



**ODS/HFC reclamation and destruction technologies - Insights into the new
COPA publication**
10 January 2024

AGENDA

Welcome Remarks

Ellen Michel, GIZ; COPA Secretariat

**Presentation of the study ODS/HFC
reclamation and destruction technologies**

Manuel Prieto Garcia, HEAT GmbH

Q&A

All participants



1. Opening
Ellen Michel, GIZ

INTRODUCTION

Approach

COPA works jointly with partner countries and diverse actors across private and public sectors to advance the holistic solutions needed to reduce ODS and HFC banks, and ultimately complete the shift in the cooling sector to sustainable refrigerant management.

Implemented by:



In cooperation with:



Supported by:



on the basis of a decision
by the German Bundestag

ODS AND HFC BANKS MANAGEMENT

the gap

Due to a general **lack of appropriate regulatory frameworks, financial means as well as infrastructure**, the collection, reclamation or destruction of waste containing ODS and HFC presents a major challenge.



CLIMATE AND OZONE PROTECTION ALLIANCE (COPA)

Activities

COPA works jointly with partner countries and diverse actors across private and public sectors to advance the holistic solutions needed to **reduce ODS and HFC banks**, and ultimately complete the shift in the cooling sector to **sustainable refrigerant management**.



Implemented by:



In cooperation with:



Supported by:



on the basis of a decision by the German Bundestag

COUNTRY MEMBERS

Africa

Asia



**Latin
America
and
Caribbean**

NON-COUNTRY MEMBERS



SET ALLIANCE





2. Presentation of the study "ODS/HFC Reclamation and Destruction Technologies: A review for Article 5 Countries"
Manuel Prieto Garcia HEAT

OUTLINE

- 1) **Introduction**
 - I. Scope and Methodology of the study
 - II. Background (ODS/HFC banks)
- 2) **Reclamation**
 - I. New projects and Facilities worldwide
 - II. Technologies (advantages and disadvantages)
 - III. Reclamation practices in Article 5 countries
 - IV. List of reclamation facilities
- 3) **Destruction**
 - I. Projects and Facilities worldwide and MLF projects
 - II. Overview of the 4 destruction technologies for Article 5 countries
 - III. List of destruction facilities
- 4) **Conclusions and recommendations for Article 5 countries**

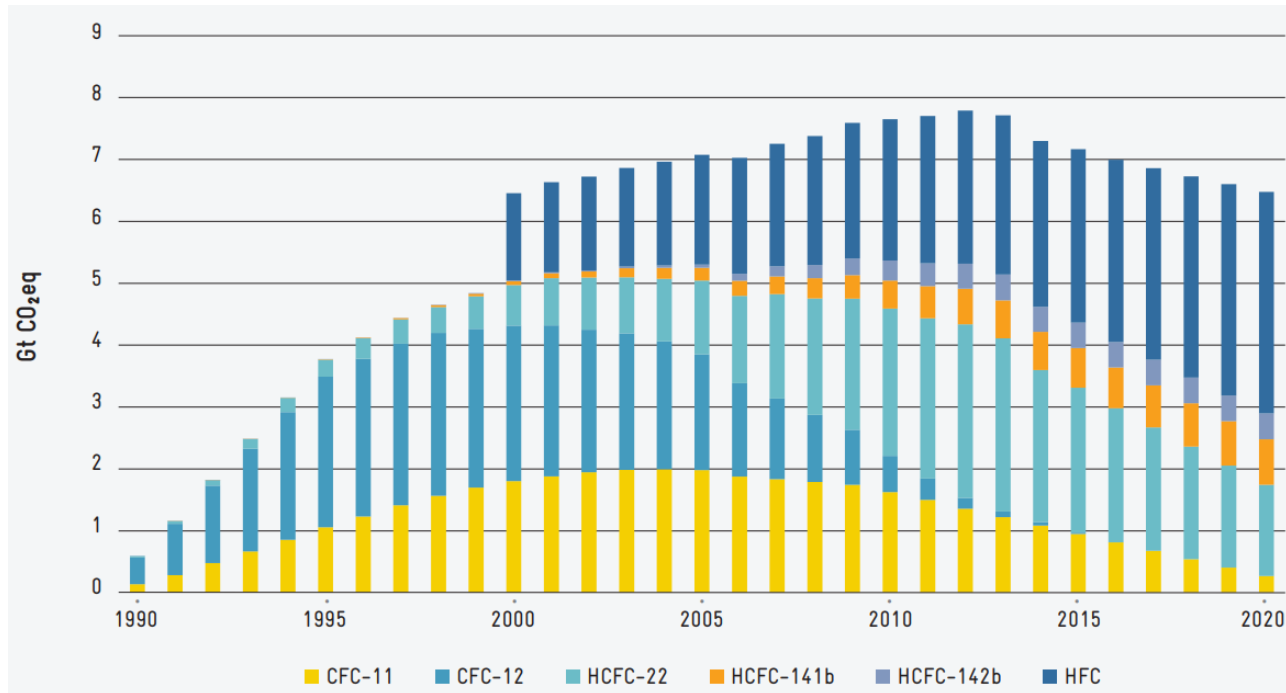
SCOPE

- Do a review of **reclamation** and **destruction technologies** and focusing on their **suitability** for **Article 5 countries**.

METHODOLOGY

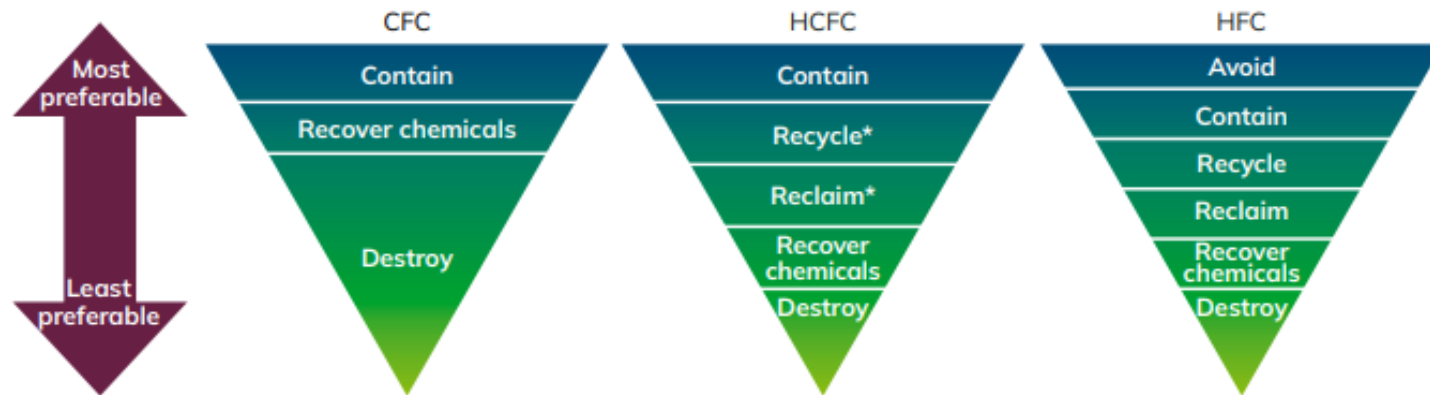
- **Reclamation:** a **literature review** of available information on **interviews** and background discussions **reclamation companies**, **RAC equipment recycling centres** and a **university**.
- **Destruction:** **only a literature review** was conducted to assess the most relevant destruction technologies. **MLF demonstration projects** were the focus of this review.

ESTIMATED BANKS IN ARTICLE 5 COUNTRIES



Source:
GIZ. 2017. Global Banks
of Ozone Depleting
Substances - A Country-
Level Estimate.

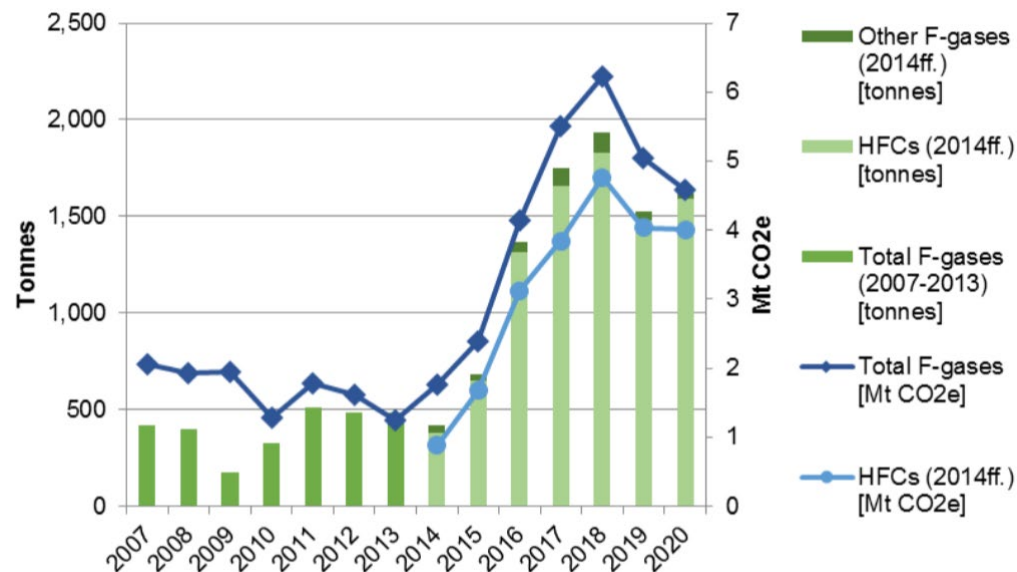
ODS/HFC BANK MANAGEMENT HIERARCHY



**Recycling and Reclaim of HCFCs should be subject to a cutoff date that is aligned with the phase-out of HCFCs*
Source: HEAT 2023

RECLAMATION OF ODS/HFCs

- US: 63 reclaimers. More than 5500 tonnes of refrigerant reclaimed in 2021
- EU: Reclaimed gas is 11% of the production and 3% of total consumption
- Chile: 31.3t of R-22 and 0.62t of R-134a



Source:
EEA 2021. <https://www.eea.europa.eu/publications/fluorinated-greenhouse-gases-2021>

RECLAMATION TECHNOLOGIES

Distillation

- ✓ Low Costs
- ✓ Processing time
- ✓ Commercially **available**
- ✗ **Not effective** for Blends
- ✗ Compressor needed

Adsorption

- ✓ **Most effective** method
- ✓ Only **one step** required
- Costs
- ✗ Technology design for **one type** of refrigerant
- ✗ Material **loses** its adsorption **capacity**

Subcooling

- ✓ Easy set up
- ✓ Low risk of **leakage**
- ✓ Works with **small amounts**
- ✗ **High costs**
- ✗ Not suitable for blends (?)

RECLAMATION ACTIVATES IN PRACTICE

Case of *Regener* (Chile)

- Refrigerant reclaim and WEEE recycling
- Great efforts to acquire the refrigerant from large manufactures in the country
- **Technology:** Distillation - BullDog 460 by RefTec

Case of *Enviroserve* (UAE)

- Refrigerant reclaim and WEEE recycling
- Appealing to the environmental and corporate social responsibility of tech companies.
- **Technology:** Distillation - JV90 reclaim system by Ekotez

Refrigerant	UAE		Chile		Units
	Reclaimed	New	Reclaimed	New	
HCFC-22	3.0-3.3	4.9	3.0	3.0-3.5*	US\$/kg
HFC-134a	2.7-3.0	6.8-7.6	-	-	US\$/kg
HFC-410A	4.9	8.7-9.8	-	-	US\$/kg

LIST OF RECLAMATION FACILITIES BY COUNTRY

No	Country	Number of Known ODS/HFC Reclamation Facilities in Operation	Known Technologies Utilized	ODS/HFC Reclamation Capacity (incl. substances)
1	Austria	3	NA	NA
2	Australia	3	NA	NA
3	Belgium	3	NA	NA
4	Bulgaria	2	NA	NA
5	Canada	8	NA	NA
6	Chile	1	Distillation	NA
7	Croatia	1	NA	NA
8	Czech Republic	3	NA	NA
9	Estonia	1	NA	NA
10	Denmark	5	NA	NA
11	France	3	NA	NA
12	Germany	2	NA	NA
13	Hungary	1	NA	NA
14	Italy	14	NA	NA
15	Japan	6	NA	NA
16	Lithuania	1	NA	NA
17	Luxembourg	1	NA	NA
18	Netherlands	3	NA	NA

19	New Zealand	1	NA	NA
20	Norway	2	NA	NA
21	Poland	1	NA	NA
22	Slovakia	2	NA	NA
23	Slovenia	1	NA	NA
24	Singapore	2	NA	NA
25	Slovakia	5	NA	NA
26	Spain	3	NA	NA
27	South Africa	1	NA	NA
28	Russia	4	NA	NA
30	Thailand	1	NA	NA
31	United Araba Emirates	1	Distillation	NA
32	United Kingdom	3	NA	NA
33	United States	63	Distillation Adsorption Subcooling	NA

DESTRUCTION OF ODS/HFCs

- There are **172 destruction facilities** worldwide that we are aware of.
- **Japan** is the leader with **80**
- Italy **12**
- United States **11**
- Germany **7**
- **9 MLF projects reviews**
- **Export:** Georgia, Ghana, Türkiye and ECA region
- **Rotary kiln incineration:** China, Nigeria
- **MSWI and HTI:** Colombia
- **Argon plasma arc:** Mexico
- **Cement kiln:** Mexico

TECHNOLOGIES FOR THE DESTRUCTION OF ODS/HFCs

Approved destruction technologies		Advantages for Article 5 countries	Disadvantages for Article 5 countries
Thermal Oxidation technologies	Cement kilns	<p>Already exist in many countries.</p> <p>Already established for hazardous waste treatment.</p> <p>Adjustments are easy and relatively cheap.</p>	<p>Low to high emissions, depending on adaptation of the technology.</p> <p>Measuring the emissions can be challenging.</p>
	Municipal solid waste incineration (MSWI)	<p>Useful if there are already operating plants in the country/area.</p>	<p>High investment and operational cost for new plants.</p> <p>Not very effective as destruction method for ODS/HFCs.</p> <p>Risk of high emission if the incineration is not done properly.</p>
	Rotary kiln incineration	<p>Already exists in Article 5 countries.</p> <p>Only approved technology for the destruction of all ODS/HFCs (excluding Methyl Bromide).</p> <p>Low emissions.</p>	<p>Useful only if already established (e.g., by chemical companies).</p> <p>High investment and operational costs.</p>
Plasma technologies	Argon plasma arc	<p>Very low emissions.</p> <p>Compatible with the chemical industry.</p> <p>Effective destruction method.</p>	<p>High costs and high requirements make their implementation difficult in Article 5 countries.</p> <p>Low availability for acquisition, including spare parts (only one company holds the patent)</p>

TECHNICAL OVERVIEW OF THE TECHNOLOGIES

Technology	Cement Kiln	MSWI	Rotary kiln Incineration	Argon Plasma Arc
Accessibility	High	Low	Low to medium	Low to medium
Degree of operational complexity	Low	High	High to medium	High
Building/adjustment costs	Low to medium (liquid feeding lines to kiln, storage facilities)	High building costs and low adjustments costs	High (Ghana – Zeal over 3 million USD)	High (4.2 million USD + installation and transportation)
Energy Consumption kWh/kg	NA	NA	NA	4.32
Destructions Costs USD/kg	6.0	5.2-6.2	1.9-2.5 (non-Article 5) 8.0-29.8 (Article 5)	7.5

LIST OF DESTRUCTION FACILITIES BY COUNTRY

Country	Number ODS/HFC Destruction Facilities in Operation	Known Technologies Utilized	ODS/HFC Destruction Capacity (incl. substances)	Typical Destruction Costs (US\$)
1. Algeria	1	Cement Kiln	NA	NA
2. Argentina	2 or more	NA	NA	NA
3. Australia	2	Argon Plasma Arc (1) Cement Kiln (1)	600 MT/year	\$7/kg
4. Austria	1	NA	NA	NA
5. Belgium	2	Rotary Kiln	NA	NA
6. Brazil	4 or more	Rotary Kiln Cracking Reactor Argon Plasma Arc Chemical Reaction with H2 and CO2	NA	NA
7. Canada	1	Rotary Kiln	Not accepting ODS for commercial destruction	\$12/kg
8. China	5	Plasma technology (1) Rotary Kiln (3) Local hazardous waste facility (1)	NA	Rotary kiln: \$813/kg

9. Colombia	1	Rotary Kiln	NA	High temperature incineration: \$5-6/kg
10. Cuba	1	Cement Kiln	NA	NA
11. Czech Republic	1	Rotary Kiln	40 MT/year	NA
12. Denmark	4	Catalytic Cracking	NA	NA
13. Estonia	1	NA	NA	NA
14. Finland	1	Rotary Kiln	545 MT/year	NA
15. France	2	NA	NA	NA
16. Germany	7	Hazardous Waste Incinerator Reactor Cracking Porous Reactor	1,600 MT/year (Reactor Cracking)	NA
17. Ghana	1	Rotary Kiln	In construction	NA
18. Hungary	5	Rotary Kiln Liquid Injection Incineration	75 MT/year (Rotary Kiln) 13 MT/year (Liquid Injection Incineration)	NA
19. Indonesia	1	Cement kiln	600 MT/year	NA
20. Italy	12	NA	NA	NA

LIST OF DESTRUCTION FACILITIES PER COUNTRY

Country	Number ODS/HFC Destruction Facilities in Operation	Known Technologies Utilized	ODS/HFC Destruction Capacity (incl. substances)	Typical Destruction Costs (US\$)
21. Japan	80	Cement Kilns/Lime Rotary Kilns (7) Nitrogen Plasma Arc (8) Rotary Kiln Incineration/Municipal Solid Waste Incinerators (24) Liquid Injection Incineration (7) Microwave Plasma (5) Inductively Coupled Radio Frequency Plasma (1) Gas-Phase Catalytic Dehalogenation (1) Superheated Steam Reactors (25) Solid-Phase Alkaline Reactor (1) Electric Furnace (1)	36 MT/year (one catalytic facility) 2,600 MT/year (one incinerator)	Rotary Kilns: \$4/kg Superheated Steam: \$5/kg Plasma Arc: \$9/kg Reactor Cracking: \$4-6/kg Gas Phase Catalytic Dehalogenation: \$5-7/kg
22. Mexico	2	Plasma Arc Cement Kiln		Plasma Arc: \$8/kg Cement Kiln: \$6/kg
23. Netherlands	6	NA		NA
24. Nigeria	1	Rotary Kiln		\$30/kg
25. Poland	1	NA		NA
26. Slovakia	1	NA		NA
27. Spain	1	NA		NA
28. Sweden	4	Air Plasma		100 MT/year NA
29. Switzerland	4 or more	Rotary Kiln, among others		910 MT/year (Rotary Kiln) > 320 MT/year NA
30. United Kingdom	2	High-Temperature Incineration		NA NA
31. United States	11	Rotary Kilns Plasma Arc Fixed Hearth Units Liquid Injection Units Cement Kilns Lightweight Aggregate Kilns		318 MT/year (Plasma Arc) \$2 - \$13/kg
32. Venezuela	2 or more	NA		NA

CONCLUSIONS AND RECOMMENDATIONS FOR ARTICLE 5 COUNTRIES ON RECLAMATION

Promote stakeholder engagement in EOL management of ODS/HFCs to facilitate collection of the gases.

Appeal to the environmental obligations of end users to enhance the collection and ODS/HFC.

Diversify the activities in the reclamation centres to create a strong business model.

Engage with governmental institutions and universities.

Build a network with servicing companies and other stakeholders to promote best practices and the safe collection of refrigerants.

Before opening a reclamation centre is very important to ensure that there are enough ODS/HFCs available.

Regulations that reduce the amount of virgin refrigerant in the market contribute to the economic viability of reclaimed refrigerant.

CONCLUSIONS AND RECOMMENDATIONS FOR ARTICLE 5 COUNTRIES ON DESTRUCTION

A detailed analysis of the costs of destruction in the country compared to exporting these gases for destruction abroad is recommended.

The adaptation of technologies that have previously been used for the destruction of other types of waste should be subject to testing and emission control.

Destruction facilities should focus not only on ODS/HFCs but also diversify on the type of waste that they can destroy.

Appealing to the environmental and social responsibility of large companies to collect and manage their used ODS/HFCs.

The establishment of an EPR system that allocates responsibility for the proper end-of-life management of ODS/HFCs to importers or producers.

For Destruction of ODS/HFCs is financed with carbon credits in the voluntary market, it is crucial to ensure that there is both a destruction facility and enough substances available for destruction.

Questions?



Thank you for your attention!



3. Q&A
All participants

QUESTIONS ON COST CONSIDERATIONS

Is subcooling the most expensive method?

The operating costs of subcooling are the highest of the three recovery methods due to its high energy consumption. Building costs may vary from case to case. However, as subcooling is a state-of-the-art technology, its building costs are also high compared to the other technologies.

What are the charges for recovering refrigerants in different countries?

As a source for this information, UNEP/TEAP did a study in 2009 where they calculated all the costs of collection, recovery, transport and destruction of refrigerants in the RAC sectors. This can be used as a guide. Reference: UNDP and TEAP (2009). UNEP Technology and Economic Assessment Panel Task Force Decision XX/7-Phase 2 Report "Environmentally Sound Management of Banks of Ozone Depleting Substances."

What is the estimated cost of reclaimed R-22 compared to the cost of virgin R-22?

Prices for R-22 in Chile and the UAE can be found in the [COPA study](#) "ODS/HFC Reclamation and Destruction Technologies A review for Article 5 Countries".

If the cost of reclaimed refrigerant is higher than the virgin chemical, do we consider reclamation as a viable solution?

It depends, there is proof that from a financial point of view reclamation can be viable. See the examples in pages 19-23 of the [COPA study](#) "ODS/HFC Reclamation and Destruction Technologies A review for Article 5 Countries". Reclamation also makes sense from an environmental point of view. It is also important to consider that the prices of virgin HCFCs and HFCs are expected to rise because of the phase-out and phase-down plans. There are also regulations, such as import bans, that can make the reclaimed refrigerant more competitive. On the other hand, some companies might be interested in paying more money for a refrigerant that is reclaimed if they want to achieve "carbon neutrality" for example and are looked to have label on their products that certifies this.

For more information have a look at the [ODS/HFC Reclamation and Destruction Technologies A review for Article 5 Countries by COPA 2023](#).

QUESTIONS ON FINANCIAL VIABILITY AND BUSINESS STRATEGY:

Do the prices indicated in slide number 17 cover the recovery, transportation, storage, handling, and other associated costs?

Yes, this is the selling price, so it includes any costs carried out by the reclamation centers. You can find more information on page 20 and 21 of the [COPA study](#) "ODS/HFC Reclamation and Destruction Technologies A review for Article 5 Countries"

If reclamation is not financially viable, how do you suggest the establishment of reclamation centres in the private sector?

Reclamation can be economically viable. However, in countries where there are no external producer responsibility (EPR) schemes or other regulations to ensure the collection and recovery of refrigerants, the private sector will have to go the extra mile to find enough refrigerant for reclamation. As for the selling prices of refrigerants, these are expected to increase as a result of the phase-down and phase-out plans. In addition, some companies may be interested in paying more for a reclaimed refrigerant if, for example, they want to achieve "carbon neutrality" and have a label on their products certifying this.

A full list of recommendations for reclamation centres can be found on page 21,22 and 23 of the [COPA study](#) "ODS/HFC Reclamation and Destruction Technologies A review for Article 5 Countries".

What is the current value of Carbon Credits, and is it a financially viable option?

The price for carbon credits varies from country to country, you check some of them here: <https://carboncredits.com/carbon-prices-today/>. Yes, in some cases it is a viable option, companies like [Recoolit](#) finance destruction of ODS/HFCs with carbon credits.

For more information have a look at the [ODS/HFC Reclamation and Destruction Technologies A review for Article 5 Countries by COPA 2023](#).

QUESTIONS ON ENVIRONMENTAL IMPACT AND TECHNOLOGY:

Do you think there is a design and operation problem with using reclaimed refrigerants?

No, there isn't. If the standards are followed, reclaimed refrigerant is as good as new refrigerant from an operational point of view. See the *AHRI. 2016. Standard for Specifications for Refrigerants Standard 700*.

What technology would you suggest to reclaim refrigerants for High Ambient Temperature (HAT) countries?

Distillation is supposed to be the best technology for a reclaim center to start with as it is commercially available and easy to operate,. R-22 and R-134a are still the most common refrigerants in most countries. Adsorption is the most desired technology. However, it is difficult to find or build and requires a high level of expertise, especially for the adsorbent materials. A full list of recommendations for reclamation centres and more about the reclamation technologies can be found on pages 16-23 of the [COPA study](#) "ODS/HFC Reclamation and Destruction Technologies A review for Article 5 Countries".

QUESTIONS ON POLICY AND CERTIFICATION:

Do you suggest checking (certifying) purity after reclaim?

Checking purity after reclaim is recommended. In countries such as the USA and in the EU refrigerant is only considered reclaimed if it reaches 99.5% of purity. Selling certified reclaimed refrigerant helps businesses trust the product and get used to using reclaimed refrigerant. See HARH guidelines. See the *AHRI. 2016. Standard for Specifications for Refrigerants Standard 700*.

A full list of recommendations for reclamation centres can be found on page 21, 22 and 23 in the [COPA study](#) "ODS/HFC Reclamation and Destruction Technologies A review for Article 5 Countries".

For more information have a look at the [ODS/HFC Reclamation and Destruction Technologies A review for Article 5 Countries by COPA 2023](#)

BECOME A MEMBER

Find more Information on our [Website](#)



Members gain access to a global network of knowledge and resources

Match-making between actors will be enabled and a flexible array of services provided.

The network will amplify the reach of actors and enhance the impact of activities in the field of ODS and HFC banks management.

COPA is open to all countries and organisations, willing to support the global shift to sustainable refrigerant management and closing the loop to a circular economy in the cooling sector.

Join COPA and become a member

CLIMATE AND OZONE PROTECTION ALLIANCE (COPA)

Thematic Working Groups (TWG)

Together with our partners and members, we are working on the following topics in dedicated
**THEMATIC
WORKING GROUPS**



Policy Framework

For an effective management of refrigerants and foams at end-of-life, **suitable policy measures are required** like venting bans or mandatory recovery



Technology Solutions

Working towards the **best technical solutions** for ODS and HFC recovery, reclamation and destruction



Financing Mechanism

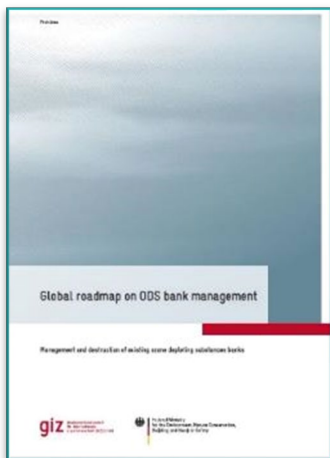
The infrastructure for and operation of a collection scheme and the destruction or reclamation of ODS and HFCs needs to be based on a **sustainable financing mechanism**



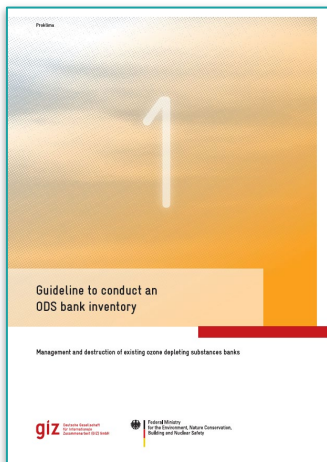
Implementation Models

Putting theory into practice and demonstrating how sustainable refrigerant management can be implemented

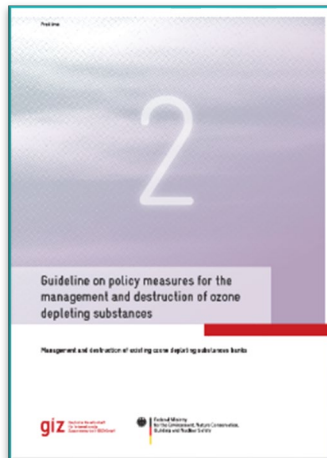
RELEVANT PUBLICATIONS AND TOOLS



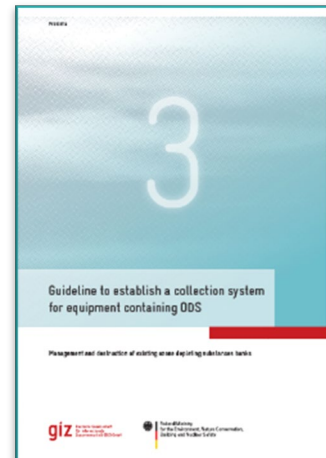
Global roadmap on ODS bank management ([Download](#))



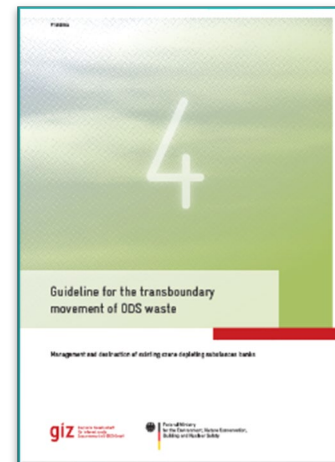
Guideline to conduct an ODS bank inventory ([Download](#))



Guideline on policy measures for the management and destruction of ODS ([Download](#))

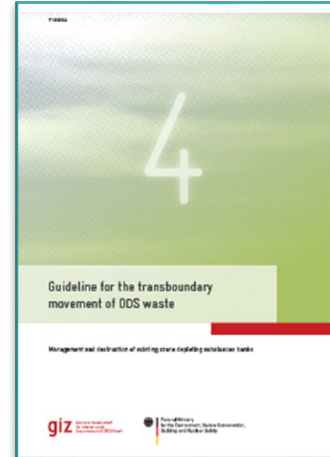
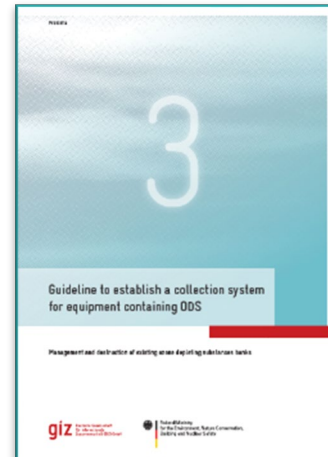
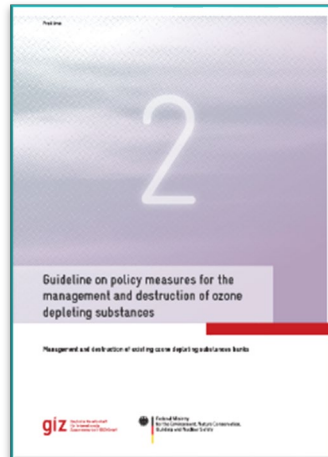
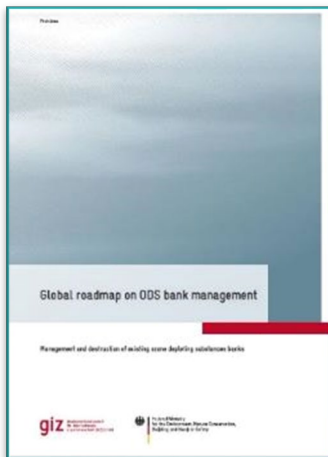


Guideline to establish a collection system for equipment containing ODS ([Download](#))



Guideline for the transboundary movement of ODS waste ([Download](#))

RELEVANT PUBLICATIONS AND TOOLS



Global roadmap on ODS bank management ([Download](#))

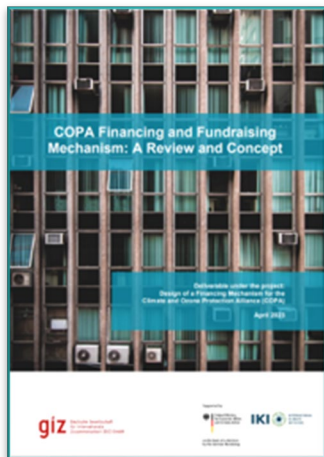
Updated Guideline to conduct an ODS and HFC bank inventory ([Download](#))

Guideline on policy measures for the management and destruction of ODS ([Download](#))

Guideline to establish a collection system for equipment containing ODS ([Download](#))

Guideline for the transboundary movement of ODS waste ([Download](#))

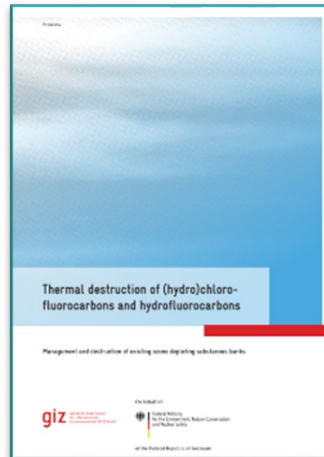
RELEVANT PUBLICATIONS AND TOOLS



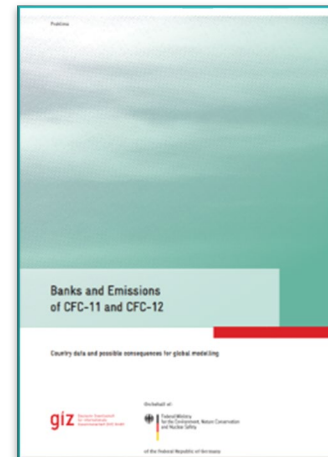
Design of a Financing Mechanism for the Climate and Ozone Protection Alliance
([Download](#))



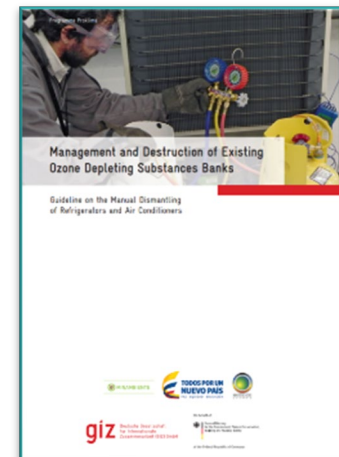
Global Banks of ozone depleting substances.
A country-level estimate ([Download](#))



Thermal destruction of (H)CFCs and HFCs
([Download](#))

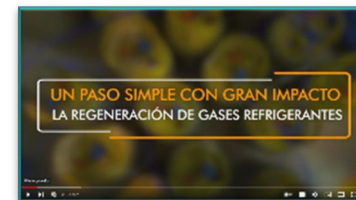
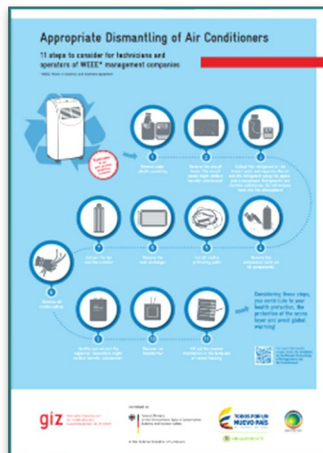
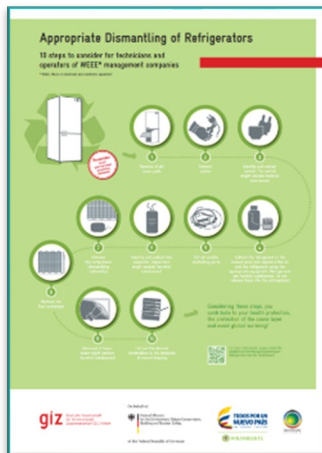


Banks and Emissions of CFC-11 and CFC-12
([Download](#))



Guideline on the Manual Dismantling of Refrigerators and Air Conditioners
([Download](#))

RELEVANT PUBLICATIONS AND TOOLS



Poster: Appropriate Dismantling of Refrigerators ([Download](#))

Poster: Appropriate Dismantling of Air Conditioners ([Download](#))

Poster: Key processes to manage ODS banks ([Download](#))

Video: ODS Banks – An unseen threat ([Download](#))

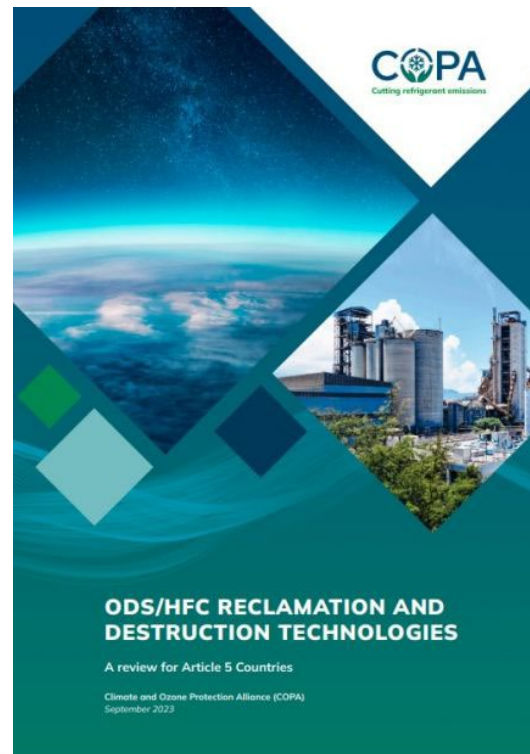
Video: A simple step with great impact: The reclaim process of refrigerants ([Download](#))

NEXT WEBINAR

Financing refrigerant management - including Article 6 of the Paris Agreement applicability to refrigerant recovery/reclaim/destruction projects

24th January 2024, 3 – 4 pm (UTC+1)

Register on www.copalliance.org/events



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THANK YOU FOR YOUR PARTICIPATION