American Carbon Registry
AT WINROCK INTERNATIONAL

METHODOLOGY FOR THE QUANTIFICATION, MONITORING, REPORTING AND VERIFICATION OF GREENHOUSE GAS EMISSIONS REDUCTIONS AND REMOVALS FROM

ADVANCED REFRIGERATION SYSTEMS

VERSION 2.0

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American Carbon Registry®

WASHINGTON DC OFFICE
c/o Winrock International
2451 Crystal Drive, Suite 700
Arlington, Virginia 22202 USA
ph +1 703 302 6500

ACR@winrock.org
americancarbonregistry.org

ABOUT AMERICAN CARBON REGISTRY® (ACR)

A leading carbon offset program founded in 1996 as the first private voluntary GHG registry in the world, ACR operates in the voluntary and regulated carbon markets. ACR has unparalleled experience in the development of environmentally rigorous, science-based offset methodologies as well as operational experience in the oversight of offset project verification, registration, offset issuance and retirement reporting through its online registry system.

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ACRONYMS AND DEFINITIONS

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

TERM	ACRONYM (if applicable)	DEFINITION
Ammonia	NH_3	A chemical compound composed of nitrogen and hydrogen. Can be used as a low-GWP refrigerant.
Advanced refrigeration system		A refrigeration system deploying advanced technology that uses low-GWP refrigerants instead of CFCs, HCFCs, or HFCs as a 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

TERM	ACRONYM (if applicable)	DEFINITION
		achievable through primary or secondary refrigerant systems.
Chlorofluorocarbon	CFC	A class of compounds of carbon, hydrogen, chlorine, and fluorine that are commonly used as refrigerants.
End-of-Life	EOL	Emissions resulting from the disposal of refrigeration products and refrigerant.
GHG Source, Sink, or Reservoir	SSR	• GHG Source – Physical unit or process that releases a GHG into the atmosphere • GHG Sink – Physical unit or process that removes a GHG from the atmosphere • 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.

TERM	ACRONYM (if applicable)	DEFINITION
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.
Large Commercial Refrigeration		Equipment used to store and display chilled and frozen goods for commercial sale such as in food retailers, supermarkets, convenience stores, bakeries, and restaurants. For the purposes of this methodology, this includes commercial refrigeration units with an initial charge of 50 lbs or more of refrigerant.
Low-GWP		For the purposes of this methodology, a GWP <15 is considered low-GWP.
Project activity		Projects that avoid the emissions of CFC, HCFC, or HFC gases through the

TERM	ACRONYM (if applicable)	DEFINITION
		deployment of an advanced refrigeration system using a SNAP approved low-GWP refrigerant in Large Commercial Refrigeration or Stand-alone Commercial Refrigeration systems. See Applicability Conditions in Section 1.2.
Project Start Date		The date that the advanced refrigeration system(s) became operational and, therefore began to reduce GHG emissions against the baseline.
Refrigeration equipment		An Appliance[1], 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.
Significant New Alternative Policy	SNAP	The U.S. Environmental Protection Agency's (EPA) SNAP program implements section 612 of the amended Clean Air Act of 1990, which requires EPA's continuous review of alternatives to find those that pose less overall risk to human health and the environment. Through these evaluations, SNAP generates lists of acceptable and unacceptable substitutes for each of the major industrial use sectors. The intended effect of the SNAP program is to promote a smooth transition to safer alternatives.

[1] 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 refrigerator, chiller, or freezer."

TERM	ACRONYM (if applicable)	DEFINITION
Stand Alone Commercial Refrigeration		Refrigerators, freezers, reach-in coolers (either open or with doors), and refrigerated food processing and dispensing equipment where all refrigeration components are integrated, and, for the smallest types, the refrigeration circuit is entirely brazed or welded. These systems are fully charged with refrigerant at the factory and typically require only an electricity supply to begin operation.

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1 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.[2] 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 focuses on reductions from new equipment, as described below.

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 systems. These alternatives include hydrocarbons, ammonia, carbon dioxide, and hydrofluoroolefins (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. For example, secondary loop and cascade refrigeration systems used in supermarkets often use HFC refrigerants in combination with refrigerants that

[2] 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.

have lower GWPs (such as carbon dioxide) or heat transfer medium (such as glycol). These types of systems are eligible under this Methodology.

Table 1: Eligible Refrigerant Sectors and Segments[3]

Segment	ELIGIBLE SEGMENTS IN SECTOR
Large Commercial Refrigeration	Equipment used to store and display chilled and frozen goods for commercial sale such as in supermarkets, convenience stores, bakeries, and restaurants. For the purposes of this methodology, this includes commercial refrigeration units with an initial charge of 50 lbs or more of refrigerant.
Stand-Alone Commercial Refrigeration	Refrigerators, freezers, reach-in coolers (either open or with doors), and refrigerated food processing and dispensing equipment where all refrigeration components are integrated, and, for the smallest types, the refrigeration circuit is entirely brazed or welded. These systems are fully charged with refrigerant at the factory and typically require only an electricity supply to begin operation.

This Methodology provides the quantification framework for the creation of carbon offset credits from the reductions in GHG emissions resulting from 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 2016 ICF Accounting Tool to Support Federal Reporting of Hydrofluorocarbon Emissions, the United States EPA GreenChill Partnership, and the 2006 International Panel on Climate Change Guidelines for Greenhouse Gas Inventories.

1.2 APPLICABILITY CONDITIONS

For the purposes of this Methodology, projects that avoid the emissions of CFC, HCFC, or HFC gases in the following activity are considered a "project activity":

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

- Deployment of an advanced refrigeration system using a SNAP-approved low-GWP refrigerant in Large Commercial Refrigeration or Stand-alone Commercial Refrigeration systems.

For purposes of this Methodology, a project activity may comprise of (i) the complete replacement of CFC, HCFC or HFC-based equipment (including all components) with an advanced refrigeration 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:

I. The project is located in North America.
II. 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)).
III. For a project activity that involves replacement of CFC, HCFC, or HFC-based equipment with an advanced refrigeration system where the original equipment is decommissioned, 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 and any HFCs must be managed in accordance with EPA regulations (40 CFR Part 82, Subpart F) under Section 608 of the Clean Air Act[4].
IV. 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.[5]

1.3 REPORTING PERIODS

- A project shall have one reporting period that shall not exceed more than 12 months in length.
- The Reporting Period begins on the Project Start Date.

[4] EPA regulations (40 CFR Part 82, Subpart F) under Section 608 of the Clean Air Act restrict the resale of used ozone depleting and HFC refrigerant to a new owner unless it has been reclaimed by an EPA-certified refrigerant re-claimer. Refrigerant that has been recovered and/or recycled can be returned to the same system or other systems owned by the same person without being reclaimed.
[5] http://www.epa.gov/ozone/snap/refrigerants/index.html

1.4 CREDITING PERIOD

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. The crediting period begins on the Project Start Date.

1.5 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 PROJECT BOUNDARIES

2.1 GEOGRAPHIC BOUNDARY

The project boundary, depicted by the figure below, includes the physical and geographical site where the advanced refrigerant system is installed, as well as the locations involved in disposal of the older technology, including management 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 Advanced Refrigeration Systems

The GHG emission sources included within the project boundary are depicted in the dark blue boxes in Figure 1. They include emissions from the operation of the refrigeration equipment, emissions resulting from the recharging and servicing of that equipment, and end-of-life (EOL) / disposal emissions. Table 2 lists the GHG sources included and excluded depending on whether the sources are inside or outside project boundaries.

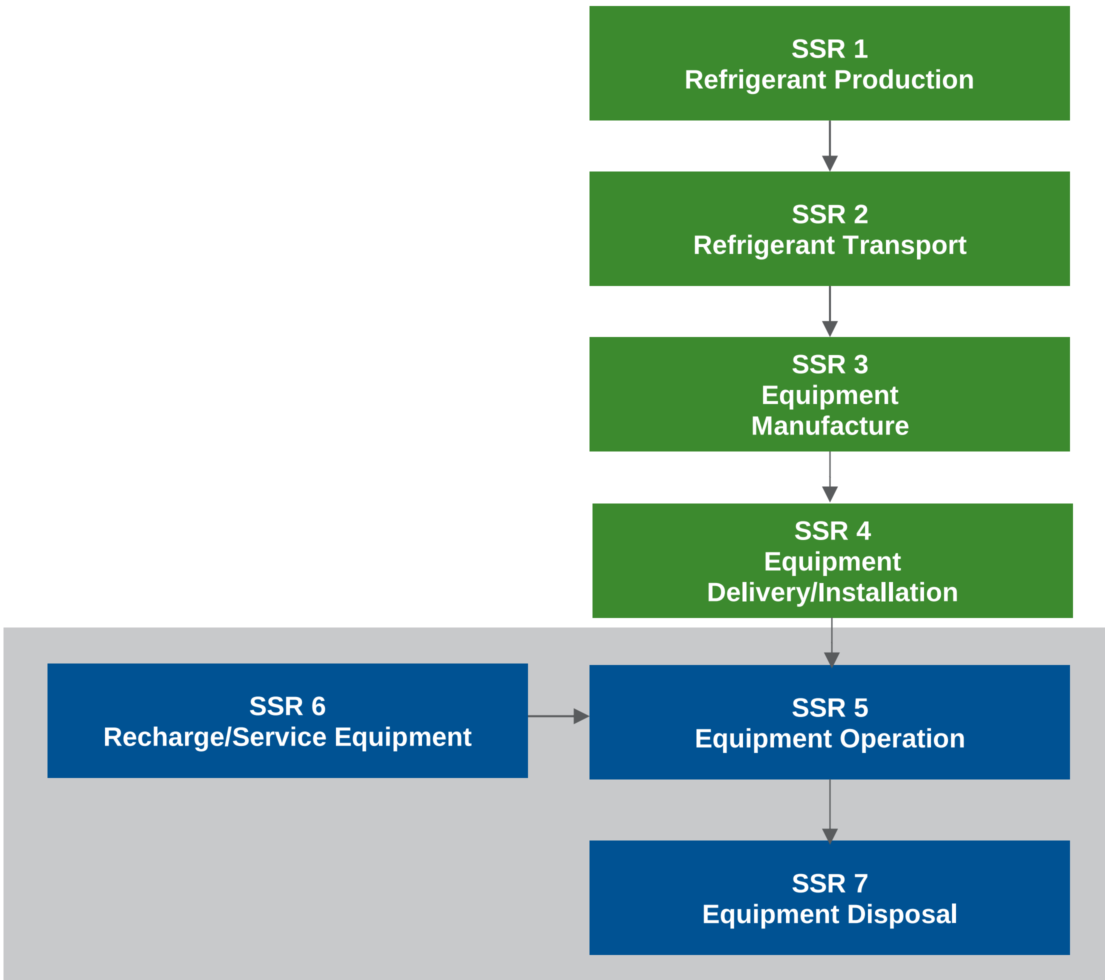

Table 2: Greenhouse Gases and Sources

SSR	SOURCE DESCRIPTION	GAS	INCLUDED (I) OR EXCLUDED (E)	QUANTIFICATION METHOD
1 Refrigerant Production	Fossil fuel emissions from the production of refrigerants	CO_2	E	N/A
		CH_4	E	N/A
		N_2O	E	N/A
	Refrigerant leaks during production	HFC	E	N/A
		Low GWP Refrigerant	E	N/A
2 Refrigerant Transport	Fossil fuel emissions from transport of refrigerants	CO_2	E	N/A
		CH_4	E	N/A
		N_2O	E	N/A
	Refrigerant leaks during transport	HFC	E	N/A
		Low GWP refrigerant	E	N/A
3 Equipment Manufacture	Fossil fuel emissions from the operation of the refrigeration system in the baseline and the project.	CO_2	E	N/A
		CH_4	E	N/A
		N_2O	E	N/A
4 Equipment Delivery and Installation	Fossil fuel emissions from the delivery and installation of the advanced refrigeration system.	CO_2	E	N/A
		CH_4	E	N/A
		N_2O	E	N/A
5 Equipment Operation	Fossil fuel emissions from the operation of the refrigeration system in	CO_2	E	N/A
		CH_4	E	N/A

SSR	SOURCE DESCRIPTION	GAS	INCLUDED (I) OR EXCLUDED (E)	QUANTIFICATION METHOD
	the baseline and the project.	N_2O	E	N/A
	Refrigerant leaks from the operation of the refrigeration system in the baseline and the project.	CFC	I	See Table 4
		HCFC	I	See Table 4
		HFC	I	See Table 4
		Low GWP refrigerant	I	See Table 4
6 Equipment Service/ Recharges	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
	Refrigerant emissions occurring from servicing refrigeration or A/C equipment or system to replace leaked refrigerant	HFC	I	See Table 4
		Low GWP Refrigerant	I	See Table 4
7 EOL/ Equipment Disposal	Emissions from the disposal of the equipment at end-of-life (EOL), including destruction of refrigerant.	CO_2	E	N/A
		CH_4	E	N/A
		CFCs	I	See Table 4
		HCFC	I	See Table 4
		HFCs	I	See Table 4

3 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.

Food retailers rely heavily on various types of refrigeration systems such as centralized compressor racks that provide cooling throughout the stores via an extensive network of pipes and valves, distributed racks, walk-in coolers, stand-alone units, and beverage refrigerators. Refrigeration systems are "charged" with refrigerant, either at the manufacturing plant, or at the facility where a system is installed (e.g., a supermarket or other food retailer). These systems tend to leak and release refrigerant during normal operations and servicing. The leak rate is dependent upon the type of refrigeration system and is the basis for determining the annual emission rate used in this Methodology.

Under normal operating conditions, depending on the type of equipment and the location, between 1 and 50% of the refrigerant in stationary refrigeration systems leaks each year (ICF 2016; IPCC, 2006; RTOC 2010; EPA, 2015; ACR ODS Destruction Methodology 2017). Even with active leak detection and aggressive maintenance efforts, it is difficult to eliminate leaks completely. Consequently, to maintain proper performance, leaky equipment and systems require periodic servicing to replace the lost refrigerant. Additionally, refrigerants are released at EOL if the refrigerants are not recovered prior to destruction.

For the purposes of determining the annual leak rates, data from the EPA Vintaging Model and from Table 3.3 of the 2016 ICF Accounting Tool to Support Federal Reporting of Hydrofluorocarbon Emissions is used.

Both EPA's Vintaging Model and the 2016 ICF Accounting Tool assume an industry-wide average annual leak rate of 25% for large commercial refrigeration units and a 1% annual leak rate for stand-alone-units. Additionally, according to Table 3.3 of the 2016 ICF Accounting Tool, 25% of stand-alone-units and 85% of large commercial refrigeration units recover refrigerant prior to EOL destruction. Due to the significant amount of refrigerant that leaks at EOL, this methodology includes EOL emissions by amortizing EOL refrigerant losses over the 10-year crediting period.

To date, the industry has relied on R-404a, R-407a, and HFC-134a. In a small number of cases, supermarkets and food retailers have installed systems with non-HFC refrigerants with zero or low-GWP such as CO_2, HCs, and ammonia (see Table 3).

Table 3: Select Low-GWP Alternatives

LOW-GWP SNAP-APPROVED REFRIGERANT	GLOBAL WARMING POTENTIAL
R-290 (propane)	3
R-600a (isobutane)	3
R-1270 (propylene)	1.8
R-744 (CO_2)	1
R-717 (ammonia)	0

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.

This Methodology includes scenarios where advanced refrigeration systems are installed in both new and existing commercial facilities. A measure of the penetration rate of these newer technologies is the number of food retailers certified by EPA's GreenChill Partnership as having a "platinum" rating. The GreenChill platinum certification does not meet the definition of an advanced refrigeration system, as defined by this Methodology, due to the 150 GWP refrigerant threshold[6]. However, it is demonstrative of the low market adoption rate of low-GWP refrigerants. As of June 2018, of the more than 38,500 food retailers in the U.S., only seventy-four (74), or 0.19%, are certified as platinum by GreenChill. Table 4 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 1 and 2 of Section 4.1.

[6] Food retailers qualify for GreenChill platinum certification by either 1) having a refrigeration system that uses a re-frigerant 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.[6]

Table 4: Baseline Default Assumptions for Advanced Refrigeration Projects

SEGMENT	EQUIPMENT	CHARGE SIZE (KG)[7]	BASELINE REFRIGERANT[8]	ANNUAL AMORTIZED EMISSION RATE[9]
Large Commercial Refrigeration	Commercial Refrigeration with initial refrigerant charge size of 50 lbs or more.	1.16 kgs refrigerant per MBTU/hr of cooling capacity of the new system	R-407-A (50%) and R-404A (50%) (GWP = 3,014)	25.75%
Stand-Alone Commercial Refrigeration	Vertical Closed Refrigerators	1.3	R-404a (25%) and HFC-134a (75%) (GWP = 2,053)	7.75%
	Vertical Closed Freezers	1.7		
	Vertical Open Refrigerators	1.1		
	Horizontal Open Refrigerator	0.8		
	Horizontal Open Freezer	1.0		
	Deli Cases Refrigerator	0.6		
	Drink Dispensing	0.85		

[7] P&S Research provided the market research for charge sizes (see Appendix A, Table 6).

[8] The potential future applicability of EPA's SNAP 20 and SNAP 21 shall be considered in light of EPA rulemaking following the decision by the Court of Appeals for the District of Columbia in No. 15-1328, 866 F3rd 451 (2017 and Executive Order 13783 (March 28, 2017, 82 FR 16093-97) and any other state or local regulations (such as those being considered by the State of California), with respect to refrigerant use limitations, and addressed through addendums or revisions to this methodology, as needed.

[9] The annual amortized emission rate includes the EOL emissions by amortizing EOL refrigerant losses over the 10-year crediting period. See Appendix A “Baseline Systems Data”.

SEGMENT	EQUIPMENT	CHARGE SIZE (KG)[7]	BASELINE REFRIGERANT[8]	ANNUAL AMORTIZED EMISSION RATE[9]
	Ice Machines	0.85		
	Soft Serve Ice Cream and Frozen Beverages	1.125		
	Food Prep Tables	0.55		
	Blast Chillers	1.25		

For Large Commercial Refrigeration projects that replace an existing 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 1 and 2 of Section 4.1 to establish the appropriate baseline refrigerant, charge size, and annual amortized leak rates.

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 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.

- Regulatory Surplus Test, and
- 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 installing advanced refrigeration technologies.

There are no requirements in the United States that require installation of advanced refrigeration technology. EPA issued a regulation that would have prohibited the use of several HFC blends, including R404A and R507A – in new commercial refrigeration installations beginning August 2017, but it was declared invalid by the Court of Appeals for the D.C. Circuit.[10] Therefore, R404A and R507A currently remain available for use.

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 advanced refrigeration technology. A market adoption analysis, and hence the additionality demonstration under Applicability Condition 1.2(II), was conducted for the relevant sectors and segments (see Table 1).

A review of US EPA's GreenChill Partnership program data (see Appendix A) indicate that both large commercial and stand-alone commercial refrigeration have low market adoption rates for advanced refrigeration technology. Therefore, project activities within these sectors qualify for offset credit creation under this Methodology.

[10] 80 FR 42869; July 20, 2015; Mexichem Fluor Inc. v. Environmental Protection Agency, D.C. Cir No. 15-1328 (August 2017). A rehearing on that decision was denied on January 25, 2018.

4 QUANTIFICATION OF GHG EMISSION REDUCTIONS

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

4.1 BASELINE EMISSIONS

Other than for Large Commercial Refrigeration projects that are replacing an existing system, Project Proponents shall use the default emission rates, charge rates, and GWP values listed in Table 4.

For Large Commercial Refrigeration projects that are replacing an existing system, project proponents shall use historical system-specific data for refrigerant type, charge rate of system, and annual emission rates. This data can be generated from regulatory compliance reporting and other verifiable, historical operating documentation.

Baseline emissions will be calculated according to the following formula:

Equation 1

$$BE_y = \sum_i [(Q_{BR,j,i} \times ERA_{REF,j} \times 10)] / 1000 \times GWP_{REF,j}]$$

WHERE

BE_y	Baseline emissions in year y (MT CO_2e)
$Q_{BR,j,i}$	Quantity of refrigerant j in equipment i used in baseline system (Charge Size of equipment in kgs). Other than for Large Commercial Refrigeration projects where an existing system is being replaced, use the Refrigerant Charge Size default values in Table 4. For Large Commercial Refrigeration projects where existing equipment is being replaced, use regulatory compliance reporting or verifiable historical operating records to establish the charge size of the replaced baseline system.

$ERA_{REF,j}$	Annual amortized emission rate of refrigerant j in baseline system (%). Other than for Large Commercial Refrigeration projects where an existing system is being replaced, use the Annual Emission Rate default values in Table 4. For Large Commercial refrigeration projects where existing equipment is being replaced, 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 two years of baseline system operation prior to installation of advanced refrigeration system.
10	Number of years in the crediting period[11]
$GWP_{REF,j}$	Global warming potential of baseline refrigerant j. Other than for Large Commercial Refrigeration projects where an existing system is being replaced, use the GWP default values in Table 4. For Large Commercial refrigeration projects where existing equipment is being replaced, use regulatory compliance reporting or verifiable historical operating records to establish the type of refrigerant historically used.[12]

4.2 PROJECT EMISSIONS

Project emissions will be calculated according to the following formula:

Equation 2

$$PE_y = \sum_i \left[AR_{k,i} \times ERA_{REF,k} \times 10\right] \div 1000 \times GWP_{REF,k}$$

WHERE

PE_y	Project emissions in year y (MT CO_2e)
$AR_{k,i}$	Charge size of alternative refrigerant k used in project system from manufacturer specifications i (kgs) [13]

[11] All offsets for a project over the 10-year crediting period will be issued following verification.

[12] For installation of a Large Commercial Refrigeration system at an existing facility, project proponents shall use the GWP of the refrigerant used in the system that is replaced. Project proponents shall apply the 100-year value for refrigerant GWPs found in the IPCC Fourth Assessment Report for the historical refrigerant used.

[13] 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 set equal to emission rate for baseline system (% per year).
10	Number of years in the crediting period
$GWP_{REF,k}$	Global warming potential of alternative refrigerant k used in the project.

4.3 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 1.2 (III) and 1.2 (IV) any refrigerant recovered in the old system must be destroyed (if CFC or HCFC) or managed in accordance with EPA regulations (40 CFR Part 82, Subpart F) under Section 608 of the Clean Air Act (if HFC). Thus, for this Methodology, leakage can be disregarded.

4.4 PROJECT EMISSION REDUCTIONS

Equation 3

$$\mathbf{ER_y = [BE_y - PE_y]}$$

WHERE

ER_y	Emission reductions in year y (MT CO_2e)
BE_y	Baseline emissions in year y (MT CO_2e)
PE_y	Project emissions in year y (MT CO_2e)

5 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

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

- Identifying and logging the equipment/systems to be installed
- Documentation of the charge size of the alternative refrigerant used in the project from manufacturer specifications.
- For Large Commercial Refrigeration projects that are replacing existing systems, 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 two years of baseline system operation prior to installation of advanced refrigeration system.
- For Large Commercial Refrigeration projects that are replacing 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[14]
- 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 Large Commercial Refrigeration projects that are replacing HFC-based systems, documentation showing proof of management in accordance with EPA regulations (40 CFR Part 82, Subpart F) under Section 608 of the Clean Air Act. 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 management in accordance with EPA regulations.
  - Attestation from project proponent that the volume of displaced HFC from the baseline system was managed in accordance with EPA regulations.

5.2.1 Parameters Monitored

PARAMETER	$Q_{BR,j,i}$
UNITS	kg
DESCRIPTION	Quantity of refrigerant **j** in equipment **i** used in baseline system (charge size of equipment in kgs). Other than for Large Commercial Refrigeration projects where an existing system is being replaced, use the Refrigerant Charge size default values in Table 4. For Large Commercial Refrigeration projects where existing equipment is being replaced, use regulatory compliance reporting or verifiable historical operating records to establish the charge size of the replaced baseline system.
RELEVANT SECTION	4.1
RELEVANT EQUATION(S)	1
SOURCE OF DATA	Table 4, installation, regulatory compliance, or operating records

[14] 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%.

MEASUREMENT FREQUENCY	Determined once

PARAMETER	$AR_{k,i}$
UNITS	kg
DESCRIPTION	Quantity of alternative refrigerant **k** used in project system **i.**
RELEVANT SECTION	4.2
RELEVANT EQUATION(S)	2
SOURCE OF DATA	Manufacturer specifications
MEASUREMENT FREQUENCY	Determined once

PARAMETER	$ERA_{REF,j}$
UNITS	% per year
DESCRIPTION	Annual amortized emission rate of refrigerant **j** in baseline system (%). Other than for Large Commercial Refrigeration projects where an existing system is being replaced, use the annual amortized emission rate default values in Table 4. For Large Commercial refrigeration projects where existing equipment is being replaced, the annual amortized emission rate is determined using actual annual leak rates based on the average of the verifiable operating records from the previous two years of baseline system operation prior to installation of advanced refrigeration system.
RELEVANT SECTION	4.1

RELEVANT EQUATION(S)	1
SOURCE OF DATA	Table 4, installation, regulatory compliance, or operating records
MEASUREMENT FREQUENCY	Determined once

PARAMETER	$ERA_{REF,k}$
UNITS	% per year
DESCRIPTION	Annual emission rate of alternative refrigerant k used in project system
RELEVANT SECTION	4.2
RELEVANT EQUATION(S)	2
SOURCE OF DATA	Set equal to the emission rate of the baseline system.
MEASUREMENT FREQUENCY	Determined once

PARAMETER	$GWP_{REF,k}$
UNITS	Global Warming Potential (GWP)
DESCRIPTION	GWP of alternative refrigerant k used in project system.
RELEVANT SECTION	4.2
RELEVANT EQUATION(S)	2
SOURCE OF DATA	IPCC, published governmental reference (e.g., EPA SNAP), or scientific, peer reviewed publication
MEASUREMENT FREQUENCY	Determined once

APPENDIX A: PERFORMANCE STANDARD DEVELOPMENT AND BASELINE DATA INPUTS

A.1 Performance Standard Development

Section 3.1 summarizes trends in the adoption of advanced refrigeration systems. A measure of the penetration rate of these newer technologies is the number of food retailers certified by EPA's GreenChill Partnership as having a "platinum" rating. The GreenChill platinum certification does not meet the definition of an advanced refrigeration system, as defined by this Methodology, due to the 150 GWP refrigerant threshold[15]. However, it is demonstrative of the low market adoption rate of low-GWP refrigerants. As of June 2018, of the more than 38,500 food retailers in the U.S., only seventy-four (74), or 0.19%, are certified as platinum by GreenChill.[16] 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 and food retailers in the United States with advanced refrigeration systems is negligible.

A.2 Baseline System Data

Table 5 presents default refrigerants, charge size, and annual emission rates for Large Commercial Refrigeration and Stand-Alone Commercial Refrigeration derived from four sources –the US EPA Vintaging Model, the 2006 IPCC Guidelines for National GHG Inventories, the 2016 ICF Accounting Tool to Support Federal Reporting of Hydrofluorocarbon Emissions, and P&S Market Research. Charge sizes are based on actual market data gathered by P&S Market Research (Table 6).

For the purposes of determining the annual amortized emission rates, data from the EPA Vintaging Model and from Tables 3.3 (Table 7) and 3.6 (Table 8) of the 2016 ICF Accounting Tool are used. For large commercial refrigeration units, the annual amortized emission rate of 25.75% is calculated using an annual leak rate of 25%, a product lifetime of 18 years, 90% of refrigerant remaining at EOL, and a 15% refrigerant disposal rate at EOL. For stand-alone commercial refrigeration, an annual amortized emission rate of 7.75% is calculated using a 1%

[15] Food retailers 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.
[16] http://www2.epa.gov/greenchill/greenchill-store-certification-awards

annual leak rate, a 10-year product lifetime, 90% of refrigerant remaining at EOL, and a 75% refrigerant disposal rate.

Large Commercial Refrigeration Annual Amortized Emission Rate Calculation

- 25% annual leak rate (see Table 7)
- 18-year equipment lifetime (see Table 8)
- 25% annual leak rate * 18 years = ***450% lifetime refrigerant loss***[17]
- 90% refrigerant remaining at EOL (see Table 7)
- 15% disposal rate (85% is recovered) (see Table 7)
- 90% * 15% = ***13.5% refrigerant loss at EOL***
- (450% refrigerant loss + 13.5% EOL refrigerant loss) /18 years = ***25.75% annual amortized emission rate***

Stand-Alone Commercial Refrigeration Annual Amortized Emission Rate Calculation

- 1% annual leak rate (see Table 7)
- 10-year equipment lifetime (see Table 8)
- 1% annual leak rate * 10 years = ***10% lifetime refrigerant loss***
- 90% refrigerant remaining at EOL (see Table 7)
- 75% disposal rate (25% is recovered) (see Table 7)
- 90% * 75% = ***67.5% refrigerant loss at EOL***
- (10% refrigerant loss + 67.5% EOL refrigerant loss) /10 years = ***7.75% annual amortized emission rate***

[17] Large commercial refrigeration units are re-charged on a regular basis.

Table 5: Baseline System Charge Size and Emission Rates

SEGMENT	PRODUCT	CHARGE SIZE (KGS)[18]	BASELINE REFRIGERANT[19]	ANNUALIZED EMISSION RATE[20]
Large Commercial Refrigeration	Commercial refrigeration with initial refrigerant charge size of 50 lbs or more.	1.16 kgs refrigerant per MBTU/hr of cooling capacity of the new system	R-407-A (50%) and R-404A (50%) (GWP = 3,014)	25.75%
Stand-Alone Commercial Refrigeration	Vertical Closed Refrigerators	1.3	Refrigerant: R-404a (25%) and HFC-134a (75%) (GWP = 2,053)	7.75%
	Vertical Closed Freezers	1.7		
	Vertical Open Refrigerators	1.1		
	Horizontal Open Refrigerator	0.8		
	Horizontal Open Freezer	1.0		
	Deli Cases Refrigerator	0.6		
	Drink Dispensing	0.85		
	Ice Machines	0.85		

18 P&S Research provided the market research for stand-alone commercial refrigeration charge sizes (see Table 6)

19 The potential future applicability of EPA's SNAP 20 and SNAP 21 shall be considered in light of EPA rulemaking following the decision by the Court of Appeals for the District of Columbia in No. 15-1328, 866 F3rd 451 (2017 and Executive Order 13783 (March 28, 2017, 82 FR 16093-97) and any other state or local regulations (such as those being considered by the State of California), with respect to refrigerant use limitations, and addressed through addendums or revisions to this methodology, as needed.

20 The annualized emission rate includes the EOL emissions by amortizing EOL refrigerant losses over the 10-year crediting period. See Appendix A "Baseline Systems Data".

SEGMENT	PRODUCT	CHARGE SIZE (KGS)[18]	BASELINE REFRIGERANT[19]	ANNUALIZED EMISSION RATE[20]
	Soft Serve Ice Cream and Frozen Beverages	1.125		
	Food Prep Tables	0.55		
	Blast Chillers	1.25		

Table 6: P&S Market Survey Data on Charge Size

PRODUCT	CHARGE RANGE (KGS)
Vertical Closed Refrigerators	1.2 – 1.4
Vertical Closed Freezers	1.5 – 1.9
Vertical Open Refrigerators	1.0 – 1.2
Horizontal Open Refrigerator	0.7 – 0.9
Horizontal Open Freezer	0.9 – 1.1
Deli Cases Refrigerator	0.4 – 0.8
Drink Dispensing	0.7 – 1.0
Ice Machines	0.6– 1.1
Soft Serve Ice Cream and Frozen Beverages	1.05 – 1.2
Food Prep Tables	0.4 – 0.7
Blast Chillers	1.1 – 1.4

Table 7: ICF 2016 Accounting Tool Table 3.3

Table 3-3. Default F-gas Emission Factors for Refrigeration and A/C Equipment

Equipment Type	Installation Emission Factor [a] k (% of capacity)	Operating Emission Factor x (% of capacity/yr)	Refrigerant Remaining at Disposal y (% of capacity)	Recovery Efficiency z (% of remaining)
Room A/C		0.9%	94%	21%
Other residential A/C and heat pumps		8%	80%	50%
Other commercial A/C and heat pumps		8%	80%	70%
Chillers	0.5%	2%	95%	85%
Household refrigerators and/or freezers		0.5%	91%	31%
Stand-alone retail refrigerators and freezers		1%	90%	25%
Walk-in refrigerators and freezers	2.0%	12%	90%	70%
Supermarket refrigeration and condensing units	2.0%	25%	90%	85%
Medium cold storage	1.0%	25%	80%	80%
Large cold storage	1.0%	25%	80%	80%
Refrigerated transport - land		20%	50%	60%
Refrigerated transport - marine		20%	50%	60%
Passenger car A/C		8.9%	50%	20%
Light-duty or heavy-duty truck A/C		8.9%	50%	20%
Bus A/C		10%	50%	40%

Table 8: ICF 2016 Accounting Tool Table 3.6[21]

Table 3-6. Default Refrigerant Types and Charge Sizes for Refrigeration and A/C Equipment

Equipment Type	Equipment Charge Size (kg)	Equipment Lifetime (yrs)	Default Refrigerant[a]	Refrigerant F-Gas Composition	GWP (SAR)	GWP (AR4)	Percent Containing HFCs in 2014
Household refrigerators and/or freezers	0.15	14	R-134a	100% HFC-134a	1,300	1,430	100%
Stand-alone retail refrigerators and freezers	0.4	10	R-134a	100% HFC-134a	1,300	1,430	100%
Walk-in refrigerators and freezers	10	20	R-404A	44% HFC-125; 4% HFC-134a; 52% HFC-143a	3,260	3,922	50%
Supermarket refrigeration	1,360	18	R-404A	44% HFC-125; 4% HFC-134a; 52% HFC-143a	3,260	3,922	50%
Refrigerated transport - land	6	12	R-134a	100% HFC-134a	1,300	1,430	100%
Refrigerated transport - marine	6	12	R-134a	100% HFC-134a	1,300	1,430	100%
Medium cold storage	565	25	R-404A	44% HFC-125; 4% HFC-134a; 52% HFC-143a	3,260	3,922	50%
Large cold storage	7,546	25	R-404A	44% HFC-125; 4% HFC-134a; 52% HFC-143a	3,260	3,922	50%
Chillers	500	23	R-134a	100% HFC-134a	1,300	1,430	30%
Room A/C	0.5	12	R-410A	50% HFC-32; 50% HFC-125	1,725	2,088	40%
Other residential A/C and heat pumps	5	15	R-410A	50% HFC-32; 50% HFC-125	1,725	2,088	40%
Other commercial A/C and heat pumps	13	25	R-410A	50% HFC-32; 50% HFC-125	1,725	2,088	30%
Passenger car A/C	0.6	12	R-134a	100% HFC-134a	1,300	1,430	100%
Light-duty or heavy-duty truck A/C	0.8	12	R-134a	100% HFC-134a	1,300	1,430	100%
Bus A/C	5	12	R-134a	100% HFC-134a	1,300	1,430	90%

[21] Per the ICF report, the HFC default refrigerant presented in Table 8 is the one assumed to represent the single highest share of installed refrigerants for a particular equipment type according to the U.S. EPA Vintaging Model. In this methodology, ACR has chosen to be more precise in its representation of default refrigerants and therefore have included blended baseline refrigerants based on market research and expert review. These are presented in Tables 4 and 5.

APPENDIX B: REFERENCES

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