The American Carbon Registry™

EMISSION REDUCTION MEASUREMENT AND MONITORING METHODOLOGY FOR USE OF CERTIFIED RECLAIMED HFC REFRIGERANTS AND ADVANCED REFRIGERATION SYSTEMS

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1.0 BACKGROUND AND APPLICABILITY

1.1 Summary Description of the Methodology

Modern society is dependent on refrigeration to process, store and transport food, as well as on air conditioning in the built environment and motor vehicles. Reliable and cost-effective cooling is also critical for other commercial and industrial processes, such as in pharmaceutical and chemical production, oil refining, aerospace and defense technologies, data servers, and ice rinks. These diverse applications typically rely on refrigerants, the chemical coolants that can reach low temperatures and transfer heat by undergoing a phase change between liquid and gas (through condensation).

Up until the mid-1990s, chlorofluorocarbons (CFCs) were in widespread use as refrigerants. CFCs destroy the Earth's protective ozone layer and are also powerful greenhouse gases (GHGs). Under the Montreal Protocol and United States Clean Air Act, nearly all CFC production ended in the United States in 1996.[1] As a result, many applications transitioned to using hydrochlorofluorocarbon (HCFC) refrigerants, which also contribute to ozone depletion and climate change, although to a lesser extent than CFCs. With the phase out of HCFCs currently underway, the most commonly used refrigerants today are hydrofluorocarbons (HFCs). HFCs, while safe for the ozone layer, are also powerful GHGs when released to the atmosphere.

Across the various refrigeration and air conditioning applications, there are a number of approaches that can be used to reduce GHG emissions from both new and installed equipment. This Methodology highlights two of these approaches, one that focuses on reductions from installed equipment and one that focuses on reductions from new equipment, as described below.

1. Use of Certified Reclaimed HFC refrigerants

For the large installed base of HFC equipment and infrastructure that will continue to operate, there are a number of ways that emissions can be reduced, including:

- Monitoring and timely leak repair for systems that are inherently prone to leaks,
- Proper training and practices by professional engineers and contractors that install and service equipment, and
- Refrigerant management practices throughout the lifecycle of the refrigerant, from production, distribution, recovery, reclamation, and end-of-life disposal.

Another opportunity to mitigate emissions is by filling refrigeration equipment with reclaimed HFC refrigerants. Typically, virgin (newly produced, never previously used) refrigerant is used to "charge" refrigeration and A/C systems and various types of equipment when they are manufactured and installed, and when the systems leak during normal operations. Re-using previously used HFC that has been

[1] After 1996, the Montreal Protocol authorized limited production of CFCs for "essential uses" as propellants in medical devices (metered dose inhalers relied upon by asthmatics) and for laboratory and analytical uses. Production for essential medical uses ended in the U.S. on January 1, 2012. The exemption for de minimis CFC production essential laboratory and analytical uses remains in effect.

recovered[2], and *reclaimed*[3] to virgin-grade refrigerant purity, either to "recharge" existing systems that require servicing, or in newly manufactured equipment, displaces new production of virgin refrigerant that would otherwise be manufactured to meet that demand.

This Methodology focuses only on HFCs, and does not address HCFC-22, which is being phased out of production[4].

2. Advanced Refrigeration Systems[5]

For limited applications, some businesses are using alternatives to HFC refrigerants with little or no global warming potential (GWP) as they manufacture and install *new* refrigeration and air conditioning equipment and systems. These alternatives include hydrocarbons, ammonia, carbon dioxide, and hydrofluoro-olefins (HFOs). In some advanced commercial refrigeration systems, these alternatives completely replace the use of HFC refrigerants, while in other advanced systems these alternatives are used in combination with HFCs. Under this Methodology, secondary loop and cascade refrigeration systems used in supermarkets, for example, which often use HFC refrigerants in combination with refrigerants that have lower GWPs (such as carbon dioxide) or a heat transfer medium (such as glycol), are eligible within this project activity category.

Table 1 lists the sectors that are eligible under this Methodology.

Table 1: Eligible Refrigerant Sectors and Segments

Project Activity	Refrigerant Sector	Eligible Segments in Sector
Use of Certified Reclaimed HFC refrigerants	Domestic Refrigeration	Residential refrigerators and freezers
	Commercial Refrigeration, also known as Retail Food Refrigeration	Equipment used to store and display chilled and frozen goods for commercial sale such as in supermarkets, convenience stores, bakeries, and restaurants. This equipment includes centralized supermarket systems, remote condensing units, and stand-alone equipment (e.g., beverage vending machines, stand-alone display cases).

[2] Refrigerant that is recovered from refrigeration or air conditioning equipment is removed/extracted by a certified technician using certified recovery equipment from appliances during servicing or at end-of-life. HFCs can also be recovered from other sources including discarded aerosol cans, and reclaimed for re-use as refrigerant.

[3] Reclaimed refrigerant is used (recovered) refrigerant that has been processed to remove impurities and tested by an EPA certified reclaimer and certified to meet the AHRI 700-2015 Standard for Specifications for Fluorocarbon Refrigerants.

[4] Production and import of R-22 is regulated in the United States by annual allocations issued by the EPA, in accordance with the phasedown schedule established in the Montreal Protocol and United States Clean Air Act. Until the complete phaseout in 2020, R-22 can only be produced/imported, and used, to service equipment manufactured prior to 2010. This methodology makes a conservative assumption that 100% of the remaining EPA allocations will be filled, i.e., the same quantity of R-22 will be produced/imported and ultimately used regardless of whether individual facilities or manufacturers choose to use reclaimed R-22 instead of virgin R-22. While not accounted for in this methodology, greater use of reclaimed R-22 absolutely has positive environmental benefit that was accounted for by the United States EPA in determining the annual R-22 allocations. In contrast, there are no controls in the United States on production/import of HFC refrigerants so increased use of reclaimed HFC refrigerant to meet demand has a direct impact on the volumes of HFC refrigerants that would otherwise be produced/imported.

[5] For a general discussion of advanced refrigeration systems, see the United States EPA discussion here: http://www2.epa.gov/greenchill/advanced-refrigeration

	Cold Storage Warehouses	Storage for meat, produce, dairy products, and other perishable goods.
	Industrial Process Refrigeration	Chemical, pharmaceutical, petrochemical and manufacturing industries, industrial ice machines and ice rinks.
	Transport Refrigeration	Refrigerated truck trailers, railway freight cars, ship holds, and other shipping containers.
	Mobile Air Conditioning	Automobiles, trucks, buses, and other motor vehicles.
	Stationary Air Conditioning	Comfort cooling for homes and commercial buildings, including multi-family buildings, office buildings, hospitals, universities, shopping malls, airports, sports arenas.
Advanced Refrigeration Systems	Commercial Refrigeration, also known as Retail Food Refrigeration	Equipment used to store and display chilled and frozen goods for commercial sale such as in supermarkets, convenience stores, bakeries, and restaurants. This equipment includes centralized supermarket systems, remote condensing units, and stand-alone equipment (e.g., beverage vending machines, stand-alone display cases).

This Methodology provides the quantification framework for the creation of carbon offset credits from the reductions in GHG emissions resulting from either: 1) the use of certified reclaimed HFCs or 2) transitioning to advanced refrigeration systems in the eligible sectors. The Methodology is intended to be used as an incentive within the relevant industries to increase these activities.

This Methodology is based on a robust data set, including the United Nations Environment Programme Technical Options Committee for Refrigeration, Air Conditioning and Heat Pumps, the United States EPA Vintaging Model, the United States EPA GreenChill Partnership, the California Air Resources Board Offsets Methodology for Destruction of Ozone Depleting Substances, and the 2006 International Panel on Climate Change Guidelines for Greenhouse Gas Inventories.

1.2 Definitions and Acronyms

If not explicitly defined here, the current definitions in the latest version of the American Carbon Registry (ACR) Standard apply.

Table 2: Definitions

Term	Acronym (if applicable)	Definition
Ammonia	NH_3	A chemical compound composed of nitrogen and hydrogen. Can be used as a low-GWP refrigerant.

Term	Acronym (if applicable)	Definition
Aerosol Product		A product pressurized by a propellant that expels its contents from a canister through a nozzle. Propellants include compressed gases and liquefied gases. Liquefied gases include HFCs, including HFC-134a, which can be recovered and reclaimed for re-use as a refrigerant, at which point it is considered a reclaimed HFC refrigerant.
Carbon Dioxide	CO_2	A chemical compound composed of two oxygen atoms and a single carbon atom. Can be used as a low-GWP refrigerant.
Carbon dioxide equivalent	CO_2e	A standard unit of measure to express the impact of each different greenhouse gas in terms of the amount of CO_2 that would create the same amount of global warming.
Carbon offset credits	Offsets	A carbon offset is a reduction in emissions of carbon dioxide or greenhouse gases made in order to compensate for or to offset an emission made elsewhere.
Cascade Refrigeration System		Similar to a secondary refrigeration system, a cascade system employs dual cycles, and utilizes a heat exchanger and two types of refrigerants. This enables the system to achieve colder temperatures that may not be achievable through primary or secondary refrigerant systems.
Certified reclaimed HFC refrigerant		Used (recovered) HFC that has been reclaimed by an EPA-certified reclaimer to meet the AHRI 700-2015 Standard for Specifications for Fluorocarbon Refrigerants[6] by an EPA certified reclaimer, and tested by an AHRI certified refrigerant testing laboratory to meet the AHRI Standard.
Chlorofluorocarbon	CFC	A class of compounds of carbon, hydrogen, chlorine, and fluorine that are commonly used as refrigerants.

[6] Air Conditioning, Heating, and Refrigeration Institute (AHRI) 700-2015 Standard for *Specifications for Fluorocarbon Refrigerants.* www.ahrinet.org

Term	Acronym (if applicable)	Definition
GHG Source, Sink, or Reservoir	SSR	1) GHG Source – Physical unit or process that releases a GHG into the atmosphere 2) GHG Sink – Physical unit or process that removes a GHG from the atmosphere 3) GHG Reservoir - Physical unit or component of the biosphere, geosphere or hydrosphere with the capability to store or accumulate a GHG removed from the atmosphere by a GHG sink or captured from a GHG source.
Global warming potential	GWP	An index that attempts to integrate the overall climate impacts of a specific action (e.g., emissions of CH_4, NO_x or aerosols). It relates the impact of emissions of a gas to that of emission of an equivalent mass of CO_2.
Hydrocarbon	HC	A class of compounds containing only hydrogens and carbons (e.g. propane, isobutene, propylene). Certain HCs can be used as low-GWP refrigerants.
Hydrochlorofluorocarbon	HCFC	A class of compounds of carbon, hydrogen, chlorine, and fluorine that are commonly used as refrigerants.
Hydrofluorocarbon	HFC	A class of compounds that contain carbon, fluorine, and hydrogen that are commonly used as refrigerants, as well as solvents, aerosol propellants, and foam blowing agents.
Hydrofluoroolefins	HFO	A class of compounds composed of hydrogen, fluorine, and carbon. This class of compounds can be used as low-GWP refrigerants. Some HFO refrigerants are comprised of a mix of HFOs, referred to as an HFO blend.
HFC Refrigerant		Refrigerant comprised of either a mix of hydrofluorocarbons (HFCs) referred to as an "HFC blend", or a single HFC.

Term	Acronym (if applicable)	Definition
Project activity		1) The reclamation and use of certified reclaimed HFC refrigerants to service existing refrigeration and air conditioning equipment, 2) The reclamation and use of certified reclaimed HFC refrigerants in newly manufactured refrigeration or air conditioning equipment, and 3) Deployment of an advanced refrigeration system by installing newly manufactured commercial refrigeration.
Refrigeration or air conditioning equipment		An Appliance[7], or component parts of a system, that uses refrigerant to provide cooling under controlled conditions.
Secondary Loop Refrigeration System		An advanced refrigeration system where a heat transfer medium (e.g. glycol) is used in conjunction with a primary refrigerant.
Use of certified reclaimed HFC refrigerant		Production by the reclaimer, plus transfer/return/sale of certified reclaimed HFC refrigerant to refrigerant distributors, wholesalers, original equipment manufacturers, service technicians, or refrigerant end-users who are in the business of selling or using HFC refrigerant for use in refrigeration or air conditioning equipment.

1.3 Applicability Conditions

1.3.1 Use of Certified Reclaimed HFC Refrigerants

Projects that avoid the emissions of refrigerant gases in the following activities are considered a "project activity":

1) The reclamation and use of certified reclaimed HFC refrigerants to service existing refrigeration and air conditioning equipment, and
2) The reclamation and use of certified reclaimed HFC refrigerants in newly manufactured refrigeration or air conditioning equipment.

For purposes of this Methodology, "reclamation and use" of certified reclaimed HFC refrigerant refers specifically to the production of such refrigerant (by a certified refrigerant reclaimer) and the subsequent sale, title transfer or return to a refrigerant distributor, refrigerant wholesaler, or an end-user (either through

[7] Per 40 CFR §82.3, an "Appliance" is defined as "any device which contains and uses a refrigerant and which is used for household or commercial purposes, including, without limitation, any air conditioner, refrigerator, chiller, or freezer."

direct sale, title transfer or return to an end user or through installation conducted via service technician) for use in refrigeration or air conditioning equipment.

In addition to satisfying the latest ACR program eligibility requirements as found in the *ACR Standard*, project activities must satisfy the following conditions to be applicable:

a) The project is located in North America.
b) The project is within a sector and segment which has a low adoption rate for the relevant project activity ("Eligible Project Activity" & "Eligible Refrigerant Sector/Segment" (see Table 1)).
c) The refrigerant must meet the definition of certified reclaimed HFC refrigerant found in this Methodology.

1.3.2 Advanced Refrigeration Systems

Projects that avoid the emissions of CFC, HCFC, or HFC gases in the following activity is considered a "project activity":

- Deployment of an advanced refrigeration system by installing newly manufactured commercial refrigeration.

For purposes of this Methodology, "installing newly manufactured commercial refrigeration" refers specifically to (i) the complete replacement of CFC, HCFC or HFC–based equipment (including all components) with an advanced refrigerant system at an existing facility, (ii) the installation of an advanced refrigeration system as a new and additional system at an existing facility, or (iii) the installation of an advanced refrigeration system in new construction.

In addition to satisfying the latest ACR program eligibility requirements as found in the *ACR Standard*, project activities must satisfy the following conditions for this Methodology to be applicable:

a) The project is located in North America.
b) The project is within a sector and segment which has a low adoption rate for the relevant project activity ("Eligible Project Activity" & "Eligible Refrigerant Sector/Segment" (see Table 1)).
c) For a project activity that involves replacement of CFC or HCFC-based equipment with an advanced refrigerant system, any CFCs or HCFCs in the original equipment must be recovered and destroyed in accordance with ACR or the California Air Resource Board ODS Destruction Methodology.
d) For a project activity that involves replacement of HFC-based equipment with an advanced refrigerant system, any HFCs in the original equipment must be reclaimed.
e) Any refrigerant used in the advanced refrigeration system must be an acceptable substitute according to United States EPA Significant New Alternatives Policy (SNAP) program for use in commercial refrigeration end-uses and be used in accordance with SNAP use conditions.[8]

[8] http://www.epa.gov/ozone/snap/refrigerants/index.html

1.4 Reporting Periods

1.4.1 Use of Certified Reclaimed HFC Refrigerants

a. Projects shall have one reporting period which must not exceed 12 months in length.

b. Emission reductions shall be quantified for a period not to exceed 12 months based on the total amount of certified reclaimed HFC produced and the subsequent sale, title transfer or return to a refrigerant distributor, refrigerant wholesaler, or an end-user (either through direct sale, title transfer or return to an end user or through installation conducted via service technician) for use in refrigeration or air conditioning equipment.

c. A reporting period begins on the date that the initial volume of certified reclaimed HFC is sold, title transferred, or returned to a refrigerant distributor, refrigerant wholesaler, or and end-user (either through direct sale, title transfer or return to an end user or through installation conducted via service technician) for use in refrigeration or air conditioning equipment.

1.4.2 Advanced Refrigeration Systems

a. A reporting period shall not exceed more than 12 months in length.

b. Projects may incorporate up to 10 reporting periods.

c. A reporting period begins on the date that the advanced refrigeration system became operational and therefore began to reduce GHG emissions against its baseline.

1.5 Crediting Periods

A Crediting Period is the finite length of time for which a GHG Project Plan is valid, and during which a project can generate offsets against its baseline scenario. The crediting period for all project activities shall be ten years.

1.6 Periodic Reviews and Revisions

ACR may require revisions to this Methodology to ensure that monitoring, reporting, and verification systems adequately reflect changes in the project's activities. This Methodology may also be periodically updated to reflect regulatory changes, emission factor revisions, or expanded applicability criteria. Before beginning a project, the project proponent should ensure that they are using the latest version of the Methodology.

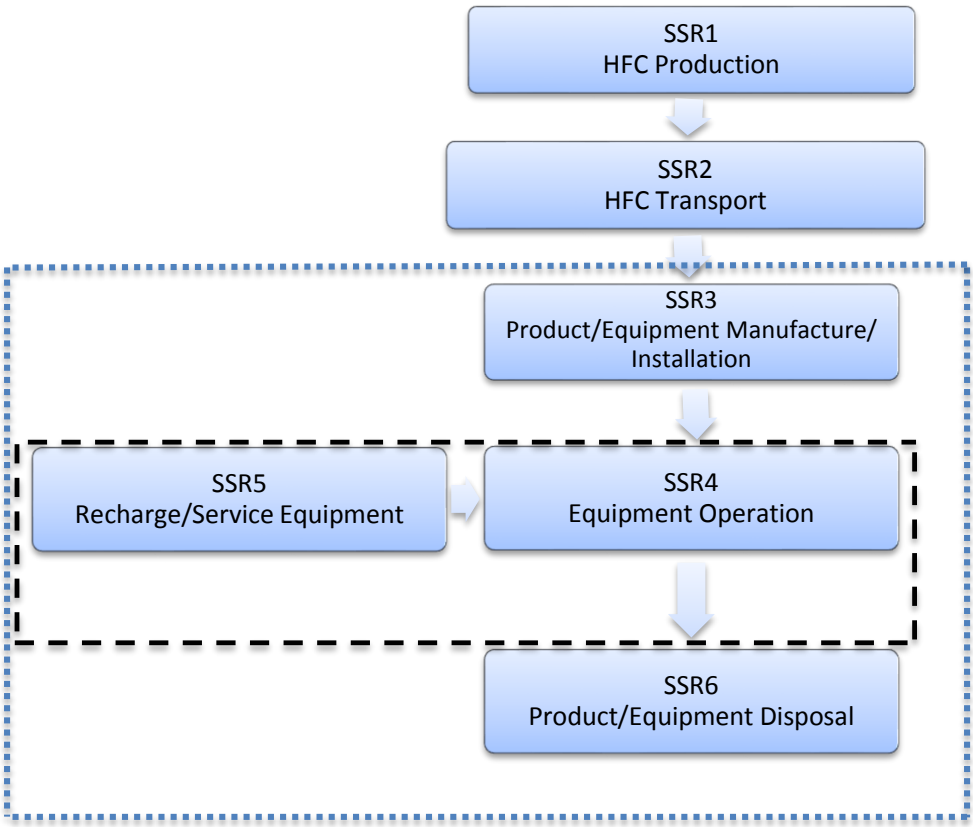
2.0 PROJECT BOUNDARIES

2.1 Geographic Boundary

For projects using certified reclaimed HFC refrigerant, the project boundary, depicted by the dashed line in Figure 1, is the physical and geographical site where the reclaimed HFC refrigerant is produced in the project by a certified refrigerant reclaimer, for use in equipment operations and servicing/recharging to replace refrigerant that leaks or to charge newly manufactured refrigeration or air conditioning equipment.

For projects deploying an advanced refrigeration system, the project boundary, depicted by the dotted line below (i.e. inclusive of SSR6), includes the physical and geographical site where the system is installed, as well as the locations involved in disposal of the older technology, including reclamation of any previously used HFC or destruction of the CFC or HCFC refrigerant in the older system that is replaced.

Figure 1: Project Boundary Diagram for Certified Reclaimed Refrigerant (Black Dashed Line) and Advanced Refrigeration Systems (Blue Dotted Line)



Within the boundaries, the sources of GHG emissions are from the operations of the refrigeration and air conditioning equipment, including recharging equipment that has leaked. Table 3 lists the GHG sources included and excluded depending on whether the sources are within or outside project boundaries.

Table 3: Greenhouse Gases and Sources

SSR		Source Description	Gas	Included (I) or Excluded (E)	Quantification Method
1	HFC Production	Fossil fuel emissions from the production of HFCs	CO_2	E	N/A
			CH_4	E	N/A
		HFC leaks during HFC production	HFCs	E	N/A
2	Refrigerant Transport	Fossil fuel emissions from transport of HFCs	CO_2	E	N/A
			CH_4	E	N/A
			N_2O	E	N/A
		HFC leaks during transport	HFCs	E	N/A
3	Equipment Manufacture and Installation	Emissions of HFCs during manufacture or installation of refrigeration or A/C equipment or system or product	HFCs	E	N/A
4	Equipment Operations	Fossil fuel emissions from the operation of the refrigeration or A/C equipment or system	CO_2	E	N/A
			CH_4	E	N/A
			N_2O	E	N/A
		CFC, HCFC leaks from the operation of the refrigeration system	CFC, HCFC	E	See Methodology
		HFC leaks from the operation of the refrigeration or A/C equipment or system or product	HFCs	I	
		CO_2 leaks from operation of a new refrigeration system	CO_2	I	
		Leaks of non-GHG refrigerants from operation of a new refrigeration system	NH_3, Hydro-carbons	E	N/A
5	Service Equipment	Fossil fuel emissions from servicing refrigeration or A/C equipment or system to replace leaked refrigerant	CO_2	E	N/A
			CH_4	E	N/A
			N_2O	E	N/A
		HFC emissions from servicing refrigeration or A/C equipment or system to replace leaked refrigerant	HFCs	I	See Methodology
6	Equipment Disposal	Emissions from the disposal of the equipment at end-of-life including destruction of refrigerant	CO_2	E	N/A
			CH_4	E	N/A
			CFCs	E	N/A
			HCFC	E	N/A
			HFCs	E	N/A

3.0 BASELINE DETERMINATION AND ADDITIONALITY

3.1 Baseline Determination

The baseline for a project activity is determined utilizing industry standards and represents the most commonly used practices and technologies.

3.1.1 Use of Certified Reclaimed HFC Refrigerants

Refrigeration and air conditioning (A/C) appliances and other components that comprise a system are "charged" with refrigerant, either at the manufacturing plant, or at the facility where a system is installed, e.g., a supermarket.

Under normal operating conditions, depending on the type of equipment and the location, between 1 and 50% of the refrigerant in stationary and mobile air conditioning and refrigeration systems leaks each year (IPCC/TEAP, 2006; IPCC, 2006; RTOC 2010; EPA, 2014; CAR ODS Methodology 2010). Even with active leak detection and aggressive maintenance efforts, it is difficult to eliminate leaks completely.[9] Consequently, to maintain proper performance, leaky equipment and systems require periodic servicing to replace the lost refrigerant.

In the majority of situations, virgin (newly produced, never previously used) refrigerant is used both to charge newly manufactured equipment and systems, and to "recharge" systems that leak during normal operations.

As an alternative, reclaimed refrigerant can be used. This is refrigerant that has been previously used, recovered from other air conditioning or refrigeration equipment or disposed aerosol products (e.g., cleaning and personal care products, office dusters, safety horns, asthma inhalers), and processed to remove impurities and restored to virgin-grade quality.[10] Using reclaimed refrigerant effectively displaces the use – and therefore avoids production and eventual emissions – of virgin refrigerant. Within the existing reclamation industry, there is capacity to significantly increase reclaimed refrigerant use (EPA, 2014). Thus, using reclaimed refrigerant would result in a net GHG reduction.

Reclaimed HFCs comprise a small proportion of the HFC refrigerants that are in use today in the United States. Unlike the strong incentive to reclaim CFC refrigerants and HCFC-22 that have been or are being phased out, there is currently little incentive for recovery, reclamation, and re-sale of HFC refrigerants.

Appendix A.1 provides the basis for the rate by which HFCs are reclaimed in the United States under the baseline scenario in this Methodology.

To calculate baseline emissions of HFC refrigerants in the United States, emission factors for individual HFC refrigerants were calculated, as detailed in Appendix A.2. Table 4 lists the operating emission factors

[9] Refrigerants can also be released during equipment servicing or when the system is decommissioned.
[10] HFCs recovered from air conditioning or refrigeration equipment, or discarded aerosol products can be restored to virgin grade quality for re-use as refrigerant, whereupon the material becomes defined as "reclaimed HFC refrigerant". In other words, this Methodology allows credits for use of reclaimed HFC refrigerants sourced from both refrigeration and air conditioning equipment, and from discarded aerosol products.

used in this Methodology for HFCs that are recovered from refrigeration, A/C equipment, or aerosol products (see Appendix A.3 for a discussion of the baseline emission factor for aerosol products).

All HFC refrigerants that are placed into commerce – either through sale or through any other method to transfer title – are used. For purposes of this Methodology, it is assumed that from the time that any reclaimed HFC refrigerant is sold or otherwise transferred from the reclaimer to a distributor, wholesaler, service technician, or an end-user (e.g., equipment manufacturer, supermarket) that refrigerant will be used.

Emissions of refrigerant that occur during equipment manufacturing or installation are less than 3% of the initial charge (IPCC, 2006) and are therefore considered negligible and not included in this Methodology.

Table 4: 10-Year Emission Rates for Predominant HFCs[11]

HFC Recovered from Refrigeration or A/C Equipment	**10-year Emission Rate (%)**
HFC-134a	76%
HFC-23	73%
HFC-32	64%
R-404A	89%
R-407A	89%
R-407C	68%
R-410A	66%
R-417C	86%
R-422B	68%
R-422C	89%
R-422D	89%
R-507A	89%
HFC Recovered from Discarded Aerosol Products	**10 Year Emission Rate (%)**
HFC-134a	100%
HFC-152a	100%

As discussed in Appendix A.1, for purposes of this Methodology, the baseline reclamation rate for HFCs in the United States is set conservatively at 8.9% which is the R-22 reclaim rate from 2013 which is the most recent year in which there are EPA published data. As new data become available on R-22 reclamation, and eventually HFC reclamation, ACR will update this factor.

Table 5 lists the GWPs of the HFC refrigerants for both the baseline and project scenario calculations. As additional refrigerants become available through United States EPA SNAP listings[12] and market adoption, ACR will update this table.

[11] See Appendices A.2 and A.3
[12] http://www.epa.gov/spdpublc/snap/refrigerants/lists/index.html

Table 5: GWPs of Predominant HFC Refrigerants

HFC Refrigerant	Global Warming Potential[13]
HFC-152a	124
HFC-32	675
HFC-134a	1,430
R-407C	1,774
R-417C	1,820
R-410A	2,088
R-407A	2,107
R-422B	2,525
R-422D	2,730
R-422C	3,085
R-404A	3,922
R-507A	3,985
HFC-23	14,800

3.1.2 Advanced Refrigeration Systems

According to United States EPA, at least 70% of United States supermarkets rely on refrigeration systems that are comprised of centralized compressor racks that provide cooling throughout the stores via an extensive network of pipes and valves.[14] These systems tend to leak during normal operations, at an average rate between 15 and 35% per year (EPA, 2010) releasing refrigerant to the atmosphere therefore they require regular servicing and "re-charging" to maintain required performance.

Today, nearly all refrigeration systems in supermarkets, smaller grocery stores and restaurants use HCFC-22 or HFC refrigerants.[15] Because HCFC-22 is being phased out in the U.S., the majority of new installations (either new stores or retrofits to existing stores) have relied on HFC blends such as R-404A and R-507A. However, the EPA has proposed restrictions on the use of these HFCs beginning in 2016.

To date, the industry has relied on R-22 and more recently R-407A, an HFC blend. In a small number of cases, new supermarkets have installed systems with non-HFC refrigerants with zero or low GWP such as CO_2, HCs, and ammonia (see Table 6).

Table 6: Select Low-GWP Alternatives

Low-GWP Refrigerant	Global Warming Potential
R-290 (propane)	3.3
R-600a (isobutane)	3
R-1270 (propylene)	1.8
R-744 (CO_2)	1
R-717 (ammonia)	0

[13] IPCC, Fourth Assessment Report (100 year)
[14] Supermarkets also use distributed racks, and supermarkets and smaller grocery and convenience stores use other refrigeration equipment and appliances such as walk-in coolers, stand-alone "coffin cases", and beverage refrigerators.
[15] The large refrigeration systems in food warehouses and distribution centers and food manufacturing plants typically use ammonia although high GWP refrigerants are also used in these facilities.

These new systems encompass a wide variety of designs, including use of one refrigerant throughout the entire system, or for example, secondary loop systems where the compressor uses a relatively small charge of HFC refrigerant, and the piping throughout the store is filled with heat exchange fluid such as glycol. As of July 2015, of the more than 37,000 supermarket stores in the U.S., eight are certified by EPA's GreenChill Partnership as having an advanced refrigeration system (see Appendix A.3).[16]

This Methodology includes scenarios where advanced commercial refrigeration systems are installed in both new facilities and existing facilities. In addition, this Methodology calculates both the emissions from the initial refrigerant charge over a 10-year period, plus emissions of refrigerant that is required to service the equipment (re-charge) over that same 10 year period.

Table 7: Baseline Default Assumptions for New Commercial Refrigeration Projects lists the default baseline factors in projects involving new commercial refrigeration systems that are installed at *new* facilities. These default assumptions shall be applied in Equations 3 and 4 of Section 4.2.

For *existing* facilities that install an advanced refrigeration system, the actual refrigerant used in the system that was replaced and the refrigerant charge size of the replaced system shall be used. For these projects, data from regulatory compliance reporting or other verifiable historical operating records shall be used in Equations 3 and 4 of Section 4.2 to establish the appropriate baseline refrigerant, charge size, and annual leak rates.

Table 7: Baseline Default Assumptions for New Commercial Refrigeration Projects

Segment	Baseline Parameter	Factor	Reference
Commercial Refrigeration (all but Stand-Alone Commercial Refrigeration)	Refrigerant: R-407A	GWP = 2107	US EPA
	Refrigerant Charge Size	2.56 lbs (1.16 kgs) refrigerant per MBTU/hr of cooling capacity of the new system	US EPA
	Annual Leak Rate	20%	US EPA; see Appendix A.2
Stand-Alone Commercial Refrigeration	Refrigerant: R-404a (50%) and HFC-134a (50%)	Blended GWP = 2676	US EPA
	Refrigerant Charge Size	2.67kg	OEM
	Annual Leak Rate	8%	US EPA; see Appendix A.2

3.2 Additionality Assessment

Emission reductions from the project must be additional, or deemed not to occur in the "business-as-usual" scenario. Assessment of the additionality of a project will be made based on passing the two tests cited

[16] As of July 2015, the GreenChill Program has also awarded 82 United States stores with silver-level certification and 32 stores with gold-level certification, signifying those stores as having an annual storewide average emission rate below 15%, with an average HFC refrigerant charge per MBTU/hr. total evaporator heat load less than 1.75 lbs (silver level) or 1.25 lbs (gold level); www2.epa.gov/greenchill/greenchill-store-certification-awards.

below. These two tests require the project proponent to demonstrate that the project activity is surplus to regulations and reduces emissions below the level established in the Methodology.

1. Regulatory Surplus Test, and
2. Practice-Based Performance Standard

3.2.1 Regulatory Surplus Test

In order to pass the regulatory surplus test a project must not be mandated by existing laws, regulations, statutes, legal rulings, or other regulatory frameworks in effect as of the project start date that directly or indirectly affect the credited GHG emissions associated with a project. The project proponent must demonstrate that there is no existing regulation that mandates the project or effectively requires the GHG emission reductions associated with 1) using certified reclaimed HFC refrigerant; or 2) installing advanced commercial refrigeration technologies.

Use of Certified Reclaimed HFC Refrigerants

Currently, there are no restrictions in the United States or elsewhere in North America on the quantities of HFCs that can be produced, imported, or used. There are no requirements on the quantities of reclaimed HFC refrigerants that must be used for any application. Users are free to use virgin HFC, stockpiled HFC, or recycled or reclaimed HFC refrigerant in any amount of their choosing. There are regulatory requirements pertaining to certification of the equipment used to recover ODS refrigerants and the service technicians that handle ODS refrigerants, as well as certification requirements for refrigerant reclaimers. All of these regulatory requirements that apply to ODS refrigerants must be complied with as part of projects involving HFC refrigerants under this Methodology.

As discussed in Section A.1, because of the lack of production controls for HFCs, combined with the additional costs to recover, transport, and separate/process refrigerants back to virgin purity levels, there is currently little incentive for recovery, reclamation, and re-sale of HFC refrigerants. Based on U.S. EPA data on reclamation of HCFC-22 (for which there is a strong incentive to recover and reclaim), and industry information, the percentage of available HFCs that are reclaimed in the U.S. is extremely low. For purposes of this Methodology, a conservative assumption is made that the rate by which HFC refrigerants are reclaimed under the baseline scenario is the same (8.9%) as the R-22 reclaim rate based on the most recent data.

Advanced Refrigeration Systems

There are no requirements in the United States that require installation of advanced refrigeration technology. EPA recently issued a regulation that will prohibit use of several HFC blends, including R404Aand R507A – in new commercial refrigeration installations beginning August, 2017.[17] Other HFCs or HFC blends, e.g., R407A – would be allowed for use in new installations. As noted above, non-HFC refrigerants are available but in the United States have had an insignificant adoption rate. In this Methodology, the default baseline refrigerant will be R407A for new refrigeration systems in commercial refrigeration systems.

[17] 80 FR 42869; July 20, 2015; R404A, and R507A will be prohibited from use in retail food refrigeration retrofits beginning in 2016.

3.2.2 Practice-Based Performance Standard

In order for a project to qualify for offset credits under this Methodology it must be demonstrated that the sector has a low market adoption rate for both certified reclaimed HFC refrigerant, or advanced commercial refrigeration technology. A market adoption analysis, and hence the additionality demonstration under Applicability Conditions 1.3.1(b) and 1.3.2(b), was conducted for the relevant sectors and segments (see Table 1). Review of US EPA's reclamation data (see Appendix A.1), and EPA's GreenChill Partnership program data (see Appendix A.3) indicate that these sectors and segments have a low market adoption rate for using certified reclaimed HFCs and for advanced commercial refrigeration technologies. Therefore, project activities within these sectors and segments qualify for offset credit creation under this Methodology.

4.0 QUANTIFICATION OF GHG EMISSION REDUCTIONS

Quantification of project emission reductions requires calculation of baseline emissions and project emissions.

4.1 Use of Certified Reclaimed HFC Refrigerants

4.1.1 Baseline Emissions

This is the amount of baseline emissions that would take place without the use of certified reclaimed HFCs. It is equal to the total amount of reclaimed HFC refrigerant produced and the subsequent sale, title transfer or return to a refrigerant distributor, refrigerant wholesaler, or an end-user (either through direct sale, title transfer or return to an end user or through installation conducted via service technician) for use in refrigeration or air conditioning equipment during the reporting period. In the absence of the project, most of the refrigerant used to recharge the system would have come from virgin HFC production, and some would come from HFCs that would normally be reclaimed.

For projects using certified reclaimed HFC refrigerant, the baseline emissions are calculated by the following:

Equation #1

$$BE_{HFC_{rp}} = \sum_{n}^{y} [(VR_{HFC,j,_{rp}} \times ER10_{HFC,j} \times GWP_{HFC,j})] \times (1 - RR_{BL}) \div 1000$$

Where:

$BE_{HFC_{rp}}$	Baseline emissions during the reporting period (tonnes CO_2e)
$VR_{HFC,j,_{rp}}$	Total quantity of virgin HFC refrigerant *j* used to recharge equipment during the reporting period (kgs), derived from the quantity of monitored certified reclaimed HFC refrigerant that is documented according to the procedures in Section 3.1.1 and Section 5
$ER10_{HFC,j}$	The 10-year loss rate of HFC refrigerant *j* from equipment (%; see Table 4)
$GWP_{HFC,j}$	The global warming potential of HFC refrigerant *j* (see Table 5)
RR_{BL}	Baseline Refrigerant Reclamation Rate (% per year)[18]

[18] Percentage of HFC refrigerant that would be reclaimed in the business-as-usual case, currently estimated to be 8.9% per year (see Appendix A.1)

4.1.2 Project Emissions

As discussed above in Section 2, by using previously used, reclaimed HFC refrigerants, project participants are displacing new production of virgin HFC. In this Methodology, any project related emissions from using reclaimed refrigerant, for example, from transport of certified reclaimed HFCs, are considered negligible and outside the project boundary. As a result, project activity emissions can be disregarded.

4.1.3 Leakage

In GHG project literature, leakage is a term that refers to secondary effects associated with where the GHG emission reductions of a project may be negated by shifts in market activity or shifts in materials, infrastructure, or other physical assets associated with the project. Projects involving certified reclaimed HFC refrigerant would not increase demand for refrigerant beyond current baseline demand, i.e., use of more reclaimed refrigerant would not cause an increase in virgin HFC production (to the contrary), or increase refrigerant emission rates. Therefore, for this Methodology, "leakage" can be disregarded.

4.1.4 Project Emission Reductions

Equation #2

$$ER_{rp} = BE_{HFC_{rp}}$$

Where:

ER_{rp}	Project emission reductions during reporting period (tonnes CO_2e)
$BE_{HFC_{rp}}$	Baseline emissions of HFC refrigerant during reporting period (tonnes CO_2e)

4.2 Advanced Refrigeration Systems

4.2.1 Baseline Emissions

For projects located at new facilities, project proponents shall use default leakage rates and default assumptions for type of refrigerant/GWP listed in Table 7. To calculate the refrigerant charge for the baseline scenario, project proponents shall use the conversion factor in Table 7 of 1.16 kg of refrigerant per MBTU of cooling capacity of the new system (for all systems but stand-alone commercial refrigeration) or 2.67kg (for stand-alone commercial refrigeration).

For projects that involve newly installed systems or equipment in existing facilities, project proponents shall use historical system-specific data for refrigerant type, quantity of refrigerant used, and annual leak rates. These data shall be generated from regulatory compliance reporting and other verifiable, historical operating documentation.

Baseline emissions will be calculated according to the following formula:

Equation #3

$$BE_y = \sum_i [(Q_{BR,j,i} \times ERA_{REF,j})] / 1000 \times GWP_{REF,j}]$$

Where

BE_y Baseline emissions in year y (tonnes CO_2e)

$Q_{BR,j,i}$ Quantity of refrigerant *j* in equipment *i* used in baseline system (kgs; for projects located at new facilities, see Table 7; for projects located at existing facilities, use regulatory compliance reporting or verifiable historical operating records to establish the charge size of the replaced baseline system)

$ERA_{REF,j}$ Annual emission rate of refrigerant *j* in baseline system (for projects located at new facilities, see percentage emission rate in Table 7; for projects located at existing facilities, use regulatory compliance reporting or verifiable historical operating records to establish the annual leak rate of the replaced baseline system which shall be based on the average of the previous five years of baseline system operation prior to installation of advanced refrigeration system)

$GWP_{REF,j}$ Global warming potential of baseline refrigerant *j* (for projects located at new facilities, see Table 7; for projects located at existing facilities, use regulatory compliance reporting or verifiable historical operating records to establish the type of refrigerant historically used)[19]

4.2.2 Project Emissions

Project emissions will be calculated according to the following formula:

Equation #4

$$PE_y = \sum_i [AR_{k,i} \times ERA_{REF,k}] \div 1000 \times GWP_{REF,k}$$

Where

PE_y Project emissions in year y (tonnes CO_2e)

$AR_{k,i}$ Quantity of alternative refrigerant *k* used in project system *i* (kgs) [20]

[19] For installation of an advanced refrigeration system in an existing facility, project developers shall use GWP of the refrigerant used in the existing system that is replaced. Table 5 provides the GWP for predominant HFCs. If the historical system did not use an HFC found in this table, use the GWP, found in the IPCC Fourth Assessment Report, of the historical refrigerant that was used.

[20] For secondary loop systems, the parameter $AR_{,k,i}$ should only include the quantity of primary refrigerant used in the system.

$ERA_{REF,k}$ Annual emission rate of alternative refrigerant *k* (% per year)

$GWP_{REF,k}$ Global warming potential of refrigerant *k* used in the project (see Table 5)

4.2.3 Leakage

By installing an advanced refrigeration system, a project is not increasing overall market demand for refrigeration systems. Thus, there would be no "market-shifting" associated with this project type. Regarding "activity-shifting" leakage, implementation of a project at an existing facility may result in the recovery of refrigerant used in the system that was replaced. However, per applicability conditions 1.3.2 (c) and (d), any refrigerant recovered in the old system must be destroyed (if CFC or HCFC) or reclaimed (if HFC). Thus, for this Methodology, leakage can be disregarded.

4.2.4 Project Emission Reductions

Equation #5

$$ER_y = BE_y - PE_y$$

Where

ER_y Emission reductions in year y (tonnes CO_2e)

BE_y Baseline emissions in year y (tonnes CO_2e)

PE_y Project emissions in year y (tonnes CO_2e)

5.0 MONITORING AND DATA COLLECTION

Each project shall include a monitoring, reporting and verification plan sufficient to meet the requirements of the ACR Standard. The plan shall collect all data required to be monitored and in a manner which meets the requirements for accuracy and precision of this Methodology.

5.1 Description of the Monitoring Plan

These are expanded upon in the sections below. The project proponent must prepare a monitoring plan describing (for each separately) the following: a) project implementation; b) technical description of the monitoring task; c) data to be monitored and collected; d) overview of data collection procedures; e) frequency of the monitoring; f) quality control and quality assurance procedures; g) data archiving; and h) organization and responsibilities of the parties involved in all the above.

The rationale of monitoring project implementation is to document all project activities implemented by the project that could cause an increase in GHG emissions compared to the baseline scenario.

5.2 Data Collection and Parameters to be Monitored

5.2.1 Use of Certified Reclaimed HFC Refrigerants

For a specific quantity of HFC refrigerants that are reclaimed, the process for monitoring the emission reduction parameters includes:

- Where the HFC was recovered by service technicians in individual containers of 500 pounds gross refrigerant weight or more, documentation of the point of origin of the reclaimed HFC including:
  - Facility name and address where HFC was recovered;
  - Equipment/product (including, if available, manufacturer, model number, and serial number; if unavailable, a description of the equipment/product) from which HFC was extracted;
  - Date(s) of recovery;
  - The cylinder number, gross refrigerant weight, and net refrigerant weight of each container received by the EPA-certified reclaimer;
  - Date(s) received by the EPA-certified reclaimer;
  - Attestation from EPA-certified reclaimer regarding the source of the HFC refrigerant that is reclaimed. Specifically, this attestation must document whether the reclaimer has previously obtained recovered HFC refrigerant from the source and, if so, the dates on which that HFC refrigerant was acquired; and
  - Chain of custody and ownership of the recovered HFC must be demonstrated from the point of origin through the delivery of recovered HFC to the EPA-certified reclaimer. The following information must be provided to track chain of custody:
    - Names and addresses for all persons/entities buying and selling the recovered HFC;
    - The quantity of HFC purchased/sold at each transaction.

- Where HFCs were recovered by service technicians in individual containers of less than 500 pounds and aggregated with other recovered HFCs to greater than 500 pounds gross refrigerant weight in an individual container prior to delivery to an EPA-certified reclaimer, documentation of the point of origin of the reclaimed HFC including:
  - Name and address of the service company, wholesaler or distributor where recovered

HFC was aggregated to individual containers of greater than 500 pounds;
    - If applicable, chain of custody and ownership of the recovered HFC must be demonstrated from the point of origin (location where recovered HFC was aggregated into individual containers to greater than 500 pounds) through to the delivery of recovered HFC to an EPA-certified reclaimer. The following information must be provided to track chain of custody:
        - Names and addresses for all entities buying and selling the recovered HFC;
        - The quantity of HFC purchased/sold at each transaction.
    - The cylinder number, gross refrigerant weight, and net refrigerant weight of each container received by the reclaimer; and
    - Date(s) received by the reclaimer.

- Where the HFC was recovered by service technicians in an individual container of less than 500 pounds gross refrigerant weight and delivered to a wholesaler or distributor, or delivered directly to an EPA-Certified reclaimer, documentation of the point of origin of the reclaimed HFC including:
    - Name and address of the service company, wholesaler or distributor that delivered the individual container of less than 500 pounds to the reclaimer;
    - The cylinder number, gross refrigerant weight, and net refrigerant weight of each container received by the EPA-certified reclaimer; and
    - Date(s) received by the EPA-certified reclaimer.

- For disposed aerosol products, documentation on the point of origin of the HFC including:
    - Name and address of the entity that delivered the disposed aerosol products to the EPA-Certified reclaimer;
    - The weight of the recovered HFC after processing by the EPA-certified reclaimer; and
    - Date(s) received by the EPA-certified reclaimer.

- Tracking of the containers that are used for collection and transport to the reclaimer of the recovered HFC refrigerant (e.g. unique identification with serial number or barcode).
- Documentation on the type of HFC that is recovered from equipment or product and that is subsequently reclaimed.
- Documentation on the quantity of HFC refrigerant produced in the reclamation process, accounting for contaminants that are removed in the reclamation process.[21]
- Documentation that the same quantity of reclaimed HFC refrigerant (i.e. equal to the volume of HFC that was reclaimed during the reporting period) is transferred, sold, or returned to a refrigerant wholesaler, distributor, or end-user (either through direct sale, title transfer or return to an end user or through installation conducted via service technician).
- Documentation demonstrating that the reclaimer is an EPA-Certified reclaimer and reclaimed the refrigerant using equipment listed with the EPA, including:
    - The most recent equipment list provided to the EPA by the EPA Certified reclaimer; and
    - The physical address where the reclamation was conducted.
- Documentation showing that used HFC refrigerant processed by the EPA-Certified reclaimer is tested by an AHRI certified refrigerant testing laboratory to meet the AHRI 700-2015 Standard for Specification for Fluorocarbon Refrigerants.

[21] In any measurement of the quantity of refrigerant that involves weighing of a cylinder(s) (e.g., refrigerant recovered from equipment), the weight of the "empty" cylinder(s) (prior to filling with refrigerant) must be measured so that that any residual refrigerant (the cylinder "heel") is taken into account.

5.2.2 Advanced Refrigeration Systems

The process for monitoring the project's emission reduction parameters includes:

- Identifying and logging the equipment/systems to be installed
- For projects located at new facilities and existing facilities, recordkeeping of project related refrigerant usage
- For projects located at existing facilities, recordkeeping of historical refrigerant usage
- For projects located at existing facilities that replace previous CFC or HCFC-based systems, documentation showing proof of destruction for the displaced CFC and HCFC. This documentation shall include the following:
  - Bills of lading for shipments of CFC or HCFC from the facility to a destruction facility[22]
  - Attestation from project proponent and signed by representatives from the project proponent and the destruction facility that the volume of displaced CFC or HCFC from the baseline system was destroyed including the dates of destruction
- For projects located at existing facilities that replace previous HFC-based systems, documentation showing proof of reclamation of the displaced HFC. This documentation shall include the following:
  - Documentation of the recovery of the HFC (i.e. receipts or invoices documenting recovery by service technician) and subsequent transfer of recovered HFC to EPA certified reclaimer
  - Attestation from project proponent and signed by representatives from the project proponent and reclamation facility that the volume of displaced HFC from the baseline system was reclaimed per the AHRI 700 Standard

5.2.3 Parameters Monitored

Parameter	$VR_{HFC,j,rp}$
Units	kg
Description	Total quantity of virgin HFC refrigerant *j* that would have been used to recharge equipment during the reporting period (kgs), derived from the quantity of monitored certified reclaimed HFC refrigerant that is documented according to the procedures in Section 3.1.1 and Section 5
Relevant Section	4.1
Relevant Equation(s)	1
Source of Data	Operating Records
Measurement Frequency	Determined once for each project (which consists of only one reporting period).

Parameter	$Q_{BR,j,i}$
Units	kg

[22] Destruction shall be conducted at either an approved hazardous waste combustor subject to the Resource Conservation and Recovery Act (RCRA) that maintains a current RCRA permit that states an ODS destruction efficiency of at least 99.99% or at a destruction facility that meets the Montreal Protocol's Technology and Economic Assessment Panel standard that a destruction facility must demonstrate a destruction and removal efficiency of 99.99%.

Description	Quantity of refrigerant *j* that would have been used in initial charge of system *i* in absence of project activity based on: • For projects located at new facilities, the cooling capacity of the newly installed equipment, or • For projects located at existing facilities, use (charge size) records from regulatory compliance reporting or verifiable historical operating records
Relevant Section	4.2.1
Relevant Equation(s)	3
Source of Data	Installation and regulatory compliance or operating records
Measurement Frequency	Determined once and recorded annually

Parameter	$AR_{k,i}$
Units	kg
Description	Quantity of alternative refrigerant *k* used in project system *i*
Relevant Section	4.2.2
Relevant Equation(s)	4
Source of Data	Installation records or regulatory compliance reports
Measurement Frequency	Determined once and recorded annually

Parameter	ERA_{REF_j}
Units	% per year
Description	For advanced refrigeration systems installed at *existing* facilities: Annual emission rate of refrigerant *j* used in baseline system. Emission rate shall be based on the average of the previous five years of baseline system operation prior to installation of advanced refrigeration system.
Relevant Section	4.2.2
Relevant Equation(s)	4
Source of Data	Determined from operating records or regulatory compliance reports
Measurement Frequency	Determined once and recorded annually

Parameter	ERA_{REF_k}
Units	% per year
Description	Annual emission rate of alternative refrigerant *k* used in project system *i*
Relevant Section	4.2.2
Relevant Equation(s)	4
Source of Data	Operating records or regulatory compliance reports
Measurement Frequency	Annual

APPENDIX A: BASELINE DATA INPUTS

A.1 Rate of HFC Reclamation

Reclaimers in the United States are required to report to EPA the quantities of CFCs and HCFCs that they reclaim. Currently there are no reporting requirements for HFC reclamation. Because CFC production ended in 1996, reclaimed CFCs are essentially the only source of CFCs for CFC-based equipment still in use. Similarly, because HCFC-22 production is being phased out and will end in 2020, there is a strong incentive for system owners and service technicians to recover and re-use as much R-22 as possible to service equipment.

In contrast, there are no restrictions on production of HFCs, and because of the additional costs to recover, transport, and separate/process back to virgin purity levels[23] - unlike the strong incentive to reclaim CFCs and R-22 - there is currently little incentive for recovery, reclamation, and re-sale of HFCs. Thus, a conservative approach to estimate the amount of HFC refrigerant that is reclaimed in the baseline scenario is to use data from the United States EPA on R-22 reclamation, described below.

Table A.1 presents the most recent data on the quantity of reclaimed R-22 in the U.S., as reported to the EPA.

Table 8: Total reclaimed R-22 reported to EPA

Year	Amount Reclaimed in Pounds[24]
2010	7,985,289
2011	8,325,390
2012	9,401,446
2013	8,898,470

To calculate the R-22 reclaim rate (%) for a given year, the quantity of R-22 reclaimed is divided into the estimated quantity of R-22 being recovered from end-of-life equipment:

RR_{BL} = R-22 Reclaimed/R-22 coming off-line

Based on data presented in an EPA report, for the most recent year (2013), it is estimated that 100 Million pounds of R-22 came “off-line”:

- Estimated installed base of R-22 based refrigeration and air conditioning equipment contained 1.5 billion pounds of R-22 (ICF 2009; Tables A-1 and B-1)
- Assumed turnover rate of 7% per year on average (1/15 lifetime of equipment) (ICF, 2009; Table

[23] http://ozone.unep.org/new_site/en/ozone_data_tools_reclaimation_facilities.php
[24] EPA (2014)

A-1)

The R-22 reclaim rate for 2013 is calculated as:
8.9 M / 100 M = 8.9%

Based on industry communications, the reclaim rate for HFC refrigerants is significantly lower than 8.9%. This is expected because R-22 production and import is being phased out and is tightly controlled under EPA's annual allocations. However, for purposes of this Methodology, a conservative assumption is made that the rate by which HFC refrigerants are reclaimed under the baseline scenario is the same (8.9%) as the R-22 reclaim rate based on the most recent data. As new data become available on R-22 reclamation, and eventually HFC reclamation, ACR will update this factor.

This Methodology also allows credits for use of HFCs that are recovered from discarded aerosol products and subsequently reclaimed for re-use as refrigerant. Since R-22 is not used as an aerosol propellant, the EPA data on R-22 reclamation would not reflect the baseline rate of reclamation of HFC aerosols. Industry information indicates that there may be very small quantities of HFCs in discarded medical aerosol products that are being recovered in the U.S. (e.g., less than a few thousand pounds per year) and that none of the non-medical aerosol products that are discarded in the U.S. are being managed at end-of-life such that none of the HFCs in those products are being recovered. Therefore, using the current reclamation rate of R-22 as a proxy for the baseline reclamation rate for HFCs that are recovered from aerosol products is an extremely conservative approach.

A.2 HFC Refrigerant Emission Factors

Under this Methodology, baseline emissions for reclaimed HFC refrigerant projects are estimated in reference to the emission loss rates of equipment into which virgin HFC refrigerants would have been installed. The calculation is based on the actual quantities of certified reclaimed HFC refrigerant that enter commerce through sale, transfer, or return to a refrigerant end-user or distributor. It would be difficult to track the exact equipment where the reclaimed HFC refrigerant is ultimately used. Therefore the baseline is defined for a specific HFC refrigerant by the weighted-average emission rate for the equipment where that refrigerant is typically used.

Some HFC refrigerants are used in predominantly single applications, e.g., R-404A in commercial multiplex refrigeration systems. In this example, the average emission rate used in this Methodology for R-404A would be the average emission leak rate for commercial refrigeration.

In contrast, other HFC refrigerants are used in a variety of applications, e.g., HFC-134a is used for automotive A/C, residential refrigerator-freezers, stand-alone commercial refrigerators, and large chillers. In this case, a weighted-average emission rate is calculated for the refrigerant based on its "market share" across the various end-uses (e.g., 30% of HFC-134a refrigerant is used for automotive A/C, 25% of HFC-134a refrigerant is used for residential refrigerator-freezers, etc.), multiplied by the average leak rates for those particular end-uses.

Table 9 presents average annual emission rates for the major refrigeration and air conditioning end-use categories, derived from two sources –the US EPA Vintaging Model and the 2006 IPCC Guidelines for National GHG Inventories. The EPA Vintaging Model outputs are publicly available (CAR, 2012; EPA,

2015). To be conservative, the values from the IPCC Guidelines are the low end of ranges presented in Table 7.9 of that report.

Table 10 presents the 10-year weighted-average leak rates incorporating the data in Table 9.[25]

Table 9: Emission Factors for Refrigeration and Air Conditioning Systems

Refrigerant Sector	Segment	Average Annual Emission Rate[1]
Domestic Refrigeration	Residential refrigerators and freezers	0.6%
Commercial or Retail Food Refrigeration	Equipment used to store and display chilled and frozen goods for commercial sale such as supermarkets, convenience stores, bakeries, and restaurants. This equipment includes centralized supermarket systems, remote condensing units, and stand-alone equipment (e.g., beverage vending machines, stand-alone display cases).	20% (all but stand-alone equipment) 8% (stand-alone equipment)
Cold Storage Warehouses		12.3-15%
Industrial Process Refrigeration	Chemical, pharmaceutical, petrochemical and manufacturing industries, industrial ice machines and ice rinks.	12.3-15%
Transport Refrigeration	Refrigerated truck trailers, railway freight cars, ship holds, and other shipping containers.	20.6-27.9%
Stationary Air Conditioning (including chillers)	Comfort cooling for homes and commercial buildings, including multi-family buildings, office buildings, hospitals, universities, shopping malls, airports, sports	2-11.8%

[25] 10-year emission rates are calculated from the annual emission rates using the following formula:
10 yr ER = 1-(1-Annual ER)^{10})

	arenas.	
Mobile Air Conditioning	Automobiles and Trucks	18%[2]

[1]Unless otherwise noted, emission rates are from the US EPA Vintaging Model as reported in ICF (2009) and EPA (2015).
[2] Lowest value in range in Table 7.9 of the 2006 IPCC Guidelines.
[3] GreenChill Partners represent roughly 20% of United States supermarket stores; for this Methodology, the average leak rate for centralized commercial refrigeration systems in the United States is assumed to be 20%.

Table 10: 10-Year Emission Rates for Individual HFC Refrigerants

Refrigerant	End-Use	Deployment of Refrigerant by End-Use (%)	End-Use Weighted Emission Rate (%/year)[1]	10-year Emission Rate (%)
HFC-134a	Mobile A/C	60%	18%	76%
	Commercial Refrigeration	5%	20%	
	Stand-Alone Commercial Refrigeration	15%	8%	
	Chillers	5%	6.5%	
	Domestic Refrigeration	15%	0.6%	
HFC-23	Industrial Process Refrigeration	85%	13.7%	74%
	Chillers	15%	6.5%	
HFC-32	Residential and Commercial A/C	85%	10.2%	64%
	Chillers	15%	6.5%	
R-404A	Commercial Refrigeration	80%	20%	84%
	Stand-alone Commercial Refrigeration	5%	8%	
	Industrial Process Refrigeration	15%	13.7%	
R-407A	Commercial Refrigeration	100%	20%	89%
R-407C	Residential and Commercial A/C	95%	10.2%	68%
	Commercial Refrigeration	5%	20%	
R-410A	Residential and Commercial A/C	100%	10.2%	66%
R-417C	Mobile A/C	100%	18%	86%
R-422B	Residential and Commercial A/C	95%	10.2%	68%
	Commercial	5%	20%	

	Refrigeration			
R-422C	Commercial Refrigeration	100%	20%	89%
R-422D	Commercial Refrigeration	100%	20%	89%
R-507A	Commercial Refrigeration	100%	20%	89%
R-508B	Stand-Alone Commercial Refrigeration	100%	8%	57%

[1]Annual emission rates for specific refrigerant end-uses taken from Table 9. Where those emission rates are presented as ranges in Table 8, the midpoint of the range is used.

A.3 HFC Aerosol Emission Factor

For projects conducted under this Methodology involving HFCs that are recovered from discarded aerosol products, and subsequently reclaimed for re-use as refrigerant, baseline emissions for reclaimed HFC refrigerant projects are estimated in reference to the emission loss rate of products in which virgin HFCs would have been used as aerosol propellants. The HFCs that are currently used in aerosol products are HFC-134a and HFC-152a, both of which could be re-used as refrigerants[26], and HFC-227ea, which is not used as a refrigerant.[27]

Unlike refrigeration and air conditioning equipment, which leak gradually under normal operations, aerosol products are designed to release their contents (including propellant) completely with each use. All HFCs used in aerosols are assumed to be emitted in the year of manufacture (EPA, 2015). The 10-year cumulative emission factor used in this Methodology for HFCs originating from aerosol products is 100%.

A.4 Advanced Refrigeration Systems

Section 3.1.2 summarizes trends in the adoption of advanced refrigeration systems. A measure of the penetration rate of these newer technologies is the number of supermarkets certified by EPA's GreenChill Partnership as having an advanced refrigeration system. Supermarkets qualify for GreenChill "platinum" certification by either 1) having a refrigeration system that uses a refrigerant with a GWP less than 150, or 2) having a very small HFC refrigerant charge (less than 0.5 lbs per MBTU/hr total evaporator heat load) and achieving an annual leak rate of 5% or less.[28] As of October 2015, of the more than 37,000 supermarket stores in the U.S., eight are certified by GreenChill.[29] There may be additional stores in the United States that have advanced refrigeration systems that have not yet been recognized by the EPA GreenChill Partnership. However, under any scenario, currently the percentage of supermarkets in the United States with advanced refrigeration systems is negligible.

[26] In contrast to HFC-152a, HFC-134a is a commonly used refrigerant so the expectation is that a very large proportion of any HFC aerosols that will be recovered for re-use will be HFC-134a.
[27] In addition to its use as an aerosol propellant, HFC-227ea is also used in fire-fighting applications.
[28] http://www2.epa.gov/sites/production/files/2013-08/documents/greenchill_store_certification_program_guidance_7.29.13.pdf
[29] http://www2.epa.gov/greenchill/greenchill-store-certification-awards

APPENDIX B: OTHER METHODOLOGY CONSIDERATIONS AND GUIDANCE

B.1 Emissions Inventory Reporting

Project proponents interested in using this Methodology are likely to include companies that report their emissions under programs such as the Carbon Disclosure Project. Many of these companies report emissions in terms of Scope 1 (direct emissions), Scope 2 (indirect) and Scope 3 (emissions associated with the supply chain). Avoided emissions generated under this Methodology from the use of certified reclaimed HFC refrigerants would be considered within Scope 1.

In cases where the generator or user of the certified reclaimed HFC refrigerant does not retire or claim the associated emission reductions, those reductions could be made available to other entities for crediting in their GHG reporting. In the case of advanced refrigeration technologies, the use of non-HFC alternative refrigerants directly displaces what would have occurred in the absence of the project *on the site* where the system is located. This would be considered Scope 1 emissions.

B.2 Lifecycle GHG Reduction of Certified Reclaimed Refrigerant

This Methodology provides the method to quantify GHG emission reductions over a 10-year "crediting period" associated with specific "project activities" within a specific project boundary, e.g., Company A uses X lbs of certified reclaimed HFC-404A in 2016 to re-charge a supermarket refrigeration system.

Another quantification approach is to measure the climate benefits of certified reclaimed HFC refrigerant over its full lifecycle. This approach is based on the fact that all refrigeration and A/C equipment leaks, and that in the absence of any incentive or requirement to destroy HFC refrigerants at equipment end-of-life, all HFC refrigerants are ultimately emitted. In other words, under current regulatory and economic conditions, the lifecycle of HFC refrigerants ends with release to the atmosphere, regardless of what equipment the refrigerants are used in, the annual leak rates of that equipment, how the equipment is serviced, and the lifetime of that particular equipment.

As described in this Methodology, using certified reclaimed HFC refrigerant displaces production of virgin refrigerant, and therefore, prevents the inevitable release of that virgin refrigerant to the atmosphere. To account for the fact that some amount of HFC refrigerant is being reclaimed under business as usual, the baseline rate of HFC reclamation cited in Section 3.1.1 of this Methodology shall be applied.

Under this approach, the full lifecycle climate benefit of certified reclaimed HFC refrigerant is calculated by:

$$ER_y = \sum_i [Q_{HFC,Reclaimed\,j} \times (1 - RR_{BL})] \times GWP_{HFC,j} / 1000$$

Where:

ER_y	Emission reductions in year *y* (tons CO_2eq per year)
$Q_{HFC,Reclaimed,j}$	Total quantity of certified reclaimed HFC refrigerant *j* used to recharge equipment *i* in year y (kg per year).

RR_{BL} Baseline Refrigerant Reclamation Rate (% per year)[30]

$GWP_{HFC,j}$ Global warming potential of refrigerant *j* used in the project (see Table 5)

B.3 Best Practices

Users of this Methodology should ensure that best practices for managing refrigerants are incorporated throughout their operations, and to the extent practicable, adopted by other companies in their supply chain or other network. This section focuses on two areas: (1) tracking refrigerants within the organization and (2) ensuring proper control of refrigerants off-site. For the second category, even though refrigerants may be under the control of an outside party, this section provides guidance to consider when selecting a contractor or other partner.

- If a system owner, facility operator, or other party that controls refrigeration or air conditioning operations (collectively referred to as the "organization") has refrigeration equipment or a cooling system that contains an operating charge of 50 lbs or more per circuit, the organization should have a refrigerant tracking system. A tracking system must enable the organization to quantify leaks, isolate leak sources, and manage and repair refrigerant leaks across multiple systems and facilities. The organization should use the tracking system to establish a benchmark against industry trends and set and meet leak reduction goals. The organization should set a goal in terms of maximum amount and rate of refrigerant leakage.

- Refrigerant tracking software should have the ability to view inventory in systems and storage, generate targeted compliance reports and track refrigerants or refrigerant assets (e.g., 1000 lbs of R-22 owned by Party A) across their lifespan, including use in equipment, recovery/processing/reclamation, and disposal/destruction. The tracking system should have the following minimum capabilities:

    - Record & track properties & location of refrigerants
    - Record & track properties & location of cylinders
    - Record & track properties & location of systems
    - Record & track who owns each of the above assets wherever they are in the supply chain.
    - Record & track when & who performed all maintenance/service events

- When refrigeration equipment reaches its end of life, or when equipment is serviced and evacuated, all refrigerant must be recovered and if either recycled or reclaimed, it must be done in conformance with EPA Section 608 requirements. Refrigerant should not simply be taken out and put back into another system (re-use) without removing impurities that can affect the performance of the equipment receiving the used refrigerant.

- Filling of the recovery cylinder should be done carefully by monitoring the mass of refrigerant added into the cylinder, thus the cylinder should be kept preferably on electronic balance throughout the

[30] Percentage of refrigerant that would be reclaimed in the business-as-usual case, currently estimated to be 8.9% per year; see Appendix A.1.

entire procedure. Ensure that the cylinder does not overfill, that means the cylinder is not filled to more than 80% of its volume with liquid refrigerant. Similarly, the discharge pressure should also be monitored to ensure that the maximum allowable pressure of the recovery cylinder is never exceeded. After recovery has been completed, the recovery cylinder should be labelled with the type and mass of refrigerant it now contains; this information should be entered into the electronic tracking system.

- Refrigerant handlers must recover the existing refrigerant charge from the system into proper pressure-rated recovery cylinders as specified in AHRI Guideline K-2009 for Containers for Recovered Non-Flammable Fluorocarbon Refrigerants. Any refrigerant shipped must comply with all DOT regulations and be in DOT-approved cylinders. Cylinders must be weighed with scales that are calibrated annually at a minimum to ensure accuracy.

- For any refrigerants that are shipped offsite for reclamation, a monitoring system should be used that enables the project participants to track cylinders so its location can be viewed online.

- Refrigerants should be managed so that system owners can access information that shows the cylinder number, the location of the refrigerant, the quantity and overall status (reclaimed, needs to be reclaimed, etc.). Owners of refrigerant must be able to know the location of their cylinders at all times.

Used refrigerant must be reprocessed to at least the purity level specified in Appendix A to 40 CFR Part 82, Subpart F.4 Reclaimed refrigerant must be verified to meet AHRI-700 standards.[31]

[31]AHRI Standard 700, *Specifications for Fluorocarbon Refrigerants.* www.ahrinet.org

APPENDIX C: REFERENCES

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