consumption and production. This report focuses on refrigerant bank management, which targets emissions throughout the life cycle of HFCs by preventing leakage and ensuring proper disposal. Since there is a large quantity of HFCs stored in equipment around the United States (US) today, responsible refrigerant bank management can lead to significant emissions reductions. Of concern are not only HFCs stored in existing equipment; some of the chemicals that preceded HFCs are still in use – mostly hydrochlorofluorocarbons (HCFCs) and small amounts of CFCs. These chemicals deplete the ozone layer in addition to being powerful GHGs.[4] Measures to ensure HFCs, HCFCs, and CFCs are not released into the atmosphere are important for mitigating climate change and additional damage to the recovering ozone layer. Refrigerant bank management can complement the phasedown of HFCs, which is the gradual reduction of their production and use.

Eliminating leakage is key to stopping emissions. The average supermarket leaks 25% of its refrigerant charge each year, which, depending on the refrigerant used, can be equivalent to the yearly emissions from four hundred cars.[5] With proper management to reduce leaks, it is possible to significantly reduce these emissions. However, if HFC

2 Office of Environmental Quality, The Montreal Protocol on Substances That Deplete the Ozone Layer, (United States Department of State, n.d.), https://www.state.gov/key-topics-office-of-environmental-quality-and-transboundary-issues/the-montreal-protocol-on-substances-that-deplete-the-ozone-layer/.

3 Climate and Clean Air Coalition, "Hydrofluorocarbons," accessed February 2, 2021, https://www.ccacoalition.org/fr/slcps/hydrofluorocarbons-hfc.

4 A. Larkin and K. Davies, "HFCs and other F-gases: The Worst Greenhouse Gases You've Never Heard Of." GreenPeace, accessed April 1, 2021, https://www.greenpeace.org/usa/wp-content/uploads/legacy/Global/usa/binaries/2009/4/hfc-fact-sheet.pdf.

5 Environmental Investigation Agency, *Search Reuse and Destroy: How States Can Take the Lead on a 100 Billion Ton Climate Problem*. (Environmental Investigation Agency, n.d.), https://content.eia-global.org/posts/documents/000/000/829/original/EIAReport_100billiontonclimateopportunity.pdf?1550165022.

emissions go unchecked, they will add an additional 0.5°C of warming by 2100.[6] Without proper refrigerant bank management and an accelerated phasedown, HFCs will represent a significant barrier to meeting the Paris Agreement's goal of limiting global warming to 1.5°C above pre-industrial levels.[7]

Successfully managing the refrigerant bank while the phasedown of these chemicals progresses is a top priority. The reasons are the following: 1) climate benefit of abated emissions of HFCs, HCFCs, and CFCs; 2) reduced damage to the ozone layer due to abated emissions of the ozone-depleting chemicals (HCFCs and CFCs); 3) reduced reliance on virgin HFCs through the use of reclamation; 4) potential for phasedown acceleration. With effective refrigerant bank management, the amount of HFCs that are recycled or reclaimed can be increased, which can reduce the demand for new HFCs. Recycling and reclamation of HFCs are important considerations for achieving climate change mitigation goals.

About This Report

For this report, we conducted a policy survey of existing HFC regulations in the US, Australia, Japan, and the European Union (EU). These regions were selected because they are markets with established regulatory frameworks and can act as blueprints for policies to be applied elsewhere. Assessing these frameworks can help US regulators develop successful refrigerant management policies. They can also be useful in developing countries that will need to establish their own refrigerant management programs, as they are the most rapidly growing refrigerant markets.

Since many HFC-related regulations are quite recent, and thus lacking in robust datasets, our research also examined the targets, structures, economic incentives, and industry responses for each region. We consulted primary sources, third-party analyses, and interviews with experts from policy NGOs, trade associations, and environmental management firms. The findings were then consolidated to determine which policy recommendations had the most utility and applicability in the context of the US refrigerant bank.

In December 2020, Congress passed the American Innovation and Manufacturing (AIM) Act, which requires an 85% phasedown of HFC consumption and production by 2036.[8] This legislation gives the US Environmental Projection Agency (EPA) explicit authority to promulgate regulations to properly manage the refrigerant bank. This report offers

6 Xu, "The Role of HFCs in Mitigating 21st Century Climate Change," 6083–89.

7 Natural Resources Defense Council, "U.S. States Take the Lead in HFC Phasedown," https://www.nrdc.org/sites/default/files/media-uploads/fact_sheet_on_state_hfc_action_0.pdf.

8 United States Government Publishing Office, *American Innovation and Manufacturing Act of 2019*, (116th Congress, 2019-2020), https://www.congress.gov/bill/116th-congress/senate-bill/2754.

recommendations specifically to manage HFCs from commercial refrigeration and air conditioning. Additional research and policy analysis will be needed to manage other sources of HFC emissions, such as mobile and residential refrigeration units.

Overview of Bank Management Needs

Emissions from refrigerant banks occur during use, maintenance, and transport, at end-of-life, and from bulk inventories and stockpiles. During use, maintenance, and transport, refrigerant leaks tend to be unintentional, caused by leaky equipment or lack of adherence to best practices. At end-of-life, refrigerants are often vented into the atmosphere, even though the practice is already illegal.[9] To avoid this harmful practice, refrigerants can be reused through recycling and reclamation. When too contaminated or when no longer marketable, HFCs can be destroyed so they are no longer greenhouse gases.

Use and Maintenance

Refrigeration units function by facilitating the diffusion of heat through the expansion and contraction of gases, such as HFCs. Due to the dynamic connection of various components of HVACR equipment, elements such as valves, pipes, and gaskets are susceptible to leakage without proper maintenance. Leakage rates vary from system to system but generally range between 11-30%.[10] Leaked HFCs contribute directly to climate change when they are released into the atmosphere. HFC leakage due to wear and tear of equipment cannot be completely eliminated, but it can be minimized through use of regulation and proper detection processes.

In addition to the direct contribution of HFCs to climate change, leakage of fluorinated gases can also contribute indirectly, as it can cause decreases in energy efficiency. Leaky valves, pipes, and gaskets necessitate additional energy consumption, which can result in significant lifetime GHG emissions. Depending on how quickly the system develops leaks and to what extent, this can create undue financial burdens for cooling system operators.[11] It is therefore essential to limit and prevent leakage. Fundamental changes in leak-tight design are required when equipment is first put into use. Mandatory

9 United States Environmental Protection Agency, *Stationary Refrigeration - Prohibition on Venting Refrigerants, Other Policies and Guidance*, (United States Environmental Protection Agency, 2015), https://www.epa.gov/sites/production/files/2018-09/documents/section_608_of_the_clean_air_act.pdf.

10 C. Francis, G. Maidment and G. Davies, "An Investigation of Refrigerant Leakage in Commercial Refrigeration," *International Journal of Refrigeration*, February 1, 2017, 74: 2, https://doi.org/10.1016/j.ijrefrig.2016.10.009.

11 Francis, Maidment and Davies, "An Investigation of Refrigerant Leakage in Commercial Refrigeration," 2.

leakage detection systems and scheduled inspections can address this problem and simultaneously improve energy efficiency.

Proper End-of-Life Disposal

Proper end-of-life management of HFCs is critical to the industry-wide phasedown of HFC use. When managing used HFCs, the three options to avoid venting are recycling, reclamation, and destruction. Recycling occurs when recovered HFCs are cleaned and returned to their original equipment to be reused.[12] Reclamation involves reprocessing recovered HFCs in order to restore them to a high purity standard so that they are comparable in performance to virgin refrigerants.[13] Destruction involves transforming or decomposing HFCs into more stable substances so that they are no longer considered fluorinated GHGs.[14]

Reusing HFCs is critical to reduce demand for virgin HFCs, which is why it is recommended that consumers send their used refrigerant to a reclamation facility or, if that is not feasible, recycle them. While it is illegal to trade recycled refrigerants, recycled refrigerants can be reinstalled in the same system or in other systems owned by the same entity.[15] When recycling refrigerants, the equipment used in recycling must meet EPA standards and be certified by an EPA-approved testing organization.[16]

According to EPA, the preferred method of processing used HFCs is reclamation, which involves transporting refrigerants to an offsite reclamation facility to be purified and sold for reuse.[17] HFCs have almost unlimited reclamation potential as they do not degrade when reclaimed.[18] Using reclaimed HFCs will expedite the phasedown of HFC production required in the AIM Act by reducing the demand for virgin refrigerants. The cost for reclamation can vary based on the market value of HFCs, the level of contamination, and the distance to reclamation facilities.[19] The resale of used

12 Environmental Investigation Agency, *National Producer Responsibility Schemes Under the EU F-Gas Regulation*, (Environmental Investigation Agency, 2019), https://eia-international.org/wp-content/uploads/EIA-Briefing-Note-National-Producer-Responsibility-Schemes-FINAL.pdf.

13 Environmental Investigation Agency, *National Producer Responsibility*, 1.

14 Environmental Investigation Agency, *National Producer Responsibility*, 2.

15 United States Environmental Protection Agency, *Stationary Refrigeration Refrigerant Reclamation Requirements*, (United States Environmental Protection Agency, 2015), https://www.epa.gov/section608/stationary-refrigeration-refrigerant-reclamation-requirements.

16 United State Environmental Protection Agency, "Refrigerant Recovery and Recycling Equipment Certification," (United State Environmental Protection Agency, 2015), https://www.epa.gov/section608/refrigerant-recovery-and-recycling-equipment-certification.

17 Environmental Investigation Agency, *National Producer Responsibility Schemes Under the EU F-Gas Regulation*.

18 Helen Walter-Terrinoni, Interview with Policy Expert from the Air Conditioning, Heating, and Refrigeration Institute (AHRI). February 16, 2021.

19 Environmental Investigation Agency, *National Producer Responsibility*, 1.

refrigerants is prohibited unless those refrigerants have been reclaimed by an EPA-certified refrigerant reclaimer.[20]

Destruction should not be considered a priority because it increases the demand for virgin HFCs. This position can be reconsidered when the HFC phasedown has progressed to a point at which widespread reclamation is no longer needed. Ozone-depleting substance (ODS) destruction facilities are commonly used to destroy HFCs. The cost of destroying HFCs is similar to that of ODSs because they use the same incineration and plasma arc destruction technologies.[21]

Industry Overview

The HFC industry can be segmented into 1) the producers of HFC chemicals and equipment and 2) their commercial customers. End-users comprise all facets of the US economy – residential, domestic, industrial, and commercial. In 2016, the HVACR industry employed 2.5 million Americans and contributed $621 billion to the US economy.[22] The installation, distribution, and maintenance sub-sectors of the industry had nearly three times the economic output of the manufacturing sub-sector.[23] The global HVACR industry is expected to grow at least 200% in the next ten years.[24] US HFC manufacturers are well-positioned to fulfill the growth in demand for HFC alternatives and lower-GWP HFCs. The industry also has an opportunity to grow the domestic installation, distribution, and maintenance sub-sectors by investing in recovery and reclamation infrastructure.

The US HVACR industry overwhelmingly supports the AIM Act and the HFC transition, with some caveats.[25] US producers welcome the transition as they stand to gain from selling alternatives to high-GWP HFCs and their associated equipment. Industry

20 United States Environmental Protection Agency, *Questions and Answers about the Refrigerant Sales Restriction*, (United States Environmental Protection Agency, 2021), https://www.epa.gov/section608/questions-and-answers-about-refrigerant-sales-restriction.

21 United States Environmental Protection Agency, *ODS Destruction in the United States and Abroad*, ICF. EPA 430-R-18-001, Washington, D.C.: Environmental Protection Agency, 2018, https://www.epa.gov/sites/production/files/2018-03/documents/ods-destruction-in-the-us-and-abroad_feb2018.pdf.

22 INFORUM, JMS Consulting, Alliance for Responsible Atmospheric Policy, AHRI, "Economic & Consumer Impacts of HFC Phasedown," https://www.congress.gov/116/meeting/house/110388/documents/HHRG-116-IF18-20200114-SD003.pdf.

23 INFORUM, JMS Consulting, Alliance for Responsible Atmospheric Policy, AHRI, "Economic & Consumer Impacts of HFC Phasedown."

24 INFORUM, JMS Consulting, Alliance for Responsible Atmospheric Policy, AHRI, "Economic & Consumer Impacts of HFC Phasedown."

25 B. Lieberman, "Businesses Critical of Costly Climate Bill Finally Get to Weigh In," Competitive Enterprise Institute, accessed April 1, 2021, https://cei.org/blog/businesses-critical-of-costly-climate-bill-finally-get-to-weigh-in/.

customers who rely on such materials have been relatively more opposed, likely due to the potential for higher supply and transition costs as well as safety concerns.[26]

Recommendations for EPA

A slate of new regulations are required to address the life cycle emissions of HFCs and support a rapid transition to more climate-friendly refrigerants. The regulatory recommendations in this report incorporate the roles played by diverse actors in HFC management. These recommendations assign primary responsibility to producers but also acknowledge the key roles of equipment manufacturers, operators, servicers, and waste disposers. We recommend that EPA:

- act as a facilitator, creating a registry and tracking system that will enable other regulations,
- assign key responsibility to HFC producers, primarily through an extended producer responsibility scheme,
- require equipment manufacturers to take measures to reduce leakage,
- require operators to service their equipment with reclaimed HFCs, increasing the demand for reclamation, and also take on responsibility for preventing leakage,
- ensure that service technicians are well-trained to reduce leakage and facilitate best practices,
- and incentivizes destruction when needed.

Recommendations for needed improvements are organized by regulated entities. Complementary recommendations are discussed alongside these primary recommendations.

Facilitate Life Cycle Management

EPA has a crucial role to play, not only in enacting regulations for producers and operators but also by itself facilitating compliance with and enforcement of those regulations. Two key recommendations are:

26 T. Keating, "Letter to Senate Committee on Environment and Public Works," accessed April 1, 2021, https://www.epw.senate.gov/public/_cache/files/d/1/d152a591-878f-4a4d-b9c1-dc7121c06e-ca/9D366FF1E61F7EFFD6A71C37C92924A5.04.03.2020-boeing.pdf.

RECOMMENDATION 1:

EPA should develop a **central registry and comprehensive tracking system** to improve the implementation of all other HFC regulations found below.

Current Status

EPA regulations under Section 608 of the Clean Air Act require refrigerant recordkeeping and reporting requirements for technicians, owners and operators, reclaimers, and retailers and wholesalers. However, many requirements apply only to ODSs, and records are only required to be submitted to EPA in certain instances.[27] A robust registry and comprehensive tracking system would allow EPA to more successfully enforce related regulations and provide additional benefits. This system should track the movements and transactions of HFCs needed for manufacturing, service inputs, and leakage quantities during operation.

Policy Tools

While relatively straightforward in principle, a registry and tracking system may prove to be one of the most complex policy tools to successfully implement. That said, it could provide significant benefits in facilitating other HFC regulations. Two different options which may be considered for an HFC tracking system are a wholesale approach in which only the initial HFC content of each piece of equipment is recorded, or a more stringent tracking by which HFC producers, importers, and operators would all be required to register HFC-containing equipment and record transactions in which HFC ownership and responsibility is transferred. The latter approach would require analysis of expected or realized leakage from the equipment as well as the cooperation of equipment servicers when replacing HFCs but would provide a more accurate assessment of the amount of each chemical in circulation and its emissions potential. This approach has been used in Japan as part of comprehensive guidelines to monitor leakage.[28]

The most successful countries have implemented systems that are capable of tracking HFC production, use, and leakage at every step of the product's life cycle. A robust HFC registry would provide vital information to operators, who might not be aware of the added costs of HFC loss and equipment inefficiency as well as federal regulators. This information would obviously be a boon for EPA, which could use it to devise additional strategies and promulgate new rules to lower the rate of leakage. Such public information would also be useful for corporate Securities and Exchange Commission

27 United States Environmental Protection Agency, *Recordkeeping and Reporting Requirements for Stationary Refrigeration*, (United States Environmental Protection Agency, 2015), https://www.epa.gov/section608/recordkeeping-and-reporting-requirements-stationary-refrigeration.

28 Japanese Law Translation, *Act on Rational Use and Appropriate Management of Fluorocarbons*, (Japanese Law Translation, n.d.), http://www.japaneselawtranslation.go.jp/law/detail/?vm=04&id=3236&re=02.

filings as they relate to climate change disclosures. Providing additional data about HFCs in carbon disclosure reports would allow investors and regulators to compare firms to one another and subsequently reward good management with heightened investment.

EPA should implement tracking requirements similar to recently-rescinded regulations from Section 608 of the Clear Air Act. These rules formerly required periodic leak inspections, verification tests for repairs, and reporting and record keeping requirements.[29] A new rulemaking should require consumers whose use of HFCs exceeds a threshold determined by EPA to produce a report detailing their HFC disposal plan. This reporting would include 1) quantity of HFC purchased and disposed, 2) method of disposal (i.e. reclamation, recycling, or destruction), 3) partnership with an EPA-approved refrigerant recovery program, and 4) record of the collection of HFCs by the refrigerant recovery program. This would give EPA vital information about the consumption and disposal patterns of HFCs.

International Examples

Record keeping and reporting requirements are central tenets of the EU and Japan requirements for HFCs. In Europe, the record keeping burden falls mainly on operators of commercial refrigeration equipment, who must keep records of the quantity and type of fluorinated gases in their systems, quantities added during installation, maintenance or servicing, whether such quantities are recycled or reclaimed, the quantity recovered, dates and results of leak checks, and the identity of technicians performing these functions. HFC suppliers must also keep records on their purchases and quantities of gas purchased. Both groups are required to furnish records to the member state concerned or the European Commission upon request.[30]

In Japan, record keeping requirements are stringent. Equipment operators are required to report the amount of leaked HFCs to the government each year.[31] Likewise, each filling and recovery technician, recycling operator, and waste disposer must prepare records on the HFCs taken in at that step and passed on to the next step and report those records annually.[32] The life cycle reporting in Japan allows the government to clearly track the movement of HFCs within the system. While some of the stricter guidelines of the Japanese system might provoke opposition in the US, the policy serves as a helpful model from which EPA could draw.

29 M. Garry, "U.S. EPA Rescinds Obama-Era Leak-Repair Rules for HFCs," accessed April 1, 2021, http://www.r744.com/articles/9405/u_s_epa_rescinds_obama_era_leak_repair_rules_for_hfcs.

30 Official Journal of the European Union, *Regulation (EU) No 517/2014 of the European Parliament and of the Council of 16 April 2014 on Fluorinated Greenhouse Gases and Repealing Regulation (EC) No 842/2006*, (2014), 9–10, https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32014R0517&from=EN.

31 Japanese Law Translation, *Act on Rational Use and Appropriate Management of Fluorocarbons*, 10.

32 Japanese Law Translation, *Act on Rational Use and Appropriate Management of Fluorocarbons*, 27, 35, 40.

RECOMMENDATION 2:

EPA should **use carbon dioxide equivalent** (CO_2e) as the measurement for all refrigerant management regulations.

In the European Commission's 2014 regulation, requirements were modified to classify systems for leak checking and detection systems by CO_2e GWP.[33] Previously, European regulations classified equipment by mass of HFCs in the system.[34] Other provisions of the regulation, including quota allocation, are also calculated in CO_2e.[35] Using CO_2e allows progress towards climate goals to be measured easily. It also incentivizes managers to phase out high-GWP HFCs more quickly to avoid stricter regulatory requirements.

The AIM Act specifies exchange values (equivalent to CO_2e GWP) for use in the production and consumption baselines and phasedown. Using these same values for all bank management requirements will provide consistency, certainty, and incentive for transition.

Transfer Responsibility to Producers and Manufacturers

Much improvement of HFC management should begin at the source: HFC producers. When regulating producers, EPA has the opportunity to tap into their technical expertise and ensure that appropriate management covers the entire life cycle of HFCs.

RECOMMENDATION 3:

EPA should implement an **extended producer responsibility** scheme that would make HFC producers ultimately responsible for proper reclamation or destruction and incentivize reductions in leakage and venting at all stages of life cycle management through fees or regulatory requirements.

Current Status

Venting HFCs as a method of disposal is illegal under Section 608 of the Clean Air Act.[36]

33 Official Journal of the European Union, *Regulation (EU) No 517/2014 of the European Parliament and of the Council of 16 April 2014 on Fluorinated Greenhouse Gases and Repealing Regulation (EC) No 842/2006*, 8, https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32014R0517&rid.

34 Official Journal of the European Union, *Regulation (EU) No 842/2006 of the European Parliament and of the Council of 17 May 20006 on Certain FLuorinated Greenhouse Gases (EC) No 842/2014*,4, https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32006R0842&from=EN.

35 Official Journal of the European Union, *Regulation (EU) No 517/2014 of the European Parliament and of the Council of 16 April 2014 on Fluorinated Greenhouse Gases and Repealing Regulation (EC) No 842/2014*, 31.

36 United States Environmental Protection Agency, *Stationary Refrigeration - Prohibition on Venting Refrigerants*, (United States Environmental Protection Agency, n.d.), https://www.epa.gov/section608/stationary-refrigeration-prohibition-venting-refrigerants.

Despite this regulation, venting is still a common practice. While there are penalties and fines for venting, the general perception in the industry is that operators will not be caught and penalties will not be enforced.[37] A new approach to venting prevention is needed. An extended producer responsibility scheme would shift recovery obligations to the producer, reducing venting by operators and technicians.

Policy Tools

Deposit-refund mechanisms or take-back requirements place the financial burden of recovery and reclamation or destruction on producers of virgin HFCs or on corporations initially charging equipment with these HFCs. These actors would pay a fee based on the HFCs they produce or sell, which they would recoup by recovering the gases at end-of-life and providing proof that they have been reclaimed or destroyed. Such extended producer responsibility schemes would function best when complemented by a robust registry and tracking system. An inherent advantage of this approach is that it can preempt the need for new actors establishing a collection network; instead, refrigerants can follow the distribution network directly back to their place of origin for reuse or destruction.[38] However, it must be noted that depending on the fee structure, implementation may require legislative support, as without an effective collection program they would effectively represent a tax that may be passed along to equipment operators. Depending on the change in revenue, such an initiative may potentially qualify for the budget reconciliation process and should thus be considered in advance of the next budget period.

International Examples

Successful recovery programs typically involve incentives that make reclamation and/or proper destruction more attractive than venting at the end-of-life for equipment. These incentives take a variety of forms. Examples suggest that extended producer responsibility may be the best option for the US.

The EU regulation encourages member states to set up extended producer responsibility schemes.[39] In France, distributors of HFCs are required to collect, store, and deliver used HFCs to reclamation and destruction facilities, at no cost to equipment operators or technicians. Distributors may levy a fee upfront to cover recovery costs.[40] More information about this program is needed to fully analyze it, but a key weakness is that

37 Christina Starr, Interview with Policy Experts from the Environmental Investigation Agency, February 25, 2021.
38 Christina Starr, Interview with Policy Experts from the Environmental Investigation Agency, February 25, 2021.
39 Official Journal of the European Union, *Regulation (EU) No 517/2014 of the European Parliament and of the Council of 16 April 2014 on Fluorinated Greenhouse Gases and Repealing Regulation (EC) No 842/2006*, 11.
40 Environmental Investigation Agency, *National Producer Responsibility Schemes Under the EU F-Gas Regulation*, (Environmental Investigation Agency, n.d.), 17.

it imposes a recovery obligation on operators and technicians without incentivizing them to participate. In Denmark, there is an industry collective that operates a deposit-refund scheme. Deposits from equipment operators are used to partially refund technicians for delivery of used HFCs and the collective undertakes reclamation and destruction.[41] Recovery rates in Denmark are high.[42] Important aspects of this program are its voluntary nature that includes industry restrictions on non-members, that it pays technicians to deliver the HFCs, and that the collective self-manages reclamation and destruction.

In Japan, there is not a financial incentive to send refrigerants for reclamation or destruction. Rather, the operator of the equipment typically must pay the recovery operator, who then must pay the recycling operator.[43] However, the Japanese law includes strict punishments for non-compliance: certain violations can be punished by imprisonment of up to a year, and many others, including the false preparation of records, incur fines.[44]

The US could consider either a voluntary or mandatory extended producer responsibility model, ensuring that operators and technicians have appropriate incentives to deliver HFCs to reliable reclamation and destruction networks. Given the potentially high costs and adversarial nature of enforcing penalties such as Japan's, an appropriately incentivized take-back scheme is likely to be a better approach for the US.

Industry Perspective

Producers would likely prefer the onus of proper recovery and reclamation to lie on the maintenance sub-sector of the HVACR industry. However, maintenance and service providers, particularly where transportation costs may be high, may not have adequate financial or logistical resources to fulfill these duties. Notably, the maintenance sector is composed of small-to-medium sized businesses that lack a strong lobbying presence, relative to producers. Service technicians may need to increase maintenance costs to comply with regulations, which will likely be paid by the operators. However, this would make non-compliant servicers more competitive because they would avoid the increased costs, meaning EPA would need to enforce compliance among the whole sector to prevent cheating and undercutting.

Indeed, US producers have the largest capacity to reclaim existing HFCs at scale in a timeline that aligns with the forthcoming accelerated demand. Some producers, such as

41 Environmental Investigation Agency, *National Producer Responsibility Schemes Under the EU F-Gas Regulation*, 19.
42 Ministry of Environment of Denmark, *Danish Consumption and Emission of F-Gases in 2019*, 41–43, https://www2.mst.dk/Udgiv/publications/2021/02/978-87-7038-274-8.pdf.
43 Japanese Law Translation, *Act on Rational Use and Appropriate Management of Fluorocarbons*, 42.
44 Japanese Law Translation, *Act on Rational Use and Appropriate Management of Fluorocarbons*, 51–53.

A-Gas, have invested in providing life cycle services to their customers.[45] It is important that policy design consults with leading producers to understand how regulation can spur other producers to adopt similar practices.

RECOMMENDATION 4:

EPA should **standardize labeling requirements** on produced HFCs as well as on HFC-containing equipment. Labeling should include tonnage in terms of CO_2e.

Current Status

There are no current federal labeling requirements for HFCs or stationary HVACR equipment under Section 608 of the Clean Air Act.[46] California requires labeling of refrigerant type, amount, and date.[47] Expanding upon and standardizing the California regulations would strongly support other regulatory mechanisms.

Policy Tools

EPA should strive to create uniform labeling requirements for HFC equipment, containment cylinders and other relevant elements of the refrigerant bank system. Quantities of HFC should be labeled in CO_2e and EPA should strive to ensure that variations among state governments, if allowed at all, are kept to a minimum. As for the structure of labeling requirements, it is advisable that EPA seek to coordinate with the EU to ease the burden of cross-border transactions. Administrative delays associated with cross border adjustments can be a significant burden and cost for involved businesses.

Since different HFCs have varying GWPs, it is important to specify HFC content and CO_2e in the filling, maintenance, and refilling stages. Labeling in CO_2e can incentivize the transition towards low-GWP alternatives. Also, clear labeling from the beginning stage helps operators to keep a consistent record when leakage does occur.

Examples and Analysis

Strict requirements for the labeling of HFC-containing equipment have served as a policy staple in several foreign jurisdictions, including the EU and Japan, and have

45 A-Gas Global, "Refrigerant Buyback, Recovery, Total Solutions," accessed April 1, 2021, https://www.agas.com/media/4854/a-gas-americas-refrigerants.pdf.

46 United States Environmental Protection Agency, *Managing Refrigerant in Stationary Refrigeration and Air-Conditioning Equipment*, (Collections and Lists, 2015), https://www.epa.gov/section608/managing-refrigerant-stationary-refrigeration-and-air-conditioning-equipment.

47 California Air Resources Board, *Proposed Prohibitions on High-GWP HFCs in New Refrigeration and Air-conditioning*, (California Air Resources Board, 2020), https://ww2.arb.ca.gov/sites/default/files/2020-06/January%2030%2C%202020%20Workshop%20Slides.pdf.

been considered in several states in the US.[48] Some states have generally adopted uniform labeling policies for certain HFC-containing products and equipment. The basic premise of such requirements is that labels which describe the type and quantity of gases must be provided either at the point of production or upon import for all HFC-containing equipment.[49] This serves to facilitate other initiatives for the monitoring and regulation of HFCs and also provides a basic benefit to operators by simplifying the process to have equipment serviced. To standardize information provided between different classes of HFCs as well as for regulated chemicals, European Union's F-gas Regulation specifically requires that the labels affixed detail the gas quantity in terms of metric tons of CO_2e.[50] This method is recommended especially to support other policies aimed at reducing climate impact.

In addition to the merits of these requirements in terms of supporting other regulatory mechanisms, labeling policies are an appealing solution because they are both straightforward and relatively difficult for any party to object to. Labeling for safety or energy efficiency regulations is already required for many of the relevant types of equipment. HFC labeling requires minimal additional effort from producers or importers and no downstream actions for operators to comply. However, it is important to note that as a standalone policy, labeling would not necessarily make any impact on the continued production or use of HFCs and so must be paired with other initiatives in order to effect positive change.

RECOMMENDATION 5:

EPA should **ban the use of disposable cylinders** for transport to reduce leakage and improve tracking. If disposable cylinders are not banned, EPA should **ensure that residual refrigerant is properly recovered**.

The storage containers for fluorinated gases and HFCs are a potential source for leakage. Pressure vessels could replace cylinders, especially disposable cylinders, to reduce and even eliminate the leakage when HFCs are stored. Disposable cylinders have a roughly 2-3% annual leak rate, including valve leaks, because they are not designed for long-term storage and transportation.[51] Pressure vessels are extremely unlikely to leak, so this characteristic makes them an appropriate substitute to prevent leakage.[52]

48 Air-Conditioning, Heating & Refrigeration Institute, "HFC Regulation in the US," accessed April 1, 2021, https://www.ahrinet.org/resources/regulatory-support/refrigerant-resources.
49 J. Fitzgibbon, "Hydrofluorocarbon Greenhouse Gas Emissions," Pub. L. No. 1112, 6 (2019), https://www.ahrinet.org/App_Content/ahri/files/RESOURCES/1112-S2.SL.pdf.
50 W. Jörß, "Information for Importers of Equipment Containing Fluorinated Greenhouse Gases on Their Obligations Under the EU F-Gas Regulation," *Guidance: Imports of Pre-Charged Equipment,* (Germany: European Commission, February 2020), 10.
51 United States Environmental Protection Agency, *ODS Destruction in the United States and Abroad*, 5.
52 United States Environmental Protection Agency, *ODS Destruction in the United States and Abroad*, 5.

When HFCs are used from a disposable cylinder, there is a residual quantity of refrigerant that is unnecessarily released into the atmosphere when the cylinder is cut to enter the waste stream. In addition, disposable cylinders are difficult to trace. They have been banned in the EU, Australia, Canada, and India.[53] If EPA does not institute a ban on disposable cylinders, technicians should be required to empty disposable cylinders into larger tanks with other recovered gas to be sent to reclamation facilities.

RECOMMENDATION 6:

EPA should require **automatic HFC leak detection systems** to be installed on all new HFC-containing commercial equipment.

Manufacturers of commercial HVACR equipment also play a vital role in management and phasedown, since equipment requires certain refrigerants and its quality can play an important role in leak management. This recommendation applies to equipment and storage container manufacturers.

Current Status

According to a 2015 United Nations Environment Programme study, the addition of HFCs to compensate for leakage accounts for approximately 55-65% of total HFC consumption in the HVACR sector, indicating an enormous opportunity for improvement.[54] Reducing and controlling leakage through the use of automatic detection systems is one of the most straightforward and feasible methods to reduce consumption.

Policy Tool

Equipment with HFCs can be required to install leak detection systems to avoid waste. Large systems have greater savings potential if leakage is found promptly rather than waiting until the next check to find the leakage. In the EU, leak detection systems are mandatory for systems with 500 metric tons or more of CO_2e.[55] EPA can tailor the charge threshold based on the needs of the US market.

53 Environmental Investigation Agency, *Search Reuse and Destroy: How States Can Take the Lead on a 100 Billion Ton Climate Problem*.

54 United Nations Environmental Program Ozone Secretariat, *Fact Sheet 2: Overview of HFC Market Sectors*, (United Nations Environmental Program, 2015), https://ozone.unep.org/sites/ozone/files/Meeting_Documents/HFCs/FS_2_Overview_of_HFC_Markets_Oct_2015.pdf.

55 Official Journal of the European Union, *Regulation (EU) No 517/2014 of the European Parliament and of the Council of 16 April 2014 on Fluorinated Greenhouse Gases and Repealing Regulation (EC) No 842/2014*, 7-8.

Make Equipment Operators Responsible

Equipment owners and operators are responsible for equipment during the years of operation when leaks, repairs, and retirement all take place. Regulation of their behavior can stimulate the market for reclamation, prevent leaks, and encourage the transition away from HFCs. EPA should couple requirements on operators with an expansion of existing, successful voluntary programs to encourage first movers.

RECOMMENDATION 7:

EPA should require that **only reclaimed or recycled chemicals are used** to recharge existing equipment.

Policy must stimulate the market for reclaimed refrigerants in order to make them financially viable and avoid use of virgin substances. Some existing equipment will need to be recharged with HFCs during the phasedown; spurring the reclamation market will make transition easier for operators. A requirement that HFCs used to recharge equipment are recycled or reclaimed would both reduce the market for virgin HFC production, supporting phasedown, and encourage further development of a reclamation market. Demand for reclaimed HFCs also reduces the risk of venting at end-of-life.[56]

International Example

In the EU, a ban on servicing existing equipment with virgin HFCs with GWPs over 2,500 was implemented in 2020.[57] This was an important step both for the phasedown of HFC consumption and in spurring reclamation. Due to the phasedown and service ban, two of the largest global HFC producers ceased supplying R-404a and R-507a in Europe (Chemours in 2020 and Honeywell in 2018), which provided a huge incentive to reclaim or move away from those gases. Because industry was warned well in advance, supermarkets have tended to purchase climate-friendly equipment in recent years. The reduced supply of virgin HFCs has resulted in price parity between virgin and reclaimed R-404a, helping smooth the service ban transition.[58]

Challenges

A significant barrier to achieving higher market penetration of reclaimed gases is inconsistent price signaling. Reclaimed gas has only recently reached price parity with

56 J. Kleinschmidt, B. Gschrey, and S. Barrault, "Briefing Paper: HFC Availability on the EU Market," n.d., 4.
57 Official Journal of the European Union, *Regulation (EU) No 517/2014 of the European Parliament and of the Council of 16 April 2014 on Fluorinated Greenhouse Gases and Repealing Regulation (EC) No 842/2006*, 15.
58 Sophie Geoghegan, Interview with Policy Experts from the Environmental Investigation Agency, February 25, 2021.

virgin HFCs in the EU, because the cap system created a shortage of virgin gases and increased how lucrative reclaiming gases can be.[59] This has been positive for HFC reclaimers and has encouraged private parties to use reclaimed gases as virgin HFC prices rise. Inconsistent price signals can hinder market share growth of reclaimed HFCs. EPA should track reclamation and how fast it is growing and then apportion only as many HFC production or import credits as needed to meet projected market demand based on the availability of that reclaim.

This has also been an issue in Australia where importers have engaged in significant stockpiling of HFCs.[60] The Australian quota system has encouraged stockpiling of high-GWP HFCs during the different phases, sending the opposite market signal than the quota had intended. While this is technically legal, it undermines phasedown goals by increasing supply of virgin HFCs. Stockpiling has warped the market and potentially discouraged reclamation of HFCs (currently 0.005% reclamation rate), despite being an import-dependent nation.[61] Because of lax regulations on reclamation processes and a lack of clear-cut incentives for a market phasedown, there is little price signal to industry to encourage a switch. The EU has endured similar issues, with illegal imports of virgin HFCs through the eastern bloc.[62] Illegal imports added roughly 15 megatons of CO_2e, or 12%, to the HFC bank GWP in the EU in 2018.[63] The Environmental Investigation Agency suggests changes such as non-freely allocated permits or a central HFC registry system to track shipments of HFCs.[64] Despite years of work by some member states and NGOs to combat illegal imports of HFCs, it would likely require a bloc-wide effort to track HFCs and penalize bad actors.

Requiring the use of reclaimed HFCs is important in creating a market that reinforces regulations. Higher costs for reclaimed refrigerant are a deterrent for market growth, which is why the price convergence in the EU is so important.[65] If there is a mismatch in the phasedown of production with the reclamation capacity buildout, there can be pricing and transition issues. Reclamation also makes the continued production of virgin HFCs unnecessary as demand simultaneously drops.[66] Currently, reclaimed HFCs represent roughly 4% of the virgin HFC market in the EU, despite aggressive

59 Sophie Geoghegan, Interview with Policy Experts from the Environmental Investigation Agency, February 25, 2021.
60 Australian Government Department of Agriculture, Water, and the Environment, *Cold Hard Facts 2020*, (Canberra, Australia: Australian Government Department of Agriculture, Water, and the Environment, 2020), https://www.environment.gov.au/system/files/resources/cd4e7429-8c16-4bca-8c6c-4ba1f436ecb3/files/cold-hard-facts-2020.pdf.
61 Environmental Investigation Agency, *Refrigerant Reclaim Australia*, (Environmental Investigation Agency, n.d), https://refrigerantreclaim.com.au/.
62 Environmental Investigation Agency, *Doors Wide Open*, (Environmental Investigation Agency, 2019), https://eia-international.org/wp-content/uploads/EIA-report-Doors-wide-open.pdf.
63 Environmental Investigation Agency, *Doors Wide Open*, 4.
64 Environmental Investigation Agency, *Doors Wide Open*, 22.
65 Sophie Geoghegan, Interview with Policy Experts from the Environmental Investigation Agency, February 25, 2021.
66 Kleinschmidt, Gschrey, and Barrault, "Briefing Paper: HFC Availability on the EU Market," 6.

reclamation goals.[67] However, even this small amount has helped stabilize R-404a prices and prices of other common refrigerants, as demand also drops as equipment reaches end-of-life.[68] Therefore, policy to increase the use of reclaimed refrigerants in the US is vital.

RECOMMENDATION 8:

To encourage a transition to more efficient HFC-containing equipment, policymakers should **establish a trade-in program** under which operators could trade in leak-prone or high-GWP equipment to receive rebates for the purchase of more efficient replacements.

Current Status

The AIM Act currently allows EPA to issue grants for small businesses to purchase equipment used to recycle or reclaim HFCs.[69] The AIM Act does not outline appropriated funding for equipment trade-ins, however, which may require additional funding and policy development to operationalize.

Policy Tools

Policymakers could seek to build on this act by providing funds for operators who wish to replace older, leaking, or high-GWP HFC-containing equipment with more emissions-efficient appliances or to encourage reclamation. There are several policy tools to accomplish this goal. Regarding proper disposal of old equipment, financing could be provided through a trade-in plus rebate mechanism in which equipment operators receive rebates toward the purchase of new equipment based on the proper disposal of their existing systems and HFCs with certified dealers. Similarly, EPA can request revenue-altering adjustments from Congress in the upcoming budget to levy fees on HFC leaks as well as create incentives for the adoption of climate-friendly equipment through the budget reconciliation process.

Challenges

Primary challenges remain in obtaining financing and ensuring that the incentives are the most efficient allocation of those funds, given that cash handouts may be unnecessary where operators would already choose to make efficiency improvements without prompting. Therefore, such programs must be cognizant of where transitions

67 Kleinschmidt, Gschrey, and Barrault, "Briefing Paper: HFC Availability on the EU Market," 4.
68 Sophie Geoghegan, Interview with Policy Experts from the Environmental Investigation Agency, February 25, 2021.
69 United States Government Publishing Office, *H.R.133 - Consolidated Appropriations Act, 2021*, (116th Congress, 2019-2020), https://www.congress.gov/bill/116th-congress/house-bill/133/text.

are already occurring and ensure that funds either accelerate or expand upon these successes or target areas of equity concern. The greatest support should be allocated to operators that could not finance equipment upgrades on their own.

RECOMMENDATION 9:

EPA should **require frequent leak inspections** (e.g. every one to eight months) to reduce inadvertent emissions.

Current Status

A recent Environmental Investigation Agency investigation discovered that 55% of supermarkets were experiencing detectable leaks and leaks persisted for months in the stores that were revisited.[70] Supermarkets participating in the EPA's GreenChill voluntary refrigerant emissions reduction program, which includes goal-setting, reporting, and education, tend to have lower leakage rates, averaging 12.9%.[71] The success of this voluntary program shows that leakage can be improved. Regular leak checks are an important component of improving leakage rates.

Regulations under Section 608 of the Clean Air Act currently require leak repairs for appliances containing ozone depleting substances under certain conditions. Owners or operators must make repairs when a system with 50 pounds or more of refrigerant leaks greater than 10-30% of its charge in a year, depending on the type of system.[72] These thresholds make a huge amount of leakage allowable, even when enforced. An average supermarket contains 3,500 pounds of HFCs.[73] At the 20% allowable leak rate for commercial refrigeration,[74] one supermarket can annually leak the emissions equivalent of hundreds of passenger vehicles without being subject to repair requirements.[75] Therefore, EPA must strengthen leakage requirements for HFCs as well as ODSs.

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70 Environmental Investigation Agency, *Leaking Havoc: Exposing Your Supermarket's Invisible Climate Pollution*, (Environmental Investigation Agency, 2021), https://www.climatefriendlysupermarkets.org/leaking-havoc.

71 United States Environmental Protection Agency, *U.S. EPA's GreenChill Partnership: 10 Years of Progress*, (United States Environmental Protection Agency, December 2018), 2, https://www.epa.gov/sites/production/files/2018-12/documents/greenchill_progress_report_12122018_final.pdf.

72 United States Environmental Protection Agency, *Stationary Refrigeration Leak Repair Requirements*, (United States Environmental Protection Agency, 2015), https://www.epa.gov/section608/stationary-refrigeration-leak-repair-requirements.

73 Environmental Investigation Agency, *Leaking Havoc: Exposing Your Supermarket's Invisible Climate Pollution*.

74 United States Environmental Protection Agency, *Stationary Refrigeration Leak Repair Requirements*.

75 United States Environmental Protection Agency, *Greenhouse Gas Emissions from a Typical Passenger Vehicle*, (United States Environmental Protection Agency Overviews and Factsheets, 2016), https://www.epa.gov/greenvehicles/greenhouse-gas-emissions-typical-passenger-vehicle.

International Examples

Leak detection and repair are tenets of the EU and Japanese programs and are vital to reducing unintentional emissions of HFCs. Both programs require periodic leak checks. In Japan, most commercial sources must be checked by the operator at least every three months and by a certified technician at least once per year. If leakage is detected, the part must be replaced as quickly as possible, and filling of HFCs is prohibited until the leak is repaired.[76] Operators must keep records on the history of inspection, repair, and filling. Additionally, firms must report leaks on a company-wide basis. Leakage is calculated based on additional filling and reported in tons of CO_2e.[77]

In Europe, leak checks are required every three to twenty-four months, depending on the size of the system and whether a leakage detection system is installed. Operators of the largest classification of equipment are required to use leakage detection systems. If a leak is detected, it must be repaired within one month, and a certified technician must verify the repair.[78]

Challenges

Leakage requirements were already present in the EU's 2006 HFC regulation, and a decade later, supermarket chains were reporting mixed results. According to the Environmental Investigation Agency, chains were experiencing anywhere from 6-60% leakage in 2015, partially reflecting mixed results across European nations.[79] One standout supermarket chain said that the EU's requirements were not enough to contain leakage. Instead, that chain required annual preventative maintenance and monthly leak testing of all refrigeration equipment, plus scheduled maintenance based on historical leakage.[80] Therefore, EPA should set stronger leak requirements and work with the GreenChill program to incentivize willing partners to exceed regulatory standards.

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76 Ministry of the Environment, *Act on Rational Use and Proper Management of Fluorocarbons Japan*, (Ministry of the Environment, Government of Japan, 2016), https://www.env.go.jp/en/earth/ozone/laws/ozone4.pdf.

77 Ministry of the Environment, *Act on Rational Use and Proper Management of Fluorocarbons Japan*, 5.

78 Official Journal of the European Union, *Regulation (EU) No 517/2014 of the European Parliament and of the Council of 16 April 2014 on Fluorinated Greenhouse Gases and Repealing Regulation (EC) No 842/2014*, 8-9.

79 Environmental Investigation Agency, *Chilling Facts VII: Are Europe's Supermarkets Ready to Quit HFCs?*, Environmental Investigation Agency, 2017), https://eia-international.org/wp-content/uploads/Chilling-Facts-VII-FINAL.pdf.

80 Environmental Investigation Agency, *Chilling Facts VII: Are Europe's Supermarkets Ready to Quit HFCs?*, 17–18.

RECOMMENDATION 10:

Along with mandatory leak detection systems, EPA should **require a leak detection threshold** for automatic leak detectors to be set at a level that can reliably detect leaks that occur away from the monitor. This should be at most 25 ppm and, ideally, 5 ppm.

Current Status

In California, there is a requirement for operators of refrigeration systems with over 50 pounds of high-GWP refrigerants to either perform periodic inspections or use automatic leak detection systems. Leak detection systems must alert the operator if refrigerant concentration exceeds 100 ppm.[81] However, this usually only occurs if the monitor is very close to the leak, since leaks diffuse through the air.[82] Bacharach, a company that sells leak detection equipment, models that a leak of 330 pounds per year in a room much smaller than an average supermarket would only produce a gas concentration of 23 ppm.[83] Clearly, a 100 ppm threshold for alerting operators to leaks is too high.

Nationwide, there is no current regulation for a minimum detection threshold for HFC leak detection systems. EPA revised its Section 608 Refrigerant Management Regulations in 2020 to rescind the requirements for operators of equipment containing 50 or more pounds of HFCs to 1) report chronically leaky appliances to EPA, 2) periodically check for leaks, and 3) repair leaks.[84]

Policy Tools

EPA can reinstate Section 608 Regulations for Refrigerant Management for equipment containing 50 or more pounds of HFCs. EPA, under the AIM Act, can also add requirements for leak detection equipment, recommended above, to have a minimum detectable threshold in the low ppm range (1-25 ppm), which can be reliably and accurately reported by automatic leak detection systems.[85] These low concentrations can signal either a small leak close to the source or a large leak with a detector far from

81 California Air Resources Board, *Regulation for the Management of High Global Warming Potential Refrigerants for Stationary Sources*, (California Air Resources Board, 2010), 15, https://ww3.arb.ca.gov/regact/2009/gwprmp09/finalfro.pdf.

82 Christina Starr, Interview with Policy Expert from the Environmental Investigation Agency, February 25, 2021.

83 Bacharach, *Refrigerant Leak Detector Sample Point Locations for Food Retail*, (Bacharach, 2019), 6, accessed April 5, 2021, https://ss-usa.s3.amazonaws.com/c/308475912/media/3367601c-2c9d7e0cb50706998951771/Refrigerant-Leak-Detection-Sample-Locations-Food-Retail.pdf.

84 United States Environmental Protection Agency, *Revised Section 608 Refrigerant Management Regulations*, (Other Policies and Guidance, United States Environmental Protection Agency, 2016), https://www.epa.gov/section608/revised-section-608-refrigerant-management-regulations.

85 UK Institute of Refrigeration, "Fixed Refrigerant Detection Systems for HFCs, HFC/HFO Blends, HFOs and HCFCs," UK Institute of Refrigeration, accessed April 1, 2021, https://www.eurotec.co.nz/wp-content/uploads/2020/05/GN-20-Leak-Dectector-guide.pdf.

the source. Regardless, low detection thresholds can help catch leaks early and prevent leaks from growing over time.[86]

International Examples

According to the Institute of Refrigeration in the United Kingdom, the primary regulations on HFC leak detection systems are to signal safety issues. These monitors signal issues with the refrigeration system that might be safety concerns related to flammability, exposure, or maintenance issues. They are not directly intended for leak management. This is why leak detection thresholds in the EU are generally between 100 ppm-1,000 ppm, depending on the country and intended appliance use.[87] If the US adopted an appropriate threshold to minimize leakage emissions, it could be a leader in this area.

RECOMMENDATION 11:

EPA should continue to **support and expand voluntary compliance programs,** such as GreenChill, because they can be used to further push the bounds of climate-friendly refrigeration and heat pump dissemination as well as expand technical skills in the field.

Current Status

The existing GreenChill program is a partnership between EPA and US supermarkets which set voluntary emissions reduction targets and report to EPA each year about their progress.[88] The partners of the program receive support and technical assistance from EPA, and in return EPA reports lower emissions of HFCs in the US.[89] Additionally, EPA reports substantial savings (nearly $2,500 per store) for the supermarket partners that have worked hard to reduce leaks under the GreenChill partnership.[90]

Policy Tool

EPA should leverage existing relationships within the private sector to trial new policies. For example, recycling systems are potentially quite suitable for entities that consume large quantities of HFCs on site. As a preview to any regulation requiring recycling in such cases, EPA could work with willing volunteers to identify challenges and opportunities. Likewise, EPA could work with GreenChill partners to pilot a service

86 UK Institute of Refrigeration, "Fixed Refrigerant Detection Systems for HFCs, HFC/HFO Blends, HFOs and HCFCs," 3.
87 UK Institute of Refrigeration, "Fixed Refrigerant Detection Systems for HFCs, HFC/HFO Blends, HFOs and HCFCs," 3.
88 United States Environmental Protection Agency, *U.S. EPA's GreenChill Partnership: 10 Years of Progress*, (United States Environmental Protection Agency, 2018), https://www.epa.gov/sites/production/files/2018-12/documents/greenchill_progress_report_12122018_final.pdf.
89 United States Environmental Protection Agency, *U.S. EPA's GreenChill Partnership: 10 Years of Progress*, 2.
90 United States Environmental Protection Agency, *U.S. EPA's GreenChill Partnership: 10 Years of Progress*, 2.

ban on the use of virgin HFCs before mandating this industrywide. EPA could then determine what regulations would be effective and what challenges the industry may experience during a service ban.

Address Service Technicians' Role in the Phasedown

The technicians who install, service and maintain, and transport HFCs from producers to operators to reclamation or disposal are a key link in the chain to prevent venting and encourage reclamation. Their participation is vital in any extended producer responsibility scheme, as discussed above. In addition, ensuring proper training for servicers can minimize leakage and venting and encourage the shift away from HFCs.

RECOMMENDATION 12:

EPA should expand upon and provide additional access to job **training and certification programs** that will require all technicians to be trained in leak minimization and climate-friendly refrigerants.

Current Status

EPA already requires the certification of installation, maintenance, and recovery technicians in order to minimize misconduct and unprofessional installation practices. The Section 608 Technician Certification Program covers many topics, including substitutability of refrigerants, recovery practices, and the dangers of on-site recycling.[91] However, the most obvious example of missing topics necessary for the HFC phasedown include low-GWP alternatives to HFCs and training to encourage the use of reclaimed refrigerants over the use of virgin HFCs. This is important because technicians are not receiving training that would 1) reduce emissions of high-GWP refrigerants and 2) allow technicians to advise clients on alternatives to HFCs during equipment purchasing. By mandating the inclusion of training on alternative refrigerants such as CO_2, propane, and ammonia, EPA can guide the market away from HFCs by building a knowledge base about alternatives through training.

Additionally, if robust reporting requirements are implemented under EPA, technicians will have additional responsibilities that will be crucial to refrigerant bank tracking. This will require enhanced training methods that address the importance and methodology of tracking to ensure an accurate HFC registry. EPA will almost certainly address this

91 United States Environmental Protection Agency, *Section 608 Technician Certification Test Topics*, (United States Environmental Protection Agency, Other Policies and Guidance, 2015), https://www.epa.gov/section608/section-608-technician-certification-test-topics.

through training, but technicians need to share responsibility with equipment operators, producers, and disposers for the accuracy of reports.

Policy Tool

EPA should initiate new rulemaking that sets federal standards for the inclusion of reclamation, HFC tracking, and low-GWP alternatives in worker training programs. This would not only avoid an excess of different state-based regulations but also help the reclamation industry ramp up its technical capacities in preparation for much higher volumes of throughput in the next few years. To the extent possible, certification programs should be given federal support either in subsidies or direct training programs, if at all possible, or at the very least with the publication of a "model certification program" to help industry facilitate its own certification programs.

International Example

The EU requires member states to establish or adopt certification programs for technicians working with fluorinated gases. The certification programs must comply with minimum requirements set out by the European Commission, and the member states must recognize each other's certifications.[92] However, in meetings with experts from the Environmental Investigation Agency, industrywide shortfalls in training capacity were cited as barriers to implementing HFC alternatives and reclamation.[93] A report from the European Commission also showed that low-GWP alternative (e.g. propane, ammonia) uptake has faltered because of a lack of training in the industry.[94] The report recommends a shift in the minimum training standards for HFC and HVACR technicians to prevent technicians from skirting HFC alternatives.[95] This is another area that also plays into inconsistent price signaling: if there are not enough trained technicians to reclaim various gases or to recommend alternatives, then the market signals are distorted.

Technician training can help ensure that systems are properly installed and maintained, reducing leakage during use. It can also ensure that HFCs are recovered without leakage at end-of-life.[96] The European Partnership for Energy and the Environment

92 Official Journal of the European Union, *Regulation (EU) No 517/2014 of the European Parliament and of the Council of 16 April 2014 on Fluorinated Greenhouse Gases and Repealing Regulation (EC) No 842/2014*, 11-12.

93 Sophie Geoghegan, Interview with Policy Experts from the Environmental Investigation Agency, February 25, 2021.

94 Ray Gluckman and Gluckman Consulting, "Assessment of Training for the Safe Handling of Alternative Low GWP Refrigerants," December 2015, 2, accessed April 1, 2021, https://ec.europa.eu/clima/sites/clima/files/f-gas/legislation/docs/assessment_of_training_en.pdf.

95 Gluckman and Consulting, "Assessment of Training for the Safe Handling of Alternative Low GWP Refrigerants," 7.

96 Official Journal of the European Union, *Regulation (EU) No 517/2014 of the European Parliament and of the Council of 16 April 2014 on Fluorinated Greenhouse Gases and Repealing Regulation (EC) No 842/2014*, 11-12.

found that training required by the EU regulations has been effective for reducing refrigerant emissions. It also has additional benefits because correct refrigerant charge increases energy efficiency, and reducing leaks saves costs of additional refrigerant, energy, and system maintenance.[97] For best results, certification requirements should include knowledge of leakage and disposal requirements as well as an understanding of climate-friendly refrigerants that will be phased in.

Challenges

EPA will need to ensure that regulations are preemptive of state rules around HFCs to avoid a regulatory patchwork. This became an issue in the EU, where breakdown in HFC management tended to occur upon delegation of necessary tasks to member states. Without clear guidelines and standardization across states in the assignment of roles and responsibilities in the reclamation supply chain, implementation efforts could often be lackadaisical. Nowhere is this more important than the creation of a trained reclamation and technician workforce that is attuned to the challenges and opportunities of reclaiming HFCs as well as dealing with substitute refrigerants such as ammonia, CO_2, and hydrofluoroolefins (HFOs).

Study and Create Incentives for Proper Destruction When Needed

Because there is a large stock of existing equipment that uses HFCs, this report focuses on reclamation in order to continue servicing that equipment while minimizing the production of new HFCs. However, as the phasedown proceeds and equipment is retired, some HFCs will need to be destroyed.

RECOMMENDATION 13:

Once the phasedown process has progressed to the point where HFCs can be phased out of the refrigerant bank without encouraging unproductive destruction, EPA should **design a tax incentive or other monetary rebate** for the proper and verified destruction of HFCs, potentially similar to the route found in the 45Q tax credit.

Without detailed information about the cost challenges of HFC destruction, it is difficult to say where monetary incentives would be best targeted. There are not currently any incentives for destroying HFCs, which will be a barrier to destruction when it is needed. While working with voluntary partners of GreenChill, EPA might be able to determine where financial incentives for destruction can be additive in the supply chain. Financial constraints on destruction may occur at any stage of equipment use or they may be

97 EPEE, *Lessons Learned from the EU F-Gas Regulation*, (EPEE, August 11, 2018), 7, https://www.epeeglobal.org/wp-content/uploads/EPEE_Lessons-Learned-document.pdf.

geographic. However, if EPA identifies areas where incentives can significantly improve proper HFC destruction, it can work with the Office of Management and Budget to request funding to support a tax credit or similar program for HFC destruction.

Conclusion

Bending the curve on HFC emissions is imperative for achieving our climate ambitions. This report has identified economic and policy barriers to proper HFC refrigerant management. Currently, it is easier and cheaper for entities at all points in the management chain to allow HFCs to escape into the atmosphere rather than take measures to avoid unintentional leakage or pay for proper disposal. EPA regulations under the AIM Act have a vital opportunity to change this state of affairs. EPA should promulgate a comprehensive set of regulations that combines administrative oversight and industry incentives to fully address the life cycle of HFCs.

Regulations must incentivize recovery and reclamation while discouraging avoidable releases. Requirements for extended producer responsibility, a registry system, and standardized labeling would together create the needed incentives and enforcement mechanisms. It is also critical that EPA regulations provide support to the HVACR industry and spur positive feedback, making recovery and reclamation progressively more appealing. Regulations such as a service ban on virgin HFCs would help expand the market for reclamation, and technician training requirements would build a workforce that favors climate-friendly practices in the long term. Stimulating effective bank management practices in private industry is essential for ensuring that policy endures in changing political climates.

Recent models show that the Paris Agreement's goal of limiting warming to 1.5°C over the pre-industrial era is still within reach, but only if short lived, high-GWP pollutants such as HFCs are cut substantially in the next decade and all but eliminated by 2050.[98] Strong EPA regulations, along with the AIM Act's prescribed phasedown, will enable the US to make a sizable contribution to this goal.

98 R. Orvis, "A 1.5° Celsius Pathway to Climate Leadership for the United States," Energy Innovation Policy & Technology, LLC., accessed April 1, 2021, https://energyinnovation.org/wp-content/uploads/2021/02/A-1.5-C-Pathway-to-Climate-Leadership-for-The-United-States.pdf.

Appendix: Case Studies

EPA has the authority to regulate HFCs with the newly passed AIM Act, so other countries with strong regulations were selected to analyze what has worked well for them in their efforts to reduce HFCs.

1. Past EPA Regulatory Frameworks for CFCs and HCFCs

In response to the Montreal Protocol, EPA set guidelines primarily for CFC manufacturers and allowed both public pressure and the resulting changes in market supply to force industry users to transition as well. Industries that faced more technical challenges in transitioning had the option to seek exemptions from certain requirements but were required to file for these each year, meaning that they were not without recourse but had increasing pressure to adapt. These factors allowed the phasedown to complete four to six years faster than predicted and at 70% of the expected cost, even as additional harmful chemicals were found and added to the regulatory framework.[99]

2. California Air Resources Board

Assembly Bill 32 Global Warming Solutions Act of 2006 (AB 32) was the first piece of legislation to specifically limit HFCs in California. The goal of AB 32 was to prompt the California Air Resources Board (CARB) to reduce California's GHG emissions to 1990 levels by 2020.[100] A Scoping Plan for accomplishing this reduction was released in 2008 and later updated in 2014 and in 2017 to include new input from stakeholders and new actions for achieving GHG reduction.[101]

The AB 32 and the CARB Scoping Plans outline several strategies for achieving HFC emission reduction. These methods include a fee levied on the upstream sales of high-GWP gases applied on a CO_2e bases, a ban on high-GWP gases in non-essential

99 United States Environmental Protection Agency, *The Clean Air Act – Highlights of the 1990 Amendments*, (United States Environmental Protection Agency, n.d.), https://www.epa.gov/sites/production/files/2015-11/documents/the_clean_air_act_-_highlights_of_the_1990_amendments.pdf.

100 California Air Resources Board, *AB 32 Global Warming Solutions Act of 2006*, (California Air Resources Board, 2018), https://ww2.arb.ca.gov/resources/fact-sheets/ab-32-global-warming-solutions-act-2006.

101 California Air Resources Board, *California Greenhouse Gas Emissions for 2000 to 2018*, (California Air Resources Board, 2018), https://ww3.arb.ca.gov/cc/inventory/pubs/reports/2000_2018/ghg_inventory_trends_00-18.pdf.

consumer products, and requiring owners of refrigerators that use high-GWP refrigerants to register with CARB as well as pay a fee while operating them.[102]

The Short-Lived Climate Pollutant Reduction Strategy, another plan adopted by CARB in 2017, included proposals for HFC emissions reductions measures, such as providing financial incentives for early adopters of low-GWP refrigerants, a prohibition on the sale of refrigerants with a hundred-year GWP of 2,500 or higher, and a prohibition on the use of high-GWP refrigerants in new stationary systems.[103] These stationary systems would include commercial, industrial, residential refrigeration, and air conditioning. These methods were designed to discourage the consumption of high-GWP HFCs and encourage the quick adoption of low-GWP alternatives.[104]

3. European Union

The EU has legislated fluorinated gases (including some HFCs) since 2006.[105] EU regulations primarily cover stationary sources of HFCs and encourage rigorous life cycle management through leak checks, detailed operation records, and disposal requirements for large systems. The task of national regulations and certifications for technicians has been delegated to the EU member states. Despite stringent regulations, leaks remain a common problem among large HFC users in the EU, such as supermarkets and manufacturers. Regular maintenance, standard installation practices, and better equipment design are crucial to reducing leakage. Increased responsibility for HFC producers could help manage the reclamation, recycling, and destruction supply chains. Suggestions include monetizing collection of HFCs through deposit fees on virgin HFCs, supporting contractors with direct payments for recycling and reclamation, and coordinating between waste management and regulators.

4. Australia

Following its role in the 2016 Kigali Amendment negotiations, Australia amended its domestic Ozone Protection and Synthetic Greenhouse Gas Management Act to

102 California Air Resources Board, *Regulation for the Management of High Global Warming Potential Refrigerants for Stationary Sources*, (California Air Resources Board, California Code of Regulations, 2017), https://ww2.arb.ca.gov/sites/default/files/2020-07/finalfro_0.pdf.
103 California Air Resources Board, *Short-Lived Climate Pollutant Reduction Strategy*, (California Air Resources Board, 2017), https://ww2.arb.ca.gov/sites/default/files/2020-07/final_SLCP_strategy.pdf.
104 California Air Resources Board, *First Update to the Climate Change Scoping Plan*, (California Air Resources Board, 2014), https://ww2.arb.ca.gov/sites/default/files/classic//cc/scopingplan/2013_update/first_update_climate_change_scoping_plan.pdf.
105 European Commission, *EU Legislation to Control F-Gases*, (European Commission, 2016), https://ec.europa.eu/clima/policies/f-gas/legislation_en.

include the regulation of HFCs.[106] Effective January 1, 2018, this began an eighteen-year phasedown to reduce Australia's bulk HFC imports to 15% of their 2011-2013 level.[107] HFCs in pre-charged equipment were not included, placing responsibility for their regulation on the country of manufacture. This effort has shown positive results, with a brief 2017 spike in high-GWP HFC imports but a decrease in the refrigerant bank growth rate and a general shift toward low-GWP alternatives.[108]

5. Japan

HFC management regulation began in Japan in 2001, making it one of the longest standing regulatory frameworks in the world. Since then, several laws have been added, mostly focused on commercial HVACR as well as vehicles. The 2015 Act on Rational Use and Appropriate Management of Fluorocarbons currently regulates commercial units. It seeks to minimize losses during use and at end-of-life by requiring extensive record-keeping, reporting, and certification for all operators involved in fluorocarbon management.[109] It appears to have been successful at increasing recycling and destruction. While the cause and effect at this increase in recycling and destruction is still slightly unclear and more data is needed to examine all aspects of the law, this experience demonstrates that Japan has successfully lowered HFC emissions through stringent certification and reporting requirements.

106 S. Rossi, "Australia Ratifies Kigali Amendment to Reduce HFCs," *Climate Control News*, October 30, 2017, http://www.climatecontrolnews.com.au/news/latest/australia-ratifies-kigali-amendment-to-reduce-hfcs.
107 Australian Government Department of Agriculture, Water and the Environment, *HFC Phase-Down - Frequently Asked Questions*, (Australian Government Department of Agriculture, Water and the Environment, n.d.), https://www.environment.gov.au/protection/ozone/hfc-phase-down/hfc-phase-down-faqs.
108 Australian Government Department of Agriculture, Water, and the Environment, *Cold Hard Facts 2020*.
109 S. Kawagishi, B. Magori and T. Kasai, "Japan's Fluorinated Gases Control Policy as a Measure of Climate Change Mitigation in the Building Sector," *IOP Conf. Series: Earth and Environmental Science*, 294.