COPA
Cutting refrigerant emissions

GUIDELINE TO CONDUCT AN INVENTORY OF USED OR UNWANTED CONTROLLED SUBSTANCES: ODS AND HFC BANKS

Climate and Ozone Protection Alliance (COPA)

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giz Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH

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ODS/HFC BANKS ARE DEFINED AS "THE TOTAL AMOUNT OF SUBSTANCES CONTAINED IN EXISTING EQUIPMENT, CHEMICAL STOCKPILES, FOAMS AND OTHER PRODUCTS NOT YET RELEASED TO THE ATMOSPHERE".

IPCC/TEAP, 2005

CONTENTS

ABBREVIATIONS

AC	Air Conditioning
CFC	Chlorofluorocarbon
EPR	Extended Producer Responsibility
GDP	Gross Domestic Product
GHG	Greenhouse Gas
GIZ	Deutsche Gesellschaft für Internationale Zusammenarbeit GmbH
GWP	Global Warming Potential
HCFC	Hydrochlorofluorocarbon
HFC	Hydrofluorocarbon
HPMP	Hydrochlorofluorocarbon Phase Out Management Plan
HS code	Harmonized System Code
IMF	International Monetary Fund
IPCC	International Panel on Climate Change
MLF	Multilateral Fund
MRV	Measurement, Reporting and Verification
KIP	Kigali Implementation Plan
NAMA	National Appropriate Mitigation Actions
NDCs	Nationally Determined Contributions
ODP	Ozone Depletion Potential
ODS	Ozone Depleting Substances
RAC&F	Refrigeration, Air Conditioning and Foam
RMP	Refrigerant Management Plans
RTOC	Refrigeration Technical Options Committee
TEAP	Technology and Economic Assessment Panel
UNEP	United Nations Environment Programme
US EPA	US Environmental Protection Agency
TCCCA	Transparency, Consistency, Comparability, Completeness and Accuracy

1. INTRODUCTION

This guideline is intended for inventory compilers involved in quantifying the amount of ozone depleting substances (ODS) and hydrofluorocarbon (HFC) banks in their country and, based on this, quantifying the mitigation potential. This guideline was updated to reflect all requirements stated by decision 91/66 of the Executive Committee to the Multilateral Fund (MLF) for the implementation of the Montreal Protocol on the provision of a funding window for establishing an inventory of controlled substances and a plan for their treatment. While the ODS/HFC bank inventory is one key element, documenting common practice concerning waste- ODS/HFC, policy analysis and stakeholder consultations are equally necessary for the planning of environmentally sound management of waste-ODS/HFCs.

A sound understanding of ODS/HFC banks on the country level is the basis for any action and policy decisions in the field of bank management.

In particular, the inventory is important to:

- assess the general need for action in the field of ODS/HFC bank management
- assess the potential environmental benefits to the ozone layer and the climate
- assess the potential for substance recycling and reclamation for re-use
- decide whether to export ODS/HFC or to find a local reclamation and/or destruction solution
- design optimal capacities for reclamation and destruction technology in case of local options
- assess long-term availability of ODS and HFC to guarantee economic viability of a reclamation and destruction plant
- design appropriate policy measures for effective collection and sustainable financing.

Specifically, decision 91/66 calls for the several aspects to be included in the analysis, as presented in *Table 1*. The items are structured along three elements: (a) analysis to be performed, (b) methods to be used, (c) outcomes to be derived.

While this guideline focuses on how to best conduct an ODS/HFC banks inventory, several other guidelines and a template roadmap are available on the website of the Climate and Ozone Protection Alliance (COPA)[1].

Table 1 indicates the resources to draw from for the specific items.

1 https://www.copalliance.org/resources

Table 1: *Items to cover within the inventory of banks of used or unwanted controlled substances and a plan for the collection, transport, and disposal of such substances according to decision 91/66*

Analysis to be performed	
National inventory of used or unwanted controlled substances, with distinction of amounts for recycling, reclamation and disposal, taking into account amounts that were previously collected and are awaiting disposal	This guideline
Review of current regulatory frameworks, policies and existing programmes, including Extended Producer Responsibility (EPR), waste and hazardous waste management policies	• *Fact sheet and gap analysis (Annex of roadmap)* • *Resource Book for Life Cycle Management of Fluorocarbons*
Stakeholder analysis with responsibilities and roles	• *Gap analysis (Annex of roadmap)* • *Collection guideline*
Assessment of technology options for recycling, reclamation and disposal for destruction: opportunities of co-processing or possibility for export (technical feasibility and cost)	• *Assessment of ODS/HFC reclamation and destruction technologies* • *Thermal destruction of (H)CFCs and HFCs*
Methods to be used	
Transparent methodology	This guideline
Coordinated with national phase out/down plans	
Stakeholder engagement on objective of inventory, methodology and validation for results	
Additional data collection (depending on national circumstances), potentially focussing on • waste sources • collection practices (including informal sector)	• This guideline • *Collection guideline*
Outcomes to be derived	
Required policies and regulations incl. on trans-boundary movement if required for the export of ODS/HFCs (also in relation to policy development under the Kigali Implementation Plan (KIP))	• *Roadmap* • *Guideline policy measures* • *Transboundary movement*
Action plan for effective collection, transport, storage and setting up the infrastructure for recycling and reclamation including a tracking system	• *Roadmap* • *Collection guideline*
Business plan for collection and treatment	• *Roadmap*

An exemplary procedure for carrying out the analysis could look like this:

- Preliminary desk study on available data (using the guide on ODS/HFC banks inventory below) and regulatory framework
- Identify data gaps (ODS/HFC banks in certain sectors, recovery practices, collected amounts, etc.)
- Conduct stakeholder analysis, based on knowledge from the HCFC Phase-out Management Plan (HPMP), consider other stakeholders, such as e-waste handlers
- Start stakeholder consultation: present preliminary findings and stakeholder mapping, outline whole procedure, objectives and expected outcome, discuss and integrate stakeholder opinions
- Conduct further data collection and survey to complete ODS/HFC banks inventory, policy analysis, collection, treatment practice and waste quality
- Based on expected amounts to be treated, conduct assessment of the technical feasibility of ODS/HFC treatment options (including reclamation and destruction), as well as cost estimates. Develop plan and present it in draft report:
  - How to improve collection in conjunction with HPMP/KIP implementation
    - › Policies and regulation including potential for EPR and incentive schemes
    - › Required infrastructure and equipment
  - Decision on favoured treatment options for collected refrigerant
  - Business plan for collection and treatment
  - Action plan
- Stakeholder consultations for validation and action plan refinement
- Final report

2. ODS/HFC BANK INVENTORY

ODS/HFC banks are defined as the 'total amount of substances contained in existing equipment, chemical stockpiles, foams and other products not yet released to the atmosphere' (IPCC/TEAP 2005). Thus, ODS/HFC can either be quantified in an aggregated manner such as bulk/cylinder (stockpiles), or estimated via ODS/HFC-containing equipment. Sometimes countries report on ODS/HFC to be stored in cylinders, but this is usually not indicative of the total amount of ODS/HFC in the country. Please note that **we refer to 'reachable banks'** (TEAP 2006), i.e., excluding ODS/HFC contained in landfilled products, as these are considered to be unreachable. Regarding blowing agents in foam, we recommend focusing on appliance foam only. In developing countries, ODS/HFC blowing agents are not common in the building sector. Precise amounts are difficult to assess, and once assessed, their management is not viable. Foam blowing agents in the building sector have only low 'accessibility' (TEAP 2009) with technological barriers to recovery and associated high costs.

The most important ODS are chlorofluorocarbons (CFCs) and hydrochlorofluorocarbons (HCFCs). CFCs, HCFCs and substituting HFCs are predominantly used in the refrigeration, air conditioning and foam (RAC&F) sectors (e.g. US EPA 2011). Consequently, this guideline focuses on these sectors and substances. If considerable amounts are used for fire protection, this sector needs to be included. When ODS/HFCs are used in other sectors, such as medical dose inhalers and solvents, they usually do not form a bank, as their use leads to the release of the substance to the atmosphere.

ODS are currently being phased out under the Montreal Protocol and are partly being replaced by HFC. The use of CFC is already banned all over the world, while the HCFC-phase out was completed in 2020 in non-Article 5 countries and will be completed by 2030 in Article 5 countries. Due to past and current excessive use of ODS and increasingly also HFCs, large ODS/HFC banks have accumulated worldwide

– mainly as refrigerants in equipment and blowing agents in appliance foam. This is also because some ODS/HFC-containing appliances have long lifetimes and ODS/HFC blowing agents from foam are being emitted at a very slow rate. Therefore, equipment that reaches its end-of-life today partly still contains CFCs (e.g., domestic refrigerators).

Not strictly part of an inventory, but an essential step for the planning of ODS/HFC waste management is the projection of the future bank development. Depending on present and future refrigerant and blowing agent use, banks of controlled substances will increase or decrease and influence the time span and total amount of ODS/HFC awaiting management and treatment at the equipment's' end-of-life.

This step-by-step guideline presents **two approaches for assessing current ODS/HFC banks** as a basis for future forecasts, reduction targets and policy actions:

1) equipment approach and
2) chemical consumption approach

While the first approach may be more accurate but also more resource intensive, the second is less precise but data are mostly already available through the HPMPs and CFC Refrigerant Management Plans (RMPs) and KIPs.

As a basis for an ODS/HFC management plan, the equipment approach is highly recommended. To plan collection and treatment routes, facilities and capacities, it is vital to gather information on where refrigerant amounts are located, both in terms of in which equipment and where this equipment is situated. The equipment approach enables the link between the location of the equipment and type and amount of contained refrigerant. Analysing which (economic) activities entail the application of AC and refrigeration systems also aids the identification of stakeholders to be involved in the data gathering, such as certain industry associations.

The equipment approach can also be used as a basis for conducting a greenhouse gas (GHG) emission inventory, following a Tier 2 approach[2] (IPCC 1997, 2006). More information on developing an inventory of climate relevant gases in the refrigeration and air conditioning sectors can be found in the technical handbook 'NAMAs in the refrigeration, air conditioning and foam sectors' (GIZ, 2014).

The major principles underlying the process for compiling ODS/HFC bank inventories, which are similar to greenhouse gas inventories, are transparency, consistency, comparability, completeness and accuracy (TCCCA). More specifically, all data sources must be referenced and the data must be processed in a stringent and transparent manner. The same holds true when calculating the mitigation potential. Other guidelines might be used as complementary source to develop an ODS/HFC bank inventory, such as the technical guide from UNEP (2013).

Ideally, the data in the inventory should be updated continuously as part of a measurement, reporting and verification (MRV) system in the country. If a country integrates ODS and HFC bank reductions into its Nationally Determined Contributions (NDCs), an update of the data is recommended every 5 years at the latest.

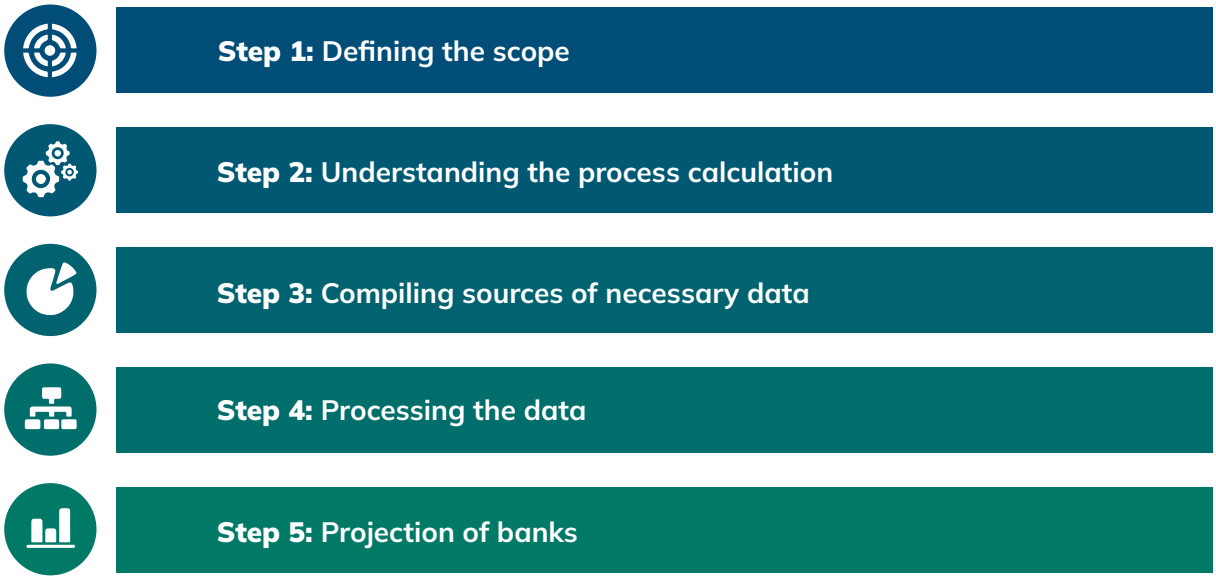
This guide aims to provide practical instructions for deriving an ODS/HFC bank inventory with limited resources. This is particularly important, as the inventory compilation can be a time consuming and complex task, and many countries lack the necessary resources to conduct one. Although funding is currently available from the Multilateral Fund (MLF), it is still wise to effectively use the resources and direct efforts to areas with high mitigation potential.

2 The Tier 2 approach considers detailed equipment data on the subsector level (e.g. domestic refrigeration) and applies manufacturing, operating and end-of-life emission factors to quantify the emissions.

3. EQUIPMENT APPROACH

The equipment approach follows a step-by-step method as illustrated in *Figure 1*. Each step is described in detail to provide practical guidance.

Figure 1: *Overview of the different steps to conduct an ODS and HFC bank inventory*



STEP 1: DEFINING THE SCOPE

ODS/HFCs are mainly used in the refrigeration, air conditioning and foam (RAC&F) subsectors and systems, presented in *Table 1*. Their use as refrigerants and/or blowing agents for the different systems is indicated below.

Inventory compilers should therefore focus on estimating the amount of existing systems in *Table 1*. Each category encompasses appliance systems with similar key characteristics, such as initial charge, typical refrigerants and equipment lifetime.[3]

In order to plan the management of ODS/HFC banks, an important information is to know where the banks are located: Which systems contain large banks (sector distribution) and where are those systems located (spatial distribution). As an example, the scope of a national ODS and HFC banks inventory can be expanded to more detailed assessments for densely populated metropolitan areas with usually high amounts of ODS and HFC banks (more details in *Box 1*).

3 The suggested subsectors and systems are based on the UNEP RTOC report (UNEP, 2011). More information on where these systems are used can be found under *step 3* as well as in UNEP (2013).

Box 1: *Detailed ODS and HFC banks inventories for metropolitan areas*

The amount of ODS/HFC banks per area is usually higher in densely populated metropolitan areas with dense housing, offices as well as commercial and industrial sites. As shorter transportation is required to collect more refrigerants, collection efforts in these areas are lower, mitigation potentials higher and measures to reduce banks are more cost-efficient. When confronted with limited resources or in order to develop cost-efficient measures with high mitigation potential, it is advised to either concentrate or expand inventory efforts to more detailed assessments in such areas. Starting with such area's ODS/HFC bank inventory can also be a way to fast track the planning and implementation of collection and treatment measures in the selected area. In case it is decided to limit the inventory to a selected area - or to conduct a more detailed inventory for a selected area - the same steps apply as for a national inventory. Extra care needs to be taken to clearly define boundaries in terms of geographical and sectoral scope.

When conducting an inventory of a selected metropolitan area, the stock that is attributed to the area needs to be determined. For sales-based calculations, this means the percentage of the national sales that occurs in the specified area. This share can be estimated based on the population residing in the specified area, taking into account that urban population tends to have more disposable income and thus owns more RAC appliances. Also, air-conditioned office buildings are usually located in metropolitan areas. Depending on their common AC system – split ACs or centralized chiller installations, this affects the share of sales.
For stock-based calculations, the analysis needs to focus on where the commercial and industrial sites are located that use RAC systems. For example, food processing and supermarkets tend to be more spread over the whole country than industrial sites.

As the scope of the MLF funding window is limited, the Climate and Ozone Protection Alliance can support countries in expanding the objective of an ODS and HFC banks inventory and action plan by identifying concrete mitigation measures for metropolitan areas.

Table 2: *Important ODS and HFC containing subsectors and systems*

Subsector	Systems	Refrigerant	Foam
Unitary air conditioning	Self-contained air conditioners	x	
	Split residential air conditioners	x	
	Split commercial air conditioners	x	
	Duct split residential air conditioners(*)	x	
	Commercial ducted splits(*)	x	
	Rooftop ducted(*)	x	
	Multi-splits(*)	x	

Subsector	Systems	Refrigerant	Foam
Chillers	Air conditioning chillers(*)	x	
	Process chillers*	x	
Mobile AC	Car air conditioning*	x	
	Large vehicle air conditioning*	x	
Domestic refrigeration	Domestic refrigeration	x	x
Commercial Refrigeration	Stand-alone equipment	x	x
	Condensing units*	x	x
	Centralised systems for supermarkets*	x	x
Industrial Refrigeration	Stand-alone equipment	x	x
	Condensing units*	x	x
	Centralised systems*	x	x
Transport Refrigeration	Refrigerated trucks/trailers*	x	x

* For these systems, we recommend estimating stock figures directly rather than deriving stock figures from sales figures (see *step 2* and *step 3*).

(*) A sales approach is possible for these systems, but experience showed that sales data is difficult to obtain as there is no custom code covering them. Thus, a stock approach can be considered too.

Some sectors, such as the mobile AC and transport refrigeration subsectors are dominated by HFC, which means that they were not routinely covered by HPMP data collection.

STEP 2: UNDERSTANDING THE CALCULATION PROCESS

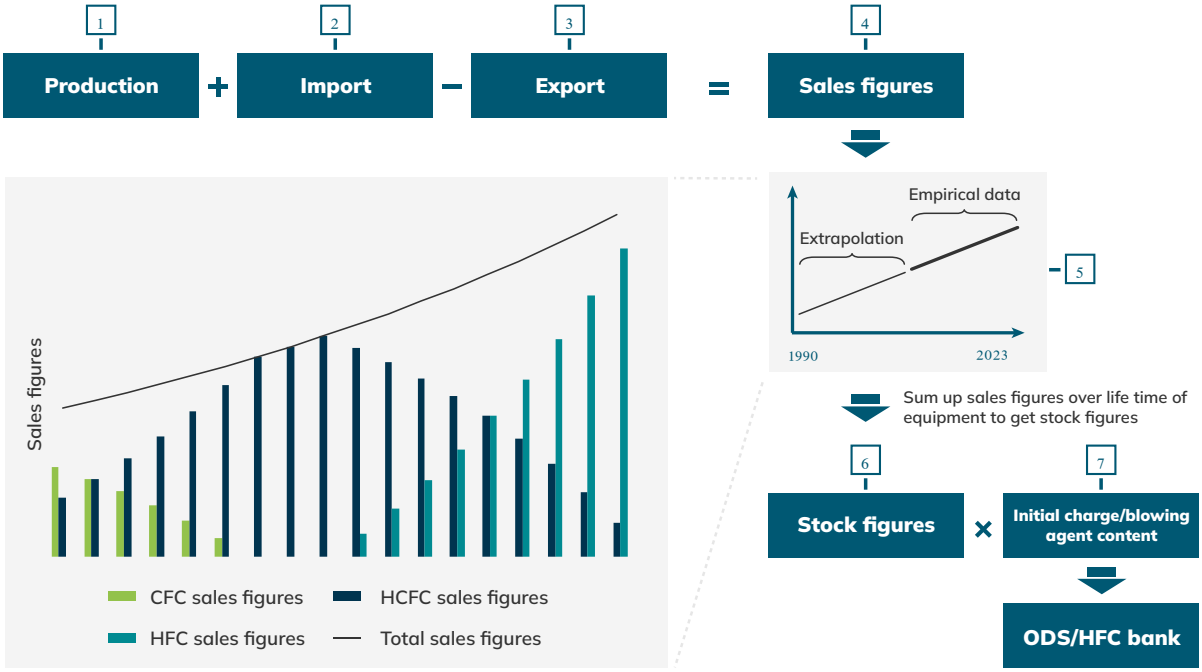
There are two parameters of key importance

1) stock (number of equipment units)
2) share of refrigerant/blowing agent (e.g. 20% of stock has CFC-11 and 80% has HCFC-22)

When both parameters are available, the total amount of ODS/HFC banks in the country can easily be assessed by multiplying the number of equipment units by the average initial charge of refrigerants and the amount of blowing agent respectively. Future bank estimates can also be calculated using sector-specific growth rates.

However, usually there is limited data available for these parameters and they must be derived from other information. This process is illustrated in *Figure 2*.

Figure 2: *Schematic framework to derive stock figures*



Production figures [1] plus **import figures** [2] minus **export figures** [3] will result in **domestic sales figures** [4] of ODS-containing equipment. If sales figures are already known, e.g. from associations which regularly collect and update data, these sales figures can be used directly.

Sales figures should come as a time series, **reaching back as far as possible into the past, but at least 5 years** [5]. The time series is then extrapolated into the past, using either the growth rate derived from the empirical data or from historical gross domestic product (GDP) growth rates. To calculate the stock, sales figures must be extrapolated to cover the average lifetime of the systems. For example, when a system has an average lifetime of 10 years, the sales figures from the last 10 years are needed, because the current stock (year 2023) is derived by summing up these sales figures (from 2014 to 2023). This process is repeated, moving into the past year by year. Thus, summing up the sales figures over the lifetime of the equipment will provide the **stock figures** [6], which is the key parameter for the ODS/HFC bank inventory.

It is imperative to know when CFCs, HCFCs, HFCs or natural refrigerants have been introduced into the different systems. Only with this information will the dynamic phase-in/out process (bar chart in *Figure 2*) be adequately reflected; this also influences the share of ODS, HFC and other substances in the stock.

Multiplying the stock figures with the average **initial charge of refrigerants and amount of blowing agent** respectively [7] will result in the ODS/HFC banks.

For certain types of equipment (indicated by * in *Table 2*), we recommend estimating stock figures directly from appropriate sources rather than deriving the stock figures from sales figures. The reason is that certain ODS and HFC-containing systems (non-appliance sector), e.g. cold rooms or centralised systems used in supermarkets, are not imported as one piece, but rather are assembled on site. Consequently, stock figures are more likely to be available, for example in the form of annual reports from super-

market chains (number of stores with refrigeration system). Other ways of estimating refrigeration capacity and thus equipment stock, are from statistics of annual food production and an empirically derived ratio between the amount of certain food types and required refrigeration capacity (*Box 2*).

Box 2: *ODS and HFC banks in the commercial and industrial refrigeration sector*

In contrast to the appliance sector, the number of refrigeration systems in the commercial and industrial refrigeration sector are sometimes hard to attain because these systems are not industrially mass-manufactured products.

If these data are missing, an alternative approach can be applied:
To quantify the amount of ODS banks in supermarkets, refrigerant ratios need to be determined. In European countries, the typical ratio is 0.19 – 0.23 kg of refrigerant/m². This amount is simply multiplied by the sales area of the supermarket to derive the refrigerant bank figure.

In industrial refrigeration, the amount of produced food and drinks that need cooling must first be quantified. In a second step, the installed cooling capacity per produced tonne (kW/tonne) of food/beverage is identified, e.g. via personal interviews. Note that these values are different depending on the type of food/beverage and should be identified separately.

Next, the amount of refrigerant per installed cooling capacity is determined, which again depends on the temperature level (plus/minus cooling) and the type of refrigeration system (direct/indirect cooling). The amount of refrigerant varies between 2 – 9 kg/kW, with the lowest value found at indirect plus cooling and the highest value at direct minus cooling. Finally, the total installed cooling capacity will be multiplied by the amount of refrigerant per installed cooling capacity to derive the ODS/HFC banks.

In case the inventory is conducted for a metropolitan area, the square meters of supermarkets and the amounts of produced food and drinks need to be determined for the specified metropolitan area. While analysing the output of a certain industry, the information on where production sites are located add an important dimension to the data collection, which is especially relevant when it comes to the planning of collection and treatment infrastructure.

For **ODS/HFC bank management, two other key parameters are of interest**: the amount of ODS/HFC that is

1) **potentially available for management**
2) **effectively available for management**

Whether the ODS/HFC amount is **potentially or effectively available is determined by the recovery rates and the effectiveness of the collection scheme** (recovery/collection rate): only a fraction of the waste stream and available ODS/HFC will be captured by the collection scheme.

To determine the amount of ODS/HFC potentially available for management, inventory compilers can either consider the historical sales figures or the current stock. Which method is chosen mainly depends on the quality of the respective data. If reliable historical records exist, then these should be used. If historical sales figures are available for the past few years only, but a robust stock estimate exists, then stock figures should be used.

To estimate the ODS/HFC amounts from historical sales figures, the average lifetime of the equipment must be determined (e.g. 10 years). The historical

sales figures are extracted, going back 10 years (average life of the equipment). That is, if the current year is 2020, then the sales figure from 2011 represents the current potential waste stream (2020 minus the average lifetime of 10 years). Equipment that was placed on the market at that time will be decommissioned today and is available for ODS/HFC bank management.

To estimate the available waste stream from current stock figures, these stock figures are divided by the average lifetime of the equipment. Both approaches will provide the number of equipment units that are discarded due to end-of-life and are multiplied with the initial charge of the equipment to generate the amount of ODS/HFC potentially available for management.

The effectiveness of the collection scheme[4] determines which part is actually captured. Specifically, the ODS/HFC potentially available for management can be multiplied with a recovery rate to ascertain the ODS/HFC amount effectively available for management. Such recovery rates can be estimated based on historical experience from other (e-) waste sectors, or field studies need to be undertaken to assess current collection practices and amounts reaching collection centers. As this is key information to gather, a specific guidance for analysing waste sources and waste quality is provided in *chapter 5*.

STEP 3: COMPILING SOURCES OF NECESSARY DATA

Generally, **inventory compilers should make use of published statistical data as much as possible**. Therefore, extensive literature research is needed, involving browsing all potential data sources as listed below.

This is considered the most cost-effective approach, as it avoids time consuming interviews or the distribution of questionnaires. However, the quality of the published data must be ensured and, if necessary, experts from the field should be consulted.

If no sales and stock figures are available, inventory compilers must start from scratch using production/import/export figures.

1 Potential data sources for **production figures**:

- manufacturers
- associations
  (e.g. AC or refrigeration association)
- relevant institutes, e.g. industrial institutes, electronic/electric institutes
- Ministry of Industry, Ministry of Economics, Ministry of Trade, Ministry of Transport
- relevant literature (e.g. BSRIA[5], JARN[6] etc.)

2 3 Potential data sources for **import and export figures**:

- importers
- distributors/dealers
- customs department

When inventory compilers are using data from the customs department, they will be confronted with the harmonized system code (HS code). Imported goods are labelled according to the HS code and should be allocated to the above listed categories (*Table 2*).

4 See also Guideline to establish a collection system for ODS containing equipment, GIZ 2016.
5 https://www.bsria.co.uk/ (last access May 2023).
6 https://www.ejarn.com/ (last access May 2023).

4 Potential data sources for **sales figures**:

- national statistical databases
- associations (e.g. AC or refrigeration association)
- relevant institutes, e.g. industrial institutes, electronic/electric institutes
- relevant literature (e.g. BSRIA, JARN etc.)
- reports commissioned by governments/ relevant ministries

6 Potential data sources for **stock figures**:

- reports indicating the average number of equipment units per household
- HPMPs, in particular when significant amounts of ODS are used for servicing of equipment
- for commercial refrigeration[7]: supermarket reports with multiple different stores; reports/associations with various butcher and bakery shops, kiosks, ice cream parlours, restaurants, flower shops, canteen kitchens etc.
- for industrial refrigeration: reports/ associations with multiple slaughter houses, breweries, milk industry establishments, cold stores etc.
- Ministry of Industry, Ministry of Economics, Ministry of Trade, Ministry of Transport
- relevant literature (e.g. BSRIA, JARN etc.)

Sometimes country surveys include data on the average number of appliances per household. Based on this parameter, stock figures can easily be derived by multiplying by the number of households. The number of households is generally known, or can be calculated based on the population[8] and the number of households per 1,000 inhabitants (Ironmonger et al. 2000). Even though the factor might be available, a sound understanding of the sales figures and the associated introduction of ODS/HFC is indispensable to ascertain the above-mentioned refrigerant and blowing agent share of the stock.

7 Potential data sources for **initial charges and blowing agent contents**:

- manufacturers
- product information sheets

As a benchmark, we provide the average initial refrigerant charges together with the average blowing agent content for systems typically found in A5 countries[9], which was compiled for a study by GIZ (2014). Please note that these numbers are indicative only; large variations are observed depending on the design and size of the systems but also on the type of refrigerant and blowing agent respectively.

7 The commercial and industrial refrigeration sectors are complex. Depending on the data availability different approaches can be used; for example, if only the sales area of supermarkets are available, then average refrigerant amounts per sq. m. can be applied.

8 https://globaldatalab.org/areadata/table/hhsize/?levels=1 (last access May 2023).

9 List of Parties categorised as operating under Article 5 paragraph 1 of the Montreal Protocol are considered as developing countries (so-called A5 countries).

Table 3: *Indicative initial refrigerant charge and blowing agent contents of refrigeration and air conditioning systems*[10]

Subsector	Systems	Initial refrigerant charge (kg)*	Blowing agent content (kg)*
Unitary air conditioning	Self-contained air conditioners	0.8	
Unitary air conditioning	Split residential air conditioners	0.25 kg/kW	
Unitary air conditioning	Split commercial air conditioners	0.25 kg/kW	
Unitary air conditioning	Duct split residential air conditioners	5	
Unitary air conditioning	Commercial ducted splits	10	
Unitary air conditioning	Rooftop ducted	10	
Unitary air conditioning	Multi-splits	15	
Chillers	Air conditioning chillers	35	
Chillers	Process chillers	35	
Mobile AC	Car air conditioning	0.6	
Mobile AC	Large vehicle air conditioning	8	
Domestic refrigeration	Domestic refrigeration	0.2	0.8 - 1.5
Commercial Refrigeration	Stand-alone equipment	0.4	~ 1.0
Commercial Refrigeration	Condensing units	4	Largely depends on size
Commercial Refrigeration	Centralised systems for supermarkets	230	Largely depends on size
Industrial Refrigeration	Integral	0.5	~ 1.0
Industrial Refrigeration	Condensing units	5.0	Largely depends on size
Industrial Refrigeration	Centralised systems	500	Largely depends on size
Transport Refrigeration	Refrigerated trucks/trailers	6.5	~ 6

* Please note that these numbers are indicative only; large variations are observed depending on the design and size of the system as well as on the type of refrigerant and blowing agent.

We recommend using a country specific average or, ideally, a weighted average (weighted according to the sales figures of different models). In all cases, data sources and assumptions made should be indicated to provide transparency and comparability.

10 Sources are Schwarz et al 2011, IPCC 2006, as well as expert opinions

STEP 4: PROCESSING THE DATA

There are various software options for processing data, but the most commonly and widely used programme is MS Excel. The steps as defined under *Step 2* should be transferred into MS Excel.

A time series should be established, including the parameters as described under *Step 2*. To reduce complexity, we suggest creating one Excel file for the entire inventory with different sheets for each of the systems. *Table 3* gives an example on how the data can be organised for each of the systems.

The example in *Figure 3* shows historical sales figures of split air conditioners, assuming an initial charge of 1 kg and an average lifetime of 15 years. The recovery rate is estimated to be 5%.

Figure 3: *Sample calculation to determine the ODS/HFC bank, and the amount of ODS/HFC potentially/effectively available for management.*

Year	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
	100	200	300	400	500	600	700	800	900	1,000	1,100	1,200	1,300	1,400	1,500

Stock = $\sum_{i=2009}^{2023}$ = **12.000 units**

ODS/HFC banks = **Stock * initial charge**

= **12.000 units * 1 kg** = **12.000 kg**

ODS/HFC potentially available for management = **Sales figures** $_{i=2009}$ *** initial charge**

= **100 units* 1 kg** = **100 kg**

ODS/HFC effectively available for management = **ODS potentially available for management * recovery rate**

= **100 kg * 5% = 5 kg**

STEP 5: PROJECTION OF FUTURE BANKS

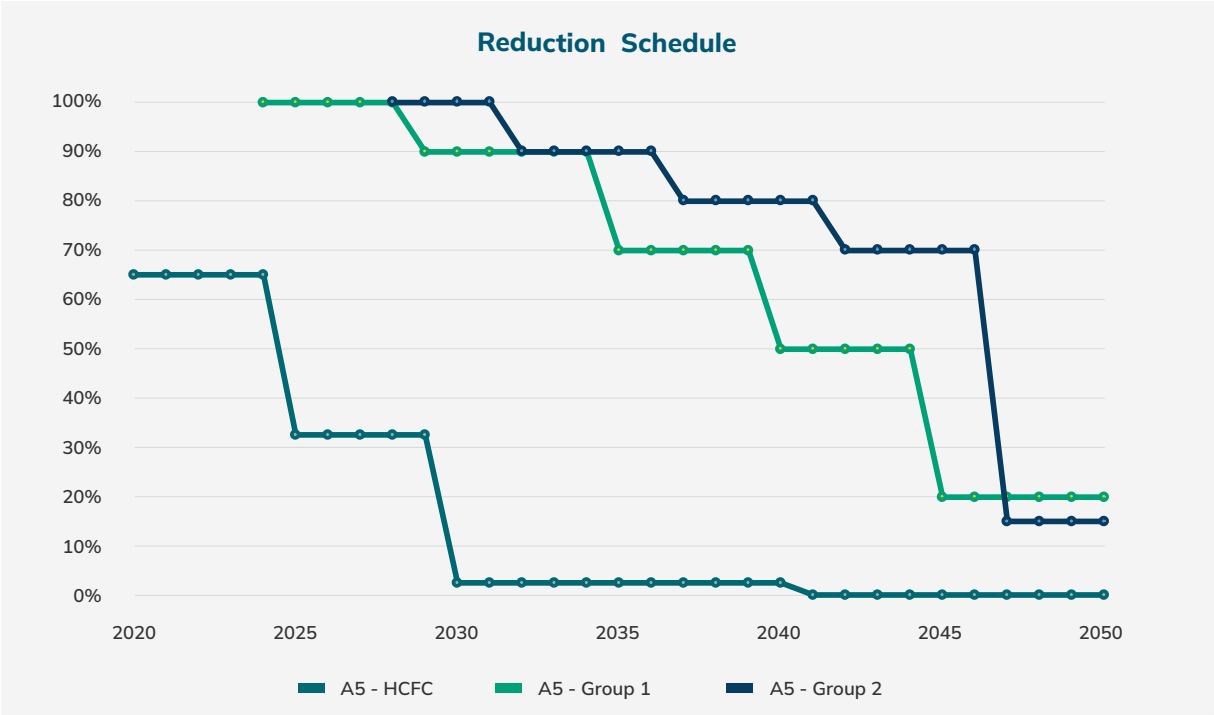
The projection of ODS/HFC banks follows the same logic as in *Step 4*. Instead of using collected data as for past years, expected trends for future sales and stock, as well as refrigerant choice are applied. Those trends can be deducted from historic developments, projected population and trends for the GDP, as well as the expected effect of HPMP and KIP activities on refrigerant choice. The most useful approach is to carry out projections for each type of equipment, and the timeframe for the projection should cover the period up to 2050. There is not one specific method to determine the growth projections of sales and stock. Rather, it is an informed estimated based on the above-mentioned projections and discussion with stakeholders, especially RAC equipment importers and distributors.

Potential data sources for the **projection of population** are the national statistical office or the World Bank DataBank[11], where population time series per country up to 2050 are available.

GDP trends are available again either from national authorities or – up to 2028 - from the International Monetary Fund (IMF)[12]. Longer time frames per country are not easily accessible. The World Bank DataBank offers one-year projections[13]. If required, conservative estimates based on historic time series are advised.

As a reaction to the phase-out and phase-down schedules for ODS and HFC respectively, the **shares of refrigerant** contained in new equipment and, to a limited extent also in existing equipment will move away from ODS and to lower global warming potential (GWP) refrigerants for both HFCs and alternatives to HFCs. As the schedules refer to overall consumption for new equipment and servicing, the shift in new equipment is expected to take place ahead of the reduction steps to allow for a timely shift in servicing demands. The Phase-out and phase-down schedules applying to article 5 countries are shown in *Figure 4*.

Figure 4: *Reduction schedule for HCFCs and HFCS in Article 5 countries*



11 https://databank.worldbank.org/source/population-estimates-and-projections (last access May 2023)
12 https://www.imf.org/external/datamapper/NGDP_RPCH@WEO/OEMDC/ADVEC/WEOWORLD (last access May 2023)
13 https://databank.worldbank.org/source/global-economic-prospects (last access May 2023)

For new equipment, this means that no HCFCs are expected in the future and HFCs need to be shifted to medium and low GWP alternatives within the next years. Initial estimates should be cross-checked with the national KIP, once it is developed.

The calculation of the projection is done by applying the same procedure as developed under *Step 4*, using projected time series as shown in *Figure 5*. The shown formula using a growth factor is one possible method. Others could entail target stock numbers for certain years and interpolation between those years.

Figure 5: *Sample calculation to determine projected ODS/HFC bank, and the amount of ODS/HFC potentially/effectively available for management in the future.*

Year	2023	2024	2025	2030	2035	2040	2045	2050	Estimate sales figures based on estimated annual growth g
Sales	1500	1500*(1+g)	1500*(1+g)^2	1500*(1+g)^7	1500*(1+g)^{12}	1500*(1+g)^{17}	1500*(1+g)^{22}	1500*(1+g)^{27}	
Refrigerant share e.g. R410A in split ACs	80%	65%	50%	5%	0%	0%	0%	0%	Estimate share based on KIP

Apply linear interpolation to estimate annual data points, select suitable time span as developed in step 4

Stock = e.g. in 2030 $\sum_{i=2030-LT}^{2030}$ **Sales figures**

ODS/HFC banks = Stock * initial charge

ODS/HFC potentially available for management = Sales figures $_{i=\text{projection year-LT}}$ *** initial charge**

ODS/HFC effectively available for management = ODS potentially available for management * recovery rate

4. CHEMICAL CONSUMPTION APPROACH

The methodological approach is similar to the equipment approach as presented in *Figure 2*. The main **difference is that now the consumption of chemical substances is considered instead of equipment**. Furthermore, this approach does not allow a detailed sector split, because aggregated consumption on the national level is considered. Consequently, the chemical consumption approach will only provide an initial rough estimate and can be completed as a cross-check to the equipment approach.

The **advantage** of this approach is that inventory compilers can **make use of the widely available consumption data** that has been collected during the RMPs, HPMPs and KIPs.

These generally contain information about:

- past consumption of CFC, often given in ozone depletion potential (ODP) tonnes
- past and current consumption of HCFC (split into refrigerants and blowing agents), often given in ODP tonnes which can easily be converted into metric tonnes using the substance specific ODP values
- sector specific consumption of HCFC (e.g. amount of ODS used in AC, refrigeration, firefighting, aerosol etc.)
- breakdown of ODS according to its use: for manufacturing/installation (initial charge) or servicing (re-fill)

For the inventory, only ODS/HFC for manufacturing or installation of equipment are of importance. Refrigerants used for servicing are replacing refrigerants that have already been emitted into the atmosphere and therefore do not add to the ODS/HFC bank[14]. However, with this approach it is equally essential to attain data about pre-charged imported and exported equipment [2] [3] , because the consumption of ODS/HFC for the manufacturing of equipment will not contribute to the national ODS/HFC bank when the equipment is exported to other countries.

In terms of the time of market entry of specific substances, a calculation can be made to extrapolate the consumption figure – separated by single substances and subsector when information is available – that is similar to the procedure as described in *Figure 2*. The only difference is that ODS/HFC banks are calculated directly and not by the equipment containing them.

This approach appears to be similar to the Tier 1 approach as described in the IPCC guidelines for national GHG inventories (IPCC, 2006). However, the IPCC Tier 1 approach estimates the bank by the accumulation of total consumption, accounting for a 15% loss of the bank each year. We assume that the consumption approach, as described in this guideline, will result in more robust ODS/HFC bank estimates. However, it is important to have a sound understanding of the consumption figure that is used to fill new systems and to refill existing systems.

5. WASTE SOURCES AND WASTE QUALITY

The overall ODS/HFC bank is determined to assess the amount of ODS/HFC potentially requiring treatment currently and in the years to come depending on refrigerant uptake.

For the formulation of suitable policies promoting environmentally sound management of ODS/HFC banks, current practices regarding refrigerant containment and recovery during equipment service and end-of-life need to be studied. Questions to be answered are listed below. If possible, analysis should be per subsector/system type.

Those questions need to be directed to a representative group of RAC technicians, including those working informally, and collection centers. Keep in mind, that refrigerant importers/distributers might have established own collection routes, especially if reclamation is deemed economically viable. If this is the case, include them in your survey.

Questions to RAC technicians

- Do you have the necessary equipment to collect refrigerants?
- What percentage of equipment is serviced using recovery machines to prevent refrigerant leakage during work at the open refrigerant circuit?
- What percentage of the recovered refrigerant is recycled on-site? What equipment is used for refrigerant cleaning prior to the on-site refill?
- What happens to refrigerant that is not recycled on-site?
- What percentage of equipment undergoes refrigerant recovery at decommissioning? What percentage of the initial charge is recovered on average?
- What cylinders are used for this recovery (clean, refillable containers, separate collection of refrigerants)?
- Is all recovered refrigerant delivered to collection centers, or do you store it at your premises? How much is stored at your premises?
- What do you think are the barriers to the collection, recycling and transport of used refrigerants?

14 If the HPMP does not differentiate between consumption for manufacturing and servicing, the equipment approach should be used.

Additional questions for those technicians who do recovery

- Who pays for your extra time that you need for recovery?
- Are your customers aware of the environmental damage for HCFC/HFC? Are they aware of regulations/the venting ban?[15]
- Do you actively sell that extra service?
- Are they willing to pay for refrigerant recovery and treatment?

Questions to collection centers/refrigerant distributors, if applicable

- What is the quality of refrigerant being delivered to collection centers?
- How is the quality of delivered refrigerant tested?
- How is it stored? Are there separate cylinders for each refrigerant?
- Are cylinder cleaning facilities available?
- How much refrigerant is collected per year?
- Is there a treatment facility? Reclamation and/or destruction?
- What is the currently stored amount of refrigerant that require treatment?
- What percentage of the expected waste refrigerant (determined from ODS/HFC bank inventory) reaches collection centers?

Overall recovery rates can be determined based on the collected answers. Information from this survey needs to be considered when defining policy action to improve collection.

6. RESOURCES TO CONDUCT AN ODS/HFC BANK INVENTORY

The following table is based on previous experience of developing ODS banks inventories, strategies and action plans[16] and is intended to give a broad estimate of the required time and effort. The expert days are given in a range, whereby the lower figure refers to smaller countries such as Grenada and the higher figure to more complex countries such as Colombia or Iran.

Table 4: *Resource estimate for inventory work and action plan development*

Items	Expert days	Estimated share of total effort
• **Preliminary desk study on available data and regulatory framework** • **Gap analysis**	4 - 13 days	10%
• **Stakeholder analysis** • **Stakeholder consultation**	2 - 5 days	5%
• **Data collection and survey**	14 – 96 days	35%
• **Development of action plan** • **Draft report** • **Stakeholder consultation** • **Final report**	25 – 110 days	50%

15 Specify according to national regulations

16 ODS/HFC banks inventories, strategies and action plans were developed under the following GIZ Proklima projects
ODS Banks: Colombia, Dominican Republic, Ghana, Iran, Tunisia.
Cool Contributions fighting Climate Change, phase 1 (C4 I): Grenada, Indonesia, Iran, Philippines, Costa Rica, Ghana, Vietnam.
Sustainable and climate-friendly phase-out of ozone-depleting substances (SPODS): Grenada, Colombia.

The MLF funding window provides between $70,000 and $100,000 per country for the implementation of inventories and action plans. The complexity of the country and the level of detail of the assessment will determine whether the funds can cover the scope. Should countries decide to expand the scope and, for example, develop concrete mitigation measures for metropolitan regions or individual sectors, COPA can complement and precede the work funded by the MLF. The experience and lessons learned from metropolitan regions can then feed into the national inventory of ODS/HFC banks and the action plan. With this approach, the overall result will be a more disaggregated stocktake, leading to a more detailed national action plan.

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T +49 6196 - 79 - 0
E *info@giz.de*
I *www.giz.de*

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Authors:
Irene Papst (2023) & Dr. Jonathan Heubes (2017),
HEAT GmbH, Königstein (Germany)

Responsible:
Ellen Michel, COPA Project manager

Acknowledgment for Inputs and Review:
Dr. Johanna Gloël (HEAT GmbH, Königstein)
Franziska Schmittner (GIZ)
Anna Maier (GIZ)
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