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

Table of Contents

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. Under the Montreal Protocol and U.S. Clean Air Act, CFC production ended in the U.S. in 1996. While some older equipment still contain CFCs, the most commonly used refrigerants today are hydrochlorofluorocarbons (HCFCs)[1] and hydrofluorocarbons (HFCs)[2]. These chemicals, while safer for the ozone layer, are powerful GHGs when released to the atmosphere.

Across the various refrigeration and air conditioning applications, there are at least two types of activities to avoid GHG emissions; Table 1 lists the sectors that are eligible under this Methodology:

1. Use of reclaimed HFC refrigerants

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

- 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
- Tracking of refrigerant across its lifecycle, from production, distribution, equipment operation, 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 refrigerant that has been recovered[3] from equipment, and *reclaimed*[4] to virgin-grade 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

[1] HCFCs also deplete the ozone layer and are being phased out of production in the U.S.
[2] HFCs were developed as "ozone-friendly" alternatives to CFCs and HCFCs.
[3] Refrigerant that is recovered is removed/extracted by a certified technician using certified recovery equipment) from appliances during servicing or at end-of-life.
[4] Reclaimed refrigerant is processed by an EPA certified reclaimer to remove impurities and restored to virgin-grade purity.

production[5].

2. Use of zero/low-GWP alternative technologies

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) used for commercial refrigeration, stand-alone refrigerator-freezers, and automobile air conditioning.

Table 1: Eligible Refrigerant Sectors

Project Activity	Refrigerant Sector	Example Segments in Sector
Use of Reclaimed HFC Refrigerant	Domestic Refrigeration	Residential refrigerators and freezers
	Commercial Refrigeration	Refrigeration equipment in “retail”, including supermarkets, convenience stores, restaurants and other food service establishments. Also, equipment used for “cold 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.
	Mobile Air Conditioning	Automobiles, trucks
	Stationary Air Conditioning	Comfort cooling for homes and commercial buildings, including multi-family buildings, office buildings, hospitals, universities, shopping malls, airports, sports arenas.
Low/zero GWP Technologies	Commercial Refrigeration	See above
	Industrial Process Refrigeration	

This Methodology provides the quantification framework for the creation of carbon offset credits from the reductions in greenhouse gas emissions (GHGs) resulting from either: 1) the use of reclaimed HFCs; or 2) transitioning to low/zero GWP technologies 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

[5] Production and import of R-22 is regulated in the U.S. by annual allocations issued by the U.S. EPA, in accordance with the phasedown schedule established in the Montreal Protocol and U.S. 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 should be accounted for by the U.S. EPA in determining the annual R-22 allocations. In contrast, there are no controls in the U.S. 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.

Technical Options Committee for Refrigeration, Air Conditioning and Heat Pumps, the U.S. EPA Vintaging Model, the U.S. 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.
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.
Certified, reclaimed HFC refrigerant		Refrigerant that has been reclaimed by an EPA-certified reclaimer to virgin-grade purity, according to relevant AHRI standards.[6] Reclaimer must have paper or electronic records that document the source and chain-of-custody of the reclaimed refrigerant.
Chlorofluorocarbon	CFC	A class of compounds of carbon, hydrogen, chlorine, and fluorine that are commonly used as refrigerants.
Eligible Refrigerant Sector		Those sectors for which the adoption rate of the use of certified, reclaimed HFC or advanced refrigeration systems utilizing low-GWP alternatives is sufficiently low.

[6] Reclaimed refrigerant must be verified to meet *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	An organic compound containing only hydrogens and carbons (e.g. propane, isobutene, propylene). Certain HCs can be used as low-GWP refrigerants.
Hydrochlorofluorocarbon	HCFC	A class of inert compounds of carbon, hydrogen, hydrocarbons, chlorine, and fluorine that are commonly used as refrigerants.
Hydrofluorocarbon	HFC	A gaseous compound that contains carbon, fluorine, and hydrogen and is commonly used as a refrigerant.
Hydrofluoroolefins	HFO	A chemical compound composed of hydrogen, fluorine, and carbon. This class of compounds can be used as low-GWP refrigerants.
HFC Refrigerant		Refrigerant comprised of either a mix of hydrofluorocarbons (HFCs) referred to as an "HFC blend", or a single HFC.
Low-GWP refrigerant		Refrigerant that has a GWP less than 20 and which can be lawfully used as a refrigerant in commercial or industrial refrigeration.

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 the manufacture of new refrigeration or air conditioning equipment, and 3) Deployment of alternative refrigerants with low global warming potential in commercial and industrial process refrigeration.
Use of certified, reclaimed HFC refrigerant		Production plus transfer/return/sale of certified, reclaimed refrigerant to refrigerant distributors, wholesalers, or refrigerant end-users who are in the business of selling or using refrigerant for use in refrigeration or air conditioning equipment.

1.3 Applicability Conditions

Projects that avoid the emissions of HFC gases in any of the following activities are considered a "project activity" under this Methodology:

4) the reclamation and use of certified, reclaimed HFC refrigerants to service existing refrigeration and air conditioning equipment,
5) the reclamation and use of certified, reclaimed HFC refrigerants in the manufacture of new refrigeration or air conditioning equipment, and
6) deployment of alternative refrigerants with low global warming potential in commercial and industrial process refrigeration.

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 subsequent sale, title transfer or return to a refrigerant distributor, wholesaler, or end-user who are in the business of selling refrigerant, or using refrigerant, 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 for this Methodology to be applicable:

a) The project is located in North America.
b) The project is within a sector which has a low adoption rate of the relevant project activity ("Eligible Project Activity" & "Eligible Refrigerant Sector")
c) For the project that uses reclaimed HFC refrigerant, the refrigerant must meet the definition of certified, reclaimed HFC refrigerant in this Methodology.
d) For either type of project activity that involves conversion of CFC-based equipment, either to HFC-based equipment where certified, reclaimed HFC refrigerant is subsequently used, or a transition to commercial refrigeration technology using alternative low-GWP refrigerant, any CFCs in the original equipment must be recovered and destroyed in accordance with ACR or the

California Air Resource Board ODS Destruction Methodology.

1.4 Crediting Periods

The crediting period shall be ten years.

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.

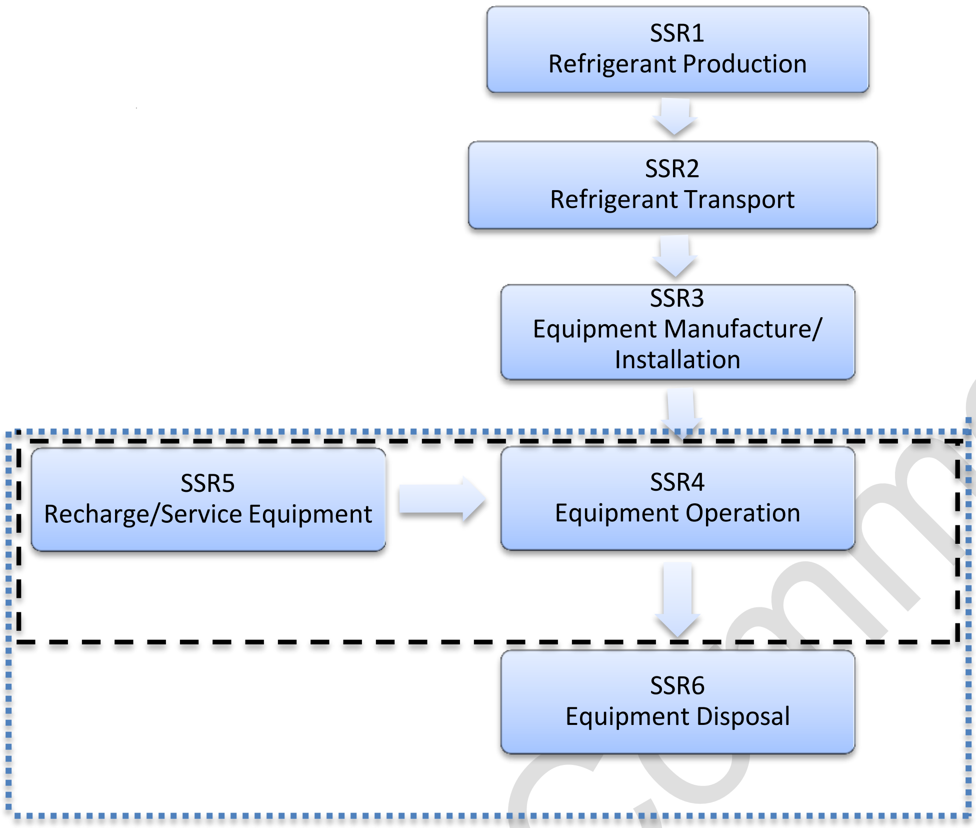
2.0 PROJECT BOUNDARIES

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 technology with low/zero GWP refrigerant, the project boundary, depicted by the dotted line below (i.e. inclusive of SSR6), includes the physical and geographical site where the technology is installed, as well as the locations involved in disposal of the older technology, including destruction of the refrigerant in the older system that is replaced.

Figure 1: Project Boundary Diagram for Certified Reclaimed Refrigerant



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. **Error! Reference source not ound.** shows the emission rates of the refrigerants during equipment operations.

Table 3: 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 HFC refrigerants	CO_2	E	N/A
			CH_4	E	N/A
		HFC leaks during refrigerant production	HFCs	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
		HFC leaks of refrigerant during transport	HFCs	E	N/A
3	Equipment Manufacture	Emissions of HFCs during manufacture or installation of	HFCs	E	N/A

	and Installation	refrigeration or A/C equipment or system			
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	I	See Methodology
		HFC leaks from the operation of the refrigeration or A/C equipment or system	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 Reclaimed HFC Refrigerant

Newly manufactured 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.

Once installed or commissioned, 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.[7] Consequently, to maintain proper performance, leaky equipment and systems require periodically 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 equipment, and processed to remove impurities and restored to virgin-grade quality. 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 HFC refrigerants are reclaimed in the U.S. 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. **Error! Reference source not found.** lists he operating emission factors used in this Methodology for the different HFC refrigerants. If a project involves use of a refrigerant that is not listed in Table 4 or Table 5, the project proponent should provide the GWP and 10-year emission rates, with corresponding documentation and any relevant calculations.

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 either a distributor, wholesaler, 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 1% of the initial charge and are therefore considered negligible and not included in this Methodology.

Table 4: 10-Year Emission Rates for Individual HFC Refrigerants[8]

Refrigerant	10-year Emission Rate (%)
HFC-134a	76%
HFC-23	89%
HFC-32	64%
R-401A	84%
R-404A	89%
R-407A	89%

[7] Refrigerants can also be released during equipment servicing or when the system is decommissioned.
[8] See Appendix A.2

R-407C	70%
R-410A	69%
R-417C	86%
R-422B	70%
R-422C	89%
R-422D	89%
R-507A	89%
R-508B	57%

As discussed in Appendix A.1, for purposes of this Methodology, the baseline reclamation rate for HFCs in the U.S. 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 2 lists the GWPs of the HFC refrigerants for both the baseline and project scenario calculations. As additional refrigerants become available through U.S. EPA SNAP listings[9] and market adoption, ACR will update this table.

Table 2: GWPs of HFC Refrigerants

HFC Refrigerant	Global Warming Potential[10]
R-502	4,657
R-404A	3,922
R-407A	2,107
R-407C	1,774
HFC-134a	1,430
R-32	675
HFC-23	14,800
R-401A	970
R-410A	2,088
R-417C	1,820
R-422B	2,525
R-422C	3,085
R-422D	2,730
R-500	8,100
R-507A	3,985
R-508B	13,400

Table 6: Selected 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

[9] http://www.epa.gov/spdpublc/snap/refrigerants/lists/index.html
[10] IPCC, Fourth Assessment Report (100 year)

3.1.2 Low/Zero GWP Technology in Commercial/Industrial Refrigeration

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.[11] 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. As noted in Section 2.11, leaky systems 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.[12] 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.

The industry is reacting by increasingly relying on R-407C, an HFC blend with a lower GWP, and 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. To date, of the approximately 35,000 supermarket stores in the U.S., five have been certified by EPA's GreenChill Partnership as having an advanced refrigeration system with zero/low-GWP refrigerants (see Appendix A.3)

This Methodology also includes scenarios where existing commercial refrigeration systems are retrofitted to a zero/low-GWP system. Retrofitting an existing supermarket to a secondary loop system, for example, is possible but typically requires an extensive remodeling and has not been done to date in the U.S.

Table lists the default baseline factors in projects involving new commercial/industrial refrigeration systems.

Table 7: Baseline Default Assumptions for New Commercial/Industrial Refrigeration Projects

Baseline Parameter	Factor	Reference
Refrigerant Charge	3500 lbs.	US EPA
Refrigerant: R-407C	GWP = 1774	US EPA
Annual Leak Rate	20%	US EPA; see Appendix A.2
10-year Leak Rate	89%	
Equipment Lifetime	15 years	ICF, 2009

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.

[11] 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.

[12] 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.

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 zero/low-GWP commercial or industrial refrigeration technologies.

Use of Reclaimed HFC Refrigerant

Currently, there are no restrictions in the U.S. 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 refrigerants and the service technicians that handle refrigerants, as well as certification requirements for refrigerant reclaimers. All of these regulatory requirements must be complied with as part of projects under this Methodology.

Zero/Low-GWP Refrigeration Technology

There are no requirements in the U.S. that require installation of HFC-free, zero or low-GWP refrigeration technology. EPA recently proposed a regulation that would prohibit use of two HFC blends –R404A and R510A – in new commercial refrigeration installations beginning in 2016. Other HFCs or HFC blends, e.g., R407C – would be allowed for use in new installations. This proposed regulation is expected to be finalized in 2015. As noted above, non-HFC refrigerants are available but in the U.S. have had an insignificant adoption rate. In this Methodology, the default baseline refrigerant will be R407C for new refrigeration systems in commercial and industrial refrigeration systems.

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 zero/low GWP refrigerant technology. A market adoption analysis, and hence the additionality demonstration under Applicability Condition 1.3(b) was conducted for the relevant sectors. 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 have a low market adoption rate for using certified, reclaimed HFCs and for zero/low GWP refrigerant technologies. Therefore, project activities within these sectors 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 Certified Reclaimed HFC Refrigerant

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 refrigerant used to recharge a particular piece of equipment in year y of a crediting 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

$$BE_{HFC_y} = \sum_{n}^{y} [(VR_{HFC,j,i_y} \times AL_{HFC,j,i} \times GWP_{HFC,j})] \times (1 - RR_{BL}) \div 1000$$

Where:

BE_{HFC_y} Baseline emissions in year *y* (tonnes CO_2e) [13]

VR_{HFC,j,i_y} Total quantity of virgin HFC refrigerant *j* used to recharge equipment *i* in year *y* (kgs)

$AL_{HFC,j,i}$ The 10-year loss rate of HFC refrigerant *j* from equipment *i* (%; see **Error! Reference ource not found.**)

$GWP_{HFC,j}$ The global warming potential of HFC refrigerant *j* (see Table 2)

RR_{BL} Baseline Refrigerant Reclamation Rate (% per year)[14]

VR_{HFC,j,i_y} Derived from the quantity of monitored certified, reclaimed HFC refrigerant that is documented according to the procedures in Section 3.1.1

[14] 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 Activity 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 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

$$ER_y = BE_{HFC_y}$$

Where:

ER_y	Project emission reductions during year *y* (tonnes CO_2e)
BE_{HFC_y}	Baseline emissions of HFC refrigerant in year *y* (tonnes CO_2e)

4.2 Low/Zero GWP Refrigerant Technology

4.2.1 Baseline Emissions

For projects involving newly installed refrigeration systems, project proponents shall use default leakage rates and other default assumptions for charge size, type of refrigerant/GWP, and equipment lifetime listed in Table . For projects that involve retrofitting existing systems, project proponents can use system-specific data for these parameters from regulatory compliance reporting and other verifiable documentation.

Baseline emissions will be calculated according to the following formula:

Equation #3

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

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 (kg)
$AL_{REF,j,i}$	10-year loss of refrigerant *j* (% per year; see Table 7)
$GWP_{REF,j}$	Global warming potential of baseline refrigerant *j* listed in Table 2.[15]
LS_i	Lifespan of equipment *i* (yrs)

4.2.2 Project Emissions

To determine project emissions, project proponents shall use the default leak rate listed in Table 7.

Project emissions will be calculated according to the following formula:

Equation #4

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

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)
AL	10-year loss of alternative refrigerant (% per year; see Table 7)
$GWP_{REF,k}$	Global warming potential of refrigerant *k* used in the project (see Table 2)

4.2.3 Leakage

By installing new zero/low-GWP refrigeration technology, a project is not increasing overall market demand for refrigeration systems. Thus, there would be no "market-shifting" associated with this project type. Also, there would be no "activity-shifting" because the project would involve only new installations. As noted previously, this Methodology does not address retrofits where an existing system is upgraded, so there are no residual materials, including refrigerants, that would be resulting from the project. Thus, for this Methodology, leakage can be disregarded.

[15] Project developers may use GWPs assigned to new refrigerants under the EPA's Significant New Action Policy (SNAP) program.

4.2.4 Emission Reductions (ER)

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 procedure; e) frequency of the monitoring; f) quality control and quality assurance procedure; 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 HFCs

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

- Documentation of the point of origin of the reclaimed refrigerant including location, equipment, date(s) of recovery.
- Unique identification (e.g., serial number, barcode) for the containers that are used for collection and transport of the recovered HFC refrigerant.
- Documentation on the quantity and type of the HFC refrigerant that is recovered from equipment 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.
- Documentation that the same quantity of reclaimed HFC refrigerant is transferred, sold, or

returned to a refrigerant wholesaler, distributor, or end-user.

5.2.2 Installation of Low/Zero GWP Refrigeration Technology

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

- Identifying and logging the equipment/systems to be installed
- Recordkeeping of project related refrigerant usage
- Maintaining any documentation showing GWP of project-related refrigerant used

5.2.3 Parameters Monitored

Parameter	VR_{HFC,j_y}
Units	kg
Description	Quantity of virgin HFC refrigerant *j* that would have been used to charge or recharge equipment or system *i* in absence of project activity
Relevant Section	4.1
Relevant Equation(s)	1
Source of Data	Operating Records
Measurement Frequency	Determined once and recorded annually

Parameter	$Q_{BR,I}$
Units	kg
Description	Quantity of refrigerant *j* that would have been used in initial charge of system *i* in absence of project activity
Relevant Section	4.2.1
Relevant Equation(s)	3
Source of Data	Operating Records
Measurement Frequency	Determined once and recorded annually

Parameter	LS_i
Units	years
Description	Lifespan of equipment *i* that would have been installed in absence of project activity
Relevant Section	4.2.1
Relevant Equation(s)	3
Source of Data	Operating Records
Measurement Frequency	Determined once and recorded annually

Parameter	$AR_{p,i}$
Units	kg
Description	Quantity of alternative low/zero GWP refrigerant *k* used in initial charge of project system *i*
Relevant Section	4.2.2
Relevant Equation(s)	4
Source of Data	Operating Records
Measurement Frequency	Determined once and recorded annually

APPENDIX A: BASELINE DATA INPUTS

A.1 Refrigerant Reclamation

Reclaimers in the U.S. are required to report to EPA the quantities of HCFC-22 (R-22) that they receive and reclaim. Currently there are no reporting requirements for HFC reclamation. Because R-22 production is being phased out, 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 HFC refrigerant, with the price of virgin generally lower than reclaimed gas because of the additional costs to recover, transport, and separate/process back to virgin purity levels[16]. Unlike the strong incentive to reclaim CFC refrigerants and R-22 there is currently little incentive for recovery, reclamation, and re-sale of HFC refrigerants. Thus, it is a conservative approach to estimate the amount of HFC refrigerant that is reclaimed in the baseline scenario based on data from the U.S. EPA on R-22 reclamation.

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[17]
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 A-1)

The R-22 reclaim rate for 2013 is calculated as:

[16] http://ozone.unep.org/new_site/en/ozone_data_tools_reclamation_facilities.php
[17] EPA (2014)

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, as noted above, 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.

A.2 HFC Refrigerant Emission Factors

Under this Methodology, baseline emissions 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 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). To be conservative, the values from the IPCC Guidelines are the low end of ranges presented in Table 7.9 of that report.

Table presents the estimated "market share" of individual HFC refrigerants across different end-uses and the 10-year weighted-average leak rates incorporating the data in Table .

Table 9: Emission Factors for Refrigeration and Air Conditioning Systems

Sub-Sector/End-Use	Average Annual Emission Rate[1]
Domestic Refrigeration	<0.1[2]
Stand-Alone Commercial Applications	8%
Medium and Large Commercial Refrigeration[3]	20%
• US Average Supermarket	25%

• US GreenChill Certified Supermarket	13%
Transport Refrigeration	28-33%
Industrial Refrigeration including Food Processing and Cold Storage	20-25%
Chillers	1-5%
Residential and Commercial A/C, including Heat Pumps	10-12%
Mobile A/C	18%[2]

[1]Unless otherwise noted, emission rates are from the US EPA Vintaging Model as reported in ICF (2009).

[2] Lowest values in range in Table 7.9 of the 2006 IPCC Guidelines.

[3] Less than 1% of U.S. supermarket stores have GreenChill certification; for this Methodology, the average leak rate for centralized commercial refrigeration systems in the U.S. 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%
	Large Commercial Refrigeration	5%	20%	
	Stand-Alone Commercial Refrigeration	15%	8%	
	Chillers	5%	3%	
	Domestic Refrigeration	15%	0.1%	
HFC-23	Industrial Process Refrigeration	85%	23%	89%
	Chillers	15%	3%	
HFC-32	Residential and Commercial A/C	85%	11%	64%
	Chillers	15%	3%	
R-401A	Large Commercial Refrigeration	80%	20%	84%
	Chillers	20%	3%	
R-404A	Large Commercial Refrigeration	100%	20%	89%
R-407A	Large Commercial Refrigeration	100%	20%	89%
R-407C	Residential and Commercial A/C	95%	11%	70%
	Commercial Refrigeration	5%	20%	
R-410A	Residential and Commercial A/C	100%	11%	69%

R-417C	Mobile A/C	100%	18%	86%
R-422B	Residential and Commercial A/C	95%	11%	70%
	Commercial Refrigeration	5%	20%	
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 8. Where those emission rates are presented as ranges in Table 8, the midpoint of the range is used.

A.3 Adoption of Low-GWP Commercial Refrigeration Technologies

Section 3.1.2 summarizes trends in commercial refrigeration technologies that use low or zero-GWP refrigerants. 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 with low/zero GWP refrigerants. 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.[18] As of March 2015, of the approximately 35,000 supermarket stores in the U.S., five have been certified by GreenChill at the "platinum" level (0.01%).[19] There may be additional stores in the U.S. that have very low GWP refrigeration systems not recognized by EPA because they are owned by companies that are not members of the GreenChill Partnership. However, under any scenario, currently the percentage of supermarkets in the U.S. with advanced, low-GWP refrigeration systems is negligible.

[18] http://www2.epa.gov/sites/production/files/2013-08/documents/greenchill_store_certification_program_guidance_7.29.13.pdf
[19] 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 reclaimed HFC refrigerants would be considered within Scope 1.

In cases where the generator or user of the 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 zero/low-GWP alternative 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 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 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 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)[20]

$GWP_{HFC,j}$ Global warming potential of refrigerant *j* used in the project (see Table 2)

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 entire procedure. Ensure that the cylinder does not overfill, that means the

[20] 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.

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 at a qualified facility, where system owners can view their accounts online. The information should show 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.[21]

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

APPENDIX C: REFERENCES

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