THE U.S. PHASEOUT OF HCFCS:

PROJECTED SERVICING NEEDS IN THE U.S. AIR-CONDITIONING AND REFRIGERATION SECTOR

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PRELIMINARY DRAFT REPORT

Disclaimer

This report presents estimates of the projected quantity of HCFC-22 needed to service air-conditioning and refrigeration equipment and the anticipated installed base of such equipment beyond 2010 in the United States. The objective of this analysis is to provide a resource to assist in the allocation of future HCFC consumption caps. The analyses prepared to date are preliminary in nature and will be revised based on input from stakeholders. A revised report will be prepared.

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Executive Summary

Hydrochlorofluorocarbons (HCFCs) are a class of chemicals that deplete the stratospheric ozone layer, leading to overexposure of ultraviolet (UV) radiation at the earth's surface. Excessive UV radiation damages biological systems and causes malignant melanoma and other skin cancers, cataracts, and harm to certain crops and marine organisms. Reversing the course of ozone depletion is crucial to human and environmental health worldwide. As a Party to the Montreal Protocol, the United States is subject to a cap on the consumption of HCFCs in an international effort to protect the stratospheric ozone layer. Specifically, the United States is obligated to phaseout consumption of HCFCs by 2030 by making graduated reductions in HCFC consumption by certain dates. In order to meet these interim reduction targets, the U.S. Environmental Protection Agency (EPA) began by establishing a schedule for the phaseout of HCFCs with the highest ozone depletion potentials (ODPs), namely HCFC-141b, HCFC-142b, and HCFC-22. The next phaseout milestone occurs on January 1, 2010, when the production and import of HCFC-142b and HCFC-22 (unless for use in equipment manufactured prior to January 1, 2010) will cease. Under the restrictions, between 2010 and 2020, both the production and import of HCFC-142b and HCFC-22 are still permitted to service existing equipment.

In the United States and worldwide, the primary use of HCFC-22 is as a refrigerant (UNEP 2003a). While HCFC-142b is also used as a refrigerant (blended with other constituents), its primary use is as a blowing agent in the foam industry. Estimated consumption of HCFC-22 in the U.S. air-conditioning (AC) and refrigeration industry currently totals approximately 111,510 metric tons, and is by far the largest use of an HCFC by any U.S. industry (EPA 2005a). For this reason, and because the allowable servicing of existing equipment between 2010 and 2020 is applicable primarily to the AC and refrigeration industry, this report presents estimates of the projected quantity of HCFC-22 needed to service AC and refrigeration equipment and the anticipated installed base of such equipment beyond 2010. In quantifying future servicing needs and evaluating how these needs can be met, the objective of this analysis is to provide a resource to assist in the allocation of future consumption caps.

In projecting servicing needs, this report examines the primary sources of R-22[1] to service and maintain equipment after 2010, which include the amounts recovered from converted or retired equipment that are subsequently recycled or reclaimed (i.e., "recovered") and the limited virgin production and import quantities distributed through allowances.[2] It is projected that in 2010, approximately 66,300 metric tons of R-22 will be required to service installed AC and refrigeration equipment, with 29 percent of these needs projected to be met through the use of recovered refrigerant—although 100 percent of the anticipated servicing demand could be met within the U.S. consumption cap if needed. In 2015, 49,600 metric tons of R-22 is projected to be required for servicing, with 61 percent of demand projected to be met through the use of recovered refrigerant supplies. In 2020, the projected quantity required for servicing is 25,600 metric tons, which, because of the phaseout requirements, must be met entirely through the use of recovered material.

Table ES-1 and Figure ES-1 present the overall projected R-22 servicing demand compared to two U.S. HCFC consumption cap scenarios: in the first scenario, it is assumed that 100 percent of the HCFC cap in 2010 and 2015 will be assigned to R-22; in the second scenario, only a portion (i.e., 90 percent) is assigned to R-22 in 2010 and 2015. These scenarios illustrate the amount of leeway available if the projected quantities of recovered supplies are not as robust as anticipated in this analysis, or if actual demand is greater than projected. As shown, in both scenarios, the consumption cap is significantly greater than projected R-22 servicing demand in 2010, including the anticipated demand that can be met through recovered R-22 supplies. Additionally, the table and figure show that, in 2015 through 2020 (and beyond), the total projected R-22 servicing demand is estimated to exceed the consumption cap, and therefore, the use of recovered refrigerant will be necessary to avoid R-22 supply shortfalls.

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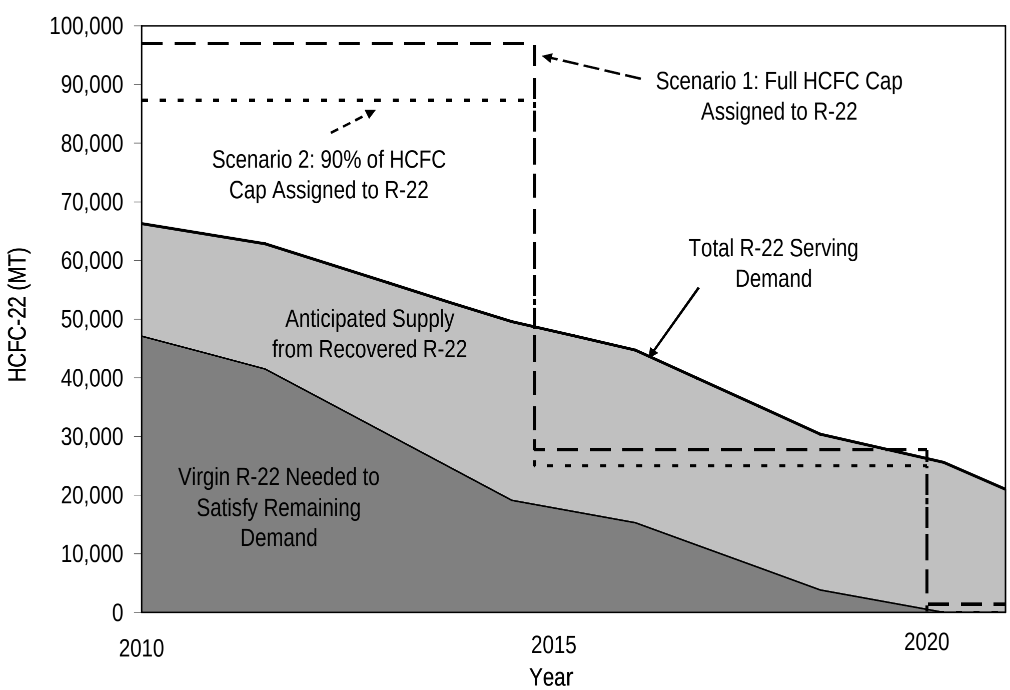
[1] The nomenclature 'R' as used in this report denotes an HCFC and an HCFC blend when it is used as a refrigerant.
[2] The import of used R-22 as approved by EPA is another source; however, this source is not included in the projections of this analysis.

Table ES-1: Summary of Projected R-22 Supply, Demand, and Surplus (R-22 Metric Tons)[a]

Projected R-22 Servicing Demand Summary	2010	2015	2020
Total R-22 servicing demand	66,300	49,600	25,600
Anticipated R-22 supplied from recovery/reuse	19,100	30,400	25,600
Estimated virgin R-22 supply needed to satisfy remaining demand	47,100	19,100	0
Scenario 1: Full HCFC Cap Assigned to R-22			
Virgin R-22 supply available under cap	96,982	27,709	0[b]
Estimated virgin R-22 supply needed to satisfy remaining demand	47,100	19,100	0
Additional virgin R-22 allowable under cap	49,882	8,609	0
Scenario 2: 90% of HCFC Cap Assigned to R-22			
Virgin R-22 supply available under cap	87,283	24,938	0[b]
Estimated virgin R-22 supply needed to satisfy remaining demand	47,100	19,100	0
Additional virgin R-22 allowable under cap	40,184	5,838	0

[a]Quantity expressed in R-22 metric tons, calculated using an ODP of 0.55 for HCFC-22.
[b]In 2020, 0.5 percent of the U.S. consumption cap remains; however, the phaseout schedule in 2020 prevents any allocation of the remaining cap to R-22.

Figure ES-1: Total Projected R-22 Servicing Demand[a]



[a]Scenario 1, as shown in this figure, assumes that 100% of the cap is assigned to R-22. In 2020, 0.5 percent of the U.S. consumption cap remains; however, the phaseout schedule in 2020 prevents any allocation of the remaining cap to R-22.

Under the future scenarios developed in this analysis, the AC and refrigeration industry can satisfy future R-22 servicing needs using both recovered refrigerant and limited amounts of virgin refrigerant without jeopardizing U.S. compliance with the Montreal Protocol. Moreover, it is projected that the U.S. consumption cap will accommodate limited consumption of other HCFCs for use in the AC/refrigeration or other industries (e.g., blends containing HCFC-123 in the fire protection industry, HCFC-225 ca/cb in the solvent cleaning industry). However, the use of significant quantities of recovered refrigerant will be necessary to avoid R-22 supply shortfalls within the AC and refrigeration industry.

This analysis used EPA's Vintaging Model in conjunction with industry collaboration to form the quantitative estimates on projected servicing needs. It is important to note, however, that future R-22 servicing demand and available supply estimates presented in this report are dependent on various market trends, including:

- Changes in equipment charge sizes to accommodate the 13 SEER energy standard;
- Rate of market transition to alternative refrigerants in the United States;
- Assumed equipment leak and servicing loss rates;
- Levels of refrigerant recovery for reuse, reclamation, and/or banking;
- Levels of imports of used R-22; and
- Levels of imports of precharged R-22 equipment.

These factors are addressed in this report, to the extent possible.

The primary use of HCFC-142b is in the U.S. foam industry, where there is no servicing of equipment. Although not thoroughly explored in this analysis, servicing needs for R-142b equipment (currently used mostly in a blend in retail food refrigeration equipment) are not projected to exist beyond 2010 for the AC and refrigeration industry.

The projected scenarios highlighted in this analysis provide a basis for further collaboration with the AC and refrigeration community to gain consensus on future servicing needs and to solidify efforts to maximize supplies (through reuse) in order to achieve the next HCFC phaseout targets.

1. Background: The U.S. HCFC Phaseout Schedule

Title VI of the Clean Air Act (CAA) mandates the development and implementation of regulations to protect the stratospheric ozone layer and ensure U.S. compliance with the *Montreal Protocol on Substances that Deplete the Ozone Layer* (the Protocol). Under the Protocol, the United States and other signatories are obligated to achieve progress toward the total phaseout of the consumption and production of hydrochlorofluorocarbons (HCFCs), which are ozone depleting substances (ODS) widely used as refrigerants, solvents, foam blowing agents, and fire extinguishants.[3] Consumption is defined as "production plus import minus export," and production is defined as the manufacture of a controlled substance from any raw material or feedstock chemical, but does not include production of feedstocks or the reuse or recycling of a controlled substance.

Table 1-1 presents the HCFC consumption cap and the graduated reductions to allowable HCFC consumption for the United States (and all non-Article 5 [developed] countries), as determined for compliance with the Protocol. The first HCFC phaseout milestone was in 1996, when HCFC consumption levels were capped at 1989 ozone depleting potential (ODP)-weighted HCFC consumption levels plus 2.8 percent of the ODP-weighted 1989 CFC consumption. The second phaseout milestone occurred on January 1, 2004, when HCFC consumption limits were reduced by 35 percent of the above cap, which is to be followed by a 65 percent reduction in 2010, a 90 percent reduction in 2015, a 99.5 percent reduction in 2020, and a complete phaseout in 2030.

Table 1-1: U.S. HCFC Consumption Phaseout Targets Under the Montreal Protocol

Date	Consumption Cap	ODP Weighted Quantity	Quantity Expressed in R-22 Metric Tons[a]
Jan 1, 1996	Consumption freeze capped at 2.8% of the 1989 ODP-weighted CFC consumption plus 100% of the 1989 ODP-weighted HCFC consumption	15,240 ODP-metric tons (33.6 mm ODP lbs)	277,091 metric tons (610 mm lbs)
Jan 1, 2004	35% reduction of the cap	9,906 ODP metric tons (21.8 mm ODP lbs)	180,109 metric tons (396 mm lbs)
Jan 1, 2010	65% reduction of the cap	5,334 ODP metric tons (11.8 mm ODP lbs)	96,982 metric tons (214 mm lbs)
Jan 1, 2015	90% reduction of the cap	1,524 ODP metric tons (3.36 mm ODP lbs)	27,709 metric tons (61 mm lbs)
Jan 1, 2020	99.5% reduction of the cap	76.2 ODP metric tons (167,992 ODP lbs)	1,385 metric tons (3.05 mm lbs)[b]
Jan 1, 2030	100% reduction of the cap	0	0

[a]Calculated using an ODP of 0.055 for HCFC-22.
[b]In 2020, only 0.5 percent of the U.S. consumption cap remains; however, the phaseout schedule in 2020 prevents any allocation of the remaining cap to R-22.

Table 1-2 details the U.S. phaseout schedule for HCFCs established under the CAA to comply with the targets set by the Montreal Protocol (as presented in Table 1-1). As shown, the production and import of HCFC-141b, the HCFC with the highest ODP, was banned with limited exemptions beginning January 1, 2003. To meet the next phaseout milestone beginning January 1, 2010, the production and import of HCFC-142b and HCFC-22 (unless for use in equipment manufactured prior to January 1, 2010) will cease. The phaseout for all other HCFCs, such as HCFC-123, begins on January 1, 2015, when production and import is restricted except for use as a refrigerant in equipment manufactured before January 1, 2020. The final phase out for all HCFCs occurs on January 1, 2030.

[3] The production and import of other ODS used by these industries, including chlorofluorocarbons, carbon tetrachloride, and methyl chloroform, were phased out in 1996 – halons in 1994 (with limited exemptions).

Table 1-2: U.S. HCFC Phaseout Schedule Mandated Under the CAA (to Comply with the Protocol)

Date	Affected Substances	Restriction
Jan 1, 2003	HCFC-141b	• No production and no import of HCFC-141b
Jan 1, 2010	HCFC-142b, HCFC-22	• No production and no import of HCFC-142b and HCFC-22, except for use in equipment manufactured before 1/1/2010
Jan 1, 2015	All Other HCFCs	• No production and no import of any HCFCs, except for use as a refrigerant
Jan 1, 2020	HCFC-142b, HCFC-22	• No production and no import of HCFC-142b and HCFC-22 • No production and no import of any other HCFCs except for use as a refrigerant in equipment manufactured before 1/1/2020
Jan 1, 2030	All Other HCFCs	• No production and no import of any HCFCs

Source: EPA (2004a; 2005a)

In 2003, the U.S. Environmental Protection Agency (EPA) established an allowance system to control the U.S. consumption and production of HCFCs, at which time, HCFC allowances were distributed for HCFC-141b, HCFC-22, and HCFC-142b (EPA 2003a).[4] Allowances for other HCFCs must still be distributed by EPA; additionally EPA will re-evaluate HCFC-142b and HCFC-22 allocation levels prior to 2010 to determine whether modifications are necessary to meet the 65 percent consumption reduction required in 2010 by the Protocol.

1.1 Report Objective

The objective of this report is to present quantitative estimates of the projected amount of (a) units of equipment using HCFCs beyond 2010 and (b) HCFCs needed to service equipment beyond 2010. In an effort to prepare for the next phaseout scheduled for the United States, this report presents possible future scenarios on the servicing needs for air-conditioning (AC) and refrigeration equipment that will be in use after 2010. These estimates will aid EPA in allocating future HCFC consumption caps.

This analysis focuses primarily on R-22 servicing needs in the AC and refrigeration industry, the largest HCFC market and the largest industry sector using HCFCs in the United States.

The remainder of the report is organized as follows:

- Section 2 provides a brief overview of the methodology used in this analysis to project servicing scenarios. A further discussion on the methodologies can be found in Appendix A.
- Section 3 provides an overview of the AC and refrigeration industry and presents current consumption and servicing estimates for all HCFCs used in this sector;
- Section 4 provides projected scenarios for units of equipment utilizing R-22 and R-22 servicing needs.
- Section 5 summarizes the key findings of the analysis.
- Appendix A presents the projection methodology and the associated limitations.
- Appendix B provides AC and refrigeration projections by end-use.

[4] The production of one kilogram of HCFC requires the expenditure of one production allowance and one consumption allowance. The import of one kilogram of HCFC requires the expenditure of one consumption allowance. While the import of *used* HCFCs does not require the expenditure of allowances, it does require petition approval by EPA; see Section 4.2.1 for more detail.

2. Methodology Overview

The main tool used to launch the analysis and form the basis for quantitative estimates on current and projected HCFC consumption was EPA's Vintaging Model. The Vintaging Model was developed as a tool for estimating the annual chemical emissions from industry sectors that have historically used ODS, including AC, refrigeration, foams, solvents, aerosols, and fire protection. Within these industry sectors, there are over 40 independently modeled end-uses. The model uses information on the market size and growth for each of the end-uses, as well as a history and projections 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 each of its substitutes.

The model tracks emissions of annual "vintages" of new equipment that enter into operation by incorporating information on estimates of the quantity of equipment or products sold, serviced, and retired each year, and the quantity of the chemical required to manufacture and/or maintain the equipment. The Vintaging Model makes use of this market information to build an inventory of in-use stocks of equipment and ODS/ODS substitutes in each of the end-uses. A detailed discussion of the Vintaging Model is provided in Appendix A.

As an initial step in this analysis of current and projected HCFC use in the United States, an investigation was conducted into the entire HCFC market, covering all end-uses that utilize HCFCs in the AC and refrigeration, foam, solvents, aerosols, and fire protection sectors. This analysis was conducted by compiling estimates from EPA's Vintaging Model on HCFC consumption for both new manufacturing and the servicing of existing equipment, and the total units of equipment containing HCFCs from 2005 through 2030 by end-use (EPA 2005a). The Vintaging Model data indicate that in 2005, the AC and refrigeration industry represents 96 percent of total HCFC-22 consumption and 86 percent of total HCFC consumption. Therefore, this analysis was narrowed to focus on R-22 servicing needs in the AC and refrigeration industry.

Having established initial estimates, a limited number of industry experts were then contacted to corroborate the findings and market dynamics affecting the servicing needs of the AC and refrigeration industry after 2010. Representatives including those from the Association of Home Appliance Manufacturers (AHAM); Air-Conditioning and Refrigeration Institute (ARI); Carrier Corporation; Heating, Air-Conditioning & Refrigeration Distributors International (HARDI); Hill Phoenix; Honeywell; Raleys; and York were contacted to discuss stationary AC and refrigeration end-uses.[5]

The informal discussions were used to confirm or modify preliminary estimates obtained from the Vintaging Model; information gathered from the discussions was in turn used to refine assumptions and inputs in the Model to improve the estimates provided in this analysis. Additionally, through these efforts, several supplemental analyses were identified and performed to account for several trends expected to affect the AC and refrigeration market and better estimate the projected quantities of R-22 required to service equipment post 2010. Appendix A also includes a discussion of the assumptions and adjustment factors used to develop the supply and demand estimates presented in this report and the limitations and caveats inherent in the analysis.

[5] In order to comply with the Paperwork Reduction Act of 1995, less than ten people were contacted regarding each information category (44 U.S.C. 3502(3)).

3. Current HCFC Use in Air-Conditioning and Refrigeration Equipment

The AC and refrigeration industry encompasses a wide variety of equipment and employs a diversity of HCFC and other refrigerants. This section is organized as follows:

- Sections 3.1 and 3.2 present an overview of AC and refrigeration end-uses, respectively; and

- Section 3.3 provides an overview of HCFC refrigerants used in the AC and refrigeration industry.

3.1 Air-Conditioning End-Uses

AC equipment can be categorized as either mobile or stationary. These broad end-use categories are discussed further below.

Mobile air-conditioning systems include all forms of AC that provide cooling to passenger compartments in all types of moving vehicles. This category can be further broken down into motor vehicle air-conditioning and other mobile air-conditioning systems.

- *Motor vehicle air-conditioning (MVAC)* includes AC in the passenger compartments of light duty vehicles – both cars and trucks (i.e., pick-up trucks, minivans, sport utility vehicles, etc.). A variety of refrigerant blends, many of them including HCFCs, are approved for use in the United States by EPA as replacements for CFC-12 in MVACs. However, these blends have not been endorsed by vehicle or system manufacturers for such use, thereby capturing only a small and declining share of the retrofit market, which consists mainly of HFC-134a. Therefore, the MVAC sector is not discussed further in this analysis.
- *Other mobile air-conditioning* includes AC in the passenger compartments of both buses (including school, transit, and tour buses) and trains (including heavy, light, and commuter rail, and Amtrak trains).[6] Although school bus AC systems converted directly from CFC-12 to HFC-134a, the majority of transit buses, tour buses, and trains continue to use R-22 in their AC systems (Sartin Services 2005; Motorcoach Training 2005; WMATA 2005; Amtrak 2005; NJ Transit 2005).

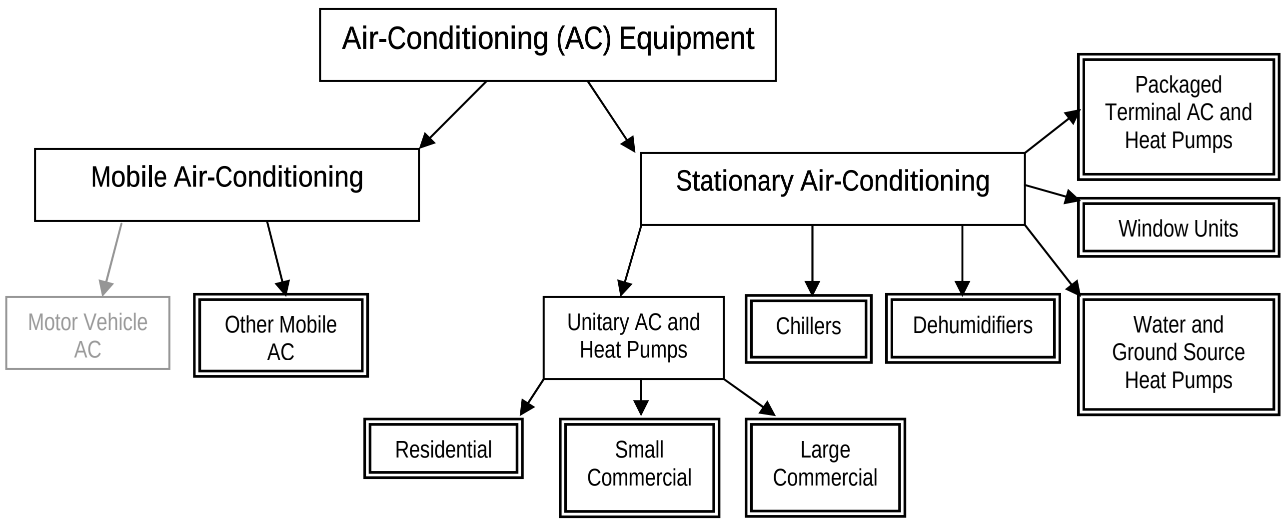
Stationary air-conditioning includes a wide variety of equipment, further categorized into the following six end-uses.

- *Unitary air-conditioners and heat pumps* include both split systems and packaged units and are designed for air circulating, cooling, cleaning, and dehumidifying in residential and small and large commercial applications.
- *Chillers* regulate the temperature and humidity in offices, hotels, shopping centers, and other large buildings. There are four major types of chillers — centrifugal, scroll, reciprocating, and screw — each of which is named for the type of compressor employed. Often, standard AC systems, such as chillers, are customized to be used for industrial applications. Modifications are made to customize the equipment for unusual circumstances (e.g., protection from flammability, high temperatures, or for outdoor use).
- *Dehumidifiers* are mechanical refrigeration systems designed to remove moisture from the air by drawing air first over cold evaporator coils and then warm condenser coils, causing the moisture in the air to condense onto the cold coils. Examples include indoor pool dehumidifiers and portable units used to dehumidify basements.

[6] For the purposes of this report, "other mobile AC" does not include ships, planes, RVs, or construction/farm equipment. In the case of boats, some R-22 is used in AC systems (UNEP 2003a), but this consumption is accounted for in this report under stationary AC equipment, such as packaged terminal units or chillers (Cold Ships 2005).

- *Water and ground source heat pumps* use fluid circulated in a common piping loop as a heat source/sink to cool and heat air. Water-source heat pumps typically use water pumped from a well, lake, or stream as a heat source/sink. Direct expansion geothermal heat pumps circulate refrigerant through piping in the earth.
- *Window units*, also known as room air-conditioners, are small appliances used to condition the air in a single room.
- *Packaged terminal units* are ACs or heat pumps that are mounted on the wall. They are often used in hotel rooms, dormitories, or classrooms.

Figure 3-1: Types of Air-Conditioning Systems[a]



[a]The shaded end-use (MVACs) is assumed to not use HCFC refrigerants; double boxed end-uses are those for which supply and demand projections are estimated in this report.

3.2 Refrigeration End-Uses

Refrigeration equipment can be broken down into four categories: domestic refrigeration, refrigerated transport, industrial process refrigeration, and commercial refrigeration. These categories are described further below.

Domestic refrigeration includes household refrigerators, household freezers, and water coolers. These equipment types are not further analyzed in this report because the refrigerants used for household refrigeration do not typically include HCFCs or blends containing HCFCs.

Refrigerated transport includes refrigeration used in equipment that moves products from one place to another and includes refrigerated ship holds, truck trailers, railway freight cars, and other shipping containers.

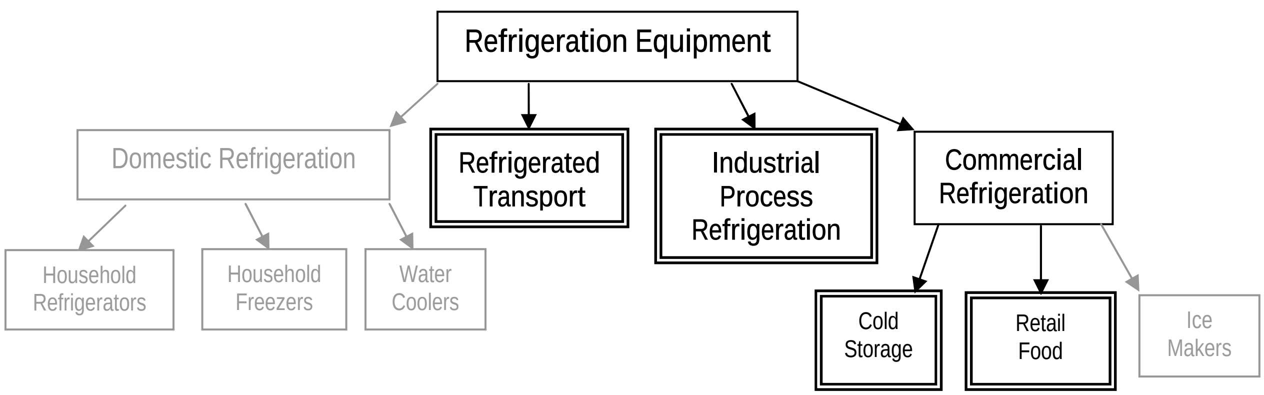
Industrial process refrigeration (IPR) systems are complex, customized systems used to cool process streams in the chemical, food processing, pharmaceutical, petrochemical, and manufacturing industries. This sector also includes industrial ice machines, equipment used directly in the generation of electricity, and ice rinks.

Commercial refrigeration is further broken down into three end-uses:

- *Cold storage warehouses* are refrigeration systems with varying designs and charge sizes. They are used to store meat, produce, dairy products, and other perishable goods before and after food processing.

- *Retail food systems* are used to refrigerate food in commercial retail establishments, such as grocery stores. These systems can be classified as either centralized or self-contained units. Centralized retail food systems, also known as remote systems, consist of a series of compressors and condensers located in a remote machinery room, providing a cooling medium to display cabinets and cold storage rooms in other parts of the building. The most common form of centralized systems circulate refrigerant throughout the store. Alternatives to these types of systems include secondary loop and distributed systems using HFC refrigerant blends. Self-contained retail food units, also referred to as stand-alone systems, are factory produced with all the components integrated. Examples include walk-in refrigerators/coolers/freezers, roll-in refrigerators/freezers, under-counter refrigerators/freezers, reach-in refrigerators/freezers, wine and beer coolers, ice cream machines, beverage vending machines, and all kinds of stand-alone upright or horizontal display cases (e.g., beverage merchandisers, deli cases).
- *Ice makers* are factory-made units used in commercial establishments to produce ice for consumer use (e.g., in hotels, restaurants, and convenience stores). Ice makers are not further analyzed in this report because they do not typically employ HCFCs or blends containing HCFCs.

Figure 3-2: Types of Refrigeration Systems[a]



[a]Shaded areas are assumed to not use HCFC refrigerants; double boxed end-uses are those for which supply and demand projections are estimated in this report.

3.3 HCFC Refrigerants

Historically, chlorofluorocarbons (CFCs) were extensively used as refrigerants in the AC and refrigeration industry; by the 1970s, R-22 and R-502 (a blend of CFC-115 and R-22) were also well established refrigerants. On January 1, 1996, the production and import of CFC refrigerants, classified as Class I ODS under the CAA Amendments of 1990, was phased out. HCFC refrigerants, which also deplete the ozone layer and are classified as Class II ODS under the CAA, were allowed as interim substitutes. Table 3-1 lists the Class II ODS used as refrigerants (or components of refrigerant blends), in descending order according to their ODP.[7] Table 3-1 also lists the phaseout schedule for Class II substances used in both new and existing AC and refrigeration equipment, as required under the CAA.

[7] An ODP value is a measure of a chemical's relative ability to deplete ozone. A reference level of 1.0 is assigned to CFC-11.

Table 3-1: Class II ODS Used as Refrigerants

Class II ODS	CAS Number	Atmospheric Lifetime (years)	ODP[a]	Consumption Phaseout (Starting Jan. 1)	
				New Equipment	Existing Equipment
HCFC-142b (CH_3CF_2Cl)	75-68-3	17.9	0.065	2010	2020
HCFC-22 (CHF_2Cl)	75-45-6	12.0	0.055	2010	2020
HCFC-124 (CF_3CHFCl)	2837-89-0	5.8	0.022	2020	2030
HCFC-123 ($CHCl_2CF_3$)	306-83-2	1.3	0.02	2020	2030

[a]ODP values are taken from the Montreal Protocol (UNEP 2003b).

The remainder of Section 3.3 provides current estimates of the HCFCs and blends containing HCFCs consumed as refrigerants.

3.3.1 HCFC-22

HCFC-22, otherwise known as R-22, was first commercialized as a refrigerant in the 1930s and has been used continuously since that time (UNEP 2003a; Dupont 2005; Calm and Domanski 2004). R-22 is the most common HCFC refrigerant used in AC and refrigeration applications.

Potential non-ODS candidates to replace R-22 vary by application and include HFC-134a, R-404A (composed of HFC-125/HFC-143a/HFC-134a), R-407C (composed of HFC-32/HFC-125/HFC-134a), R-410A (composed of HFC-32/HFC-125) and R-507A (composed of HFC-125/HFC-143a).

Table 3-2 presents current estimates of R-22 consumption and the estimated percent of that consumption that is used to service AC and refrigeration equipment. These estimates were developed based on data from the Vintaging Model (EPA 2005a) and information provided by industry contacts. Appendix A explains the methodology used to develop these estimates and disaggregates servicing estimates by equipment type. As shown in Table 3-2, current estimated consumption of R-22 for both AC and refrigeration equipment totals approximately 111,600 metric tons. Approximately 63 percent of this consumption is for servicing existing equipment, with the refrigeration industry using a higher percentage of its total consumption to service equipment than the AC industry. The majority of R-22 consumption for servicing is currently attributed to residential and small commercial unitary AC equipment and chillers, followed by retail food refrigeration equipment (see Appendix B).

Table 3-2: Summary of U.S. R-22 Consumption (2005)[a]

Equipment Type	Total Consumption for New Manufacturing and Servicing (Metric Tons)	Consumption for Servicing (Metric Tons)	% of Total Consumption for Servicing
Total AC	100,800	60,900	60%
Total Refrigeration	10,800	9,400	87%
Total	111,600	70,300	63%

[a]Quantities of R-22 from blends containing R-22 are factored into these estimates. See Section 3.3.5 for a discussion of blends containing HCFCs.

Since R-22 represents the largest HCFC market in the United States, the projected servicing needs presented in Section 4 focus solely on the use of R-22 and blends containing R-22 in the U.S. AC and refrigeration industry.

3.3.2 HCFC-142b

HCFC-142b, also known as R-142b, is not used as a stand-alone refrigerant but as a constituent of R-409A (composed of HCFC-22/HCFC-124/HCFC-142b). As Table 3-3 presents, only about 100 metric tons of HCFC-142b (used in refrigerant blends) was consumed by the AC and Refrigeration industry in 2005, the majority of which was used to service retail food refrigeration equipment.

The estimates presented in Table 3-3 are drawn directly from the Vintaging Model; this HCFC was not discussed during consultations with industry representatives. The phaseout schedule for HCFC-142b is the same as that for HCFC-22. While the projected servicing needs are not fully explored in the analysis, base estimates from the Vintaging Model indicate that no R-142b will be required to service existing refrigeration equipment beyond 2009.

Table 3-3: Summary of R-142b Consumption (2005)[a]

Equipment Type	Total Consumption for New Manufacturing and Servicing (Metric Tons)	Consumption for Servicing (Metric Tons)	% of Total Consumption for Servicing
Total AC	NA	NA	NA
Total Refrigeration	100	100	100%
Total	100	100	100%

[a]These estimates represent quantities of R-142b from blends containing R-142b. See Section 3.3.5 for a discussion of blends containing HCFCs.

3.3.3 HCFC-123

HCFC-123, also known as R-123, is primarily used as a refrigerant in centrifugal chillers for commercial comfort AC and in industrial process refrigeration. R-123 is the second most commonly used HCFC refrigerant (after R-22), with current overall consumption totaling around 3,200 metric tons—equivalent to about three percent of R-22 consumption. As Table 3-4 indicates, the majority of R-123 is used in AC equipment, specifically for chillers.

The estimates presented in Table 3-4 are drawn directly from the Vintaging Model; R-123 was not discussed during industry consultations. The production and import of virgin HCFC-123 is scheduled for phaseout in 2020 for use in new AC and refrigeration equipment[8] and in 2030 for use in existing AC and refrigeration equipment.

Table 3-4: Summary of R-123 Consumption (2005)

Equipment Type	Total Consumption for New Manufacturing and Servicing (Metric Tons)	Consumption for Servicing (Metric Tons)	% of Total Consumption for Servicing
Total AC	2,600	<50	<1%
Total Refrigeration	600	300	50%
Total	3,200	300	10%

3.3.4 HCFC-124

HCFC-124, otherwise known as R-124, was introduced into the market as a replacement for CFC-114 in specialized centrifugal chillers. Although this use has predominately been phased out, this HCFC is also used in blends, such as R-401A and R-409A, in AC equipment.

As Table 3-5 shows, in 2005, total consumption of R-124 (used in blends) was estimated to be approximately 600 metric tons (or about one percent of total R-22 consumption used in AC and refrigeration applications), all of which was for servicing refrigeration equipment.

[8] In 2015, HCFC-123 production and import will be phased out for all non-refrigerant uses.

The estimates presented in Table 3-5 are taken directly from the Vintaging Model; R-124 was not discussed during industry consultations. The production and import of virgin HCFC-124 is scheduled for phaseout in 2020 for use in new AC and refrigeration equipment[9] and in 2030 for use in existing AC and refrigeration equipment.

Table 3-5: Summary of R-124 Consumption (2005)[a]

Equipment Type	Total Consumption for New Manufacturing and Servicing Demand (Metric Tons)	Consumption for Servicing (Metric Tons)	% of Total Consumption for Servicing
Total AC	NA	NA	NA
Total Refrigeration	600	600	100%
Total	600	600	100%

[a]These estimates represent quantities of R-124 from blends containing R-124. See Section 3.3.5 for a discussion of blends containing HCFCs.

3.3.5 HCFC Refrigerant Blends

Often refrigerants are formulated with several HCFCs and other substances, such as hydrofluorocarbons (HFCs) or propane. R-22 is used as both a stand-alone refrigerant and a component of blends; when used in blends R-142b and R-124 are only used in combination with R-22.[10] Table 3-6 presents the composition of the more common refrigerant blends containing HCFCs.[11]

Table 3-6: HCFC Refrigerant Blend Compositions

Blend	R-22	R-124	R-142b	Other
R-401A	53%	34%		13% R-152a
R-402A	38%			60% R-125, 2% propane (R-290)
R-409A	60%	25%	15%	
R-502	48.8%			51.2% CFC-115

Table 3-7 presents the end-uses in which some of the more common refrigerant blends containing HCFCs are currently used.

Table 3-7: Uses of HCFC-Containing Refrigerant Blends by End-Use

Refrigeration Equipment Type	Refrigerant Type			
	R-401A	R-402A	R-409A	R-502
Retail Food	x	x	x	x
Cold Storage	x	x		x
IPR	x			
Transport	x	x		x

9 In 2015, HCFC-124 production and import will be phased out for all non-refrigerant uses.
10 R-123 is only used as a stand-alone refrigerant.
11 HCFC consumption data presented in this analysis include quantities consumed in blends by employing the percent composition of the corresponding HCFC constituent(s) of that blend. In order to accurately portray the number of units containing HCFC blends, however, blends are not disaggregated when presenting the number of units of equipment (i.e., a unit running on an HCFC-containing blend counts as 1 unit).

4. Projected R-22 Scenarios

Section 4 presents projections of the number of R-22-containing units of equipment and the associated servicing needs for 2010, 2015, and 2020. R-22 scenarios were developed by investigating various trends that are expected to affect future market needs. Such trends include changes to charge sizes, the transition to alternative refrigerants, imports of precharged equipment, and the anticipated changes to refrigerant recovery and reuse.

The remainder of this section is organized as follows:

- Section 4.1 summarizes the projected market size of R-22 containing equipment beyond 2010 in the United States.
- Section 4.2 provides projected estimates of the quantity of R-22 that will be required to service existing equipment beyond 2010, including a breakdown by source (i.e., virgin manufacture or recovered material).
- Section 4.3 discusses the factors that may affect estimates of the installed base and servicing needs for R-22 equipment.

Appendix B presents further detail on the estimates provided in Section 4, disaggregating R-22 containing equipment and overall service demand estimates into end-use specific projections.

4.1 R-22 Equipment Beyond 2010

The majority of equipment that is projected to be in use (i.e., within the installed base) from 2010 onward will be used for AC applications, including window units, packaged terminal units, residential and commercial unitary AC, chillers, dehumidifiers, water and ground source heat pumps, and other mobile AC. As presented in Table 4-1, it is estimated that approximately 74.9 million units of all such types of AC equipment will be in use in 2010, decreasing by about 39 percent in 2015, and 58 percent in 2020. It is projected that in 2010 there will be approximately 33,400 units of refrigeration equipment, including retail food, industrial process refrigeration, and transport refrigeration equipment (but not including cold storage warehouses). The installed base is projected to decrease by about 30 percent in 2015 and by 67 percent in 2020. These estimates were developed based on the Vintaging Model and input from industry representatives. Appendix A provides more detail on the methodology used to develop these projections. Appendix B provides projections disaggregated by end-use.

Table 4-1: Projected Number of R-22 Units (2010-2020)[a,b]

Equipment Type	2010	2015	2020
Total AC	74,858,500	45,565,600	19,138,800
Total Refrigeration	33,400	23,300	7,700
Total	74,891,900	45,588,900	19,146,500

[a] Including units that use blends containing R-22.
[b] The estimates in this table do not include cold storage warehouses, which are expressed in cubic footage. The projected stock of cold storage warehouses is 146,136,700 ft^3 in 2010, 124,468,700 ft^3 in 2015, and 54,055,100 ft^3 in 2020.

4.2 Projected R-22 Servicing Needs

AC and refrigeration equipment commonly require servicing, which may include the need to add refrigerant to account for refrigerant losses (i.e., leaks) that occur over time. While the production and import of R-22 is banned for use in new equipment in 2010, the use of R-22 will still be permitted for servicing and maintenance purposes for equipment manufactured prior to January 1, 2010. Table 4-2 presents projected R-22 demand (including that used in blends) for servicing equipment in 2010, 2015, and 2020. These estimates were developed based on the Vintaging Model and industry input. Appendix A provides further detail on the methodology used to develop these projections. Appendix B provides servicing demand projections disaggregated by end-use.

As presented in Table 4-2, it is projected that in 2010, approximately 66,300 metric tons of R-22 will be required to service AC and refrigeration equipment, of which the majority—60,000 metric tons (90%)—will be used to service AC systems. In 2015, servicing demand is projected to reach approximately 49,600 metric tons of R-22 for AC and refrigeration equipment, and in 2020, the projected quantity declines to 25,600 metric tons. Both the 2015 and 2020 projections of servicing demand exceed the U.S. consumption cap for virgin HCFCs for these years; however, a portion of the servicing needs can be met by using recovered refrigerant, thus decreasing the need for virgin R-22.

Table 4-2: Projected R-22 Servicing Demand (2010-2020) (Metric Tons)

Equipment Type	2010	2015	2020
Total AC	60,000	45,000	23,900
Total Refrigeration	6,300	4,600	1,700
Total	66,300	49,600	25,600

4.2.1 R-22 Sources

To meet servicing demand starting in 2010, the AC and refrigeration industry will be able to produce and import controlled quantities of virgin R-22 limited through allowance allocations distributed by EPA until 2020 (commonly referred to as the service tail).[12] Additionally, the following existing sources of R-22 are available to the AC and refrigeration industry to meet this servicing need, which can offset the need for virgin material:

1. Recovered (i.e., recycled or reclaimed) R-22. Under the current codified regulations (EPA 2004a), refrigerants containing HCFCs must be recovered. After the recovery process, the refrigerant held in the storage container may be:
   a. Recycled (i.e., cleaned through the use of recycling equipment and recharged back into the equipment);
   b. Reclaimed (shipped to an EPA-certified reclaimer); or
   c. Destroyed through the use of environmentally-acceptable technologies (e.g., liquid injection incinerators, rotary kilns) (EPA 2003b).
2. Import of used R-22 that companies can acquire through a petition process.

Each of these existing sources of R-22 is described in more detail below.

Recycled R-22

The recycling process cleans the refrigerant for reuse without meeting all the requirements of reclamation, discussed further below. HCFC refrigerants are commonly recovered from a piece of equipment, adequately cleaned, and then recharged into the same piece of equipment using a recycling device (EPA 2003b).

EPA regulations allow for the recharge of used refrigerant without subsequent reclamation for refrigerants recovered and charged back into the same appliance or to another appliance *if* those appliances are owned by the same establishment.[13] Several establishments, such as supermarkets, employ recycling

[12] Virgin R-22 may be stockpiled; however, the extent to which this activity may occur is unknown. A discussion on stockpiling plans is covered in Section 4.3.3.
[13] If refrigerant changes ownership, however, that refrigerant must be reclaimed.

plans through which the refrigerant is recovered when dismantling one store's equipment and reused to service equipment at another store.

Reclaimed R-22

Refrigerants and refrigerant blends that are resold to be used in other equipment must be reclaimed to a standard level of purity based on the ARI Standard 700, to ensure sufficient purity of the reclaimed refrigerant. Refrigerant reclaimers process recovered refrigerant and send samples of the purified refrigerant off-site for purity verification through numerous tests required by the ARI 700 Standard.

Industry representatives have indicated that the current use of reclaimed HCFCs is minimal because virgin R-22 is less expensive. In 2003, the amount of pure R-22 reclaimed by EPA-certified reclaimers totaled approximately 1,976 metric tons, or 4.36 million pounds (EPA 2005b). The refrigerant blend R-502, composed of 48.8 percent R-22 and 51.2 percent CFC-115, was also reclaimed, representing another 20 metric tons (or 44,088 pounds) of HCFC-22 reclaimed in 2003 (EPA 2005b). Reclamation data from 2000 to 2003 is presented in Table 4-3 below.

Table 4-3: Reclaimed R-22 by Year (Metric Tons)[a]

	2000	2001	2002	2003
R-22	3,218	1,960	2,230	1,976
R-502	281	113	150	41
R-22 in R-502	137	55	73	20
Total	3,355	2,015	2,303	1,996

[a]Source: EPA 2005b.

As 2010 approaches, the price of R-22 will likely increase, and it is expected that the reclamation of R-22 will also increase (Powell 2004). Industry representatives are already reporting market signals indicating that several U.S. companies are expecting a surge in R-22 reclamation (Powell 2004). Where there is a monetary incentive, distributors are more likely to collect refrigerant and pass it on to reclaimers (HARDI 2005).

Imports of Used R-22

Unlike virgin HCFCs, there are no Protocol restrictions on the consumption of used HCFCs.[14] However, in creating the allocation system for the use of HCFCs, EPA developed a shipment-by-shipment petition process for importing used HCFCs as described in 40 CFR Part 82 (EPA 2003a). The petition process ensures that HCFCs are used (and not newly produced) prior to import. An importer needs to petition EPA to import each individual shipment over five pounds of used HCFCs at least 40 working-days before the shipment is to leave the country of export, beginning on the day following the date the petition was received by EPA. EPA reviews and verifies data in the petition and issues the importer an objection notice or a non-objection notice based on their findings. Petitioners that receive a non-objection notice can proceed with the import provided that the non-objection letter received from EPA and the petition accompany the shipment through U.S. Customs within the same control period as the date stamped on the non-objection notice.

Currently, the quantity of used R-22 imports is minimal. The projections in this report do not include the potential future quantities obtained from the import of used R-22; however, this source of already existing used material can offset future demand for virgin production.

[14] "Used controlled substances" are controlled substances that have been recovered from their intended use systems (which may include controlled substances that have been, or may be subsequently, recycled or reclaimed) (EPA 2003a).

4.2.2 Meeting R-22 Service Demand

Table 4-4 provides rough estimates of the projected supply of R-22 that will be (a) recovered refrigerant (i.e., recycled and reclaimed) and (b) new refrigerant. These estimates were developed based on a variety of assumptions, without input from industry (see Appendix A for more details).[15]

Table 4-4: Projected R-22 Supply by Source (Metric Tons)[a]

Equipment Type	2010	2015	2020
Recovered	19,100	30,400	25,600
New	47,100	19,100	0
Total	66,300	49,600	25,600

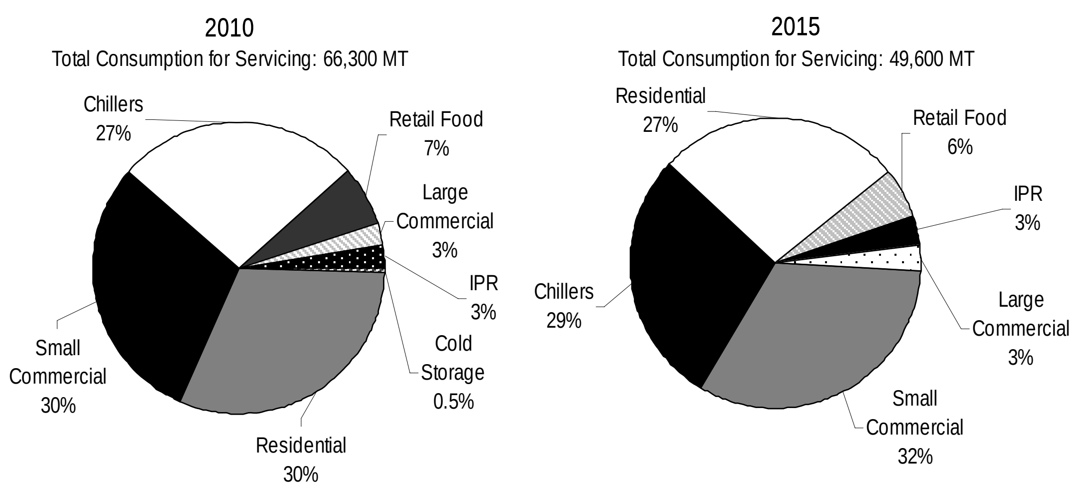
[a]Recovered R-22 includes refrigerant that is either recycled and reused or reclaimed and reused.

As presented, 47,100 metric tons, or 71 percent, of overall R-22 servicing demand is projected to be sourced from virgin manufacture in 2010, decreasing to around 19,100 metric tons (39 percent) in 2015.

Although there is great uncertainty associated with the amounts of R-22 that will actually be recovered and reused in the future, these projections indicate that if recovery and reuse is practiced as modeled, the allowable supply of virgin R-22 is expected to be more than adequate to satisfy any remaining servicing demands in the AC and refrigeration industry, and will be below the U.S. consumption cap in all years. Additionally, imports of used R-22 can supplement supply and alleviate the need for virgin material.

Figure 4-1 displays the breakdown of R-22 servicing demand by AC and refrigeration equipment type for 2010 and 2015. As shown, residential and small commercial AC equipment, followed by chillers, are projected to account for the majority of the R-22 need in 2010. By 2015, small commercial AC, chillers, and residential unitary AC equipment are each projected to account for around 30 percent of the AC and refrigeration market R-22 needs. By 2020, all equipment types are expected to be either retired or utilizing reclaimed or recycled R-22.

Figure 4-1: R-22 Demand for Servicing Equipment, by End-Use



[15] When estimating the projected use of re-used HCFC, the model assumes that a certain percentage of refrigerant, which varies by end-use, is recovered from discarded equipment. The model then assumes that the entire pool of recovered refrigerant re-enters the market (see Appendix A for further details).

Table 4-5 and Figure 4-2 present the overall projected R-22 servicing demand compared to two U.S. HCFC consumption cap scenarios: in the first scenario, it is assumed that 100 percent of the HCFC cap in 2010 and 2015 will be assigned to R-22; in the second scenario, only a portion (i.e., 90 percent) is assigned to R-22 in 2010 and 2015. These scenarios illustrate the amount of leeway available if the projected quantities of recovered supplies are not as robust as anticipated in this analysis, or if actual demand is greater than projected. As shown, in both scenarios, a significant portion of the consumption cap remains available in 2010 beyond what is required to satisfy the projected R-22 servicing demand. Additionally, the table and figure show that, in 2015 through 2020 (and beyond), the use of recovered refrigerant will be necessary to avoid R-22 supply shortfalls.

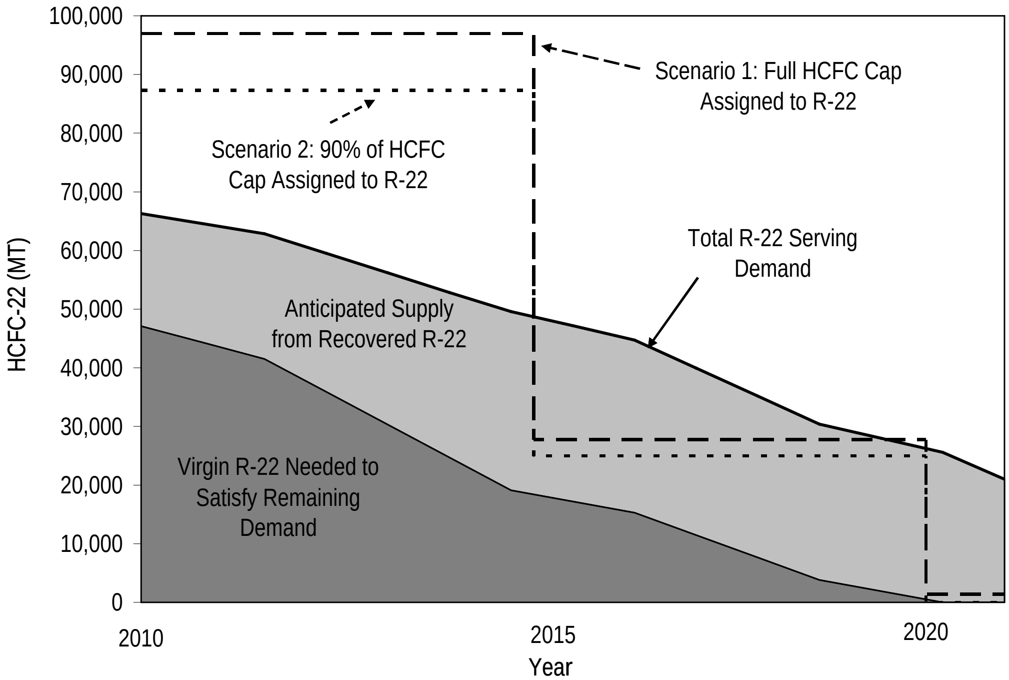
Table 4-5: Summary of Projected R-22 Supply, Demand, and Surplus (R-22 Metric Tons)[a]

Projected R-22 Servicing Demand Summary	2010	2015	2020
Total R-22 servicing demand	66,300	49,600	25,600
Anticipated R-22 supplied from recovery/reuse	19,100	30,400	25,600
Estimated virgin R-22 supply needed to satisfy remaining demand	47,100	19,100	0
Scenario 1: Full HCFC Cap Assigned to R-22			
Virgin R-22 supply available under cap	96,982	27,709	0[b]
Estimated virgin R-22 supply needed to satisfy remaining demand	47,100	19,100	0
Additional virgin R-22 allowable under cap	49,882	8,609	0
Scenario 2: 90% of HCFC Cap Assigned to R-22			
Virgin R-22 supply available under cap	87,283	24,938	0[b]
Estimated virgin R-22 supply needed to satisfy remaining demand	47,100	19,100	0
Additional virgin R-22 allowable under cap	40,184	5,838	0

[a]Quantity expressed in R-22 metric tons, calculated using an ODP of 0.55 for HCFC-22.
[b]In 2020, 0.5 percent of the U.S. consumption cap remains; however, the phaseout schedule in 2020 prevents any allocation of the remaining cap to R-22.

As shown in Figure 4-2, if the projected supply of recovered R-22 is fully utilized to satisfy the servicing demand from AC and refrigeration equipment in 2015 and 2020, the U.S. will remain under the consumption cap.

Figure 4-2: Total Projected R-22 Servicing Demand[a]



[a]Scenario 1, as shown in this figure, assumes that 100% of the cap is assigned to R-22. In 2020, 0.5 percent of the U.S. consumption cap remains; however, the phaseout schedule in 2020 prevents any allocation of the remaining cap to R-22.

As the market prepares for the phaseout, it is critical to ensure that recovered R-22 is recycled, stockpiled, or reclaimed to maximize available supply. Increased reuse of R-22 will be needed to satisfy future servicing needs that cannot be met through virgin supplies alone. By 2010, the total amount of recovered R-22 needed will be approximately 19,100 metric tons, followed by 30,400 metric tons in 2015 and 25,600 metric tons in 2020. For comparison, as noted in Table 4-3, in 2003 a total of 2,000 metric tons of HCFC-22 was reclaimed (the amount of refrigerant recovered, recycled and reused without being reclaimed is not known), down from over 3,300 metric tons in 2000. If the 2003 level of reclamation remains constant, reclaimed R-22 would fulfill only 10 percent of the anticipated supply of R-22 from recovered refrigerant in 2010, dropping to 8 percent in 2020.

4.3 Factors Affecting Projections

Several market dynamics will have an effect on the projections of future servicing needs of R-22. Certain equipment specification requirements, the transition to alternative refrigerants, the stockpiling of refrigerant as well as equipment manufactured with HCFCs for sale after the phaseout, and the import of equipment precharged with HCFC refrigerant can all potentially alter the projected servicing scenarios. Each of these issues is discussed further below.

4.3.1 13 Seasonal Energy Efficiency Rating (SEER)

The Department of Energy (DOE) published a rule in January 2001 enforcing a stricter seasonal energy efficiency ratio (SEER) standard for residential unitary ACs and heat pumps. The minimum efficiency standard of residential unitary ACs and heat pumps will be raised by 30 percent to a 13 SEER for all such units manufactured for sale on or after January 23, 2006 (DOE 2001; DOE 2004).

According to industry representatives, residential AC equipment will generally require a larger charge size to meet this standard because efficiency improvements are often achieved by increasing the size of the evaporator and condenser, which in turn requires an increase in refrigerant charge (Powell 2004; Honeywell 2005; ARI 2005; Carrier Corporation 2005a). It is not expected that these changes will affect equipment lifetime, leak rates, or the frequency of servicing (ARI 2005). The average unit sold today is approximately 11.5 SEER, with an average charge size of around 3.4 kilograms (7.5 pounds) (ARI 2005).[16] In 2006, the charge size for central ACs is expected to increase by approximately 30 to 50 percent (to approximately 4.4 to 5.1 kilograms [9.7 to 11.2 pounds]) because of the changes to the energy efficiency standards (Carrier Corporation 2005a).

Consequently, the amount of R-22 contained in new residential AC systems starting in 2006 will increase, resulting in an increase in projected servicing demand (assuming that service and leak losses, as a percentage of the equipment charge, do not change as a result). The projections provided in this analysis incorporate the additional R-22 that is expected to be needed to service higher efficiency residential AC equipment after 2010 (see Appendix A for more details).

4.3.2 Transitioning to Alternative Refrigerants

A wide range of EPA alternative refrigerants approved under EPA's Significant New Alternatives Policy (SNAP) program are available in the AC and refrigeration sector. HFC-134A, R-410A, R-407C, R-404A, and R-507A are widely used in the industry today. The pace of transition to equipment production with these alternatives has varied by industry and type of equipment. Several AC and refrigeration equipment manufacturers have indicated that they will completely phaseout the production of equipment that uses R-22 prior to 2010 (York 2005; Hill Phoenix 2005). In projecting servicing needs, this analysis accounts for these transition trends, discussed in further detail below.

Air-Conditioning Industry

HFC-134a, R-410A, and R-407C are currently being used to replace R-22 in some new stationary and mobile AC equipment, a trend that is expected to continue as R-22 is phased out. Some mobile AC equipment have been using alternatives since the early 1990s, with some buses and trains using HFC-134a, and some heavy rail cars using R-407C (WMATA 2005; Amtrak 2005; Motorcoach Training 2005; Greyhound 2005; Carrier Corporation 2005b). Stationary AC equipment using R-410A has been commercially available since 1996 (HARDI 2004), and is expected to dominate the U.S. residential market in the future (EPA 2004b). Some industry representatives have indicated that the change to 13 SEER for residential ACs and heat pumps in 2006 will accelerate the rate of conversions to R-410A, with the production of residential equipment using R-410A possibly surpassing new equipment charged with R-22 between 2006 and 2007 (Powell 2004). However, to be conservative, the projections in this analysis are based on an assumed slower rate of conversion with R-410A equipment surpassing R-22 equipment between 2008 and 2009.

The transition to alternatives for AC equipment is just beginning. Despite the availability of alternatives, more than 90 percent of new AC systems sold in 2004 were still charged with R-22 (RTOC 2003; Honeywell 2005). AC equipment manufacturers indicated that, while the transition to buying commercial equipment that uses alternatives will occur in the next few years, consumers will continue to buy residential equipment that uses R-22 until the phaseout date, especially if R-22 remains cheaper than the alternatives (York 2005). Because consumers of residential AC equipment may not be as informed about the phaseout as commercial consumers, equipment manufacturers and dealers can encourage the transition away from R-22 by communicating to consumers the implications of the HCFC phaseout. Ultimately, however, the market price tends to drive many consumer choices.

[16] Typical factory charges for cooling only equipment are around 3 kilograms (6.6 pounds); however, the average unit considered accounts for heat pumps, which have a higher charge size and make up between 15 to 25 percent of the residential AC and heat pump market (ARI 2005; Carrier Corporation 2005a).

Refrigeration Industry

Industry experts have indicated that retail food refrigeration end-uses will transition to alternatives more quickly than AC end-uses. Currently, the majority of existing U.S. supermarkets use R-22 in their refrigeration systems, with only a few supermarket chains having converted existing stores to use ODS alternatives (Hill Phoenix 2005; Raleys 2005).[17] Although the life expectancy of commercial refrigeration equipment is around 20 years, supermarkets tend to remodel every 7 to 10 years, which offers supermarkets the opportunity to install new equipment that uses an alternative more often than the typical equipment lifetime would imply (Hill Phoenix 2005). For the next five to 10 years, it is anticipated that approximately 200 to 300 stores per year will transition away from R-22 in the United States (Honeywell 2005). Some transitions are occurring for commercial refrigeration because of the economic incentives, including the higher efficiency of alternatives in low-temperature applications. Additionally, for systems holding more than 50 pounds of R-22, the concerns regarding potential leakage and fines from EPA may be encouraging conversions to HFC refrigerants, as was seen with the bakery industry in recent years (Powell 2004).

In new supermarket construction, the transition away from HCFCs is occurring more quickly. Currently, about 65 percent of new stores being constructed are using ODS alternatives—a trend that is growing and expected to continue over time (Hill Phoenix 2005).

4.3.3 Stockpiling Plans

As a preparation strategy for the 2010 phaseout, refrigerant recycling plans could evolve into banking or stockpiling plans. With proper storage tanks, a reserve of recycled R-22 can be collected, stored, and accessed to service equipment owned by the same company years later, when R-22 is expected to be less affordable and less available. A report released in 1995 by the Food Marketing Institute (FMI) included a survey issued to supermarket operators on the use of refrigerant management plans (RMP) as a strategy to ensure an adequate supply of CFC refrigerants for use after the December 31, 1995 production phaseout (FMI 1995). Of those surveyed, 52 percent were banking recovered CFC refrigerant, an activity adopted primarily by store operators with 11 or more stores (FMI 1995).

Although the extent to which such refrigerant management plans for HCFCs are currently in place is unknown, it is possible that the AC and refrigeration industry will increasingly adopt such plans and bank refrigerant in preparation for the HCFC phaseout, especially those that own a large number of stores. In addition to supermarkets, businesses that operate chillers, industrial process refrigeration, and central AC, as well as large operations, such as Amtrak, also have the opportunity to internally bank refrigerant to meet future servicing needs.

While refrigerant banking is a strategy that companies may pursue, the lack of data has limited the projections in this report from quantifying stockpiles from refrigerant management plans. The banking of refrigerant may impact the results of this analysis by affecting future availability of recovered and reusable refrigerant. Stockpiling refrigerant ensures additional supply for a given user for later years; however, a large end-user stockpiling R-22, which may otherwise re-enter the market after being reclaimed, could result in the premature shortage of reusable refrigerant for other R-22 users (see Appendix A for more information).

The potential to stockpile new equipment also exists, but it may be a risky business practice due to the costs associated with storing the equipment and the potential uncertainties associated with market trends. Therefore, industry experts do not consider it a significant issue for projecting future servicing needs.

[17] For example, 56 percent of supermarket refrigeration systems were using R-22 in 2001 within the South Coast Air Quality Management District (SCAQMD), a four county region with a population of 15 million people in southern California (Bivens and Gage 2004). As of 2004, Raley's supermarket chain, which operates in northern California, Nevada, and New Mexico, reported only 28 percent R-22 out of their entire refrigerant use (FMI 2004).

Stockpiling of virgin R-22 also may be pursued, particularly prior to 2020 when production is entirely phased out; however, it is premature to state the extent to which this option will be technically and economically viable. As such, projections on future inventories of virgin stockpiles are not explored further in this analysis.

4.3.4 Precharged Imports

AC equipment precharged with HCFCs is currently imported into the United States predominantly from Korea, Brazil, and China. In recent years, there has been a shift to overseas manufacturing; the number of imports of AC equipment into the United States more than doubled between 2001 and 2003 (Honeywell 2005; UNEP 2003a). For example, the current demand for room ACs, such as window units, through-the-wall, split, and mini-split systems, which predominately use R-22 (some new units are also being charged with R-407C and R-410A), is being met almost entirely through foreign manufacture (AHAM 2005). Central AC systems from foreign manufacturers such as Samsung, LG, and HAIER are also entering the U.S. market. Additionally, some U.S. manufacturers are starting to relocate plants to Mexico and other countries (Honeywell 2005), while others import equipment from international manufacturers that is then sold under their labels (HARDI 2005).

To project the impact of precharged imports on future servicing demand for R-22 equipment, servicing estimates were calculated conservatively assuming that precharged imports will continue to enter the U.S. market after 2010. Projected estimates of precharged imports were developed through a scenario using the Vintaging Model that assumed the entire window unit and dehumidifier market and a small portion (10 percent) of the residential unitary AC and packaged terminal unit market will be imported and will continue to use R-22 after 2010. Further details regarding the assumptions used to project imports are provided in Appendix A. Given the assumptions used, Table 4-6 and Table 4-7 show the breakdown of equipment types containing R-22 that are assumed to enter the U.S. market from 2010 to 2020 and the associated servicing needs that will result from these imports. The projected estimates of units of precharged imports in Table 4-6 are in addition to the total projected estimates of units of equipment presented in Section 4.1.

Table 4-6: Projected Units of Imported Precharged R-22 Equipment

Air-Conditioning Equipment Type	2010	2015	2020
Window Units	7,501,400	10,813,900	15,589,000
Dehumidifiers	3,762,100	3,857,100	3,954,500
Packaged Terminal Units	28,000	31,700	35,900
Residential Unitary AC	314,900	345,900	380,100
Total	11,606,400	15,048,600	19,959,500

The projected servicing estimates for imports presented in Table 4-7 are in addition to the total projected servicing estimates presented in Section 4.2.

Table 4-7: Projected R-22 Service Needs for Precharged Imports (Metric Tons)

Air-Conditioning Equipment Type	2010	2015	2020
Window Units	100	300	500
Dehumidifiers	100	100	100
Packaged Terminal Units	<50	<50	<50
Residential Unitary AC	300	1,200	2,300
Total	500	1,600	2,900

As shown, above, an estimated 11.6 million units of precharged AC equipment are projected to enter the United States in 2010, growing to 15 million in 2015, and 20 million in 2020; this translates into a projected servicing need of approximately 500 metric tons in 2010, 1,600 metric tons in 2015, and 2,900 metric tons in 2020.

Table 4-8 presents a scenario of projected servicing needs for all AC and refrigeration equipment assuming imports of window units, dehumidifiers, packaged terminal units, and residential unitary AC units precharged with R-22 continue to enter the U.S. market after the end of 2009.

Table 4-8: Projected R-22 Servicing Scenario for all AC and Refrigeration Equipment (Including Imports) (Metric Tons)

Servicing Scenarios	2010	2015	2020
Servicing Needs of Domestically Manufactured Equipment and Equipment Imported Before 2010	66,300	49,600	25,600
Servicing Needs of Equipment Imported After 2009	500	1,600	2,900
Total Servicing Needs Including Imports	66,800	51,200	28,500

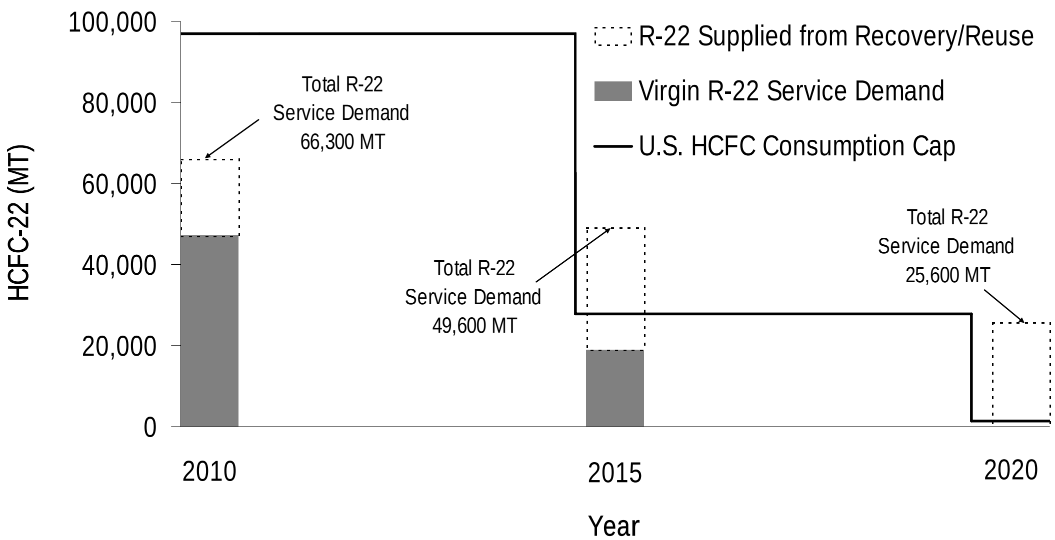
As shown in Table 4-8, the projected quantities of R-22 required to service precharged post-2009 imports comprise only one percent of the total servicing needs in 2010, growing to three percent in 2015 and 10 percent in 2020. For the purpose of this analysis, import projections are based on the type and amount of equipment currently imported; however, if higher percentages of these types (particularly residential unitary AC) are imported, or if the import trend extends to other AC and refrigeration equipment types, particularly those with higher charge sizes, leak rates, and service rates (e.g., retail food equipment), the demand for R-22 for servicing will increase.

5. Conclusion

On January 1, 2010, production and import of HCFC-142b and HCFC-22 will be phased out except for on-going service needs for equipment manufactured on or before December 31, 2009. In an effort to determine the allocation level for the 2010 reduction step in HCFC-142b and HCFC-22 allowances, this report provides projections on the quantity of R-22 needed for servicing AC and refrigeration equipment manufactured on or before December 31, 2009.

Under the scenarios developed in this analysis, the AC and refrigeration industry can satisfy a large portion of future R-22 servicing needs using recovered refrigerant and can thus be allocated limited quantities of virgin manufactured R-22 to satisfy the remaining service needs without jeopardizing the U.S. compliance with the Montreal Protocol. In 2010, approximately 47,100 metric tons of R-22 (or 49 percent of the ODP-weighted cap) from virgin manufacture is expected to be required to service installed AC and refrigeration equipment, decreasing to 19,100 metric tons (or 69 percent of the ODP-weighted cap) in 2015, and to zero metric tons in 2020. These projections indicate that supplies of recycled or reclaimed refrigerant in these years are expected to be adequate, such that servicing needs requiring R-22 allowances remain under the U.S. HCFC consumption cap reductions, as shown in Figure 5-1.

Figure 5-1: Total Projected Virgin R-22 Service Needs for AC and Refrigeration Equipment Compared to the U.S. HCFC Consumption Cap[a]



[a]The U.S. HCFC Consumption Cap shown in this figure assumes that 100% of the cap is assigned to R-22 for comparison purposes. In 2020, 0.5 percent of the U.S. consumption cap remains; however, the phaseout schedule in 2020 prevents any allocation of the remaining cap to R-22.

Future HCFC refrigerant servicing needs depend on various market trends. While the changes to charge sizes to accommodate the 13 SEER energy standard and the transition to alternative refrigerants are accounted for in these projections, any stockpiling of refrigerant or equipment is not accounted for in this analysis. Refrigerant stockpiling can be expected to increase as businesses prepare for the phaseout—as seen in the retail food industry prior to the CFC phaseout. Such activities could cause market fluctuations that would impact the future availability of recovered and reusable refrigerant and potentially alter the projections in this analysis. Additionally, current projections indicate that precharged imports are not expected to have a significant impact on R-22 servicing needs, as the majority of imported equipment (i.e., window units and dehumidifiers) is not commonly serviced or maintained.

The analysis presented in this report provides background necessary for taking initial steps in determining servicing needs of R-22 post 2010. Further collaboration with the AC and refrigeration community is needed to ensure that R-142b and R-22 allowance levels for 2010 are reduced appropriately.

Appendix A: Methodology Used to Calculate Projected Servicing Needs

This appendix outlines the methodology used to calculate the projected servicing needs of AC and refrigeration equipment using R-22. This appendix contains three sections:

- Section A.1 provides an overview of EPA's Vintaging Model, which was used to establish the initial estimates of units of equipment using R-22 and R-22 servicing demand beyond 2010.
- Section A.2 details the second phase of the analysis, which involved the adjustment of initial estimates from the Vintaging Model based on information obtained from industry during the first half of 2005.
- Section A.3 discusses the limitations to the servicing projections presented in this report.

A.1 EPA's Vintaging Model

The 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-Extinguishing; and 6) Sterilants. Within these sectors, there are over 40 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 chemicals based on:

1) Estimates of the quantity of equipment or products sold, serviced, and retired each year, and
2) 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.

The model simulation is considered to be a "business-as-usual" baseline case and does not incorporate external measures to reduce

Box A-1: Developing and Maintaining EPA's Vintaging Model

The Vintaging Model synthesizes data from a variety of sources, including:

- The ODS Tracking System and submissions to the Significant New Alternatives Policy (SNAP) program both maintained by the U.S. EPA Stratospheric Protection Division;
- Published literature from the United Nations Environment Programme (UNEP) Technical Options Committees, the Alternative Fluorocarbons Environmental Acceptability Study (AFEAS), and those provided in industry-related and EPA conference proceedings (such as the Earth Technologies Forum); and
- Numerous companies and trade associations, such as the Alliance for Responsible Atmospheric Policy, the Air-Conditioning and Refrigeration Institute, the Association of Home Appliance Manufacturers, and the American Automobile Manufacturers Association.

In some instances the unpublished information that the U.S. EPA uses in the model is classified 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 learned from these sources. Additionally, while this model served as the initial basis for the projected estimates in this analysis, the adjustment methodologies developed through the discussions with industry representatives for this analysis have in turn served as a resource for refining assumptions and inputs in the model.

or eliminate the emissions of these gases, except those regulated by U.S. law or otherwise common in the marketplace. For example, the ban on the production and import of HCFC-142b and HCFC-22 for new equipment in 2010 is modeled such that estimates for servicing equipment equal estimates of total consumption for a given end-use. Furthermore, in 2020 when the production and import of HCFC-142b and HCFC-22 to service existing equipment is banned, it is assumed in the model that servicing may still occur, but that industry is employing reclaimed or recycled HCFC-142b and HCFC-22.

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. This first category, emissions during equipment lifetime, 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 demand 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 eventually 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:

Es = Emissions from Equipment Serviced. Emissions in year j from normal leakage and servicing of equipment.

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

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

Qc = 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 and refrigerant, and vintage, reflecting that, as new technologies replace older ones, improvements in their leak, service, and disposal emission rates are assumed to occur.

For the purpose of this analysis, the following data from the Vintaging Model were compiled and summarized for the AC and refrigeration sector:

1) <u>Consumption for Servicing</u>, which is equal to the demand to service (i.e., refill) existing equipment. These data are back-calculated using service and leak emissions because the quantity emitted during the lifetime of equipment drives the demand to replace such losses. These estimates are further distinguished between consumption of virgin and recycled/reclaimed chemical. The model assumes that a certain percentage of refrigerant, which varies by end-use, is recovered from discarded equipment. The model then assumes a "best-case" scenario in which all recovered and re-usable refrigerant re-enters the market. See Section A.3 for further discussion on this "recovery pool."

2) <u>Number of Units of Equipment</u>, which is equal to, for "*year X*", the number of units existing in "*year* X-1" plus the number of new units produced in "*year X*" minus the number of units disposed in "*year X*".

For example:

No. of Units in 1999 = No. of Units in 1998 + New Units in 1999 – Units Disposed in 1999

Table A-1 presents the input assumptions used to develop the projections presented in this report. The leak rates represent the percent of the total charge that leaks in a given year. The service leak rates are calculated by annualizing the loss at service, based on the average number of times a piece of equipment is serviced over its lifetime and the amount lost at each servicing event; both the service and leak rates are expressed as a percentage of total chemical charge. The growth rates refer to the market growth of the entire end-use and are not specific to the refrigerant. When the transition to different equipment and different refrigerants occur, the input assumptions are adjusted to account for these changes.

Table A-1: Input Assumptions, Years 2005 to 2020

Current Refrigerant	Equipment Type and Original ODS Refrigerant	Leak Rate	Service Rate	Charge Size[1]	Growth Rate	Lifetime (Years)
AC Equipment						
R-22	R-11 Centrifugal Chillers	7.8%	6.3%	700.0	0.5%	25
R-22	R-12 Centrifugal Chillers	4.4%	3.6%	720.8	0.5%	27
R-22	R-22 Chillers	4.0%	4.3%	1,818.0	0.5%	20
R-22	R-500 Chillers	6.0%	4.9%	926.1	0.5%	27
R-22	R-22 Residential Unitary AC (2005-2006)	5.0%	6.9%	3.4	1.9%	15
R-22	R-22 Residential Unitary AC (2006-2020)	5.0%	7.0%	4.8	1.9%	15
R-22	R-22 Small Commercial Unitary AC	5.0%	6.0%	7.5	2.5%	15
R-22	R-22 Large Commercial Unitary AC	5.0%	5.2%	15	2.5%	15
R-22	R-22 Water & Ground Source Heat Pumps	3.0%	2.1%	4.1	2.5%	20
R-22	R-22 Dehumidifiers (2005-2010)	0.5%	0.0%	0.2	0.0%	15
R-22	R-22 Dehumidifiers (2010-2020)	0.5%	0.0%	0.2	0.5%	15
R-22	R-22 Packaged Terminal Units	3.0%	2.1%	0.7	2.5%	12
R-22	R-22 Window Units	0.2%	0.4%	0.6	5.0%	12
R-22	R-12 Tour Buses	8%	2%	5	0.92%	12
R-22	R-22 Transit Buses	14%	30%	8	1.47%	12
R-22	R-22 Trains	0.2%	43%	22	0.91%	5
Refrigeration Equipment						
R-22	R-12 Cold Storage	10.1%	7.1%	0.0088	2.5%	20
R-401A	R-12 Cold Storage	16.8%	7.1%	0.0088	2.5%	20
R-22	R-22 Cold Storage	16.5%	3.5%	0.0088	2.5%	25
R-22	R-502 Cold Storage	9.7%	7.4%	0.0088	2.5%	25
R-402A	R-502 Cold Storage	17.6%	7.4%	0.0088	2.5%	25
R-502	R-502 Cold Storage	17.6%	7.4%	0.0088	2.5%	25
R-22	R-11 Industrial Process Refrigeration	7.0%	5.0%	952	2.5%	25
R-22	R-12 Industrial Process Refrigeration	4.8%	0.6%	992	2.5%	25
R-401A	R-12 Industrial Process Refrigeration	4.8%	0.6%	850	2.5%	25
R-22	R-22 Industrial Process Refrigeration	8.0%	4.3%	9,100	2.5%	25
R-22	R-12 Retail Food	12.4%	5.2%	1,800	1.7%	15
R-401A	R-12 Retail Food	24.8%	5.2%	1,800	1.7%	15
R-409A	R-12 Retail Food	24.8%	5.2%	1,800	1.7%	15
R-22	R-22 Retail Food	5.3%	1.1%	93	1.7%	20
R-22	R-502 Retail Food	7.5%	6.3%	6.3	1.7%	20
R-402A	R-502 Retail Food	15.0%	6.3%	6.3	1.7%	20
R-502	R-502 Retail Food	15.0%	6.3%	6.3	1.7%	20
R-22	R-12 Transport	16.5%	11.4%	7.53	2.5%	12
R-402A	R-12 Transport	16.5%	11.4%	7.53	2.5%	12
R-401A	R-502 Transport	16.5%	11.4%	7.53	2.5%	12
R-502	R-502 Transport	16.5%	11.4%	7.53	2.5%	12

[1]Charge size presented in kilograms. Cold storage charge size presented in kilograms/cubic foot.

A.2 Adjustment Methodology

Section A.2 is organized into two parts; the first part discusses the adjustment methodology used for stationary AC end-uses, and the second part discusses adjustments to refrigeration end-uses. The general approach in treating information received from industry experts on historical, current, and projected trends involved directly replacing the preliminary modeled estimates when possible, adjusting other related model estimates and/or assumptions, and scaling projections based on calculated adjustment factors. In cases where industry did not provide information for a given end-use or a particular trend, the default was to use estimates and/or assumptions provided by the Vintaging Model. For example, because industry did not provide projections on the quantity of recoverable and re-usable R-22, servicing projections were disaggregated into re-usable versus virgin R-22 by applying the percentages assumed in the Vintaging Model (Table A-1).

A.2.1 Stationary Air-Conditioning

Through industry discussions, initial estimates on the current and projected total units of equipment using R-22 were revised. When industry data on equipment stock were only available for certain years, the ratios of the industry-received estimates to Vintaging Model estimates were used to scale the original (Vintaging Model) estimates on equipment stock for all other years.

Subsequently, the revised stock estimates of AC equipment (by type) were employed in the following formula, using the inputs as provided in Section A.1, to determine adjusted servicing estimates by end-use:

*Adjusted Units of Equipment * Charge Size * (Leak Rate + Service Rate) = Adjusted HCFC for Servicing*

The charge size, leak rate, and service rate used in these calculations were derived from the Vintaging Model and averaged by end-use. For small and large commercial unitary AC equipment, charge sizes were provided by industry experts; these inputs (7.5 kg and 15 kg respectively) were used to update the Vintaging Model version used for this analysis.

The resulting overall servicing demand projections for all stationary AC end-uses (derived by summing the servicing demand for each end-use, based on the above formula) were then compared to the overall servicing projections as provided by one industry source. On average, the industry estimates were less than 10 percent different than those generated by this analysis.

In order to back calculate total consumption from the updated servicing estimates, the adjusted servicing estimates were multiplied by the average ratio of consumption to servicing emissions from the Vintaging Model and industry estimates, using the following formula:

*Adjusted Servicing Estimates * [((VM Total Consumption / VM Servicing Estimates) + (Industry Total Consumption/Industry Servicing Estimates)) / 2] = Adjusted Total Consumption*

Supplemental Analyses

Through discussions with industry representatives, it was determined that two analyses, in addition to the adjustments made to the Vintaging Model output, were required to take into account 1) the change to the 13 SEER standard in 2006 for residential ACs and heat pumps; and 2) the anticipated trends in imports of equipment precharged with R-22. Each is described in more detail below.

13 SEER

The minimum efficiency standard of residential and central unitary ACs and heat pumps will be raised by 30 percent to a 13 SEER for all residential central ACs manufactured for sale on or after January 23, 2006 (U.S. DOE 2001; U.S. DOE 2004). According to industry, residential equipment will generally require a larger charge size to meet the 13 SEER standard because efficiency improvements are often achieved by increasing the size of the evaporator and condenser, which in turn requires an increase in refrigerant charge. Since the Vintaging Model does not assume any changes in the charge sizes of residential unitary AC equipment using R-22, a sensitivity analysis was performed.

The scenario parameters were determined through discussions with industry representatives (Carrier Corporation 2005a; ARI 2005), which provided the following key pieces of information:

- The average charge size of 3.4 kg that is currently used in the Vintaging Model to represent residential AC and heat pump units is a reasonable assumption for equipment currently produced and installed.
- The charge size will increase by approximately 40 percent when converting from 10 SEER to 13 SEER.
- Approximately 98 percent of the current installed base is 12 SEER equipment or lower, while nearly all of remainder is currently at 13 SEER.

The residential unitary AC end-use in the Vintaging Model was adapted to run a scenario that reflects this information. The results from this adjustment to the projected service estimates for residential unitary AC were then incorporated into the servicing projections presented in this report.

Imports

The Vintaging Model assumes that no new R-22 equipment enters the market after 2010. To create a scenario that reflects the fact that R-22 equipment may in fact be imported post 2010, the Vintaging Model inputs of four end-uses—window units, dehumidifiers, packaged terminal units, and residential unitary ACs— were altered to run a scenario that reflects the assumptions listed in Table A-2 below.

Table A-2: Assumptions for the Import Sensitivity Analysis[a]

<table>
<tr><th>End-use</th><th>Transition Modification</th></tr>
<tr><td>Window Units</td><td rowspan="2">100% of the market remains R-22 through 2030 (i.e., no transitions away from R-22)</td></tr>
<tr><td>Dehumidifiers</td></tr>
<tr><td>Packaged Terminal Units</td><td rowspan="2">10% of the market remains R-22 through 2030 while the remaining 90% of the transitions are left unmodified.</td></tr>
<tr><td>Residential Unitary AC</td></tr>
</table>

[a]These end-uses and transition modifications were chosen based on industry contacts, which indicated that currently almost all window units and dehumidifiers sold in the U.S. are imported and that a smaller percentage of residential unitary AC systems and packaged terminal units are imported (ARI 2005; AHAM 2005).

A.2.2 Refrigeration

The adjustment methodology for the refrigeration sector was based on overall servicing estimates for the refrigeration industry, as provided by industry experts. Specifically, the ratios of industry versus servicing demand estimates from the Vintaging Model were used to scale the preliminary servicing demand estimates (generated by the Vintaging Model) by each refrigeration equipment end-use.

Subsequently, the scaled servicing estimates for refrigeration were used in the following formula, using the inputs as provided in Section A.1, to determine adjusted units of equipment by end-use:

*Adjusted HCFC for Servicing / (Charge Size * (Leak Rate + Service Rate)) = Adjusted Units of Equipment*

The charge size, leak rate, and service rate used in these calculations were derived from the Vintaging Model, as provided in Section A.2. Furthermore, because the overall refrigeration servicing estimates provided by industry did not incorporate R-22 use as part of blends, the ratio of R-22 use as part of a blend (as opposed to neat R-22 use) to total R-22 use (neat plus blended) was determined using

Vintaging Model data. These percentages were then applied to the scaled estimates in order to incorporate blended R-22 use into the totals for years 2005 to 2020.

A.3 Limitations and Caveats

This analysis utilized the best data available from various sources. However, when making projections several assumptions are required. The Vintaging Model was used to determine the quantities of R-22 from existing (recycled or reclaimed) sources that can meet post-2010 servicing needs and the remaining quantities required through virgin manufacture. For a given year, the model assumes that a certain percentage of refrigerant, which varies by end-use, is recovered from discarded equipment, while the remainder is emitted. The model aggregates the quantities recovered but does not distinguish the "pool" of refrigerant between quantities that are reclaimed versus those that are recycled. The model then assumes that the entire pool of recovered refrigerant re-enters the market within the same year; any additional demand for refrigerant, above that which is thus assumed to be met by recovered refrigerant, is calculated to be virgin manufacture. It is important to note that the recovery pool and the remaining virgin manufacture can be evaluated only at the most aggregate level, across all end-uses, and not at the end-use level, as the model does not serve to differentiate between virgin and recycled chemical 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 refrigerant originated; rather, reclaimed refrigerant can be retailed to the overall AC and refrigeration industry.

Under this modeled approach, the following caveats should be noted:

- The model does not consider the quantity of refrigerant that companies send off for destruction (generally through incineration) after equipment is decommissioned. Because quantities of destroyed refrigerant are *not* subtracted from the recovered pool, the quantity available for reuse may be overestimated in the model.
- The model does not account for any stockpiling of recovered refrigerant beyond a one-year timeframe, as discussed in Section 4.3. To the extent that stockpiling activities occur over the next few years, the quantity of recovered refrigerant modeled as re-entering the market may be overestimated in earlier years (i.e., when refrigerant is banked), and the quantity modeled as re-entering the market in later years may be underestimated (i.e., when the accumulated bank is accessed as a source).

Appendix B: HCFC Projections by End-Use

This Appendix provides more detailed projections for future servicing needs and is organized as follows:

- Section B.1 provides estimates of the projected installed base of R-22 equipment by end-use and the projected quantities of R-22 needed to service AC and refrigeration equipment.

- Section B.2 provides estimates of the quantities of R-123, R-124, and R-142b needed to service AC and refrigeration equipment by end-use.

Estimates are provided for AC and refrigeration equipment by end-use from 2005 to 2020 in five year increments. Descriptions of end-uses are provided in Section 3 of the report. For the purpose of this analysis, data on HCFC blend consumption for servicing are divided among the corresponding HCFC constituent(s) of that blend, according to the percent composition. However, in order to accurately portray the number of units containing pure R-22, blends are not disaggregated when presenting the number of units of equipment (i.e., a unit running on a blend containing R-22 counts as one unit).

B.1 R-22 Equipment and Servicing Demand by End-Use

Table B-1 presents the number of units of equipment using R-22 that are estimated to be in use in 2005, 2010, 2015, and 2020. Sections 3.1 and 3.2 provide an overview of these AC and refrigeration end-uses.

Table B-1: Estimated Number of R-22 Units Installed

Equipment Type	2005	2010	2015	2020
Window Units	67,300	57,500	25,000	0
Packaged Terminal Units	3,400,000	3,200,000	2,000,000	600,000
Residential Unitary AC	47,345,800	46,448,200	30,209,000	14,338,400
Small Commercial Unitary AC	23,700,000	19,400,000	10,800,000	3,300,000
Large Commercial Unitary AC	1,100,000	850,000	350,000	51,000
Chillers (including centrifugal)	165,000	130,000	80,000	17,000
Dehumidifiers	11,423,500	3,555,200	1,238,700	353,900
Water & Ground Source Heat Pumps	1,357,400	1,188,200	854,400	478,500
Other Mobile AC	68,100	29,400	8,500	0
Total AC	88,627,100	74,858,500	45,565,600	19,138,800
Cold Storage[1]	166,472,000	146,136,700	124,468,700	54,055,100
Retail Food	45,400	27,000	16,900	4,400
Refrigerated Transport	31,400	0	0	0
Industrial Process Refrigeration	7,100	6,400	6,400	3,300
Total Refrigeration	83,900	33,400	23,300	7,700
Total[2]	88,711,000	74,891,900	45,588,900	19,146,500

[1] Cold storage units are presented in cubic feet.
[2] Totals do not include cold storage.

Table B-2 presents the metric tons of R-22 estimated to be needed to service AC and refrigeration equipment in 2005, 2010, 2015, and 2020.

Table B-2: Projected R-22 Servicing Demand (Metric Tons)

Equipment Type	2005	2010	2015	2020
Window Units	200	200	100	0
Packaged Terminal Units	100	100	100	<50
Residential Unitary AC	20,900	20,400	13,300	5,800
Small Commercial Unitary AC	19,600	19,600	16,000	8,900
Large Commercial Unitary AC	1,700	1,700	1,300	500
Chillers (including centrifugal)	17,700	17,700	14,000	8,600
Dehumidifiers	<50	<50	<50	<50
Water & Ground Source Heat Pumps	300	200	200	100
Other Mobile AC	300	100	<50	0
Total AC	60,800	60,000	45,000	23,900
Cold Storage	300	300	200	100
Retail Food	7,200	4,300	2,700	700
Refrigerated Transport	100	0	0	0
Industrial Process Refrigeration	1,900	1,700	1,700	900
Total Refrigeration	9,500	6,300	4,600	1,700
Total	70,300	66,300	49,600	25,600

Although the equipment-specific servicing estimates can not be broken down into recovered versus new refrigerant, the overall servicing demand is expected to be met in part by the use of recovered refrigerant. By 2010, it is projected that about 29 percent of all equipment can be serviced with recovered refrigerant. The use of recovered R-22 (as a percent of overall servicing demand) is projected to increase to about 61 percent by 2015, and to 100 percent by 2020. Servicing demand is assumed to be increasingly satisfied by recovered (as opposed to virgin) refrigerant, as an increasing number of old equipment units gets retired, and their installed refrigerant becomes available for reuse.

B.2 Other HCFC Refrigerants Projected by End-Use

Table B-3 presents the estimated servicing demand, in metric tons, of R-142b, R-123, and R-124 in 2005, 2010, 2015, and 2020, as broken down by equipment type. The estimates are drawn directly from the Vintaging Model, as they were not discussed with industry representatives.

Table B-3: Other HCFC Servicing Demand (Metric Tons)[a]

	2005	2010	2015	2020
R-142b				
Retail Food	100	0	0	0
Total	100	0	0	0
R-123				
Chillers	<50	<50	<50	<50
IPR	300	300	400	400
Total	300	300	400	400
R-124				
Cold Storage	<50	<50	0	0
Retail Food	600	0	0	0
Transport	<50	0	0	0
IPR	<50	<50	<50	<50
Total	600	<50	<50	<50

[a]Recovered R-142b, R-123, and R-124 includes refrigerant that is either recycled and reused or reclaimed and reused.

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