Proklima

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Guideline to conduct an ODS bank inventory

Management and destruction of existing ozone depleting substances banks

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Content

Abbreviations

AC	Air Conditioning
CFC	Chlorofluorocarbon
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 Plans
HS code	Harmonized System Code
IPCC	International Panel on Climate Change
NAMA	National Appropriate Mitigation Actions
ODP	Ozone Depletion Potential
ODS	Ozone Depleting Substances
RAC&F	Refrigeration, Air Conditioning and Foam
RMP	Refrigerant Management Plans
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) banks in their country and, based on this, quantifying the mitigation potential. **A sound understanding of ODS banks on the country level is the basis for any action and policy decisions** in the field of ODS bank management. In particular, the inventory is important to:

- assess the general need for action in the field of ODS bank management;
- assess the potential environmental benefits to the ozone layer and the climate;
- decide whether to export ODS or to find a local destruction solution;
- design optimal capacities for destruction technology in case of local destruction options;
- assess long-term availability of ODS to guarantee economic viability of a destruction plant;
- design appropriate policy measures.

A comprehensive overview of ODS banks is still the exception in many countries. ODS 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 can either be quantified in an aggregated manner such as bulk/cylinder (stockpiles), or estimated via ODS-containing equipment. Sometimes countries report on ODS to be stored in cylinders, but this is usually not indicative of the amount of ODS in the country. Please note that **we refer to 'reachable banks'** (TEAP, 2006), i.e. excluding ODS 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 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 hydrofluorocarbons (HFC) 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.

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 will be completed by 2020 in A2 countries and by 2030 in A5 countries. Due to past and current excessive use of ODS, large ODS banks have accumulated worldwide – mainly as refrigerants in equipment and blowing agents in appliance foam. This is also because some ODS-containing appliances have long lifetimes and ODS blowing agents from foam are being disseminated slowly. Therefore, currently used equipment often still contains CFCs (e.g. domestic refrigerators).

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

- **Equipment approach and**
- **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 HCFC Phase-out Management Plans (HPMPs) and CFC Refrigerant Management Plans (RMPs). The equipment approach can also be used as a basis for conducting a greenhouse gas (GHG) emission inventory, following a Tier 2 approach[1] (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 bank inventories[2], 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 bank inventory, such as the technical guide from UNEP (2013).

This guide aims to provide practical instructions for deriving an ODS bank inventory with limited resources.

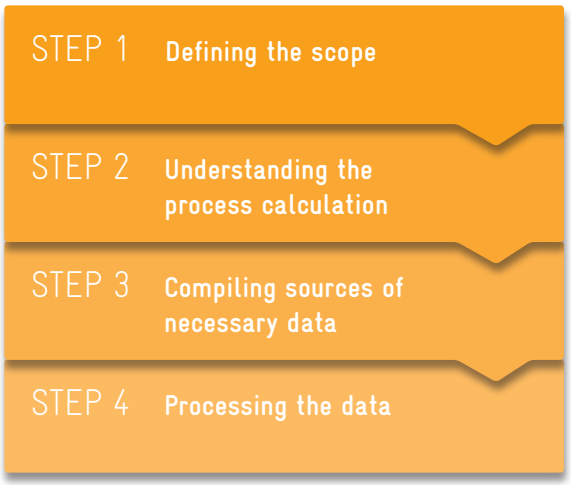
1 The Tier 2 approach considers detailed equipment data on the subsector level (e.g. domestic refrigeration) and applies manufacturing, operating and end-of-life emission factors to quantify the emissions.

2 An ODS bank inventory should include HFC, because these substances are used in the same equipment. Furthermore, both ODS and HFC amounts must be assessed when evaluating management and destruction options. Depending on the technology, ODS and HFC can be processed together. Additionally, it is also valuable to consider HFC in view of the Kigali Amendment to the Montreal Protocol.

2 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 bank inventory.



STEP 1

Defining the scope

ODS 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[3].

In contrast, the mobile AC and transport refrigeration subsectors are dominated by HFC, and hardly any ODS banks will be found in these subsectors. Consequently, other sectors should be given priority when the quantification of ODS banks is of key interest.

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).

Table 1: 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	
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).

STEP 2

Understanding the calculation process

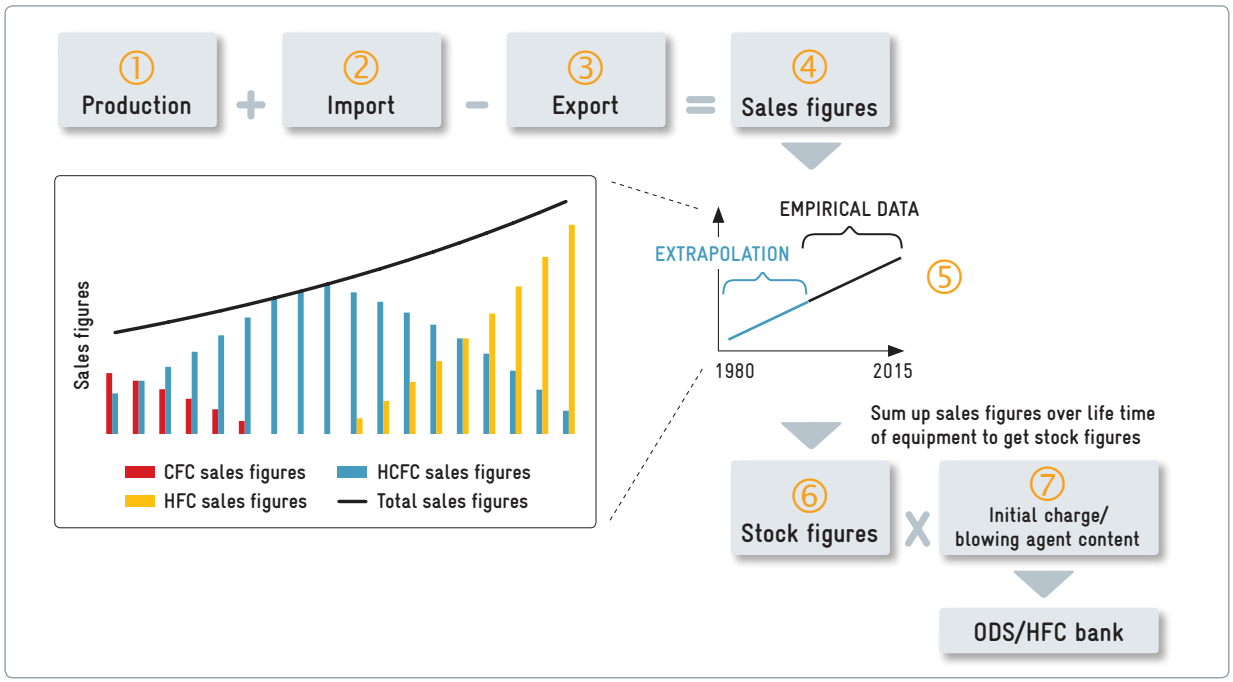
There are two parameters of key importance

- stock (number of equipment units);
- 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 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, which is the key parameter to calculate ODS banks.



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 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 2015) is derived by summing up these sales figures (from 2006 to 2015). 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 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 1), we recommend estimating stock figures directly from appropriate sources rather than deriving the stock figures from sales figures. The reason for this is that certain ODS-containing systems (non-appliance sector), e.g. centralised systems used in supermarkets, do not come from assembly lines but rather are assembled on site. Consequently, stock figures are more likely to be available, for example in the form of annual reports from supermarket chains (number of stores with refrigeration system).

BOX 1

ODS 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 industrial manufactured mass 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/m^2. 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 banks.

For **ODS banks management, two other key parameters are of interest,** the amount of ODS

- **potentially available for management;**
- **effectively available for management.**

Whether the ODS 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 will be captured by the collection scheme.

To determine the amount of ODS 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 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 2015, then the sales figure from 2006 represents the current potential waste stream (2015 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 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 potentially available for management.

The effectiveness of the collection scheme[4] determines which part is actually captured. Specifically, the ODS potentially available for management can be multiplied with a recovery rate to ascertain the ODS amount effectively available for management. Based on historical experience from other (e-)waste sectors, it is possible to define realistic recovery/collection rates using this method.

STEP 3

Compiling sources of necessary data

Generally, **inventory compilers should make use of published statistical data as far 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 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.).

②③

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.

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.

4 See also Guideline to establish a collection system for ODS containing equipment, GIZ 2016.

5 https://www.bsria.co.uk, last access November 2016.

6 https://www.ejarn.com, last access November 2016.

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 slaughtehouses, breweries, milk industry establishments, cold stores etc.;
- Ministry of Industry, Ministry of Economics, Ministry of Trade, Ministry of Transport;
- relevant literature (e.g. BSRIA[8], JARN[9] 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[10] 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:

- manufactures;
- 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[11], 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.

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.

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://www.bsria.co.uk, last access November 2016.

9 https://www.ejarn.com, last access November 2016.

10 https://esa.un.org/wpp, last access November 2016.

11 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 2: Indicative initial refrigerant charge and blowing agent contents of refrigeration and air conditioning systems

SUBSECTOR	SYSTEMS	INITIAL REFRIGERANT CHARGE (kg)*	BLOWING AGENT CONTENT (kg)*
Unitary air conditioning	Self-contained air conditioners	0.8	
	Split residential air conditioners	1.3	
	Split commercial air conditioners	1.8	
	Duct split residential air conditioners	5	
	Commercial ducted splits	10	
	Rooftop ducted	10	
	Multi-splits	15	
Chillers	Air conditioning chillers	35	
	Process chillers	35	
Mobile AC	Car air conditioning	0.6	
	Large vehicle air conditioning	8	
Domestic refrigeration	Domestic refrigeration	0.2	0.8 – 1.5
Commercial Refrigeration	Stand-alone equipment	0.4	~ 1.0
	Condensing units	4	Largely depends on size
	Centralised systems for supermarkets	230	Largely depends on size
Industrial Refrigeration	Integral	0.5	~ 1.0
	Condensing units	5.0	Largely depends on size
	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.

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 2 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 bank, and the amount of ODS potentially/effectively available for management.

YEAR	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
	100	200	300	400	500	600	700	800	900	1,000	1,100	1,200	1,300	1,400	1,500

Stock $= \sum_{i=2001}^{2015} \text{Sales figures}_i$ = 12,000 units

ODS banks = Stock x initial charge
= 12,000 units x 1 kg = 12,000 kg

ODS potentially available for management = Sales figures $_{i=2001}$ x initial charge
= 100 units x 1 kg = 100 kg

ODS effectively vailable for management = ODS potentially available for management x recovery rate
= 100 kg x 5 % = 5 kg

3 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 have been collected during the RMPs and HPMPs. These generally contain information about:

- past consumption of CFC, often given in 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 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 bank[12]. 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 for manufacturing of equipment will not contribute to the national ODS bank when the equipment is exported to other countries.

In terms of the point in time when specific substances entered the market, 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 banks are calculated directly and not by first using equipment.

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 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.

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

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