DRAFT REPORT

THE U.S. PHASEOUT OF HCFCS:

PROJECTED SERVICING DEMAND IN THE U.S. AIR-CONDITIONING, REFRIGERATION, AND FIRE SUPPRESSION SECTORS FOR 2020-2030

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Background

Hydrochlorofluorocarbons (HCFCs) are a class of chemical compounds that deplete the stratospheric ozone layer, increasing the chances of overexposure to ultraviolet (UV) radiation at the earth's surface. Excessive UV radiation damages biological systems and causes malignant melanoma and other skin cancers, cataracts and other eye damage, and harm to certain crops and marine organisms. Reversing the course of stratospheric ozone depletion is crucial to protecting human and environmental health worldwide. Under the *Montreal Protocol on Substances that Deplete the Ozone Layer* (Montreal Protocol), a global agreement to protect the stratospheric ozone layer, all countries including the United States have agreed to phase out HCFC consumption and production on set schedules. Full implementation of the Montreal Protocol globally is expected to avoid more than 280 million cases of skin cancer, approximately 1.6 million skin cancer deaths, and more than 45 million cases of cataracts in the United States among individuals born between 1890 and 2100 (EPA 2015).

The HCFC Phaseout Schedule

Table 1 shows the HCFC consumption[1] phaseout schedule that applies to the United States under the Montreal Protocol. The upcoming milestone is the commitment to reduce HCFC consumption by 99.5% below the baseline by January 1, 2020, with consumption from 2020-2029 restricted to the servicing of air-conditioning (AC) and refrigeration equipment existing on January 1, 2020.

Table 1: U.S. HCFC Consumption Phaseout Schedule under the Montreal Protocol

Date	Control Measure	Maximum Consumption (ODP Weighted MT)[a]
January 1, 1996	Baseline set at 2.8% of the 1989 ODP-weighted CFC consumption plus 100% of the 1989 ODP-weighted HCFC consumption	15,240
January 1, 2004	35% reduction from the baseline	9,906
January 1, 2010	75% reduction from the baseline	3,810
January 1, 2015	90% reduction from the baseline	1,524
January 1, 2020	99.5% reduction from the baseline; consumption restricted to the servicing of AC and refrigeration equipment existing on January 1, 2020	76.2
January 1, 2030	100% reduction from the baseline	0

[a] An ozone depletion potential (ODP-)weighted metric ton (MT) takes into account each ozone depleting substance's relative contribution to ozone depletion. One MT equals approximately 2,205 pounds (lbs.).

Table 2 shows the HCFC phaseout schedule contained in EPA regulations (40 CFR Part 82 subpart A), which takes into account both Montreal Protocol and Clean Air Act requirements and adopts a "worst-first" approach to phasing out HCFCs, restricting the most-ozone depleting HCFCs first.

[1] Consumption is defined as production plus imports minus exports; production is defined as the manufacture of a controlled substance minus amounts destroyed and amounts completely used as feedstock in the manufacture of other chemicals. Neither consumption nor production includes amounts that are reused or recycled.

Table 2: Detailed Regulatory HCFC Phaseout Schedule

Date	Restriction
January 1, 2003	• Ban on production and import of HCFC-141b.
January 1, 2010	• Ban on production and import of HCFC-22 and HCFC-142b except for on-going servicing demand in equipment manufactured before January 1, 2010.[a]
January 1, 2015	• Ban on the production, import, and introduction into interstate commerce or use of HCFCs except where the HCFCs are used as a refrigerant in equipment manufactured prior to January 1, 2020, or where HCFCs are used as a fire suppression agent for non-residential applications. [a]
January 1, 2020	• Ban on remaining production and import of HCFC-22 and HCFC-142b.[a] • Ban on production and consumption of all other HCFCs except for use in servicing AC and refrigeration equipment manufactured before January 1, 2020.
January 1, 2030	• Ban on production and import of all HCFCs.[a]

[a] Exemptions apply, including exemptions for (1) HCFCs used in processes resulting in their transformation or destruction, or (2) HCFCs that are recovered and either recycled or reclaimed.

Report Objective

This report evaluates the amount of HCFCs that would allow U.S. AC and refrigeration equipment owners to service equipment using HCFCs between 2020-2029, consistent with the phaseout schedule as summarized in Table 2. As such, the report only considers the markets for HCFC-123 and HCFC-124. The report presents quantitative estimates of:

- the projected number of units of equipment using HCFC-123 between 2020 and 2030 in the United States;
- HCFC-123 and HCFC-124 servicing demand for AC and refrigeration equipment that will be in use after 2019; and
- possible future recovery scenarios and estimates of future reclamation between 2020 - 2030.

EPA understands that the fire suppression market will likely continue to use HCFC-123 during at least part of the period covered in the report and this sector cannot be sourced from new production or consumption. Under current regulations at 40 CFR Part 82 Subpart A, only used, recovered and recycled material, or HCFC-123 imported prior to January 1, 2020, can be used for this purpose in 2020 and beyond. As such, the report also estimates the market demand for HCFCs for charging and servicing non-residential fire suppression applications.

The remainder of the report is organized as follows:

- Section 2 provides an overview of HCFC-123 and HCFC-124 use in the United States in AC, refrigeration, and fire suppression.
- Section 3 provides the projected market demand for HCFC-123 and HCFC-124.

- Section 4 provides projected recovery and reclamation scenarios for HCFC-123.
- Appendix A: Methodology Used to Calculate Projected Servicing Demand

Section 2. HCFC-123 and HCFC-124 Uses in the United States

Historically, HCFCs have a variety of applications in the foam, aerosol, solvent cleaning, fire protection, and sterilization industry sectors; however, their largest use is in the AC and refrigeration sector.

2.1 HCFC-123: AC and Refrigeration

Chillers regulate the temperature and humidity in offices, hotels, shopping centers, and other buildings. There are two major categories of chillers—centrifugal and positive displacement. Centrifugal chillers are centralized AC systems typically used in larger buildings. Positive displacement chillers are smaller and may be water-cooled or air-cooled. There are three principle types of positive displacement chillers: reciprocating, screw, and scroll, each of which is named for the type of compressor employed. Historically, these chillers used CFC-11, CFC-12, CFC-114, and R-500 as refrigerants. Today, HCFC-22 and HCFC-123 chillers are still in use, as are chillers using HFC-134a, R-407C, and R-410A. More recently, newer alternatives, such as R-513A, R-514A, and HCFO-1233zd(E), have been listed by the Significant New Alternatives Policy (SNAP) program as acceptable.

Industrial process refrigeration (IPR) systems are complex, customized systems used to cool process streams in industrial applications in the chemical, food processing, pharmaceutical, petrochemical, and manufacturing industries. The choice of refrigerant for a specific application depends on ambient and required operating temperatures and pressures. IPR systems historically used CFC-11 and CFC-12. Today, IPR systems with HCFC-22, HCFC-123, and R-401A (a component of which is HCFC-124) are still in use, though this market may be transitioning to R-717 (ammonia), R-744 (carbon dioxide), R-448A, R-449A, R-450A, R-513A, R-514A, and HCFO-1233zd(E), in addition to using HFC-134a, R-404A, R-407A, R-407C, and R-410A.

2.2 HCFC-123: Fire Suppression

HCFC-123 is also used in fire-suppression applications, which can be divided into two categories: streaming applications (i.e., portable fire extinguishers) that historically used halon 1211, and total flooding applications that historically used halon 1301, or halon 2402 in limited applications (EPA 2006). Streaming applications are used to protect against fires of limited size in commercial and industrial facilities, (e.g., computer rooms, data and telecommunications centers, ship control rooms, art galleries, libraries, warehouses, clean rooms, motor control rooms, and nuclear and oil/gas facilities), aerospace and aviation (e.g., spacecraft, onboard aircraft, aircraft rescue and firefighting (ARFF) vehicles, and areas on aircraft fields and the hangers where airplanes are parked and serviced, which are also known as aircraft flightlines), and the military (e.g., ship control rooms and aircraft flightlines). To replace halon 1211 in streaming applications, the SNAP program has listed the use of in-kind clean agent substitutes (e.g., CO_2, Halotron I, HFC-236fa, and other halocarbons such as the fluoroketones FK-5-1-12 (Novec 1230) and FK-6-1-14 (C7 Fluoroketone)) and not-in-kind substitutes (e.g., water, dry chemical, foam) as acceptable. Approximately 75% of streaming applications in the United States in 2015 were using CO_2, water, or dry chemicals; however, water and dry chemicals are not considered clean agents (i.e., does not leave residue on equipment or in the protected enclosure after discharge). Where clean agent alternatives are preferred, there is still a sizeable installed base of halon 1211. Recycled halon 1211 is also used to service these portable fire extinguishers (EPA 2018).

HCFC-123 is the primary constituent in Halotron I (also referred to as HCFC Blend B in EPA regulations). Specifically, the blend Halotron I is used in commercial/industrial, maritime, and military applications in the United States (Halotron 2008). After January 1, 2020, recovered and recycled or reclaimed HCFC-123, as well as stockpiled material imported prior to 2020, can be used to meet fire suppression demand. There are no known technical reasons that would prevent the recycling or reclaiming of HCFC-123 to appropriate purity levels sufficient for use in fire suppression applications (UNEP 2016). Furthermore, imports of used and/or recycled HCFC-123 may also meet demand similar to how the United States manages used halon through the import petition process at 40 CFR Part 82.13(g)(2).

2.3 HCFC-124: AC and Refrigeration

HCFC-124 is minimally used as a refrigerant; its primary use as a refrigerant is in blends, mainly R-401A which is used in industrial process and transport refrigeration equipment, as well as the blends R-409A and R-414B which are used in commercial refrigeration applications. As a stand-alone refrigerant, it is used in some niche applications that reach high condensing temperatures and as an alternative for CFC-114 in some naval chillers. Its use in blends R-401A, R-401B, R-409A, R-414A, R-414B and others is constrained because those blends also contain HCFC-22 and in some cases HCFC-142b. Starting in 2020, HCFC-22 and HCFC-142b will not be produced or imported for use in these blends, although reclaimed and previously produced or imported HCFCs will still be available for use. HCFC-124 is also a component of R-416A, which does not contain any other ODS.

Section 3. Estimated Market Demand for HCFC-123 and HCFC-124

3.1. HCFC-123

As discussed above, HCFC-123 is used in the AC and refrigeration sector mainly in centrifugal chillers and IPR as well as in the fire suppression sector. Average consumption of HCFC-123 over the past 5 years has been stable at approximately 1,200 MT per year.[2] This number is lower than the approximately 2,000 MT of annual consumption allowances provided during the same period.

As presented in Table 3, approximately 47,000 units of AC equipment using HCFC-123 are estimated to be in use in 2020. The number of HCFC-123 chillers is projected to decrease by 42 percent between 2020 and 2030. Approximately 14,000 units of HCFC-123 IPR systems are estimated to be in use in 2020, decreasing by approximately 37 percent by 2030. EPA's Vintaging Model (see Appendix A) does not provide a disaggregated estimate of fire suppression equipment by specific product type, so this information is not provided in Tables 3 and 4 below.

Table 3: Projected Number of HCFC-123 AC and Refrigeration Units in Operation (1000s of Units), 2020-2030

Equipment Type	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Chillers (AC)	47	45	43	41	39	37	35	33	31	29	27
IPR	14	13	13	12	12	11	11	10	10	9	9

Source: EPA (2018).

[2] Based on average consumption in 2012-2016.

The Vintaging Model assumes the average charge of HCFC-123 in centrifugal chillers to be 445 kg (980 lbs.). IPR has a modeled charge of approximately 618 kg (1,360 lbs.) of HCFC-123, an average to represent the wide variety of such systems.

Table 4 presents the projected installed base of HCFC-123 in chillers and IPR in metric tons (MT).

Table 4: Projected Installed Base of HCFC-123 in AC, Refrigeration, and Fire Suppression Units (MT), 2020-2030

Equipment Type	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Chillers (AC)	20,900	20,000	19,100	18,300	17,400	16,500	15,600	14,700	13,800	13,000	12,100
IPR	8,400	8,100	7,800	7,500	7,200	6,900	6,600	6,300	6,000	5,700	5,300
Total	**29,300**	**28,100**	**26,900**	**25,800**	**24,600**	**23,400**	**22,200**	**21,000**	**19,800**	**18,700**	**17,400**

Source: EPA (2018).

Projected AC and refrigeration demand for HCFC-123 was approximately 1,990 MT in 2015, decreasing to 1,010 MT in 2019. Table 5 presents projected HCFC-123 demand for servicing equipment from 2020 through 2030. In 2020, approximately 560 MT of HCFC-123 is estimated for servicing AC and refrigeration equipment. This estimate is projected to decrease to 320 MT by 2030. To estimate future market demand for HCFC-123 fire extinguishers, EPA consulted with industry. Over the past several years, demand has varied. The average is approximately 260 MT per year.[3] For purposes of this report, EPA is assuming that current fire suppression demand remains at this average level through 2030, and the demand for fire suppression can be met with pre-2020 inventory of HCFC-123 and/or recycled or reclaimed material.[4]

Table 5: Projected HCFC-123 Demand for AC, Refrigeration, and Fire Suppression Equipment (MT), 2020-2030

Equipment Type	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Chillers (AC)	210	200	190	180	170	160	150	150	140	130	120
IPR	350	330	320	310	290	280	260	240	230	210	200
Fire Suppression [a]	260	260	260	260	260	260	260	260	260	260	260
Total	820	790	770	750	720	700	670	650	630	600	580

Source: EPA (2018) and stakeholder input.

[a] Assumes no change from current demand. Is inclusive of charging new fire suppression equipment and servicing existing equipment.

Note: Numbers may not sum due to independent rounding.

3.2 HCFC-124

HCFC-124 is used in the refrigeration sector mainly in IPR and medium temperature retail food refrigeration (small condensing units). Average consumption of HCFC-124 over the past 5 years was 250 MT per year.[5] That number has varied significantly, but is reasonably consistent with the 2015-2019 consumption allocation of approximately 200 MT. Reclamation of HCFC-124 is minimal (averaging 2 MT per year), so servicing demand for equipment operating on HCFC-124 and blends thereof is primarily met from consumption.

[3] EPA has some information that suggests there could be stockpiling of HCFC-123 underway for fire suppression or for other uses and will continue to examine the 2018 data.

[4] This projection does not consider the role that alternatives could play in affecting future market demand for HCFC-123 in fire suppression.

[5] Based on average consumption in 2012-2016.

Because the market for refrigerants containing HCFC-124 is so small and is primarily for use in equipment that was retrofitted from a CFC refrigerant, EPA is relying on recent refrigerant sales data collected by the California Air Resources Board (CARB). The CARB data summary displayed in Table 6 shows that in California, the amount of HCFC-124 included in blends and as neat refrigerant sold in 2013 totaled 18 MT, which decreased to 12 MT in 2015, and further decreased to 8 MT in 2016. If use were proportional to population, the California values would imply approximately 150 MT of HCFC-124 for the entire United States in 2013, decreasing to 98 MT in 2015, and further decreasing to 65 MT in 2016 (CARB 2018).[6] The 2013-2016 trend provides insight into the transition away from HCFCs and the retirement of legacy CFC systems that were retrofitted to use an HCFC blend, and is consistent with feedback from stakeholders.

Table 6: Summary of California Sales Data for HCFC-124 in Blends and Refrigerant (MT), 2012-2016

HCFC	2012	2013	2014	2015	2016
HCFC-124	43	18	18	12	8

Based on recent sales data in California, recent consumption, and feedback from stakeholders, EPA estimates that annual demand for HCFC-124 is 100 to 200 MT for servicing AC and refrigeration equipment in 2020, with a lower amount estimated for servicing in 2030.

Section 4. Projected Recovery and Reclamation Scenarios for HCFC-123

The Vintaging Model provides an estimate of how much HCFC-123 can be recovered from retiring equipment for reuse. The modeled recovery scenario for HCFC-123 assumes a 90 percent recovery rate for HCFC-123 chillers and IPR systems that have reached end of life. The Vintaging Model does not project whether the recovered HCFC-123 is reclaimed (it could be stockpiled and/or used by the same owner in other equipment); however, the amount recovered from retiring equipment provides an estimate of the amount that may be available for use in other equipment, after it is reclaimed.

Figure 1 below shows how reported HCFC-123 reclamation, which could include material recovered from retiring equipment or recovered during servicing events of equipment still in operation, compares to the Vintaging Model's modeled recovery. Based on the comparison, the Vintaging Model projection and actual amounts of reclaimed HCFC-123 both increase at a similar rate. However, the model projects higher estimates of recovered HCFC-123, particularly after 2010, than the amount that was reclaimed.[7] An increase in recovered HCFC-123 is expected in the future, because HCFC-123 systems have such long lifetimes and many have not reached their end of life yet. As these appliances are retired, more HCFC-123 will likely be available for recovery and reclamation given the low leak rates and large charge sizes.

[6] Population data from the United States Census Bureau, available at https://factfinder.census.gov/faces/tableservices/jsf/pages/productview.xhtml?pid=PEP_2017_PEPANNRES&src=pt. Accessed on March 13, 2018.

[7] Annual reclaim totals disaggregated by ODS are available at www.epa.gov/section608/summary-refrigerant-reclamation.

Figure 1: Comparison of HCFC-123 Reported Reclamation and Modeled Recovery (MT), 2000-2017

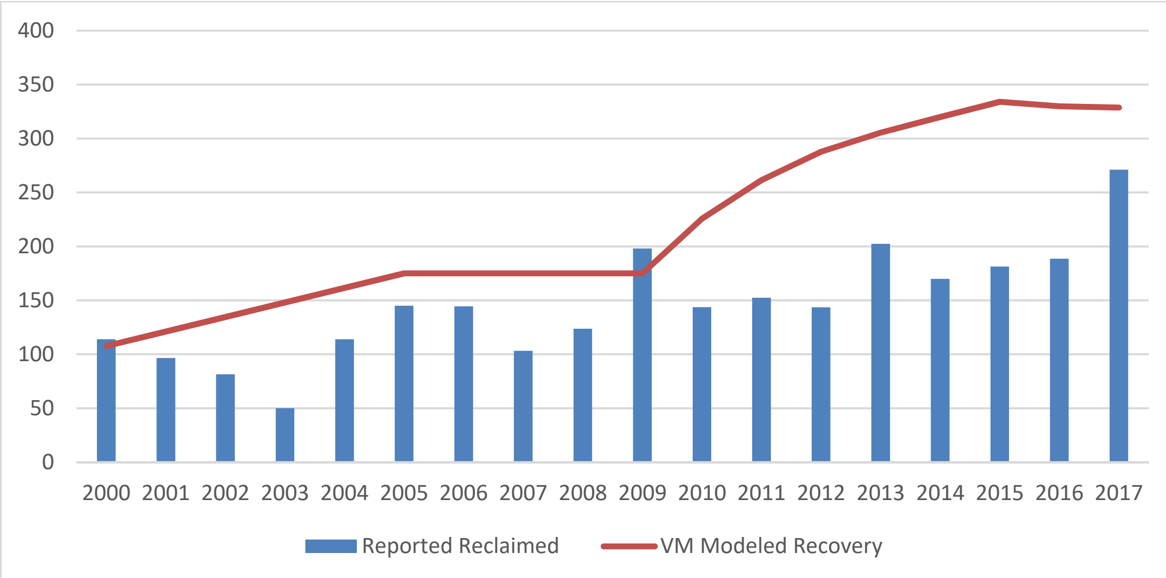

Table 7 provides annual HCFC-123 reclamation data since 2009.

Table 7. Reported HCFC-123 Reclamation (MT), 2009 - 2017

	2009	2010	2011	2012	2013	2014	2015	2016	2017
Reclamation	198	145	152	145	202	170	181	188	271

As noted above, while EPA expects the amount of HCFC-123 that is recovered for reuse to rise, that number is higher than what is reclaimed in most years. Table 8 below shows an estimate of future reclamation values based on recent trends in HCFC-123 reclamation shown in Table 7. The range in each year is calculated based on average growth in HCFC-123 reclamation between 2009 and 2017 on the low end of the range, and 2012 and 2017 on the high end.

Table 8: HCFC-123 Expected Reclamation (MT), 2020-2030

	2020	2025	2030
Expected Reclamation (Extrapolated)[a]	300-350	340-480	390-610

[a] Linearly extrapolated HCFC-123 reclamation data from 2009 to 2017 on the low end of the range, and 2012-2017 on the high end.

Table 9 shows the total estimated market demand for HCFC-123 for all AC, refrigeration, and fire suppression uses, and the expected recovery and reclamation of HCFC-123.

Table 9: HCFC-123 Modeled Supply and Demand (MT), 2020-2030

	2020	2025	2030
Estimated Demand	820	700	580
Modeled Recovery [a]	970[b]	1,060	1,120
Expected Reclamation (Extrapolated)[c]	300-350	340-480	390-610

Source: EPA (2018).
[a] HCFC-123 recovery estimates are modeled from the Vintaging Model. These estimates do not reflect potential increases in recovery associated with the increased equipment estimates for HCFC-123 fire suppression systems.
[b] There is a large modeled increase in HCFC-123 recovery in 2018 when the first vintages of HCFC-123 chillers (assumed to have entered the market in 1992) reach end-of-life. Prior to 2018, there was a minimal amount of recovery from older HCFC-22 units that were replaced with HCFC-123. For 2015-2017, EPA estimated 330 MT of HCFC-123 was available for recovery and reclamation.
[c] Linearly extrapolated HCFC-123 reclamation data from 2009 to 2017 on the low end of the range, and 2012-2017 on the high end.

Appendix A: Methodology Used to Calculate Projected Servicing Demand

This appendix outlines the methodology used to calculate the projected servicing demand and new chemical demand of refrigeration, AC, and fire suppression equipment using HCFC-123 and HCFC-124. This appendix contains two sections:

- Section 1 provides an overview of EPA's Vintaging Model (EPA 2018), which was used to estimate the units of equipment using HCFC-124 for servicing demand and HCFC-123 for new equipment demand and servicing demand beyond 2020.
- Section 2 discusses the limitations to the servicing projections presented in this report.

1. EPA's Vintaging Model

EPA's Vintaging Model was developed as a tool for estimating the annual chemical emissions from industrial sectors that have historically used ODS in their products. Emissions are estimated from the following end-use sectors: 1) Air-Conditioning and Refrigeration; 2) Foams; 3) Aerosols; 4) Solvents; 5) Fire Suppression; and 6) Sterilants. Within these sectors, there are over 65 independently modeled end-uses. The model requires information on the market growth for each of the end-uses, as well as a history and projection of the market transition from ODS to alternatives. As ODS are phased out, a percentage of the market share originally filled by the ODS is allocated to substitutes.

The model, named for its method of tracking the emissions of annual "vintages" of new equipment that enter into service, is a "bottom-up" model. This means it models the consumption of controlled ozone-depleting substances and their substitutes based on:

- Estimates of the quantity of equipment or products sold, serviced, and retired or retrofitted each year, and

> **Box A-1: Developing and Maintaining EPA's Vintaging Model**
>
> The Vintaging Model synthesizes data from a variety of sources, including:
>
> - EPA's ODS Tracking System and submissions to the SNAP program, both maintained by the U.S. EPA Stratospheric Protection Division;
> - Published literature from the United Nations UNEP Technical Options Committees, the Alternative Fluorocarbons Environmental Acceptability Study (AFEAS), and those provided in industry-related and EPA conference proceedings; and
> - Numerous representatives at companies and trade associations, such as the Alliance for Responsible Atmospheric Policy, the Air-Conditioning Heating and Refrigeration Institute (AHRI), the Association of Home Appliance Manufacturers (AHAM), and the Alliance of Automobile Manufacturers.
>
> In some instances, the unpublished information that EPA uses in the model is claimed as Confidential Business Information (CBI). The annual emissions inventories of chemicals are aggregated in such a way that CBI cannot be inferred.
>
> The Vintaging Model is continually updated to improve assumptions and modeling techniques and refine inputs based on information received from these sources. Since 2014, the AC and refrigeration sectors of the Vintaging Model have been updated multiple times. In 2017, an update to the centrifugal chillers end-uses had an impact on the projected service, leak, and new chemical demand, as well as disposal recovery of HCFC-123.
>
> EPA shares the revised assumptions and results of model improvements with industry through the annual *Inventory of U.S. Greenhouse Gas Emissions and* Sinks and other publications such as this one as well as through presentations, such as those given at the March 2014 Spring Meeting of the Halon Alternatives Research Corporation (HARC). In 2017, a peer review was conducted on end-uses within the refrigeration/AC and fire suppression sectors.

- The quantity of the chemical required to manufacture and/or maintain the equipment.

The model makes use of this market information to build an inventory of in-use stocks of equipment and quantities of ODS/ODS substitutes in each of the end-uses.

Emissions are estimated by applying annual leak rates, service emission rates, and disposal emission rates to consumption data for each vintage of equipment. Emissions from AC and refrigeration equipment are split into two categories: emissions during equipment lifetime and disposal emissions. The first category includes the amount of chemical leaked during equipment operation and the amount of chemical emitted during service. Consumption required to service or refill equipment is driven by the need to replace such losses, and therefore, emissions during the lifetime of equipment are equal to consumption for servicing (since it is assumed that all leaked refrigerant is replaced). Emissions, and therefore, consumption from leakage and servicing can be expressed as follows:

$$\mathbf{Es_j = (l_a + l_s) \times \Sigma\, Qc_{j-i+1} \text{ for } i=1 \rightarrow k}$$

Where:

E_{sj} = Emissions from Equipment Serviced. Emissions in year j from normal leakage and servicing of equipment.

l_a = Annual Leak Rate. Average annual leak rate during normal equipment operation (expressed as a percentage of total chemical charge).

l_s = Service Leak Rate. Average leakage during equipment servicing (expressed as a percentage of total chemical charge).

Q_c = Quantity of Chemical in New Equipment. Total amount of a specific chemical used to charge new equipment in a given year by weight.

i = Counter, runs from 1 to lifetime (k).

j = Year of emission.

k = Lifetime. The average lifetime of the equipment.

The assumptions used in this calculation range by equipment, refrigerant, and vintage, reflecting that as new technologies replace older ones, improvements in their leak, service, and disposal emission rates are assumed to occur.

Estimates from EPA's Vintaging Model are often cross-checked with actual historical data from EPA's ODS Tracking System, which tracks actual ODS production and consumption (including import and export) by U.S. companies, and to data reported under the Greenhouse Gas Reporting Program, which implements 40 CFR Part 98.

2. Limitations and Caveats

This analysis utilized the best data available from various sources. Nonetheless, when making projections several assumptions are required. The following caveats are noted below.

a. Recycled or Reclaimed Material

EPA's Vintaging Model was used to inform the quantities of HCFC-123 from existing (recycled or reclaimed) sources that can meet post-2020 servicing demand. Throughout an equipment's lifetime, the Vintaging Model assumes a loss rate that represents the percent of the total charge that leaks in a given year plus the amount, on an annual basis, emitted at service. Because the amount lost from leaks and servicing is annualized, equipment is assumed to reach the end of its lifetime with a full charge.[8] EPA's Vintaging Model then applies a "recovery rate," which refers to the percent of total charge of the equipment that is recovered and reused at the time of disposal. These recovery rates represent averages, intended to capture the range of possible practices occurring at disposal.

Differences between modeled and actual equipment lifetimes, recovery rates, and charge sizes can affect estimated recovery. For example, the Vintaging Model predicts a significant increase in modeled recovery of HCFC-123 in 2018, because that is the first year the Vintaging Model assumes HCFC-123 chillers are retired (i.e., 25 years after installation). A similar increase in actual HCFC-123 recovery is expected in the future as HCFC-123 systems are retired.

The model aggregates the quantities recovered but does not distinguish the "pool" of available material (e.g., refrigerant) between quantities that are reclaimed versus those that are possibly recycled and reused. The model then assumes that the entire pool of recovered material re-enters the market within the same year. The model assumes that any additional demand for material above the estimated amount recovered is met by virgin manufacture. The recovery pool and the remaining virgin manufacture are evaluated only at the most aggregate level, across all end-uses, and not at the end-use level, as the model does not differentiate between virgin and recycled material when calculating demand for each end-use. This model attribute reflects a more realistic scenario in that reclaimers are not likely to only sell back to the end-use market sector from which the used material originated (e.g., chillers); rather, reclaimed material can be retailed to the overall market for each specific HCFC.

The model does not consider the quantity of material that companies send off for destruction after equipment is decommissioned. Although the quantities of destroyed material are very small, they are *not* subtracted from the recovered pool, so the quantity available for reuse may be slightly overestimated in the model. Additionally, the model does not account for any stockpiling of recovered material beyond a one-year timeframe. To the extent that stockpiling has occurred over the last few years, the quantity of recovered material modeled as re-entering the market may be overestimated in earlier years (i.e., when material is banked), and the quantity modeled as re-entering the market in later years may be underestimated (i.e., when the accumulated stockpile is accessed as a source).

To address these potential limitations in modeled demand and recovery, EPA has presented both a modeled recovery number, as well as an estimate based on recent reclamation trends to support HCFC-123 demand assumptions.

b. Date of Retirement and Date of Installation of HCFC-123 and HCFC-124 Units

The model assumes that the entire vintage of HCFC-123 and HCFC-124 units within a given end-use sold or shipped in a given year are being installed and retired in the same year, whereas, in reality some of these units may instead be installed a year or two after shipment, starting their lifetime and servicing demand a year or two after the shipment date. Given the use of an average lifetime in the model, variations of a year or two between shipment and installation date should fall within "normal" fluctuations in lifetime seen in actual equipment use. Furthermore, equipment operating conditions and

[8] For the majority of equipment types, the assumption that equipment contains a full charge at the end of life is theoretically applicable. To ensure proper and continual functioning of equipment, homeowners and businesses typically have their AC and refrigeration systems serviced regularly. Technicians will check these systems for leaks using proper techniques and if a loss of refrigerant is found, will refill the system to ensure it is functioning efficiently after repairing any leaking seals or damaged components.

owner decisions may limit or extend the actual time from equipment installation until retirement. For these reasons, the model is not necessarily accurately reflecting the actual start and end date for servicing demand for this subset of equipment. Instead, the model uses an average lifetime for each unique equipment type. This average is intended to account for units that are used for a few years less than the assumed useful life as well as those that are used well beyond their assumed useful life.

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