

Public Comments and Responses on Draft Methodology Version 1.0

Response to Public Comment

Recovery and Destruction of Hydrofluorocarbon Refrigerant Gases in Article 5 Countries Version 1.0

May 2024

Background

The [Carbon Containment Lab](#) (CC Lab) is a 501(c)(3) nonprofit that supports the development, testing, and implementation of novel and neglected climate solutions. The CC Lab measures its progress with explicit quantitative goals around the mitigation of climate change. We work with academic advisors, students, technical experts, and other collaborators to pursue these goals. The CC Lab spun out of the [Yale School of the Environment](#) in early 2024. You can read more about the spinout [here](#).

The CC Lab has three main program areas, (1) Anthropogenic – mitigating GHG emissions from human activities; (2) Biologic – containing the carbon captured through photosynthesis; and (3) Geologic – enhancing geochemical processes or underground storage to remove and store CO₂.

The [Anthropogenic Program](#) seeks to abate emissions from industrial and other man-made processes. This program area focuses on short-lived climate pollutants such as methane and hydrofluorocarbons (HFCs). These gases are much more potent than CO₂ and have outsized effects on atmospheric warming over short time scales. Much of the CC Lab's work on HFCs involves scaling [lifecycle refrigerant management](#) (LRM) practices globally. LRM activities include:

- Maintaining accurate and comprehensive refrigerant bank inventories and emissions estimates.
- Implementing best practices for installation, servicing, and monitoring to reduce leakage during the operating lifetime of cooling equipment.
- Ensuring refrigerant recovery at equipment end-of-life.
- Recycling or reclaiming used refrigerant to ease demand for virgin refrigerant production and create end markets for recovered gases.
- Destroying recovered refrigerant for which there is little or no demand, using environmentally sound technology.
- Improving design of new equipment to use climate-friendly refrigerants to increase energy efficiency, reduce leakage during operating lifetime, and facilitate responsible decommissioning and recycling.

As part of its early work on LRM, the CC Lab identified a financing gap for projects that recover and mitigate HFCs (see our [fact sheet on existing methodologies](#)). Currently, no country in the world has succeeded in recovering HFCs from end-of-life equipment at satisfactory scale. When equipment reaches end-of-life, the refrigerant contained inside is almost always vented to the

atmosphere. In Article 5 countries, there is also scant infrastructure and market for reclaimed refrigerant,¹ making destruction of HFCs arguably the environmentally preferable option.

In early 2023, the CC Lab drafted a methodology and white paper for the recovery and destruction of HFCs in Article 5 countries. These documents drew on our field research in Article 5 countries and interviews with technical experts, methodology writers, policymakers, and project developers. We solicited two rounds of peer review on both the methodology and white paper, with a focus around additionality and fraud prevention. We published all peer review comments and responses alongside a version 1.0 of the [methodology](#) and [white paper](#) in May 2023. We posted version 1.0 for public comment between May and December 2023. We have since collated, reviewed, and responded to all public comments.

This document contains the following materials:

- 1) A description of the public comment process and timeline;
- 2) Public comments to the methodology submitted between May and December 2023 and our replies; and
- 3) The draft of version 1.0 of the methodology (published in May 2023) with line numbers for reference.

The updated version of the draft methodology—with all addressed comments included—will be published online alongside these documents.

In addition, the peer review and public comment process led us to a deeper review of existing methodologies for refrigerant abatement. Our findings are summarized in replies to commenters (herein) and reflected in version 2.0 of our draft methodology.

The goal of our work is to provide project developers a real, verifiable pathway toward addressing these sources of refrigerant emissions, and to help credit buyers distinguish between low- and high-quality projects and methodologies. Toward this goal, we intend to continue to publish discussions on this topic and to solicit further scrutiny and support from those who are interested.

¹ TEAP, “Technology and Economic Assessment Panel 2022 Assessment Report,” Assessment Report (UNEP, March 2023), <https://ozone.unep.org/system/files/documents/TEAP-Assessment-Report-2022-April23.pdf>.

Our Review Process

While at the Yale Carbon Containment Lab, staff Charlie Mayhew and Tilden Chao led multiple rounds of peer review and public comment for the methodology and white paper. We highlight the timing and steps of peer review(s) in the timeline below. Work in reviewing comments and updating the version 1.0 of the methodology rolled over into our existing independent structure as the Carbon Containment Lab.

Peer Review and Public Comment Process and Timeline		
<i>Date</i>	<i>Stage</i>	<i>Notes</i>
2022 - present	Background Research	CC Lab interviews experts to learn more about refrigerant recovery and conditions in Article 5 countries, including conducting field research in Southeast Asia on fluorocarbon emissions and recovery practices.
Jan. 2023	1 st Draft Methodology	CC Lab staff drafts white paper and methodology
Feb. 2023	Peer Review Round 1	White paper and draft methodology sent to expert peer reviewers
Mar. 2023	2 nd Draft Methodology	All comments considered, addressed, and incorporated into new white paper and draft methodology
Apr. 2023	Peer Review Round 2	Updated drafts sent out to expert peer reviewers for second round of comments
May 2023	Methodology Version 1.0	Remaining comments considered and incorporated. White paper and draft methodology posted on website.
May 2023 - Feb. 2024	Public Comment Period	Published drafts available on CC Lab website & solicitation for comments sent out
May 2024	Methodology Version 2.0	Public comments collated and addressed in final peer review document alongside new report on existing methodologies

The following section contains all comments collected as part of the public comment. The Anthropogenic Team has reviewed these comments, consulted experts in the field, and formulated responses. We are continuing to accept additional comments at info@cclab.org on a rolling basis. If interested in commenting further, please attach your comments and include in the subject line: “Public Comments on Draft HFC Methodology Version 2.0.”

Public Comments & Replies

Topic: STOCKPILE ELIGIBILITY

Comment: Stockpiles of refrigerants shouldn't be included in the methodology, unless the methodology is used solely for mitigation contributions as opposed to offsets. Refrigerants already contained should be considered as a waste stream first and foremost. Poorly stored or handled cylinders & tanks may certainly be subject to leakage. However, applying an assumption that all are emissive is incorrect. Creating a measured leak baseline for a stockpile is also difficult given leaks are often catastrophic in nature (i.e. they are not always gradual or linear). In short, crediting a potential future HFC release from a stockpile is generating a 'maybe' ton, which is often traded for the release of a definite CO₂ ton today. If mitigation contributions are used instead of offsets (i.e., a company invests in HFC destruction for value chain impact as opposed to offsets) then the need to establish the same level of baseline accuracy for stockpiles is not as important.

Initial Text (lines 215 – 225):

“For HFC refrigerants the realistic and credible alternative(s) may include, *inter alia*

- R1 Project activity not performed as emission reduction project
- R2 Products are disposed of into an incineration facility and thereby HFC refrigerants are destroyed
- R3 Atmospheric release of the HFC refrigerant or partial capture and destruction
- R4 Atmospheric release of the HFC refrigerant or partial capture and reuse in existing products or continued storage in stockpile
- R5 Products partially or entirely remain installed in existing equipment.

The methodology is only applicable for HFC refrigerants if the most plausible baseline scenario for the HFC refrigerant is either R3 or R4 or a combination of both.”

Response: We thank the reviewer for this comment. In response to this feedback, we investigated the likelihood of emissions from stockpiles and temporal concerns associated with the issuance of credits compared with their associated emissions reductions. This investigation led us to remove stockpile eligibility. In Methodology version 2.0, R4 now reads:

“For HFC refrigerants the realistic and credible alternative(s) may include, inter alia

- R1 Project activity not performed as emission reduction project*
- R2 Products are disposed of into an incineration facility and thereby HFC refrigerants are destroyed*

- R3 Atmospheric release of the HFC refrigerant or partial capture and destruction*
- R4 Atmospheric release of the HFC refrigerant or partial capture and reuse in existing products*
- R5 Products partially or entirely remain installed in existing equipment.*

The methodology is only applicable for HFC refrigerants if the most plausible baseline scenario for the HFC refrigerant is either R3 or R4 or a combination of both.”

Other mentions of stockpile eligibility have also been removed from the methodology in our version 2.0.

Before reaching this conclusion, we first revisited the foundational methodology from which we based our initial decision to include stockpiles — Destruction of Ozone-Depleting Substances (ODS) and High GWP-Foam methodology.²

The rationale for crediting the destruction of stockpiled ODS in ACR’s methodology is that the ODS leaks from the containers in which it is stored. Leaks occur in two ways. First, gas can leak out of cylinders slowly over time. Second, gas can leak out of cylinders all at once in a catastrophic leak event such as a cylinder puncture or valve failure. These leaks often occur in situations where cylinders of ODS have been exposed to weather, moisture, or extreme temperatures.

ODS and high-GWP foam destruction are typically understood to be highly permanent and additional project activities, but their quantification strategies are more contested. The environmental value of these projects is in avoiding emissions that have *not yet but will almost certainly occur* in the future – thus making it difficult to forecast and conservatively quantify emissions over a reasonable time horizon.

Previously, ACR dealt with this uncertainty about how and when emissions will occur by assuming that the baseline scenario for ODS sources was not stockpiling but rather reclamation and reuse in equipment. Leak rates are generally more predictable for gases in operating equipment than for gases in stockpiles. Using standard estimates for leak rates of different gases based on their primary uses, the ACR methodology calculated that most of the ODS destroyed in the project scenario (between 70% and 95%) could be expected to leak from equipment over 10 years in the baseline scenario. As a further conservative measure, ACR included a "substitute emissions" penalty in the project scenario, for the emissions in equipment that could be expected from the gas substituting the gas destroyed. These arguments also underpin the quantification methods for similar methodologies from Verra, Climate Action Reserve, and the California Air Resources Board.

² American Carbon Registry, “Destruction of Ozone Depleting Substances and High-GWP Foam Version 2.0” (American Carbon Registry, March 1, 2023), <https://acrcarbon.org/methodology/destruction-of-ozone-depleting-substances-and-high-gwp-foam/>.

ACR eliminated these parameters in version 2.0 of their methodology, such that project developers are credited for 100% of the gas they destroy and are not penalized for substitute emissions. Several factors appear to have prompted ACR's decision to eliminate these discounting parameters. First, ACR changed its conception of the baseline case for ODS from "continued use in existing equipment" to stockpiling. This change in the baseline case likely arose from published data on refrigerant reclamation volumes from EPA, which show steady declines in the amount of ODS being recovered and reclaimed each year.³ These data could support the argument that ODS is increasingly being stockpiled or vented to the atmosphere, rather than being reused in equipment. Second, methodology peer reviewers agreed with ACR that stockpiled ODS would eventually be emitted, helping to rationalize crediting expansion.

One criticism of this revised approach that has been raised (including by the commenter above) is that probable, eventual emissions (*i.e.*, emissions being prevented in the project activity) should not always be treated as fungible with certain, present emissions (*i.e.*, emissions being offset by the project activity). The timescales over which ODS is emitted from a stockpile could be next year, or, with good cylinder maintenance and storage practices, several decades to centuries. As the commenter above notes, future avoided emissions — even if highly probable or certain — do not counterbalance continued emissions today. Yet a carbon credit buyer could purchase and retire stockpile credits today to make a net zero claim based on far-future emissions reductions.

This temporal mismatch between credit vintage and the "true" date of the associated emissions reduction does not necessarily mean that stockpile credits are inherently fraudulent or low-quality. However, if buyers use credits to become net zero, it requires a rigorous quantification of what the counterfactual, or business-as-usual, in the absence of the project activity would be. Therefore, we agree with the commenter that this is more an issue of timing and amounts of emissions that are justified by the purchase of a carbon credit, rather than a fundamental flaw in the underlying methodology, as we believe that ACR is correct in asserting that 100% of gas stockpiled will "eventually" reach the atmosphere unless destroyed. This question around the timing of credit generation is one that is attracting significant attention in the carbon removal space (including with nature-based solutions and Biomass Carbon Removal and Storage), as it can have significant effects on cumulative radiative forcing at the aggregate level.

However, to err on the side of conservatism, and especially given that HFCs are still widely produced and consumed, we believe it is safer to restrict the eligibility of the methodology to cases where baseline emissions would have occurred *during or before* the credit vintage year: in other words, to restrict eligibility to the recovery and disposal at equipment end-of-life where the baseline is intentional venting. We reflected this change by removing stockpile eligibility from our version 2.0.

³ Office of Air and Radiation Environmental Protection Agency, "Summary of Refrigerant Reclamation Trends," Data and Tools, November 28, 2023, <https://www.epa.gov/section608/summary-refrigerant-reclamation-trends>.

Topic: REGULATORY DEFINITION OF ADDITIONALITY

Comment #1: If there is a venting prohibition on HFCs in place, then the methodology cannot be considered additional.

Comment #2: The additionality conditions could be updated according to guidance from the section of ICVCM's CCP Assessment Framework on existing host country legal requirements, which require authoritative and up-to-date information of nonenforcement for regulation to be deemed unenforced.

Initial Text (lines 261-279):

"Projects that meet all the applicability conditions in Section 4 of this methodology, as well as the following requirements, are deemed additional.

- 1) The project activity consists of the collection, aggregation, and destruction of HFC refrigerants recovered at equipment end-of-life or during servicing in which venting would otherwise occur. Government seizures of illegal shipments are also an approved source insofar as seized refrigerants are turned over to project developers for the express purpose of destruction. When refrigerant is recovered from equipment, the project proponent must distinguish between refrigerant recovered at equipment end-of-life and during equipment servicing. In the latter case, the project proponent must provide documentation regarding the service call, and demonstrate the following:
 - (a) Evacuation of refrigerant from the equipment was required or is common practice before such servicing; and
 - (b) Onsite recycling of the recovered refrigerant and refilling of the serviced equipment was not feasible.
- 2) The project activity does not consist of the destruction of HFCs from, or as part of, a product stewardship scheme or other program incentivizing HFC recovery as an industry common practice. At validation, the project proponent must provide a description of any schemes or programs designed to incentivize HFC recovery, reclamation, or destruction in the jurisdictions in which the refrigerant is collected."

Response: We thank the commenters for their perspective. During the process of circulating our methodology, we heard frequent concerns about additionality, given that refrigerant recovery is often nominally mandated by domestic regulations. However, as we explain below, we believe that the current, prevailing understanding of additionality allows for nominally regulated project activities, insofar as they occur in developing countries with evidence on unenforced regulations. In the context of this methodology, issuing credits from HFC recovery and destruction would be considered additional in Article 5 countries with venting prohibitions, if there is evidence that the prohibitions are not being enforced.

To address this concern, we consulted the Integrity Council on the Voluntary Carbon Market’s (ICVCM) 2024 Core Carbon Principles (CCPs).⁴ The ICVCM CCPs aim to become a benchmark for credit quality in the voluntary carbon market. On page 74 of their CCPs, ICVCM writes:

“In addition to CORSIA requirements related to additionality, the carbon-crediting program shall:

- 1. ensure that the mitigation activity is registered only if the resulting carbon credits represent emission reductions or removals that exceed those required due to relevant legal requirements that are enforced. For high-income countries, all legal requirements shall be deemed to be enforced. For countries other than high-income countries, legal requirements shall only be deemed to be unenforced based on authoritative and up-to-date information of nonenforcement that is relevant and applicable to the mitigation activity;*
- 2. require that the evaluation of 1) above to be conducted either by the mitigation activity proponents and be validated by a VVB and/or the carbon-crediting program. The evaluation shall be conducted:*
 - i. prior to the registration of the mitigation activity; and*
 - ii. at an appropriate frequency thereafter, for example, at each renewal of a crediting period or at every verification where the crediting period is longer than five years.”*

The relevant section regarding additionality states that for “**countries other than high-income countries, legal requirements shall only be deemed to be unenforced based on authoritative and up-to-date information of nonenforcement that is relevant and applicable to the mitigation activity.**” We believe that ICVCM’s understanding of additionality aligns closely with the one presented in our methodology and white paper. In these documents, we argue that refrigerant venting is indisputably the baseline practice in Article 5 countries, substantiated further with interviews with technical experts, methodology writers, policymakers, and our own field research in Article 5 countries. We also remind readers that version 1.0 methodology discounts crediting in line with low but non-zero recovery rates. This quantification strategy has rolled over into version 2.0.

Topic: DOWNRAMP FOR CARBON CREDITING

Comment: Care should be taken to ensure that the methodology does not discourage the adoption of regulation, such as EPR or product stewardship schemes.

Response: We thank the reviewer for their comment. We agree in concept that effective extended producer responsibility (EPR) policies or product stewardship are preferable to carbon crediting schemes. EPR and product stewardship could achieve significant emissions reductions while not resulting in a corresponding offsetting claim. We are aware of early-stage work, particularly in the

⁴ ICVCM, “Section 4: Assessment Framework” (ICVCM, April 2024), <https://icvcm.org/wp-content/uploads/2024/05/CCP-Section-4-V3-FINAL-10May24.pdf>.

Paris Agreement Article 6 framework, to use carbon credits to finance the initial build-out of refrigerant recovery infrastructure, with a plan to transition from crediting to regulation after a defined period. We are interested in contributing to these efforts and in tracking their success. We continue to believe in the usefulness of methodologically robust carbon crediting to develop the reverse supply chain for recovered refrigerant. We believe that it is more appropriate for registries or country regulators to determine how/whether credits can phase into regulation.

As for our methodology, we do include the following text (Lines 316-324, version 1.0): “When recovery of the HFC refrigerants by the project activity is mandated by law, statute or other regulatory framework applying in the host country, and this mandate is demonstrably enforced, the baseline shall be the gradually increasing compliance with such law, statute or other regulatory framework, and the baseline GHG emissions shall be calculated as follows:

$$BE_{HFC_{ref,y,a}} = BE_{HFC_{ref,y}} \times (1 - CR_y)$$

Where:

$BE_{HFC_{ref,y,a}}$ = Adjusted baseline emissions to be used for the calculation of emission reductions in year y [tCO₂e]

$BE_{HFC_{ref,y}}$ = Baseline emissions from HFC refrigerants which would be released into the atmosphere in the absence of the project activity in year y [tCO₂e]

CR_y = Host country-level compliance rate of the law, statute, or other regulatory framework in the year y . Calculation of the compliance rate shall exclude other projects implemented under GHG programs. If the compliance rate exceeds 50% (0.50), the project shall receive no further credit.

We welcome any comments or critiques for how this methodology, or the Carbon Containment Lab, could better support the implementation of EPR policies or product stewardship schemes. Ultimately, our goal is to create sustainable business models for HFC recovery, which can be ultimately financed via a range of mechanisms, from carbon markets to EPR.

Topic: ESTABLISHING BASELINES

Comment: The methodology should provide more guidance on how to robustly define and secure confidence in baselines. For example, the methodology could propose a procedure for gathering evidence on baseline practice, including listing necessary data and testimonials, or requiring a third-party survey to confirm business-as-usual practice.

Response: Thank you – this is a particularly important comment. In our updated methodology, we add guidance on the collection of data for baselines and provide several tests that project developers

could potentially use to gain confidence in business-as-usual practice. However, we contend that a registry or VVB should provide final guidance on required evidence to establish the baseline.

First, we propose that project developers show evidence for baseline emissions by:

- Demonstrating a lack of in-country destruction facilities and reclamation infrastructure, or refrigerant recovery rates in the market measurably below 50% (acknowledging that version 2.0 of the methodology accounts for non-zero recovery rates); and
- Showing that insignificant volumes of recovered refrigerant are being exported from the country for reclamation or destruction.

Project developers may also establish evidence for baselines by:

- Providing evidence that a country does not have a venting prohibition in place for ODS and/or HFCs and no policies and tools to recover refrigerant at scale; or
- Obtaining an attestation from the National Ozone Officer or a relevant government office that a venting prohibition, if in place, is not enforced and that refrigerant venting is baseline practice.

Looking forward, we believe that registries, NGOs and third parties, or another independent body should maintain up-to-date data on refrigerant recovery rates on a country-level basis. These data would streamline project eligibility. In providing this guidance, we acknowledge that establishing refrigerant venting as business-as-usual practice has inherent difficulties. If a country has a nominal venting prohibition, policymakers tend to be reluctant to admit that venting is baseline practice. Furthermore, because venting is indeed business-as-usual practice in most countries, data on refrigerant recovery rates, reclamation, and destruction are often difficult to obtain. We continue to be interested in receiving input about how baselines can be established more confidently, especially as countries improve the granularity of data collection for compliance with the Kigali Amendment and their Nationally Determined Contributions.

These recommendations are presented in lines 253 - 263 of version 2.0 of our methodology.

Topic: TEAP CERTIFICATION

Comment: Do approved destruction facilities have to meet co-pollutant emissions guidelines that are in the TEAP report? Is it okay if facilities satisfy national standards?

Initial Text (lines 660-663): “Destruction of HFCs must occur at a facility that has a valid host country permit for refrigerant destruction and meets the screening criteria for destruction technologies set out in the report, as may be updated from time to time, by the

UNEP Technology and Economic Assessment Panel (TEAP) Task Force on Destruction Technologies.”

Response: After we published version 1 of our methodology, we became aware of widespread confusion among project developers about “TEAP certification” as a requirement for facilities destroying ODS or HFCs for carbon credits. Specifically, the Montreal Protocol Technology and Economic Assessment Panel (TEAP) has previously established destruction removal efficiency and emissions criteria for facilities that destroy HFCs and ODS. These standards have been adopted by existing voluntary market methodologies.

In some cases, however, project developers may have access to a destruction technology, such as a cement kiln, that destroys refrigerant at TEAP-required removal efficiencies, but that emits co-pollutants (such as particulate matter) above levels included in TEAP’s report. There was previously ambiguity about whether these facilities would be eligible to destroy fluorocarbons under the methodology. We believe that these cases are particularly common for Article 5 countries that have less stringent air pollutant regulations than non- Article 5 countries.

It is important to note that TEAP’s list of destruction technologies applies narrowly for the purposes of Article 7 data reporting and for the destruction of HFC-23 under Article 2J. Article 7 reporting requires, among other things, for countries to report the quantity of controlled substances destroyed and accounted for within the Montreal Protocol’s definition of “production.” Parties are explicitly allowed to manufacture or import an amounts of controlled substances equivalent to the quantity of controlled substances destroyed using an approved technology, within the same year as destruction, within the same group of substances.⁵ Importantly, TEAP is also clear that in meeting any broader (non- Article 7) needs for destruction (e.g., destruction for credits on the voluntary carbon market), parties are free to apply technologies, whether on the approved list or not, that satisfy national regulatory standards and TEAP destruction removal efficiency requirements.⁶ **Thus, in the case described above, the hypothetical cement kiln would be appropriate for destruction for the voluntary carbon market, if it satisfies national emissions standards and DRE requirements.**

We have now included wording to clarify this point in version 2.0 of the methodology (lines 599 - 601).

⁵ TEAP, “Medical and Chemical Technical Options Committee 2022 Assessment Report,” Assessment Report (UNEP, December 2022), <https://ozone.unep.org/system/files/documents/MCTOC-Assessment-Report-2022.pdf>.

⁶ TEAP, “Medical and Chemical Technical Options Committee 2018 Assessment Report” (UNEP, December 2018), <https://ozone.unep.org/sites/default/files/2019-04/MCTOC-Assessment-Report-2018.pdf>.

Topic: REFRIGERANT RECLAMATION AND CONSEQUENCES OF DESTRUCTION

Comment #1: The methodology should include HFC reclamation and resale as an eligible activity alongside or instead of destruction. Reclaiming and reusing refrigerant displaces demand for virgin refrigerant, thereby decreasing an equivalent amount of production and emissions. Furthermore, given that HFC production is still ongoing and widespread, destroying HFCs merely effectuates the production of more virgin gas. Refrigerant reclamation is therefore the preferable climate solution. In fact, there is no point in destroying HFCs until they are no longer being produced.

Comment #2: HFCs should not be destroyed until the tap (new production) is completely turned off.

Response: We thank the reviewers for their perspective, which is representative of much feedback we received before and after the publication of our initial draft methodology. These comment makes two main claims: first, that refrigerant reclamation and resale displaces virgin production, which can be quantified for a carbon credit; and second, that destruction of HFCs must necessarily effectuate new production if HFCs are not completely phased out.

We agree that refrigerant reclamation is an important pillar of Lifecycle Refrigerant Management (LRM), which in some cases can generate emissions reductions from decreased demand for virgin material. We also agree that crediting the destruction of HFCs poses the risk of effectuating more virgin production, particularly early in phasedown schedules. However, for reasons detailed below, we have decided to maintain eligibility for destruction while not expanding eligibility to reclamation.

I. Reclamation and the Displacement of Virgin Production

To our knowledge, there are two existing methodologies that credit the recovery and/or reclamation of refrigerants. The first and most significant methodology is the American Carbon Registry's Certified Reclaimed HFC Refrigerants, Propellants, and Fire Suppressants methodology.⁷ This methodology, which is limited to the United States, Canada, and Mexico, has issued approximately 8.9 million credits, about 6 percent of which have been retired as of early 2024.⁸ The other

⁷ American Carbon Registry, "Certified Reclaimed HFC Refrigerants, Propellants, and Fire Suppressants," *ACR* (blog), April 14, 2022, <https://acrcarbon.org/methodology/certified-reclaimed-hfc-refrigerants-propellants-and-fire-suppressants/>.

⁸ Berkeley Carbon Trading Project, "Berkeley Carbon Trading Project's Voluntary Registry Offsets Database," January 31, 2023, <https://gspp.berkeley.edu/research-and-impact/centers/cepp/projects/berkeley-carbon-trading-project/offsets-database>.

methodology is for a collaboration between South Korea and Vietnam via the Paris Agreement's Article 6.2 Mechanism, aiming to reduce 30,000 tCO₂e a year.⁹

When refrigerant is recovered, reclaimed, and recharged into equipment, it can be expected to leak back into the atmosphere. Therefore, existing reclamation methodologies do not credit projects for preventing the emission of the gas they recover and reclaim. Rather, as the commenter notes, they assume that reclaimed fluorocarbons, when sold into the market, permanently displace demand for virgin fluorocarbons.

Indeed, refrigerant reclamation, in certain market contexts and at high enough volumes, can theoretically displace demand for virgin refrigerant gases and create strong financial incentives for refrigerant recovery. These benefits make refrigerant reclamation an important tool in executing HFC phasedown policies. However, the precise effect of reclamation on virgin production is difficult to measure and not necessarily one-to-one. While displacement of demand may be true on a micro basis (for an individual end user, for example), it is not necessarily true on a macro basis (for the entire market). In many cases, reclamation primarily plays a role in meeting excess demand for fluorocarbons in markets in which demand for fluorocarbons remains high.

Such an elastic model is not supported by the limited data on reclamation rates in the United States, where most reclamation credits have been issued. In 2022, the earliest year for which consumption allowance expenditure data are available, regulated entities expended 271.7 million of 273.5 million allocated allowances. In other words, regulated entities left only 0.65 percent or **1.8 million allowances** unused.¹⁰ Meanwhile, EPA reported 7.5 million pounds (**7.2 million MTCO₂e**) of reclaimed HFCs in 2022.¹¹ U.S. project developers generated over **3.9 million credits** from ACR's reclamation methodology with a 2022 vintage year.¹² Since the gap between allocated and expended allowances is only 1.8 million, refrigerant reclamation could not have displaced the virgin production or import of 3.9 million MTCO₂e in 2022. If reclaimed HFCs were displacing virgin supply in the year of the credit issuance, the number of issued credits would be at most the number of unused allowances in the market.

Even if consumption expenditures were far below quotas, there would be insufficient causal evidence to conclude that this is solely the result of reclamation. For example, a large economic downturn might reduce demand for fluorocarbons, resulting in excess consumption allowances. An aggressive

⁹ VWS, "ECOYEYE-VWS Signs MOU for Application for Waste Refrigerant Recovery and Reclamation," Press Release, accessed May 6, 2024, <https://v-ws.com.vn/ecoeye-vws-signs-mou-for-application-to-wastere-frigerant-recovery-and-rectamation-refrigerant-charge-business/>.

¹⁰ Environmental Protection Agency and Office of Air and Radiation, "HFC Data Hub," Other Policies and Guidance, September 28, 2023, <https://www.epa.gov/climate-hfcs-reduction/hfc-data-hub>.

¹¹ Environmental Protection Agency, "Summary of Refrigerant Reclamation Trends."

¹² American Carbon Registry, "ACR Issuance Registry," Issued Credits, May 6, 2024, <https://acr2.apx.com/myModule/rpt/myrpt.asp?r=112>.

transition to low-Global Warming Potential refrigerants would also reduce demand for HFCs. These factors are additional forces that could affect virgin fluorocarbon supply. It is therefore extremely challenging to disaggregate these factors to determine the true contribution of refrigerant reclamation to displaced demand at the macro level.

One may argue that, even if reclamation and resale each year do not displace virgin production in that same year, they may still do so in some indeterminate future year. However, this *ex ante* emissions reduction is in conflict with the Integrity Council on the Voluntary Carbon Market's (ICVCM) 2024 Core Carbon Principles (CCPs),¹³ which we have used as an informal guidepost for methodology quality. Furthermore, ACR defines the "vintage" of a carbon credit as "the calendar year in which a GHG emission reduction or removal is verified to have occurred" in their ACR Standard (version 8.0).¹⁴ Therefore, this claim would be incompatible with the methodology itself.

Our concerns around displacement and quantification have made us reticent to develop a reclamation methodology.

II. Destruction and the Effectuation of Virgin Production

As the reviewer notes, there are circumstances under which destruction of HFCs can effectuate virgin production. To our knowledge, concern about linkages between destruction and virgin production arise from three sources.

Concern #1: Country-level

The first concern is on the country level and relates to how individual countries calculate and allocate production allowances. Specifically, the Kigali Amendment to the Montreal Protocol requires countries to report baseline production and consumption, from which HFC phasedown limits are calculated.

$$Production = CS_{Produced} - CS_{Destroyed} - CS_{Feedstock} \quad (\text{Equation 1})$$

$$Consumption = Production + Imports - Exports \quad (\text{Equation 2})$$

where *CS* or "controlled substance" refers to a substance in Annex A, B, C, E or F to the Montreal Protocol, whether existing alone or in a mixture. Substituting equation (1) into equation (2) yields the following consumption equation:

¹³ ICVCM, "Section 4: Assessment Framework."

¹⁴ American Carbon Registry, "The ACR Standard: Requirements and Specifications for the Quantification, Monitoring, Reporting, Verification, and Registration of Project-Based GHG Emissions Reductions and Removals" (American Carbon Registry, July 2028), <https://acrcarbon.org/wp-content/uploads/2023/10/ACR-Standard-v8.0.pdf>.

$$\text{Consumption} = CS_{\text{Produced}} - CS_{\text{Destroyed}} - CS_{\text{Feedstock}} + \text{Imports} - \text{Exports}$$

(Equation 3)

Because destruction is subtracted from production in both baseline and stepdown calculations, the main concern is whether destruction of refrigerants in countries already in phasedown effectuate an equal magnitude of increase in production (or imports).

For example, consider the following scenarios:

Producing Country A

- Imagine the baseline consumption level for Country A has already been set to 100 MTCO_{2e}
- In the first stepdown period, Country A is required to reduce their consumption by 15%, so their allowable consumption in the first stepdown period is 85 MTCO_{2e}
- They can achieve this stepdown by reducing the amount of HFC produced by 15 MTCO_{2e} (desired result), **or** they can destroy an existing 15 MTCO_{2e} of HFC that is recovered from equipment
- In this case, destroying 15 MTCO_{2e} increases the allowable production amount from 85 MTCO_{2e} (in the absence of destruction) to 100 MTCO_{2e}

Importing Country B

- Assume Country B has no production or exports and follows the same phasedown schedule as Country A
- Country B can similarly achieve stepdown by reducing the amount of HFC imported by 15 MTCO_{2e} (desired result), **or** they can destroy an existing 15 MTCO_{2e} of HFC that is recovered from equipment
- If the imported HFC comes from Country C which has not yet set its baseline (e.g., India or other HFC-producing Article 5 Group 2 country), Country C could increase its production to supply the additional imports permitted by the destruction in Country B
- In this case, Country B's increased import (15 MTCO_{2e}) can effectuate an increase in the baseline of Country C, which affects the Country C's production not just in the baseline year but for all subsequent stepdowns

Both scenarios lead to increased production of refrigerants that would otherwise not have been permitted in the absence of destruction. Given that the GWP of the virgin gas is comparable (or identical) to that of the destroyed gas, this effect substantially reduces the impact and desired outcome of the methodology.

As such, we sought clarification from the Ozone Secretariat on whether these scenarios were realistic. The Secretariat provided clarity and a pathway for safeguarding against the above

scenarios. First, the Secretariat outlined scenarios that could feasibly lead to negative outcomes: production quotas are set for manufacturers at the country level, so a country could, in theory, estimate and/or keep track of destruction throughout the year and continuously increase the quotas of national manufacturers to mirror the volumes of destruction occurring.

However, the Secretariat noted that such a scheme would require an improbable deal of oversight, planning, and motivation to increase production. Further, they knew of neither any instances in which a country anticipated destruction or adjusted quotas in the allocation of allowances, nor any in which a country would have exceeded its allowance cap but for destroyed refrigerant each year.

To test this hypothesis, the Secretariat analyzed past reported data to see if destruction was the basis for compliance by any Article 5 party for the years 1986 to 2022, inclusive of all controlled substances. They found the following:

- 1. One A5 country with regular annual by-production of CTC, all of which gets destroyed within the year. This happens in a similar fashion for NON-Article 5 parties and would not count as using destruction to boost production.*
- 2. One A5 country with one year in which a small amount of destruction of Halon helped the country comply with the Montreal Protocol. The amount destroyed is considered small because it is about 0.1% of the total production reported by that country in that year.*

The Secretariat concluded that *“as per my indication during our teleconference, we do not seem to have cases of countries using destruction to boost their annual production or consumption”* (Mr. Gerald Mutisya; March 28, 2023). Since countries must report these data to the Ozone Secretariat to achieve compliance, this required transparency in country is itself a safeguard against overcrediting. If countries use destruction to achieve compliance, credits should be discounted (by excess over the cap) or the country can be removed from eligibility. Moreover, production and consumption allowances reset annually, so there is no risk of a previous year’s destruction affecting the following year’s production. Thus, one alternative approach to safeguard against increasing quotas would be to destroy all recovered refrigerant at end of year or to simply report substances destroyed on an annual basis (provided this is compliant with local or host country regulation).

Ultimately, our due diligence has helped build our confidence that this methodology will incentivize collection of HFCs that would have otherwise been vented, with clear safeguards against adversely affecting production or consumption phasedowns.

Concern #2: Market-level

Moving from county-level to market-level, the second concern with destruction is around how markets will respond to destruction if the baseline practice is refrigerant recovery and reclamation. If recovery and reclamation is indeed the baseline, destroying HFCs could effectuate an increase in virgin production to meet market demand. However, as we discuss extensively above, there is strong evidence to suggest that the baseline practice is refrigerant venting in Article 5 countries. We additionally propose a quantification methodology that accounts for non-zero refrigerant recovery and reclamation rates, to ensure conservative quantification.

Concern #3: Project-level

Finally, the third concern with destruction is on the level of the project developer and is around the difficulty of preventing nefarious, fraudulent activity. This fear dates back to the Kyoto Protocol's Clean Development Mechanism (CDM) crediting the destruction of HFC-23.

HFC-23, a greenhouse gas controlled by the Kyoto Protocol, is an unwanted byproduct of HCFC-22 production. The CDM protocol intended to incentivize fluorocarbon manufacturers to capture HFC-23 from their existing production of HCFC-22. Unfortunately, certain manufacturers responded by increasing HCFC-22 production, for the sole purpose of generating carbon credits from HFC-23 destruction. These fraudulent projects made windfall profits while increasing emissions harmful to the climate and ozone layer.¹⁵

Stakeholders have frequently cited this failure as a primary reason why other HFC destruction methodologies have been slow to reach publication. However, the refrigerant sources eligible under our Methodology version 2.0 and previous iterations — *i.e.*, used cooling equipment — are entirely different from the industrial process that was covered by the CDM protocol. As such, the baseline calculations, additionality arguments, and verification requirements within this methodology share little with those utilized by the CDM. Although both protocols describe HFC destruction, the two should not be conflated.

Nevertheless, we believe that our Draft Methodology should undergo rigorous vetting for perverse incentives, as discussed in Section 4.III of our white paper, “Documenting Recoveries to Improve Credit Legitimacy.” In the white paper, we discuss documentation requirements for refrigerant recoveries, which far exceed the rigor of requirements for recovery ODS on major voluntary carbon market registries. These requirements ensure that the HFCs being destroyed were legitimately recovered.

We welcome further suggestions for enhancing safeguards to prevent fraudulent activity.

¹⁵ David Doniger, “The Curious Case of HFC-23,” Natural Resources Defense Council, November 11, 2010, <https://www.nrdc.org/experts/david-doniger/curious-case-hfc-23>.

Concluding Thoughts & Next Steps

We are incredibly grateful to the expert peer reviewers and the public for providing several rounds of thoughtful, critical, and constructive feedback. This feedback, as discussed above, has led to substantive changes in the methodology that we believe makes it more rigorous and impactful.

We maintain that the rigor of both the methodology and its accompanying process warrants inclusion on a major carbon market registry. Currently, no voluntary market registry supports HFC recovery and destruction on a significant basis, creating an obstacle to project finance. HFC recovery continues to be an unsolved problem, in both the developed and developing world.

The CC Lab continues to have no financial stake in the carbon market. Our choice to write this methodology was and continues to be motivated by our desire to fill gaps in the carbon market with independent, rigorous, and well-researched methodologies. We encourage any registry personnel, project developers, or other stakeholders in this area to reach out to us if you have any desire to learn more or get involved.

For anyone interested in collaborating further or submitting comments on version 2.0, please email us at info@cclab.org and include in the subject line: “Collaboration on Draft HFC Methodology Version 2.0.”

1 Methodology

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4 Recovery and Destruction of Hydrofluorocarbon
5 Refrigerant Gases in Article 5 Countries

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6 April 2023

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16 Prepared by:

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19

20 **Yale Carbon Containment Lab**

21 83-87 Audubon St.

22 New Haven, CT 06510

23 <https://carboncontainmentlab.yale.edu/>

24

25 Authors: Charlie Mayhew¹⁶, Tilden Chao, Sinead Crotty, Eleri Phillips,
26 Anastasia O'Rourke, and Dean Takahashi

27

28

29 *Developed as a set of revisions to Verra Methodology VM0016, Recovery and*
30 *Destruction of Ozone-Depleting Substances (ODS) from Products, v1.1.*

¹⁶ Corresponding author: Charlie Mayhew; email: charlie.mayhew@yale.edu

31 Disclaimer

32
33 This draft methodology for the recovery and destruction of HFC refrigerants in Article 5 countries was written as a
34 set of revisions to the existing Verra Carbon Standard methodology VM0016 v1.1, developed by USG Umweltservice
35 GmbH and Energy Changes Projektentwicklung GmbH, assessed by TÜV SÜD Industrie Service GmbH and Bureau
36 Veritas Certification Holdings SAS, and approved for project development on November 30, 2017.

37
38 The development of this set of revisions was carried out by the Yale Carbon Containment Lab, independently from
39 Verra Carbon Standard or the original authors and assessors of VM0016 v1.1 (or v1.0). This draft methodology
40 cannot be used to certify carbon credits for the Verra registry, or any other registry named within.

41
42 This draft methodology has been through one round of peer review. Prior to publishing, this methodology will go
43 through a second round of peer review, followed by a formal assessment by a verification body to ensure that the
44 process can be verified. The Yale Carbon Containment Lab welcomes all comment on this document, from project
45 developers, certification bodies, regulators, and any other stakeholders.

46

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67			

68 **1 SOURCES**

69 This methodology refers to the latest version of the following approved methodologies and standards:
70

- 71 • Verra (VCS) methodology *VM0016 Recovery and Destruction of Ozone-Depleting*
- 72 *Substances*
- 73 • *VCS Standard*
- 74 • Climate Action Reserve (CAR) methodology *U.S. Ozone Depleting Substances Project*
- 75 *Protocol, Destruction of U.S. Ozone Depleting Substances Banks*
- 76 • Climate Action Reserve (CAR) methodology *Article 5 Ozone Depleting Substances Project*
- 77 *Protocol, Destruction of Article 5 Ozone Depleting Substances Banks*

78 This methodology refers to the latest version of the following approved tools and modules:
79

- 80 • CDM tool *Tool for the demonstration and assessment of additionality*
- 81 • CDM tool *Tool to calculate the emission factor for an electricity system*
- 82 • VCS module *VMD0048 Activity method for the determination of additionality for recovered and*
- 83 *stockpiled ODS refrigerant projects*

84 The following have also informed the development of the methodology:
85

- 86 • American Carbon Registry (ACR) methodology *Destruction of Ozone Depleting*
- 87 *Substances from International Sources*
- 88 • CDM tool *Tool to calculate project or leakage CO₂ emissions from fossil fuel combustion*
- 89 • CDM tool *Tool to calculate baseline, project and/or leakage emissions from electricity*
- 90 *consumption and monitoring of electricity generation*
- 91 • *UNEP Technology and Economic Assessment Panel (TEAP) Report of the Task Force on*
- 92 *Destruction Technologies, UNEP, 2002.*
- 93 • *UNEP TEAP, April 2018 Report, Vol. 2: Decision XXIX/4 Task Force Report on Destruction*
- 94 *Technologies for Controlled Substances, UNEP, 2018.*

95 **2 SUMMARY DESCRIPTION OF THE METHODOLOGY**

Additionality and Crediting Method	
Additionality	Project
Crediting Baseline	Project

98 Building upon previous ODS destruction methodologies, this methodology quantifies the GHG
99 emission reductions from activities that recover and destroy hydrofluorocarbons (HFC) from
100 products where a partial or total atmospheric release of HFCs occurs in the baseline scenario. This
101 methodology is applicable to HFCs recovered from equipment within Montreal Protocol Article 5
102

103 countries. While not explicitly stated throughout, all project activities are relevant and applicable to
104 eligible ODS refrigerants, inclusive of HCFCs.

105

106 **3 DEFINITIONS**

107

108 In addition to the definitions set out in VCS document *Program Definitions*, the following definitions
109 and acronyms apply to this methodology.

110

Hydrofluorocarbon (HFC)

111

112 A family of man-made compounds that contain carbon, fluorine, and hydrogen. Although HFCs do not
113 deplete stratospheric ozone, many are Greenhouse Gases (GHGs) with high Global Warming Potentials
(GWPs). The Kigali Amendment to the Montreal Protocol governs a global phasedown of HFC production.

114

HFC refrigerant

115

116 A chemical (being an HFC) used or intended for use in a cooling mechanism, such as an air
117 conditioner or refrigerator, as the heat carrier which changes from gas to liquid and then back to gas
in the refrigeration cycle.

118

Article 5 Country

119

120 Any party to the Montreal Protocol that is a developing country and whose annual calculated level of
121 consumption of the controlled substances in Annex A (of the Montreal Protocol) is less than 0.3
122 kilograms per capita. Article 5 countries are separated into two groups. Group 1 is the majority of
123 Article 5 countries, while Group 2 is composed of Bahrain, India, Iran, Kuwait, Oman, Pakistan, Qatar,
124 Saudi Arabia, and the United Arab Emirates. Group 2 countries have a delayed freeze (2028 compared
with 2024) and phasedown schedule.

125

Non-Article 5 Country

126

Any party to the Montreal Protocol which is not an Article 5 country.

127

Product

128

Any of the following: refrigeration, air conditioning or fire suppression equipment, systems or appliances.

129

Recovery

130

To remove refrigerant in any condition from a product and store it in an external container.

131

Recovery Site

132

133 The location where the project proponent recovers HFCs from appliances, including stationary
equipment such as a chiller, or obtains appliances from which HFCs are to be recovered.

134

Aggregation

135

The collection of HFC refrigerant in any condition in a centralized holding location. Aggregation can

136 include the combining of HFC refrigerants in a single container or refer to the storage of multiple
137 containers in a single location.

138 **Aggregation Facility**

139 Any facility in which HFC refrigerant or products containing HFC refrigerant are aggregated or stored for the
140 purposes of the project activity, additional to the recovery site. Aggregation facilities are not a requirement of
141 the full system (i.e., recovered HFC refrigerant can be transported directly to the destruction facility).

142 **Destruction Facility**

143 The facility where the destruction of the HFC refrigerant takes place and which meets the screening
144 criteria for destruction technologies set out in the report, as may be updated from time to time, by
145 the UNEP Technology and Economic Assessment Panel (TEAP) Task Force on Destruction
146 Technologies. *UNEP Technology and Economic Assessment Panel (TEAP) Report of the Task Force on
147 Destruction Technologies*, UNEP, 2002.

148 **Recycle**

149 To extract refrigerants from an appliance and clean them using oil separation and single or multiple
150 passes through filter-driers, which reduce moisture, acidity, and particulate matter.

151 **Reclaim**

152 To reprocess used HFC refrigerants, typically by distillation, to specifications that meet or exceed
153 virgin product specifications with the objective of reusing the refrigerant.

154 **Venting**

155 To directly release a chemical to the atmosphere. In the case of HFC refrigerants, venting refers to
156 the process whereby HFC is directly released to the atmosphere during the servicing of or at the
157 end-of-life of a product.

158 **Leakage**

159 A scenario that arises when efforts to reduce fossil fuel or other emissions in one place simply shift
160 emissions to another sector or location where they remain uncontrolled or uncounted.

161 **Leak Rate**

162 The rate at which HFC refrigerant escapes from the product through normal operation.
163
164

165 **4 APPLICABILITY CONDITIONS**

166
167 This methodology applies to project activities that recover and destroy HFCs where the baseline
168 scenario is their total atmospheric release, such as routine venting before servicing or at equipment
169 end-of-life. This methodology does not apply to HFC refrigerant that is manufactured for the sole
170 purpose of their subsequent destruction, or to HFC refrigerant that would remain in equipment in
171 the baseline scenario.

172
173 Applicable HFC refrigerant must be recovered from Article 5 countries which have ratified the Kigali
174 Amendment and where regulatory prohibitions against refrigerant venting do not exist or are not enforced
175 (see Appendix I for country-level inclusion criteria and additionality check). The remainder of project
176 activities (e.g., aggregation, destruction, or reclaim) can be implemented in Article 5 as well as in Non-Article 5
177 countries.¹⁷

178
179 In addition to all eligible refrigerant gases in VM0016, the following HFC species and blends, with their
180 associated GWPs (100-year values taken from the IPCC’s Fifth Assessment Report), are eligible under this
181 methodology:

182
183 **Table 1. HFC Refrigerants and their GWPs**

184

<i>HFC Refrigerant</i>	<i>GWP</i>
<i>HFC-23</i>	12,400
<i>HFC-32</i>	677
<i>HFC-125</i>	3,169
<i>HFC-134a</i>	1,301
<i>HFC-152a</i>	137
<i>HFC-227ea</i>	3,348
<i>R-404A</i>	3,945
<i>R-407A</i>	1,923
<i>R-407C</i>	1,301
<i>R-410A</i>	1,923
<i>R-417C</i>	1,643
<i>R-422B</i>	2,289
<i>R-422C</i>	2,794
<i>R-422D</i>	2,473
<i>R-507A</i>	3,987
<i>R-508B</i>	11,710

185
186 All HFCs must be collected, stored, and transported in cylinders or other hermetically sealed
187 containers.
188

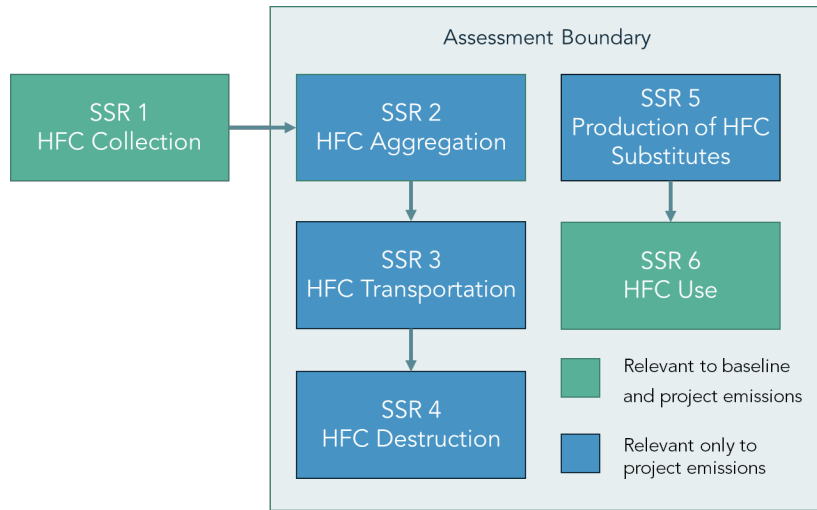
¹⁷ For the avoidance of doubt: Recovery and destruction activities can take place in separate countries.

189 **5 PROJECT BOUNDARY**

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The spatial extent of the project boundary encompasses the following sources, sinks, and reservoirs (SSRs):

- The recovery site or sites
- The aggregation facility or facilities
- The destruction facility
- Transportation between recovery sites, aggregation facilities, and the destruction facility
- Leakage from production of substitute gas and use of HFC or substitute refrigerant



199
200
201
202

SSR 1 HFC Collection	Fossil fuel emissions from collection of HFCs; Excluded; No difference from baseline
SSR 2 HFC Aggregation	HFC and fossil fuel emissions from recovery of HFC at servicing or end of life; Included; Venting assumed 100% in baseline, complete capture assumed in project scenario
SSR 3 HFC Transportation	Fossil fuel emissions associated with transport of HFC from collection to aggregation and from aggregation to destruction facility; Included; Estimated based on distance and weight
SSR 4 HFC Destruction	Emissions of incomplete HFC destruction, emissions from oxidation of carbon contained in destroyed HFC, fossil fuel emissions from destruction facility operation, indirect emissions from use of grid- delivered electricity; Included; Based on HFC destroyed or included in default deduction
SSR 5 Production of HFC Substitutes	Fossil fuel and substitute refrigerant emissions from production of substitute refrigerant; Included; Based on reclamation rate in project location; expected to be negligible in Article 5 countries
SSR 6 HFC Use	HFC or substitute gas emissions from leaks resulting from continued operation; Included; Project emissions based on market-weighted emission rates and reclamation rates

203
204

205 **6 BASELINE SCENARIO**

206
207 The project proponent must use Step 1 of the latest version of the CDM *Tool for the demonstration*
208 *and assessment of additionality*, to identify all realistic and credible baseline alternatives. In doing so,
209 relevant policies and regulations related to the management of installed refrigerant banks should be
210 considered. Such policies or regulations may include mandatory HFC capture or destruction
211 requirements because of regional or local environmental regulations. In addition, the assessment of
212 alternative scenarios should account for regional economic and technological circumstances.

213
214 **For HFC refrigerants the realistic and credible alternative(s) may include, *inter alia***

- 215 R1 Project activity not performed as emission reduction project
- 216 R2 Products are disposed of into an incineration facility and thereby HFC refrigerants are
217 destroyed
- 218 R3 Atmospheric release of the HFC refrigerant or partial capture and destruction
- 219 R4 Atmospheric release of the HFC refrigerant or partial capture and reuse in existing
220 products or continued storage in stockpile
- 221 R5 Products partially or entirely remain installed in existing equipment

222
223 The methodology is only applicable for HFC refrigerants if the most plausible baseline scenario for
224 the HFC refrigerant is either R3 or R4 or a combination of both.
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7 ADDITIONALITY

The project proponent should use the two-step process set out below for the demonstration of additionality for projects that destroy HFC refrigerant. A third country-level check should be completed annually to ensure that destruction is not enabling production or import of controlled substances above set limits (Appendix I).

Step 1: Regulatory surplus

The project proponent must demonstrate regulatory surplus in accordance with the following requirement, adapted from those regarding regulatory surplus set out in the January 2022 version of the *VCS Standard*:

The project shall not occur within a host country in which HFC refrigerant recovery is mandated by any law, statute or other regulatory framework, or the compliance rate of any such law, statute or other regulatory framework during (part of) the project crediting period shall be below 50 percent.

All Article 5 countries are assumed to meet the regulatory surplus requirement and are therefore eligible for host country status. As changing conditions continue to be monitored, eligibility conditions may be updated accordingly.

Step 2: Positive list

The positive list for this methodology is adapted from the applicability conditions of VCS activity method module VMD0048, *Activity method for the determination of additionality for recovered and stockpiled ODS refrigerant projects*. VMD0048 was established using the revenue streams option (Option C in the *VCS Standard*) only for the destruction of CFCs and other ozone-depleting substances. However, the justification of this option in Appendix II of VMD0048 was found to apply equally to HFCs. Specifically, there is a comparable lack of revenue streams for the collection, aggregation, and destruction of HFCs, and the venting of HFCs during servicing or at end-of-life is common practice across the world, especially in Article 5 countries.

Projects that meet all the applicability conditions in Section 4 of this methodology, as well as the following requirements, are deemed additional.

- 3) The project activity consists of the collection, aggregation, and destruction of HFC refrigerants recovered at equipment end-of-life or during servicing in which venting would otherwise occur. Government seizures of illegal shipments are also an approved source insofar as seized refrigerants are turned over to project developers for the express purpose of destruction. When refrigerant is recovered from equipment, the project proponent must distinguish between refrigerant recovered at equipment end-of-life and during equipment servicing. In the latter case, the project proponent must provide documentation regarding the service call, and demonstrate the following:

- 270 a) Evacuation of refrigerant from the equipment was required or is common practice before
271 such servicing; and
- 272 b) Onsite recycling of the recovered refrigerant and refilling of the serviced equipment was not
273 feasible.
- 274 4) The project activity does not consist of the destruction of HFCs from, or as part of, a product
275 stewardship scheme or other program incentivizing HFC recovery as an industry common
276 practice. At validation, the project proponent must provide a description of any schemes or
277 programs designed to incentivize HFC recovery, reclamation, or destruction in the jurisdictions
278 in which the refrigerant is collected.

279
280 The project proponent must provide appropriate documentation to demonstrate that the project
281 activity meets all applicability conditions. Documentation may include but is not limited to: bills of
282 landing, invoices, receipts, chains of custody, inventory records, contracts, or other signed
283 statements or agreements.
284

285 8 QUANTIFICATION OF GHG EMISSION REDUCTIONS AND REMOVALS

286 8.1 Baseline Emissions

288 **Baseline emissions from HFC refrigerants are determined as follows:**

$$289 \quad BE_{HFC_ref,y} = \sum_{i=1}^n ((M_{DESTR,eHFC,i,y} \times VR_{HFC,i} \times EF_{VR}) + (M_{DESTR,eHFC,i,y} \times RR_{HFC,i} \times EF_{RR,HFC,i}) \\ 290 \quad + (M_{DESTR,eHFC,i,y} \times DR_{HFC,i} \times EF_{DR})) \times GWP_{HFC,i} \quad (1)$$

$$291 \quad 1 = VR_{HFC,i} + RR_{HFC,i} + DR_{HFC,i} \quad (2)$$

292 Where:

293 $BE_{HFC_ref,y}$ = Baseline emissions from HFC refrigerants which would be released into the atmosphere in the absence of the project activity in year y [tCO₂e]

294 $M_{DESTR,eHFC,i,y}$ = Eligible quantity HFC refrigerant i sent for destruction by the project activity in year y [tHFC_i]

295 $VR_{HFC,i}$ = Rate of HFC refrigerant i which would be vented into the atmosphere in the baseline [0-1]

296 EF_{VR} = Emission factor for HFC refrigerant i which would be vented into the atmosphere [1]

297 $RR_{HFC,i}$ = Rate of HFC refrigerant i which would be used, reused or remain in storage in the baseline [0-1]

298 $EF_{RR,HFC,i}$ = Emission factor for HFC refrigerant i which would be reused in the baseline [0-1]

299 $DR_{HFC,i}$ = Rate of HFC refrigerant i destroyed by the project activity which would also be destroyed in the baseline [0-1]

300 EF_{DR} = Emission factor for HFC refrigerant i which would also be destroyed in the baseline [0]

301 $GWP_{HFC,i}$ = Global warming potential of HFC refrigerant i [tCO₂e/tHFC_i]

$$302 \quad EF_{VR} = 1 \quad (3)$$

$$303 \quad EF_{DR} = 0 \quad (4)$$

310 $EF_{RR,HFC,i} = 1 - (1 - LR_{HFC,i,y})^{tcp}$ (5)

311 Where:
312

$EF_{RR,HFC,i}$ = Emission factor for HFC refrigerant i which would be reused in the baseline [0-1]

$LR_{HFC,i,y}$ = Leak rate of HFC refrigerant i which would be used as refrigerant for existing equipment or remain in storage in the baseline in year y [0-1]

tcp = Project crediting period in years [10]

313
314
315 When recovery of the HFC refrigerants by the project activity is mandated by law, statute or other
316 regulatory framework applying in the host country, and this mandate is demonstrably enforced, the
317 baseline shall be the gradually increasing compliance with such law, statute or other regulatory
318 framework, and the baseline GHG emissions shall be calculated as follows:

319
320 $BE_{HFC_ref,y,a} = BE_{HFC_ref,y} \times (1 - CR_y)$ (6)

321 Where:
322

$BE_{HFC_ref,y,a}$ = Adjusted baseline emissions to be used for the calculation of emission reductions in year y [tCO₂e]

$BE_{HFC_ref,y}$ = Baseline emissions from HFC refrigerants which would be released into the atmosphere in the absence of the project activity in year y [tCO₂e]

CR_y = Host country-level compliance rate of the law, statute or other regulatory framework in the year y. Calculation of the compliance rate shall exclude other projects implemented under GHG programs. If the compliance rate exceeds 50% (or 0.50), the project shall receive no further credit [0-1]

323
324
325

326 8.2 Project Emissions

327

328 Project emissions in year y are:

329 • Emissions that are caused by the project activity due to energy consumption at aggregation
330 facilities

331 • Emissions that are caused by the project activity due to transportation of HFC refrigerant between
332 recovery sites, aggregation facilities, and the destruction facility

333 • Emissions that are caused by the project activity due to HFC destruction (including energy
334 consumption due to project activity at the destruction facility)

335

336

337 Project emissions are determined as follows:

338

339

$$340 PE_y = PE_{Energy_Consump,y} + PE_{HFC_Transport,y} + PE_{HFC_Destruct,y} \quad (7)$$

341

342

343

344

Where:

PE_y = Project emissions during year y [tCO₂e]

$PE_{Energy_Consump,y}$ = Project emissions from energy consumption due to project activity at aggregation facilities during year y [tCO₂e]

$PE_{HFC_Transport,y}$ = Project emission from HFC transportation during year y [tCO₂e]

$PE_{HFC_Destruct,y}$ = Project emission from HFC destruction during year y [tCO₂e]

345

346

347 Determination of $PE_{Energy_Consump,y}$:

348

$$349 PE_{Energy_Consump,y} = PE_{EC,y} + PE_{FC,j,y} \quad (8)$$

350

351

352

353

Where:

$PE_{Energy_Consump,y}$ = Project emissions from energy consumption attributable to the project activity at aggregation facilities during year y [tCO₂e]

$PE_{EC,y}$ = Project emissions from electricity consumption from the grid attributable to the project activity at aggregation facilities during year y [tCO₂e]

$PE_{FC,j,y}$ = Project emissions from fossil fuel consumption attributable to the project activity, including third party used fossil fuel to generate energy, at aggregation facilities during year y [tCO₂e]

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Determination of $PE_{EC,y}$:

$$PE_{EC,y} = EC_{PJ,y} \times EF_{grid,y} \times (1 + TDL_y) \quad (9)$$

Where:

- $PE_{EC,y}$ = Project emissions from electricity consumption from the grid due to project activity at the HFC aggregation facilities during year y [tCO₂e]
- $EC_{PJ,y}$ = Amount of electricity consumed due to project activity at the HFC aggregation facilities from the grid during year y [MWh]
- $EF_{grid,y}$ = Grid emission factor during the monitoring period y [tCO₂e /MWh]
- TDL_y = Average technical transmission and distribution losses in the grid for the voltage level at which electricity is obtained from the grid at the aggregation facilities during year y [0-1]

365
366

For determination of $EF_{grid,y}$ the project proponent shall choose one of the following options:

- 367
- Calculate the combined margin emission factor, using the procedures in the latest approved version of the CDM “Tool to calculate the emission factor for an electricity system”; or
 - Use a conservative default value of 1.3 tCO₂/MWh

371
372

For determination of TDL_y , the project proponent shall choose one of the following options:

- 373
- Use recent, accurate and reliable data available within the country; or
 - Use a conservative default value of 20%
- 374

375
376

Determination of $PE_{FC,j,y}$:

$$PE_{FC,j,y} = \sum_{i=1}^n FC_{i,j,y} \times COEF_{i,y} \quad (10)$$

378
379
380

Where:

- $PE_{FC,j,y}$ = Project emissions from fossil fuel consumption attributable to the project activity at aggregation facilities, including third party used fossil fuel to generate energy, during year y [tCO₂e]
- $FC_{i,j,y}$ = Amount of fuel type i combusted in process j at an aggregation facility or at any third party generating energy for an aggregation facility during year y [mass or volume unit]
- $COEF_{i,y}$ = CO₂ emission coefficient of fuel type i in year y [tCO₂e / mass or volume unit] i are the fuel types combusted in process j

381 The CO₂ emission coefficient $COEF_{i,y}$ can be calculated according to two different procedures,
382 depending on the available data about the fossil fuel type i;

383 **Option A:** The CO₂ emission coefficient $COEF_{i,y}$ is calculated based on the chemical composition
384 of the fossil fuel type i, using the following approach:

385
386
387 If $FC_{i,j,y}$ is measured in a mass unit: $COEF_{i,y} = w_{C,i,y} \times 44/12$

388
389 If $FC_{i,j,y}$ is measured in a volume unit: $COEF_{i,y} = w_{C,i,y} \times \rho_{i,y} \times 44/12$

390
391
392 Where:

- 393
- $COEF_{i,y}$ = CO₂ emission coefficient of fuel type i during year y [tCO₂e / mass or volume unit]
 - $w_{C,i,y}$ = Weighted average mass fraction of carbon C in fuel type i during year y [tC / mass unit of the fuel]
 - $\rho_{i,y}$ = Weighted average density of fuel type i during year y [mass unit / volume unit of the fuel]

394
395 **Option B:** The CO₂ emission coefficient $COEF_{i,y}$ is calculated based on net calorific value and
396 CO₂ emission factor of the fuel type i, as follows:

397
398
399
$$COEF_{i,y} = NCV_{i,y} \times EF_{CO_2,i,y} \tag{11}$$

400
401
402 Where:

- 403
- $COEF_{i,y}$ = CO₂ emission coefficient of fuel type i during year y [tCO₂e / mass or volume unit]
 - $NCV_{i,y}$ = Weighted average net calorific value of the fuel type i during year y [GJ/mass or volume unit]
 - $EF_{CO_2,i,y}$ = Weighted average CO₂ emission factor of fuel type i during year y [tCO₂e /GJ]

404 Where necessary data is available option A should be used.

405 Determination of $PE_{HFC_Transport,y}$ and $PE_{HFC_Destruct,y}$:

406 For project emissions due to HFC transportation and destruction, the project proponent shall apply
407 a default factor of 9 tCO₂/tHFC. This was calculated using the methods and conservative default
408 values found in Appendix D of the *CAR Article 5 Ozone Depleting Substances Project Protocol*, v2.0,
409 with the exception of the electricity grid emissions factor, which was increased from 0.889
410 tCO₂/MWh to 1.3 tCO₂/MWh, to reflect that destruction activities may occur outside the United
411 States. This emissions factor may be periodically re-assessed and updated.

412
413
414

$$PE_{HFC_Transport,y} + PE_{HFC_Destruct,y} = M_{DESTR,HFC,i,y} \times EF_{HFC_Transport+Destruct,y} \quad (12)$$

415 Where:
416

$PE_{HFC_Transport,y}$	=	Project emission from HFC transportation during year y [tCO ₂ e]
$PE_{HFC_Destruct,y}$	=	Project emission from HFC destruction during year y [tCO ₂ e]
$M_{DESTR,HFC,i,y}$	=	Quantity of HFC refrigerant i sent for destruction, including eligible and ineligible material by the project activity during year y [tHFC _i]
$EF_{HFC_Transport+Destruct,y}$	=	Default emission factor aggregating both transportation and destruction emissions [9 tCO ₂ /tHFC]

417 8.3 Leakage

418
419 Leakage emissions occur where in the baseline HFC refrigerant would have been re-used or
420 reclaimed, and in the project scenario, must be substituted by other chemicals. Leakage is considered
421 in cases where the reclamation rate, $RR_{HFC,i}$, is greater than 5%. Leakage is assumed to be 0 in cases
422 where the venting rate of the destroyed gas, $VR_{HFC,i}$, is 100%.

423
424 When refrigerant HFCs are destroyed instead of reclaimed, continued demand for refrigeration will
425 lead to the production and consumption of other refrigerant chemicals whose production is still
426 legally allowed. Emissions associated with the production of new refrigerants, $PE_{Sub,i}$, are
427 considered leakage and are included below in Equation 13.

428
429 Whether HFCs are destroyed or reclaimed, the resulting case will likely result in a gradual release,
430 or leak, of HFCs or substitute gases over the project crediting period. The leakage calculation
431 therefore additionally includes the difference between the leaked refrigerant GWP in the
432 reclamation versus destruction case. To be conservative, the GWP of the substitute gas is always
433 assumed to be greater than or equal to the GWP of the destroyed gas, such that project developers
434 are not credited for decreased leakage due to a lower GWP substitute gas.

435
436 Leakage emissions are calculated as follows:
437

438

$$LE_{Total} = \sum_{i=1}^n RR_{HFC,i} \times (PE_{Sub,i} + (M_{DESTR,HFC,i,y} \times TLR) \times \max [0, (GWP_{Sub,i} - GWP_{HFC,i})])$$

439 (13)

440 Where:
441

LE_{Total}	=	Total leakage emissions by the project activity over project crediting period [tCO ₂ e]
--------------	---	--

$RR_{HFC,i}$	=	Rate of HFC refrigerant i which would be used, reused or remain in storage in the baseline [0-1]
$PE_{Sub,i}$	=	Emissions associated with production of substitute refrigerant for HFC refrigerant i [tCO ₂ e]
$M_{DESTR,HFC,i,y}$	=	Quantity of HFC refrigerant i which is sent to destruction by the project activity in year y [tHFC _i]
$GWP_{HFC,i}$	=	Global warming potential of destroyed HFC refrigerant i [tCO ₂ e/tHFC _i]
$GWP_{Sub,i}$	=	Global warming potential of substitute refrigerant for HFC refrigerant i [tCO ₂ e/tSubstitute]

443
444 $TLR = 1 - (1 - LR_{HFC,i,y})^{tcp}$ (14)

445 Where:
446

TLR	=	Total leakage rate over the project crediting period [0-1]
$LR_{HFC,i,y}$	=	Leak rate of HFC refrigerant i or substitute chemical in year y [0-1]
tcp	=	Project crediting period [10]

447
448 The project proponent shall apply a substitute chemical derived from either official published data,
449 research, industry studies, or default values provided in the latest version of the *CAR Article 5 Ozone*
450 *Depleting Substances Project Protocol*. The leak rate $LR_{HFC,i,y}$ shall be obtained from either official
451 published data, research, industry studies, or default values provided in the latest version of the *CAR*
452 *Article 5 Ozone Depleting Substances Project Protocol*.

453

454

455 **8.4 Net GHG Emission Reduction and Removals**

456

457 Emission reductions are calculated as follows:

458

459 $ER_{HFC,y} = BE_{HFC,ref,y,a} - PE_y - (LE_{total} / tcp)$ (15)

460 Where:

461

$ER_{HFC,y}$	=	Total emission reductions during year y [tCO ₂ e]
$BE_{HFC,ref,y,a}$	=	Adjusted baseline emissions from HFC refrigerants which would be released into the atmosphere in the absence of the project activity during year y [tCO ₂ e]
PE_y	=	Project emissions by the project activity during year y [tCO ₂ e]
LE_{Total}	=	Total leakage emissions by the project activity over project crediting period [tCO ₂ e]
tcp	=	Project crediting period [10]

462 **9 MONITORING**

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464 **9.1 Data and Parameters Available at Validation**

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Data / Parameter:	$GWP_{HFC,i}$
Data unit:	tCO ₂ e/tHFC _i
Description:	Global warming potential of HFC refrigerant i
Source of data:	IPCC
Description of measurement methods and procedures to be applied:	See Table 1 above for values. Shall be updated according to any future COP/MOP decisions or Assessment Reports.
Comments:	

Data / Parameter:	$GWP_{Sub,i}$
Data unit:	tCO ₂ e/tSubstitute
Description:	Global warming potential of substitute refrigerant for HFC refrigerant i
Source of data:	IPCC
Description of measurement methods and procedures to be applied:	See Table 1 above for values. Shall be updated according to any future COP/MOP decisions or Assessment Reports. The project proponent shall apply a substitute chemical derived from either official published data, research, industry studies, or assume destroyed refrigerants to be replaced by HFC-134a (as per the latest version of the Climate Action Reserve's <i>Article 5 ODS Project Protocol</i>). This will be periodically re-assessed and updated.
Comments:	

481

Data / Parameter:	$VR_{HFC,i}$
Data unit:	%; expressed as a proportion [0-1]
Description:	Rate of HFC refrigerant i which would be vented in the baseline
Source of data:	Default value given below or project-specific rate(s) sourced from officially published data, research studies, industry data, etc. The default rate is 0% unless the project proponent demonstrates that all or a portion of the refrigerant destroyed meets the requirements of Section 7 above. For refrigerant from such sources, the venting rate is assumed to be 100%.

Description of measurement methods and procedures to be applied:	For default rate, see documentation as outlined in Section 7. For project-specific rate, consult officially published country data, research studies, industry data, etc.
Comments:	Calculated as a cumulative rate over the 10-year period following HFC destruction.

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Data / Parameter:	$RR_{HFC,i}$
Data unit:	%; expressed as a proportion [0-1]
Description:	Rate of HFC refrigerant i which would be used, reused or remain in storage in the baseline
Source of data:	Default value given below or project-specific rate(s) sourced from officially published data, research studies, industry data, etc. The default rate is 100% unless the project proponent demonstrates that all or a portion of the refrigerant destroyed meets the requirements of Section 7 above. For refrigerant destroyed from such sources, the recovery rate is assumed to be 0%.
Description of measurement methods and procedures to be applied:	For default rate, see documentation as outlined in Section 7. For project-specific rate, consult officially published data, research studies, industry data, etc.
Comments:	Calculated as a cumulative rate over the 10-year period following HFC destruction.

483

Data / Parameter:	$DR_{HFC,i}$
Data unit:	%; expressed as a proportion [0-1]
Description:	Rate of HFC refrigerant i which would be destroyed in the baseline
Source of data:	Default value given below or project-specific rate(s) sourced from officially published data, research studies, industry data, etc. In the absence of a government mandate, product stewardship scheme, or other program that creates an incentive or mechanism for HFC refrigerant destruction in the country(ies) where the project activity occurs, the default rate is 0%.
Description of measurement methods and procedures to be applied:	
Comments:	Calculated as a cumulative rate over the 10-year period following HFC destruction.

484

Data / Parameter:	$LR_{HFC,i,y}$
Data unit:	%; expressed as a proportion [0-1]
Description:	Leak rate of HFC refrigerant i or substitute chemical in year y [0-1]
Source of data:	Default values given below or project-specific rate(s) sourced from officially published data, research studies, industry data, etc. Default values for HFC refrigerant used or reused in existing equipment are the applicable annual emission rates given in the latest version of the Climate Action Reserve's <i>Article 5 ODS Project Protocol</i> .
Description of measurement methods and procedures to be applied:	
Comments:	

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Data / Parameter:	$EF_{HFC_Transport+Destruct,y}$
Data unit:	tCO ₂ e/tHFC
Description:	Default emission factor aggregating both transportation and destruction emissions
Source of data:	Default value is 9 tCO ₂ e/tHFC, calculated using the method found in Appendix D of <i>CAR Article 5 ODS Project Protocol</i> .
Description of measurement methods and procedures to be applied:	
Comments:	

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Data / Parameter:	$PE_{Sub,i}$
Data unit:	tCO ₂ e
Description:	Emissions associated with production of substitute refrigerant for HFC refrigerant i [tCO ₂ e]
Source of data:	Officially published data, research studies, LCA, or industry data.
Description of measurement methods and procedures to be applied:	
Comments:	Shall be updated to reflect the results of a refrigerant production LCA in a later version. In scenarios where $RR_{HFC,i} = 0$, estimation of $PE_{Sub,i}$ may be omitted.

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9.2 Data and Parameters Monitored

Data / Parameter:	$M_{DESTR,HFC,i,y}$
Data unit:	tHFC _i
Description:	Quantity of HFC refrigerant <i>i</i> sent for destruction by the project activity, including eligible and ineligible material, during year <i>y</i>
Source of data:	<ul style="list-style-type: none"> • Operation logbook of recovery facility • Identification note for each individual HFC container by a bill of lading • Certificate of Destruction for each individual HFC container (refer to Section 9.3 of this methodology "Monitoring Methodology")
Description of measurement methods and procedures to be applied:	Refer to Section 9.3 of this methodology "Monitoring Methodology"
Frequency of monitoring/recording:	Each container with HFC sent for destruction
QA/QC procedures to be applied:	All measurements should be conducted with calibrated measurement equipment according to relevant industry standards (refer to Section 9.3 of this methodology "Monitoring Methodology")
Comments:	

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Data / Parameter:	$M_{DESTR,eHFC,i,y}$
Data unit:	tHFC _i
Description:	Eligible quantity of HFC refrigerant <i>i</i> sent for destruction by the project activity, including eligible and ineligible material, during year <i>y</i>
Source of data:	<ul style="list-style-type: none"> • Operation logbook of recovery facility • Identification note for each individual HFC container by a bill of lading • Certificate of Destruction for each individual HFC container (refer to Section 9.3 of this methodology "Monitoring Methodology")
Description of measurement methods and procedures to be applied:	Refer to Section 4 of this methodology "Applicability Conditions"

Frequency of monitoring/recording:	Each container with HFC sent for destruction
QA/QC procedures to be applied:	All measurements should be conducted with calibrated measurement equipment according to relevant industry standards (refer to Section 9.3 of this methodology “Monitoring Methodology”)
Comments:	

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Data / Parameter:	CR_y
Data unit:	%; expressed as a proportion [0-1]
Description:	Host country-level compliance rate of the law, statute or other regulatory framework in the year y. Calculation of the compliance rate shall exclude other projects implemented under GHG programs. If the compliance rate exceeds 50% (or 0.50), the project shall receive no further credit.
Source of data:	Default rate given below or officially published data, inventories, research studies, industry data etc. In countries eligible under this methodology, the default compliance rate is assumed to be 0%.
Description of measurement methods and procedures to be applied:	
Frequency of monitoring/recording:	Annually
QA/QC procedures to be applied:	
Comments:	Should baseline rates begin to increase due to increased enforcement of venting prohibitions or for any other reason, the methodology will be revised and further guidance will be provided on the calculation protocols.

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Data / Parameter:	$FC_{i,j,y}$
Data unit:	Mass or volume unit per year (e.g. ton/y or m ³ /y)
Description:	Quantity of fuel type i combusted in process j in year y
Source of data:	Onsite measurements

<p>Description of measurement methods and procedures to be applied:</p>	<p>Use utility bills or invoices for purchased fuel, or alternatively, either mass or volume meters onsite. In cases where fuel is supplied from small daily tanks, rulers can be used to determine mass or volume of the fuel consumed, with the following conditions: The ruler gauge must be part of the daily tank and calibrated at least once a year and have a book of control for recording the measurements (on a daily basis or per shift);</p> <p>Accessories such as transducers, sonar and piezoelectronic devices are accepted if they are properly calibrated with the ruler gauge and receiving a reasonable maintenance;</p> <p>In case of daily tanks with pre-heaters for heavy oil, the calibration will be made with the system at typical operational conditions.</p>
<p>Frequency of monitoring/recording:</p>	<p>Continuously</p>
<p>QA/QC procedures to be applied:</p>	<p>If onsite measurements are used, the consistency of metered fuel consumption quantities should be cross-checked by an annual energy balance that is based on purchased quantities and stock changes. Where the purchased fuel invoices can be identified specifically for the project activity, the metered fuel consumption quantities should also be cross-checked with available purchase invoices from the financial records.</p>
<p>Comments:</p>	

Data / Parameter:	$W_{C,i,y}$	
Data unit:	tC/mass unit of the fuel	
Description:	Weighted average mass fraction of carbon C in fuel type i in year y	
Source of data:	The following data sources may be used if the relevant conditions apply:	
	Data source	Conditions for using the data source
	a) Values provided by the fuel supplier in invoices	Where relevant information is available use option a)
	b) Measurements by the project proponent	If a) is not available
Description of measurement methods and procedures to be applied:	Measurements should be undertaken in line with national or international fuel standards.	
Frequency of monitoring/recording:	The mass fraction of carbon should be obtained for each fuel delivery, from which weighted average annual values should be calculated.	
QA/QC procedures to be applied:	Verify if the values under a) and b) are within the uncertainty range of the IPCC default values as provided in Table 1.2, Vol. 2 of the 2006 IPCC Guidelines. If the values fall below this range collect additional information from the testing laboratory to justify the outcome or conduct additional measurements. The laboratories in b) should have ISO17025 accreditation or justify that they can comply with similar quality standards.	
Comments:	Applicable where option A is used	

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Data / Parameter:	$\rho_{i,y}$	
Data unit:	Mass unit/volume unit of the fuel	
Description:	Weighted average density of fuel type i in year y	
Source of data:	The following data sources may be used if the relevant conditions apply:	
	Data source	Conditions for using the data source
	a) Values provided by the fuel supplier in invoices	Where relevant information is available use option a)

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	b) Measurements by the project proponent	If a) is not available
	c) Regional or national default values	If a) is not available These sources can only be used for liquid fuels and should be based on well documented, reliable sources (such as national energy balances).
Description of measurement methods and procedures to be applied:	Measurements should be undertaken in line with national or international fuel standards.	
Frequency of monitoring/recording:	The density of the fuel should be obtained for each fuel delivery, from which weighted average annual values should be calculated.	
QA/QC procedures to be applied:		
Comments:	Applicable where option A is used and where $FC_{i,j,y}$ is measured in a volume unit. Preferably the same data source should be used for $W_{C,i,y}$ and $\rho_{i,y}$.	

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Data / Parameter:	$NCV_{i,y}$	
Data unit:	GJ per mass or volume unit (e.g., GJ/m ³ , GJ/ton)	
Description:	Weighted average net calorific value of fuel type i in year y	
Source of data:	The following data sources may be used if the relevant conditions apply:	
	Data source	Conditions for using the data source
	a) Values provided by the fuel supplier in invoices	Where relevant information is available use option a)
	b) Measurements by the project proponent	If a) is not available
	c) Regional or national default values	If a) is not available. These sources can only be used for liquid fuels and should be based on well documented,

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		reliable sources (such as national energy balances).
	d) IPCC default values at the upper limit of the uncertainty at a 95% confidence interval as provided in Table 1.2 of Chapter 1 of Vol. 2 (Energy) of the 2006 IPCC Guidelines on National GHG Inventories	If a) is not available
Description of measurement methods and procedures to be applied:	For a) and b): Measurements should be undertaken in line with national or international fuel standards	
Frequency of monitoring/recording:	For a) and b): The NCV should be obtained for each fuel delivery, from which weighted average annual values should be calculated For c): Review appropriateness of the values annually For d): Any future revision of the IPCC Guidelines should be taken into account	
QA/QC procedures to be applied:	Verify if the values under a), b) and c) are within the uncertainty range of the IPCC default values as provided in Table 1.2, Vol. 2 of the 2006 IPCC Guidelines. If the values fall below this range collect additional information from the testing laboratory to justify the outcome or conduct additional measurements. The laboratories in a), b) or c) should have ISO17025 accreditation or justify that they can comply with similar quality standards.	
Comments:	Applicable where option B of this methodology is used	

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Data / Parameter:	$EF_{CO_2,i,y}$	
Data unit:	tCO ₂ e/GJ	
Description:	Weighted average CO ₂ emission factor of fuel type i in year y	
Source of data:	The following data sources may be used if the relevant conditions apply:	
	Data source	Conditions for using the data source
	a) Values provided by the fuel supplier in invoices	Where relevant information is available use option a).

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	b) Measurements by the project proponents	If a) is not available
	c) Regional or national default values	If a) is not available These sources can only be used for liquid fuels and should be based on well documented, reliable sources (such as national energy balances).
	d) IPCC default values at the upper limit of the uncertainty at a 95% confidence interval as provided in table 1.4 of Chapter1 of Vol. 2 (Energy) of the 2006 IPCC Guidelines on National GHG Inventories	If a) is not available
Description of measurement methods and procedures to be applied:	For a) and b): Measurements should be undertaken in line with national or international fuel standards.	
Frequency of monitoring/recording:	For a) and b): The CO ₂ emission factor should be obtained for each fuel delivery, from which weighted average annual values should be calculated For c): Review appropriateness of the values per monitoring interval y For d): Any future revision of the IPCC Guidelines should be considered	
QA/QC procedures to be applied:		
Comments:	Applicable where option B is used. For a): If the fuel supplier does provide the NCV value and the CO ₂ emission factor on the invoice and these two values are based on measurements for this specific fuel, this CO ₂ factor should be used. If another source for the CO ₂ emission factor is used or no CO ₂ emission factor is provided, options b), c) or d) should be used	

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Data / Parameter:	$EC_{PJ,y}$
Data unit:	MWh
Description:	Amount of electricity consumed at the HFC aggregation facility from the grid during year y
Source of data:	Onsite measurements and recorded by a computer system and/or by printed journals; or, alternatively, utility bills or invoices for purchased electricity
Description of measurement methods and procedures to be applied:	Directly measured by calibrated electricity meter installed at the project site.
Frequency of monitoring/recording:	Continuously, aggregated at least annually
QA/QC procedures to be applied:	If onsite measurements are used, cross check measurement results with invoices for purchased electricity if relevant
Comments:	

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Data / Parameter:	$EF_{grid,y}$
Data unit:	tCO ₂ /MWh
Description:	Grid emission factor during the monitoring period y
Source of data:	Choose one of the following options: <ul style="list-style-type: none"> Calculate the combined margin emission factor, using the procedures in the latest approved version of the CDM “Tool to calculate the emission factor for an electricity system”; or Use a conservative default value of 1.3 tCO₂/MWh.
Description of measurement methods and procedures to be applied:	
Frequency of monitoring/recording:	
QA/QC procedures to be applied:	If the “Tool to calculate the emission factor for an electricity system” will be used the source and/or the calculation shall be available by printed journals.
Comments:	

517

Data / Parameter:	TDL_y
Data unit:	%, expressed as proportion [0-1]
Description:	Average technical transmission and distribution losses in the grid for the voltage level at which electricity is obtained from the grid at the project site during year y
Source of data:	Choose one of the following options: a) Use recent, accurate and reliable data available within the country; or b) Use a conservative default value of 20%
Description of measurement methods and procedures to be applied:	For a) TDL_y should be estimated for the distribution and transmission networks of the electricity grid of the same voltage as the connection where the proposed project activity is connected to. The technical distribution losses should not contain other types of grid losses (e.g. commercial losses/theft). The distribution losses can either be calculated by the project proponent or be based on references from utilities, network operators or other official documentation.
Frequency of monitoring/recording:	
QA/QC procedures to be applied:	In the absence of data from the relevant year, most recent figures should be used, but not older than 5 years.
Comments:	

521 **9.3 Description of the Monitoring Plan¹⁸**

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Composition and Quantity Analysis Requirements

The requirements of this section must be followed to determine the quantities of HFC refrigerants. Prior to destruction, the precise mass and composition of HFCs to be destroyed must be determined. The following analysis must be conducted:

Mass shall be determined by individually measuring the weight of each container of HFCs:

1. When it is full prior to destruction; and
2. After it has been emptied and the contents have been fully purged and destroyed. The mass of HFCs and any contaminants is equal to the difference between the full and empty weight, as measured.

The following requirements must be met when weighing the containers of HFCs:

1. A single scale must be used for generating both the full and empty weight tickets at the destruction facility;
2. Weighing instruments must comply with the relevant national requirements and/or international standards – such as EC Directive 2009/23/EC or International Organization for Legal Metrology OIML R 76-1 – and be subject to regular calibration, as set out in the relevant national requirements and/or international standards to accuracy appropriate to its accuracy class. These instruments shall have a measuring range corresponding to the capacity of containers and tanks weighed. If a scale is found to be out of tolerance, it must be recalibrated;
3. The full weight must be measured no more than two days prior to commencement of destruction per the Certificate of Destruction; and
4. The empty weight must be measured no more than two days after the conclusion of destruction per the Certificate of Destruction.

Composition and concentration of HFCs shall be established for each individual container by taking a sample from each container of HFCs and having it analyzed for composition and concentration at a lab accredited to perform analyses in compliance with the applicable International Organization for Standardization (ISO) standard or equivalent standards. Further, where national standards exist, they may be used in lieu of ISO standards provided that they have been the subject of a verification or validation process addressing their accuracy and representativeness. In the case where no such standards exist, the US Air-Conditioning, Heating and Refrigeration Institute 700-2006 standard shall be applied.

¹⁸ This section is mainly based on Climate Action Reserve (CAR): U.S. Ozone Depleting Substances Project Protocol Version 2 February 27 2012 and on RAL Quality Assurance and Test Specifications for the Demanufacture of Refrigeration Equipment version: 2007/09

561 The laboratory performing the composition analysis must not be affiliated with the project
562 proponent or the project activities beyond performing these services.

563
564 The following requirements must be met for each sample:

- 565 1. The sample must be taken while the HFC is in the possession of the company that will
566 destroy the HFC;
- 567 2. Samples must be taken by a technician unaffiliated with the project developer;
- 568 3. Samples must be taken with a clean, fully evacuated sample bottle that meets applicable U.S. DOT
569 requirements or an equivalent national (host country) or ISO standard;
- 570 4. The technician must ensure that the sample is representative of the contents of the container;
- 571 5. Each sample must be taken in liquid state;
- 572 6. A minimum sample size of 0.453592 kg (1 pound) must be drawn for each sample;
- 573 7. Each sample must be individually labeled and tracked according to the container from
574 which it was taken, and the following information recorded:
 - 575 • Time and date of sample
 - 576 • Name of project developer
 - 577 • Name of technician taking sample
 - 578 • Employer of technician taking sample
 - 579 • Volume of container from which sample was extracted
 - 580 • Ambient air temperature at time of sampling
- 581 8. Chain of custody for each sample from the point of sampling lab must be documented by
582 paper bills of lading or electronic, third-party tracking that includes proof of delivery.

583
584 All project samples shall be analyzed using the International Organization for Standardization (ISO)
585 standard applicable. Further, where national standards exist, they may be used in lieu of ISO
586 standards provided that they have been the subject of a verification or validation process addressing
587 their accuracy and representativeness. In the case where no such standards exist, the US Air-
588 Conditioning, Heating and Refrigeration Institute *700-2006* standard shall be applied. The analysis
589 shall provide:

- 590 1. Identification of the refrigerant
- 591 2. Purity (%) of the HFC mixture by weight using gas chromatography
- 592 3. Moisture level in parts per million. The moisture content of each sample must be less than
593 75% of the saturation point for the HFC based on the temperature recorded at the time the
594 sample was taken. For containers that hold mixed HFC, the sample's saturation point shall
595 be assumed to be that of the HFC species in the mixture with the lowest saturation point
596 that is at least 10 percent of the mixture by mass.

- 597 4. Analysis of high boiling residue, which must be less than 10% by mass
598 5. Analysis of other HFCs in the case of mixtures of HFCs, and their percentage by mass
599

600 If any of the requirements above are not met, no GHG reductions may be verified for HFC
601 destruction associated with that container. If a sample is tested and does not meet one of the
602 requirements as defined above, the project proponent may elect to have the material re-sampled and
603 re-analyzed. The project proponent may sample for moisture content and perform any necessary
604 de-watering prior to the required sampling and laboratory analysis.

605
606 If the container holds non-mixed HFC (defined as greater than 90% composition of a single HFC
607 species), no further information or sampling is required to determine the mass and composition of
608 the HFC. If the container holds mixed HFCs, which is defined as less than 90% composition of a single
609 HFC species, the project proponent must meet additional requirements as provided below.

610
611 **Composition and Quantity Analysis Requirements for Mixed HFCs**

612
613 If a container holds mixed HFCs, its contents must also be processed and measured for composition
614 and concentration according to the requirements of this section. The sampling required under this
615 section may be conducted at the final destruction facility or at an aggregation facility. However, the
616 circulation and sampling activities must be conducted by a third-party organization (i.e., not the
617 project proponent), and by individuals who have been properly trained for the functions they
618 perform. Circulation and sampling may be conducted at the project proponent's facility, but all
619 activities must be directed by a properly trained and contracted third-party. The project description
620 must specify the procedures by which mixed HFCs are analyzed.

621
622 The composition and concentration of HFCs on a mass basis must be determined using the results of
623 the analysis of this section for each container. The results of the composition analysis in the section
624 above shall be used by verifiers to confirm that the destroyed HFC refrigerant is in fact the same HFC
625 refrigerant that is sampled under these requirements. Prior to sampling, the HFC mixture must be
626 circulated in a container that meets all the following criteria:

- 627 1. The container has no solid interior obstructions; mesh baffles or other interior structures that do not
628 impede the flow of HFCs are acceptable;
- 629 2. The container was fully evacuated prior to filling;
- 630 3. The container must have sampling ports to sample liquid and gas phase HFC;
- 631 4. The liquid port intake must be at the bottom of the container, and the vapor port intake
632 must be at the top of the container. For horizontally oriented mixing containers, the
633 intakes must be located in the middle third of the container; and
- 634 5. The container and associated equipment can circulate the mixture via a closed loop
635 system from the bottom to top.

636
637 If the original mixed HFC container does not meet these requirements, the mixed HFC must be
638 transferred into a temporary holding tank or container that meets all the above criteria. The weight
639 of the contents placed into the temporary container shall be calculated and recorded.

640 During transfer of refrigerant into and out of the temporary container, refrigerant shall be recovered
641 to the vacuum levels required by the U.S. EPA for that refrigerant (see 40 CFR 82.156) or any
642 national (host country) or ISO standard.

643
644 Once the mixed HFCs are in a container or temporary storage unit that meets the criteria above,
645 circulation of mixed HFCs must be conducted as follows:

- 646 1. Liquid mixture shall be circulated from the liquid port to the vapor port;
- 647 2. A volume of the mixture equal to two times the volume in the container shall be circulated;
- 648 3. Circulation must occur at a rate of at least 113.6l/minute; and
- 649 4. Start and end times shall be recorded.

650
651 Within 30 minutes of the completion of circulation, a minimum of two samples shall be taken from
652 the bottom liquid port and analyzed according to the procedures above. The mass composition and
653 concentration of the mixed HFCs shall be equal to the lesser of the two GWP-weighted
654 concentrations.

655
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657

Destruction Facility Requirements

658
659 Destruction of HFCs must occur at a facility that has a valid host country permit for refrigerant
660 destruction and meets the screening criteria for destruction technologies set out in the report, as may
661 be updated from time to time, by the UNEP Technology and Economic Assessment Panel (TEAP) Task
662 Force on Destruction Technologies.

663
664 The UNEP TEAP Task Force on Destruction Technologies has reviewed HFC destruction and
665 concluded "that no additional performance criteria [beyond ODS protocols] are necessary for
666 assessing destruction technologies for the destruction of HFCs." ICF International, in a report
667 commissioned by US EPA, similarly advises that "the best installation, handling, recovery,
668 reclamation, and disposal practices are identical between ODS and HFCs." Thus operating parameters
669 of the destruction unit while destroying HFC material shall be monitored and recorded as described
670 in the Code of Good Housekeeping¹⁹ (as reproduced in full in Appendix II) approved by the Montreal
671 Protocol, with only the substitution of "HFC" for "ODS" where applicable. Likewise, the Technology
672 Screening Process for ODS destruction technologies (reproduced in full in Appendix III from TEAP
673 *Report of the Task Force on Destruction Technologies*, Chapter 2 (2002)) is equally valid for HFCs, and
674 should be followed with only the substitution of "HFC" for "ODS" where applicable.

675

¹⁹ TEAP, Code of Good Housekeeping in *Handbook for the Montreal Protocol on Substances that Deplete the Ozone Layer - 7th Edition* (2006).

676 **10 REFERENCES**

677
678 TEAP, Code of Good Housekeeping in *Handbook for the Montreal Protocol on Substances that Deplete*
679 *the Ozone Layer - 7th Edition* (2006)

680
681 *UNEP Technology and Economic Assessment Panel (TEAP) Report of the Task Force on Destruction*
682 *Technologies*, UNEP, 2002.

683 **APPENDIX I: COUNTRY-LEVEL INCLUSION CRITERIA AND ADDITIONALITY CHECK**

684
685 The Kigali Amendment to the Montreal Protocol assigns each signatory country to one of four possible HFC
686 phasedown schedules, summarized in the table below.²⁰

687
688 **Table AI-1. HFC Phasedown Schedules**

Article/Group HFC Phasedown Schedules Pursuant to Kigali Amendment				
Country Group	Countries Included	Baseline Calculation Years	Freeze Year	First Stepdown Year
Non-Article 5 (Main)	Most of the developed world	2011, 2012, 2013	--	2019
Non-Article 5 (Other)	Belarus, Russia, Kazakhstan, Turkmenistan, Uzbekistan	2011, 2012, 2013	--	2020
Article 5 (Group 1)	Most of the developing world (includes China)	2020, 2021, 2022	2024	2029
Article 5 (Group 2)	The Middle East (also includes India)	2024, 2025, 2026	2028	2032

704
705 The Kigali Amendment to the Montreal Protocol requires the determination of baseline production and consumption,
706 from which HFC phasedown schedules are calculated:

707
$$Production = CS_{Produced} - CS_{Destroyed} - CS_{Feedstock} \quad \text{(Equation AI-1)}$$

708
$$Consumption = Production + Imports - Exports \quad \text{(Equation AI-2)}$$

709 where *CS* or "controlled substance" refers to a substance in Annex A, B, C, E or F to the Montreal Protocol, whether
710 existing alone or in a mixture. It includes the isomers of any such substance, except as specified in the relevant Annex,
711 but excludes any controlled substance or mixture which is in a manufactured product other than a container used for
712 the transportation or storage of that substance.

713 Substituting Equation AI-1 into Equation AI-2 yields the following equation for consumption:

714
$$Consumption = CS_{Produced} - CS_{Destroyed} - CS_{Feedstock} + Imports - Exports \quad \text{(Equation AI-3)}$$

715 The interaction between the Montreal Protocol and carbon crediting for HFC destruction depends on a country's
716 phasedown stage because destroyed refrigerant ($CS_{Destroyed}$, Equation AI-3) is subtracted from both the baseline and
717 stepdown consumption values. Specifically, if destruction occurs during baseline setting years, it will decrease the
718 baseline consumption calculation and all subsequent stepdown year values will follow. As a result, destruction in
719 Article 5 Group 2 countries is especially effective if completed in 2024-2026 (Table AI-1).

720 When a country is already in phasedown, however, subtracting destroyed refrigerant from the calculated
721 consumption level may increase allowable production or imports. Such manipulations would be highly improbable
722 and have never been exploited, despite the existence of destruction credits for controlled substances such as ODS
723 (Office of the Ozone Secretariat, unpublished data²¹).

²⁰ Clark, E., & Wagner, S. (n.d.). The Kigali Amendment to the Montreal Protocol: HFC Phase-down. OzonAction ([link](#)).

²¹ Mr. Gerald Mutisya, Office of the Ozone Secretariat, analyzed past reported data to assess if destruction was among the uses allowing the party to stay in compliance by any Article 5 party from 1986-2022, inclusive of all controlled substances. Results indicated only one A5 country with one year in which a small amount of destruction was the basis for compliance. The amount destroyed is considered small because it was approximately 0.1% of the total production reported by that country in that year.

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Nevertheless, to safeguard against this issue, eligibility requirements for countries that use destruction to comply with their consumption limits may be updated to reflect this (Table A1-2). Specifically, Ozone Secretariat data can be monitored annually to ensure that destruction, as described in this methodology, is not enabling additional production of refrigerant gas.

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If a country does increase its production or imports due to destruction, pathways for addressing this could include discounting total credits (by the excess over the cap) or removing them from the list of eligible countries. With these safeguards in place, this methodology can safely apply to all A5 countries which have ratified the Kigali Amendment.

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733

Table A1-2. Proposed criteria for inclusion and exclusion

Scenario	Kigali Ratified	Baseline Set	Producer	Result	Who does this apply to?	Key considerations
I	No			Exclude	Any Article 5 country yet to ratify the Kigali Amendment (e.g., Qatar)	N/A
II	Yes	No		Include	Article 5 Group 2 (with Kigali Amendment ratified; e.g., India)	Destruction can be included in baseline calculation: <i>Baseline Consumption</i> $= CS_{Prod} - CS_{Dest} - CS_{Feedstock} + Imports - Exports$ Given effect on baseline calculation, all efforts to raise awareness and promote inclusion should be a priority
III	Yes	Yes	No	Include, with check	Article 5 Group 1 countries with zero production (e.g., Indonesia)	It is essential that destruction does not enable production above set stepdown limits. A country is eligible if the following is true: $Consumption\ Limit \geq Imports - Exports - CS_{Feedstock}$ If not, then the destruction enabled consumption that would have otherwise been above phasedown limits. Courses of action can include assigning discounts to generated credits, [e.g., $Discount = (Imports - Exports - CS_{Feedstock}) - Consumption\ Limit$], or amending inclusion criteria if non-compliance continues for >1 year.
IV	Yes	Yes	Yes	Include, with check	Article 5 Group 1 countries with non-zero production (e.g., China)	It is essential that destruction does not enable production above set stepdown limits. A country is eligible if the following is true: $Consumption\ Limit \geq CS_{Prod} + Imports - Exports - CS_{Feedstock}$ If not, then the destruction enabled consumption that would have otherwise been above phasedown limits. Courses of action can include assigning discounts to generated credits, [e.g., $Discount = (Imports - Exports - CS_{Feedstock}) - Consumption\ Limit$], or amending inclusion criteria if non-compliance continues for >1 year.

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736 **APPENDIX II: CODE OF GOOD HOUSEKEEPING²²**

737
738 To provide additional guidance to facility operators, in May 1992 the Technical Advisory Committee
739 prepared a “Code of Good Housekeeping” as a brief outline of measures that should be considered to ensure
740 that environmental releases of ozone-depleting substances (ODS) through all media are minimized. This
741 Code, updated by the Task Force on Destruction Technologies and amended by the Parties at their Fifteenth
742 Meeting, in 2003, is also intended to provide a framework of practices and measures that should normally be
743 adopted at facilities undertaking the destruction of ODS.

744
745 Not all measures will be appropriate to all situations and circumstances and, as with any code, nothing
746 specified should be regarded as a barrier to the adoption of better or more effective measures if these can
747 be identified.

748
749 **Pre-delivery**

750
751 This refers to measures that may be appropriate prior to any delivery of ODS to a facility.

752
753 The facility operator should generate written guidelines on ODS packaging and containment criteria, together
754 with labelling and transportation requirements. These guidelines should be provided to all suppliers and
755 senders of ODS prior to agreement to accept such substances.

756
757 The facility operator should seek to visit and inspect the proposed sender’s stocks and arrangements
758 prior to movement of the first consignment. This is to ensure awareness on the part of the sender of
759 proper practices and compliance with standards.

760
761 **Arrival at the facility**

762
763 This refers to measures that should be taken at the time ODS are received at the facility gate. These include
764 an immediate check of documentation prior to admittance to the facility site, coupled with a preliminary
765 inspection of the general condition of the consignment. Where necessary, special or “fast-track” processing
766 and repackaging facilities may be needed to mitigate risk of leakage or loss of ODS. Arrangements should
767 exist to measure the gross weight of the consignment at the time of delivery.

768
769 **Unloading from delivery vehicle**

770
771 This refers to measures to be taken at the facility in connection with the unloading of ODS. It is generally
772 assumed that ODS will normally be delivered in some form of container, drum or other vessel that is
773 removed from the delivery vehicle in total. Such containers may be returnable.

774
775 All unloading activities should be carried out in properly designated areas, to which restricted access of
776 personnel applies. Areas should be free of extraneous activities likely to lead to, or increase the risk of,
777 collision, accidental dropping, spillage, etc. Materials should be placed in designated quarantine areas for
778 subsequent detailed checking and evaluation.

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²² Reproduced in full from: TEAP, Code of Good Housekeeping in *Handbook for the Montreal Protocol on Substances that Deplete the Ozone Layer - 7th Edition* (2006)

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Testing and verification

This refers to the arrangements made for detailed checking of the ODS consignments prior to destruction.

Detailed checking of delivery documentation should be carried out, along with a complete inventory, to establish that delivery is as advised and appears to comply with expectations.

Detailed checks of containers should be made both in respect of accuracy of identification labels, etc, and of physical condition and integrity. Arrangements must be in place to permit repackaging or “fast-track” processing of any items identified as defective. Sampling and analysis of representative quantities of ODS consignments should be carried out to verify material type and characteristics. All sampling and analysis should be conducted using approved procedures and techniques.

Storage and stock control

This refers to matters concerning the storage and stock control of ODS.

ODS materials should be stored in specially designated areas, subject to the regulations of the relevant local authorities. Arrangements should be put in place as soon as possible to minimize, to the extent practicable, stock emissions prior to destruction.

Locations of stock items should be identified through a system of control that should also provide a continuous update of quantities and locations as stock is destroyed and new stock delivered. In regard to storage vessels for concentrated sources of ODS, these arrangements should include a system for regular monitoring and leak detection, as well as arrangements to permit repackaging of leaking stock as soon as possible.

Measuring quantities destroyed

It is important to be aware of the quantities of ODS processed through the destruction equipment. Where possible, flow meters or continuously recording weighing equipment for individual containers should be employed. As a minimum, containers should be weighed “full” and “empty” to establish quantities by difference.

Residual quantities of ODS in containers that can be sealed and are intended to be returned for further use, may be allowed. Otherwise, containers should be purged of residues or destroyed as part of the process.

Facility design

This refers to basic features and requirements of plant, equipment and services deployed in the facility.

In general, any destruction facility should be properly designed and constructed in accordance with the best standards of engineering and technology and with particular regard to the need to minimize, if not eliminate, fugitive losses.

Particular care should be taken when designing plants to deal with dilute sources such as foams. These may

827 be contained in refrigeration cabinets or may be part of more general demolition waste. The area in which
828 foam is first separated from other substrates should be fully enclosed wherever possible and any significant
829 emissions captured at that stage.

830
831 *Pumps:* Magnetic drive, sealers or double mechanical seal pumps should be installed to eliminate
832 environmental releases resulting from seal leakage.

833
834 *Valves:* Valves with reduced leakage potential should be used. These include quarter-turn valves or valves
835 with extended packing glands.

836
837 *Tank vents (including loading vents):* Filling and breathing discharges from tanks and vessels should be recovered or
838 vented to a destruction process.

839
840 *Piping joints:* Screwed connections should not be used and the number of flanged joints should be kept to the
841 minimum that is consistent with safety and the ability to dismantle for maintenance and repair.

842
843 *Drainage systems:* Areas of the facility where ODS are stored or handled should be provided with sloped
844 concrete paving and a properly designed collection system. Water that is collected should, if contaminated, be
845 treated prior to authorized discharge.

846 847 **Maintenance**

848
849 In general, all maintenance work should be performed according to properly planned programmes and
850 should be executed within the framework of a permit system to ensure proper consideration of all aspects of
851 the work.

852
853 ODS should be purged from all vessels, mechanical units and pipework prior to the opening of these items to
854 the atmosphere. The contaminated purge should be routed to the destruction process or treated to recover
855 the ODS.

856
857 All flanges, seals, gaskets and other sources of minor losses should be checked routinely to identify
858 developing problems before containment is lost. Leaks should be repaired as soon as possible.

859
860 Consumable or short-life items, such as flexible hoses and couplings, must be monitored closely and replaced
861 at a frequency that renders the risk of rupture negligible.

862 863 **Quality control and quality assurance**

864
865 All sampling and analytical work connected with ODS, the process and the monitoring of its overall
866 performance should be subject to quality assessment and quality control measures in line with current
867 recognized practices. This should include at least occasional independent verification and confirmation of data
868 produced by the facility operators.

869
870 Consideration should also be given to the adoption of quality management systems and environment quality
871 practices covering the entire facility.

872 873 **Training**

874
875 All personnel concerned with the operation of the facility (with “operation” being interpreted in its widest
876 sense) should have training appropriate to their task. Of particular relevance to the ODS destruction
877 objectives is training in the consequences of unnecessary losses and in the use, handling and maintenance of
878 all equipment in the facility. All training should be carried out by suitably qualified and experienced
879 personnel and the details of such training should be maintained in written records. Refresher training should
880 be conducted at appropriate intervals.

881
882 **Code of transportation**

883
884 In the interest of protecting the stratospheric ozone layer, it is essential that used ODS and products
885 containing ODS are collected and moved efficiently to facilities practising approved destruction technologies.
886 For transportation purposes, used ODS should receive the same hazard classification as the original
887 substances or products. In practice, this may introduce restrictions on hazardous waste shipment under the
888 Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and their Disposal and
889 this should be consulted separately. In the absence of such specific restrictions, the following proposed code
890 of transportation for ODS from customer to destruction facilities is provided as a guide to help minimize
891 damage caused to the ozone layer as a result of ODS transfers. Additional guidance is contained in the United
892 Nations Transport of Dangerous Goods Model Regulations.

893
894 It is important to supervise and control all shipments of used ODS and products containing ODS according to
895 national and international requirements to protect the environment and human health. To ensure that ODS
896 and products containing ODS do not constitute an unnecessary risk, they must be properly packaged and
897 labelled. Instructions to be followed in the event of danger or accident must accompany each shipment to
898 protect human beings and the environment from any danger that might arise during the operation.

899
900 Notification of the following information should be provided at any intermediate stage of the shipment from
901 the place of dispatch until its final destination. When making notification, the notifier should supply the
902 information requested on the consignment note, with particular regard to:

- 903 a. The source and composition of the ODS and products containing ODS, including the customer’s
904 identity;
- 905 b. Arrangements for routing and for insurance against damage to third parties;
- 906 c. Measures to be taken to ensure safe transport and, in particular, compliance by the carrier with the
907 conditions laid down for transport by the States concerned;
- 908 d. The identity of the consignee, who should possess an authorized centre with adequate technical
909 capacity for the destruction;
- 910 e. The existence of a contractual agreement with the consignee concerning the destruction of ODS and
911 products containing ODS.

912
913 This code of transportation does not necessarily apply to the disposal of ODS-containing rigid insulation
914 foams. The most appropriate way to dispose of such products may be by direct incineration in municipal
915 waste incinerators or rotary kiln incinerators.

916
917 **Monitoring**

918
919 The objectives of monitoring should be to provide assurance that input materials are being destroyed with an
920 acceptable efficiency generally consistent with the destruction and removal efficiency (DRE)
921 recommendations listed in annex II to the present report and that the substances resulting from destruction
922 yield environmentally acceptable emission levels consistent with, or better than, those required under
923 national standards or other international protocols or treaties.

924
925 As there are as yet no International Organization for Standardization (ISO) standards applicable for the
926 sampling and analysis of ODS or the majority of the other pollutants listed in annex IV to the present report,
927 where national standards exist they should be employed. Further, where national standards exist they may
928 be used in lieu of ISO standards provided that they have been the subject of a verification or validation
929 process addressing their accuracy and representativeness.

930
931 As ISO develops international standards for pollutants listed in annex IV to the present report, the
932 technical bodies charged with developing such standards should take note of the existing national
933 standards including those identified in appendix F to the report of the Technology and Economic
934 Assessment Panel (TEAP) of April 2002 (volume 3, report of the Task Force on Destruction Technologies)
935 and strive to ensure consistency between any new ISO standards and the existing standard test methods,
936 provided that there is no finding that those existing methods are inaccurate or unrepresentative.

937
938 Where national standards do not exist, the Technical Advisory Committee recommends adoption of the
939 following guidelines for monitoring of destruction processes operating using an approved technology.

940
941 Recognizing that the United States of America Environmental Protection Agency (EPA) methods have been
942 the subject of verification procedures to ensure that they are reasonably accurate and representative, that
943 they cover all of the pollutants of interest (although not all ODS compounds have been the specific subject of
944 verification activities), that they provide a comprehensive level of detail that should lead to replicability of
945 the methods by trained personnel in other jurisdictions and that they are
946 readily available for reference and downloading from the Internet without the payment of a fee, applicable
947 EPA methods as described in appendix F to the 2002 report of TEAP may be employed.

948
949 In the interest of ensuring a common international basis of comparison for those pollutants or parameters
950 where ISO standards exist (currently particulates, carbon monoxide, carbon dioxide and oxygen), use of
951 those standards is encouraged and jurisdictions are encouraged to adopt them as national standards or
952 acceptable alternatives to existing national standards.

953
954 The use of EPA or other national standards described in appendix F is also considered acceptable, however.
955 The precedence given to the EPA methods in the present code is based on the relative comprehensiveness of
956 the methods available (both in scope and content), and the relative ease of access to those methods.

957
958 **Measurement of ODS**

959
960 Operators of destruction facilities should take all necessary precautions concerning the storage and
961 inventory control of ODS-containing material received for destruction. Prior to feeding the ODS to the
962 approved destruction process, the following procedures are recommended:

- 963 a. The mass of the ODS-containing material should be determined, where practicable;
- 964 b. Representative samples should be taken, where appropriate, to verify that the concentration of
- 965 ODS matches the description given on the delivery documentation;
- 966 c. Samples should be analysed by an approved method. If no approved methods are available, the
- 967 adoption of United States EPA methods 5030 and 8240 is recommended;
- 968 d. All records from these mass and ODS-concentration measurements should be documented and kept
- 969 in accordance with ISO 9000 or equivalent.

970
971

Control systems

972
973 Operators should ensure that destruction processes are operated efficiently to ensure complete destruction

974 of ODS to the extent that it is technically feasible for the approved process. This will normally include the use

975 of appropriate measurement devices and sampling techniques to monitor the operating parameters, burn

976 conditions and mass concentrations of the pollutants that are generated by the process.

977
978 Gaseous emissions from the process need to be monitored and analysed using appropriate instrumentation.

979 This should be supplemented by regular spot checks using manual stack-sampling methods. Other

980 environmental releases, such as liquid effluents and solid residues, require laboratory analysis on a regular

981 basis.

982
983 The continuous monitoring recommended for ongoing process control, including off-gas cleaning systems,

984 is as follows:

- 985 a. Measurement of appropriate reaction and process temperatures;
- 986 b. Measurement of flue gas temperatures before and after the gas cleaning system;
- 987 c. Measurement of flue gas concentrations for oxygen and carbon monoxide.

988
989 Any additional continuous monitoring requirements are subject to the national regulatory authority that has

990 jurisdiction. The performance of online monitors and instrumentation systems must be periodically checked

991 and validated. When measuring detection limits, error values at the 95 per cent confidence level should not

992 exceed 20 per cent.

993
994 Approved processes must be equipped with automatic cut-off control systems on the ODS feed system, or

995 be able to go into standby mode whenever:

- 996
997 a. The temperature in the reaction chamber falls below the minimum temperature required to
- 998 achieve destruction;
- 999 b. Other minimum destruction conditions stated in the performance specifications cannot be
- 1000 maintained.

1001
1002

Performance measurements

1003
1004 The approval of technologies recommended by TEAP is based on the destruction capability of the technology

1005 in question. It is recognized that the parameters may fluctuate during day-to-day operation from this generic

1006 capability. In practice, however, it is not possible to measure against performance criteria on a daily basis.
1007 This is particularly the case for situations where ODS only represents a small fraction of the substances being
1008 destroyed, thereby requiring specialist equipment to achieve detection of the very low concentrations
1009 present in the stack gas. It is therefore not uncommon for validation processes to take place annually at a
1010 given facility.

1011
1012 With this in mind, TEAP is aware that the measured performance of a facility may not always meet the
1013 criteria established for the technology. Nonetheless, TEAP sees no justification for reducing the minimum
1014 recommendations for a given technology. Regulators, however, may need to take these practical variations
1015 into account when setting minimum standards.

1016
1017 The ODS destruction and removal efficiency²³ for a facility operating an approved technology should be
1018 validated at least once every three years. The validation process should also include an assessment of other
1019 relevant stack gas concentrations identified in annex II to decision XV/[...] and a comparison with maximum
1020 levels stipulated in relevant national standards or international protocols/treaties.

1021
1022 Determination of the ODS destruction and removal efficiency and other relevant substances identified in
1023 annex IV to the present report should also be followed when commissioning a new or rebuilt facility or when
1024 any other significant change is made to the destruction procedures in a facility to ensure that all facility
1025 characteristics are completely documented and assessed against the approved technology criteria.

1026
1027 Tests shall be done with known feed rates of a given ODS compound or with well-known ODS mixtures. In
1028 cases where a destruction process incinerates halogen-containing wastes together with ODS, the total
1029 halogen load should be calculated and controlled. The number and duration of test runs should be carefully
1030 selected to reflect the characteristics of the technology.

1031
1032 In summary, the destruction and removal efficiency recommended for concentrated sources means that less
1033 than 0.1 gram of total ODS should normally enter the environment from stack-gas emissions when 1,000
1034 grams of ODS are fed into the process. A detailed analysis of stack test results should be made available to
1035 verify emissions of halogen acids and polychlorinated dibenzodioxin and dibenzofuran (PCDD/PCDF). In
1036 addition, a site-specific test protocol should be prepared and made available for inspection by the
1037 appropriate regulatory authorities. The sampling protocol shall report the following data from each test:

- 1038 a. ODS feed rate;
- 1039 b. Total halogen load in the waste stream;
- 1040 c. Residence time for ODS in the reaction zone;
- 1041 d. Oxygen content in flue gas;
- 1042 e. Gas temperature in the reaction zone;
- 1043 f. Flue gas and effluent flow rate;
- 1044 g. Carbon monoxide in flue gas;

²³ Destruction and removal efficiency 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

- 1045 h. ODS content in flue gas;
- 1046 i. Effluent volumes and quantities of solid residues discharged;
- 1047 j. ODS concentrations in the effluent and solid residues;
- 1048 k. Concentration of PCDD/PCDF, particulates, HCl, HF and HBr in the flue gases;
- 1049 l. Concentration of PCDD/PCDF in effluent and solids.

APPENDIX III: TECHNOLOGY SCREENING PROCESS²⁴

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 3-1. 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 below.

Table A3-1: Summary of Technical Performance Qualifications²⁵

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	mg/NM ³	50	50
CO	mg/NM ³	100	100

²⁴ Reproduced in full from: *UNEP Technology and Economic Assessment Panel (TEAP) Report of the Task Force on Destruction Technologies*, UNEP, 2002. Available at:

http://ozone.unep.org/teap/Reports/Other_Task_Force/TEAP02V3b.pdf

²⁵ 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.

1082 ***Destruction and Removal Efficiency***

1083
1084 Destruction Efficiency (DE)²⁶ is a measure of how completely a particular technology destroys a contaminant
1085 of interest – in this case the transformation of ODS material into non-ODS by-products. There are two
1086 commonly used but different ways of measuring the extent of destruction – DE and Destruction and Removal
1087 Efficiency (DRE)²⁷. For a more detailed explanation of how DRE is calculated, see section 4.2.1. The terms are
1088 sometimes interchanged or used inappropriately. DE is a more comprehensive measure of destruction than
1089 DRE, because DE considers the amount of the chemical of interest that escapes destruction by being removed
1090 from the process in the stack gases and in all other residue streams. Most references citing performance of
1091 ODS destruction processes only provide data for stack emissions and thus, generally, data is only available
1092 for DRE and not DE.

1093
1094 Because of the relatively volatile nature of ODS and because, with the exception of foams, they are generally
1095 introduced as relatively clean fluids, one would not expect a very significant difference between DRE and DE.
1096 For these reasons this update of ODS destruction technologies uses DRE as the measure of destruction
1097 efficiency. For the purposes of screening destruction technologies, the minimum acceptable DRE is:

- 1098
- 95% for foams; and,
 - 99.99% for concentrated sources.
- 1099

1100
1101 It should be noted that measurements of the by-products of destruction of CFCs, HCFCs and halons in a
1102 plasma destruction process have indicated that interconversion of ODS can occur during the process. For
1103 example, under some conditions, the DRE of CFC-12 (CCl₂F₂) was measured as 99.9998%, but this was
1104 accompanied by a conversion of 25% of the input CFC-12 to CFC-13 (CClF₃), which has the same ozone-
1105 depleting potential. The interconversion is less severe when hydrogen is present in the process, but can
1106 nonetheless be significant.²⁸ For this reason, it is important to take into account all types of ODS in the stack
1107 gas in defining the DRE.

1108
1109 For the reasons described in the previous paragraph, the Task Force recommends that future calculations
1110 of DRE use the approach described below²⁹.

1111

²⁶ 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.

²⁷ 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

²⁸ 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.

²⁹ 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.*

1112 DRE of an ODS should be determined by subtracting from the number of moles of the ODS fed into a
1113 destruction system during a specific period of time, the total number of moles of all types of ODS that are
1114 released in stack gases, and expressing that difference as a percentage of the number of moles of the ODS fed
1115 into the system.

1116
1117 In mathematical terms, $DRE = \frac{N_i^{in} - \sum_i N_i^{out}}{N_i^{in}}$ where N_i^{in} is the number of moles of ODS fed into the destruction
1118 system and N_i^{out} is the number of moles of the i th type of ODS that is released in the stack gases.

1119 1120 ***Emissions of Dioxins and Furans***

1121
1122 Any high temperature process used to destroy ODS has associated with it the potential formation (as by-
1123 products) of polychlorinated dibenzo-paradioxins (PCDDs) and polychlorinated dibenzofurans (PCDFs).
1124 These substances are among the products of incomplete combustion (or PICs) of greatest concern for
1125 potential adverse effects on public health and the environment. The internationally recognized measure
1126 of the toxicity of these compounds is the toxic equivalency factor (ITEQ),³⁰ which is a weighted measure
1127 of the toxicity for all the members of the families of these toxic compounds that are determined to be
1128 present.

1129
1130 The task force members note that the World Health Organization has developed a new system for calculating
1131 TEQs, however, most of the existing data on emissions is expressed in the former ITEQ system established in
1132 1988.

1133
1134 For purposes of screening destruction technologies, the maximum concentration of dioxins and furans in the
1135 stack gas from destruction technologies is:

- 1136 • 0.5 ng-ITEQ/Nm³ for foams; and,
- 1137 • 0.2 ng-ITEQ/Nm³ for concentrated sources.

1138
1139 These criteria were determined to represent a reasonable compromise between more stringent standards
1140 already in place in some industrialized countries [for example, the Canada-Wide Standard of 0.08 ng/m³
1141 (ITEQ)], and the situation in developing countries where standards may be less stringent or non-existent.
1142 Although a previous standard of 1.0 ng/m³ (ITEQ) had been suggested in the UNEP 1992 report, advances in
1143 technology in recent years, and the level of concern for emissions of these highly toxic substances justified a
1144 significantly more stringent level.

³⁰ 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.]

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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.

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).*

- 1188 • The processing capacity of an acceptable pilot plant or demonstration plant must be no less than
1189 1.0 kg/hr of the substance to be destroyed, whether ODS or a suitable surrogate.

1190

1191 These criteria of technical capability will minimize the risk associated with technical performance and ensure that
1192 destruction of ODS will be performed in a predictable manner consistent with protecting the environment.