



CLIMATE
ACTION
RESERVE

**U.S. Ozone Depleting Substances
Project Protocol**
Destruction of Domestic Ozone Depleting
Substances

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Abbreviations and Acronyms

AHRI	Air-Conditioning, Heating and Refrigeration Institute
CAA	Clean Air Act
CH ₄	Methane
CO ₂	Carbon dioxide
CRT	Climate Reserve Tonne
DRE	Destruction and removal efficiency
EPA	United States Environmental Protection Agency
GWP	Global warming potential
HWC	Hazardous waste combustor
MACT	Maximum available control technology
NESHAP	National Emissions Standards for Hazardous Air Pollutants
NIST	National Institute of Standards and Technology
ODS	Ozone depleting substances
RCRA	Resource Conservation and Recovery Act
REFPROP	Reference Fluid Thermodynamic and Transport Properties Database
Reserve	Climate Action Reserve
TEAP	Technology & Economic Assessment Panel

1 Introduction

The Climate Action Reserve U.S. Ozone Depleting Substances Project Protocol provides guidance to account for, report, and verify greenhouse gas (GHG) emission reductions associated with destruction in the U.S. of high global warming potential ozone depleting substances (ODS) sourced from within the U.S., and which would have otherwise been released to the atmosphere within the U.S. This project category includes ODS used in both foam and refrigerant applications. All destroyed ODS must be fully documented, chemically analyzed, and destroyed at a qualifying facility to be eligible for GHG emission reductions. All ODS must originate in the U.S.; projects wishing to generate credits from the destruction of ODS originating outside of the U.S. must use the Imported Ozone Depleting Substances Project Protocol.

The Climate Action Reserve (Reserve) is voluntary offsets program working to ensure integrity, transparency and financial value in the North American carbon market. It does this by establishing regulatory-quality standards for the development, quantification and verification of GHG emission reduction projects in North America; issuing carbon offset credits known as Climate Reserve Tonnes (CRT) generated from such projects; and tracking the transaction of credits over time in a transparent, publicly-accessible system. Adherence to the Reserve's high standards ensures that emission reductions associated with projects are real, permanent and additional, thereby instilling confidence in the environmental benefit, credibility and efficiency of the U.S. carbon market.

The Climate Action Reserve operates as a program under the similarly named nonprofit organization. Two other programs, the Center for Climate Action and the California Climate Action Registry, also operate under the Climate Action Reserve.

Project developers that initiate ODS projects use this document to register GHG reductions with the Reserve. The protocol provides eligibility rules, methods to calculate reductions, performance-monitoring instructions, and procedures for reporting project information to the Reserve. Additionally, all project reports receive annual, independent verification by ISO-accredited and Reserve-approved verification bodies. Guidance for verification bodies to verify reductions is provided in the Reserve's Verification Program Manual and Section 8 of this protocol.

This project protocol is designed to ensure the complete, consistent, transparent, accurate, and conservative quantification and verification of GHG emission reductions associated with an ODS destruction project.¹

¹ See the WRI/WBCSD GHG Protocol for Project Accounting (Part I, Chapter 4) for a description of GHG reduction project accounting principles.

2 The GHG Reduction Project

2.1 Background

The term “ozone depleting substances” refers to a large group of chemicals known to destroy the stratospheric ozone layer when released into the atmosphere. ODS were historically used in a wide variety of applications including refrigerants, foams, solvents, and fire suppressants. In addition to their potency as ozone depleting substances, the ODS addressed by this protocol also exhibit high global warming potentials (GWP). The GWP of these ODS range from several hundred to several thousand times that of carbon dioxide (see Table 5.1).

The adoption of the Montreal Protocol on Substances that Deplete the Ozone Layer² in 1987 laid out a global framework for the phase-out of certain known ODS. The Montreal Protocol differentiated two separate phase-out schedules: one for the developing Article 5 countries³, and a more rapid phase-out for the developed Non-Article 5 countries⁴, including the United States. The current phase-out schedule for Class I and Class II ODS as dictated by the Montreal Protocol and incorporated into U.S. law is presented below in Table 2.1.

Table 2.1. Production Phase-Out Schedule of the Montreal Protocol^{5,6}

Ozone Depleting Substance	Non-Article 5 Countries	U.S.
CFCs (chlorofluorocarbons)	January 1, 1996	January 1, 1996
Halons	January 1, 1994	January 1, 1994
Carbon tetrachloride	January 1, 1996	January 1, 1996
Methyl chloroform	January 1, 1996	January 1, 1996
Methyl bromide	January 1, 2005	January 1, 2005
HBFCs (Hydrobromofluorocarbons)	January 1, 1996	January 1, 1996
HCFCs (hydrochlorofluorocarbons)	January 1, 1996: Freeze at baseline	January 1, 1996: Freeze at baseline
	January 1, 2004: cut by 35%	January 1, 2003: No production and no importing of HCFC-141b
	January 1, 2010: cut by 75%	January 1, 2010: No production and no importing of HCFC-142b and HCFC-22, except for use in equipment manufactured before 1/1/2010
	January 1, 2015: cut by 90%	January 1, 2015: No production and no importing of any HCFCs, except for use as refrigerants in equipment manufactured before 1/1/2020

² http://ozone.unep.org/Ratification_status/montreal_protocol.shtml, and subsequent revisions and amendments.

³ See http://ozone.unep.org/Ratification_status/list_of_article_5_parties.shtml for a list of countries operating under Article 5.

⁴ See http://ozone.unep.org/Ratification_status/ for a list of all countries that have ratified the Montreal Protocol.

⁵ U.S. EPA, Phase-out of Class I Ozone Depleting Substances, available at: <http://www.epa.gov/ozone/title6/phaseout/classone.html>

⁶ U.S. EPA, Phase-out of Class II Ozone Depleting Substances, available at: <http://www.epa.gov/ozone/title6/phaseout/classtwo.html>

	January 1, 2020: cut by 99.5% (can only be used for refrigerator/AC servicing after this date)	January 1, 2020: No production and no importing of HCFC-142b and HCFC-22
	January 1, 2030: full phase-out	January 1, 2030: No production and no importing of any HCFCs

The Montreal Protocol and the U.S. Clean Air Act⁷ (CAA) limit the production of ODS in the United States. However, neither framework requires the destruction of extant stocks of ODS. Rather, these stocks may be recovered, recycled, reclaimed and reused indefinitely, often in equipment with very high leak rates. Because the Montreal Protocol and Title VI of the CAA do not forbid the use of existing or recycled controlled substances beyond the phase-out dates, even properly managed ODS banks will eventually be released as fugitive emissions to the atmosphere.

Prior to the 1996 production phase-out in the U.S., equipment utilizing ODS refrigerants was preferred in a wide variety of applications. These applications include industrial and commercial refrigeration, cold storage, comfort cooling equipment (i.e. air conditioning), and various consumer applications. While the production of ODS refrigerants has been phased out (with the exception of certain HCFCs), these substances are continually recovered, reclaimed and recycled to service old equipment. As such, use of these ODS is still widespread, and can be found everywhere from vehicle air conditioners to industrial chillers.

Despite regulations prohibiting their intentional release through servicing, use, and end of life, refrigerant ODS may be released to the atmosphere at average annual rates of up to 35% per year.⁸

The ODS CFC-11, CFC-12, and HCFC-141b were used as blowing agents in the production of foam prior to their mandated production phase-out in the U.S. Many of the applications for which this foam was used, such as refrigeration or A/C units and building insulation, have extended lifetimes, and these applications with foams containing ODS will therefore be present in the waste stream for many years to come. When this foam is disposed of, ODS is released from the foam during shredding⁹ and/or degradation in the landfill.¹⁰

2.2 Project Definition

For the purposes of this protocol, a project is defined as any set of activities undertaken by a single project developer leading to the destruction of eligible ODS at a single qualifying destruction facility over a 12-month period. Destruction may take place under one or more Certificates of Destruction. Each Certificate of Destruction must document the ODS destroyed. The ODS destroyed may come from a single origin (e.g. one supermarket) or from numerous sources. However, the entire quantity of eligible ODS destroyed must be documented on a Certificate of Destruction issued by a qualifying destruction facility.

⁷ CAA, Title VI, Section 604(a).

⁸ IPCC/TEAP Special report: Safeguarding the Ozone Layer and the Global Climate System: Issues Related To Hydrofluorocarbons And Perfluorocarbons (2005).

⁹ Scheutz et al., Release of fluorocarbons from insulation foam in home appliances during shredding, *J. of the Air & Waste Mgmt. Assn.* (2007) Technical Paper.

¹⁰ Scheutz et al., Attenuation of fluorocarbons released from foam insulation in landfills, *Environ. Sci. Technol.* (2007) 41: 7714-7722.

While project developers may engage in on-going collection and destruction activities, destruction events that fall outside of the 12-month window designated for a project may only be counted as part of a separately registered project. Project developers may choose a shorter time horizon for a single project (i.e. 3 months or 6 months), but no project may run longer than 12 months.

In order for multiple Certificates of Destruction to be included under a single project, the following conditions must be met:

- The project developer and GHG ownership are the same for all ODS destroyed
- The qualifying destruction facility is the same for all Certificates of Destruction
- The destruction activities span a time-frame of no more than 12 months from commencement of the first ODS destroyed to completion of the last
- No Certificate of Destruction is included as part of another project.

For all projects, the end fate of the ODS must be destruction at either an approved Hazardous Waste Combustor (HWC) subject to the Resource Conservation and Recovery Act (RCRA), CAA, and the National Emissions Standards for Hazardous Air Pollutants (NESHAP) standards, or any other facility that meets or exceeds the Montreal Protocol's Technology & Economic Assessment Panel (TEAP) standards provided in the Report of the Task Force on Destruction Technologies.¹¹ Non-RCRA permitted facilities must demonstrate compliance with the Title VI requirements of the CAA for destruction of ODS, as well as demonstrate destruction and removal efficiency (DRE) of 99.99% and emission levels consistent with the guidelines set forth in the aforementioned TEAP report.

2.3 Eligible ODS

This protocol contains requirements and guidelines for the accounting of GHG reductions from two ODS sources eligible under the project definition:

- **Refrigerants:** a project may collect eligible ODS refrigerant from industrial, commercial or residential equipment, systems and appliances or stockpiles, and destroy it at a qualifying destruction facility.
- **Foams:** a project may either extract eligible ODS blowing agent from foams and destroy the extracted blowing agent at a qualifying destruction facility; or, a project may destroy intact foam sourced from building insulation at a qualified destruction facility.

Each of these source materials has its own unique set of tracking procedures and calculation methodologies that project developers must follow under this protocol. A single project may incorporate ODS sourced from one or both of these ODS sources.

2.3.1 Refrigerant Sources

This source category consists of ODS that would have been recycled back into the market for recharge of existing equipment. The ODS must originate from domestic U.S. supplies; imported refrigerant is excluded from this protocol. Project developers seeking to register projects from the domestic destruction of imported refrigerant must use the Reserve's Imported Ozone Depleting Substances Project Protocol.

¹¹ TEAP, Volume 3B: Report of the Task Force on Destruction Technologies (2002).

Only destruction of the following ODS refrigerants is eligible for crediting under this protocol:

- CFC-11
- CFC-12
- CFC-114
- CFC-115

ODS extracted from a foam source for use in refrigeration equipment is not considered part of this source category. Additionally, all refrigerant collection, handling, and destruction must be performed in accordance with the reporting and operation requirements of Section 0.

2.3.2 Foam Sources

This source category consists of ODS entrained in foams that would have been released at end-of-life. The ODS must originate from domestic U.S. foam sources; imported foams are excluded from this protocol. Project developers seeking to register projects from the domestic destruction of imported foams must use the Reserve's Imported Ozone Depleting Substances Project Protocol.

Only the following ODS foam blowing agents are eligible to generate reductions under this protocol:

- CFC-11
- CFC-12
- HCFC-141b

To be eligible for crediting, the foam blowing agent must be destroyed in one of two ways:

1. **ODS blowing agent extracted from foam and blowing agent destroyed.** The ODS blowing agent must be extracted from the foam to a liquid form prior to destruction. This must be done under negative pressure in a vacuum to ensure that fugitive release of ODS cannot occur. The recovered ODS must be collected, stored, and transported in cylinders or other hermetically sealed containers.
2. **Intact foam containing ODS blowing agent separated from panels and destroyed intact.** When the intact foam is separated from building panels, appliances or equipment, it must be stored, transported, and destroyed in hermetically sealed containers. Foam extracted from equipment and appliances must be categorized and stored in containers according to the type of ODS and the year the equipment or appliance was manufactured.

All foam collection, handling, extraction, and destruction must be performed in accordance with the reporting and operation requirements of Section 0.

2.4 The Project Developer

The "project developer" may be any entity that has an active account on the Reserve, submits a project for listing and registration with the Reserve, and is ultimately responsible for all project reporting and verification. Project developers may be ODS aggregators, facility owners, facility operators, or GHG project financiers. The project developer must have clear ownership of the project's GHG reductions. Ownership of the GHG reductions must be established by clear and

explicit title, and the project developer must attest to such ownership by signing the Reserve's Attestation of Title form.¹²

¹² Attestation of Title form available at <http://www.climateactionreserve.org/how/projects/register/project-submittal-forms/>.

3 Eligibility Rules

Projects that meet the definition of a GHG reduction project in Section 2.2 must fully satisfy the following eligibility rules in order to register with the Reserve.

Eligibility Rule I:	Location	→	<i>U.S. and its territories</i>
Eligibility Rule II:	Project Start Date	→	<i>Within six months prior to project submission*</i>
Eligibility Rule III:	Additionality	→	<i>Exceed legal requirements</i>
		→	<i>Meet performance standard</i>
Eligibility Rule IV:	Regulatory Compliance	→	<i>Compliance with all applicable laws</i>

* See Section 3.2 for additional information on project start date

3.1 Location

For ODS destruction to be eligible as a project under this protocol, all ODS must be sourced from U.S. stocks and destroyed within the United States or its territories. Project developers seeking to register projects from the domestic destruction of imported ODS must use the Reserve's Imported Ozone Depleting Substances Project Protocol.

3.2 Project Start Date

The project start date is defined as the date on which destruction activities are commenced, as documented on a Certificate of Destruction.

To be eligible, the project must be submitted to the Reserve no more than six months after the project start date, unless the project is submitted during the first 12 months following the date of adoption of this protocol by the Reserve Board (the Effective Date).¹³ For a period of 12 months from the Effective Date of this protocol (Version 1.0), projects with start dates no more than 24 months prior to the Effective Date of this protocol are eligible. Specifically, projects with start dates on or after February 7, 2008 are eligible to register with the Reserve if submitted by February 7, 2011. Projects with start dates prior to February 7, 2008 are not eligible under this protocol. Projects may always be submitted for listing by the Reserve prior to their start date.

3.3 Project Crediting Period

An ODS project is a discrete series of destruction events over a 12-month period. However, absent the project, the avoided ODS emissions would have occurred over a longer time horizon. For refrigerants, these emissions would have occurred when the ODS is sold into the recycling market and emitted through equipment leakage and servicing. For foams, these emissions would have occurred during end-of-life treatment of the appliance.

Under this protocol, the project crediting period is the period of time over which avoided emissions are quantified for the purpose of determining creditable GHG reductions. Specifically, ODS projects may be issued CRTs for the quantity of ODS that would have been released over

¹³ Projects are considered submitted when the project developer has fully completed and filed the appropriate Project Submittal Form and Attestation of Title, available on the Reserve's website.

a ten-year period following a destruction event. CRTs are issued for all ODS emissions avoided by a project over 10 years at the time the project is verified.

3.4 Additionality

The Reserve strives to register only projects that yield surplus GHG reductions that are additional to what might have otherwise occurred in the absence of a GHG market.

Projects must satisfy both of the following tests to be considered additional:

1. The Legal Requirement Test
2. The Performance Standard Test

3.4.1 The Legal Requirement Test

All projects are subject to a Legal Requirement Test to ensure that the GHG reductions achieved by a project would not otherwise have occurred due to federal, state or local regulations, or other legally binding mandates. A project passes the Legal Requirement Test when there are no laws, statutes, regulations, court orders, environmental mitigation agreements, permitting conditions, or other legally binding mandates requiring the destruction of ODS. To satisfy the Legal Requirement Test, project developers must submit a signed Attestation of Voluntary Implementation form¹⁴ prior to the commencement of verification activities each time the project is verified (see Section 8). In addition, the project's Monitoring Plan (Section 0) must include procedures that the project developer will follow to ascertain and demonstrate that the project at all times passes the Legal Requirement Test.

As of the Effective Date of this protocol, the proposed American Clean Energy and Security Act of 2009¹⁵ includes provisions allowing CFC destruction to be used to attain HFC allowances. Any project which seeks HFC allowances under this program (should the legislation become law), or under any other current or future regulations or regulatory programs, will be ineligible according to this protocol.

3.4.2 The Performance Standard Test

Projects pass the Performance Standard Test by meeting a performance threshold – i.e. a standard of performance applicable to all ODS management projects – as defined in this section.¹⁶

For this protocol, the Reserve uses a Performance Standard Test that serves as a national “common practice standard” for managing ODS. Because destruction of ODS is not common practice in the U.S., all ODS destruction activities that meet the project definitions and other eligibility requirements above pass the Performance Standard Test.

The Reserve will periodically re-evaluate the appropriateness of the performance standard. All projects that meet the applicable performance standard at the time of ODS destruction are eligible to generate CRTs.

¹⁴ Regulatory Attestation form available at <http://www.climateactionreserve.org/how/projects/register/project-submittal-forms/>.

¹⁵ HR 2454, American Clean Energy and Security Act of 2009

¹⁶ A summary of the study to establish the Performance Standard Test is provided in Appendix B.

3.5 Regulatory Compliance

Project developers shall attest that the project is in material compliance with all applicable laws (e.g. air, water quality, and safety) prior to verification activities commencing for each reporting period. Projects are not eligible to receive CRTs for GHG reductions that occur as the result of collection or destruction activities which are not in material¹⁷ compliance with regulatory requirements. Project developers are required to disclose in writing to the verifier any and all instances of non-compliance of the project with any law. If a verifier finds that a project is in a state of material non-compliance or non-compliance that is the result of negligence or intent, then CRTs will not be issued for GHG reductions that occurred during the period of non-compliance. Non-compliance solely due to “acts of nature” will not affect CRT crediting.

The regulatory compliance requirement extends to the operation of destruction facilities. Destruction facilities have the potential to contribute to environmental problems beyond ozone depletion and climate change. For example, emissions from destruction facilities may contribute to criteria and/or toxic pollutants. However, compliance with existing EPA regulations greatly reduces or eliminates these pollutants. Accordingly, all destruction facilities must meet the full burden of applicable regulatory requirements during the time the ODS destruction occurs.

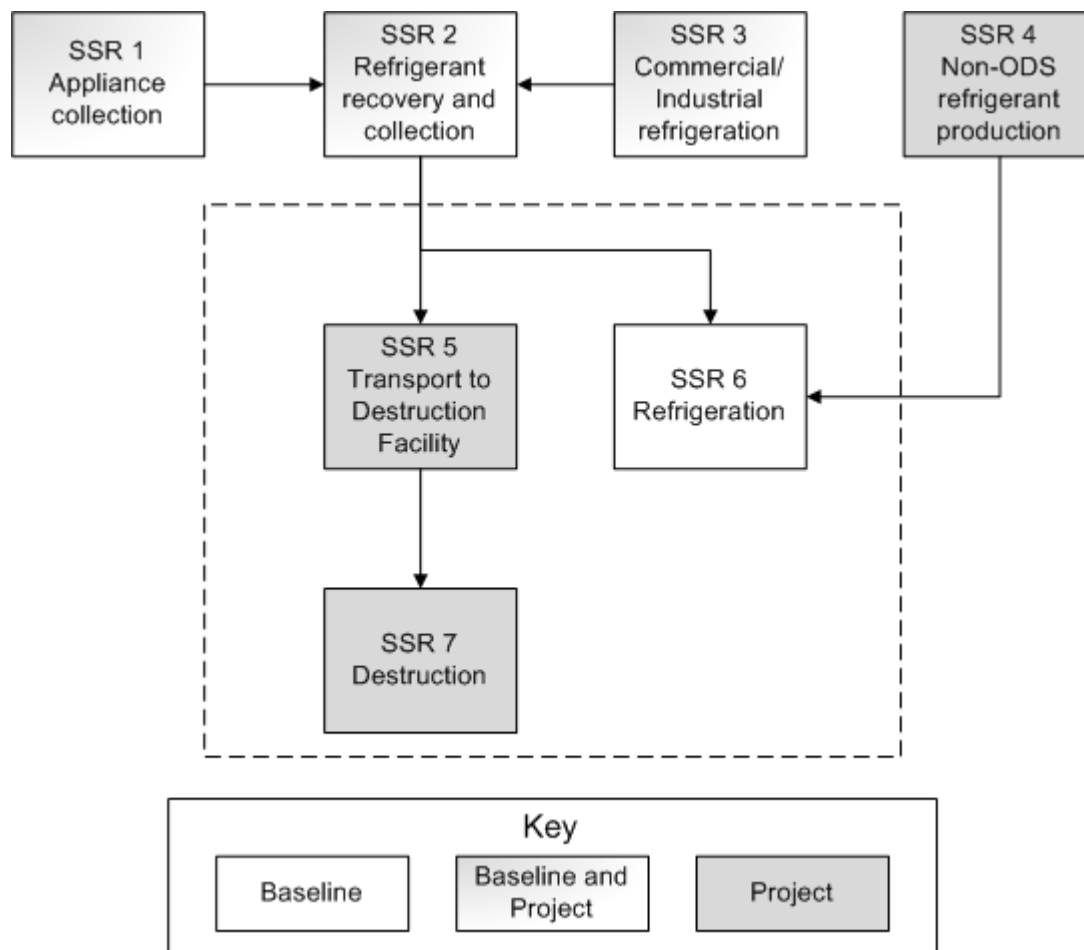
¹⁷ Non-compliances which result solely due to administrative issues are considered immaterial.

4 The GHG Assessment Boundary

The GHG Assessment Boundary delineates the GHG sources, sinks, and reservoirs (SSRs) that shall be assessed by project developers in order to determine the total net change in GHG emissions caused by an ODS project.¹⁸

Figure 4.1, Figure 4.2, and Figure 4.3 below provide a general illustration of the GHG Assessment Boundary, indicating which SSRs are included or excluded from the boundary.

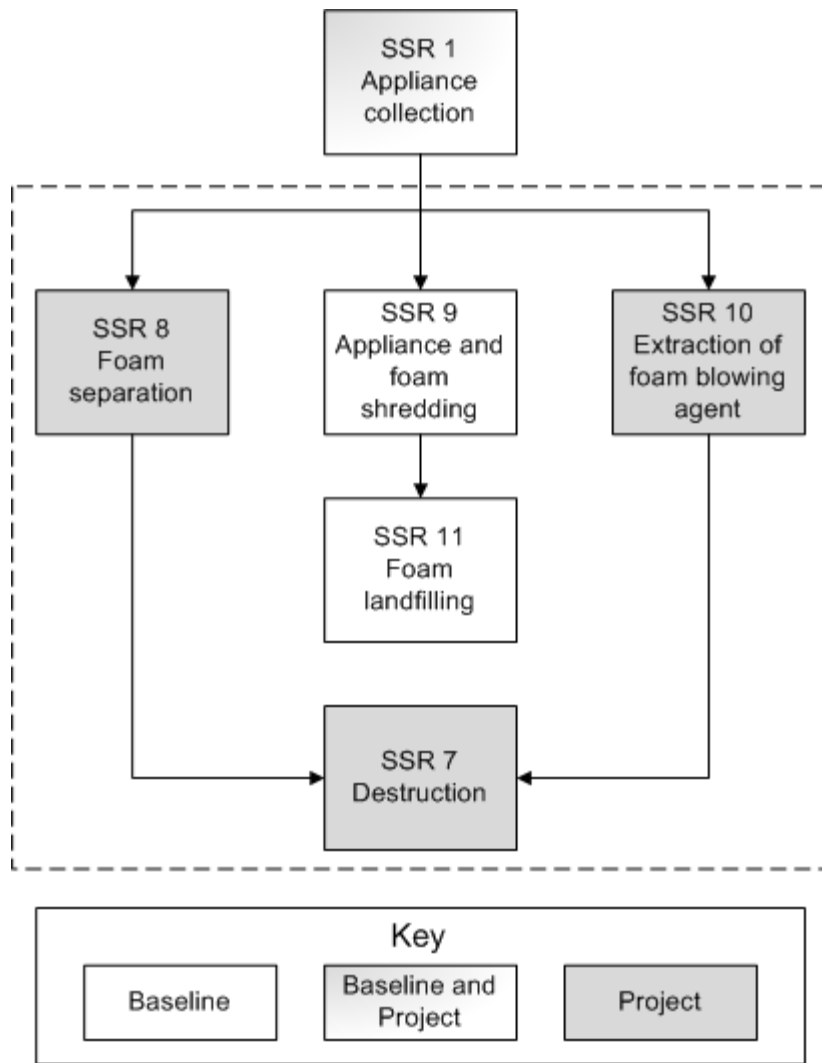
Table 4.1 gives greater detail on each SSR and provides justification for all SSRs and gases that are excluded from the GHG Assessment Boundary.



Note: Emissions from all sources within the dashed box above are accounted for within this protocol.

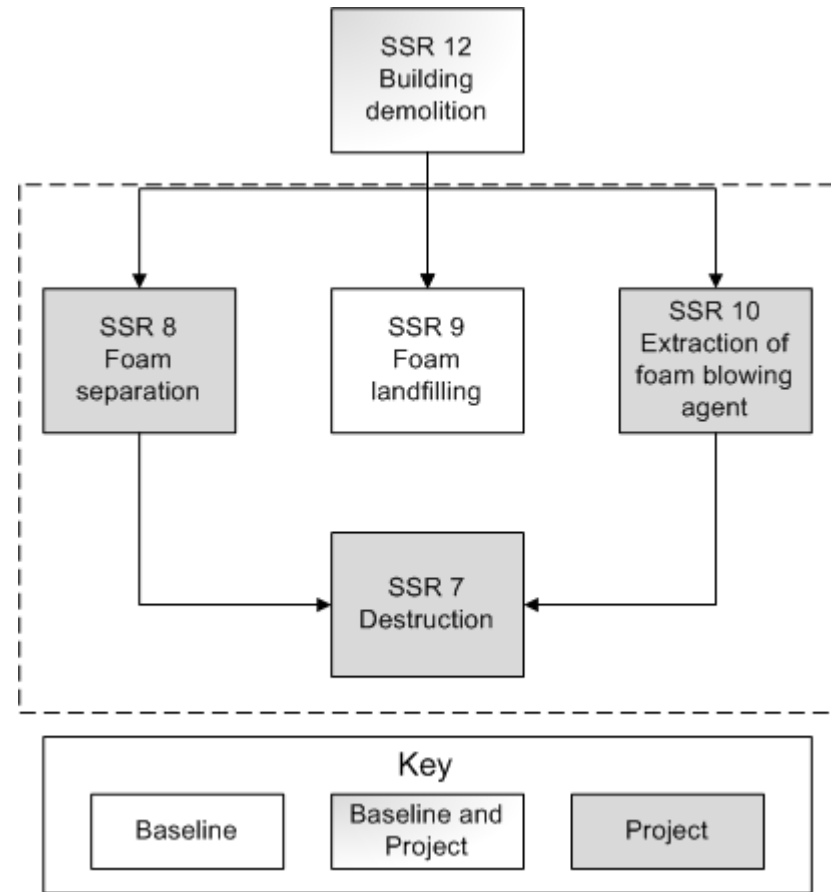
Figure 4.1. Illustration of the GHG Assessment Boundary for Refrigerant Projects

¹⁸ The definition and assessment of SSRs is consistent with ISO 14064-2 guidance.



Note: Emissions from all sources within the dashed box above are accounted for within this protocol.

Figure 4.2. Illustration of the GHG Assessment Boundary for Appliance Foam Projects



Note: Emissions from all sources within the dashed box above are accounted for within this protocol.

Figure 4.3. Illustration of the GHG Assessment Boundary for Building Foam Projects

Table 4.1. Summary of Identified Sources, Sinks, and Reservoirs

SSR		Source Description	Gas	Included (I) or Excluded (E)	Quantification Method	Justification/Explanation
1	Appliance Collection	Fossil fuel emissions from the collection and transport of end-of-life residential appliances	CO ₂	E	N/A	<i>Excluded, as project activity is unlikely to affect emissions relative to baseline activity</i>
			CH ₄	E	N/A	<i>Excluded, as project activity is unlikely to affect emissions relative to baseline activity</i>
			N ₂ O	E	N/A	<i>Excluded, as project activity is unlikely to affect emissions relative to baseline activity</i>
2	Refrigerant Recovery and Collection	Emissions of ODS from the recovery and collection of refrigerant at end-of-life or servicing	ODS	E	N/A	<i>Excluded, as project activity is likely to decrease these emissions. Therefore, exclusion is conservative</i>
		Fossil fuel emissions from the recovery and collection of refrigerant at end-of-life or servicing	CO ₂	E	N/A	<i>Excluded, as project activity is unlikely to affect emissions relative to baseline activity</i>
			CH ₄	E	N/A	<i>Excluded, as project activity is unlikely to affect emissions relative to baseline activity</i>
			N ₂ O	E	N/A	<i>Excluded, as project activity is unlikely to affect emissions relative to baseline activity</i>
3	Commercial/Industrial Refrigeration	Emissions of ODS from equipment leak and servicing	ODS	E	N/A	<i>Excluded, as project activity is unlikely to affect emissions relative to baseline activity</i>
		Fossil fuel emissions from the operation of refrigeration and AC equipment	CO ₂	E	N/A	<i>Excluded, as project activity is unlikely to affect emissions relative to baseline activity</i>
			CH ₄	E	N/A	<i>Excluded, as project activity is unlikely to affect emissions relative to baseline activity</i>

SSR		Source Description	Gas	Included (I) or Excluded (E)	Quantification Method	Justification/Explanation
			N ₂ O	E	N/A	<i>Excluded, as project activity is unlikely to affect emissions relative to baseline activity</i>
4	Non-ODS Refrigerant Production	Emissions of substitute refrigerant occurring during production Fossil fuel emissions from the production of substitute refrigerants	CO ₂ e	E	N/A	<i>Excluded, as this emission source is assumed to be very small</i>
			CO ₂	E	N/A	<i>Excluded, as this emission source is assumed to be very small</i>
			CH ₄	E	N/A	<i>Excluded, as this emission source is assumed to be very small</i>
			N ₂ O	E	N/A	<i>Excluded, as this emission source is assumed to be very small</i>
5	Transport to Destruction Facility	Fossil fuel emissions from the vehicular transport of ODS from aggregation point to final destruction facility	CO ₂	I	Baseline: N/A Project: Estimated based on distance and weight transported	<i>Project emissions will be small, and can be calculated using the default factor provided</i>
			CH ₄	E	N/A	<i>Excluded, as this emission source is assumed to be very small</i>
			N ₂ O	E	N/A	<i>Excluded, as this emission source is assumed to be very small</i>
6	Refrigeration	Emissions of ODS from leaks and servicing through continued operation of equipment	ODS	I	Baseline: Estimated based on market-weighted emission rates Project: N/A	<i>Baseline equipment emissions will be significant for refrigerant sources, but are non-applicable for foam sources</i>
		Emissions of substitute from leaks and servicing through continued operation of equipment	CO ₂ e	I	Baseline: N/A Project: Estimated based on market-weighted emissions	<i>Project equipment emissions will be significant for refrigerant sources, but are non-applicable for foam sources</i>
		Indirect emissions from grid-delivered electricity	CO ₂	E	N/A	<i>Excluded, as project activity is unlikely to affect emissions relative to baseline activity</i>
			CH ₄	E	N/A	<i>Excluded, as project activity is unlikely to affect emissions relative to baseline activity</i>

SSR		Source Description	Gas	Included (I) or Excluded (E)	Quantification Method	Justification/Explanation
			N ₂ O	E	N/A	<i>Excluded, as project activity is unlikely to affect emissions relative to baseline activity</i>
7	Destruction	Emissions of ODS from incomplete destruction at destruction facility	ODS	I	Baseline: N/A Project: Estimated based on ODS destroyed, or included in default deduction	<i>Project emissions will be small, and can be calculated using the default factor provided</i>
		Emissions from the oxidation of carbon contained in destroyed ODS	CO ₂	I	Baseline: N/A Project: Estimated based on ODS destroyed, or included in default deduction	<i>Project emissions will be small, and can be calculated using the default factor provided</i>
		Fossil fuel emissions from the destruction of ODS at destruction facility	CO ₂	I	Baseline: N/A Project: Estimated based on ODS destroyed, or included in default deduction	<i>Project emissions will be small, and can be calculated using the default factor provided</i>
			CH ₄	E	N/A	<i>Excluded, as this emission source is assumed to be very small</i>
			N ₂ O	E	N/A	<i>Excluded, as this emission source is assumed to be very small</i>
		Indirect emissions from the use of grid-delivered electricity	CO ₂	I	Baseline: N/A Project: Estimated based on ODS destroyed, or included in default deduction	<i>Project emissions will be small, and can be calculated using the default factor provided</i>
			CH ₄	E	N/A	<i>Excluded, as this emission source is assumed to be very small</i>
			N ₂ O	E	N/A	<i>Excluded, as this emission source is assumed to be very small</i>

SSR		Source Description	Gas	Included (I) or Excluded (E)	Quantification Method	Justification/Explanation
8	Foam Separation	Emissions of ODS released during the separation of foam from the insulation panel	ODS	I	Baseline: N/A Project: Estimated based on default separation loss	<i>Project emissions may be significant. Site specific separation loss may be used if available</i>
9	Appliance and Foam Shredding	Emissions of ODS from the shredding of appliances for materials recovery, releasing ODS from foam	ODS	I	Baseline: Estimated based on total quantity of ODS destroyed and default shredding factors Project: N/A	<i>Baseline shredding emissions will be significant for foam sources, but are non-applicable for refrigerant sources</i>
10	Extraction of Foam Blowing Agent	Fossil fuel emissions from the separation of foam blowing agent from foam	CO ₂	I	Baseline: N/A Project: Estimated based on energy bills	<i>Project emissions may be significant</i>
			CH ₄	E	N/A	<i>Excluded, as this emission source is assumed to be very small</i>
			N ₂ O	E	N/A	<i>Excluded, as this emission source is assumed to be very small</i>
11	Foam Landfilling	Emissions of ODS released from foam disposed of in landfills	ODS	I	Baseline: Estimated based on release and degradation of ODS in landfill Project: N/A	<i>Project emissions will be significant for foam sources, but are not applicable for refrigerant sources</i>
		Fossil fuel emissions from the transport and placement of shredded foam waste in landfill	CO ₂	E	N/A	<i>Excluded, as project activity is likely to decrease these emissions. Therefore, exclusion is conservative</i>
			CH ₄	E	N/A	<i>Excluded, as project activity is likely to decrease these emissions. Therefore, exclusion is conservative</i>
			N ₂ O	E	N/A	<i>Excluded, as project activity is likely to decrease these emissions. Therefore, exclusion is conservative</i>

SSR		Source Description	Gas	Included (I) or Excluded (E)	Quantification Method	Justification/Explanation
12	Building Demolition	Emissions of ODS from the demolition of buildings and damage to foam insulation panels	ODS	E	N/A	<i>Excluded, as project activity is unlikely to affect emissions relative to baseline activity. Destruction according to best practices is required to assure no change in this emission source</i>
		Fossil fuel emissions from the demolition of buildings	CO ₂	E	N/A	<i>Excluded, as project activity is unlikely to affect emissions relative to baseline activity</i>
			CH ₄	E	N/A	<i>Excluded, as project activity is unlikely to affect emissions relative to baseline activity</i>
			N ₂ O	E	N/A	<i>Excluded, as project activity is unlikely to affect emissions relative to baseline activity</i>

5 GHG Reductions Calculation Method

GHG emission reductions from an ODS project are quantified by comparing actual project emissions to baseline emissions. Baseline emissions are an estimate of the GHG emissions from sources within the GHG Assessment Boundary (see Section 4) that would have occurred in the absence of the ODS destruction project. Project emissions are actual GHG emissions that occur at sources within the GHG Assessment Boundary. Project emissions must be subtracted from the baseline emissions to quantify the project's total net GHG emission reductions (Equation 5.1).

As a project may not span more than a 12-month period, GHG emission reductions must be quantified and verified at least at the end of each 12-month period. Project developers may also choose to define their project over a shorter time horizon than 12 months, or undergo multiple verifications for the 12-month project life.

Equation 5.1. Total Emission Reductions

$ER = BE - PE$		
Where,		<u>Units</u>
ER	= Total quantity of emission reductions	tCO ₂ e
BE	= Total quantity of baseline emissions	tCO ₂ e
PE	= Total quantity of project emissions	tCO ₂ e

5.1 Quantifying Baseline Emissions

Total baseline emissions must be estimated by calculating and summing the expected baseline emissions for all relevant SSRs (as indicated in Table 4.1) using Equation 5.2 and the supporting equations presented below. This includes emissions from continued use in the secondary recharge market for the refrigerant category, and the emissions from end-of-life disposal for foam categories.

Equation 5.2. Total Baseline Emissions

$BE = BE_{refr} + BE_{foam}$		
Where,		<u>Units</u>
BE	= Total quantity of baseline emissions	tCO ₂ e
BE _{refr}	= Total quantity of baseline emissions from refrigerant ODS	tCO ₂ e
BE _{foam}	= Total quantity of baseline emissions from foam ODS	tCO ₂ e

Baseline emissions for an ODS destruction project are based on the total baseline emissions from each eligible source category – refrigerant and foam blowing ODS. If a project does not destroy any ODS from a particular source category, baseline emissions for that source category are assumed to be zero.

Table 5.1 provides the applicable GWP and leak rates to be used with Equation 5.3 through Equation 5.4. See Appendix D for summary of how these leak rates were determined.

Table 5.1. Global Warming Potential and Emission Rates of Refrigerants

ODS Species	100-yr Global Warming Potential (CO ₂ e) ¹⁹ (GWP)	Annual Weighted Average Emissions Rate (%/yr) ²⁰ (ER _{refr})	10-year Cumulative Emissions (%) ²¹
CFC-11	4,750	19.5%	88.5%
CFC-12	10,900	26.1%	95.2%
CFC-114	10,000	13.8%	77.4%
CFC-115	7,370	25.0%	94.4%
HCFC-141b	725	N/A	N/A

5.1.1 Baseline Emissions from Refrigerant Recovery and Resale

The refrigerant baseline scenario is defined as recovery and resale of ODS into the secondary market to recharge existing equipment. It is not required to determine why refrigerants may have been removed from certain equipment, why a chiller may have been decommissioned, or why a stockpile was not utilized. Equation 5.3 shall be used to calculate the baseline emissions that would have occurred over ten years had the destroyed ODS instead been used in existing refrigeration equipment. This equation requires the use of the ODS-specific emission rate (inclusive of both leak rate and servicing emissions) and GWP, both provided in Table 5.1.

Equation 5.3. Baseline Emissions from Refrigerant ODS

$$BE_{refr} = \sum_i Q_{refr,i} * (1 - (1 - ER_{refr,i})^{10}) * GWP_i$$

Where,

		Units
BE _{refr}	= Total quantity of refrigerant baseline emissions	tCO ₂ e
Q _{refr,i}	= Total quantity of refrigerant ODS <i>i</i> destroyed	tODS
ER _{refr,i}	= Annual emissions rate of refrigerant ODS <i>i</i> (see Table 5.1)	%
GWP _i	= Global warming potential of ODS <i>i</i>	tCO ₂ e/ tODS

5.1.2 Baseline Emissions from Shredding and/or Landfilling Foam Blowing Agents

There are two different predominant baseline practices applicable to foams; the practice utilized is dependent on the origin of the foam. The two baseline practices identified by the Reserve are as follows:

¹⁹IPCC, Errata: Climate Change 2007, The Physical Science Basis, The Working Group I contribution to the IPCC Fourth Assessment Report, available at: <http://www.ipcc.ch/pdf/assessment-report/ar4/wg1/ar4-wg1-errata.pdf>.

²⁰ EPA (2008) EPA Vintaging Model. Version VM IO file_v4.2_10.07.08. CFC-12 estimates include data from private parties on mobile sources

²¹ 10-year cumulative emissions = 1-(1-leak rate)¹⁰, or the percent of a given substance which will be released over ten years at a constant leak rate.

Origin	Baseline Practice
Insulation foam recovered from residential appliances	The foam is shredded, and subsequently landfilled
Foam recovered from building demolition	The foam is landfilled

Equation 5.4 shall be used to calculate the baseline emissions that would have occurred had the destroyed ODS been landfilled. This baseline accounts for the total emissions that would have occurred as a result of foam shredding and landfilling.²² This equation requires the inclusion of a shredding release term (column A in Table 5.2) only for those foams that are recovered from end-of-life refrigeration or A/C appliances. The applicable GWP for the foam blowing agent can be found in Table 5.1. Equation 5.4 also accounts for the breakdown of blowing agent that occurs in the landfill.

Table 5.2. Emissions from Shredding and Landfilling ODS Foam Blowing Agents

Foam Blowing Agent	<u>A</u> Percent of foam blowing agent released during shredding ^a (set to zero for demolition debris)	<u>B</u> Percent of foam blowing agent released during compaction ^b	<u>C</u> Percent of remaining foam blowing agent released during anaerobic conditions ^c	<u>D</u> Percent of released foam blowing agent degraded in anaerobic landfill conditions ^c
CFC-11	24%	19%	35%	94%
CFC-12	24%	19%	41%	60%
HCFC-141b	24%	19%	52%	43%

^aScheutz, C. et al. (2007) Release of fluorocarbons from insulation foam in home appliances during shredding. J of the Air & Waste Mgmt Assn, 57: 1452-1460.

^bFredenslund, A. et al. (2005) Disposal of Refrigerators-Freezers in the U.S. : State of the Practice. Technical University of Denmark

^cScheutz, C., et al. (2007) Attenuation of insulation foam released fluorocarbons in landfills. Environ Sci & Tech., 41:7714-7722).

²² Temperatures achieved by landfill gas flares and engines are not high enough to achieve significant ODS destruction.

Equation 5.4. Baseline Emissions from ODS Extracted from Foams

$$BE_{foam} = \sum_i [Q_{foam,i} * (BE_{treat,i} + BE_{landfill,i}) * GWP_i]$$

Where,

	<u>Units</u>
BE_{foam} = Total quantity of foam blowing ODS baseline emissions	tCO ₂ e
BE_{treat} = ODS emissions from the pre-landfill treatment of foam blowing agent <i>i</i> , from shredding and compaction of foam in the baseline	% (0-1.0)
$BE_{landfill}$ = Emissions of ODS blowing agent <i>i</i> not degraded in landfill	% (0-1.0)
$Q_{foam,i}$ = Total quantity of foam blowing ODS <i>i</i> destroyed	tODS
GWP_i = Global warming potential of ODS <i>i</i>	tCO ₂ e/ tODS

$$BE_{treat,i} = (Shred_{foam,i} + Compact_{foam,i})$$

Where,

	<u>Units</u>
$Shred_{foam,i}$ = Percent of foam blowing ODS <i>i</i> released by shredding in the baseline (Table 5.2, column A). Set to zero for building insulation.	% (0-1.0)
$Compact_{foam,i}$ = Percent of foam blowing agent ODS <i>i</i> released during compaction in the baseline. (Table 5.2, column B)	% (0-1.0)

$$BE_{landfill,i} = (1 - Shred_{foam,i} - Compact_{foam,i}) * LF_{release} * (1 - LF_{foam,i})$$

Where,

	<u>Units</u>
$Shred_{foam,i}$ = Percent of foam blowing ODS <i>i</i> released by shredding in the baseline (Table 5.2, column A). Set to zero for building insulation.	% (0-1.0)
$Compact_{foam,i}$ = Percent of foam blowing agent ODS <i>i</i> released during compaction in the baseline (Table 5.2, column B)	% (0-1.0)
$LF_{release,i}$ = Percent of remaining foam blowing agent <i>i</i> released into anaerobic landfill conditions (Table 5.2, column C)	% (0-1.0)
$LF_{foam,i}$ = Percent of foam blowing ODS <i>i</i> degraded in landfill in the baseline (Table 5.2, column D)	% (0-1.0)

5.2 Quantifying Project Emissions

Project emissions are actual GHG emissions that occur within the GHG Assessment Boundary as a result of project activities.

As shown in Equation 5.5, project emissions equal:

- Emissions from non-ODS substitutes (applicable only to refrigerant projects), plus
- Emissions from foam separation, plus
- Emissions from the transportation of ODS, plus
- Emissions from the destruction of ODS

Equation 5.5. Total Project Emissions

$PE = Sub_{ref} + Foam + Tr + Dest$		
Where,		<u>Units</u>
PE	= Total quantity of project emissions	tCO ₂ e
Sub _{ref}	= Total emissions from substitute refrigerant	tCO ₂ e
Foam	= Total emissions from separation of foam	tCO ₂ e
Tr	= Total emissions from transportation of ODS (calculated using either the default value in Equation 5.8 or Equation 5.14)	tCO ₂ e
Dest	= Total emissions from the process associated with destruction of ODS (calculated using either the default value in Equation 5.8 or Equation 5.9 through Equation 5.13)	tCO ₂ e

5.2.1 Project Emissions from the Use of Refrigerant Substitutes

Projects that destroy refrigerant ODS must account for the emissions associated with the non-ODS substitute chemicals that will be used in their place using Equation 5.6. Like the destroyed ODS calculations used in the baseline, substitute emissions shall also be accounted for based on the projected emissions over a ten year crediting period.

ODS substitute emissions are based on the weighted average of new refrigerant supplies into the refrigeration market. These substitute refrigerants were modeled using the EPA Vintaging Model and data provided by industry sources. Calculation of ODS substitute emission rates from the data provided by the EPA Vintaging Model is provided in Appendix D. The analysis identified the emission factors in Table 5.3 for each ODS refrigerant covered under this protocol.

Table 5.3. Refrigerant Substitute Emission Factors

ODS Refrigerant	Substitute Emissions (t CO ₂ e/t ODS) (SE _i)
CFC-11	245
CFC-12	771
CFC-114	725
CFC-115	1814

Project emissions from the use of substitute refrigerants shall be calculated for all ODS refrigerant projects according to Equation 5.6 using the emission factors from Table 5.3. The use of site-specific substitute parameters (refrigerant, GWP, and leak rate) are not permitted (See Appendix D for a summary of substitute refrigerant emissions development).

Equation 5.6. Project Emissions from the Use of Non-ODS Refrigerants

$$Sub_{refr} = \sum_i (Q_{ref_i} * SE_i)$$

Where,

		<u>Units</u>
Sub _{refr}	= Total quantity of refrigerant substitute emissions	tCO ₂ e
Q _{ref_i}	= Total quantity of refrigerant <i>i</i> destroyed	t
SE _i	= Emission factor for substitute emissions of refrigerant <i>i</i> , per Table 5.3 (see Appendix D for summary of the development of this factor)	tCO ₂ e/ tODS destroyed

5.2.2 Project Emissions from Foam Separation

Projects that separate foam from building or appliance panels and destroy foam intact must account for the emissions of ODS that occur during separation using Equation 5.7. Separation must be conducted in a manner that achieves at least a 90% recovery and destruction efficiency (RDE), per the recommendations of the TEAP Report of the Task Force on Foam End-of-Life Issues.²³ The losses calculated in Equation 5.7 include the original foam blowing agent that is released during the entire process of deconstruction (for buildings), de-manufacture (for appliances), and transport to destruction facility.

Equation 5.7. Calculating Project Emissions from the Release of Blowing Agent During Processing

$$Foam = \sum_i \left(Q_{foam,i} * \frac{1-0.9}{0.9} \right)$$

Where,

		<u>Units</u>
Q _{foam,i}	= Total emissions from the release of ODS blowing agent during separation of foam (only applicable for projects that destroy intact foam)	tCO ₂ e
0.9	= The RDE, defined as the percent of blowing agent (ODS) remaining in the product before decommissioning that is recovered in overall end-of-life management (=0.9 for all foam projects)	% (0-1.0)

5.2.3 Default Project Emissions from ODS Transportation and Destruction

Projects must account for project emissions that result from the transportation and destruction of ODS. Because these emission sources are both individually and in aggregate very small, the Reserve has developed default emission factors for ODS projects based on conservative assumptions and the SSRs outlined in Table 4.1 (see Appendix E). Project developers have the option of using the default emission factors provided in Equation 5.8, or using the guidance in Sections 5.2.4 and 5.2.5 to calculate project-specific emissions. If a project developer elects not to use the default emission factors, all project emissions must be fully accounted for individually.

²³ United Nations Environment Programme, Technology and Economic Assessment Panel. (2005). *Report of the Task Force on Foam End-of-Life Issues*.

Equation 5.8. Project Emissions from Transportation and Destruction Using the Default Emission Factors

$Tr + De_{def} = \sum_i (Q_{ODS,i} * EF_i)$		
Where,		<u>Units</u>
Tr+De _{def}	= Total emissions from ODS transportation and destruction, as calculated using default emission factors. ($TrDe_{def} = Tr+Dest$, Equation 5-5)	tCO ₂ e
Q _{ODS,i}	= Total quantity of ODS <i>i</i> destroyed in the project	tODS
EF _i	= Default emission factor for transportation and destruction of ODS <i>i</i> (7.5 for refrigerant or extracted blowing agent projects, and 75 for intact foam projects)	tCO ₂ e/ tODS

5.2.4 Site-Specific Project Emissions from ODS Destruction

Under this protocol, ODS must be destroyed at destruction facilities that demonstrate compliance with the TEAP recommendations.²⁴ These facilities are required by the U.S. EPA to demonstrate their ability to achieve destruction efficiencies upwards of 99.99% for substances with thermal stability ratings higher than the ODS included under this protocol.²⁵ Associated with the operation of these facilities are emissions of CO₂ from the fuel and electricity used to power the destruction, as well as emissions of un-destroyed ODS. Equation 5.9 through Equation 5.11 provide requirements for calculating emissions from ODS destruction in cases where project developers opt to not use the default factors outlined in Section 5.2.3.

Equation 5.9. Project Emissions from the Destruction of ODS

$Dest = FF_{dest} + EL_{dest} + ODS_{emissions} + ODS_{CO2}$		
Where,		<u>Units</u>
Dest	= Total emissions from the destruction process associated with destruction of ODS	tCO ₂ e
FF _{dest}	= Total emissions from fossil fuel used in the destruction facility	tCO ₂
EL _{dest}	= Total emissions from grid electricity at the destruction facility	tCO ₂
ODS _{emissions}	= Total emissions of un-destroyed ODS	tCO ₂ e
ODS _{CO2}	= Total emissions of CO ₂ from ODS oxidation	tCO ₂

²⁴ TEAP, <http://uneptie.org/ozonaction/topics/disposal.htm>

²⁵ EPA, Destruction of ODS in the United States (2008), prepared by ICF International

Equation 5.10. Fossil Fuel Emissions from the Destruction of ODS

$$FF_{dest} = \frac{\sum_i (FF_{PR,i} * EF_{FF,i})}{1000}$$

Where,

	<u>Units</u>
FF _{dest} = Total carbon dioxide emissions from the destruction of fossil fuel used to destroy ODS	tCO ₂
FF _{PR,i} = Total fossil fuel <i>i</i> used to destroy ODS	volume fossil fuel
EF _{FF,i} = Fuel specific emission factor; see Appendix E	kg CO ₂ / volume fossil fuel
1000 = kg/t of CO ₂	kgCO ₂ / tCO ₂

Equation 5.11. Electricity Emissions from the Destruction of ODS

$$EL_{dest} = \frac{(EL_{PR} * EF_{EL})}{2204.6}$$

Where,

	<u>Units</u>
EL _{dest} = Total carbon dioxide emissions from the consumption of electricity from the grid used to destroy ODS	tCO ₂
EL _{PR} = Total electricity consumed to destroy ODS	MWh
EF _{EL} = Carbon emission factor for electricity used; see Appendix E	lb CO ₂ / MWh
2204.6 = lb/t of CO ₂	lbCO ₂ / tCO ₂

Equation 5.12. Calculating Project Emissions from ODS Not Destroyed

$$ODS_{emissions} = \sum_i Q_{ODS,i} * 0.01\% * GWP_i$$

Where,

	<u>Units</u>
ODS _{emissions} = Total emissions of un-destroyed ODS	tCO ₂ e
Q _{ODS,i} = Total quantity of ODS <i>i</i> destroyed in the project	tODS
0.01 = Maximum allowable percent of ODS fed to destruction that is not destroyed	%
GWP _i = Global warming potential of ODS <i>i</i> (see Table 5.1)	tCO ₂ e/ tODS

Equation 5.13. Calculating Project Emissions of CO₂ from the Oxidation of ODS

$$ODS_{CO_2} = \sum_i Q_{ODS,i} * CR_i * \frac{44}{12}$$

Where,

	<u>Units</u>
ODS _{CO2} = Total emissions of CO ₂ from ODS oxidation	tCO ₂
Q _{ODS,i} = Total quantity of ODS <i>i</i> destroyed in the project	tODS
CR _i = Carbon ratio of ODS <i>i</i>	mole C/ mole ODS
44/12 = Ratio of CO ₂ to C	mole CO ₂ / mole C

5.2.5 Site-Specific Project Emissions from ODS Transportation

Throughout the collection, aggregation, and destruction process, ODS will be transported from aggregators to destruction facilities, and emissions from this activity must be accounted for under this protocol. Equation 5.14 provides guidance on calculating CO₂ emissions associated with the transport of ODS in cases where project developers choose not to use the default emission factors presented in Section 5.2.3. Emissions shall be calculated for each leg of the transportation process separately, and then summed according to Equation 5.14 below.

Equation 5.14. Calculating Project Emissions from the Transportation of ODS²⁶

$$Tr = \sum_i \left(\frac{TMT_i * EF_{TMT}}{1000} \right)$$

Where,

	<u>Units</u>
Tr = Total emissions from transportation of ODS	tCO ₂ e
TMT _i = Tonne-miles-traveled ²⁷ for ODS <i>i</i> destroyed (to be calculated including the ODS, any accompanying material, and containers)	tonne-miles
EF _{TMT} = CO ₂ e emissions per tonne-mile-traveled	kgCO ₂ e
On-road truck transport = 0.297	
Rail transport = 0.0252	
Waterborne craft = 0.048	
Aircraft = 1.5279	
1000 = Conversion from kg to tonnes	kg/tonne

²⁶Derived from: U.S. EPA Climate Leaders, Optional emissions from business travel, commuting, and product transport (2008).

²⁷ A tonne-mile is defined as the product of the distance travelled in miles and the mass transported in tonnes. Therefore, half a tonne transported four miles is equal to two tonne-miles.

6 Project Monitoring and Operation

The Reserve requires a Monitoring Plan to be established for all monitoring and reporting activities associated with the project. The Monitoring Plan will serve as the basis for verification bodies to confirm that the monitoring and reporting requirements in this section and Section 7 have been and will continue to be met, and that consistent, rigorous monitoring and record-keeping is ongoing for the project. The Monitoring Plan must cover all aspects of monitoring and reporting contained in this protocol and must specify how data for all relevant parameters in Table 6.1 (below) will be collected and recorded.

At a minimum the Monitoring Plan shall stipulate the frequency of data acquisition; a record keeping plan (see Section 7.2 for minimum record keeping requirements); and the role of individuals performing each specific monitoring activity. The Monitoring Plan should include QA/QC provisions to ensure that data acquisition and ODS analyses are carried out consistently and with precision.

Project developers are responsible for monitoring the performance of the project and ensuring that there is no double-counting of ODS credits. To achieve this, the Monitoring Plan must also include a description of how data will be provided to the Reserve ODS tracking system (Section 6.1).

Finally, the Monitoring Plan must include procedures that the project developer will follow to ascertain and demonstrate that the project at all times passes the Legal Requirement Test (Section 3.4.1).

6.1 Reserve ODS Tracking System

For the purposes of ensuring the integrity of ODS destruction projects, the Reserve maintains a streamlined database of all destruction activities for which CRTs are registered and issued. Entries into this system must be made by the project developer prior to the beginning of verification activities to confirm that reductions have not been claimed elsewhere for the destruction activity in question.

All projects are required to have one or more Certificate(s) of Destruction accounting for all eligible ODS destroyed as part of that project. The following information shall be entered from the Certificate(s) of Destruction issued by the destruction facility, and a copy of the certificate(s) must be provided to the project verifier:

- Project developer
- Generator EPA ID Number
- Container ID Numbers
- Hazardous Waste Manifest Numbers or Non-RCRA Destruction ID Numbers
- Start destruction date
- Ending destruction date

6.2 Point of Origin Documentation Requirements

Project developers are responsible for collecting data on the point of origin of each quantity of ODS, as defined in Table 6.1. The project developer must maintain detailed acquisition records of all quantities consolidated into the total quantity destroyed under the project.

Table 6.1. Identification of Point of Origin

ODS	Defined Point of Origin
1. Refrigerant ODS stockpiled for greater than 24 months	Location of stockpile
2. Refrigerant ODS quantities less than 500 lbs	Location where ODS is first aggregated with other ODS to greater than 500 lbs ^b
3. Refrigerant ODS quantities greater than 500 lbs	Site of installation where ODS is removed
4. ODS extracted from foam	Facility where ODS blowing agent is extracted
5. Intact foam destroyed	Facility where foam is separated from panels

^b The point of origin for ODS collected by service technicians in quantities less than 500 pounds is defined as the holding facility at which several small quantities were combined and exceeded 500 pounds in aggregate. That is, those handling quantities less than 500 pounds need not provide documentation. However, once smaller quantities are aggregated and exceed 500 pounds collectively, tracking will be required from that point in time forward.

All data must be generated *at the time of collection* from the point of origin. Documentation of the point of origin of ODS shall include the following:

- Facility name
- Point of origin zip code
- Identification of the system by serial number, if available, or description, location, and function, if serial number is unavailable (for quantities greater than 500 pounds)
- Serial Number of containers used for storage and transport

6.3 Custody and Ownership Documentation Requirements

In addition to establishing the point of origin for each quantity of ODS, project developers must also document the custody and ownership of ODS starting from the point of origin. These records shall include names, addresses, and contact information of persons/entities sending material for destruction and the quantity of the material (the combined mass of refrigerant and contaminants) sent for destruction. Such records may include Purchase Orders, Purchase Agreements, packing lists, bills of lading, lab test results, transfer container information, receiving inspections, freight bills, transactional payment information, and any other type of information that will support previous ownership of the material and the transfer of that ownership to the project developer. The verifier will review these records and will perform other tests necessary to authenticate the previous owner of the material, the physical transfer of the product, and the title transfer of ownership to the project developer.

6.4 Foam Collection and Management Requirements

Foam from appliances and equipment included in the project shall be collected and the following information recorded:

- Number of appliances processed, differentiated by blowing agent
- Facility at which appliance de-manufacture occurs
- Facility at which ODS blowing agent is extracted (if applicable)
- Year of appliance manufacture (if the foam is destroyed intact)

Foam from building insulation included in the project shall be collected and the following information recorded:

- Building address
- Date of construction

- Blowing agent used
- Building dimensions

The foam blowing agent shall be collected and destroyed to ensure a 90% recovery and destruction efficiency (RDE). This requirement is consistent with the TEAP Report of the Task Force on Foam End-of-Life Issues.²⁸ RDE describes the proportion of blowing agent (ODS) remaining in the product before decommissioning that is recovered in the overall end-of-life management step, including ultimate destruction.

90% recovery and destruction efficiency shall be demonstrated through a standard of performance that must be followed by all project developers. All foam must be recovered in a manner that meets the following criteria:

1. **ODS blowing agent extracted from foam, and only ODS blowing agent destroyed.**
 - a. The ODS blowing agent must be extracted from the foam to a liquid form prior to destruction.
 - b. ODS blowing agent shall be extracted under negative pressure in a vacuum to ensure that fugitive release of ODS cannot occur.
 - c. The recovered ODS shall be collected, stored, and transported in cylinders or other hermetically sealed containers.
2. **Intact foam containing ODS blowing agent separated from panels and destroyed intact.**
 - a. Appliance carcass shall be cut no more than 6 times (for appliances only)
 - b. Separation of foam from panels must be done by trained personnel, and in a manner demonstrated to minimize foam tearing
 - c. 90% of separated foam must be in pieces greater than 100 cubic inches
 - d. Separated foam shall be categorized and stored according to ODS species and year of manufacture
 - e. Separated foam shall be transferred to hermetically sealed containers within 15 minutes of separation
 - f. Foam shall be stored, transported, and destroyed while sealed inside hermetically sealed containers to ensure no release of blowing agent
 - g. No foam shall be shredded prior to destruction

These practices shall be documented in operating and training materials, and must be demonstrated on-site during verification activities (see Section 8.5).

6.5 ODS Composition and Quantity Analysis Requirements

6.5.1 Refrigerants and ODS extracted from foam

Prior to destruction, the precise mass and composition of ODS to be destroyed must be determined. The following analysis must be conducted:

Mass shall be determined by individually measuring each container of ODS when it is full before destruction and after it has been emptied and the contents have been fully purged and destroyed. The following requirements must be met:

²⁸ United Nations Environment Programme, Technology and Economic Assessment Panel. (2005). *Report of the Task Force on Foam End-of-Life Issues*

1. A single scale must be used for generating both the full and empty weight tickets
2. The scale used must be properly calibrated per the facility's RCRA permit, or calibrated at least quarterly for non-RCRA facilities
3. The full weight must be measured no more than 48 hours prior to commencement of the destruction process
4. The empty weight must be measured no more than 48 hours after the conclusion of the destruction process

Composition and concentration of ODS shall be established for each individual container by taking a sample from each container of ODS and having it analyzed for composition and concentration at an Air-Conditioning, Heating and Refrigeration Institute (AHRI) certified laboratory using the AHRI 700-2006²⁹ standard, or its successor.

1. A sample must be taken while ODS is in the possession of the final destruction facility
2. Sample must be taken by a technician unaffiliated with the project developer³⁰
3. Samples shall be taken with a clean, vacuum sealed stainless steel double ended bottle with minimum capacity of one pound and pressure of 600 PSI
4. Each sample must be taken in liquid state
5. A minimum sample size of one pound must be drawn for each sample
6. Each sample must be individually labeled and tracked according to the container from which it was taken, and record:
 - i. Time and date of sample
 - ii. Name of project developer
 - iii. Name of person pulling sample
 - iv. Employer of person pulling sample
 - v. Volume of container from which sample was extracted
 - vi. Ambient air temperature at time of sampling
7. Chain of custody for each sample shall be documented by a bill of lading

All project samples shall be analyzed using ARI 700-2006 or its successor to confirm the mass % and identity of each component of the sample. The analysis shall provide:

1. Identification of the refrigerant
2. Purity (%) of the ODS mixture by weight using gas chromatography
3. Moisture level in parts per million. The moisture content of each sample must be less than 90% of the saturation point for the ODS taking into account the temperature recorded at the time the sample was taken at the destruction facility.
4. High boiling residue, which must be less than 10% by mass
5. Other refrigerants in the case of mixtures of ODS and their percentage by mass

If the container holds non-mixed ODS (defined as greater than 99% composition of a single ODS species) no further information or sampling is required to determine the mass and composition of the ODS.

If the container holds mixed ODS, which is defined as less than 99% composition of a single ODS species, the project developer must meet additional requirements as provided in Section 6.5.2.

²⁹ ARI, Standard 700: 2006 Standard for Specifications for Fluorocarbon Refrigerants (2006).

³⁰ For instances where the project developer is the destruction facility itself, an outside technician must be employed for taking samples.

6.5.2 Analysis of Mixed ODS

In addition to the requirements of Section 6.5.1, mixed ODS must also be processed and measured for composition and concentration according to the requirements of this section. The sampling required under this section may be conducted at the final destruction facility or prior to delivery to the destruction facility. However, the circulation and sampling activities must be conducted by a third-party (i.e. not the project developer) organization, and by individuals who have been properly trained for the functions they perform.

The mass balance of each container shall be determined using the results of the analysis of this section. The results of the composition analysis in Section 6.5.1 shall be used to confirm that the destroyed ODS was in fact the same ODS that is sampled under these requirements.

The ODS mixture must be circulated in a container which meets the following criteria:

1. The container has no interior obstructions
2. The container was in a vacuum state prior to filling
3. The container has valves at both ends
4. The container must have a sampling port both at the bottom and top.
5. The container and associated equipment can circulate the mixture via a closed loop system both from the bottom to top and end to end.

If the original mixed ODS container does not meet these requirements, the mixed ODS must be transferred into a temporary holding tank or container which meets all of the above criteria. The weight of the contents placed into the temporary container shall be recorded.

Once the mixed ODS is in a container or temporary storage unit which meets the criteria above, circulation of mixed ODS must be conducted as follows:

1. Liquid mixture shall be circulated from the bottom port to the vapor top port.
2. The mixture shall be circulated from the port on one end of the container to the port on the opposite end.
3. Simultaneously, a mass of the mixture equal to two times the mass in the container shall be circulated both vertically and horizontally.
4. Mixing shall occur over a period greater than two hours, but no more than eight hours.
5. Start and end times shall be recorded

Within 30 minutes of the completion of circulation, a minimum of two samples shall be taken from the bottom liquid port according to the procedures in Section 6.5.1. Both samples shall be analyzed at an AHRI approved laboratory per the requirements of 6.5.1. The mass composition and concentration of the mixed ODS shall be equal to the minimum GWP-weighted concentration of the two samples.

If a temporary holding tank was used, after drawing the sample, the holding tank shall be emptied back into the original container for transport to the destruction location.

6.5.3 Analysis Requirements for ODS Entrained in Foam

Foam may be destroyed intact without extraction of the blowing agent if the following procedures are followed to characterize the mass of foam and type(s) and mass ratio of ODS contained in that foam.

The mass of the foam shall be determined through weight measurements taken at the destruction facility per the requirements of Section 6.5.1.

The composition and mass ratio of the ODS blowing agent(s) present will be determined as follows:

- 2 samples shall be taken from each air and water-tight container
- Each foam sample shall be 2 inches in length and 2 inches in width, no thicker than 0.4 inches (1 cm)
- All samples from a single site shall be placed and sealed in separate waterproof, air-tight containers, at minimum 2 millimeters of thickness for storage and transport
- The duplicate sample shall be held in inventory for verification if necessary
- The analysis of ODS blowing agent content and mass ratio shall be done at an independent laboratory
- The analysis shall be done using the heating method to extract blowing agent from the foam samples, as described in Scheutz et al. (2007):³¹
 - Each sample, no thicker than 1 cm, must be placed in a 1123 mL glass bottle, sealed with Teflon-coated septa and aluminum caps to be measured for blowing agent content
 - To release the blowing agent from the foam, the samples must be incubated in an oven for 48 hours at 140 degrees C
 - When cooled to room temperatures, gas samples must be redrawn from the headspace by gas chromatography
 - The lids must be removed after analysis, and the headspace must be flushed with atmospheric air for approximately 5 minutes using a normal compressor. Afterwards, septa and caps must be replaced and the bottles subjected to a second 48-hr heating step to drive out the remaining blowing agent from the sampled foam.
 - When cooled down to room temperature after the second heating step, gas samples must be redrawn from the headspace and analyzed by gas chromatography
- The mass of ODS blowing agent(s) recovered shall then be compared to the total mass of the initial foam samples prior to extraction to determine the mass ratio of each ODS foam blowing agent present

6.6 Destruction Facility Requirements

Destruction of ODS must occur at a facility that meets all of the guidelines provided by the TEAP Task Force on Destruction Technologies³² (see Appendix C for a summary of destruction facility requirements). This includes any RCRA-permitted hazardous waste combustor, as well as any other facility which meets the requirements of Appendix C.

At the time of destruction, all destruction facilities must have a valid Title V air permit, and any other air or water permits required to destroy ODS. Facilities must document compliance with all monitoring and operational requirements dictated by these permits, including emission limits, calibration schedules, and training. Facilities must further document operation consistent with the TEAP requirements, as defined in this section and Appendix C.

³¹ Scheutz, C.; Fredenslund, A.M.; Tant, M. and Kjeldsen, P.(2007): Release of fluorocarbons from insulation foam in home appliances during shredding. Journal of the Air & Waste Management Association, 57, 1452-1460.

³² <http://www.uneptie.org/ozonaction/topics/disposal.htm>.

Operating parameters during destruction of ODS material shall be monitored and recorded as described in the Code of Good Housekeeping³³ approved by the Montreal Protocol. This data may be used in the verification process to demonstrate that during the destruction process, the destruction unit was operating similarly to the period in which the DRE^{34,35} was calculated. The DRE is determined by using the Comprehensive Performance Test (CPT)³⁶ as a proxy for DRE and is disclosed to the public in the destruction facility's Title V operating permit.

To monitor that the destruction facility operates in accordance with applicable regulations and within the parameters recorded during DRE testing, the following parameters must be tracked continuously during the entire ODS destruction process:

- The ODS feed rate
- The amount and type of consumables used in the process
- The amount of electricity and amount and type of fuel consumed by the destruction unit
- Operating temperature and pressure of the destruction unit
- Effluent discharges measured in terms of water and pH levels
- Other continuous emissions monitoring system (CEMS) data on the operation of the destruction unit, including temperature, pressure, and emissions of criteria pollutants

The project developer must keep records of all these parameters for the verification process.

Project developers shall provide valid Certificate(s) of Destruction for all ODS destroyed as part of the project. The Certificate of Destruction shall include:

- Serial, tracking, or ID Number of all containers for which ODS destruction occurred
- Owner of destroyed ODS
- Weight and type of material destroyed from each container
- Date/time when destruction commenced
- Date/time when destruction concluded

6.7 Monitoring Parameters

Prescribed monitoring parameters necessary to calculate baseline and project emissions are provided in Table 6.2 below. In addition to the parameters below that are used in the calculations provided in Section 5, project developers are responsible for maintaining all records required under Section 0.

³³ TEAP, Code of Good Housekeeping in *Handbook for the Montreal Protocol on Substances that Deplete the Ozone Layer - 7th Edition* (2006).

³⁴ DRE disclosed in Title V operating permit.

³⁵ Title V permit is publicly available.

³⁶ CPT must have been conducted with a less combustible chemical than the ODS in question.

Table 6.2. ODS Project Monitoring Parameters

Eq. #	Parameter	Description	Data Unit	Measurement Frequency	Calculated (c) Measured (m) Reference (r) Operating records (o)	Comment
		Legal Requirement Test	N/A	For each project		Must be monitored and determined for each project.
		Mass of ODS (or ODS mixture) in each container	mass of mixture	Per container	M	Must be determined for each container
		Concentration of ODS (or ODS mixture) in each container	mass ODS/ mass of mixture	Per container	M	Must be determined for each container
Equation 5.1	ER	Total quantity of emission reductions	tCO ₂ e	For each project	C	
Equation 5.1, Equation 5.2	BE	Total quantity of baseline emissions	tCO ₂ e	For each project	C	
Equation 5.1, Equation 5.5	PE	Total quantity of project emissions	tCO ₂ e	For each project	C	
Equation 5.2, Equation 5.3	BE _{refr}	Total quantity of refrigerant baseline emissions	tCO ₂ e	For each project	C	
Equation 5.3, Equation 5.6	Q _{refr,i}	Total quantity of refrigerant ODS <i>i</i> destroyed	tODS	Annual	M	
Equation 5.3	ER _{refr,i}	Annual emission rate of refrigerant ODS <i>i</i>	0 -1.0	N/A	R	see Table 5.1
Equation 5.3	GWP _{refr,i}	Global warming potential of refrigerant ODS <i>i</i>	tCO ₂ e/ tODS	N/A	R	see Table 5.1
Equation 5.2, Equation 5.4	BE _{foam}	Total quantity of foam blowing ODS baseline emissions	tCO ₂ e	For each project	C	
Equation 5.4	Q _{foam,i}	Total quantity of foam blowing ODS <i>i</i> destroyed	tODS	For each project	M	
Equation 5.4	BE _{treat}	ODS emissions from the pre-landfill treatment of foam, from shredding and compaction of foam in the baseline	% (0-1.0)	N/A	R	See Table 5.2
Equation 5.4	BE _{landfill}	Emissions of ODS not degraded in landfill	% (0-1.0)	N/A	R	See Table 5.2
Equation 5.4	Shred _{foamil}	Percent of foam blowing ODS <i>i</i> released by shredding in the baseline (Table 5.2)	% (0-1.0)	N/A	R	See Table 5.2

Eq. #	Parameter	Description	Data Unit	Measurement Frequency	Calculated (c) Measured (m) Reference (r) Operating records (o)	Comment
Equation 5.4	Compact _{foam,i}	Percent of foam blowing agent ODS <i>i</i> released during compaction in the baseline	% (0-1.0)	N/A	R	See Table 5.2
Equation 5.4	LF _{foam,i}	Percent of foam blowing ODS <i>i</i> degraded in landfill in the baseline	0 -1.0	N/A	R	see Table 5.2
Equation 5.4	LF _{release,i}	Percent of remaining foam blowing agent <i>i</i> released into anaerobic landfill conditions	0 -1.0	N/A	R	see Table 5.2
Equation 5.4	GWP _{foam,i}	Global warming potential of foam blowing agent ODS <i>i</i>	tCO ₂ e/ tODS	N/A	R	see Table 5.1
Equation 5.5, Equation 5.6	Sub _{refr}	Total emissions from substitute refrigerant	tCO ₂ e	For each project	C	
Equation 5.5, Equation 5.7	Foam	Total emissions from separation of foam	tCO ₂ e	For each project	C	
Equation 5.5, Equation 5.14	Tr	Total emissions from transportation of ODS	tCO ₂ e	For each project	C	
Equation 5.5, Equation 5.9	Dest	Total emissions from the destruction process associated with destruction of ODS	tCO ₂ e	For each project	C	
Equation 5.6	SE _i	Emission factor for substitute emissions of refrigerant <i>i</i> , per	tCO ₂ e/ tODS destroyed	Per container	R	See Table 5.3 (see Appendix Appendix D for summary of the development of SE)
Equation 5.8	Tr+De _{def}	Total emissions from ODS transportation and destruction	tCO ₂ e	For each project	C	Calculated using default emission factors
Equation 5.8, Equation 5.12, Equation 5.13	Q _{ODS,i}	Total quantity of ODS <i>i</i> destroyed in the project	tODS	For each project	M	
Equation 5.8	EF _i	Default emission factor for transportation and destruction of ODS <i>i</i>	tCO ₂ e/ tODS	For each project	R	Equal to 7.5 for refrigerant projects, and 75 for foam projects)
Equation 5.9, Equation 5.10	FF _{dest}	Total emissions from fossil fuel used in the destruction facility	tCO ₂ e	For each project	C	
Equation 5.9, Equation 5.11	EL _{dest}	Total emissions from grid electricity at the destruction facility	tCO ₂ e	For each project	C	
Equation 5.10	FF _{PR,i}	Total fossil fuel <i>i</i> used to destroy ODS	tCO ₂ e	For each project	M	

Eq. #	Parameter	Description	Data Unit	Measurement Frequency	Calculated (c) Measured (m) Reference (r) Operating records (o)	Comment
Equation 5.10	$EF_{FF,i}$	Fuel specific emission factor	kgCO ₂ /volume fuel	N/A	R	
Equation 5.11	EL_{PR}	Total electricity consumed to destroy ODS	MWh	For each project	M	
Equation 5.11	EF_{EL}	Carbon emission factor for electricity used	lb CO ₂ /MWh	N/A	R	
Equation 5.12	$ODS_{emissions}$	Total emissions of un-destroyed ODS	tCO ₂ e	For each project	C	
Equation 5.12	GWP_i	Global warming potential of ODS <i>i</i>	tCO ₂ e/ tODS	N/A	R	
Equation 5.13	ODS_{CO2}	Total emissions of CO ₂ from ODS oxidation	tCO ₂	For each project	C	
Equation 5.13	CR_i	Carbon ratio of ODS <i>i</i>	mole C/ mole ODS	N/A	R	
Equation 5.14	TMT_i	Tonne-miles-traveled for ODS <i>i</i> destroyed	tonne-miles	For each project	M	
Equation 5.14	EF_{TMT}	Mode-specific emission factor	kgCO ₂ /tonne-mile	N/A	R	

7 Reporting Parameters

This section provides requirements and guidance on reporting rules and procedures. A priority of the Reserve is to facilitate consistent and transparent information disclosure by project developers. Project developers must submit verified emission reduction reports to the Reserve at the conclusion of every project.

7.1 Project Documentation

Project developers must provide the following documentation to the Reserve in order to register an ODS destruction project.

- Project Submittal form
- Signed Attestation of Title form
- Verification Report (for each verification)
- Verification Opinion (for each verification)
- Signed Regulatory Attestation form (for each verification)

At a minimum, the above project documentation will be available to the public via the Reserve's online registry. Further disclosure and other documentation may be made available by the project developer on a voluntary basis. Project submittal forms can be found at <http://www.climateactionreserve.org/how/projects/register/project-submittal-forms/>.

7.2 Record Keeping

For purposes of independent verification and historical documentation, project developers are required to keep all information outlined in this protocol for a period of 10 years after verification. This information will not be publicly available, but may be requested by the verifier or the Reserve.

System information the project developer should retain includes:

- All data inputs for the calculation of the project emission reductions, including all required sampled data
- Copies of all permits, Notices of Violations (NOVs), and any administrative or legal consent orders dating back at least 3 years prior to the project start date
- Copies of all import documentation from U.S. Customs
- Project developer attestation of compliance with regulatory requirements relating to the ODS project activity
- Executed Regulatory Attestation relating to the ODS project
- Destruction facility monitor information (CEMS data, DRE documentation, scale readings, calibration procedures, and permits)
- Verification records and results
- Chain of custody documentation
- ODS composition and quantity lab reports

7.3 Reporting Period & Verification Cycle

ODS projects may be no greater than 12 months in duration, measured from commencement (as defined by the project start date) to completion of ODS destruction. As stated in Section 2.2, project developers may choose a shorter time horizon for their project (i.e. 3 months or 6 months), but no project may run longer than a 12 months. At the project developer's discretion,

a project reporting period may be either the entire duration of the project, or a contiguous reporting period shorter than the twelve months, but must include all project Certificates of Destruction from the selected reporting period. As such, the project may have a single reporting period, or as many shorter reporting periods as there are Certificates of Destruction. Project verification must commence no more than six months after the end of the reporting period.

8 Verification Guidance

This section provides verification bodies with guidance on verifying GHG emission reductions from ODS destruction projects developed to the standards of this protocol. This verification guidance supplements the Reserve's Verification Program Manual and describes verification activities in the context of ODS destruction projects.

Verification bodies trained to verify ODS projects must conduct verifications to the standards of the following documents:

- Climate Action Reserve Program Manual
- Climate Action Reserve Verification Program Manual
- Climate Action Reserve U.S. ODS Project Protocol

The Reserve's Program Manual, Verification Program Manual, and project protocols are designed to be compatible with each other and are available on the Reserve's website at <http://www.climateactionreserve.org>.

In cases where the Program Manual and/or Verification Program Manual differ from the guidance in this protocol, this protocol takes precedent.

Only ISO-accredited verification bodies trained by the Reserve for this project type are eligible to verify ODS destruction project reports. Verification bodies approved under other project protocol types are not permitted to verify ODS destruction projects. Information about verification body accreditation and Reserve project verification training can be found in the Verification Program Manual.

8.1 Standard of Verification

The Reserve's standard of verification for ODS destruction projects is the U.S. Ozone Depleting Substances Project Protocol (this document), the Reserve Program Manual, and the Verification Program Manual. To verify an ODS destruction project report submitted by a project developer, verification bodies must apply the guidance in the Verification Program Manual and this section of the protocol to the standards described in Section 2 through 7 of this protocol. Sections 2 through 7 provide eligibility rules, methods to calculate emission reductions, performance monitoring instructions and requirements, and procedures for reporting project information to the Reserve.

8.2 Monitoring Plan

The Monitoring Plan serves as the basis for verification bodies to confirm that the monitoring and reporting requirements in Section 6 and Section 7 have been met, and that consistent, rigorous monitoring and record-keeping has been conducted. Verification bodies shall confirm that the Monitoring Plan covers all aspects of monitoring and reporting contained in this protocol and specifies how data for all relevant parameters in Table 6.2 are collected and recorded.

8.3 Verifying Project Eligibility

Verification bodies must affirm an ODS destruction project's eligibility according to the rules described in this protocol. The table below outlines the eligibility criteria for an ODS destruction project. This table does not represent all criteria for determining eligibility comprehensively; verification bodies must also look to Section 2 and the verification items list in Table 8.3.

Table 8.1. Summary of Eligibility Criteria

Eligibility Rule	Eligibility Criteria	Verification Frequency
Start Date	For 12 months following the Effective Date of this protocol, a pre-existing project with a start date on or after February 3, 2008 may be submitted for listing; after this 12 month period, projects must be submitted for listing within 6 months of the project start date	Once per project
Location of Destruction	United States and its territories	Once per project
Point of Origin of ODS	United States and its territories	Each verification
Project Definition	<ul style="list-style-type: none"> ▪ Project developer and GHG ownership is the same for all ODS destroyed ▪ A single destruction facility has been used for all ODS destruction ▪ All destruction spans no more than 12 months from the commencement of destruction activities (start date) to the conclusion of destruction activities ▪ Eligible refrigerant sources include CFC-11, CFC-12, CFC-114, CFC-115 ▪ Eligible foam sources include CFC-11, CFC-12, HCFC-141b 	Each verification
Performance Standard	Project destroys refrigerant or foam blowing agent ODS which meet project definitions	Each verification
Legal Requirement Test	Signed Regulatory Attestation form and monitoring procedures that lay out procedures for ascertaining and demonstrating that the project passes the Legal Requirement Test	Each verification
Regulatory Compliance Test	Project must be in material compliance with all applicable laws	Each verification
Exclusions	<ul style="list-style-type: none"> ▪ ODS sourced from outside of the U.S. ▪ ODS destroyed outside of the U.S. 	Each verification

8.4 Core Verification Activities

The Ozone Depleting Substances Project Protocol provides explicit requirements and guidance for quantifying GHG reductions associated with the destruction of ODS. The Verification Program Manual describes the core verification activities that shall be performed by verification bodies for all project verifications. They are summarized below in the context of an ODS destruction project, but verification bodies shall also follow the general guidance in the Verification Program Manual.

Verification is a risk assessment and data sampling effort designed to ensure that the risk of reporting error is assessed and addressed through appropriate sampling, testing, and review. The three core verification activities are:

1. Identifying emissions sources, sinks and reservoirs
2. Reviewing GHG management systems and estimation methodologies
3. Verifying emission reductions and estimates

Identifying emission sources, sinks, and reservoirs

The verification body reviews for completeness the sources, sinks, and reservoirs identified for a project, such as the ODS baseline emissions, substitute emissions, emissions from transportation, and emissions from the destruction of ODS.

Reviewing GHG management systems and estimation methodologies

The verification body reviews and assesses the appropriateness of the methodologies and management systems that the ODS project developer uses to gather data on ODS collected and destroyed and to calculate baseline and project emissions.

Verifying emission reduction estimates

The verification body further investigates areas that have the greatest potential for material misstatements and then confirms whether or not material misstatements have occurred. This involves site visits to the project to ensure the ODS management, sampling and destruction systems on the ground correspond to and are consistent with data provided to the verification body. In addition, the verification body recalculates a representative sample of the ODS destruction or emissions data for comparison with data reported by the project developer in order to double-check the calculations of GHG emission reductions.

8.5 Verification Site Visit

Project verifiers shall conduct one or more site visits for each project to assess management systems, QA/QC procedures, personnel training, and conformance with the requirements of this protocol. Each of the facilities identified in Table 8.2 shall be visited at least once per project by the project verifier.

Table 8.2. Verification Site Visit Requirements

Project	Site Visit(s) Required
Refrigerant collection and destruction: pure ODS	<ul style="list-style-type: none"> ▪ Destruction Facility
Refrigerant collection and destruction: mixed ODS	<ul style="list-style-type: none"> ▪ Destruction Facility ▪ Mixed ODS sampling facility
Foam collection, blowing agent extraction, and destruction	<ul style="list-style-type: none"> ▪ Facility at which blowing agent is extracted ▪ Destruction facility
Foam collection, separation, and destruction of intact foam	<ul style="list-style-type: none"> ▪ Facility at which foam is separated from panels ▪ Destruction facility

In addition to the site visits specified above, verifiers may visit any additional sites deemed necessary to verify the project in the context of the project specific risk assessment.

8.6 ODS Verification Items

The following tables provide lists of items that a verification body needs to address while verifying an ODS destruction project. The tables include references to the section in the protocol where requirements are further described. The table also identifies items for which a verification

body is expected to apply professional judgment during the verification process. Verification bodies are expected to use their professional judgment to confirm that protocol requirements have been met in instances where the protocol does not provide (sufficiently) prescriptive guidance. For more information on the Reserve's verification process and professional judgment, please see the Verification Program Manual.

Note: These tables shall not be viewed as a comprehensive list or plan for verification activities, but rather guidance on areas specific to ODS destruction projects that must be addressed during verification.

8.6.1 Project Eligibility and CRT Issuance

Table 8.3 lists the criteria for reasonable assurance with respect to eligibility and CRT issuance for ODS destruction projects. These requirements determine if a project is eligible to register with the Reserve and/or have CRTs issued for the ODS destroyed. If any one requirement is not met, either the project may be determined ineligible or the GHG reductions from the ODS destroyed (or sub-set of the ODS destroyed) may be ineligible for issuance of CRTs.

Table 8.3. Project Eligibility Verification Items

Protocol Section	Eligibility Qualification Item	Apply Professional Judgment?
2.4	Verify that credits for destroyed ODS have not been claimed on the Reserve or any other registry, using Attestation of Title and Reserve tracking software	No
2.2	Verify that the project meets the definition of a U.S. ODS project	No
2.2	Verify that the destroyed ODS is sourced from the U.S.	Yes
2.2	Verify that the destroyed ODS has been phased out in the U.S.	No
2.4	Verify ownership of the reductions by reviewing Attestation of Title	No
2.2	Verify that the project activities involve a single project developer and a single qualifying destruction facility	No
Appendix C	Verify that the destruction facility meets the requirements of this protocol	Yes
3.2	Verify eligibility of project start date	No
3.2	Verify project start date based on records	Yes
2.2	Verify that project activities span no more than 12 months	No
3.4.1	Confirm execution of the Regulatory Attestation form to demonstrate eligibility under the Legal Requirement Test	No
6	Verify that the project Monitoring Plan contains procedures for ascertaining and demonstrating that the project passes the Legal Requirement Test at all times	Yes
3.4.2	Verify that the project meets the Performance Standard Test	No
3.5	Verify that the project activities comply with applicable laws by reviewing any instances of non-compliance provided by the project developer and performing a risk-based assessment to confirm the statements made by the project developer in the Regulatory Attestation form	Yes
6	Verify that monitoring meets the requirements of the protocol; if it does not, verify that a variance has been approved for monitoring variations	Yes
	If any variances were granted, verify that variance requirements were met and properly applied	No

8.6.2 Conformance with Operational Requirements and ODS Eligibility

Table 8.4 lists the verification items to determine the project's conformance with the operational and monitoring requirements of this protocol, and the eligibility of discreet ODS sources. A

subset of destroyed ODS may be deemed ineligible if it was obtained in a manner inconsistent with this protocol, or if documentation is insufficient. If any of Table 8.4 is not met, no CRTs may be issued for that quantity of ODS.

Table 8.4. Operational Requirement and ODS Eligibility Verification Items

Protocol Section	Eligibility Qualification Item	Apply Professional Judgment?
6.1	For all ODS, verify that information has been correctly entered in Reserve tracking system, and that the entry is unique to this project	No
6.2	For all ODS, verify that the point of origin is correctly identified and documented	Yes
6.3	For all ODS, verify that the ODS can be tracked through retained chain of custody documentation from the Certificate of Destruction back to the point of origin	Yes
6.4	For foam ODS, verify that required data has been collected, per Section 6.4	
6.4	For foam ODS, verify that a 90% RDE has been achieved	Yes
6.5	Verify that the scales used for measuring mass of ODS destroyed are properly maintained per EPA permit requirements, or calibrated quarterly	No
6.5	Verify that the weight of full and empty ODS containers was measured 48 hours prior to destruction commencing, and 48 following completion, respectively	No
6.5	Verify that all ODS samples were taken by a third-party at the destruction facility	No
6.5	Verify the chain of custody by which ODS sample was transferred from the destruction facility to the lab	No
6.5	Verify that all ODS was analyzed for composition and concentration at a lab approved under the ARI-700-2006 standard, or its successor	No
6.5	Verify that the calculation of ODS composition and mass concentration correctly accounted for moisture, mixing, and high boiling residue	No
6.5	For mixed refrigerants, verify that credits are only claimed for refrigerants eligible under this protocol	No
6.5.2	For mixed refrigerants, verify that proper re-circulation occurred	Yes
6.5.2	For mixed refrigerants, verify that recirculation and sampling were performed by trained technicians	Yes
6.5.3	Verify that for destruction of ODS entrained in foam, the correct procedures have been followed for determining the type and mass ratio of ODS in the foam	No
6.5.3	If the ODS was destroyed at a RCRA approved hazardous waste combustor, verify that all permits are current	No
6.6, Appendix C	If the facility is not a RCRA approved HWC, verify that it has been third-party certified as meeting the requirements of the TEAP <i>Report on the Task Force on HCFC Issues</i> and Appendix C of this protocol	Yes
6.6, Appendix C	Verify that the destruction facility in which ODS was destroyed has a documented destruction and removal efficiency greater than 99.99%, and that CPT was conducted with a material less combustible than the ODS destroyed	No
6.6, Appendix C	Verify that the destruction facility operated within the parameters under which it was tested to achieve a 99.99% or greater destruction and removal efficiency	Yes
6.6	Verify that the destruction facility monitored the parameters identified in Section 6.6	No
6.6	Verify that the Certificate of Destruction identifies all ODS for which	No

Protocol Section	Eligibility Qualification Item	Apply Professional Judgment?
	credits are being claimed	

8.6.3 Quantification of GHG Emission Reductions

Table 8.5 lists the items that verification bodies shall include in their risk assessment and recalculation of the project's GHG emission reductions. These quantification items inform any determination as to whether there are material and/or immaterial misstatements in the project's GHG emission reduction calculations. If there are material misstatements, the calculations must be revised before CRTs are issued.

Table 8.5. Quantification Verification Items

Protocol Section	Quantification Item	Apply Professional Judgment?
4	Verify that SSRs included in the GHG Assessment Boundary correspond to those required by the protocol and those represented in the project documentation	No
6.6	Verify that all destroyed ODS for which CRTs are claimed appears on a Certificate of Destruction	No
2.3	Verify that the project was correctly characterized as a foam or refrigerant project	Yes
5.1	Verify that the appropriate baseline scenario was applied for each quantity of ODS destroyed	No
5.1	Verify that the baseline emissions were calculated with the appropriate emission rate(s) and aggregated correctly	No
5.2.1	Verify that the substitute emissions have been properly characterized, calculated, and aggregated correctly	No
5.2.3, 5.2.4	Verify that the project developer correctly quantified and aggregated electricity use, or that the default factor was applied	Yes
5.2.3, 5.2.4	Verify that the project developer correctly quantified and aggregated fossil fuel use, or that the default factor was applied	Yes
5.2.3, 5.2.4	Verify that the project developer applied the correct emission factors for fossil fuel combustion and grid-delivered electricity, or that the default factor was applied	Yes
5.2.3, 5.2.5	Verify that the project developer correctly quantified and aggregated transportation emissions, or that the default factor was applied	Yes
5.2.2	Verify that the project developer applied the correct default emission factor for foam separation	No
5.2.3, 5.2.4	Verify that emissions from incomplete ODS destruction and oxidation of ODS carbon have been correctly quantified and aggregated, or that the default factor was applied.	Yes

8.6.4 Risk Assessment

Verification bodies will review the following items in Table 8.4 to guide and prioritize their assessment of data used in determining eligibility and quantifying GHG emission reductions.

Table 8.6. Risk Assessment Verification Items

Protocol Section	Item that Informs Risk Assessment	Apply Professional Judgment?
6	Verify that the project monitoring plan is sufficiently rigorous to support the requirements of the protocol and proper operation of the project	Yes
6	Verify that appropriate monitoring equipment is in place to meet the requirements of the protocol	No
6	Verify that the individual or team responsible for managing and reporting project activities are qualified to perform this function	Yes
6.4	Verify that the foam appliance and equipment data has been collected and managed correctly	Yes
6	Verify that appropriate training was provided to personnel assigned to record-keeping, sample-taking, and other project activities	Yes
6	Verify that all contractors are qualified for managing and reporting greenhouse gas emissions if relied upon by the project developer and that there is internal oversight to assure the quality of the contractor's work	Yes
7	Verify that all required records have been retained by the project developer	No

8.7 Completing Verification

The Verification Program Manual provides detailed information and instructions for verification bodies to finalize the verification process. It describes completing a Verification Report, preparing a Verification Opinion, submitting the necessary documents to the Reserve, and notifying the Reserve of the project's verified status.

9 Glossary of Terms

Batch	A specific quantity of a single ODS species collected from a single point of origin (i.e. the refrigerant removed from a single supermarket's chiller).
Certificate of Destruction	An official document provided by the destruction facility certifying the date, quantity, and type of ODS destroyed.
Commencement of destruction process	When the ODS waste-stream is hooked up to the destruction chamber.
Commercial refrigeration equipment	The refrigeration appliances used in the retail food, cold storage warehouse, or any other sector that require cold storage. Retail food includes the refrigeration equipment found in supermarkets, grocery and convenience stores, restaurants, and other food service establishments. Cold storage includes the refrigeration equipment used to house perishable goods or any manufactured product requiring refrigerated storage.
Destruction	Destruction of ozone depleting substances by qualified destruction or conversion plants achieving greater than 99.99% destruction and removal efficiency, in order to avoid their emissions. ³⁷
Destruction facility	A facility that destroys or converts ozone depleting substances using one of the technologies defined by the UN Environment Programme Technology and Economic Assessment Panel Task Force on Destruction Technologies. ³⁸
Emissions rate	The annual rate at which ODS is lost to the atmosphere, including emissions from leaks during operation and servicing events.
ODS technician	Any person who performs maintenance, service, or repair that could reasonably be expected to release class I (e.g. CFCs) or class II (HCFCs) ozone depleting substances from appliances into the atmosphere, including but not limited to installers, contractor employees, in-house service personnel, and in some cases, owners. Technician also means any person disposing of appliances except for small appliances.
Ozone Depleting Substances (ODS)	Ozone depleting substances are substances known to deplete the stratospheric ozone layer. The ODS controlled under the Montreal Protocol and its Amendments are chlorofluorocarbons (CFCs), hydrochlorofluorocarbons (HCFCs), halons, methyl bromide (CH ₃ Br), carbon tetrachloride (CCl ₄), methyl chloroform (CH ₃ CCl ₃), hydrobromofluorocarbons (HBFCs) and bromochloromethane (CHBrCl). ³⁹

³⁷ http://www.mnp.nl/ipcc/pages_media/SROC-final/SROC_A2.pdf

³⁸ Report of the Fifteenth Meeting of the Parties to the Montreal Protocol on Substances that Deplete the Ozone Layer. United Nations Environment Programme. OzL.Pro.15/9. Nairobi, November 11, 2003.

³⁹ Source IPCC - http://www.mnp.nl/ipcc/pages_media/SROC-final/SROC_A2.pdf

Separation loss rate	The percent of original foam blowing agent which is released during the entire process of deconstruction (for buildings), de-manufacture (for appliances) and transport to destruction facility.
Recharge	Replenishment of refrigerant agent (using reclaimed or virgin material) into equipment that is below its full capacity because of leakage or because it has been evacuated for servicing or other maintenance.
Reclaim	Reprocessing and upgrading of a recovered ozone depleting substance through mechanisms such as filtering, drying, distillation and chemical treatment in order to restore the ODS to a specified standard of performance. Chemical analysis is required to determine that appropriate product specifications are met. It often involves processing off-site at a central facility.
Recovery	The removal of ozone depleting substances from machinery, equipment, containment vessels, etc., during servicing or prior to disposal without necessarily testing or processing it in any way.
Retire	The permanent removal from service of the entire appliance rendering it unfit for use by the current or any future owner or operator.
Retrofit	The conversion of a refrigerant in an appliance from a substance with high ozone depletion potential to a substitute with a lower or zero ozone-depleting potential. Retrofit includes a complete conversion of the appliance to achieve systems compatibility with the substitute and may include but is not limited to, changes in lubricants, gaskets, filters, driers, valves, o-rings or appliance components.
Reuse/recycle	Reuse of a recovered ozone depleting substance following a basic cleaning process such as filtering and drying. For refrigerants, recycling normally involves recharge back into equipment and it often occurs 'on-site'.
Substitute emissions	A term used in this methodology to describe the quantity of greenhouse gases emitted from the use of substitutes in technologies that are used to replace the ODS destroyed in a project.
Transportation system	A term used to encompass the entirety of the system that moves the gas from the central collection point of the gas drainage system to point of the ultimate destruction of the gas, possibly off-site.

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Appendix A Summary of Legal Requirement Test Development

Management of ozone depleting substances is dictated in the United States through both the Montreal Protocol, to which the U.S. is a party, and the U.S. Clean Air Act. This appendix provides background information on both of these frameworks. Further, this appendix demonstrates that neither framework requires the destruction of ODS, and destruction therefore meets the Legal Requirement Test under the Climate Action Reserve

A.1. Montreal Protocol

The original Montreal Protocol, signed in 1987, was the first international treaty with binding commitments to protect stratospheric ozone. Since that time, the Montreal Protocol has been repeatedly strengthened by both controlling additional ODS as well as by moving up the date by which previously controlled substances must be phased out. Unlike the Clean Air Act, the Montreal Protocol controls only production and consumption (production plus imports minus exports) and not emissions of ODS. There is no mandatory requirement to destroy ODS in the Montreal Protocol. Therefore, for analyses prepared under the Montreal Protocol, it is assumed that all ODS that are produced will eventually be released to the atmosphere, even though some developed countries have voluntary and/or mandatory requirements to destroy ODS.

Under the original Montreal Protocol agreement (1987), non-Article 5 countries were required to begin phasing out CFCs in 1993 and achieve a 50% reduction relative to 1986 consumption levels by 1998. Under this agreement, CFCs were the only ODS addressed. The London Amendment (1990) changed the ODS emission schedule by requiring the complete phase-out of CFCs, halons, and carbon tetrachloride by 2000 in developed countries, and by 2010 in developing countries. Methyl chloroform was also added to the list of controlled ODS, with phase-out in developed countries targeted in 2005, and in 2015 for developing countries.

The Copenhagen Amendment (1992) significantly accelerated the phase-out of ODS and incorporated an HCFC phase-out for developed countries, beginning in 2004. Under this agreement, CFCs, halons, carbon tetrachloride, methyl chloroform, and HBFCs were targeted for complete phase-out in 1996 in developed countries. In addition, methyl bromide consumption was capped at 1991 levels.

The Montreal Amendment (1997) included the phase-out of HCFCs in developing countries, as well as the phase-out of methyl bromide in developed and developing countries in 2005 and 2015, respectively.

The Beijing Amendment (1999) included tightened controls on the production and trade of HCFCs. Bromochloromethane was also added to the list of controlled substances with phase-out targeted for 2002.

At the 19th Meeting of the Parties in Montreal in September 2007, the Parties agreed to an adjustment that more aggressively phases out HCFCs in both developed and developing countries. Developed countries must reduce HCFC production and consumption by 75% of their baseline by 2010, 99.5% by 2020, and 100% by 2030. The 0.5% during the period 2020-2030 is restricted to the servicing of existing refrigeration and air-conditioning equipment and is subject to review in 2015. Developing countries must freeze production and consumption of HCFCs in 2013 at their baseline and then reduce it by 10% in 2015, 35% by 2020, 67.5% by 2025, 97.5%

by 2030 and 100% by 2040. The 2.5% during the period 2030-2039 is the average over that time frame (e.g. it can be 5% for 5 years and 0% for the other 5 years), is restricted to the servicing of existing refrigeration and air-conditioning equipment, and is subject to review in 2015.

The result of the Montreal Protocol with its amendments and adjustments is that as of January 1, 2010, CFCs, halons, methyl chloroform, carbon tetrachloride, methyl bromide, and bromochloromethane will be phased out of production in both developed and developing countries. Therefore any ongoing uses of these substances must be supplied from already existing stocks that are recycled or reclaimed. However, it should be noted that there are allowances for some ongoing limited production of these substances for certain essential uses and critical uses approved by the Montreal Protocol Parties (e.g. as process agents and for quarantine and pre-shipment uses). Also, production and use of these substances as feedstock is not considered production since they are consumed in the feedstock process.

The Reserve's review of the U.S. commitment under the Montreal Protocol and its amendments indicates that destruction of ODS is not required in the U.S. at this time. Further, review of the Montreal Protocol makes clear that destruction is not required. The scope of the Montreal Protocol is limited to the production end of ODS management, and does not require destruction of extant stocks. As such, in reference to the Montreal Protocol and international law, destruction of U.S. sources of ODS meets the Legal Requirement Test.

A.2. Title VI of the Clean Air Act and 40 CFR 82

In 1988, the United States ratified the Montreal Protocol. By ratifying the Montreal Protocol and its subsequent amendments, the United States committed to a collaborative, international effort to regulate and phase out ODS, including CFCs, HCFCs, halons, carbon tetrachloride, methyl chloroform, methyl bromide, bromochloromethane, and HBFCs.

This international agreement led to the inclusion of Title VI, Stratospheric Ozone Protection in the Clean Air Act Amendments of 1990. Title VI authorizes the EPA to manage the phase-out of ODS. Among the regulations established by EPA are requirements for the safe handling of ODS and prohibitions on the known venting or release of ODS into the atmosphere for the majority of applications, including refrigerants and fire suppressants. Therefore, as ODS are phased out, surplus ODS must be stored, reused (after recycling or reclamation), or destroyed.

EPA regulations issued under Sections 601-607 of the CAA phase out the production and import of ODS, consistent with the schedules developed under the Montreal Protocol. However, in the case of HCFCs, EPA has used a "worst-first" approach to meet the Montreal Protocol required reduction caps. Under this approach, those HCFCs with the highest ozone depletion potential (ODP) are phased out first. As of January 1, 2003, EPA banned production and import of HCFC-141b, the HCFC with the highest ODP. This action allowed the United States to reduce its consumption by 35% below the cap by the January 1, 2004 deadline and meet its obligations under the Montreal Protocol. As such, HCFC-141b is now entirely phased out and therefore eligible per this protocol.

In 2003 EPA issued baseline allowances for production and import of HCFC-22 and HCFC-142b, the two HCFCs with the next highest ODP. The United States plans to meet the rest of the Montreal Protocol phase-out schedule through the following actions:

January 1, 2010	Ban on production and import of HCFC-22 and HCFC-142b except for on-going servicing needs in equipment manufactured before January 1, 2010.*
January 1, 2015	Ban on introduction into interstate commerce or use of HCFCs except where the HCFCs are used as a refrigerant in appliances manufactured prior to January 1, 2020.*
January 1, 2020	Ban on remaining production and import of HCFC-22 and HCFC-142b.*
January 1, 2030	Ban on remaining production and import of all other HCFCs.*

*Certain additional exemptions apply, including exemptions for (1) HCFCs used in processes resulting in their transformation or destruction, or (2) pre-authorized import of HCFCs that are recovered and either recycled or reclaimed.

The Reserve's review of the CAA indicates that destruction of ODS is not required in the U.S. at this time. The CAA dictates a phase-out schedule for the production of ODS, and proffers guidance on handling, disposal, and other requirements, but does not dictate that destruction of ODS occur. As such, in reference to the U.S. CAA and domestic law, destruction of U.S. sources of ODS meets the Legal Requirement Test.

Appendix B Summary of Performance Standard Development

The Reserve assesses the additionality of projects through application of a Performance Standard Test and a Legal Requirement Test. The purpose of a performance standard is to establish a standard of performance applicable to all ODS projects that is significantly better than average ODS management practice, which, if met or exceeded by a project developer, satisfies the criterion of “additionality”.

The sections below describe the analysis that forms the basis of the performance standard for each of the ODS sources within this protocol. The analysis included an examination of current practice related to 1) the destruction of ODS refrigerant and foam blowing agent and 2) the end-of-life treatment of foam.

B.1 Destruction of ODS from Refrigerants and Foam

Appendix A described the regulatory framework surrounding the end-of-life treatment of refrigerant and foam ODS and demonstrated that destruction is not required by law in the U.S. However, the Reserve looks not only at what the regulatory requirements are, but also at the prevailing practices in the industry. Therefore, with the project defined as destruction of ODS refrigerant or foam blowing agent, the question remains: is destruction of ODS refrigerant and foam blowing agent sourced within the U.S. standard practice, or does it exceed standard practice?

For this analysis, the Reserve assessed common practice for CFC refrigerants and foams that have been phased out of U.S. production under the Montreal Protocol and U.S. Clean Air Act. This was done by comparing the proportion of recoverable ODS in the U.S. within a given year to the amount that was destroyed during that same time period to determine to what extent available ODS was being destroyed.

The Reserve’s starting point for this assessment was U.S. EPA data records, including a report produced by ICF International entitled *ODS Destruction in the United States of America and Abroad* (2009). In addition to providing information on ODS destruction techniques and practices, the report supplies the specific quantity of ODS destroyed for the years 2003 and 2004 in the U.S.

The years 2003 and 2004 are particularly useful as they represent common practice before the initiation of carbon offset projects in the U.S. Subsequent to 2004, several ODS destruction projects were conducted for carbon credits on the Chicago Climate Exchange (CCX), and in possible anticipation of other offset programs. As such, destruction numbers from this post-2004 time period may artificially inflate the amount of ODS that is destroyed due to standard industry practice. The goal of this analysis is to determine what happened *in the absence* of a carbon incentive. Therefore, the 2003-2004 data represents a balance of current data on common practice *after* the CAA phase-out of ODS went into effect but *prior* to the availability of a carbon incentive.

Table B.1. Destruction of ODS in the U.S.

CFC	2003 Destroyed (kg)	2004 Destroyed (kg)
CFC-11	58,846	109,884
CFC-12	23,709	62,364
CFC-114	464	4,044
CFC-115	4,401	6,737

Source: Reproduced from ICF, ODS Destruction in the United States of America and Abroad (2009), prepared for U.S. EPA.

While the 2003-2004 data above is useful because it is not yet influenced by the carbon market, it does nonetheless over-state the amount of common practice destruction that took place during this time period because of the inclusion of ODS sourced from outside the U.S.

The applicability of this protocol is limited to ODS sourced from within the U.S. Therefore, the analysis of common practice must include only destroyed ODS that originated within the U.S. Several countries, including Canada and Australia, have taken a proactive approach to managing ODS and have strong ODS destruction programs that regularly send material to the U.S. for destruction. The Reserve compiled data from destruction facilities to determine the amount of destruction that could be attributed to these imports and subsequently subtracted from total U.S. destruction. Table B.2 presents this analysis including the resulting net U.S. destruction. To protect proprietary company data, Table B.2 provides only the aggregate amounts of ODS that was destroyed from imported stocks.

Table B.2. ODS Destroyed from Ineligible Imported Sources

ODS	Destroyed in U.S. (kg)		Imported for Destruction (kg) ⁴⁰		Net U.S. Sourced ODS Destroyed (kg)	
	2003	2004	2003 ⁴¹	2004	2003	2004
CFC-11	58,846	109,884	-	55,113	58,846	54,771
CFC-12	23,709	62,364	-	25,611	23,709	36,753
CFC-114	464	4,044	-	2,316	464	1,728
CFC-115	4,401	6,737	-	1,710	4,401	5,027

The goal of the performance standard is to determine the market penetration of a given activity. In order to determine the extent to which destruction occurred relative to the amount of ODS available in the U.S. prior to carbon incentives, the Reserve obtained data from U.S. EPA on the amount of ODS from refrigerant and foam that could be recovered for re-use and/or destruction in 2003-2004. The data source is U.S. EPA's Vintaging Model that tracks the type, age, refrigerant, leak rates, and other information for equipment and ODS applications within the U.S. market. By tracking this data through cooperation with industry, the U.S. EPA Vintaging Model is able to approximate when stocks of ODS will reach end-of-life, and the rates at which installed banks of ODS will be emitted in various equipment categories.

At the Reserve's request, the U.S. EPA provided estimates of the quantity of ODS refrigerant that was contained in equipment reaching end-of-life in 2003-2004.⁴² In addition to determining the amount of ODS that could be made available from foam appliances, the U.S. EPA provided

⁴⁰ Data provided by industry is presented anonymously to protect proprietary information.

⁴¹ Data on imports could not be obtained for 2003. This results in a conservative performance standard analysis.

⁴² The use of data from the U.S. EPA Vintaging Model into this protocol does not constitute an endorsement by EPA of the Climate Action Reserve or its methodology. Where actual measurements or other data was made available to and used by the Reserve in this protocol in lieu of the Vintaging Model data, this has been indicated in the protocol.

estimates of the number of residential refrigerators reaching end-of-life in 2003 and 2004. U.S. EPA assumed an ODS content of 1 lb CFC-11 foam blowing agent per refrigerator to establish the total amount ODS that could be made available for destruction from these appliances.

Table B.3. Recoverable ODS from End-of-Life Refrigeration Equipment and Foam Appliances in the U.S., 2003-2004⁴³

	Recoverable Refrigerant (kg)		Residential Refrigerator Foam at End of Life (kg)		Total Available for Destruction (kg)	
	2003	2004	2003	2004	2003	2004
CFC-11	717,140	700,310	3,499,545	3,516,364	4,216,685	4,216,674
CFC-12	12,725,841	10,997,307			12,725,841	10,997,307
CFC-114	154,710	154,710			154,710	154,710
CFC-115	1,833,654	2,207,326			1,833,654	2,207,326

Using the destruction data compiled by ICF International and the data on recoverable ODS refrigerants and foam blowing agent from the U.S. EPA Vintaging Model, the Reserve derived the percentage of recoverable ODS that was destroyed in 2003-2004 (see Table B.4). Because the percentage of recoverable ODS destroyed was very low, the Reserve concluded that the destruction of refrigerant ODS without the incentive from the carbon market is not common practice. Therefore, any project that destroys the refrigerants listed in Table B.4 exceeds the performance standard.

Table B.4. Destruction of Recoverable, U.S. Sourced End-of-Life ODS

	Total Available for Destruction (kg)		Domestic Sourced Destroyed (kg)		Performance Standard (Destroyed/Available)	
	2003	2004	2003	2004	2003	2004
CFC-11	4,216,685	4,216,674	58,846	54,771	1.40%	1.30%
CFC-12	12,725,841	10,997,307	23,709	36,753	0.19%	0.33%
CFC-114	154,710	154,710	464	1,728	0.30%	1.12%
CFC-115	1,833,654	2,207,326	4,401	5,027	0.24%	0.23%

B.2 End-of-Life Treatment of Foam

The Reserve also reviewed separately the common practice in the end-of-life treatment of foams containing ODS blowing agents. Whereas U.S. EPA regulations prohibit the intentional release of ODS refrigerants to the atmosphere, there is no preclusion against disposal practices that result in release of ODS blowing agents.

Based on a review of the literature, the Reserve found that the dominant and current practice end-of-life disposal methods for foams lead to the release of some of the entrained ODS.^{44,45}

U.S. EPA's website acknowledges that current landfill disposal practices release ODS blowing agents to the atmosphere:

“Appliance recycling typically entails recovery of refrigerant and removal of hazardous components followed by shredding of evacuated appliances. Metal components are typically separated and recycled, while glass, plastics and

⁴³ U.S. EPA (2008) EPA Vintaging Model. Version VM IO file_v4.2_10.07.08

⁴⁴ For example: Scheutz, C. et al. (2007) Release of fluorocarbons from insulation foam in home appliances during shredding. *J of the Air & Waste Mgmt Assn*, 57: 1452-1460 ; Scheutz, C., et al. (2007) Attenuation of insulation foam released fluorocarbons in landfills. *Environ Sci & Tech.*, 41:7714-7722).

⁴⁵ http://ozone.unep.org/teap/Reports/TEAP_Reports/TEAP-May-2005-Vol-2-Forms-End-of-Life.pdf

polyurethane foam, are typically sent to a landfill. Because there are no legal requirements for foam recovery, the blowing agent contained in the foam insulation is emitted during shredding and landfilling—thus contributing to ozone depletion and to global climate change.” (U.S. EPA, Safe Disposal of Refrigerated Household Appliances)⁴⁶

As noted previously, disposal of ODS foam in landfills results in some degradation of the blowing agents. However, because the particular practice of destroying ODS entrained in foams is not common practice, the Reserve concluded that any project that destroys ODS entrained in or separated from foams exceeds the performance standard.

⁴⁶ Available at: <http://www.epa.gov/ozone/title6/608/disposal/household.html>

Appendix C Rules Governing ODS Destruction

This project type requires that all ODS be destroyed at a destruction facility which is compliant with both the international standards specified in the TEAP Report of the Task Force on Destruction Technologies,⁴⁷ as well as the requirements of domestic law. This appendix provides a brief summary of the U.S. rules for destruction of ODS, and the criteria that must be met for a destruction facility to qualify under this protocol.

All ODS destruction is regulated under stratospheric ozone protection regulations under the CAA (40 CFR 82). Additionally, because some ODS are classified as hazardous wastes (such as CFC-113, methyl chloroform, and carbon tetrachloride), facilities that handle these ODS are regulated under the Resource Conservation and Recovery Act (RCRA). Hazardous waste combustors (HWCs, e.g. incinerators) that destroy ODS classified as hazardous waste are also regulated by the Maximum Achievable Control Technology (MACT) standard under the CAA.

Under the authority of the CAA, the stratospheric ozone protection regulations (40 CFR Part 82, Subpart A) require that ODS be destroyed using one of the following destruction technologies approved by the Montreal Protocol Parties:

1. Liquid injection incineration;
2. Reactor cracking;
3. Gaseous/fume oxidation;
4. Rotary kiln incineration;
5. Cement kiln;
6. Radio frequency plasma; and
7. Municipal waste incinerators (only for the destruction of foams).

Additionally, if the substance is to be considered “completely destroyed” as defined in the regulations, it must be destroyed to a 98 percent destruction efficiency (DE). This is slightly different from the Montreal Protocol Technology and Economic Assessment Panel which recommends a destruction and removal efficiency (DRE) limit of 99.99 percent. DE is a more comprehensive measure of destruction than DRE as it includes emissions of undestroyed chemical from all points (e.g. stack gases, fly ash, scrubber, water, bottom ash), while DRE includes emissions of undestroyed chemical from the stack gas only. However, because of the relatively volatile nature of ODS and because, with the exception of foams, they are generally introduced as relatively clean fluids, one would not expect a very significant difference between DRE and DE.

Any destruction facility that is regulated by U.S. EPA as a RCRA-permitted HWC is automatically considered a qualifying destruction facility under this protocol.

Non-RCRA permitted facilities may also be deemed qualifying destruction facilities if they meet the pertinent guidelines provided by the TEAP Report of the Task Force on Destruction Technologies, and reproduced below. By inclusion here, the recommendations of the excerpted section of the TEAP report shall be binding on all non-RCRA destruction facilities. Destruction facilities must provide third-party certified results indicating that the facility meets all performance criteria set forth below. Following the initial performance testing, project developers must demonstrate that the facility has conducted comprehensive performance testing at least

⁴⁷TEAP, Volume 3B: Report of the Task Force on Destruction Technologies (2002).

every 3 years to validate compliance with the TEAP DRE and emissions limits as reproduced above. No ODS destruction credits shall be issued for destruction which occurs at a facility that has not passed the criteria below within three years of commencement of destruction activities.

(Reproduced in full from TEAP, *Report of the Task Force on Destruction Technologies*, Chapter 2 (2002))

CHAPTER 2

2.0 TECHNOLOGY SCREENING PROCESS

2.1 Criteria for Technology Screening

The following screening criteria were developed by the UNEP TFDT. Technologies for use by the signatories to the Montreal Protocol to dispose of surplus inventories of ODS were assessed on the basis of:

1. Destruction and Removal Efficiency (DRE)
2. Emissions of dioxins/furans
3. Emissions of other pollutants (acid gases, particulate matter, & carbon monoxide)
4. Technical capability

The first three refer to technical performance criteria selected as measures of potential impacts of the technology on human health and the environment. The technical capability criterion indicates the extent to which the technology has been demonstrated to be able to dispose of ODS (or a comparable recalcitrant halogenated organic substance such as PCB) effectively and on a commercial scale.

For convenience, the technical performance criteria are summarized in Table 2-1. These represent the minimum destruction and removal efficiencies and maximum emission of pollutants to the atmosphere permitted by technologies that qualify for consideration by the TFDT for recommendation to the Parties of the Montreal Protocol for approval as ODS destruction technologies. The technologies must also satisfy the criteria for technical capability as defined in Section 2.1.4.

Table 2-1: Summary of Technical Performance Qualifications⁴⁸

Performance Qualification	Units	Diluted Sources	Concentrated Sources
DRE	%	95	99.99
PCDDs/PCDFs	ng-ITEQ/Nm ³	0.5	0.2
HCl/Cl ₂	mg/Nm ³	100	100
HF	mg/Nm ³	5	5
HBr/Br ₂	mg/Nm ³	5	5
Particulates (TSP)	mg/Nm ³	50	50
CO	mg/Nm ³	100	100

⁴⁸ All concentrations of pollutants in stack gases and stack gas flow rates are expressed on the basis of dry gas at normal conditions of 0°C and 101.3 kPa, and with the stack gas corrected to 11% O₂.

2.1.1 Destruction and Removal Efficiency

Destruction Efficiency (DE)⁴⁹ is a measure of how completely a particular technology destroys a contaminant of interest – in this case the transformation of ODS material into non-ODS by-products. There are two commonly used but different ways of measuring the extent of destruction – DE and Destruction and Removal Efficiency (DRE).⁵⁰ For a more detailed explanation of how DRE is calculated, see section 4.2.1. The terms are sometimes interchanged or used inappropriately. DE is a more comprehensive measure of destruction than DRE, because DE considers the amount of the chemical of interest that escapes destruction by being removed from the process in the stack gases and in all other residue streams. Most references citing performance of ODS destruction processes only provide data for stack emissions and thus, generally, data is only available for DRE and not DE.

Because of the relatively volatile nature of ODS and because, with the exception of foams, they are generally introduced as relatively clean fluids, one would not expect a very significant difference between DRE and DE.

For these reasons this update of ODS destruction technologies uses DRE as the measure of destruction efficiency.

For the purposes of screening destruction technologies, the minimum acceptable DRE is:

- 95% for foams; and,
- 99.99% for concentrated sources.

It should be noted that measurements of the products of destruction of CFCs, HCFCs and halons in a plasma destruction process have indicated that interconversion of ODS can occur during the process. For example, under some conditions, the DRE of CFC-12 (CCl₂F₂) was measured as 99.9998%, but this was accompanied by a conversion of 25% of the input CFC-12 to CFC-13 (CClF₃), which has the same ozone-depleting potential. The interconversion is less severe when hydrogen is present in the process, but can nonetheless be significant.⁵¹ For this reason, it is important to take into account all types of ODS in the stack gas in defining the DRE.

For the reasons described in the previous paragraph, the Task Force recommends that future calculations of DRE use the approach described below⁵².

⁴⁹ Destruction Efficiency (DE) is determined by subtracting from the mass of a chemical fed into a destruction system during a specific period of time the mass of that chemical that is released in stack gases, fly ash, scrubber water, bottom ash, and any other system residues and expressing that difference as a percentage of the mass of the chemical fed into the system.

⁵⁰ Destruction and Removal Efficiency (DRE) has traditionally been determined by subtracting from the mass of a chemical fed into a destruction system during a specific period of time the mass of that chemical alone that is released in stack gases, and expressing that difference as a percentage of the mass of that chemical fed into the system.

⁵¹ R. T. Deam, A. R. Dayal, T. McAllister, A. E. Mundy, R. J. Western, L. M. Besley, A. J. D. Farmer, E. C. Horrigan, and A. B. Murphy, Interconversion of chlorofluorocarbons in plasmas, *J. Chem. Soc.: Chem. Commun.* No. 3 (1995) 347-348; A. B. Murphy, A. J. D. Farmer, E. C. Horrigan, and T. McAllister, Plasma destruction of ozone depleting substances, *Plasma Chem. Plasma Process.* **22** (2002) 371-385.

⁵² Since different ODS have different ODP, consideration should be given to taking into account the ODP of each type of ODS present in the stack gas in calculating the DRE. An appropriate definition that takes into account the differences in ODP is: *DRE of an ODS is determined by subtracting from the number of moles of the ODS fed into a destruction system during a specific period of time, the total number of moles of all types of ODS that are released in stack gases, weighted by their ODP relative to that of the feed ODS, and expressing that difference as a percentage of the number of moles of the ODS fed into the system.*

DRE of an ODS should be determined by subtracting from the number of moles of the ODS fed into a destruction system during a specific period of time, the total number of moles of all types of ODS that are released in stack gases, and expressing that difference as a percentage of the number of moles of the ODS fed into the system.

$$\text{In mathematical terms, DRE} = \frac{N_1^{\text{in}} - \sum_i N_i^{\text{out}}}{N_1^{\text{in}}}$$

Where N_1^{in} is the number of moles of the ODS fed into the destruction system, and N_i^{out} is the number of moles of the i th type of ODS that is released in the stack gases.

2.1.2 Emissions of Dioxins and Furans

Any high temperature process used to destroy ODS has associated with it the potential formation (as by-products) of polychlorinated dibenzo-*para*dioxins (PCDDs) and polychlorinated dibenzofurans (PCDFs). These substances are among the products of incomplete combustion (or PICs) of greatest concern for potential adverse effects on public health and the environment. The internationally recognized measure of the toxicity of these compounds is the toxic equivalency factor (ITEQ),⁵³ which is a weighted measure of the toxicity for all the members of the families of these toxic compounds that are determined to be present.

The task force members note that the World Health Organization has developed a new system for calculating TEQs, however, most of the existing data on emissions is expressed in the former ITEQ system established in 1988.

For purposes of screening destruction technologies, the maximum concentration of dioxins and furans in the stack gas from destruction technologies is:

- 0.5 ng-ITEQ/Nm³ for foams; and,
- 0.2 ng-ITEQ/Nm³ for concentrated sources.

These criteria were determined to represent a reasonable compromise between more stringent standards already in place in some industrialized countries [for example, the Canada-Wide Standard of 0.08 ng/m³ (ITEQ)], and the situation in developing countries where standards may be less stringent or non-existent. Although a previous standard of 1.0 ng/m³ (ITEQ) had been suggested in the UNEP 1992 report, advances in technology in recent years, and the level of

⁵³ There are 75 chlorinated dibenzo-*p*-dioxins and 135 chlorinated dibenzofurans that share a similar chemical structure but that have a wide range in degree of chlorination and a corresponding wide range in toxicity. Of these, one specific dioxin [2,3,7,8-Tetrachlorodibenzo-*p*-dioxin, or (TCDD)] is the most toxic and best characterized of this family of compounds. Since PCDDs and PCDFs are generally released to the environment as mixtures of these compounds, the scientific community has developed a system of toxic equivalency factors (TEFs) which relate the biological potency of compounds in the dioxin/furan family to the reference TCDD compound. The concentration of each specific compound is multiplied by its corresponding TEF value, and the resulting potency-weighted concentration values are summed to form an expression of the mixture's overall toxic equivalence (TEQ). The result of this exercise is a standardized expression of toxicity of a given mixture in terms of an equivalent amount of TCDD (the reference compound). The internationally accepted protocol for determining TEQ – i.e. ITEQ – was established by NATO in 1988. [*Scientific Basis for the Development of International Toxicity Equivalency Factor (I-TEF), Method of Risk Assessment for Risk Assessment of Complex Mixtures of Dioxins and Related Compounds*. North Atlantic Treaty Organization/Committee on the Challenge of Modern Society. Report No. 176, Washington, D.C. 1988.]

concern for emissions of these highly toxic substances justified a significantly more stringent level.

2.1.3 Emissions of Acid Gases, Particulate Matter and Carbon Monoxide

Acid gases are generally formed when ODS are destroyed and these must be removed from the stack gases before the gases are released to the atmosphere. The following criteria for acid gases have been set for purposes of screening destruction technologies:

- a maximum concentration in stack gases of 100 mg/Nm³ HCl/Cl₂;
- a maximum concentration in stack gases of 5 mg/Nm³ HF; and,
- a maximum concentration in stack gases of 5 mg/Nm³ HBr/Br₂.

Particulate matter is generally emitted in the stack gases of incinerators for a variety of reasons and can also be emitted in the stack gases of facilities using non-incineration technologies. For the purposes of screening technologies, the criterion for particulate matter is established as:

- a maximum concentration of total suspended particulate (TSP) of 50 mg/Nm³.

Carbon monoxide (CO) is generally released from incinerators resulting from incomplete combustion and may be released from some ODS destruction facilities because it is one form by which the carbon content of the ODS can exit the process. Carbon monoxide is a good measure of how well the destruction process is being controlled. For the purposes of screening technologies, the following criterion has been established:

- a maximum CO concentration in the stack gas of 100 mg/Nm³.

These maximum concentrations apply to both foams and concentrated sources. They were set to be achievable by a variety of available technologies while ensuring adequate protection of human health and the environment.

2.1.4 Technical Capability

As well as meeting the above performance requirements it is necessary that the destruction technologies have been demonstrated to be technically capable at an appropriate scale of operation. In practical terms, this means that the technology should be demonstrated to achieve the required DRE while satisfying the emissions criteria established above. Demonstration of destruction of ODS is preferred but not necessarily required. Destruction of halogenated compounds that are refractory, i.e. resistant to destruction, is acceptable. For example, demonstrated destruction of polychlorinated biphenyls (PCBs) was often accepted as an adequate surrogate for demonstrated ODS destruction.

For this evaluation, an ODS destruction technology is considered technically capable if it meets the following minimum criteria:

- It has been demonstrated to have destroyed ODS to the technical performance standards, on at least a pilot scale or demonstration scale (designated in Table 2-2 as “Yes”).
- It has been demonstrated to have destroyed a refractory chlorinated organic compound other than an ODS, to the technical performance standards, on at least a pilot scale or demonstration scale (designated in Table 2-2 as “P,” which indicates that the technology is considered to have a high potential for application with ODS,

but has not actually been demonstrated with ODS).

- The processing capacity of an acceptable pilot plant or demonstration plant must be no less than 1.0 kg/hr of the substance to be destroyed, whether ODS or a suitable surrogate.

These criteria of technical capability will minimize the risk associated with technical performance and ensure that destruction of ODS will be performed in a predictable manner consistent with protecting the environment.

Appendix B presents a detailed discussion of the selection of 1.0 kg/hr as the minimum capacity for a pilot plant in order to demonstrate technical capability, which represents a change from the criterion originally selected in the 1992 UNEP report.

Appendix D Development of Refrigerant Emissions Rates

Under this protocol refrigerant emissions are estimated in reference to the emission loss rates of the equipment into which those refrigerants would have been installed in the baseline. This appendix explains the methodology used to determine the appropriate emission rates for refrigerant baseline and project emissions.

As described in Appendix A, the CAA and 40 CFR 82 prohibit intentional venting of ODS to the atmosphere. However, ODS still have value for recovery and reuse in existing equipment, because they can no longer be produced or imported. This consideration, combined with the fact that destruction of ODS is relatively expensive, result in the CAA effectively incentivizing the continual recovery and recycling or reclamation of used ODS for recharge in existing equipment. The baseline scenario for refrigerants under this protocol is therefore defined as recharge for refrigeration and A/C applications.

The population of equipment that utilizes ODS refrigerants is rapidly aging and approaching end of life. As such, this equipment exhibits relatively high emission rates and refrigerants are lost to the atmosphere at a rapid rate. For the purposes of this protocol, the baseline emissions of ODS are defined as the amount of ODS that would have been released over the ten-year crediting period had it not been destroyed, but rather been used to recharge existing equipment (see Figure D.1).

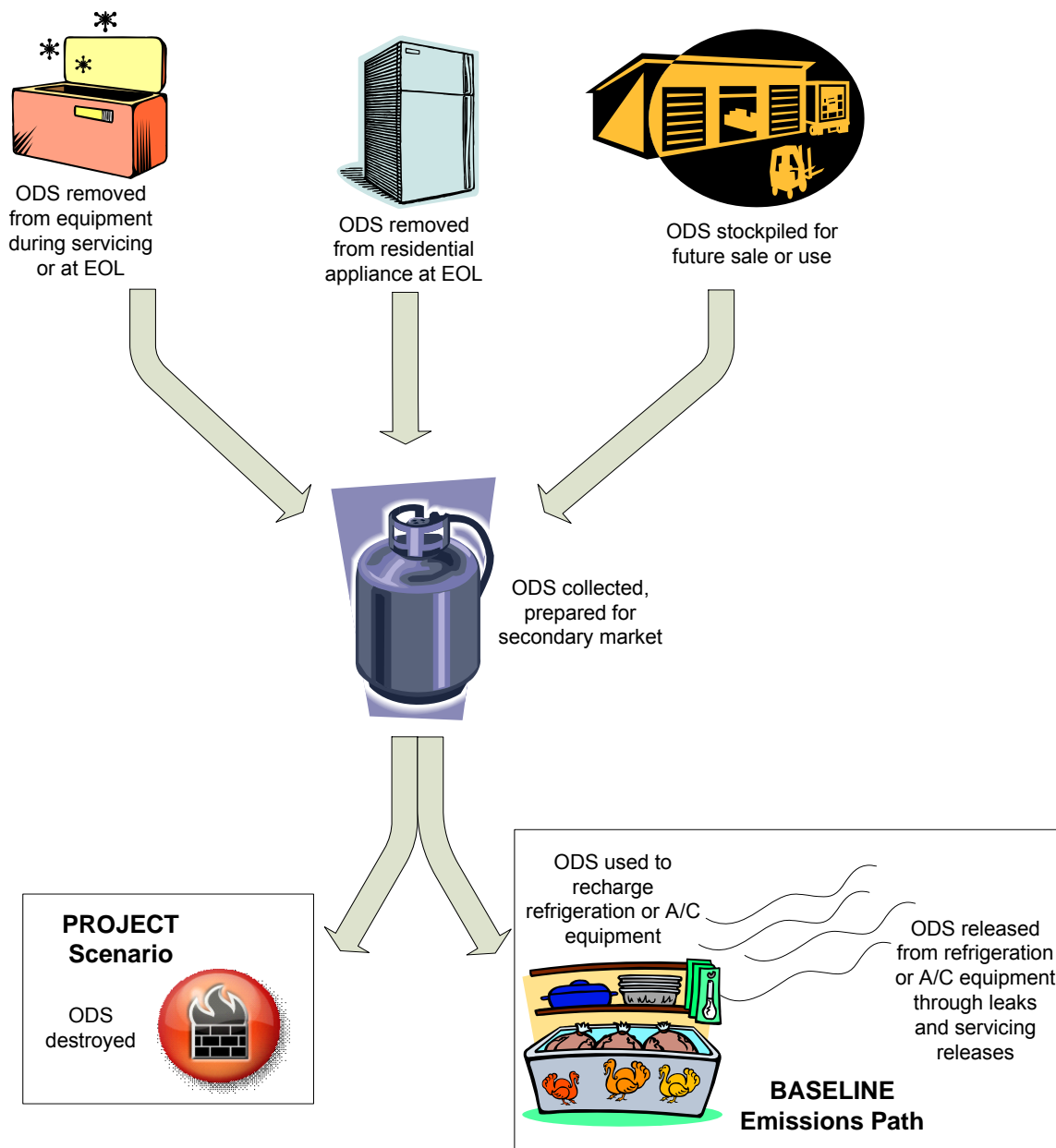


Figure D.1. Illustration of Refrigerant Project Baseline Scenario and Project Scenario

D.1. Baseline Emissions Rates

The refrigerant baseline scenario is defined as recirculation into the refrigerant re-sale market. This market can either be supplied by recovered, or recoverable, ODS refrigerant or refrigerant currently being stockpiled. Determining why refrigerant may have been removed from certain equipment, why a chiller may have been decommissioned, or why a stockpile was not utilized is beyond the scope of this protocol because it cannot be assessed in the standardized manner required by the Reserve. Therefore, the baseline focuses on what would happen to ODS refrigerant upon decommissioning or servicing of equipment when it enters into the re-sale market. By defining the baseline in this way, the Reserve is able to utilize a single baseline for refrigerant removed from residential appliances (e.g. refrigerators or A/C units) and commercial or industrial equipment.

When ODS enters the re-sale market it could be used in any refrigeration or A/C equipment that needs servicing, regardless of whether it is for large refrigeration, large A/C, or mobile A/C. Since we cannot know the exact type of equipment that the ODS will be added to, and the resulting emission rate, the ODS baseline is defined as the weighted average of all end-use emission rates of ODS refrigerant in the market under the assumption that it would be absorbed into the overall market. The emissions rate for refrigerants is defined as the total annual emissions resulting from both leaks and servicing events.

To determine the applicable weighted emission rates for each ODS refrigerant, the Reserve used data provided by the U.S. EPA from the Vintaging Model. This model compiles detailed information on the type, age, refrigerant, leak rates, servicing emission rates, and other information for equipment and ODS applications within the U.S. market. By tracking this data through cooperation with industry, the EPA Vintaging Model is able to approximate when stocks of ODS will reach end-of-life, and the rates at which installed banks of ODS will be emitted from various equipment categories.

At the Reserve's request, the EPA ran the Vintaging Model and provided data on the weighted average emission rates for CFC-11, CFC-12, CFC-114, and CFC-115 as indicated in Table 5.1⁵⁴. These outputs are composites of emission rates associated with dozens of separate subcategories within the refrigeration market. The Vintaging Model contains estimates on the specific emission rates and market share for each of these subcategories. As illustrated in Table D.1, the weighted average emission rates are based on emissions from the Mobile A/C, Large Refrigeration, and Large A/C sectors, as these were identified as the sub-sectors of the market where refrigerant recharge predominantly will occur in 2010. The Reserve selected the year 2010 to represent the baseline, since that is the first year that the Reserve will begin accepting projects under this protocol.

The EPA Vintaging Model assumptions rely on the expected life of various types of equipment that utilize ODS. Because vehicles with CFC-12 systems are older than the assumed 12-year lifespan of a vehicle, the Vintaging Model indicated that no CFC-12 is used in the automotive sector in 2010. Consultation with members of the refrigerant reclaim and wholesale industry indicated that CFC-12 is still being sold in large quantities for mobile A/C applications. In fact, upwards of 50% of the U.S. CFC-12 demand may be in the mobile market. The Reserve confirmed this finding through review of confidential sales records that indicated a majority of CFC-12 sales were intended for the automotive market. Accordingly, a 50% mobile market share has been assumed to be conservative, and the Vintaging Model data has been adjusted accordingly. For the mobile market the Reserve further assumed an emission rate of 40.7% (leak and servicing emissions) per year for CFC-12, and 18% emission rate for the replacement, HFC-134a.

The results, incorporating both industry and Vintaging Model data are presented in Table D.1.

⁵⁴ The use of data from the U.S. EPA Vintaging Model into this protocol does not constitute an endorsement by EPA of CAR or its methodology. Where actual measurements or other data was made available to and used by CAR in this protocol in lieu of the Vintaging Model data, this has been indicated in the protocol.

Table D.1. Weighted Average Annual Loss Rate % and Market Share for Class I ODS⁵⁵

	2010 Weighted Average Annual Loss Rate % and Market Share for Class I ODS							
	CFC-11		CFC-12		CFC-114		CFC-115	
Refrigeration and A/C Sector	Market Share	Loss Rate	Market Share	Loss Rate	Market Share	Loss Rate	Market Share	Loss Rate
Mobile ⁵⁶	-	-	50.0%	40.7%	-	-	-	-
Large Refrigeration	3.3%	18.6%	32.6%	10.4%	-	-	100.0%	25.0%
Large AC	96.7%	19.5%	17.4%	13.8%	100.0%	13.8%	-	-
Market-Weighted Annual Loss Rate	19.5%		26.1%		13.8%		25.0%	
10-year Total Loss	88.5%		95.2%		77.4%		94.4%	

The categories identified in Table D.1 are weighted aggregates of the subsectors presented in Table D.2.

Table D.2. Characterization of Categories from the EPA Vintaging Model

Category	End Use
Large AC	Centrifugal Chillers
	Positive Displacement Chillers
Large Refrigeration	Large Retail Food
	Cold Storage
	Refrigerated Transport
	Industrial Process Refrigeration
Mobile	Mobile AC
	School & Tour Buses AC
	Transit Buses AC
	Trains AC
Small AC	Dehumidifiers
	Window Units
	Unitary A/C
	Water & Ground Source HP
	Packaged Terminal AC/HP
Small Refrigeration	Small and Medium Retail Food
	Household Refrigerated Appliances
	Ice Makers

Interviews with industry experts indicated that a large share of recoverable refrigerant is vented to the atmosphere directly rather than re-introduced as recycled or reclaimed material into the market. As this would result in 100% immediate release, calculating all refrigerant ODS baseline emissions according to a market emission rate as described above is conservative.

The weighted annual emission rates calculated in Table D.1 are used in the protocol to calculate baseline emissions from the release of ODS refrigerant in Equation 5.3.

⁵⁵ EPA (2009) EPA Vintaging Model. Version VM IO file_v4.2_10.07.08.

⁵⁶ The market share for mobile refrigeration was derived from industry surveys conducted by Reserve staff.

D.2. Project Emissions Rates

By removing ODS refrigerant from the re-sale market through destruction projects, substitute refrigerants will be required to fulfill the U.S. refrigeration need. Much as predicting the baseline use of destroyed ODS is difficult and inappropriate, so too is predicting the specific refrigerant that will fill the void when the ODS is destroyed and the baseline does not come to pass because of the project. Therefore, the Reserve employed the same technique used for establishing the emissions rate of the baseline when developing a generic, weighted substitute GWP and emission rate for the project.

Substitute emissions for CFC-11, CFC-12, CFC-114, and CFC-115 are based on the weighted average of new market entrants for their respective refrigeration purposes as modeled by the EPA Vintaging Model for 2010. The Reserve selected the year 2010 to represent the project, since that is the first year that the Reserve will begin accepting projects under this protocol. Pulling from industry expertise and internal EPA research, the Vintaging Model predicts that the ODS substitutes in Table D.3 through Table D.6 will be the dominant refrigerant substitutes. The model further provides the emission rates associated with each substitute, the relative charge size of the substitute required to meet the same refrigerant need as the replaced ODS,⁵⁷ and data on the market share attributable to each substitute. Using this information, the Reserve calculated the weighted average substitute emissions per pound of ODS destroyed.

The parameters of substitute emissions are used in the protocol to estimate the project scenario emissions associated with the use of substitute refrigerants in Equation 5.6.

⁵⁷ In many cases, more or less of a substitute refrigerant is needed to perform the same function as the replaced ODS.

Table D.3. Calculation of Substitute Emissions for CFC-11

Application	CFC-11 Recharge Market Share	ODS Substitute	Market Share Relative to Subsector (by weight)	Overall CFC-11 market share	GWP (CO ₂ e)	Relative Charge Size (lb. Sub/lb. ODS)	Sub used to Replace One lb CFC-11 (lbs)	Loss Rate of Sub (%/yr)	10-year lbCO ₂ e/ODS destroyed
Large Refrigeration	3%	HCFC-123	59%	2%	77	0.88	0.017	5%	0.53
		HFC-134a	41%	1%	1430	1.4	0.019	5%	10.65
Large AC	97%	HCFC-123	34%	33%	77	0.88	0.289	2%	4.84
		HFC-134a	66%	64%	1430	1.4	0.894	2%	229.24
CFC-Sub Emissions (lbCO₂e/lbODS destroyed)									245

Table D.4. Calculation of Substitute Emissions for CFC-12

Application	CFC-12 Market Share of Recharge	ODS Substitute	Market Share Relative to Subsector (by weight)	Overall CFC-12 market share	GWP (CO ₂ e)	Relative Charge Size (lb. Sub/lb. ODS)	Sub used to Replace One lb CFC-12 (lbs)	Loss Rate of Sub (%/yr)	10-year lbCO ₂ e/ODS destroyed
Mobile	50%	HFC-134a	100%	50%	1430	.74	0.370	18%	456.38
Large Refrigeration	33%	HCFC-123	24%	8%	77	0.88	0.068	4%	1.92
		HFC-134a	61%	20%	1430	1.4	0.278	4%	144.05
		R-404A	10%	3%	3922	0.78	0.026	11%	71.10
		R-410A	2%	1%	2088	0.88	0.005	5%	4.42
Large AC	17%	R-507A	3%	1%	3985	0.78	0.008	12%	23.42
		HCFC-123	9%	2%	77	0.88	0.014	1%	0.11
		HFC-134a	80%	14%	1430	1.4	0.196	3%	66.43
		R-407C	9%	2%	1774	0.76	0.012	2%	2.91
		R-410A	2%	0%	2088	0.76	0.003	1%	0.72
CFC-Sub Emissions (lbCO₂e/lbODS destroyed)									771

Table D.5. Calculation of Substitute Emissions for CFC-114

Application	CFC-114 Market Share of Recharge	ODS Substitute	Market Share Relative to Subsector (by weight)	Overall CFC-114 market share	GWP (CO ₂ e)	Relative Charge Size (lb. Sub/lb. ODS)	Sub used to Replace One lb CFC-114 (lbs)	Loss Rate of Sub (%/yr)	10-year lbCO ₂ e/ODS destroyed
Large AC	100%	HFC-134a	100%	100%	1430	1.4	1.400	4%	724.95
CFC-Sub Emissions (lbCO₂e/lbODS destroyed)									725

Table D.6. Calculation of Substitute Emissions for CFC-115

Application	CFC-114 Market Share of Recharge	ODS Substitute	Market Share Relative to Subsector (by weight)	Overall CFC-115 market share	GWP (CO ₂ e)	Relative Charge Size (lb. Sub/lb. ODS)	Sub used to Replace One lb CFC-115 (lbs)	Loss Rate of Sub (%/yr)	10-year lbCO ₂ e/ODS destroyed
Large Refrigeration	100%	R-404A	53%	53%	3922	0.85	0.448	17%	1495.37
		R-507A	12%	12%	3985	0.85	0.101	15%	318.17
		Non-ODP/GWP	36%	36%	0	1	0.355	15%	0.00
CFC-Sub Emissions (lbCO₂e/lbODS destroyed)									1814

Appendix E Default Emissions Factors for Calculating Project Emissions Factor

E.1 Summary

The GHG Assessment Boundary for ODS destruction projects under the Reserve includes emissions in both the baseline and project scenario. These emission sources include the following:

Baseline	Project
<ul style="list-style-type: none"> ▪ Emissions of ODS from foam shredding ▪ Emissions of ODS from foam landfilling ▪ Emissions of ODS from refrigerant applications 	<ul style="list-style-type: none"> ▪ Extraction of foam blowing agent ▪ Emissions of substitute refrigerant applications ▪ Emissions from fossil fuel and electricity used in destruction facility ▪ Emissions from fossil fuel used in transport to destruction facility ▪ ODS emissions from incomplete destruction of ODS ▪ CO₂ emissions from ODS oxidation during destruction

All of these emission sources must be accounted for to ensure complete, accurate, and conservative calculations of project emission reductions. However, some of these emission sources are of a significantly greater magnitude than others, and some of the smaller sources are costly to track and verify, and difficult to assess. In order to lessen the burden on project developers and verifiers, the Reserve has calculated a standard deduction which can be applied to all projects to account for the following project scenario emissions:

1. Emissions from fossil fuel and electricity used by the destruction facility
2. Emissions from fossil fuel used for transporting the ODS to the destruction facility
3. ODS emissions from incomplete destruction of ODS
4. CO₂ emissions from ODS oxidation during destruction

The aggregate of these emission sources amounts to less than 0.5% of total emission reductions under even the most conservative assumptions. As a result, a conservative emission factor may be applied. This appendix provides background on the development of those emission factors.

E.2 Methodology and Analysis

The Reserve created a model to conservatively calculate all emissions in the baseline and project scenario for ODS projects. The model incorporated all equations from Section 5. The equations which have been rolled up into this emission factor are Equation 5.9 through Equation 5.14.

In many cases, the equations used for estimating emissions from the four selected sources, required additional input and emissions factors. Where calculations required such inputs (e.g. electricity grid emission factors), the most conservative factors available were used. Fossil fuel emissions from the destruction process were calculated based on industry records that describe

the energy requirements associated with ODS destruction projects. The assumptions used in this analysis are as follows:

Parameter	Assumption
ODS_i	1 tonne ODS (Intact foams assumed to be 8.5% ODS by weight)
$FF_{PR,i}$	0.0009 MMBtu natural gas/lb ODS destroyed (for foams and refrigerants)
$EF_{FF,i}$	54.01 kg CO ₂ /MMBtu ⁵⁸
EL_{PR}	0.0002 MWh/lb ODS destroyed for foam, 0.0018 MWh/lb ODS destroyed for refrigerants and extracted blowing agent
EF_{EL}	0.889 tCO ₂ /MWh ⁵⁹
TMT _i	2,000 miles
EF_{TMT}	0.297 kgCO ₂ /TMT ⁶⁰
CR _i	Actual per ODS
Foam weight	8.5% by weight (foam weight used for transport and energy use)

Under these assumptions, and the equations provided in Section 5 , the analysis provided the following results for different ODS project categories:

Table E.1. Project Emissions (Excluding Substitutes)
All quantities in tonnes CO₂/tonne ODS destroyed.

	Fossil fuel emissions from the destruction	Electricity emissions from the destruction	Emissions from ODS not destroyed	Emissions from CO ₂	Emissions from the transportation of ODS	Total
CFC-11 refrigerant or extracted BA	0.04	3.53	0.47	0.32	0.59	4.95
CFC-12 refrigerant or extracted BA	0.04	3.53	1.07	0.36	0.59	5.59
CFC-114 refrigerant	0.04	3.53	1.00	0.47	0.59	5.63
CFC-115 refrigerant	0.04	3.53	0.74	0.47	0.59	5.36
CFC-11 appliance foam	0.42	41.50	0.47	0.32	6.99	49.70
CFC-12 appliance foam	0.42	41.50	1.07	0.36	6.99	50.35
HCFC-141b appliance foam	0.42	41.50	0.07	0.00	6.99	48.98
CFC-11 building foam	0.42	41.50	0.47	0.32	6.99	49.70
CFC-12 building foam	0.42	41.50	1.07	0.36	6.99	50.35
HCFC-141b building foam	0.42	41.50	0.07	0.75	6.99	49.74

Because the ODS covered in this protocol have such high GWPs (750 to 10,900) even emissions of 50 tonnes CO₂e per tonne of ODS destroyed are relatively small compared to emissions of the overall baseline and project scenarios. For refrigerant projects, the emissions

⁵⁸ U.S. EPA Climate Leaders, Stationary Combustion Guidance (2007) Note: The highest emission factor was selected to be conservative.

⁵⁹ U.S. EPA eGRID2007, Version 1.1 Year 2005 GHG Annual Output Emission Rates (December 2008). Note: the highest emission factor in the nation was selected to be conservative.

⁶⁰ U.S. EPA Climate Leaders, Optional emissions from business travel, commuting, and product transport (2008). Note: the highest emitting mode of transportation was selected to be conservative.

amount to less than 0.15% of baseline emissions. For intact foams, emissions from the four source categories can be as high as 5% of baseline emissions.

E.3 Conclusion

To account for the emission sources analyzed above, project developers may apply a 7.5 tonne CO₂e/tonne ODS emission factor to all refrigerant projects and to foam projects destroying extracted blowing agent. A 75 tonne CO₂e/tonne ODS emission factor must be applied to all other foam projects. These default emission factors represent a conservative estimate of the potential emissions from the four selected sources and were derived using worst-case emission factors and empirical data.

Appendix F Emission Factor Tables

Table F.1. CO₂ Emission Factors for Fossil Fuel Use

Fuel Type	Heat Content	Carbon Content (Per Unit Energy)	Fraction Oxidized	CO ₂ Emission Factor (Per Unit Energy)	CO ₂ Emission Factor (Per Unit Mass or Volume)
Coal and Coke	MMBtu / Short ton	kg C / MMBtu		kg CO₂ / MMBtu	kg CO₂ / Short ton
Anthracite Coal	25.09	28.26	1.00	103.62	2,599.83
Bituminous Coal	24.93	25.49	1.00	93.46	2,330.04
Sub-bituminous Coal	17.25	26.48	1.00	97.09	1,674.86
Lignite	14.21	26.30	1.00	96.43	1,370.32
Unspecified (Residential/ Commercial)	22.05	26.00	1.00	95.33	2,102.29
Unspecified (Industrial Coking)	26.27	25.56	1.00	93.72	2,462.12
Unspecified (Other Industrial)	22.05	25.63	1.00	93.98	2,072.19
Unspecified (Electric Utility)	19.95	25.76	1.00	94.45	1,884.53
Coke	24.80	31.00	1.00	113.67	2,818.93
Natural Gas (By Heat Content)	Btu / Standard cubic foot	kg C / MMBtu		kg CO₂ / MMBtu	kg CO₂ / Standard cub. ft.
975 to 1,000 Btu / Std cubic foot	975 – 1,000	14.73	1.00	54.01	Varies
1,000 to 1,025 Btu / Std cubic foot	1,000 – 1,025	14.43	1.00	52.91	Varies
1,025 to 1,050 Btu / Std cubic foot	1,025 – 1,050	14.47	1.00	53.06	Varies
1,050 to 1,075 Btu / Std cubic foot	1,050 – 1,075	14.58	1.00	53.46	Varies
1,075 to 1,100 Btu / Std cubic foot	1,075 – 1,100	14.65	1.00	53.72	Varies
Greater than 1,100 Btu / Std cubic foot	> 1,100	14.92	1.00	54.71	Varies
Weighted U.S. Average	1,029	14.47	1.00	53.06	0.0546
Petroleum Products	MMBtu / Barrel	kg C / MMBtu		kg CO₂ / MMBtu	kg CO₂ / gallon
Asphalt & Road Oil	6.636	20.62	1.00	75.61	11.95
Aviation Gasoline	5.048	18.87	1.00	69.19	8.32
Distillate Fuel Oil (#1, 2 & 4)	5.825	19.95	1.00	73.15	10.15
Jet Fuel	5.670	19.33	1.00	70.88	9.57
Kerosene	5.670	19.72	1.00	72.31	9.76
LPG (average for fuel use)	3.849	17.23	1.00	63.16	5.79
Propane	3.824	17.20	1.00	63.07	5.74
Ethane	2.916	16.25	1.00	59.58	4.14
Isobutene	4.162	17.75	1.00	65.08	6.45
n-Butane	4.328	17.72	1.00	64.97	6.70
Lubricants	6.065	20.24	1.00	74.21	10.72
Motor Gasoline	5.218	19.33	1.00	70.88	8.81
Residual Fuel Oil (#5 & 6)	6.287	21.49	1.00	78.80	11.80
Crude Oil	5.800	20.33	1.00	74.54	10.29
Naphtha (<401 deg. F)	5.248	18.14	1.00	66.51	8.31
Natural Gasoline	4.620	18.24	1.00	66.88	7.36
Other Oil (>401 deg. F)	5.825	19.95	1.00	73.15	10.15
Pentanes Plus	4.620	18.24	1.00	66.88	7.36
Petrochemical Feedstocks	5.428	19.37	1.00	71.02	9.18
Petroleum Coke	6.024	27.85	1.00	102.12	14.65
Still Gas	6.000	17.51	1.00	64.20	9.17
Special Naphtha	5.248	19.86	1.00	72.82	9.10
Unfinished Oils	5.825	20.33	1.00	74.54	10.34
Waxes	5.537	19.81	1.00	72.64	9.58

Source: EPA Climate Leaders, Stationary Combustion Guidance (2007), Table B-2 except:

Default CO₂ emission factors (per unit energy) are calculated as: Carbon Content × Fraction Oxidized × 44/12.

Default CO₂ emission factors (per unit mass or volume) are calculated as: Heat Content × Carbon Content × Fraction Oxidized × 44/12 × Conversion Factor (if applicable).

Heat content factors are based on higher heating values (HHV).

Table F.2. CO₂ Electricity Emission Factors

eGRID subregion acronym	eGRID subregion name	Annual output emission rates	
		(lb CO ₂ /MWh)	(metric ton CO ₂ /MWh)*
AKGD	ASCC Alaska Grid	1,232.36	0.559
AKMS	ASCC Miscellaneous	498.86	0.226
AZNM	WECC Southwest	1,311.05	0.595
CAMX	WECC California	724.12	0.328
ERCT	ERCOT All	1,324.35	0.601
FRCC	FRCC All	1,318.57	0.598
HIMS	HICC Miscellaneous	1,514.92	0.687
HIOA	HICC Oahu	1,811.98	0.822
MROE	MRO East	1,834.72	0.832
MROW	MRO West	1,821.84	0.826
NEWE	NPCC New England	927.68	0.421
NWPP	WECC Northwest	902.24	0.409
NYCW	NPCC NYC/Westchester	815.45	0.370
NYLI	NPCC Long Island	1,536.80	0.697
NYUP	NPCC Upstate NY	720.80	0.327
RFCE	RFC East	1,139.07	0.517
RFCM	RFC Michigan	1,563.28	0.709
RFCW	RFC West	1,537.82	0.698
RMPA	WECC Rockies	1,883.08	0.854
SPNO	SPP North	1,960.94	0.889
SPSO	SPP South	1,658.14	0.752
SRMV	SERC Mississippi Valley	1,019.74	0.463
SRMW	SERC Midwest	1,830.51	0.830
SRSO	SERC South	1,489.54	0.676
SRTV	SERC Tennessee Valley	1,510.44	0.685
SRVC	SERC Virginia/Carolina	1,134.88	0.515

Source: UE EPA eGRID2007, Version 1.1 Year 2005 GHG Annual Output Emission Rates (December 2008).

* Converted from lbs CO₂/ MWh to metric tons CO₂/MWH using conversion factor 1 metric ton = 2,204.62 lbs.

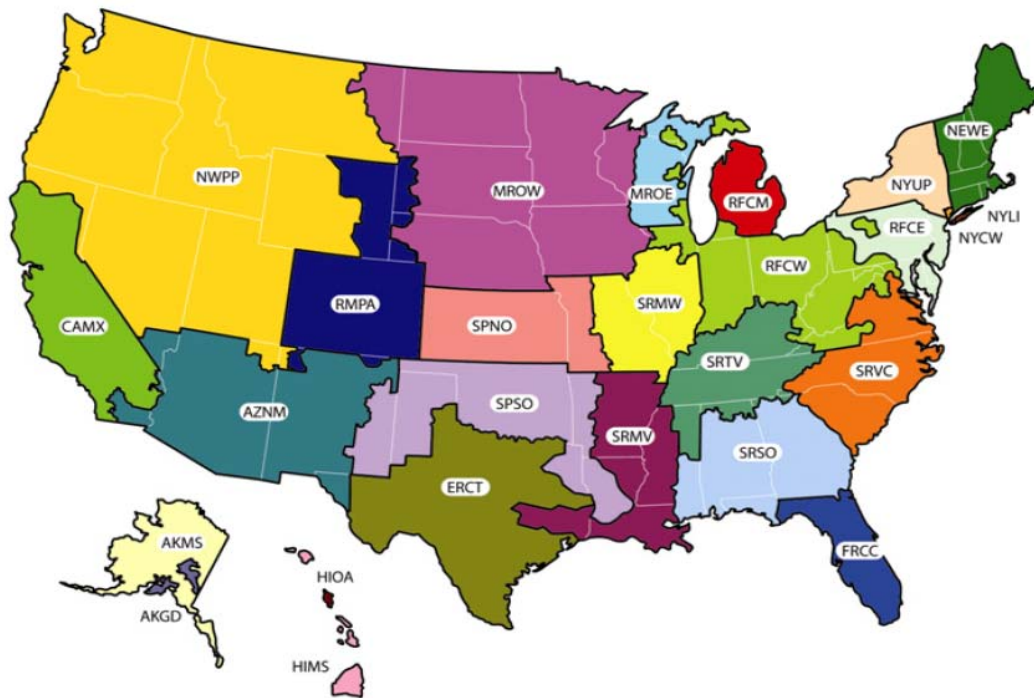


Figure F.1. Map of eGRID2007 Subregions