Using carbon markets to reduce emissions from end-of-life refrigerants and foam blowing agents

This report is commissioned by UNDP's Montreal Protocol and Chemicals and Waste Unit within the framework of the project "UNDP participation as a partner in the GIZ led initiative "Climate and Ozone Protection Alliance for HFC and ODS Banks Management (COPA)".

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Abbreviations

A5	Countries, operating under the Article 5 of the Montreal Protocol
ACR	American Carbon Registry
CAR	Climate Action Reserve
CARB	California Air Resources Board
CDM	Clean Development Mechanism
CFC	Chlorofluorocarbon
COPA	Climate and Ozone Protection Alliance
DRE	Destruction and Removal Efficiency
EOL	End-Of-Life
ERPA	Emissions Reduction Purchase Agreement
GEF	Global Environment Facility
GHG	Greenhouse Gas
GIZ	Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH
GWP	Global Warming Potential
HCFC	Hydrochlorofluorocarbons
HFC	Hydrofluorocarbons
HTI	High Temperature Incineration
IPCC	Intergovernmental Panel on Climate Change
IRR	Internal Rate of Return
ISO	International Organization for Standardization
ITMO	Internationally Transferred Mitigation Outcomes
MID	Mitigation Activity Identification
MLF	Multilateral Fund for the Implementation of the Montreal Protocol
MRV	Monitoring, Reporting and Verification
MS	Microsoft
NPV	Net Present Value
ODS	Ozone Depleting Substance
OMGE	Overall Mitigation in Global Emissions
POA	Program of Activities
PV	Present Value
SOP	Share of Proceedings
SSR	Sources, sinks, and reservoirs
TEAP	Technology and Economic Assessment Panel
UNDP	United Nations Development Programme
UNEP	United Nations Environment Programme
UNIDO	United Nations Industrial Development Organization
US	United States of America
VCS	Verified Carbon Standard

Introduction

This technical report is commissioned by UNDP's Montreal Protocol and Chemicals and Waste Unit within the framework of the project "UNDP participation as a partner in the GIZ led initiative "Climate and Ozone Protection Alliance for HFC and ODS Banks Management (COPA)". The study is focused on the assessment of the potential of using carbon markets for proper disposal of end-of-life (EOL) refrigerants and foam blowing agents with global warming potential. It is expected to assist national ozone officers in learning about existing experience of management of end-of-life refrigerants and foam blowing agents using revenues from carbon markets, including applicable methodologies, and assessing financial feasibility of covering all stages of EOL (recovery, collection, storage, transportation, destruction). The financial model presented can assist in assessing the financial feasibility of projects under Article 6.2 for Internationally Transferred Mitigation Outcomes (ITMO) but can be adapted for voluntary markets as well.

1. International experiences of EOL ODS management using revenues from carbon markets

This section provides a general perspective of how EOL ODS destruction has been managed using revenues from carbon markets in Article 5 countries (A5 countries) globally. Research has been limited to this group given that developing countries have to overcome hurdles different from those faced by developed countries when it comes to EOL ODS destruction process. Information on projects has been obtained from the "Voluntary Registry Offsets Database", a database that contains "all carbon offset projects, credit issuances, and credit retirements listed globally by four major voluntary offset project registries—Climate Action Reserve (CAR), American Carbon Registry (ACR), Verra (VCS), and Gold Standard".[1]

Projects overview

As it is well known, the Montreal Protocol regulates the production and consumption of ODS, but it does not require the elimination of ODS banks. These are also not covered by the Kyoto Protocol (with the exception of HFCs), as it does not handle gases controlled by the Montreal Protocol. Consequently, there have been few incentives to push ODS destruction projects in A5 countries, including the opportunity to be eligible for compensation through regulatory compliance mechanisms under the Kyoto Protocol. Regarding carbon markets, this has left voluntary schemes as the only alternative to assist in the implementation of ODS destruction actions. Hence, research on international experience about it is exclusively based on information found in voluntary offset project registries.

According to the Voluntary Registry Offsets Database, approximately 30 million ODS credits have been issued to date from projects developed by both A5 and non-Article 5 (nA5) countries (Canada and the United States).[2] Table 1 summarizes the ODS destruction actions carried out by the developing countries in the context of voluntary carbon markets until November 2022.

Table 1. *ODS recovery & destruction projects developed by A5 countries in the context of voluntary carbon markets*

Country	Voluntary Status	Voluntary Registry	First year of project	Credits Issued (tCO_{2eq}) to date	Credits Retired
India	Completed	CAR	2009	683,087	683,087

[1] Ivy So, Barbara K. Haya, Micah Elias. 2022. Voluntary Registry Offsets Database. Berkeley Carbon Trading Project, University of California, Berkeley.

[2] Ivy So, Barbara K. Haya, Micah Elias. 2022. Voluntary Registry Offsets Database. Berkeley Carbon Trading Project, University of California, Berkeley.

Country	Voluntary Status	Voluntary Registry	First year of project	Credits Issued (tCO_{2eq}) to date	Credits Retired
India	Completed	CAR	2010	551,802	517,957
Mexico	Completed	CAR	2010	2,602,812	2,597,770
Mexico	Completed	CAR	2012	89,834	9
Nepal	Completed	CAR	2013	82,391	31,500
Ghana	Registered	VCS	2018	155,431	145,023
Dominican Republic	Registered	VCS	2021	23,657	3,000
Saudi Arabia	Listed	ACR	--	0	0
South Africa	Under development	VCS	--	0	0
Honduras	Withdrawn	VCS	--	0	0
			Total	4,189,014	3,978,346

Source: *Authors' own elaboration based on information provided by the Voluntary Registry Offsets Database.*[3]

A brief but comprehensive description of the main aspects of projects led by India, Mexico, Nepal, Ghana, and Dominican Republic can be found as follows. Projects developed by Saudi Arabia, South Africa, and Honduras have been excluded since they withdrew or are still a work in progress.

India

"Coolgas India ODS Project 1" (2009) and "Coolgas India ODS Project 2" (2010) consisted of destruction of a virgin private stockpile of CFC-12 that was produced by and stored in a SRF Limited factory in Rajasthan, India. ODS bank was composed of nine ISO tanks of CFC-12, each containing 15 tonnes of substance (135 tonnes in total). Tanks were purchased by Coolgas, imported to the United States, and then destroyed by incineration at the Clean Harbors Environmental Services facility in El Dorado, Arkansas.[4] This project followed "CAR Article 5 Ozone Depleting Substances Protocol" (version 1.0), which was applicable for destruction of privately held CFC virgin stockpiles. The Second version of this protocol (2012) eliminated this scope.[5]

To demonstrate additionality during the verification process of both projects, Coolgas (owner of the projects) filled out and signed the "CAR Project Developer's Attestation of Voluntary Implementation". Furthermore, it complemented projects' documentation with a letter from the India Ozone Secretariat that indicates destruction of CFC-12 is not compulsory in the country, and the Agreement between India and the Executive Committee of the Multilateral Fund for the Accelerated CFC Production Phase-Out that states that destruction of the CFC-12 is not required.

Mexico

"RemTec International ODS Destruction Import Project #1" (2010) consisted of the destruction of four rail tank cars of virgin privately owned stockpile of CFC-12 that were produced by and stored in a Quimobasicos facility in Monterrey, Mexico. ODS bank —which accounted for approximately 297 tonnes of substance— was purchased by Reclamation Technologies Inc. (RemTec), imported to the United States, and then destroyed by incineration at the Clean

[3] Ivy So, Barbara K. Haya, and Micah Elias. 2022. Voluntary Registry Offsets Database. Berkeley Carbon Trading Project, University of California, Berkeley.

[4] First Environment. May 2010. Verification report for CAR 596 Coolgas India ODS Project 1. Climate Action Reserve; First Environment. September 2010. Verification Report for Coolgas India ODS Project 2—CAR 597. Climate Action Reserve.

[5] Francisco Ascui, David Brotherton, and Marianna Doria. 2013. Factors influencing the international trade of carbon offsets from the destruction of ozone depleting substances. UNIDO Working Paper.

Harbors Environmental Services facility in El Dorado, Arkansas.[6] Like India's projects, "CAR Article 5 Ozone Depleting Substances Protocol" (version 1.0) was the methodology used to implement this activity.

As required to demonstrate additionality under CAR Protocol, RemTec completed the "CAR Project Developer's Attestation of Voluntary Implementation". It also accompanied project's documentation with a letter from Mexico's Ozone Unit that indicates destruction of CFC-12 is not compulsory in the country, and a letter from Mexico's Environment and Natural Resources Ministry that points out that there are no regulations requiring the destruction of ODS in Mexico.

"O.S.L. (OEKO Service Luxembourg) ODS Destruction Project Mexico" (2012) consisted of destruction of roughly 13 tonnes of mixed CFC-12. ODS bank was aggregated by Ecofrigo, a company dedicated to recovering, recycling and reclaiming CFCs, HCFCs and HFCs from end-of-life equipment in Celaya, Mexico. Refrigerant bank was purchased by O.S.L., imported to the United States, and then destroyed by incineration at the Clean Harbors Environmental Services facility in El Dorado, Arkansas.[7] "CAR Article 5 Ozone Depleting Substances Protocol" (version 1.0) was also applied to this project, given that "used ODS refrigerants recovered from industrial, commercial or residential equipment at servicing or end of life" are substances covered by this methodology.[8]

To prove additionality, O.S.L. duly prepared and signed the "Attestation of Voluntary Implementation for the Project". Furthermore, it presented a letter from Mexico's Environment and Natural Resources Ministry indicating there are no regulations that require ODS destruction in the country.

Nepal

"EOS (EOS Climate) Article 5 - Nepal" Project (2013) consisted of destruction of an ODS stockpile composed of non-mixed CFC-12 with small quantities of CFC-11. ODS cylinders were seized by Nepal Customs in 2001 and stored at two government warehouses. Portions of the original stockpile were sold to the domestic market prior to 2010. The remaining quantity of ODS material (around 10 tonnes) was consolidated at a single government warehouse in Birgunj, Nepal, purchased by EOS Climate, and then imported to the United States to be destroyed by incineration at the Clean Harbors Environmental Services facility in El Dorado, Arkansas.[9] Unlike previously described projects, EOS Climate worked under "CAR Article 5 Ozone Depleting Substances Protocol" (version 2.0), which allows for the destruction of ODS stockpiles seized by A5 governments that can legally be sold to the market.[10]

Regarding additionality, EOS Climate completed the "Attestation of Voluntary Implementation for the Project", a statement required by CAR Protocol. Besides, during the project verification process, it was confirmed —through interviews with project personnel in Nepal and the United States as well as UNEP documentation revision— that the activity was not mandated by any international, federal, state, or local regulations.

Ghana

"TW (Tradewater) Ghana ODS Project" (2018) is the first refrigerant collection and destruction activity with participation in the voluntary carbon market, carried out in Africa. At a first stage, Tradewater (project developer) in partnership with City Waste Recycling, Ltd. (CWR – a recycling center in Pokuase, Ghana) located and collected cans and cylinders of CFC-12 that were dispersed throughout Ghana. At a second stage, ODS previously collected by CWR from

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[6] First Environment. December 2010. Verification Report for CAR691—RemTec International ODS Destruction Import Project #1. Climate Action Reserve.

[7] Ruby Canyon Engineering. May 2012. Verification Report for CAR826—O.S.L. Destruction Project Mexico.

[8] Francisco Ascui, David Brotherton, and Marianna Doria. 2013. Factors influencing the international trade of carbon offsets from the destruction of ozone depleting substances. UNIDO Working Paper.

[9] First Environment. May 2013. Verification Report for EOS Article 5 – Nepal—CAR955. Climate Action Reserve.

[10] Francisco Ascui, David Brotherton, and Marianna Doria. 2013. Factors influencing the international trade of carbon offsets from the destruction of ozone depleting substances. UNIDO Working Paper.

old refrigerators plus a considerable stockpile recovered during the first stage of the project were aggregated. Over 15 tonnes of refrigerants were then shipped to the United States for safe destruction.[11] The project was conducted under VCS methodology "VM0016 Recovery and Destruction of Ozone-Depleting Substances" (version 1.1), which allows for ODS collection and destruction to occur in any country, and lists "refrigeration equipment, systems or appliances" as eligible sources.[12]

Project verification process confirmed that "Ghana has no law, rule, or regulation requiring the destruction of ODS", and that there is no market to reuse recovered and stockpiled ODS in the country.[13] These facts prove activity's additionality insofar, absent this project, ODS banks in Ghana have no end-of-life solution other than being released to the atmosphere.

Dominican Republic

"Tradewater International Dominican Republic" (2021) provided a way for local parties to dispose a significant stockpile of old refrigerants (approximately 3.4 tonnes of mainly CFC-12 and HCFC-22) that had been stored for a long time, without a feasible solution. Along with SEMICAR, a local waste manager authorized to handle and export refrigerants, and other interested parties, Tradewater was able to export the ODS material to the United States, where it was properly destroyed.[14] Like Ghana's project, "VM0016 Recovery and Destruction of Ozone-Depleting Substances" (version 1.1) was also the methodology used to implement this activity.

Even though the Montreal Protocol and the Kyoto Protocol do not consider it as part of their members' obligations, it is a clear that ODS banks need to be recovered and properly treated to avoid their release into the atmosphere over time due to slow or catastrophic leakage, and unintentional or intentional venting.[15] Nevertheless, not being common practice in developing countries, ODS management and destruction have become a technical and financial challenge for their governments.

Strictly speaking about funding alternatives, out of all analyzed experiences, it is worth noticing that A5 countries have benefited from carbon market support mostly by selling their ODS banks to project developers, who have imported them to be destroyed in U.S. facilities. Ultimately, this activity has generated carbon credits that are used by U.S. firms mainly for voluntary carbon offsetting purposes.[16] However, ODS destruction projects implementation may pose different challenges and risks when a country's government is directly handling it. Therefore, a whole new approach (different from selling ODS banks to project developers) may need to be designed.

[11] Tradewater. 2021. Eliminating CFC Stockpiles in Ghana.

[12] Francisco Ascui, David Brotherton, and Marianna Doria. 2013. Factors influencing the international trade of carbon offsets from the destruction of ozone depleting substances. UNIDO Working Paper.

[13] Ruby Canyon Engineering. 2018. Validation & Verification Report for TW Ghana.

[14] Tradewater. 2021. Providing the missing piece in Dominican Republic.

[15] Francisco Ascui, David Brotherton, and Marianna Doria. 2013. Factors influencing the international trade of carbon offsets from the destruction of ozone depleting substances. UNIDO Working Paper.

[16] Francisco Ascui, David Brotherton, and Marianna Doria. 2013. Factors influencing the international trade of carbon offsets from the destruction of ozone depleting substances. UNIDO Working Paper.

2. Methodologies for quantifying emission reductions from EOL ODS management

A methodology for quantifying emission reductions specifies the project activity, the criteria for determining the eligibility of the project under the methodology, the calculation of the emission reductions, and the requirements for monitoring and recordkeeping. Methodologies are developed and/or approved by an independent or "third party" standard. In the case of greenhouse gas emission reductions, standards focus on legitimizing carbon credit development, but among them there are many differences in scope and approach. Specifically, the development and approval of credible ODS destruction methodologies by third-party standards may serve for the following purposes:

1. Ensure that ODS destruction activities are legitimate and verifiable, and result in real GHG reductions that would have otherwise been emitted to the atmosphere;
2. Provide assurance to market investors and buyers that the carbon credits issued to projects following a recognized methodology are real, additional, and permanent;
3. Embed provisions to avoid perverse incentives linked to the crediting of ODS destruction activities, such as the production of ODS solely for generating destruction credits, or the destruction of ODS that may be needed for future use;
4. Be flexible to account for multiple sources and scenarios of ODS origination and be accessible to a wide range of country participants, considering the needs and capacities of project proponents worldwide, including for example the possibility of exporting ODS to other countries that possess adequate destruction facilities whenever the host country lacks them.

End of life ODS may be found in a variety of circumstances and conditions that methodologies should account for, so these conditions and circumstances do not pose a barrier to the crediting of ODS destruction projects. The most frequent circumstances and the way a methodology should address them are described below:

1. **ODS recovered in the past with incomplete documentation:** a methodology must allow projects to be eligible with some basic level of documentation or other means of verification. Alternatively, the setting of a minimum volume threshold in a methodology for determining project eligibility, could promote viable ODS destruction projects and minimize its illegal destruction;
2. **ODS recently recovered with appropriate documentation:** Since this type of projects count with good documentation to demonstrate eligibility, the methodology simply must accept the destruction of ODS recovered from a variety of equipment;
3. **Accessible ODS stocks in use in equipment:** In this case ODS are currently in use in equipment, but will become a source for ODS recovery and destruction. Under this scenario, ODS is recovered after approval of an ODS destruction methodology and so the project should be expected to meet all requirements specified by the methodology;
4. **Stockpiles of non-reusable mixed and/or contaminated ODS:** In this case, an ODS destruction methodology must allow project developers to destroy mixed ODS and claim credit for the various amounts of different ODS destroyed. Additionally, the methodology might make an exception for the destruction of non-reclaimable, contaminated ODS (with appropriate proof of contamination) that has not yet been phased out of production;
5. **ODS confiscated by customs authorities:** In this case, an adequate methodology should be the one that includes the destruction of bulk stockpiled ODS (not recovered). Additionally, it should adapt to the possibility of incomplete documentation since the ODS comes from illegal shipments confiscated by authorities;
6. **Virgin ODS stockpiled in industrial facilities:** In this case, as in the previous one, an enabling methodology should be the one that allows for the destruction of bulk stockpiled ODS.

In line with the purposes and circumstances above mentioned, the objective of this section is to identify and analyze the most relevant methodologies endorsed by internationally recognized institutions for the quantification of emissions reductions resulting from the management and destruction of ODS. At least, the following methodologies' features will be analyzed, compared, and tested:

1. Applicability conditions (eligible Parties, type of ODS, and sources),
2. Project Boundary (ODS recovery, transport, and destruction);
3. Considerations for Baseline (regulatory/policy context, economic/technological circumstances);
4. Demonstration of Additionality;
5. Quantification of GHG emissions, emissions reductions and removals;
6. Monitoring and reporting (data/parameters validation, monitoring plan).

The ultimate goal will be to select those methodologies that best apply to developing countries for potential GHG mitigation projects on destruction of EOL ODS eligible under the Article 6.2 ITMOs mechanism.

Identified methodologies

After an exhaustive literature review process, the following internationally recognized methodologies for quantifying emissions reductions from ODS destruction activities have been identified and will be analyzed and compared according to the features specified above in order to select those that best apply to developing countries for carrying on EOL ODS destruction actions eligible for the transfer of mitigation actions under Article 6.2:

1. VM0016 Recovery and Destruction of Ozone-Depleting Substances v1.1 (2017);[17]
2. American Carbon Registry (ACR) Methodology for the Quantification, Monitoring, Reporting, and Verification of GHG Emissions Reductions and Removals from the Destruction of ODS from International Sources v1.0 (2021);[18]
3. Climate Action Reserve (CAR) Article 5 Ozone Depleting Substances Project Protocol v2.0 (2012).[19]

The ACR Methodology for the Quantification, Monitoring, Reporting, and Verification of GHG Emissions Reductions and Removals from the Destruction of ODS and High GWP Foams v1.2 (2021)[20], and the California Air Resources Board (CARB) Compliance Offset Protocol for the Destruction of U.S. ODS Banks (11/14/2014), were not included in the following analysis because they have been designed for the destruction of ODS originated in the US, and they do not allow ODS imports to the US for final destruction. Although the Chicago Climate Exchange ODS Destruction Protocol pioneered the introduction of ODS destruction projects into the voluntary carbon markets between 2007-2010, the protocol has not registered any project since 2009, and is considered less rigorous than the ACR, the CAR or the VCS methodologies which have been kept updated until more recently.[21] Therefore, it has also been excluded from the comparative analysis.

[17] Verified Carbon Standard. 2017. VM0016 Recovery and Destruction of Ozone-Depleting Substances (ODS) from Products, v1.1. Vienna: Energy Changes Projekt Entwicklung GmbH and Wels: USG Umweltservice GmbH.

[18] American Carbon Registry. 2021. Methodology for the Quantification, Monitoring, Reporting and Verification of Greenhouse Gas (GHG) Emissions Reductions and Removals from the Destruction of Ozone Depleting Substances (ODS) from International Sources v1.0. Washington, DC: Winrock International.

[19] Climate Action Reserve. 2012. Article 5 Ozone Depleting Substances Project Protocol Version 2.0. Destruction of Article 5 Ozone Depleting Substances Banks. The Climate Action Reserve, Los Angeles, CA.

[20] American Carbon Registry. 2021. Methodology for the Quantification, Monitoring, Reporting and Verification of Greenhouse Gas (GHG) Reductions and Removals from the Destruction of Ozone Depleting Substances (ODS) and High Global Warming Potential (GWP) Foams v1.2. Washington, DC: Winrock International

[21] Francisco Ascui, David Brotherton, and Marianna Doria. 2013. Factors influencing the international trade of carbon offsets from the destruction of ozone depleting substances. UNIDO Working Paper.

Comparative analysis of identified ODS destruction methodologies

As mentioned before, criteria related to the methodologies' eligibility requirements, additionality requirements, guidance on developing a baseline scenario, guidance on calculating emission reductions, and guidance for monitoring and recordkeeping will be analyzed and compared, in order to highlight their robustness, credibility, as well as their applicability to the developing countries. Table 2 enlists and describes the set of aspects that will be analyzed and compared among the selected methodologies, in order to obtain a clear picture of their main strengths and limitations. Table 3 compares relevant aspects such as the applicability conditions, the eligibility conditions, the GHG quantification approach, the crediting conditions, and the MRV requirements of three most representative and used ODS destruction methodologies: the ACR, the CAR, and the VCS methodology.

Table 2. *Aspects required by a methodology for an adequate quantification, monitoring, reporting and verification of GHG from ODS destruction activities.*

Methodology aspects	Description of good methodological practices
1. Applicability conditions	
Specify eligible types of ODS	All country´s phased out ODS should be eligible. Some exceptions to this rule might be: 1) if ODS have been phased out in certain sectors but not in others, only ODS recovered from the sectors in which the ODS has been phased out could be eligible for destruction, 2) ODS that have not been phased out or other halocarbons (like HFCs) could also be considered eligible for destruction if they are part of a non-separable blend or are part of a contaminated mixture.
Specify eligible ODS sources	All sectors or activities where ODS have been phased-out should be eligible.
Specify eligible parties	All parties legally established in the jurisdiction, should be eligible
2. Project Boundary	
Specify the boundaries of the project activities (recovery, transport, and destruction)	The project boundary should extend from the recovery site, the transportation of the ODS from a consolidation point to the destruction facility and include any emissions through to the actual destruction of the ODS.
Specify technical requirements for destruction facilities	Destruction and Removal Efficiency (DRE) requirements should meet 99.99% for concentrated ODS sources and 95% for dilute sources (consistent with TEAP 2002 Guidance)[22]. Emission limits for other potential products of incomplete combustion should also be specified and meet TEAP (2002) guidance.
Specify geographic eligibility for ODS collection and destruction	ODS collection and destruction should be eligible in any country, as long as national technical and legal criteria, and international treaties and best practices are met.
Specify eligible destruction technologies	A wide range of destruction technologies should be permitted, as long as they are approved or meet internationally recognized criteria for ODS destruction, such as those of the TEAP 2002.
3. Considerations for Baseline	
Ensure that ODS are destroyed in legally permitted facilities	Project developers should comply with local regulations to ensure that ODS is only destroyed by facilities legally permitted to do so. In the absence of local regulations, project developers should comply with internationally recognized ODS destruction guidelines, and the facilities chosen for ODS destruction should comply with those guidelines.

[22] Technology and Economic Assessment Panel (TEAP). 2002. Report of the UNEP Technology and Economic Assessment Panel (TEAP), Report of the Task Force on Destruction Technologies. Montreal Protocol on Substances that Deplete the Ozone Layer. April 2002.

Methodology aspects	Description of good methodological practices
Ensure non eligibility of ODS produced for the sole purpose of earning destruction credits	This can be achieved by requiring that the ODS being destroyed be phased out in the country in which it originated and requiring documentation as to the origin of the material. An appropriate balance must exist between requiring rigorous documentation and ensuring that ODS with missing documentation (either recovered in the past or confiscated by customs´ offices), can still be destroyed for credit.
Ensure that ODS import/export comply with national and international regulations	Project developers should comply with local laws, and with international treaties such as the Basel Convention.
4. Demonstration of Additionality	
Specify a methodology for determining/demonstrating additionality	Additionality tests specific to the project should be included, such as regulatory surplus, implementation barriers, common practice test, or performance threshold. At least, projects should demonstrate that there are no international, national, state, or local regulations requiring ODS destruction, and that destruction is not a common practice.
5. Quantification of GHG emissions, emissions reductions and removals	
Project activity description	It should describe in detail the sequence of activities included in the project, from the source of the ODS (for example, stockpiled ODS from commercial or industrial users, ODS contained in refrigeration of AC equipment, or ODS contained in-building or appliance foams, among others), the segregation, the collection, the recovery, the transport, and the destruction process.
Definition of relevant GHG sources, sinks, and reservoirs (SSRs) for project activity & baseline, including those directly attributable to the project activity and those related or affected by it	Besides the ODS destroyed, other sources of emissions associated with the destruction process should be subtracted, such as those emissions from the fuel and/or electricity consumption associated with the destruction process, and emissions indirectly associated such as those from the transport of the ODS. If the ODS are being recovered from equipment, and replaced with a substitute compound, the emissions from that substitute should also be included.
Provide methodology for identifying, justifying, and quantifying a baseline scenario	An equation should be provided including the elements described above.
Provide a methodology for quantifying overall emission reductions (including subtracting of direct/indirect SSRs).	An equation should be provided including the elements described above.
Define the crediting timeline	Since carbon credits and grants are the only sources of revenues for ODS destruction projects, crediting should be one-time, upfront, and preferentially right after the ODS is destroyed. This approach provides the best incentive for project developers who may incur in significant upfront costs to destroy ODS.
6. Monitoring and reporting	
Specify the types of data to be measured and recorded	These data should include the Destruction and Removal Efficiency (DRE), the amount and characteristics of the ODS fed to a destruction unit, consumption and source of the energy used by destruction unit, operating parameters during destruction, among others.
Specify the monitoring & testing methodologies	These include performance test standards, laboratory analytical methods, sampling procedures, calibration requirements, etc. All internationally recognized testing standards should be referenced.

Methodology aspects	Description of good methodological practices
Specify the monitoring times & periods	These include the times/periods prior to shipment, prior to destruction, and during the ODS destruction.
Specify roles & responsibilities for monitoring & data collection & storage	Roles and responsibilities should be specified at least for the ODS testing prior to shipment for destruction, and for the destruction process at the destruction facility.
Specify documentation requirements for project validation & verification	Any data or documentation requirements should be made clear.

Source: *Authors' own elaboration based on information provided by the World Bank & ICF.*[23]

Table 3. *Aspects covered by the most used methodologies for the quantification, monitoring, reporting and verification of GHG from ODS destruction activities.*

Methodology Aspect	ACR ODS from International Sources v1.0	VM0016 Recovery & Destruction of ODS v1.1	CAR Art.5 ODS Project Protocol v2.0
1. Applicability			
ODS	- CFC 11-13, 113-115 (R)	- CFC 11-13, 111-115, 211-217 - HCFC 21, 22, 31, 121-124 - HCFC 131-133, 141b, 142, 142b - HFC 151, 221-225, 225ca[24] - Blends of ODS applicable under the methodology	- CFC 11-13, 113-115 (R) - Blends of ODS applicable under the methodology
Use	- Refrigerant (R)	- Refrigerant (R) - Blowing Agent (BA)	- Refrigerant (R)
Source	- Bulk/Stockpiled (used and virgin) - Recovered from equipment	- Bulk/Stockpiled (only CFCs) - Recovered from equipment/foam (CFCs, HCFCs & HFCs)	- Bulk/Stockpiled (not virgin) - Recovered from equipment
Location/Party	- ODS source: outside U.S.A. - ODS destruction: U.S.A. or outside U.S.A.	- ODS source: All countries - ODS destruction: All countries	- ODS source: Art. 5 countries - ODS destruction: U.S.A.
Special conditions		- All Bulk/Stockpiled ODS must be CFC - All BA must be extracted from foam prior to destruction.	
2. Eligibility and additionality criteria			
CFCs production and import has been phased out at the project´s country.	Yes	Yes	Yes
ODS destruction is not legally required and is not a common	Yes	Yes	Yes

[23] ICF International. 2010. Study on Financing the Destruction of Unwanted Ozone-Depleting Substances through the Voluntary Carbon Market. Final Report. Washington D.C., The World Bank.
[24] These HFCs are not included under the Kigali Amendment.

Methodology Aspect	ACR ODS from International Sources v1.0	VM0016 Recovery & Destruction of ODS v1.1	CAR Art.5 ODS Project Protocol v2.0
practice at the project´s country			
Project developer must comply with local regulations.	Yes	Yes	Yes
Additionality Test	- Legal Requirement Test - Performance Std Evaluation	- For Refrigerants: Step 1 (Regulatory surplus), Step 2 (positive list in VMD0048)[25]; - For blowing agents/refrigerants: (CDM additionality demo tool).	- Legal Requirement Test - Performance Std Test
Destruction Facility	- TEAP approved technology & destruction standards. - DRE = 99.99%	- TEAP approved technology & destruction standards. - Minimum RDE (for BA) = 85% - DRE (concentrated ODS) = 99.99% - DRE (diluted ODS) = 95%	- TEAP approved technology & destruction standards. - DRE (concentrated ODS) = 99.99% - DRE (diluted ODS) = 95%
3. Baseline Emissions			
ODS released from equipment at end-of-life	Yes	Yes (includes foam shredding/disposal)	Yes
ODS from leaks/servicing due to operation of equipment	No	No	Yes
ODS released at storage facility (bulk/stockpiled)	Yes	Yes	Yes
4. Quantification of GHG emissions			
Specific emissions due to energy consumption at recovery facility (fossil fuels + electricity+ un-combusted ODS + CO2 from ODS oxidation)	No	Yes	No
Aggregated emissions due to ODS transportation & destruction	Yes	Yes	Yes
Specific emissions due to ODS transportation	No	Yes	No

[25] VMD0048. (2017). Activity Method for the Determination of Additionality for Recovered and Stockpiled ODS Refrigerant Projects, v1.0

Methodology Aspect	ACR ODS from International Sources v1.0	VM0016 Recovery & Destruction of ODS v1.1	CAR Art.5 ODS Project Protocol v2.0
Emissions from the use of ODS substitutes (leakage)	Yes	Yes	Yes
Emissions due to BA removal in non-enclosed equipment	No	No	No
5. Project and credit timing			
Crediting period (Year)	10	10	10
Project period (month)	12	Not specified	12
6. Monitoring and verification			
Specifies types of data to be measured and recorded	Yes	Yes (Monitoring Plan)	Yes (Monitoring & Operations Plan)
Specifies monitoring & testing methodologies	Yes	Yes (Monitoring Plan)	Yes (Monitoring & Operations Plan)
Specifies monitoring times & periods	Yes	Yes (Monitoring Plan)	Yes (Monitoring & Operations Plan)
Specifies roles & responsibilities for monitoring & data collection & storage	Yes	Yes (Monitoring Plan)	Yes (Monitoring & Operations Plan)
Specifies documentation requirements for project validation & verification	Yes (ACR Std project validation/verification requirements)	Yes	Yes

Source: *Authors' own elaboration based on data provided by the Climate Action Reserve, the American Carbon Registry, and the Verified Carbon Standard.*[26]

Climate Action Reserve Article 5 ODS Destruction Methodology (Version 2.0 2012)

Version 1 of this methodology was launched in 2010, the same year when the Montreal Protocol scheduled the production phase-out of CFCs in Article 5 countries, and in 2012 an updated version was approved, which is the one that prevails until today. The CAR methodology version 2 applies only for Annex A, Group 1 CFCs (CFC-11, 12, 113, 114, and 115) used in refrigeration applications. The protocol accepts CFCs refrigerants in 3 modalities:

1. Stockpiled virgin or used ODS refrigerant, including government stockpiles of seized ODS, that can legally be sold to the market
2. Government stockpiles of seized ODS that cannot be legally sold to the market;

[26] Climate Action Reserve. 2012. Article 5 Ozone Depleting Substances Project Protocol Version 2.0. Destruction of Article 5 Ozone Depleting Substances Banks. The Climate Action Reserve, Los Angeles, CA; American Carbon Registry. 2021. Methodology for the Quantification, Monitoring, Reporting and Verification of Greenhouse Gas (GHG) Emissions Reductions and Removals from the Destruction of Ozone Depleting Substances (ODS) from International Sources v1.0. Washington, DC: Winrock International; Verified Carbon Standard. 2017. VM0016 Recovery and Destruction of Ozone-Depleting Substances (ODS) from Products, v1.1. Vienna: Energy Changes Projekt Entwicklung GmbH and Wels: USG Umweltservice GmbH.

3. ODS refrigerant recovered from industrial, commercial, or residential equipment at servicing or end-of-life

It is important to note that privately held and saleable virgin ODS refrigerants are not eligible under this protocol. As well, ODS not produced for, used as, or intended for use as refrigerant, such as that produced, used as, or intended for use as solvents, medical aerosols, or other applications, are not eligible under this protocol. The protocol does not define a time limit for ODS storage, but it defines though a maximum project duration of 12 months. One important limitation of this methodology is that although it admits ODS refrigerants from all A5 countries, the destruction must be implemented in the US and its territories. The protocol's project boundary considers that project GHG emissions originate from the following activities:

1. Emissions from substitute refrigerants;
2. Emissions from the transportation of ODS; and,
3. Emissions from the destruction of ODS.

The protocol calculates both the emissions from ODS transportation and the ones from ODS destruction in an aggregated way using a default emissions factor (EF). With regard to the MRV activities, the protocol mandates the developer to implement a Monitoring and Operations Plan that must specify the data to measure and record, the monitoring times and periods, the roles and responsibilities for data collection/storage, and the testing methodologies, among other matters. Additionally, the protocol specifies in detail the documentation and activities necessary to comply with all the requirements for the project´s validation and verification processes.

Verified Carbon Standard (VCS) for Recovery and Destruction of ODS (version 1.1 2017)

In contrast with the CAR protocol which specifies its own protocols from a top-down perspective, the VCS standard accepts methodologies from other standards, such as the CDM (e.g., "tool for demonstrating and assessing additionality", or "tool for calculation of emission factor from an electricity system"), or CAR (e.g., "Calculating Default Project Emissions from ODS Destruction and Transportation"), and also allows project developers to develop their own methodologies for approval by Verra. The VCS methodology is more inclusive compared to CAR Article 5 protocol as it applies for ODS collected and destroyed in any country, as long as the project complies with other technical and regulatory conditions specified in the Standard. Additionally, the VCS methodology applies to all Montreal Protocol Group 1 ODS from Annexes A, B, and C, compared to CAR Article 5 that only applies to CFCs from Annex A. The VCS standard accepts all the refrigerant sources specified in CAR, plus the blowing agents (BA) contained in thermal insulation foams, as long as the BAs are extracted from the foam prior to destruction. The VCS standard allows destruction of stockpiled ODS as long as they are CFCs that have previously been used. It also accepts ODS refrigerants recovered from industrial, commercial, or residential equipment at servicing or end-of-life. In the case of ODS blowing agents the methodology is only applicable to project activities recovering and destroying ODS blowing agents contained in insulation foam of end-of-life refrigerator appliances. The ODS blowing agent must be extracted from the foam to a concentrated form prior to destruction. Unlike the CAR Article 5 protocol, the VCS does not fix a time limit on the development of a project, offering more flexibility to project developers. The VCS project boundary considers origination of GHG emissions from the following activities:

1. Emissions from substitute refrigerants;
2. Emissions from on-site fossil fuel and electricity consumption at the recovery facility (not included neither in the CAR protocol, nor in the ACR protocol);
3. Emissions from the transportation of ODS; and,
4. Emissions from the destruction of ODS.

The VCS standard determines an aggregated calculation method for emissions from ODS transportation and destruction (identical to that of CAR protocol), and a more precise option of calculating separately the emissions from ODS transportation and those from ODS destruction. For MRV activities, similar to CAR Article 5 Protocol, the VCS mandates the developer to implement a "Monitoring Plan" with the roles & responsibilities, and the times and periods for data collection and record, and the technical specifications and timing of testing methodologies. Additionally, the VCS standard specifies the documentation and procedures needed to comply with the validation and verification of an ODS destruction project.

American Carbon Registry (ACR) Methodology for the Quantification, Monitoring, Reporting, and Verification of GHG Emissions Reductions and Removals from the Destruction of ODS from International Sources (v1.0 2021)

The ACR was founded in 1996 as the first private voluntary GHG registry in the world and operates in the voluntary and regulated carbon markets. The ACR methodology for ODS destruction from international sources applies only for Annex A, Group 1 CFCs (CFC-11, 12, 113, 114, and 115) used in refrigeration applications. Eligible refrigerants must originate from equipment, refrigeration systems, or other supplies (cans, cylinders, and other containers) of recovered, reclaimed or unused ODS (which is not admitted by the CAR Article 5 Protocol). Similar to the CAR methodology, the ACR methodology does not define a time limit for ODS collection, recovery or storage, but it defines a maximum project duration of 12 months. This methodology is more inclusive than the CAR Protocol, since it admits ODS refrigerants from all countries except the U.S.A., and the destruction can take place in any country including the U.S.A and its territories. The methodology´s project boundary considers that project GHG emissions originate from the following activities:

1. Emissions from substitute refrigerants;
2. Emissions from use, leaks and servicing through continued operation of equipment (not considered neither in CAR nor in VCS methodologies);
3. Emissions from the transportation of ODS; and,
4. Emissions from the destruction of ODS.

Similar to the CAR protocol, the ACR methodology calculates the emissions from ODS transportation and the ones from ODS destruction in an aggregated way using a default emissions factor (EF). Regarding the MRV activities, the ACR methodology includes an exhaustive guide for the developer to plan the project´s data collection and storage, detailing the monitoring times and periods, specifying the testing methodologies, as well as the roles and responsibilities of project participants in the implementation of activities. The ACR methodology counts with standards for project validation/verification requirements.

Considerations for the use of ODS destruction methodologies for carbon revenues

The analysis carried out previously provides useful information regarding the main advantages and limitations that the three leading methodologies for quantifying GHG emissions associated with the destruction of ODS (the CAR Article 5, the ACR International, and the VCS Standard), may bring to those developers seeking projects for either voluntary markets or in the context of the Article 6.2 ITMO transfer approach. In this sense the following facts must be considered before deciding on the most convenient one:

1. The VCS standard applies to all Montreal Protocol Group 1 ODS from Annexes A, B, and C, whereas the CAR Protocol and the ACR methodology are limited to CFCs from Group 1 Annex A;
2. The VCS standard applies to ODS used either as refrigerants or blowing agents, while the CAR protocol and the ACR methodology are specific for ODS used as refrigerants;

3. The three methodologies admit ODS originated in the target countries, but the CAR Protocol limits their destruction only in the U.S.A, whereas the VCS and the ACR methodologies admit ODS destruction in any country that complies with their respective technical specifications.
4. The VCS methodology is the only one capable of quantifying disaggregated GHG emissions due to energy consumption at recovery facility, resulting from: fossil fuel combustion, electricity consumption, un-combusted ODS, and ODS oxidation, whereas the CAR and the ACR methodologies quantify aggregated GHG emissions from ODS transportation & destruction.
5. The VCS methodology is the only one that quantifies specific GHG emissions due to transportation of the ODS from the recovery/storage site to the destruction facility, whereas the CAR and ACR methodologies calculate them aggregated with the GHG emissions from ODS destruction.
6. The CAR methodology is the only one that considers ODS from leaks/servicing due to operation of equipment, for the definition of the baseline scenario.
7. The VCS methodology requires that all bulk or stockpiled ODS to be destroyed must be CFC, while the CAR and the ACR methodologies admit both CFC and HCFC bulk or stockpiled for destruction.
8. The VCS methodology requires that all blowing agents be extracted from foams prior to destruction.

Noteworthy, although the VCS methodology is the only one that includes ODS from Montreal Protocol Annex C list (HCFCs), the VCS Standard version 4.4[27] (January 17, 2023) in its paragraph 3.8.6, stipulates that for any ODS destruction project to be eligible for carbon credits, the project start date should be either:

1) After the Montreal Protocol phase-out deadline of the host country and/or of the country from which the ODS destroyed is imported; or
2) After the host country and/or the country from which the ODS destroyed is imported, implement the ODS phase-out in anticipation of the Montreal Protocol deadline, and the phase-out is implemented combined with a ban on the import of the incumbent ODS.

Since most of A5 countries have committed under the Montreal Protocol a complete phase-out of HCFCs by 2030, any A5 country who wants to implement an HCFC destruction project eligible for carbon credits or ITMO transfer, should either: 1) wait until after 2030 to start a project, or 2) announce an anticipated phase-out date before 2030 accompanied by a strategy for banning the import of HCFCs, before deciding to start a project.

[27] Verra. (2023). VCS Standard v4.4. https://verra.org/wp-content/uploads/2022/12/VCS-Standard-v4.4-FINAL.pdf

3. Business model for EOL ODS destruction projects through carbon revenues

One useful way of testing the financial viability of an ODS destruction project through carbon revenues is by estimating the “break-even cost” or emissions reduction market sales price needed to fully cover the costs of the project (based on the recovery, collection, storage, transport, destruction, and carbon project development costs). The break-even price decreases as the project size increases, as a result of realizing project economies of scale associated with the mostly fixed project development costs. While the break-even price may range from US$2.00-25.00/tCO2eq for stockpiled ODS destruction projects ranging from 0.5-10 tons of destroyed ODS, for ODS recovered from refrigeration collection the break-even price can range US$10.00-47.00/tCO2eq for projects sizing between 1,000-100,000 collected refrigeration units (see Figure 1 below).[28]

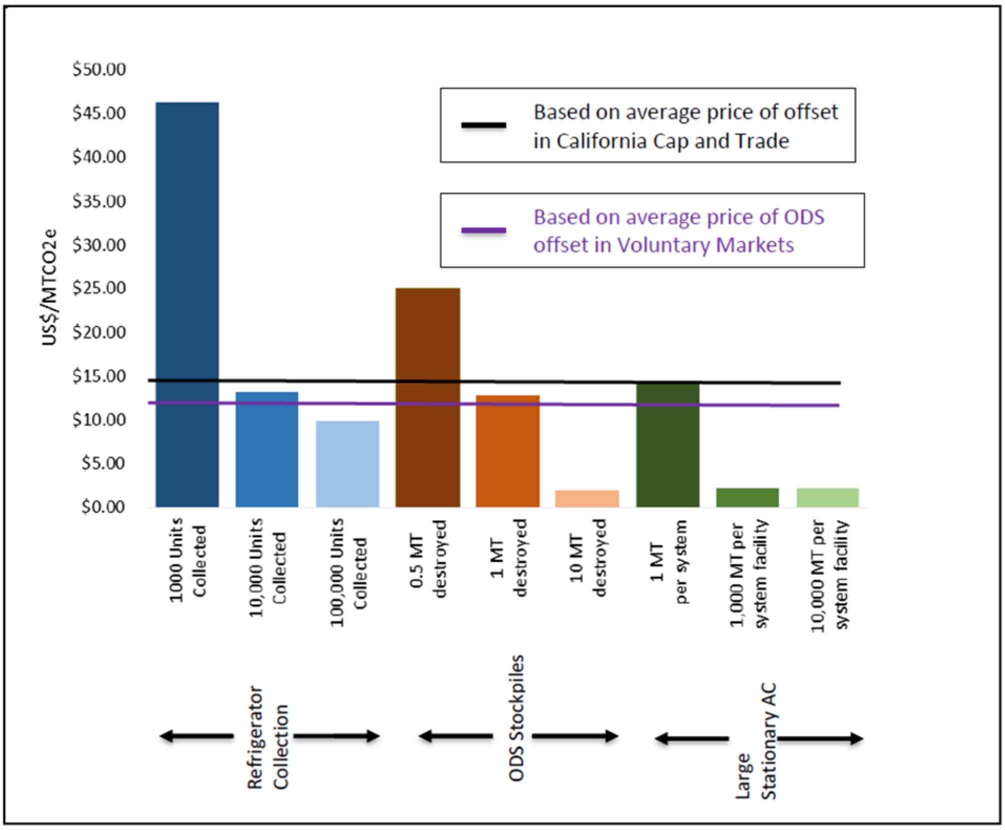

Figure 1. *Break-even costs compared to average price of offset.*
Source: *ICF.*[29]

Having in mind that financial viability of ODS destruction projects through carbon revenues depends on multiple factors including:

- Project scale.
- Emissions reduction sales price.
- Crediting timeline.
- Investment/operational costs (refrigeration collection vs. stockpiled ODS).
- Access to up-front financial assistance.
- Access to economic incentives, among others.

[28] ICF. 2017. ODS Destruction in the United States and Abroad.
[29] ICF. 2017. ODS Destruction in the United States and Abroad.

The objective and scope of this section is to develop a financial model spreadsheet of costs and revenues (including revenues from the carbon market) for ODS destruction projects, capable of estimating cash flows (investment, operational, and financial), and indicators to assess financial viability such as the internal rate of return (IRR), net present value (NPV), and optimum emission reduction sales price, or "break-even cost" (associated to project scale and crediting timeline), necessary to fully cover the project costs. This financial template can be further adapted to country specific circumstances (regulatory, economic and technological), in order to develop spreadsheets for each selected country, capable of evaluating the financial viability of specific ODS destruction projects, with the aid of carbon revenues.

General description of the model

A general template business model for implementation of EOL ODS destruction projects through carbon revenues requires the following input data:

1. Scale of the project in terms of amount and type of eliminated ODS, and equivalence in annual GHG mitigation in tCO2eq/year;
2. Potential crediting timeline in number of years;
3. Indicative price of carbon emissions reductions (in $/tCO2eq);
4. Project Capital costs estimation:
   - Operational costs (ODS recovery, collection, storage, transportation from recovery site to destruction facility, and destruction);
   - Carbon project development costs (Preparation, validation/verification, registration, MRV, credits issuance/transfer)
5. Economic incentives on investment/operation costs (subsidies, discounts, rebates, tax reductions, accelerated depreciation, etc.) ($);
6. Financial incentives, grants, or other financial assistance from government, multilateral/bilateral organizations (GEF, MLF, GIZ, etc.) ($);
7. Other Financial Sources:
   - Equity ($)
   - Debt ($)
   - Advance payment from potential buyer of emissions reductions ($)

The template business model delivers the following outputs:

1. Financial Flow from carbon revenues ($)
2. Cash flows (resulting from the balance of project costs, financial costs, carbon revenues, grants/incentives) ($)
3. IRR (@ indicative carbon price, project scale, and combination of financial options) (%)
4. NPV (@ indicative carbon price, project scale, and combination of financial options) ($)
5. Carbon Price ($/tCO2eq) and project scale (metric tonnes of ODS destroyed) at "break even cost" (NPV = 0).

Model Operational Guide

Spreadsheet structure

The financial model has been conceived as an MS Excel set of interlinked worksheets whose main characteristics are summarized in Table 4.

Table 4. *Financial Model (MS Excel Worksheets) Structure for Calculation of Costs and Revenues of ODS Destruction Carbon Projects.*

Name of worksheet	Functions	Requested Data Input	Data Output
1. Data Input & Output Results	Centralizes required input parameters for estimation of ODS destruction project costs, carbon revenues, and financial viability indicators (output results from worksheets 1, 2, & 3)).	1. Project design parameters (ODS type, application, sector, amount, etc.); 2. Project participants experience on ODS destruction project stages; 3. Carbon project preparation activities (documentation, validation, verification, registry, etc.); 4. Carbon revenue parameters (carbon price, start year of carbon revenue, Share of Proceedings (SoP) etc.); 5. Financial structure (%) (equity, debt, grant, advance payment of carbon revenues, cost of capital, etc.).	1. Project Performance (US$/tCO2, US$/mt ODS); 2. Project implementation costs per stage and total; 3. Carbon Project Transaction Costs (Total and per tCO2eq (or per ITMO); 4. Carbon revenue performance (Total revenues ($), break even cost ($/tCO2eq),
2. Single Project Cash Flow	Delivers a Projected Balance of Costs and revenues for a 1 Year ODS destruction project, using the Input data filled in worksheet "1. Data input & output results".	Total amount of ODS destroyed (mt)	1. Cash Flows ($); 2. PV of Cash Flows ($); 3. Cumulative Cash Flows ($); 4. NPV ($); 5. IRR (%); 6. Capital employed ($); 7. Payback (year)
3. POA Cash Flow	Delivers a Projected Balance of Costs and revenues for an ODS destruction Multiyear Program of Activities (POA), using the Input data filled in worksheet "1. Data input & output results".	Amount of ODS destroyed per year (mt)	1. Cash Flows ($); 2. PV pf Cash Flows ($); 3. Cumulative Cash Flows ($); 4. NPV ($); 5. IRR (%); 6. Capital employed ($); 7. Payback (year)
A1. ODS Disposal Costs	Consolidates referenced costs of the stages of an ODS project, at different project circumstances. Database used by the model.	Not required	Min & Max costs of ODS segregation, collection, processing, transportation & destruction, for different ODS types, application sectors, domain, and country experience.
A2. ODS GWP	Consolidates Referenced Global Warming Potentials of ODS controlled by the Montreal Protocol. Database used by the model.	Not required	GWP of 19 ODS controlled by the Montreal Protocol.
A3. CO2 Project	Consolidates referenced	Not required	Average transaction costs incurred in a carbon

Name of worksheet	Functions	Requested Data Input	Data Output
Transaction Costs	transaction costs of a mitigation action seeking the transfer of ITMOs under Article 6.2 of the Paris Agreement. Database used by the model.		project development: documentation & supervision, validation, verification, application fee, MID fee, corresponding adjustment fee, listing fee.
C1 Case 1 break even curve	Consolidates a break even cost curve (carbon price vs. amount of ODS @ NPV=0), for an HCFC-22 destruction project with the following financial structure: - Equity = 100%	1. Project design parameters: - Effort Level= **Low** - Pop. Density= **Dense** - Sector/activity= domestic refrigeration - ODS= **HCFC-22** - Amount of pure ODS destroyed =**Variable** - Destruction Technology=**HTI** - Destruction Site Location=**International** 2. Country experience in project implementation stages= **Low/High** 3. Carbon project preparation activities =**Yes** 4. Carbon revenue parameters - carbon price= **variable** - start year of revenue = **3** - Carbon price indexation= **3%** - Financial structure (%) Equity=**100%** - Debt=**0%** - Grant=**0%** - Advance payment of carbon revenues=**0%** - Capital cost=**10%** - Inflation rate=**3%** - Loan Duration=**0 year** - Loan fixed rate=**0%** - Credits discount rate=**0%**	For an HCFC-22 destruction project with low country experience (corresponding to high end of project implementation costs), and with project scale in the range of 3.9-10.8 mt of ODS disposed, the "break even" carbon cost (@ NPV=0) ranges from 37.5 to 50 US$/tCO2eq (see Figure 2). For an HCFC-22 destruction project with high country experience (corresponding to low end of project implementation costs), and with project scale in the range of 4.1-9 mt of ODS disposed, the "break-even" (@ NPV=0) carbon price ranges from 25 to 35 US$/tCO2eq (see Figure 2).
C2 Case 2 break even curve	Consolidates a break even cost curve (carbon price vs. amount of ODS @ NPV=0), for an HCFC-22 destruction project with the following financial structure: - Equity = 10% - Debt=10% - Grants=20%	1. Project design parameters: - Effort Level= **Low** - Pop. Density= **Dense** - Sector/activity= domestic refrigeration - ODS= **HCFC-22** - Amount of pure ODS destroyed =**Variable** - Destruction Technology=**HTI**	For an HCFC-22 destruction project with low country experience (corresponding to high end of project implementation costs), and with project scale in the range of 4.2-18.6 mt of ODS disposed, the "break-even" carbon price (@ NPV=0) ranges from 25 to 35

Name of worksheet	Functions	Requested Data Input	Data Output
	- Advance payment of carbon credits =60%	- Destruction Site Location=**International** 2. Country experience in project implementation stages= **Low/High** 3. Carbon project preparation activities =**Yes** 4. Carbon revenue parameters - carbon price= **variable** - start year of revenue = **3** - Carbon price indexation= **3%** - Financial structure (%) Equity=**10%** - Debt=**10%** - Grant=**20%** - Advance payment of carbon revenues=**60%** - Capital cost=**10%** - Inflation rate=**3%** - Loan Duration=**10 years** - Loan fixed rate=**5%** - Credits discount rate=**8%**	US$/tCO2eq (see Figure 3). For an HCFC-22 destruction project with high country experience (corresponding to low end of project implementation costs), and with project scale in the range of 3-10.9 mt of ODS disposed, the "break-even" (@ NPV=0) carbon price ranges from 17 to 30 US$/tCO2eq (see Figure 3).
C3 Case 3 break even curve	Consolidates a break even cost curve (carbon price vs amount of ODS @ NPV=0), for an HCFC-22 destruction project with the following financial structure: - Equity = 20% - Debt=60% - Grants=20%	1. Project design parameters: - Effort Level= **Low** - Pop. Density= **Dense** - Sector/activity= domestic refrigeration - ODS= **HCFC-22** - Amount of pure ODS destroyed =**Variable** - Destruction Technology=**HTI** - Destruction Site Location=**International** 2. Country experience in project implementation stages= **Low/High** 3. Carbon project preparation activities =**Yes** 4. Carbon revenue parameters - carbon price= **variable** - start year of revenue = **3** - Carbon price indexation= **3%** - Financial structure (%) Equity=**20%** - Debt=**60%** - Grant=**20%** - Advance payment of carbon revenues=**0%** - Capital cost=**10%**	For an HCFC-22 destruction project with low country experience (corresponding to high end of project implementation costs), and with project scale in the range of 4.3-18.1 mt of ODS disposed, the "break-even" carbon price (@ NPV=0) ranges from 25 to 35 US$/tCO2eq (see Figure 4). For an HCFC-22 destruction project with high country experience (corresponding to low end of project implementation costs), and with project scale in the range of 3.1-11 mt of ODS disposed, the "break-even" (@ NPV=0) carbon price ranges from 17 to 30 US$/tCO2eq (see Figure 4).

Name of worksheet	Functions	Requested Data Input	Data Output
		- Inflation rate=**3%** - Loan Duration=**10 years** - Loan fixed rate=**5%** - Credits discount rate=**0%**	

Source: *Authors' own elaboration.*

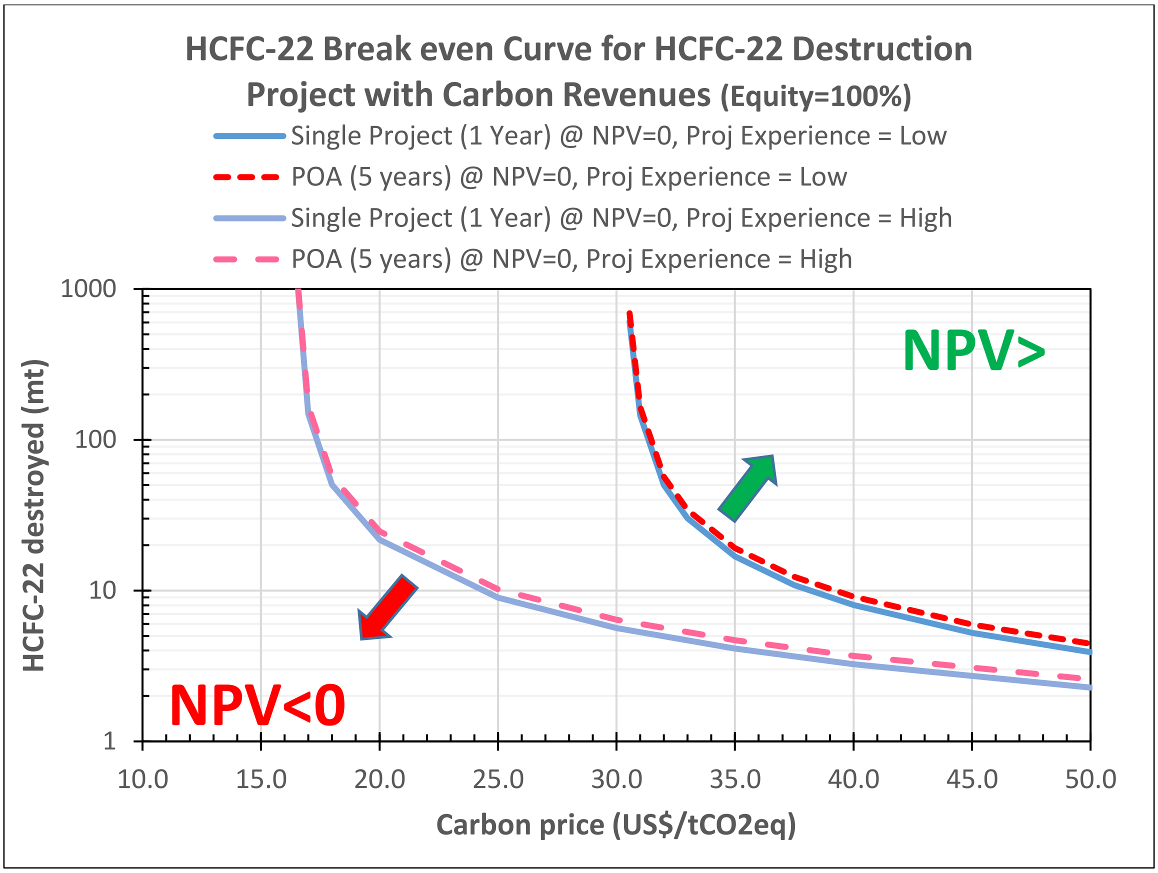

Figure 2. *Break-even costs and project scale (@ NPV =0) for HCFC-22 destruction project with carbon revenues.*
Financial structure = 100% Equity. Capital cost=10%, Annual inflation=3%
Source: *Authors' own elaboration based on results of the financial model.*

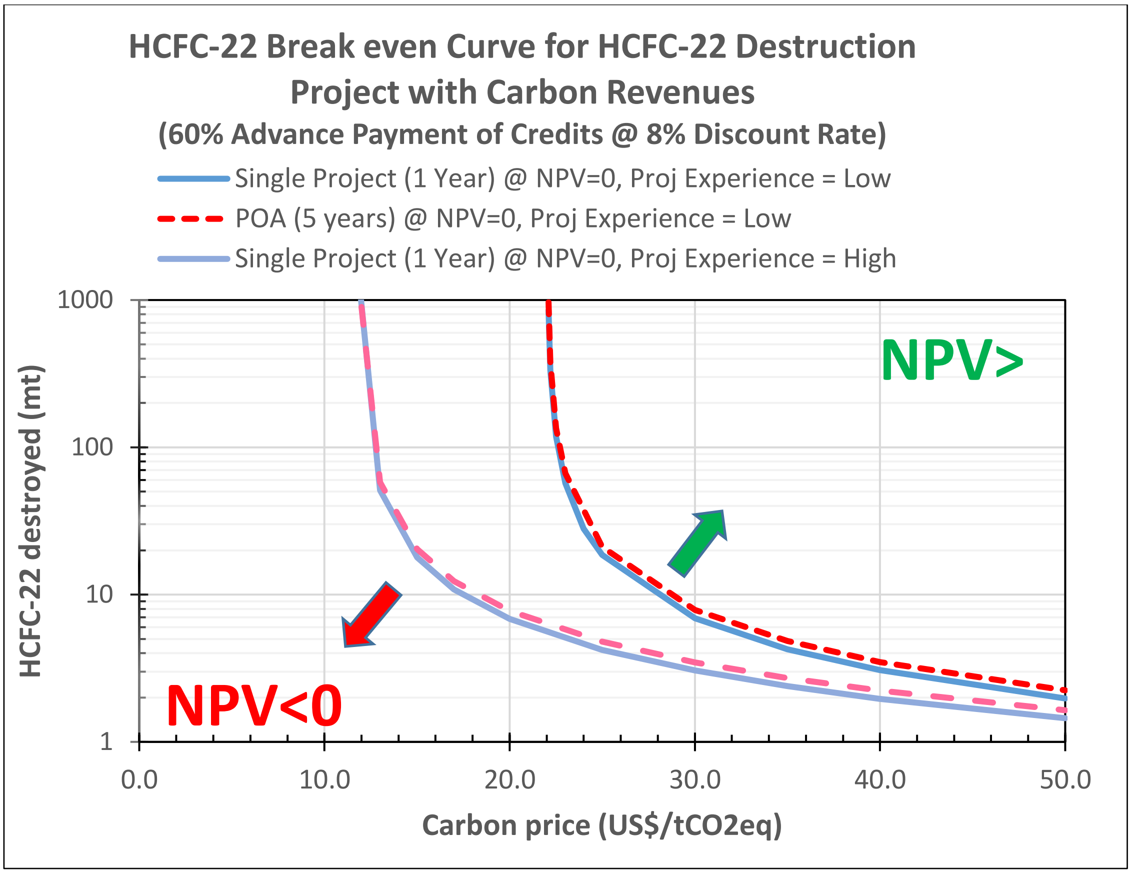

Figure 3. *Break-even costs and project scale (@ NPV =0) for HCFC-22 destruction project with carbon revenues. Financial structure = 10% Equity, 10% Debt, 20% Grant, 60% advance payment of carbon credits. Capital cost=10%, Credits discount rate=8%, Annual Inflation=3%.*
Source: *Authors' own elaboration based on results of the financial model.*

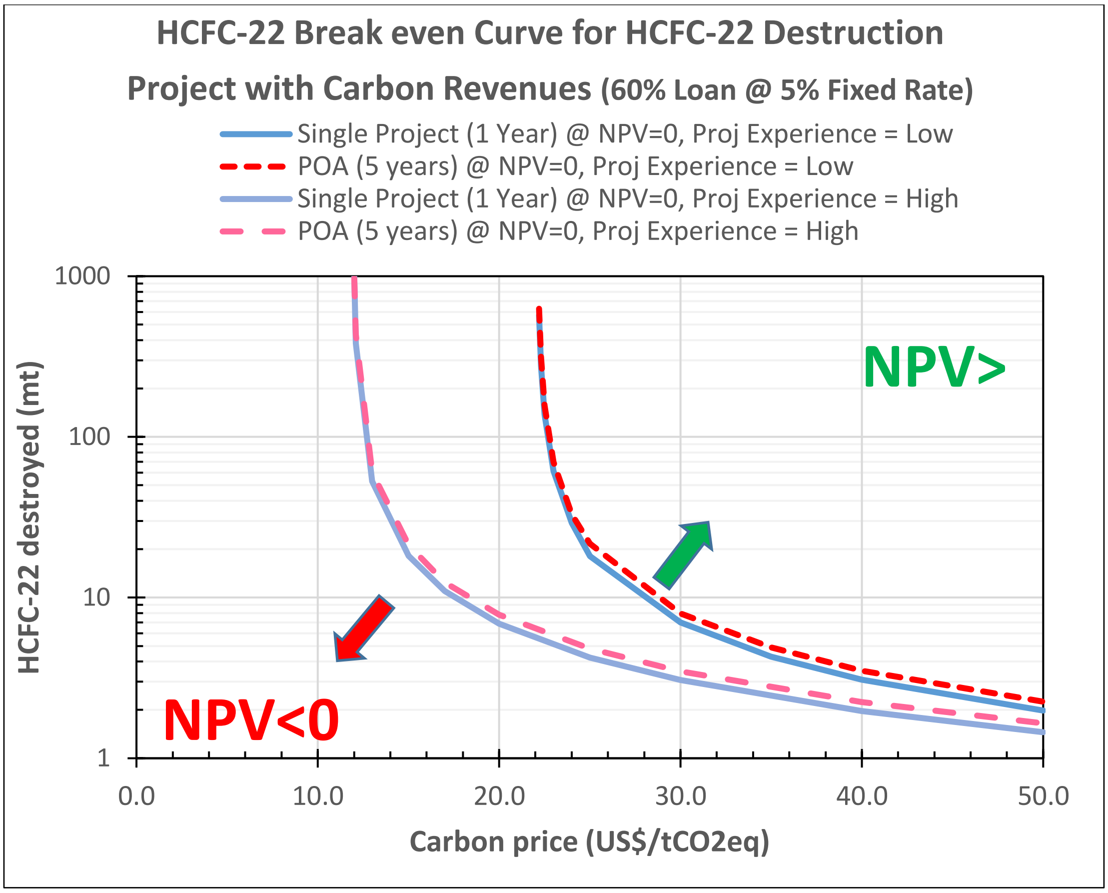

Figure 4. *Break-even costs and project scale (@ NPV =0) for HCFC-22 destruction project with carbon revenues.*
Financial structure = 20% Equity, 60% Debt, 20% Grant. Capital cost =10%, Loan fixed rate=5%, Annual Inflation=3%.
Source: *Authors' own elaboration based on results of the financial model.*

Instructions for the use of the Model

1. The input data and output results cells contained in the set of model worksheets have the following color code depending on the type of required information and the results data given by the model:

	Input data supplied by user
	Input data selected by user from a predetermined list
	Output data provided by the system
	Output results provided by the system

Input data in worksheet "1 Data Input & Output Results" such as: Amount of ODS **(mt)**, Loan duration **(year)**, or Debt cost fixed rate **(%)** have assigned a white color cell, where the user must introduce the corresponding data in the featured units.

Input data in worksheet "1 Data Input & Output Results" such as: Effort Level Required, Population Density, Sector/activity, ODS, and Use of ODS, have assigned a yellow color cell, where the user must select the corresponding data from a predetermined list supplied by the model and displayed upon clicking on the cell. For example: when filling the input data "ODS Use" one must click once on the cell in yellow located on the right-hand side in order to display a list of two options: "refrigerant" or "blowing agent". Next, select the option that corresponds to the use of the ODS in the evaluated project.

Output data in worksheet "1 Data Input & Output Results" such as: Segregation & Collection costs (US$/mt), Transport to recovery costs (US$/mt), or Recovery (processing) costs (US$/mt), are displayed in red color cells, and correspond to data provided by the model from databases in worksheets A1, A2, and A3. This data is processed by the model in combination with the input provided by the user to calculate final output results.

Output results in worksheets 1, 2, & 3 such as: Total Project Cost (US$), Total Carbon revenue (US$), Total GHG reduced (tCO2eq), NPV, IRR, or Payback period are displayed in blue color cells, and correspond to final result calculated by the model.

2. All input data and output results cells in worksheets 1 (Data Input & Output Results), 2 (Single project Cash Flow), and 3 (POA Cash Flow) count with displayable written comments that guide the user on the filling process of the input data and on the interpretation of output results (see Table 5, Table 6, and Table 7 for details).

Table 5. *Selection of input data and output results and their corresponding displayable guiding comments contained in the MS Excel worksheet "1. Data Input & output results" of the financial model for ODS destruction projects with carbon revenues.*

Project Design Parameters	Input data	Displayable Comment
Effort Level Required	Low	This data corresponds to the effort required by the project developer to locate, segregate and collect the ODS from stockpiled banks or still in use in appliances/systems. Low effort option must match with dense population. High effort must match with sparse population.
Population Density	Dense	This data corresponds to the population density in the location where the ODS is collected. A densely populated location corresponds to a low effort in collection of ODS, and vice-versa a sparsely populated location requires a high effort for ODS collection.
Sector/activity	Domestic refrigeration	This data refers to the sector and/or activity of use of the ODS considered for destruction. The "R" or "BA" next to each sector/activity specify the use of the ODS linked to the activity, either as refrigerant (R) or as blowing agent (BA).
ODS	HCFC-22	If the ODS participating in the project is a pure substance, choose the name from the list. If the ODS is a mixture of different substances, choose the option "blend" from the list. Next, select the corresponding blends of the mixture in yellow cells below, and input their respective amounts in the white cells below.
Use of ODS	Refrigerant	Select from the list the use of the ODS, either "refrigerant (R)" or "blowing agent (BA)". Make sure that the option matches with the use of ODS specified on the sector/activity selected in Cell B10. For example, the sector/activity "Transport refrigeration (R)" uses ODS only as refrigerants (R), whereas insulation parts such as Steel force panel (BW) or Block-pipe (BA), contain only blowing agents (BA). In the case of Domestic and Commercial refrigeration sectors (R or BA), either refrigerants (R) or blowing agents (BA) can be recovered for destruction.
Amount of pure ODS destroyed (mt)	10	If the ODS is pure, introduce the amount of ODS in metric tonnes. Otherwise, leave the cell in blank.

Project Design Parameters	Input data	Displayable Comment
Destruction Technology	HTI	Select from the list the type of technology used for the ODS destruction process.
Destruction´s Site Location	International	Specify here if the ODS destruction facility is located in the country of ODS collection and processing, or if the ODS has been or will be exported for destruction to another country.
Project Implementation Costs	**Output results**	**Displayable Comment**
Break even cost (US$/tCO2eq)	$ 21.14	Corresponds to an indicative "break-even" carbon price that covers total project cost (estimated on cell F33).
Total Project Cost (US$)	$ 382,620.00	Corresponds to Total Project Cost for a Single 1 Year Project with 100% Equity. Project scale corresponds to the amount of ODS defined by user on cell B14.
Total Carbon Revenue (US$)	$ 987,355.00	Corresponds to total carbon revenue with project scale defined on cell B14, a carbon price defined on cell B56, and without any upfront finance instrument (100% equity).

Source: *Authors' own elaboration based on the information contained in the MS Excel worksheet "1. Data input & output results"*

3. The input data from sections "Financial Structure" and "Carbon Finance Parameters" of Worksheet 1 (Data Input & Output Results) is used by the financial model to run the 2 Balance worksheets: "2. Single Project Cash Flow" and "3. POA Cash Flow". Table 6 enlists the parameters contained in both sections as well as the displayable comments for guiding the user in the filling of information.

Table 6. *"Financial Structure" and "Carbon Revenue Parameters" input data and their corresponding displayable guiding comments contained in the MS Excel worksheet "1. Data Input & output results" of the financial model for ODS destruction projects with carbon revenues.*

Project Design Parameters	Input data	Displayable Comment
Equity (%)	20%	Indicate the percentage of the total project cost being covered by the project developer.
Debt (%)	0%	Indicate the percentage of the total project cost financed with a bank loan.
Grants (%)	0%	Indicate the percentage of the total project cost financed with grants.
Advance payment of ERPA´s value (%)	80%	Indicate the percentage of the total project cost financed with advance payment of future carbon credits based on the Emissions Reduction Purchase Agreement´s value.
Discount on future ERPA´s value (%)	8%	Determine the percentage of discount on the future value of credits according to the ERPA´s value.
Loan duration (year)	10	Determine the duration of the Loan in years.
Debt cost fixed rate (%)	5.0%	Determine the fixed annual rate of the loan.
Cost of capital (%)	10%	Determine the cost of capital for the project.
Annual inflation rate cost (%)	3%	Determine the annual inflation rate that affects the project costs and revenues.
Carbon Revenue Parameters	**Input Data**	**Displayable Comment**
Start of Carbon credits revenue (year)	3	Select the number of years that the project developer waits to start receiving the carbon revenues.

Project Design Parameters	Input data	Displayable Comment
Carbon credit price (US$/tCO2eq)	$ 54.55	Define the carbon credit price in US$/tCO2eq.
Carbon price index (%)	3.0%	Indicate the carbon price index (percentage of annual price increment or decrease)
OMGE (%)	0%	Indicate the percentage of cancelled GHG emission reductions from total project GHG emission reductions for Overall Mitigation in Global Emissions (OMGE).
SOP (%)	0%	Indicate the percentage of relinquished GHG emission reductions from total project GHG emission reductions for Share of Proceedings (SoP).

Source: *Authors' own elaboration based on the information contained in the MS Excel worksheet "1. Data input & output results".*

4. To run Worksheets "2. Single Project Cash Flow" and "3. POA Cash Flow", the user must first fill in all Input data requested in Worksheet 1 "1. Data Input & Results Output), and once finished, move to Worksheets 2 and/or 3 depending on the project modality to be evaluated. If it is a single project with 1 year of duration, the user should access Worksheet 2 and determine the total amount of ODS to be destroyed within that year (Cell C7). If the intention is to evaluate a Program of Activities where recurrent amounts of ODS will be destroyed throughout a timeframe of several years, the user must access Worksheet 3, and determine the amount of ODS to be destroyed each year throughout the duration of the program, starting with year 1 on Cell C7 and add the subsequent amounts of ODS to be destroyed in years 2, 3, etc., on cells D7, E7, etc. Both worksheets deliver Cash Flows throughout the lifetime of the project, as well as financial indicators such as the net present value of cash flows (NPV), the Internal Rate of Return (IRR), the Cumulative Cash Flow, the Profitability Index, and the Payback Period. These parameters are useful for evaluating the economic viability of a project. Additionally, by varying the carbon price amount (cell B55 in Worksheet 1) and the amount of ODS destroyed (cell C7 in Worksheet 2 or cells C7, D7, E7, etc. in Worksheet 3) it is possible to estimate the "break-even" price of carbon at a minimum project scale (minimum amount of ODS destroyed), when the combination results in a NPV = 0. This exercise is presented on Worksheets C1, C2, and C3 (break even curves), as well as in Figure 2, Figure 3, Figure 4, and further discussed on Table 7 enlists the input data required and the output results delivered in Worksheets 2 and 3 as well as the displayable comments for guiding the user in the filling of information, and in the interpretation of results.

Table 7. *"Worksheets "2. Single Project Cash Flow" and "3. POA Cash Flow" input data, output results and their corresponding displayable guiding comments.*

Parameter	Input data	Displayable Comment
ODS destroyed (mt)	5	Insert the Total amount of ODS destroyed by the Project (in Worksheet 2). Insert the total amount of ODS destroyed per year determined in the Program of Activities (POA) (in Worksheet 3).
Carbon credit price (US$/tCO2eq)	30	Define the carbon credit price in US$/tCO2eq.
Parameter	**Output results**	**Displayable Comment**

Total Project Cost (US$)	$251,810.00 (1 year) $259,998.00 (5 years)	Corresponds to Total Project Cost for a Single 1 Year Project with financial structure defined on cells B45:B53 of Worksheet 1 (Data Input &Results Output). Project scale corresponds to the amount of ODS defined by user on cell B7 (in Worksheet 2). Corresponds to Total Project Cost for a Multiyear POA with financial structure defined on cells B45:B53 of Worksheet 1 (Data Input &Results Output). The project scale corresponds to the total amount of ODS destroyed throughout the POA´s timeframe, defined in cell A7 (in Worksheet 3).
NPV of total Cash Flows	$7,878.09 (1 year) -$6,271.51(5 years)	Delivers the Net Present Value of the total Cash Flows throughout the project´s lifetime.
IRR (%)	18.29% (1 year) 7.69% (5 years)	Delivers Internal Rate of Return of the project.
Profitability Index	0.03129 (1 year) -0.024131 (5 years)	Delivers profitability index, equivalent to the quotient of the NPV and Total Project Cost.
Payback period (year)	2.71 (1 year) 6.26 (5 years)	Delivers the payback period in years. This happens when the cumulative cash flows turn from negative value to zero.

Source: *Authors' own elaboration.*

5. Worksheet "A1 ODS Disposal" groups the cost ranges of the different steps of implementation of an ODS destruction project, from segregation, collection, and processing to the transportation and final destruction process. The cost ranges vary depending on the type of ODS, the sector of use, the population density level, the distance to the destruction site, the location of the destruction site (domestic or international), and the type of destruction technology (for details see Table 9). Once the user provides the input data on the Project design parameters of Worksheet 1, the Financial Model selects from Worksheet "A1 ODS Disposal" the adequate cost for each of the ODS destruction project steps and presents a project cost budget in Worksheet 1. Such a budget is further used in Worksheets 2 and 3, to estimate the Cash Flows and other financial indicators.
6. Worksheet "A2 ODS GWP" groups a list of the ODS controlled by the Montreal Protocol and their respective Global Warming Potentials (GWP) (see Table 10). GWPs are used to estimate the amount of CO2 equivalent mass units mitigated per mass unit of ODS destroyed. Once the user has input in Worksheet 1, either the type of pure ODS and its respective amount to be destroyed, or if the ODS is a blend, the ODS components and their respective amounts, the Model will select the GWP (from Worksheet A2) that corresponds to the pure ODS, or the GWPs of the ODS blend components, and calculate the amount of CO2 equivalent that will be reduced as a result of the ODS destruction.
7. Worksheet "A3 CO2 Transaction Costs" enlists the total costs incurred to develop, implement, and register an ODS destruction project seeking the transfer of ITMOs under Article 6.2 mechanism (for details see Table 11). The Model uses these costs to build a Carbon Project Transaction Cost Budget and present it in Worksheet 1, and further uses it to estimate Cash Flow on Worksheets 2 and 3. The Model chooses by default the maximum amount per each transaction cost to build the budget. The listing fee and the corresponding adjustment fee are charged per ton of CO2eq (or per ITMO), the rest of transaction cost are fixed costs, and the model charges each of them just one time per project or POA, except for the verification process that is charged just once for a 1 year project, but for a POA verification fee is charged every time that a destruction activity is performed during the timeframe of the POA.
8. Worksheets C1, C2, and C3 break even cost curves, contain 3 case studies of HCFC-22 destruction projects with 3 different financial structures:

   Case 1: the project costs are fully financed by the project developer (100% Equity).

Case 2: Equity=10%, Debt=10% (Loan duration of 10 years @ annual fixed rate 5%), Grant=20%, advance payment of carbon revenues=60% (with credit discount rate = 8%).

Case 3: Equity=20%, Debt=60% (Loan duration of 10 years @ annual fixed rate 5%), Grant=20%, advance payment of carbon revenues=60% (with credit discount rate = 8%).

Each case study evaluated two scenarios:

Scenario 1: The Project Developer & Country has no experience in conducting ODS destruction projects with carbon revenue (**LOW**). This implies that project costs will be in the high end of range.

Scenario 2: The Project Developer & Country has proved experience in conducting ODS destruction projects with carbon revenue (**HIGH**). This implies that project costs will be in the low end of the range.

When comparing the "break-even" carbon price ranges and the project scale ranges obtained for the three case studies, we find that previous experience of project developers/countries in handling ODS destruction projects can reduce significantly the implementation costs and consequently the "break-even" carbon price of the project. The "break-even" carbon price ranges of Scenario 2 (high experience) of the 3 Cases were around 30% lower than those of Scenario 1 (low experience). Moreover, Cases 2 and 3 delivered very similar "break-even" carbon price ranges for either of the two scenarios and were around 30% lower than those of Case 1. This can be explained in the sense that both Case 2 and Case 3 counted in their financial structure with grants worth 20% of the total project cost, and other financial instruments such as a soft loans or advance payment of carbon credits, that contribute to obtain more competitive "break-even" carbon price compared to Case 1 that did not count on any upfront finance instrument or grant (for details see

Table **8**, and Figure 2, Figure 3, and Figure 4).

Lastly, it was observed that for all Case Studies, the "break-even" carbon prices of five years POAs resulted 4.5-11% higher compared to those of 1 single year projects with same total project scale. This finding is relevant in case the minimum project scale (minimum economic viable amount of ODS) can only be achieved on a timeframe of several years, and therefore it is necessary to implement a multiannual program of activities for ODS destruction.

Table 8. *Break even carbon price ranges and project scale ranges, from 3 ODS destruction projects with different financial structures.*

		Case 1 (Equity 100%)	Case 2 (Equity 10%, Grant 20%, Debt 10%, Advance Payment of Credits 60%)	Case 3 (Equity 20%, Debt 60%, Grant 20%)
Scenario 1 (Low)	Project Scale Range (mt)	3.9-10.8	4.2-18.6	4.3-18.1
	Break Even Carbon Price Range (US$/tCO2eq)	37.5-50	25.0-35-0	25.0-35-0
Scenario 2 (High)	Project Scale Range (mt)	4.1-9.0	3.0-10.9	3.1-11.0
	Break Even Carbon Price Range (US$/tCO2eq)	25.0-35.0	17.0-30.0	17.0-30.0

Source: *Authors' own elaboration.*

9. The flowchart on Figure 5 summarizes the financial model performance and explains the interlinkage of input data and output results among the model worksheets.

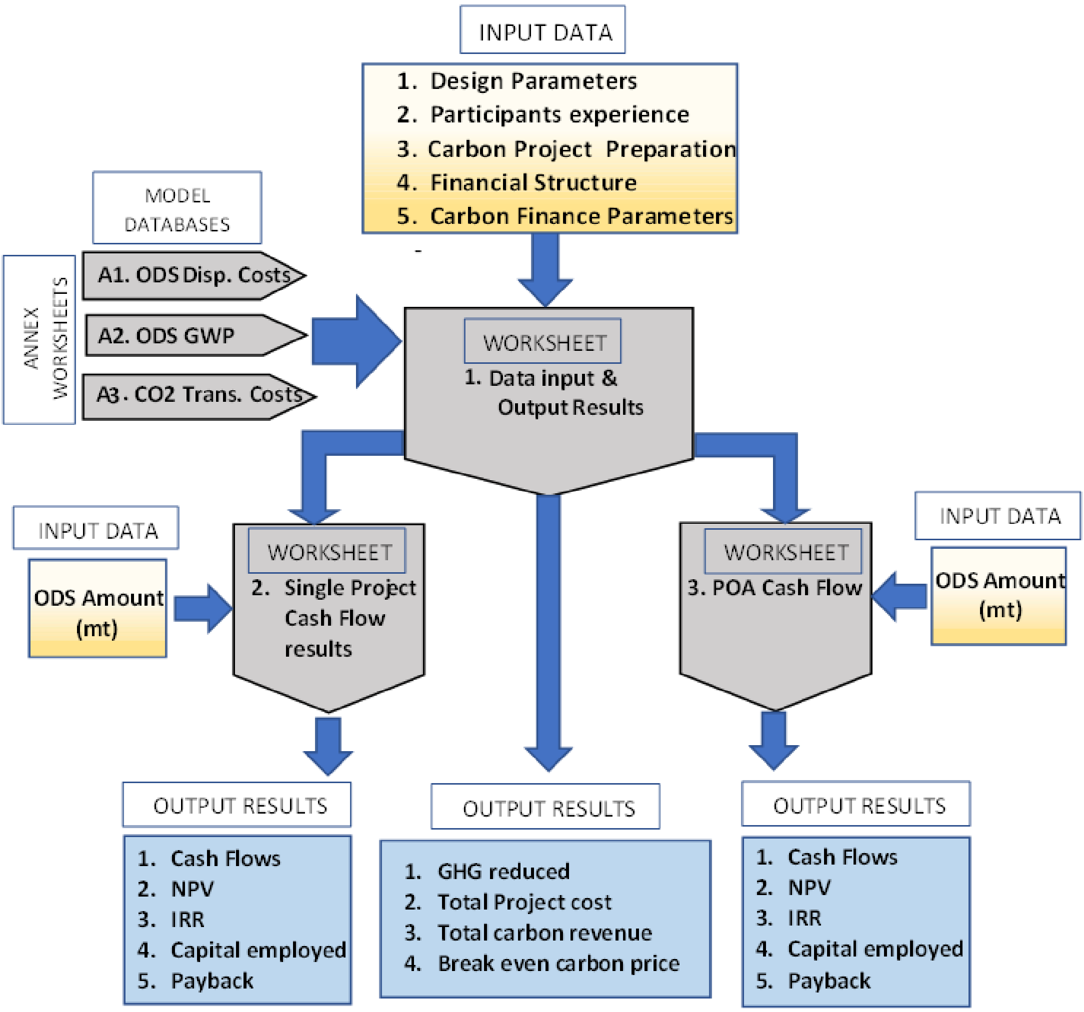

Figure 5. *Financial Model Flowchart for ODS Destruction Projects with Carbon Revenue.*
Source: *Authors' own elaboration.*

Table 9. *"Worksheet "A.1. ODS Disposal Costs". Cost ranges of ODS disposal activities (segregation, collection, recovery, processing, transport, and destruction).*

Effort Required	Sector	Population Density	ODS Type	Segregation/Collection Costs		Transport to recovery Costs		Recovery Processing Costs		Transport Costs (In country Destruction)		Transport Costs (International Destruction)		Destruction Costs (In country Destruction)		(International Destruction) (All Tech except		(International Destruction) (Plasma Arc)	
				US$/mtODS		US$/mtODS		US$/mtODS		US$/mtODS		US$/mtODS		US$/mtODS		US$/mtODS		US$/mtODS	
				min	max	min	max	min	max	min**	max**	min**	max**	min	max	min	max	min	max
Low	Domestic refrigeration	D	R	6000	10000	6000	8000	10000	20000	250	1000	1400	4000	4000	7000	2400	6000	7400	18500
	Domestic refrigeration	D	BA	6000	10000	6000	8000	20000	30000	250	1000	1400	4000	4000	7000	2400	6000	7400	18500
	Commercial refrigeration	D	R	8000	12000	8000	10000	8000	15000	250	1000	1400	4000	4000	7000	2400	6000	7400	18500
	Commercial refrigeration	D	BA	8000	12000	8000	10000	25000	35000	250	1000	1400	4000	4000	7000	2400	6000	7400	18500
	Transport refrigeration	D/S	R	N/A	N/A	N/A	N/A	15000	20000	250	1000	1400	4000	4000	7000	2400	6000	7400	18500
	Industrial refrigeration	D/S	R	N/A	N/A	N/A	N/A	4000	6000	250	1000	1400	4000	4000	7000	2400	6000	7400	18500
	Stationary A/C ^	D	R	1000	2000	N/A	N/A	4000	25000	250	1000	1400	4000	4000	7000	2400	6000	7400	18500
	Mobile A/C	D	R	1000	2000	N/A	N/A	4000	6000	250	1000	1400	4000	4000	7000	2400	6000	7400	18500
High	Domestic refrigeration	S	R	10000	15000	30000	40000	10000	20000	250	1000	1400	4000	4000	7000	2400	6000	7400	18500
	Domestic refrigeration	S	BA	10000	15000	30000	40000	20000	30000	250	1000	1400	4000	4000	7000	2400	6000	7400	18500
	Commercial refrigeration	S	R	15000	20000	40000	50000	8000	15000	250	1000	1400	4000	4000	7000	2400	6000	7400	18500
	Commercial refrigeration	S	BA	15000	20000	40000	50000	25000	35000	250	1000	1400	4000	4000	7000	2400	6000	7400	18500
	Stationary A/C ^	S	R	1000	2000	N/A	N/A	10000	35000	250	1000	1400	4000	4000	7000	2400	6000	7400	18500
	Mobile A/C	S	R	1000	2000	N/A	N/A	4000	6000	250	1000	1400	4000	4000	7000	2400	6000	7400	18500
	Steel forced panels	D	BA	75000	90000	5000	10000	30000	40000	250	1000	1400	4000	4000	7000	2400	6000	7400	18500
	Block-pipe	D	BA	10000	15000	15000	20000	30000	40000	250	1000	1400	4000	4000	7000	2400	6000	7400	18500
	Block-Slab	D	BA	80000	100000	5000	10000	30000	40000	250	1000	1400	4000	4000	7000	2400	6000	7400	18500

Source: *Authors' own elaboration based on information from the TEAP 2009.[30]*
*Population density: D=dense; S=sparse. ODS Recovered: R=Refrigerant; BA=Blowing Agent** Covering shipment distances of 200–1000 km for in-country destruction; longer distances such as those incurred through exporting materials may incur higher transport costs. International transport includes import and management fees according to Basel Convention procedures.*
^ Assumed on-site recovery.

[30] UNEP Technology and Economic Assessment Panel (TEAP). 2009. Task force Decision XX/7 – Phase 2 Report "Environmentally Sound Management of Banks of Ozone Depleting Substances". UNEP Ozone Secretariat, P.O. Box 30552, Nairobi, Kenya.

Table 10. *"Worksheet "A.2. ODS GWP". List of Global Warming Potentials of ODS controlled by the Montreal Protocol.*

Substances controlled by the Montreal Protocol	Formula	GWP (100 years)
CFC-11	CCl_3F	4,750
CFC-12	CCl_2F_2	10,900
CFC-13	$CClF_3$	14,400
CFC-113	CCl_2FCClF_2	6,130
CFC-114	$CClF_2CClF_2$	10,000
CFC-115	$CClF_2CF_3$	7,370
Halon-1301	$CBrF_3$	7,140
Halon-1211	$CBrClF_2$	1,890
Halon-2402	$CBrF_2CBrF_2$	1,640
Carbon tetrachloride	CCl_4	1,400
Methyl bromide	CH_3Br	5
Methyl chloroform	CH_3CCl_3	146
HCFC-21	$CHCl_2F$	148
R-22 (HCFC-22)	$CHClF_2$	1,810
HCFC-123	$CHCl_2CF_3$	77
HCFC-124	$CHClFCF_3$	609
HCFC-141b	CH_3CCl_2F	725
HCFC-142b	CH_3CClF_2	2,310
HCFC-225ca	$CHCl_2CF_2CF_3$	122
HCFC-225cb	$CHClFCF_2CClF_2$	595

Source: *Authors' own elaboration based on information from UNEP and IPCC.*

Table 11. *"Worksheet "A.3. CO2 Transaction Costs". Typical transaction costs of mitigation actions for ITMOs transfer under The National framework of Ghana for market and non-market mechanisms under Article 6 of the Paris Agreement.*

Typical Transaction Costs of Mitigation Actions for ITMOs Trasnfer under Ghana´s Article 6.2 Framework			
Concept	Costs (US$)		Concept Description
	min	max	
Project preparation	0	60000	This is typically the cost of consultant support to undertake an initial feasibility assessment, develop project documents, and support the validation and registration processes. This cost may be considerably lower than estimated if local consultants (in-country) are used or,particularly, if expertise exists in-house to undertake these tasks. In the case of the Swiss government, Klik foundation upfronts up to 200,000 USD for MADD development.
3rd party validation	15000	20000	This one-off fee is largely a fixed cost, but might be slightly reduced for particularly simple or small projects. Note that this fee is not required for CCX or CAR. Recent references from UNDP point to an avergae cost of validation of US$15,000-US$20,000, for ITMO projects.
3rd party verification (US$/year)	15000	20000	Like the cost of validation, this cost is fixed but might be slightly lower for particularly simple or small projects. For projects carried out on an ongoing or multi-year basis, this would be an annual cost. Recent references from UNDP point to an avergae cost of verification of US$15,000-US$20,000, for ITMO projects.
Mitigation activity participant (MAP) or entity application fee	500	1000	This fee is paid by an activity developer who has to create a Mitigation Action Project (MAP) account on the Ghana Carbon Registry (GCR) to obtain a Mitigation Identification Number (MID) for the first mitigation activity aiming to generate authorised ITMOs for transfer either on the GCR or registry linked to a preapproved International Credit Standard (ICS) in this framework. Fee is paid also by voluntary carbon project developer seeking formal recognition to create an account on the GCR and list carbon offset credit for recording on the GCR.The value ranges from US$500.00 for small scale projects or forestry projects to US$1000.00 for large scale commercial non forestry projects.
Mitigation activity identification (MID) fee	250	500	Fee is paid by activity developer seeking to create MID for additional mitigation activity other than the first activity created into the same MAP account. The value ranges from US$250.00 for small scale projects or forestry projects to US$500.00 for large scale commercial non forestry projects.
Corresponding Adjustment Fee (US$/ITMO)	3	10	Fees paid by an activity developer or participating acquiring Party to compensate for the opportunity cost for meeting Ghana NDC and the marginal cost for creating associated with the regular transfer and reporting of transferable mitigation outcomes. The value ranges from US$3.00 for small scale projects, US$8.00 or forestry projects, to US$10.00 for large scale commercial non forestry projects.
Listing fee (US$/ITMO)	0.1	0.2	A Fee of US$0.20/ITMO is paid on a retainer basis by an activity developer for each eligible activity aiming to create authorised ITMOs for transfer from and held on the GCR. A fee of US$0.10/ITMO is paid on a retainer basis by the VCM project developer for recording carbon offset credit on the GCR.

Source: *Authors' own elaboration based on information provided by the Climate Action Reserve; VCS; ICF International; and The National framework of Ghana for market and non-market mechanisms under Article 6 of the Paris Agreement.*[31]

[31] ICF International. 2010. Study on Financing the Destruction of Unwanted Ozone-Depleting Substances through the Voluntary Carbon Market. Final Report. Washington D.C., The World Bank; The National framework of Ghana for market and non-market mechanisms under Article 6 of the Paris Agreement. Schedule 11 "Fees" Page 73-74.