Measurement, Reporting & Verification (MRV) in practice

A comprehensive handbook for the measurement, reporting, and verification of greenhouse gas emissions in the refrigeration and air-conditioning sector. GIZ Proklima | 2020

giz Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH

On behalf of:

Federal Ministry for the Environment, Nature Conservation and Nuclear Safety

of the Federal Republic of Germany

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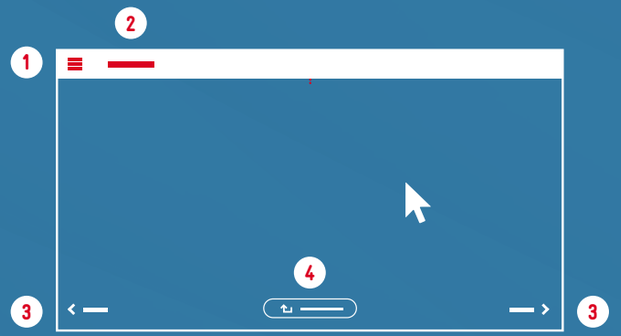
Preface: How does this handbook work?

This handbook is divided into chapters. It is possible in principle to use each chapter independently of the others and jump in at any point – depending on your specific interests and level of expertise.

The chapters are linked to one another, meaning that many parts of the handbook will refer to other sections that fit the topic. Furthermore, this handbook contains links to external websites. It makes sense to be online when you use this document.

External links 1. Link address: https://www.giz.de GIZ

Internal links in the handbook → **Chapter 2**



1.) Menu: takes you directly to the overview page (page 5) of all chapters

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Preface: About this handbook

The following document outlines a blueprint MRV system based on international best practices, which will be applicable for the refrigeration and air conditioning (RAC) sector in each country. The paper provides a practical step-by-step approach for policy makers and enforcement bodies in the RAC sector.

It is also directed at countries who have completed inventories and have recognised the importance of the RAC sector for climate mitigation. The MRV blueprint helps countries to take the next step, by making climate mitigation actions measurable and by improving the granularity of data in the inventories when shifting from the IPCC → **Tier 1** methodology to IPCC → **Tier 2**.

The handbook is divided into the following chapters:

→ **Chapter 1** demonstrates the sector's relevance to greenhouse gas mitigation and highlights the benefits and need for an MRV system in the context of international reporting mechanisms.

→ **Chapter 2** discusses the blueprint design of a RAC MRV. This entails a detailed definition of the scope and an elaboration of the individual components of the blueprint.

→ **Chapter 3** provides a step-by-step guide on how a RAC MRV system can be set-up and implemented. Guiding questions and decision trees were developed to support every step.

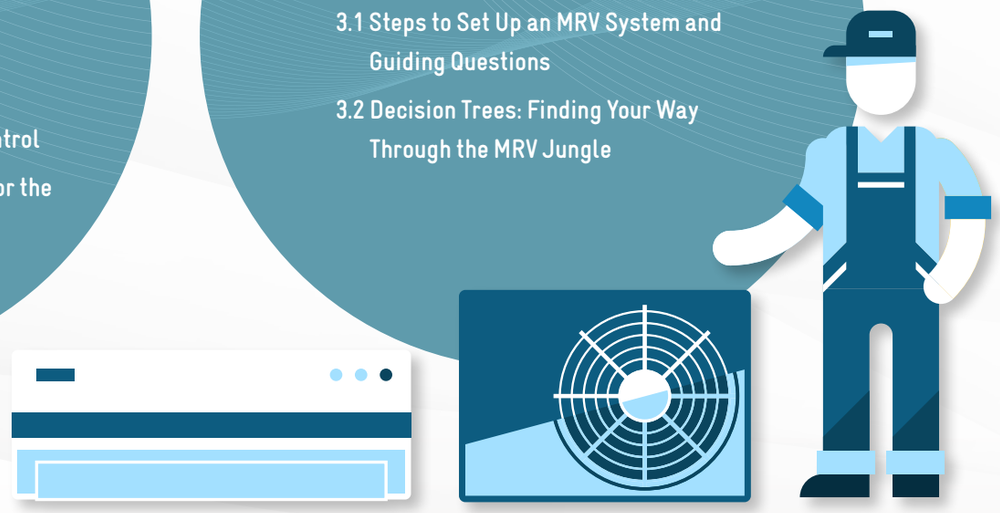
Preface: About this handbook

While elaborating the blueprint, we considered the following elements:

- Relevant activity data and emission sources (including ozone depleting substances) in the RAC sector according to the IPCC → **Tier 1** and → **Tier 2** methodology;
- Montreal Protocol (MP) and UNFCCC (NDC) reporting requirements, optionally cascaded according to different tiers of ambition levels;
- Required political, institutional (human), and technical capacities as well as legal arrangements required to establish and maintain the proposed MRV system.

Contents

Click on the main chapters or individual subtopics to go there directly



Shortcuts

You're in a hurry? Don't worry, we got you. Try taking these shortcuts to make the most of your time:

BEGINNER

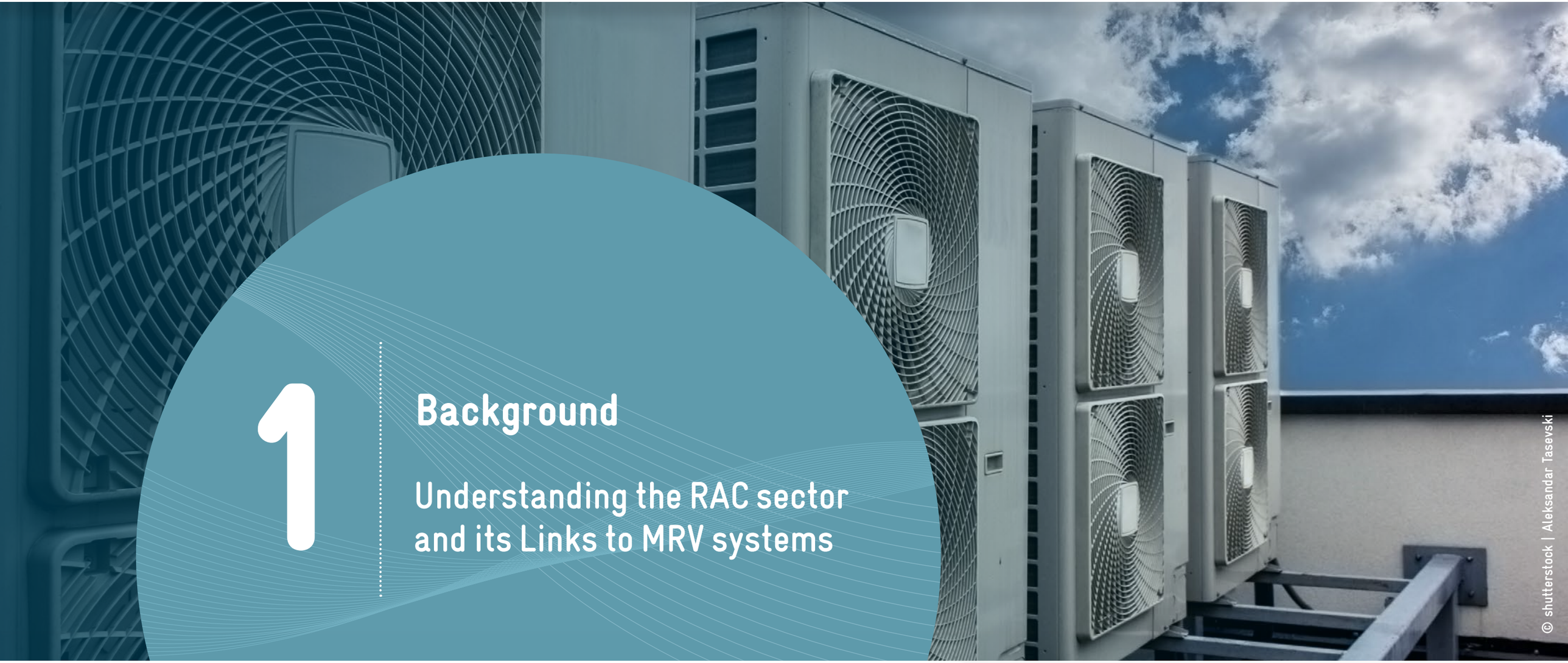
Both the cooling sector and MRV systems are new topics for me. Take me to the beginning.

INTERMEDIATE

I already understand the importance of the cooling sector, but don't have a lot of experience with MRV systems.

PRO

I understand the scope and structure of a RAC MRV system in theory – but I don't know how to put it into practice.



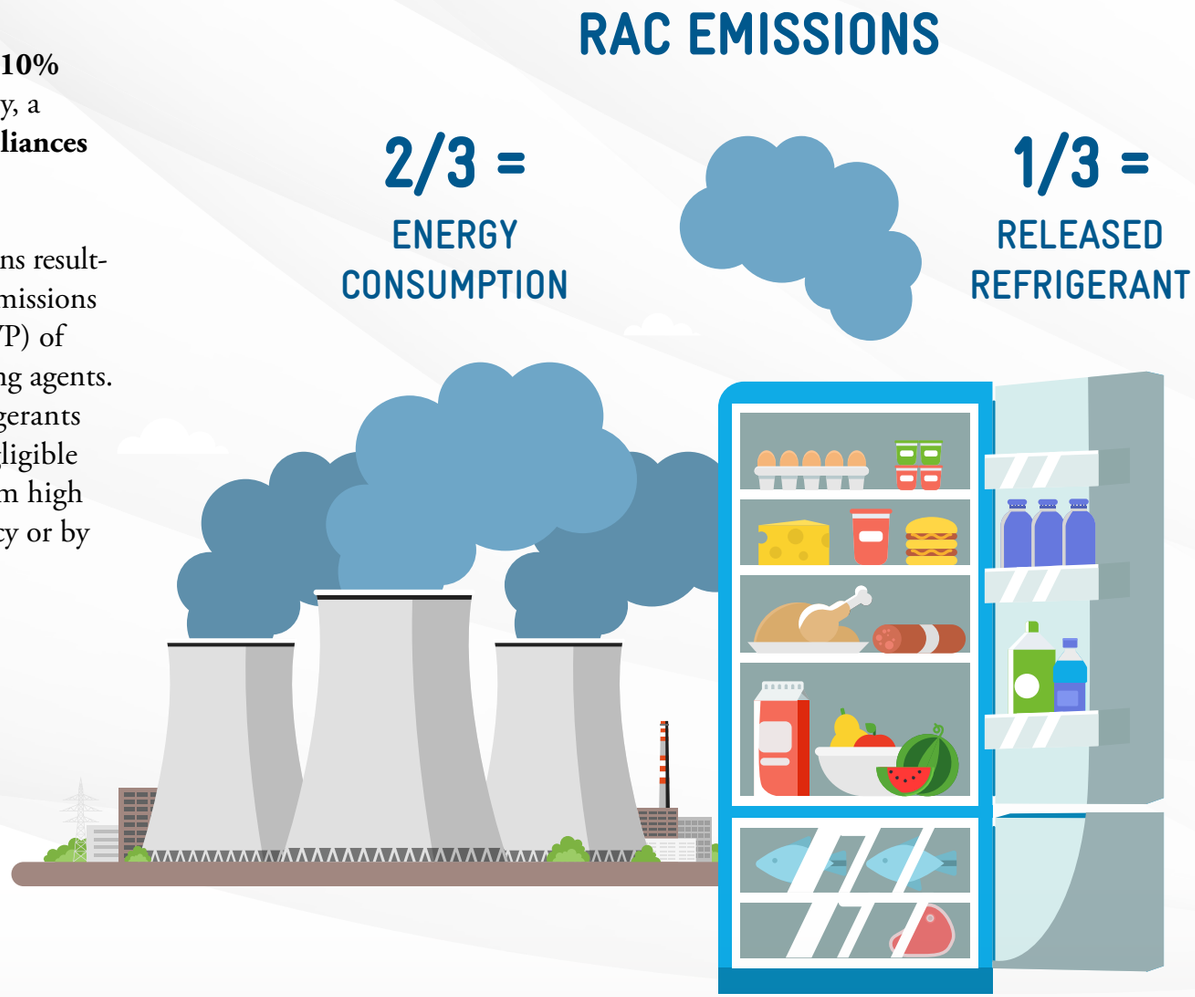
1 Background

Understanding the RAC sector and its Links to MRV systems

1.1 The Growing Demand for Cooling

In 2016, the refrigeration and air conditioning (RAC) sector emitted ca. **10% of global CO_2 emissions** (GCI/World Carbon Atlas, 2016). Additionally, a **200% increase in the market volume of cooling and refrigeration appliances** is projected to take place between 2010 and 2030 (GIZ, 2015).

According to calculations by the Green Cooling Initiative, direct emissions resulting from refrigerant leakage contribute approximately 30% to the total emissions of the RAC sector. This is due to the high global warming potential (GWP) of fluorinated greenhouse gases (F-gases) used as refrigerants or foam blowing agents. Direct emissions can be reduced by replacing F-gases with natural refrigerants (CO_2, ammonia, hydrocarbons, air and water) as they have no or a negligible GWP. The remaining 70% of emissions from the RAC sector result from high energy consumption, which can be reduced by increasing energy efficiency or by decarbonising the energy supply for cooling and refrigeration appliances.



1.2 The Need for Reporting

International reporting on the RAC sector, covering selected activities, is required under the United Nations Framework Convention on Climate Change (UNFCCC) as well as under the Montreal Protocol (MP) and its Kigali Amendment.

UNFCCC

Under the **UNFCCC**, countries, including developing countries (in their Biennial Update Reports), are required to report on their RAC related hydrofluorocarbon (HFC) emissions. These emissions can be calculated based on a → **Tier 1** emission factor approach. Additionally, with the **Paris Agreement**, an enhanced Transparency Framework was agreed. This requires countries to provide for increased accuracy of business-as-usual and mitigation reports. This includes annual Greenhouse Gas (GHG) inventories with a technical review, which are submitted periodically, not less than biennially, and reports on achieving the aims of the Paris Agreement and their national determined contributions (NDCs).

Montreal Protocol and Kigali Amendment

Under the **Montreal Protocol**, countries have to report on their consumption of ozone depleting substances like CFCs and HCFCs. This includes the reporting on bulk HCFC production, imports and exports. Under the **Kigali Amendment**, which came into force on 1st of January 2019, reporting on the CO_2eq consumption of HFC will be required. Similar to the requirements on HCFC under the Montreal Protocol, the reporting requirement is on bulk production, imports and exports. Reporting in pre-charged equipment will not be required. However, using reporting data under the Montreal Protocol on imported bulk data will neither be sufficient nor accurate as the calculation of pre-charged equipment is lacking. Here, the application of the → **Tier 1b** methodology (mass balance approach) will be required, as it specifically accounts for refrigerants that are imported or exported within appliances (GIZ, 2013). A → **Tier 2** approach, breaking down overall RAC sector HFC emissions to an application level is recommended as good practice for the largest emission sources.

Spot the Difference: IPCC Tier 1 and Tier 2 Approaches

Tier 1: Top-down approach looking at the RAC sector as a whole with no further disaggregation. Tier 1 has two emission calculation approaches:

1a) Emissions-based approach:
annual substance sales * composite emission factor + bank of substances * bank emission factor (default: 15%)

1b) Mass balance approach:
annual substance sales - amount of substance filled into new equipment
(1/3 in a mature market) + amount of substance in retiring equipment - amount of substance destroyed

Tier 2: Tier 2 emissions are calculated based on a disaggregated unit-based level, devided into six RAC sub-applications, using country specific RAC sector characteristics:

- Unitary air conditioning
- Mobile air conditioners
- Domestic refrigeration
- Commercial refrigeration
- Industrial refrigeration
- Transport refrigeration

- New appliances
- Appliances in use
- Manufacture emissions
- Service emissions
- EOL emissions

1.3 Scope of an MRV System

A **Measurement Reporting Verification (MRV) system** allows countries to improve their information basis in order to monitor their mitigation actions for national planning, implementation, and coordination.

GHG inventories compile emissions data in a one-off effort. They cannot simply be updated. MRV systems allow emissions to be constantly monitored and therefore provide up-to-date information.

GHG inventories can provide the informational basis for identifying mitigation potentials, planning mitigation actions, and tracking progress towards mitigation goals. However, inventories do not provide information on individual appliances, hence accurate accounting and inventory of HFC emissions is difficult.

An appliance-based HFC inventory and MRV system will not only allow for the accurate accounting and inventory of HFC emissions, but also the tracking of mitigation efforts in the RAC sector, related to refrigerants and energy savings. It will also assist the institutionalisation of the data collection process.

Institutionalisation is the establishment of tools and processes that ensure regular data updates with relatively little effort. Ideally, processes are defined, and responsibilities are distributed, in a way that makes data collection happen automatically with a central institution, to summarise and report sector data.

Once an MRV system for the RAC sector has been established, the RAC sector can be easily integrated into the climate agenda, e.g. through embedding it into a country's NDC, long-term sector strategies, and policy planning and implementation.

Before starting with the MRV, there must be a clear understanding and definition of the subsectors and applications, where HFC emissions occur in the RAC sector ➜ **Page 12**. There is a trade off between the level of information in terms of emissions derived from a detailed categorisation and the associated effort. More sub-sectors represent a higher degree of disaggregation. However, more specific information, such as emission factors, is needed.

Cooling Subsectors

Stationary Air Conditioning

Unitary Air-Conditioning
AC in buildings

Chiller
Central AC for large buildings

Domestic Refrigeration

Domestic Refrigeration
Household refrigerators

Commercial Refrigeration

Centralised Units
Centralises AC & refrigeration systems

Stand alone Units
Foods storesdisplay cabinets, freezers, bottle coolers

Condensing Units
Supermarkets

Mobile AC

Small to Mid-Size Vehicles
AC in cars

Large Vehicles
AC in buses

Transport Refrigeration

Trucks, Trains, Containers, Vessels

Industrial Refrigeration

Centralised systems / Stand alone units / Condensing units / Process chillers
Food processing, industrial processes

1.4 Benefits of an MRV System

An MRV system in the RAC sector can combine various objectives:

- It enables the assessment of progress towards mitigation commitments (e.g. under the Paris Agreement/Enhanced Transparency Framework and the Montreal Protocol/Kigali Amendment).
- Rigorous and easily verifiable data allows countries to tap into international finance for technology and capacity building support as a robust MRV is often a prerequisite for accessing international finance flows.
- The development of an MRV system can catalyse the coordination between different institutions within a country and facilitate information sharing on mitigation efforts, thereby also enabling targeted policy making and assessing its effectiveness.

Stakeholders	Associated benefits
Importers, retailers, manufacturers, consumers	• Provide relevant information (e.g. GHG calculators) for businesses who report their activity data • Provide market overview (e.g. sales trends, average MEPS, etc.) • Improved knowledge of type of products in markets
Climate department/ institution UNFCCC	• Inform and comply with several international reporting obligations at once (NDCs, NAMAs, National Communications, GHG Inventories, MRV for climate financing etc.)
National Ozone Unit, Montreal Protocol	• Enhance national capacities (e.g. data collection systems, data quality, etc.) • Monitor the progress of continuous data collection • If applicable: improve granularity of inventory by moving from IPCC Tier 1 to IPCC Tier 2 methodology
National entity (Energy & Environment Ministries)	• Enhance national reporting • Increase political buy-in for climate issues • Provide coherent data for national policy making (identification and prioritisation of mitigation efforts) • Regular update of label classes and Minimum Performance Standards (MEPS) • Measure effectiveness of policy actions

1.5 International MRV Framework

The aim of national inventories is to quantify GHG emissions. All Parties to the UNFCCC must submit national reports to the UNFCCC secretariat. However, contents and timetables differ between Annex I (developed countries) and non-Annex I (developing countries). National inventories give a comprehensive overview of current emission patterns.

When speaking about MRV at the domestic level, a broader definition of MRV is often used, which goes beyond the scope of the UNFCCC requirements. This definition considers any kind of data collection, management, review and reporting related to climate change mitigation requirements to be part of the MRV.

Three categories of domestic MRV processes and structures can be broadly derived from UNFCCC requirements:

1. MRV of emissions

2. MRV of mitigation actions

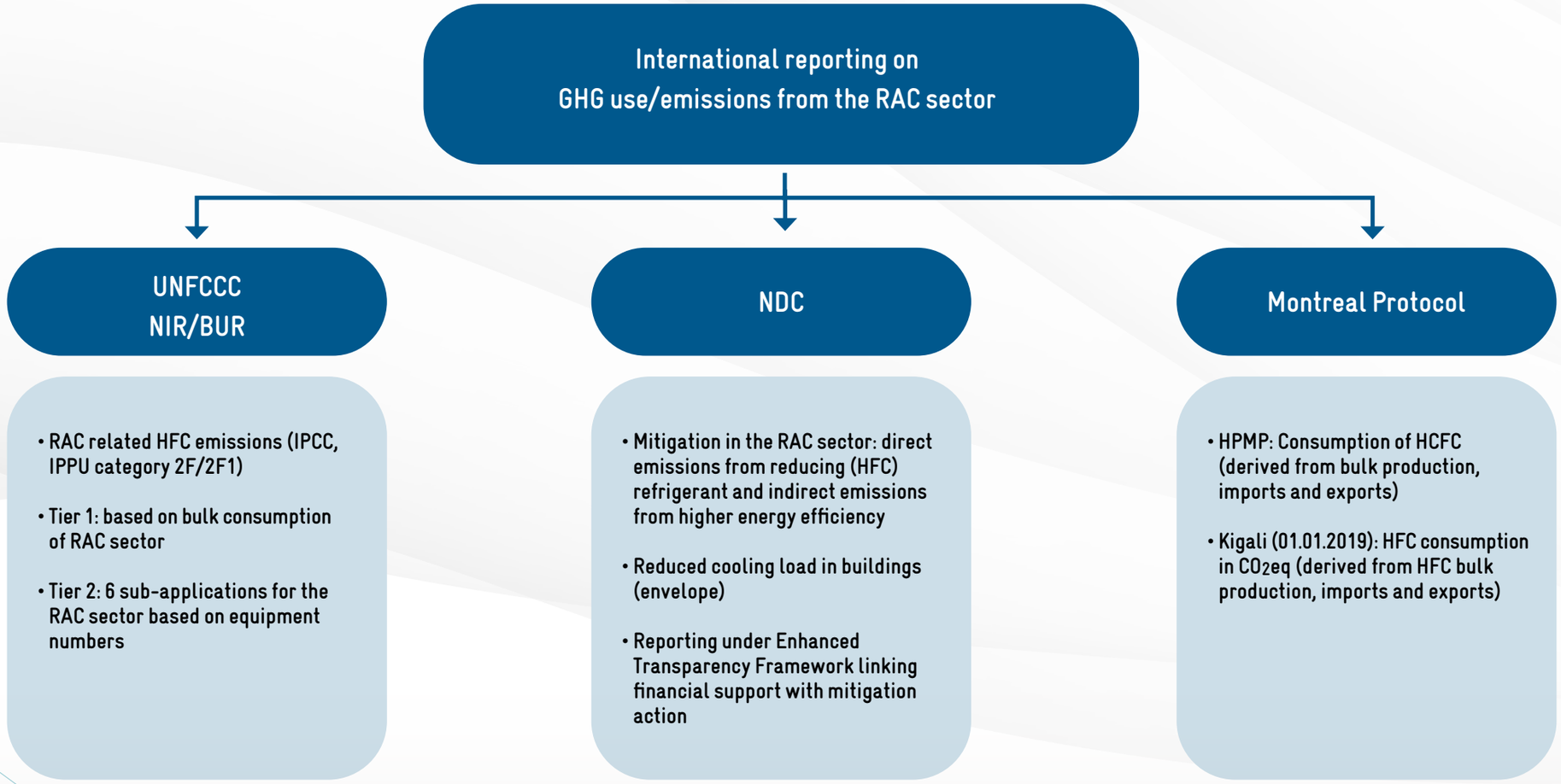
3. MRV of support (for climate finance, capacity building, or technology transfer and cooperation)

Linking the UNFCCC and the Montreal Protocol reporting

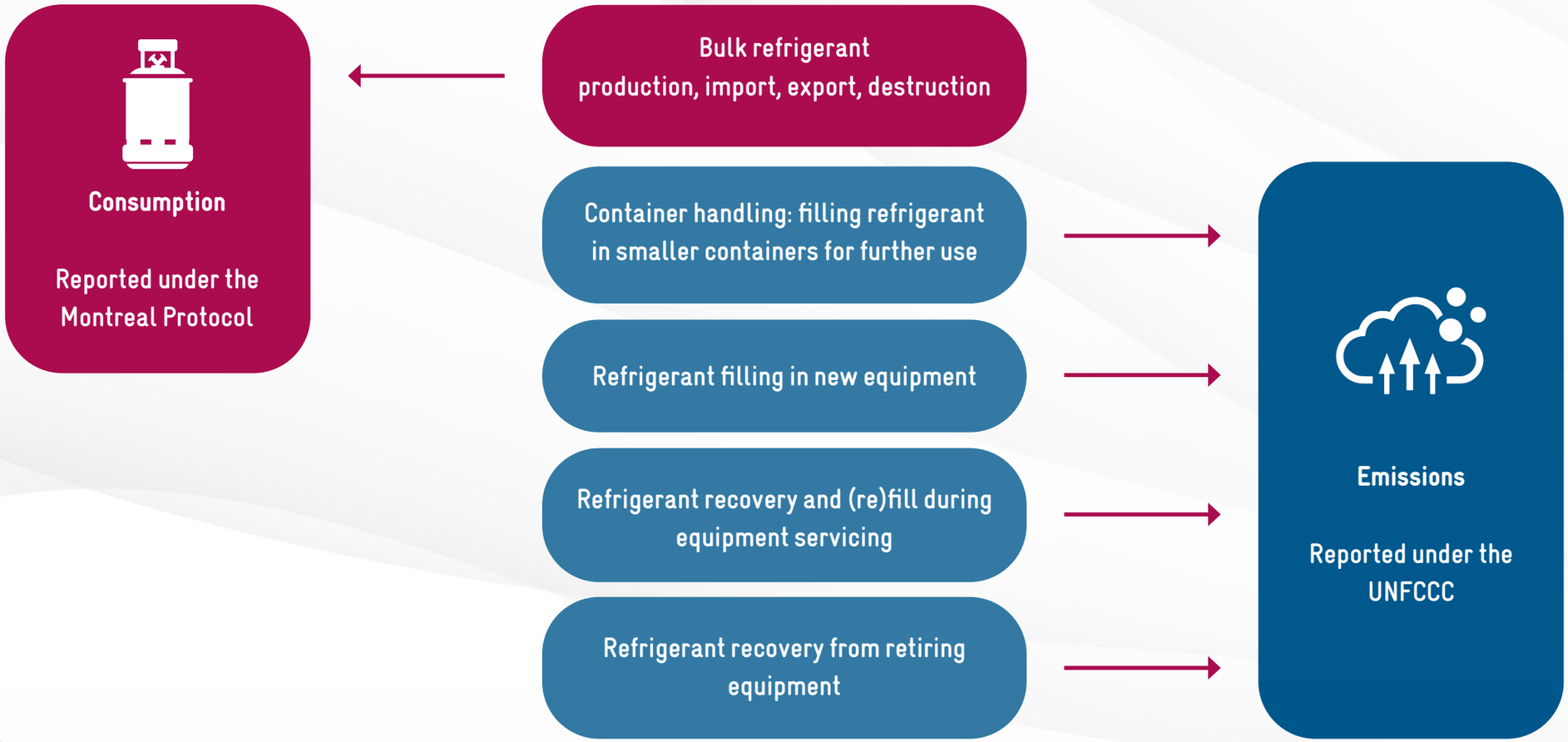
The unique feature about the MRV blueprint is that it combines GHG inventories from the RAC sector with a product database. Therewith, the RAC-MRV can be integrated into existing international Ozone Depleting Substances (ODS)/GHG reporting under the UNFCCC, the NDC and the Montreal Protocol. The RAC MRV thereby links the Montreal Protocol and the UNFCCC reporting.

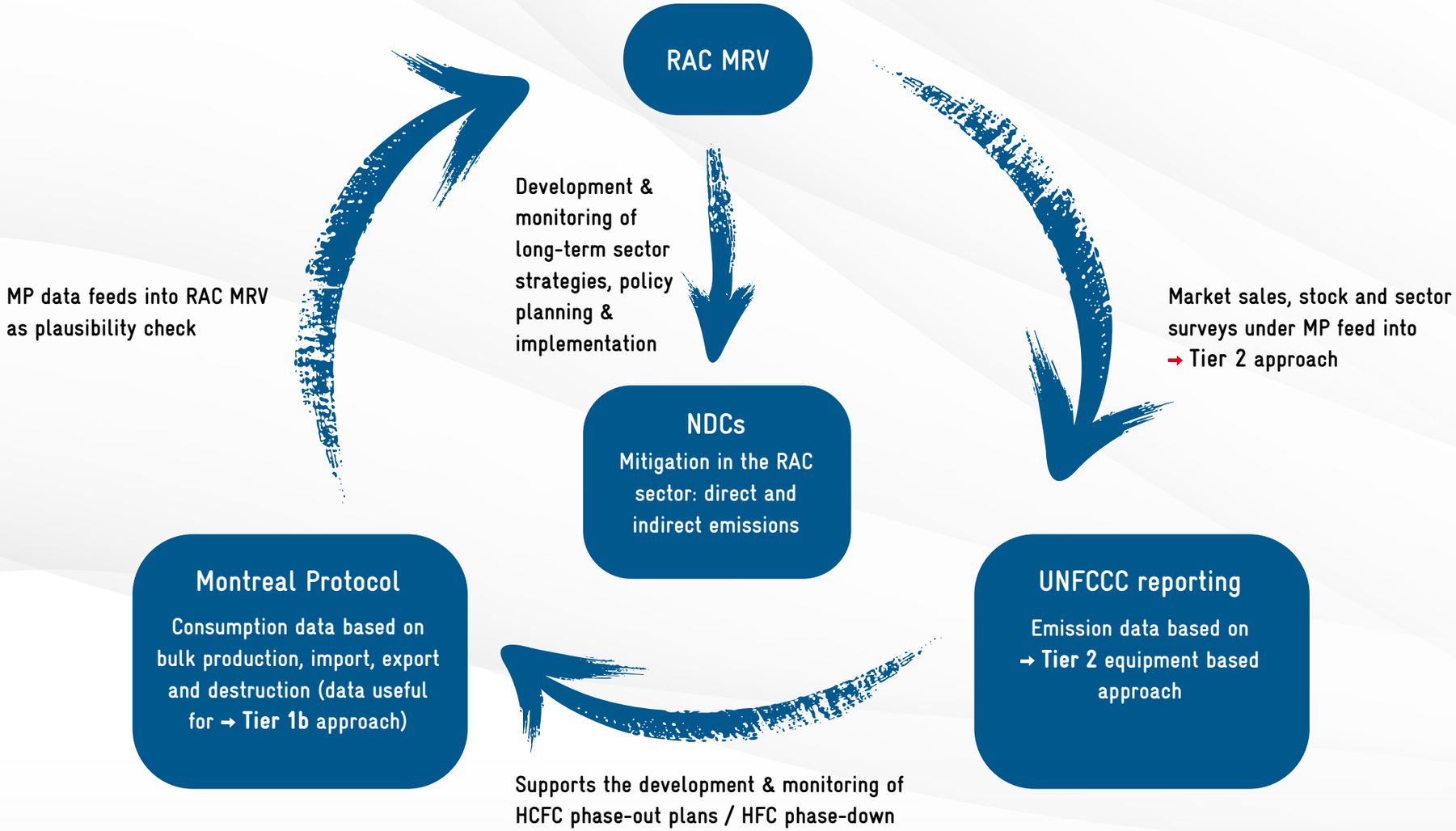
While for the UNFCCC reporting, it is recommended that emission data is calculated based on a continuous → **Tier 2** activity data reporting; consumption data collected under the Montreal Protocol reporting obligations based on bulk production and import, export, and destruction feeds into the RAC MRV as plausibility check. The data used for the UNFCCC reporting can support the development and monitoring of HCFC phase-out and HFC phase-down plans.

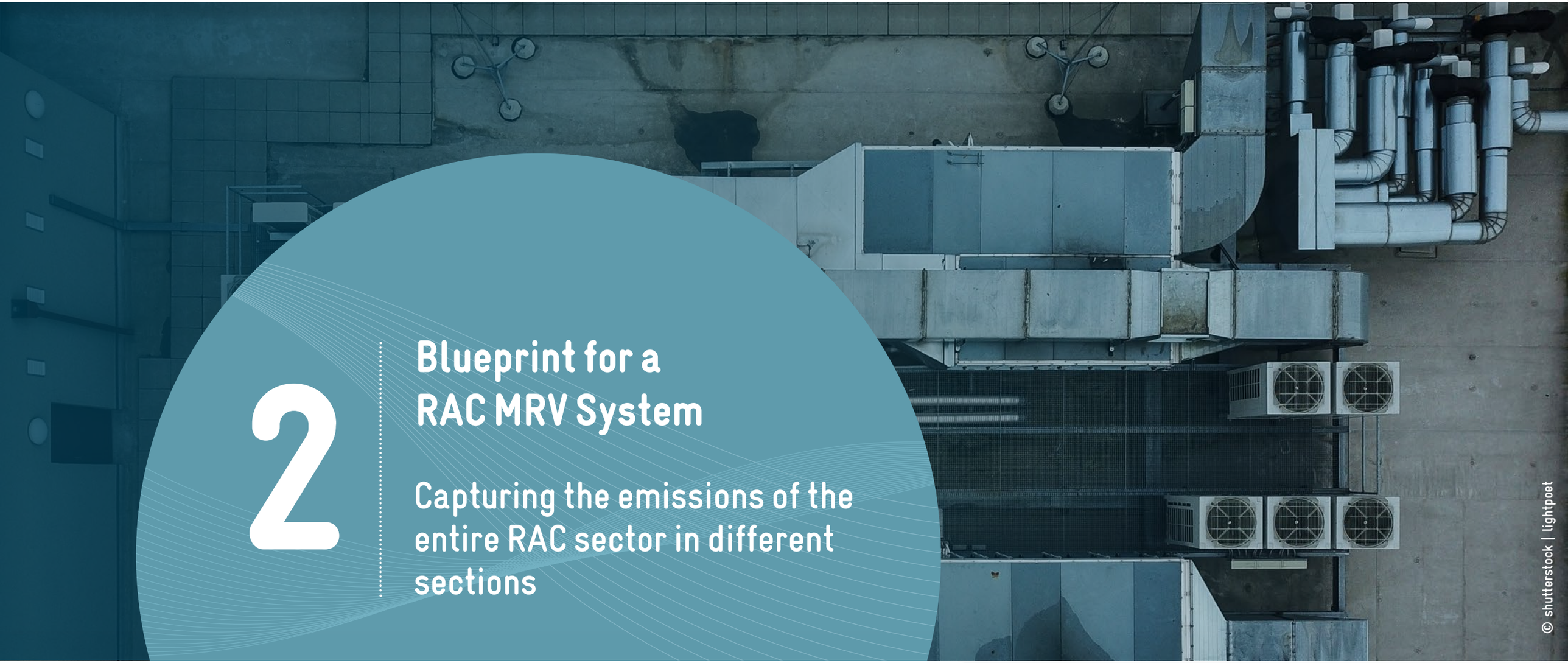
A RAC-MRV needs to be integrated into existing international ODS/GHG reporting



Reporting of Refrigerant Consumption vs. Emission




RAC MRV
Development & monitoring of long-term sector strategies, policy planning & implementation
NDCs
Mitigation in the RAC sector: direct and indirect emissions
Market sales, stock and sector surveys under MP feed into
→ Tier 2 approach
UNFCCC reporting
Emission data based on
→ Tier 2 equipment based approach
Supports the development & monitoring of HCFC phase-out plans / HFC phase-down
Montreal Protocol
Consumption data based on bulk production, import, export and destruction (data useful for → Tier 1b approach)
MP data feeds into RAC MRV as plausibility check



2 Blueprint for a RAC MRV System

Capturing the emissions of the entire RAC sector in different sections

2.1 Scope of the Blueprint

The MRV blueprint covers emissions from the "functional unit" providing air conditioning and refrigeration. It provides the data set needed to calculate emissions from container handling arising from filling refrigerant in smaller containers for further use, refrigerant filling in new equipment, refrigerant recovery and (re)fill during equipment servicing as well as refrigerant recovery from retiring equipment. Those emissions are all reported emissions under the UNFCCC.

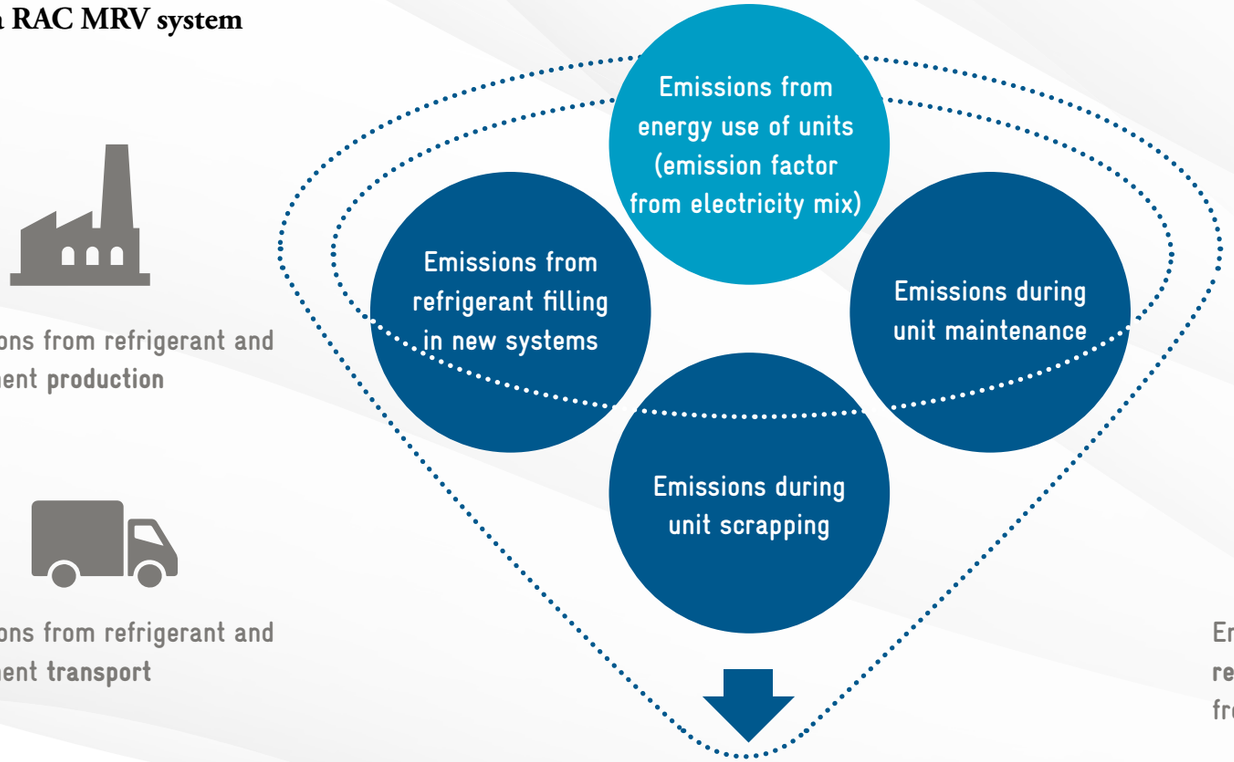
The blueprint comprehensively captures the emissions of the entire RAC sector, as under the UNFCCC, energy-related as well as F-Gas emissions are reported in different sections. This comprehensive overview is crucial for targeted mitigation pathways in the sector.

Despite the importance of cutting down increasing F-gas emissions in many countries, relevant emissions data is often not available. For the purpose of conducting inventories and quantifying emissions, the Intergovernmental Panel on Climate Change (IPCC) has published two versions of the Guidelines for National Greenhouse Gas Inventories (1996, 2006).

The methodologies described by the IPCC follow a tiered approach, where → **Tier 1** denotes the most aggregated, top-down approach using mainly national refrigerant sales data and generic emission factors as default values. It therefore provides little information on actual country specific RAC sector characteristics and no information on sub-application distribution of equipment.

The → **Tier 2** approach goes into more detail to calculate the emissions. In the RAC sector, this approach often relies on quantifying the stock of appliances which use F-gases, i.e. mainly HFCs, to estimate the demand and emissions. This can take the form of counting equipment sales/stock per sub-application, assessing the refrigeration use per sub-application, and adjusting emission factors. It therefore provides detailed information on actual country specific RAC sector characteristics.

System boundaries of a RAC MRV system



Emissions from refrigerant and equipment **production**

Emissions from refrigerant and equipment **transport**

Emissions from **equipment recycling** at waste facility and from refrigerant **destruction**

Emissions from „functional unit" providing air conditioning and refrigeration

- direct emissions
- indirect emissions
- emissions from refrigerant and equipment production, transport and recycling/destruction are not covered under the RAC MRV system

The MRV blueprint aims to set up a continuous monitoring scheme, combining different approaches for different applications. For standardised products, it proposes to count the sales via a product database and/or to estimate the stock via a statistical approach. For custom-made products, the stock can be similarly estimated via a statistical approach or counted via an operators' registration system. The attribution of applications to those two product groups is shown in the table on this page.

A number of model parameters is needed to calculate emissions from sales and stock numbers. The accuracy of calculated emissions benefits greatly from nationally specified parameters, such as equipment lifetime and refrigerant emission factors. The grid emission factor and GWP values are assumed to be updated from sources outside of the MRV blueprint. The final aim is to calculate the refrigerant emissions and the energy related emission of the RAC sector based on an equipment stock model.

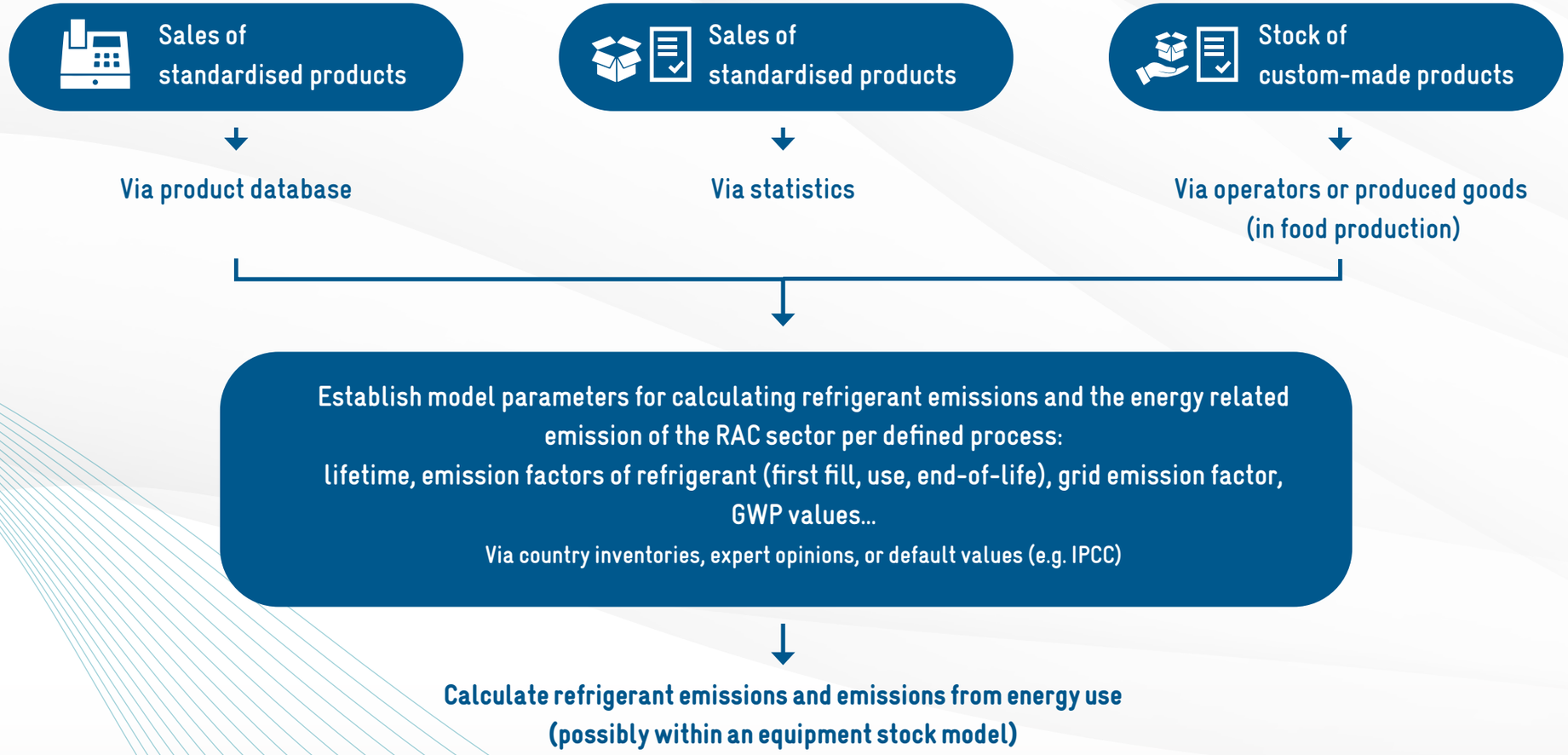
For further details about this topic, refer to **IGES List of Grid Emission Factors (2019)** and on GWP of Refrigerants refer to **IPCC(2018): Anthropogenic and Natural Radiative Forcing**.

Further information on the equipment stock model is provided in the **NAMA Handbook, Module 1**.

Standardised products (preferably in product registration database)	Custom-made products (preferably via operator registration)
Commercial and stand-alone units (e.g. bottle coolers, ice-cream cabinets)	Commercial condensing units (e.g. cold rooms) Centralised supermarket systems
Refrigerators and freezers	Industrial integral systems Industrial condensing units Industrial centralised systems
Refrigerated trucks	Refrigerated trucks
ACs in cars	ACs in larger vehicles
Self-contained (portable) ACs (Single) split ACs	Ducted ACs Rooftop (packaged) systems Multi-split and variable refrigerant flow (VRF) systems Chiller

Overview on standardised and custom-made applications

MRV of data to calculate the refrigerant emissions and the energy related emissions of the RAC sector



Data Collection Timeframes

Annual Data	Five-yearly Collected Data
• Bulk refrigerant: production import, export, and destruction • Refrigerant in pre-charged equipment imported and exported • Sales of mass-produced equipment • Features of solid equipment collected in a product database (refrigerant, initial charge, energy efficiency, label class, price) • Stock of equipment • Features of equipment in use (for custom-made equipment, if possible: refrigerant refill, energy consumption) • Refrigerant amounts collected for recycling, reclamation, or destruction	• Emission factors for refrigerants during manufacturing, service, and at decommissioning • Product lifetime • Runtime

Not all data for the MRV needs to be collected annually, as some data does not change very quickly. It can be updated in longer intervals. A timeframe of three to five years seems reasonable for reviewing the continued applicability of the current emission factors, product lifetime, and average equipment runtime hours.

2.2 Components of the MRV System

HFCs are used as refrigerants in many types of RAC equipment. The applications need to be grouped to facilitate the calculation and reporting procedures. Data collection for the different systems is based on the previously introduced → **Tier 2 method**. This approach uses information on the number of appliances that contain HFC as well as other parameters such as emission factors, lifetimes etc.

In addition to clear responsibilities of the MRV, procedures need to be established. In absence of defined rules for the verification of sectoral inventories and mitigation action, the blueprint will refer to general principles for verification and provide guidance for internal verification routines such as four eyes principle and data management. Future requirements might include third-party verification, e.g. of reported product sales or the equipments' energy efficiency. Reasons for monitoring, what needs to be monitored, data collection options and responsibilities will be outlined in the following sections for the different product groups that need to be monitored and reported.

Jump directly to the different components:

→ Overview of all Components

→ Import, Production, and Export of Refrigerants

→ Sales of Standardised Mass-produced Systems

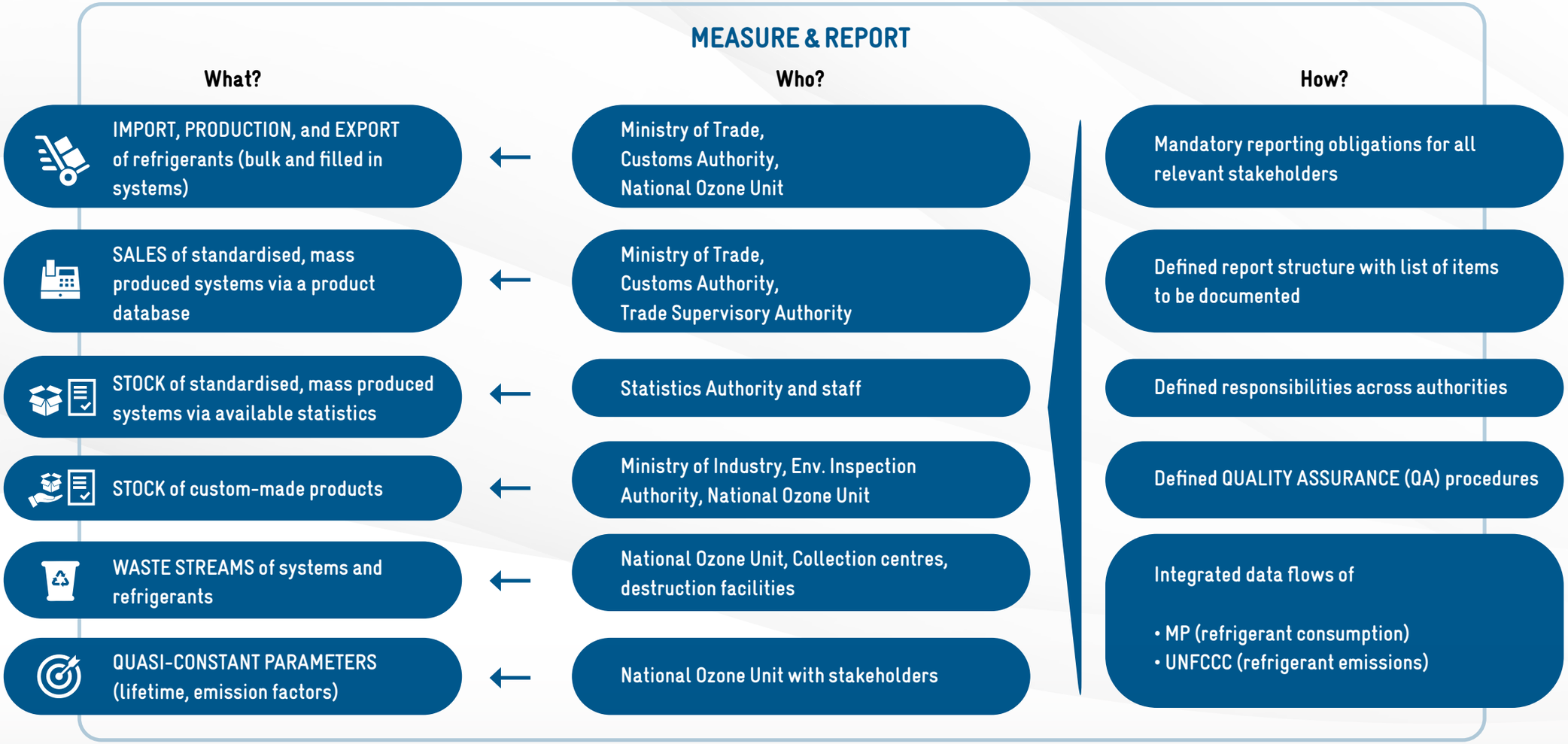
→ Stock of Standardised, Mass-produced Systems

→ Stock of Custom-made Products

→ Waste Streams of Systems and Refrigerants

→ Quasi-constant Parameters

Overview: Blueprint for an MRV system in the RAC sector



2.2.1 Import, Production, and Export of Refrigerants

According to **Article 7 of the Montreal Protocol**, countries shall provide data on their production, imports and exports of refrigerants. This is done to deduct the national consumption, according to the formula:

IMPORT + PRODUCTION – EXPORT = CONSUMPTION

The MRV blueprint is based on this basic dataset, which all countries already have and update annually. The assessment of import, production and export provides a top-down assessment of the RAC sector. It also enables for a cross-check of data which will be collected at product-specific levels.

It is important to keep in mind that reporting under Article 7 refers to all ODS and HFCs consumed in a country including the RAC sector as well as foam, fire protection, aerosols and medical aerosols. Usually the RAC sector is by far the largest sector, covering 80% and more of the consumption. It is expected that the proportion of the RAC sector will be even higher with the implementation of the Kigali Amendment, as other sectors might shift to alternatives ahead of the RAC sector.

In addition to the parameters of annual tonnes of refrigerant per substance in bulk, which is reported under the Montreal Protocol and its Kigali Amendment, pre-charged equipment (such as split ACs and fridges) should be reported, to be able to draw a complete picture of the refrigerant containing equipment in a country. The definition of consumption under the Montreal Protocol disregards this aspect, e.g. the refrigerant contained in split AC units manufactured in China and being exported are counted as Chinese consumption. However, emissions during equipment use are occurring in the country where the equipment was exported to. The European F-Gas Directive is already including pre-charged equipment under its quota system, where importers of pre-charged equipment are to acquire an allowance for this import.

2.2.1 Import, Production, and Export of Refrigerants

In most countries, customs departments have already established processes to report ODS bulks. With the Kigali Amendment, this is currently being expanded to cover HFCs. In order to also report on pre-charged equipment, customs departments will most likely need to develop sub-customs codes for the type of refrigerant as well as charging level/content. In practice, this will also require the importing agent to show a certificate with the total amount charged for all imported products together.

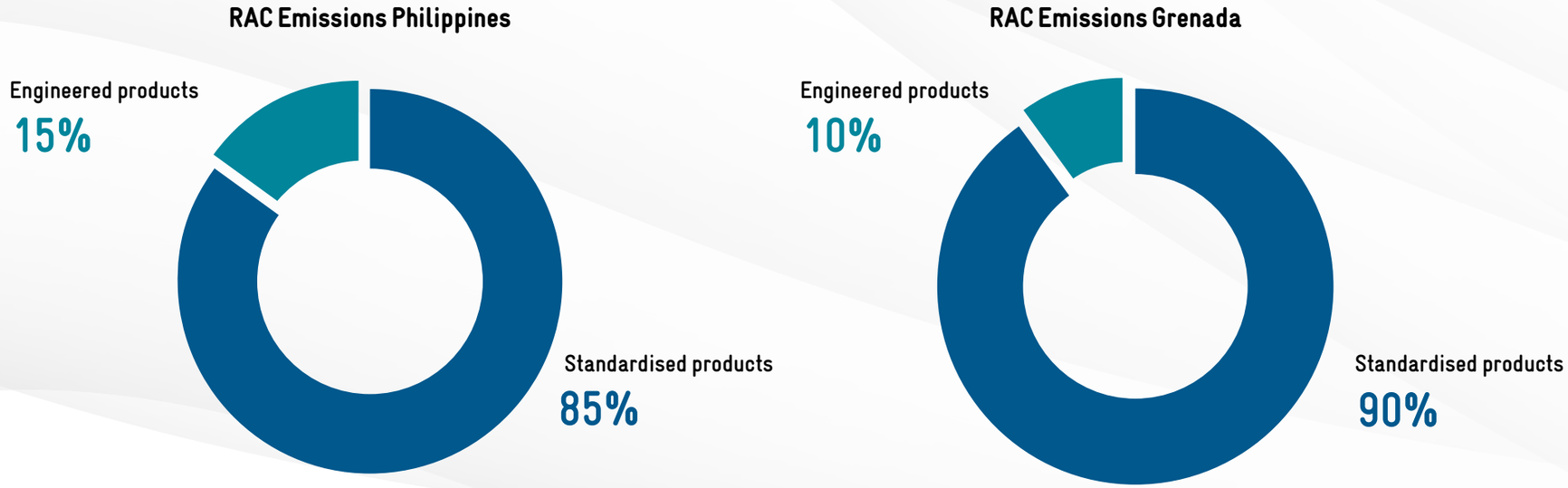
In terms of responsible agents, in addition to the customs departments, the Ministry of Trade as well as the National Ozone Units (NOU) should be involved in the process. The NOUs have a very deep and invaluable knowledge about the RAC sector.

Overview: Import, Production, and Export of Refrigerants

What to monitor?	Parameters to monitor?	How to monitor?	Who monitors?
Amounts of ODS and HFC imported, produced, exported or destroyed	Annual tonnes of refrigerant per substance in bulk Annual tonnes of refrigerant per substance filled in imported/exported equipment	Data collection of:import + production – export = consumption HFCs should be included starting in 2019 Extension necessary to include refrigerant amounts in pre-charged equipment	Ministry of Trade and Customs Authority, National Ozone Unit

2.2.2 Sales of Standardised, Mass-produced Systems

The recording of sales of standardised, mass-produced systems represents a central point of the MRV blueprint. This data is relatively easy to record. Mass-produced systems are often the main users of F-gases with a large share of the total energy consumption.



Share of different appliance groups of total RAC emissions in the Philippines and Grenada.

Sources: GHG Inventory for the RAC Sector in the Philippines (2019); GHG Inventory for the RAC Sector in Grenada (2020)

2.2.2 Sales of Standardised, Mass-produced Systems

Some countries have already implemented product databases. These include countries such as Australia, New Zealand, Korea, Ghana and China, to name a few. Further details about this can be found in → **Chapter 2.4**.

Ultimately, a product database monitors which appliances are sold in their markets to ensure compliance with national policies and reduce barriers to trade, as well as compliance complexity for importers and manufacturers. Each manufacturer and importer needs to register the model they want to sell in the country. The conformity to national regulations on energy efficiency or refrigerant use is checked upon registration. After successful registration, the number of units sold is reported by the manufacturers and importers on an annual basis.

In the product database, as part of the MRV, the national sales of all uniform RAC appliances can be recorded. The aim for each country should be to record as many appliances as possible. Nevertheless, a prioritisation is possible.

We recommend starting with split ACs and fridges, which are usually the largest groups, and expand to other appliance groups in a second step. While recording appliances, it is very important to make a differentiation between imported appliances and locally produced ones. If this distinction is made, targeted policy interventions are possible. This will, for example, allow to set MEPS and labels appropriately to national circumstances and provide support to the local manufacturers to reach the standards.

The parameters that have to be reported shall give a comprehensive view of the RAC sector in the country and allow for the assessment of the refrigerant consumption and energy efficiency of all appliances. As the effort to record further parameters per appliance is limited, once the appliance is registered, we recommend recording as many parameters as possible at the point of product registration.

2.2.2 Sales of Standardised, Mass-produced Systems

Recording the appliances will be closely linked to Step 1 as described in → **Chapter 2.2.1**, as mass products are generally pre-charged. The recording of refrigerant quantities in pre-charged equipment as required in Step 1, can thus be combined with the recording within the product database. In order to do the reporting, producers and customs will need to receive reporting obligations. These will, for example, contain information on the type of fridge, its energy efficiency, its energy label as well as the type and charge of the refrigerant. For imported products, producers will be able to complete the registration for each product type and then simply report the number of the specific product type.

In some countries, the Trade Supervisory Authority will be able to assist in the process, but they do not exist in all countries. Furthermore, a verification via the tax office might be possible, if the number of sold products is recorded per type.

Best Practice: New Zealand
New Zealand (NZ), companies are required to meet all MEPS levels and regulatory testing/reporting requirements. Since 2002, companies also have to provide sales data, which is legally covered by a confidential contractual arrangement between the NZ Government and suppliers. Sales data is not published, nor provided externally by law.

Overview: Sales of Standardised, Mass-produced Systems

What to monitor?	Parameters to monitor?	How to monitor?	Who monitors?
Standardised, mass produced units; separated in imports and locally produced (possible appliance groups are self-contained AC, split AC, refrigerators, stand-alone units, cars with AC, large vehicles with AC (buses, trucks))	Sales of imported units Sales of locally produced units Refrigerant used Charge size (refrigerant content on import, if applicable) Cooling capacity/rated capacity Energy efficiency ratio (EER) – determined according to defined standards Seasonal energy efficiency ratio (SEER) – determined according to defined standard Label class (if existing) Price	Mandatory registration for manufacturers and importers of the appliances that are intended for sale in the country. Upon initial registration, the number of units sold needs to be reported annually	Ministry of Trade and Customs Authority, Trade Supervisory Authority, etc.

2.2.3 Stock of Standardised, Mass-produced Systems

The direct determination of stock data is optional, as with reliable sales data monitoring, stock numbers can be calculated after a few years. However, establishing stock data is highly recommended as cross-check until sales-stock models realistically can predict the installed stock. Stock data also helps to provide information on ownership related to population strata, which can be used for effective policy design. A reliable estimate of stock data can be achieved based on population and/or housing statistics combined with assumptions on appliance ownership rates.

A good start for the stock database is the use of existing statistics, such as the number of households, living area, and income. Furthermore, based on expert estimates, the number of appliances and the average age of the appliance per population strata can be estimated. Information on averages per strata could also be obtained by a survey or as part of a micro census. Such surveys could be repeated every five years to monitor changing ownership rates and could also include questions on user behaviour (runtime hours, basis for buying decisions).

Best Practice: Colombia

Colombia has utilised a detailed population statistic set with income strata and geographic distribution to estimate the stock of split AC units. Colombia's population is classified as six income strata (1 "low-low", 2 "low", 3 "low-middle", 4 "middle", 5 "middle-high", 6 "high"). Regular household surveys show the ownership of different air conditioner technologies in different strata. Based on this information in combination with the projected future development of the households in the different strata, the future stock of air conditioners can be estimated (UNDP/UMPE 2015). Based on such an elaborated stock database, targeted subsidy programmes can be developed.

Overview: Stock of Standardised, Mass-produced Systems

What to monitor?	Parameters to monitor?	How to monitor?	Who monitors?
Stock of mass-produced units (incl. self-contained AC, split AC, refrigerators, stand-alone units, cars with AC, large vehicles with AC (buses, trucks)) Average appliance parameters	Link statistical data such as number of households, living areas, and income to appliance ownership Define average appliance per population strata (incl. refrigerant charge, cooling capacity/rated capacity, EER, SEER, label class, runtime hours)	Use available statistics (income per household, office building space, car registry) Define amount of systems per statistic category via survey (repeated every 5 years)	Statistics Authority and dedicated staff

2.2.4 Stock of Custom-made Products

A large share of the commercial sector uses custom-made products. In some countries, up to 38% of the RAC sector can be attributed to engineered products. Typically, refrigerant emissions as well as energy use is high in the individual equipment. Due to the individual system design, it does not make sense to count the sales of the system components. The plant's performance is the result of the system design, the features of the components, the quality of installation and the maintenance routines.

In case the operator's registration system is not a priority, the stock of engineered equipment can be estimated based on available statistics. Useful statistics could be food production, hotel beds, or other suitable proxies. For example, the refrigerant charge in a brewery can be estimated based on the ratio of 0.045 kW cooling capacity per tonne of beer and 3.65 kg refrigerant per kW cooling capacity. Such ratios are partially available from literature and always need to be locally confirmed.

2.2.4 Stock of Custom-made Products

In order to capture the emissions of these plants, the equipment operators have to be targeted. Mandatory registration of plant operators can be linked to regular leakage checking obligations and provide a complete overview on refrigerant emissions, energy use, as well as average equipment lifetimes.

The system could be further used to monitor the certification of technicians, only allowing certified technicians to undertake installation, leak checking, and maintenance routines on the registered plants. Successful implementation requires high initial resources to achieve good coverage of operators' registration and successive regular monitoring and inspections. In order to do this, ministries have to cooperate with regional implementation bodies such as environmental inspectorates.

Best Practice: Poland

For tracking refrigerant related leakage emissions, Poland has established an electronic data base. The electronic database includes a central register of operators running appliances containing F-gas. The reporting to the database is mandatory for all equipment operators with equipment containing more than 5 tons of CO_2eq F-gases. The operators must track F-gas handling activities including installations, maintenance/ servicing, repair, decommissioning, leakage checking, leakage repairs, leakage detections, the type of leakage detection systems and refrigerant recovery. For each type of equipment, one logbook must be maintained. Environmental inspectors will carry out spot checks on the proper regular compilation of the logbooks and the related reporting. The data used in the database serves as a data input for the national inventory on emissions of fluorinated GHGs under Article 4 of the UNFCCC (UNEP, Legislative, and Policy Options to Control Hydrofluorocarbons).

Overview: Stock of Custom-made Products

What to monitor?	Parameters to monitor?	How to monitor?	Who monitors?
Stock of custom-made products, such as ACs in (large) office buildings, commercial refrigeration systems (e.g. cold rooms, supermarkets), industrial installations (e.g. food production, chemical industry), refrigerated trucks	What/how much equipment is in use Year of installation Cooling capacity Energy use Refrigerant refill/emissions	Mandatory reporting of system operators Use available statistics and define process for, e.g. trade, tourism, food production	Ministry of Industry, Environmental Inspection Authority with expertise in National Ozone Unit, etc.

Bringing Sales and Stock Data Together: the Equipment Stock Model

The equipment stock model is used to calculate equipment stock from a time series of equipment sales, making use of the (country-specific or default) average equipment lifetime. It further uses a set of assumptions (either country-specific or default) equipment parameters (initial charge, emission factors, etc.) to calculate emissions. Having acquired stock data independently from equipment sales (e.g. via statistics or operators' registration) provides a great opportunity for cross-checking the stock data calculated by the model. Stock models can use different methodologies, simple to sophisticated, which aim to reflect the "real" equipment stock development. A simple Excel-based tool is provided to calculate emissions based on sales data and (default) parameters per sub-application in accordance with the Tier 2a approach of the IPCC Good Practice Guidelines. The tool shows how the resulting emissions are reported to the UNFCCC using the Common Reporting Framework (CRF) tables. Contact us (**proklima@giz.de**), if you would like to get access to the tool. Further information on the stock model is provided in Annex to the **NAMA Handbook, Module 1 (GIZ 2014)**.

2.2.5 Waste Streams of Systems and Refrigerants

Closing the loop and monitoring not only the additions to the market (as in appliance sales), but also the decommissioning, greatly improves the overall data set and enables cross checks of modelled substance and appliance flows. Collecting data on waste streams of systems and refrigerants in the same stage as data on sales and stock, will avoid extra work later. Depending on data collection methods, questions on system replacement periods and prevailing recycling practices can be included.

In particular, when monitoring refrigerant use and custom-made products, recycling and destruction can be included. The monitoring here should include refrigerant recovered from installations in the field, as well as appliances being collected in one piece. The annual amount of refrigerant entering the waste stream cannot be directly monitored.

In many countries, it is common practice for an informal sector to take apart old equipment and to sell the raw material for re-use. To close this gap, an equipment stock model (➞ **refer to info-box**), calculating the additions and decommissioned equipment based on equipment lifetimes, can be utilised to estimate the amount of equipment that is decommissioned each year.

2.2.5 Waste Streams of Systems and Refrigerants

Ideally, the refrigerant is recovered from the appliance prior to the shredding of the appliance, in a closed system to recover the foam blowing agent. In the same step, reusable metal and plastic fractions are separated. From an environmental point of view, refrigerant (and foam blowing) emissions are often substantial at the point of scrapping.

Therefore, monitoring and consequently improved enforcement of recovery and recycling practices can lead to sustained emission reductions. However, the topic will not be further detailed within this text. Documentation on good practices for refrigerant bank management can be found in the guidelines developed by the ODS banks management project.

Overview: Waste Streams of Systems and Refrigerants

What to monitor?	Parameters to monitor?	How to monitor?	Who monitors?
Units collected to be destroyed/recycled Recovered refrigerant for recycling/ reclamation/ destruction Amount of ODS/HFC entering the waste stream per year*	Type and amount of foam and refrigerant collected Amount of CO_2eq destroyed, recycled, and/ or reclaimed	At collection points At destruction facilities	National Ozone Unit Collection centers, destruction facilities

* This data is very difficult to collect, but can be estimated using an equipment stock model

2.2.6 Quasi-constant Parameters

Appliances, including the amount of refrigerant they leak and energy they consume, must be "translated" into emissions. The above-mentioned equipment stock model can be used to facilitate this process. The translation however depends on a set of parameters including maintenance practices, equipment lifetime, and user behaviour. Those items cannot usually be monitored directly and do not usually change significantly from one year to the next, unless the country's energy mix changes. Therefore, we call them "quasi-constant".

Experts have to define parameters for lifetime, emission factors, and runtime hours. These parameters can either be based on IPCC factors, or country-specific parameters can be used. It is strongly recommended that a process is defined by a country-specific estimation, as IPCC default factors tend to be conservatively estimated.

In order to define country-specific, quasi-constant parameters, a group of stakeholders should be involved. This could include representatives from the NOU, from the Association of RAC technicians, and equipment manufacturer,s among others. As a first step, the stakeholder groups have to collect feedback based on how appropriate the IPCC default values are in comparison to the national circumstances.

In the second step, via discussions and consensus, country-specific parameters are defined. For this, selected key experts can be asked for an initial estimate, including an uncertainty range. During a stakeholder workshop, opinions and ways of establishing a sound database are gathered. In case a consensus is not reached, averages can be taken. This process needs to be repeated by the same group of stakeholders every five years to update the parameters.

Countries with RAC inventories often obtain a single-year estimate, which means that data is collected within a specific year. Inventories therefore provide a "snapshot". This includes countries such as: the Philippines, Grenada, Thailand, Ghana, Vietnam, Costa Rica, Namibia, Kenya, Mauritius, Iran, Colombi and, Indonesia. However, the challenge is to establish a process with regular updates.

The methodology adopted for the inventories draws on the concepts outlined by GIZ (2014), Penman et al. (2006), and on the IPCC Tier 2 methodology from 2006.

A compilation of all published GIZ inventories is available on the **Green Cooling Initiative website**.

Overview: Quasi-constant Parameters

What to monitor?	Parameters to monitor?	How to monitor?	Who monitors?
Average parameters per appliance groups	Product lifetime Refrigerant emission factors during manufacturing/first fill of appliances, servicing and end-of-life Runtime hours	Define stakeholder process to determine parameters or use default values	National Ozone Unit with stakeholders

2.3 Quality Assurance and Quality Control

Good quality inventories need to adhere to **five basic principles** along the process, from data collection to reporting (IPCC 2006):

1. **Transparency:** transparent documentation of the process

2. **Accuracy:** due care is to be expected to avoid the over- and underestimation of emissions

3. **Completeness:** covering all sources and sinks of GHGs

4. **Consistency:** consistent calculating methods throughout the years, so that changes in results reflect actual changes in emissions

5. **Comparability:** adequate categorisation and classification in reporting allows for accurate comparison between countries

2.3 Quality Assurance and Quality Control

The team involved in the inventory must keep in mind that the outputs and outcomes of the sectoral GHG inventory for the refrigeration and air conditioning sector is part of an overall national GHG inventory that will be utilised for several international reporting obligations, such as the National Communications, Biennial Transparency Reports, NDCs, NAMAs, Climate Financing Schemes and other reports that require a RAC sector baseline.

The mandatory reporting requirements of the UNFCCC recommends the use of the IPCC inventory principles. However, other reporting schemes may have additional quality requirements aside from the IPCC. These can include an acceptable level of materiality or additional requirements that can be demonstrated through specific quality attributes.

Quality assurance (QA) consists of planned review procedures of the completed report. It is conducted by personnel who are not directly involved in the compilation/development process. Possible action includes checking for transparent and comprehensive reporting and checking for reporting consistency. A third-party verification for large reporters of sales can be established. Additionally, random sample verification of the energy efficiency of registered products can be implemented.

Quality Control

Quality control (QC) is a system that routinely controls technical activities that are performed by the compilers. Possible **actions for quality control** includes:

- Cross-checking sales and stock estimates
- Cross-checking bulk refrigerant imports with calculated refrigerant use*
- Cross-checking calculated energy use of the RAC sector with national energy consumption
- Cross-checking stock of custom-made RAC systems (industrial and commercial applications) with economic data such as food production (milk, meat) or trade on perishable goods

* The Montreal Protocol has specific verification requirements undertaken by third party verifiers: possible coordination with the MLF funded verification with the RAC GHG inventory

2.4 Good practice in data collection for the RAC Sector

Despite the intention to have an MRV blueprint which all countries can use; it is important to point out that each country has its own regulatory and legislative frameworks, needs, and capabilities, hence differences will occur in the application of the MRV blueprint. In order to bridge the gap between a theoretical blueprint and the practical application, good practices in data collection for the RAC sector are analysed. An example of the combined monitoring of refrigerant use and energy efficiency of an appliance group remains to be established.

As a first step, we will look at:

- **New Zealand**
- **Australia**
- **Korea**

…who all have product databases and thus focus their efforts on implementing energy efficiency standards. We can therefore deduce the lessons learnt for the purpose of the MRV blueprint.

New Zealand

E3 is a joint programme funded by the Government of New Zealand and Australia designed to, where possible, maintain regulatory alignment and minimise trade barriers between New Zealand and Australia, while ensuring that the energy efficiency of electrical products for sale in the two markets is optimised. Essentially, an importer or manufacturer should be able to market a product on either side of the Tasman without restriction.

In New Zealand, companies are required to meet all MEPS levels and regulatory testing/reporting requirements. Since 2002, companies also have to provide sales data, which is legally covered by a confidential contractual arrangement between the New Zealand Government and its suppliers. Sales data is not published or provided externally by law.

New Zealand and Australian companies are required to register regulated products on the Energy Rating Website. During the registration process, the performance and efficiency test results based on international standards (e.g. mostly IEC, ISO) are entered. Access to the energy rating website is public to ensure consumers can locate performance comparability information.

The Export Credit Agency in New Zealand mirrors some of the performance information on its own website, which includes online product selection tools and star rating labelling. Physical labelling for consumer (residential) products is also provided. Labels must be affixed to the product at point of sale. MEPS are currently in place for twenty product classes. Selected products include air conditioners; heat pumps (non-ducted, ducted, and multiple split systems); room air conditioners; chillers; domestic fridges and freezers.

The database stores data on the manufacturer, the model, the country of the manufacturer, standard rating conditions, registration basis, the cooling capacity, coefficient of performance (COP), Integrated Part Load Value (IPLV), expiry data and the registration number.

Australia and New Zealand both have compliance teams that monitor labelling in the field and perform test checks to ensure that the performance claimed by the manufacturer/importer is valid. Legal remedies are available to both governments for breaches of regulation. These range from very large fines to court proceedings or instant fines. However, these remedies are only used as a last resort and the compliance teams work closely with manufacturers and importers to ensure they are aware of their legal responsibilities.

New Zealand

Constant monitoring and intelligence gathering are strong features in all compliance activities, and requires input from government customs agencies. Hence, both governments use customs import codes to monitor what comes across the border. Both compliance teams firmly believe that the best type of compliance is voluntary. Therefore, their task is to ensure that legal requirements and regulation is visible and clearly understood. However, neither government hesitates to intervene when flagrant and deliberate offending takes place.

When E3 decides to regulate a new product or upgrade the regulation of an existing product, a formal consultation process takes place. A consultation regulatory impact statement is prepared, and the industry and the public are invited to engage. Sales data from New Zealand is used as an input to the consultation regulatory impact statement (including the cost/benefit analysis) to establish the impact of the proposed regulatory change (which includes GHG mitigation). Following consultation and feedback, a decision regulatory impact statement is prepared for the respective governments to approve, and after an agreed period, the new regulation is implemented.

In 2016 and 2017 more than 6.2 million appliances and products subject to labelling and regulation were bought by people in New Zealand. They included heat pumps, televisions, computers, whiteware and more than 3.1 million light bulbs. It was estimated that the product database helped to save more than 133 GWh of electricity, 18,400 tonnes of CO_2 emissions, and for the consumers, it also meant a saving of $11.7 million (IEA, 2018).

Lessons Learnt for the MRV Blueprint

New Zealand is cited across literature as the best practice example. The New Zealand sales data is valuable as it gives the New Zealand government some certainty around the size and segmentation of a regulated products market and means that impacts can be accurately modelled.

To cover all emissions from RAC equipment, it would be beneficial to also collect information on refrigerant type and refrigerant charge. It remains unclear if sales data can be shared within the government bodies to provide a database for other policies outside the energy efficiency topic, i.e. concerning refrigerant use.

Australia

In Australia, the Greenhouse and Energy Minimum Standards Act 2012 is the current federal legislation that replaced state-based programmes in 2012. As outlined above, Australia and New Zealand jointly used the product registration database.

However, Australia does not collect sales data or similar information, but they sometimes use data from the registrations system to inform policy development. Australia often uses New Zealand's trend data as a proxy for the much larger Australian market to model or forecast regulatory impacts.

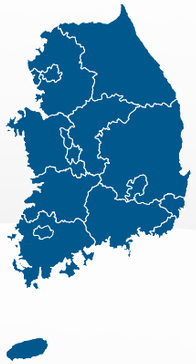
The Market Surveillance Results Report by the Australian Government (2018), which covers the period from July 2017 to June 2018, shows that a total of 9,443 products were surveyed during inspections, to ensure compliance with Energy Rating Label (ERL) requirements, with 4,338 of these checked for registration compliance.

Notable improvements were found in the rate of registration compliance for air conditioners, with 97.2 percent for 2017-18 (93 percent for 2016-17) and household refrigerators/freezers with 97.6 percent (96.3 percent for 2016-17). The results from market surveillance for 2017-18 also showed an overall ERL compliance rate of 89 percent, which is a significant improvement compared to 2016-17 which only had a compliance rate of 77.3 percent.

Lessons Learnt for the MRV Blueprint

Australia does not record sales data but relies on data from New Zealand as proxy for forecasts. This highlights the importance of a comprehensive MRV system which goes beyond product registration to also cover the number of products sold. The Market Surveillance Reports show that compliance has improved over time, which demonstrates that it takes time and effort for a product database tp become effective. Concerning refrigerant information, the comments made for New Zealand apply.

Korea



Since 1992, the Korean Energy Agency mandates energy efficiency labelling and standards on commonly used products that consume a large amount of energy. The aim of this is to accelerate the development of energy efficiency technology and encourage consumers to purchase energy saving products. In total, 35 products are regulated. Selected products include refrigerators, freezers, kimchi refrigerators, air conditioners, electric cooling and heating appliances, commercial refrigerators and gas water heaters (Korean Energy Agency, 2018).

Mandatory MEPS were introduced in 2002 and in September 2011, the Government announced the Energy Frontier programme, which sets mid-term energy efficiency goals for key appliances, including RACs, at 30-50 percent more efficient than Grade 1 (most efficient) (Park et al. 2017).

The Korean Energy Management Cooperation (KEMCO) receives a product report from the manufacturers as well as test results from independent test institutions, which are entered into a database. The following figure depicts the reporting process.

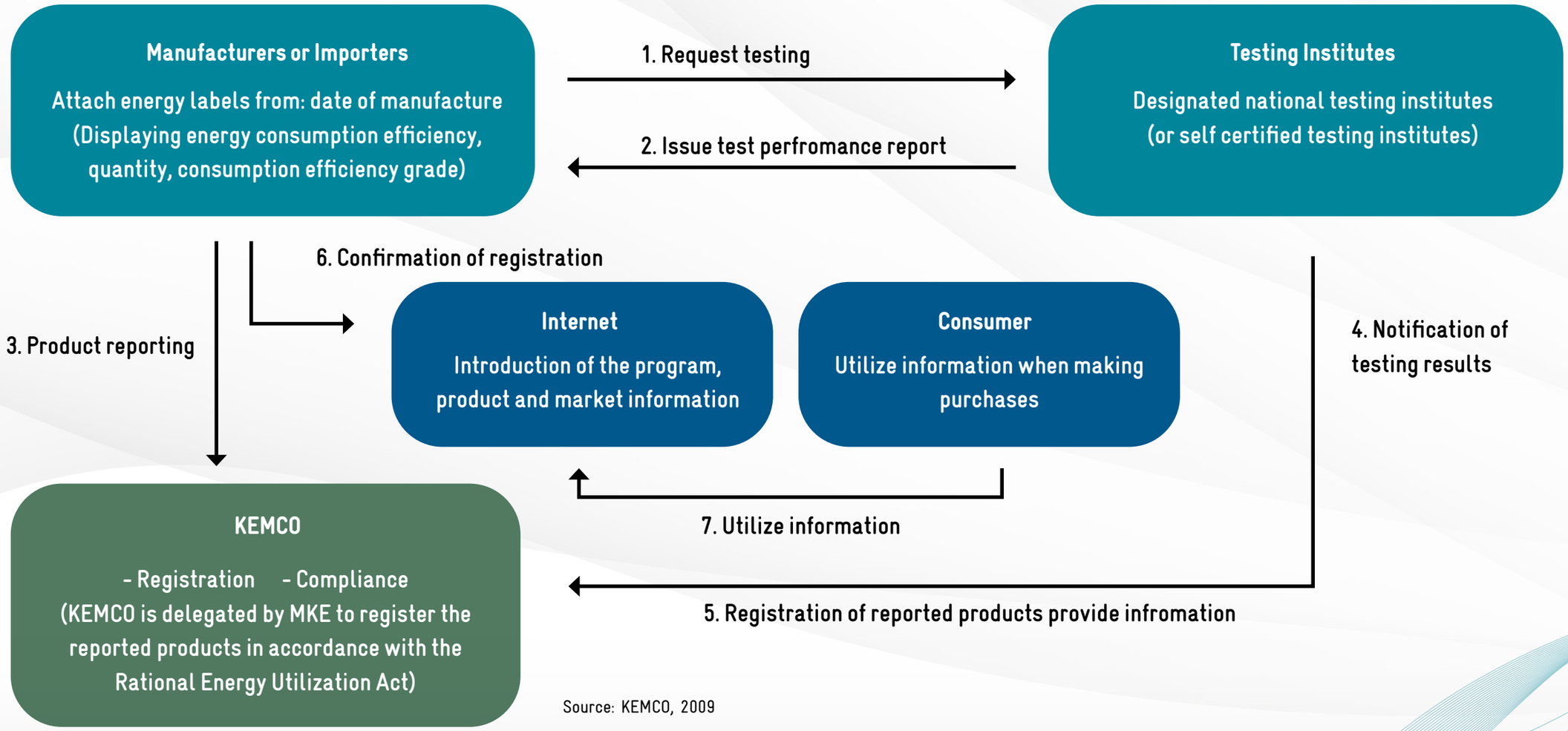
Additionally, importers and manufacturers are obliged to annually report on sales units (Ministry of Knowledge Economy, 2011). The database thereby combines information on the manufacturer, the model name, the cooling capacity, the seasonal efficiency and the refrigerant as well as RAC sales.

KEMCO also provides marketplace and product inspections to monitor compliance. If manufacturers and suppliers do not observe the regulations, they are fined up to US $18,000 (IEA DSM). The production and sales of products below the MEPS are prohibited.

Lessons Learnt for the MRV Blueprint

Korea continuously updates product classifications. With the labelling and standard programme, Korea was able to reduce the power consumption of refrigerators by 60 percent from 1995 (1.76 kWh/l) to 2009 (0.7 kWh/l) (KEMCO, 2014). Additionally, the collected sales data helps to tailor future politics and predict emission trends. Furthermore, Korea has been linking energy efficiency labels to incentive schemes, which accelerates the use of energy efficient products in the market. This highlights the various benefits associated with establishing an comprehensive MRV for the RAC sector. Emission savings could even be increased when including refrigerants into the scheme.

Korea



Source: KEMCO, 2009

giz Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH

3 Putting MRV Systems into Practice

Decision-making Trees and Guiding Questions

3.1 Steps to Set Up an MRV System and Guiding Questions

This chapter provides a step-by-step guide on how a RAC MRV system can be set up and implemented. Guiding questions and decision trees were developed to support every step. Ideally the process is managed by a team of responsible stakeholders, e.g. NOU, energy efficiency government agencies and GHG emissions officials.

Jump directly to:

Overview: Necessary stages to set-up an MRV system in the RAC sector

Standardised products (often mass produced)

Sales

- Establish **mandatory registry** of models, incl. info on EE/refrigerant link with labelling
- Establish **mandatory reporting** of sold units
- Count **national equipment sales**
- Count **units entering the waste stream**

Stock

- Check **available statistical data** of household strata/office space
- **Statistical survey of user groups** (household strata, office space): number, EE, refrigerant
- **Regular update of survey** (e.g. 3-5 years)

Custom-made products

- Count **products in operation** via the operators
- Establish **mandatory reporting** of operators
- Count **units entering the waste stream**

Calculate emissions (combine with model assumptions)
Crosscheck with MP data, use results for UNFCCC reporting Tier 2

Step 1: Define Scope

To define the scope, it might be useful to answer the following questions:

- Why do we want to establish an MRV system?
- What is the vision for a RAC sector MRV? (e.g. product registration, use of statistics, standardised products, engineered products, what appliances are to be covered)
- Are there any MRV obligations from other processes, e.g. UNFCCC, sector projects, NDCs etc.?
- What are possible quality requirements for the MRV data?
- For which subsectors do we want to establish the MRV?
- Which subsectors have to be covered in a detailed analysis?
- Which important stakeholders should be involved in the MRV setup?

The best way to discuss these questions is during a kick-of meeting. Detailed minutes will aid the process of establishing an MRV system and will serve as guidelines which stakeholders can always refer back to.

Step 2: Define Objectives, Outputs, Timeline and Responsibilities

A timeline, and responsibilities, are to be determined. If a consultant is used for further tasks regarding the data analysis and development of recommendations, it is important to ascertain whether the knowledge and information sources are recorded for further use by the government agencies. The continued implementation should not be dependent on the availability of the consultant. Terms of reference (ToRs) for the consultant can be developed, which are based on information in the guiding questions and the decision trees.

Step 3: Describe the Status Quo

A set of guiding questions (see → **Annex** for detailed tabular format) have been defined, to establish a detailed status quo, whilst encouraging creative uses of the existing data and assessment of the following points:

- data availability (direct data and statistics),
- data reliability and quality,
- collection routines,
- data flow,
- responsibility and data ownership.

The guiding questions are differentiated in → **Tier 1** and → **Tier 2**. The following table provides an overview of questions. When gathering the information, it is recommended to conduct a series of interviews. In order to identify potential interviewees, it might be helpful to start with a desk research on departments/ authorities that are potentially involved, along with pre-existing legal provisions for reporting. The questions must be assigned to the departments/authorities, that are most equipped to answer them. Start your interviews with the departments/ authorities who can answer a large number of questions.

To facilitate the tapping of new data sources, the affiliations of each interview partner should be briefly characterised. Especially when talking to private sector entities such as associations, understanding their membership structure and purpose helps to establish a common ground for MRV efforts.

Status Quo: Summary of Guiding Questions

Overarching question	Selected sub-questions
Import and export of pre-charged equipment	
Import, export, and consumption of HCFC and HFC has to be reported to the Montreal Protocol in kg or t of substance and CO_2eq. Describe how this data is assembled.	• What data is used when reporting to the Ozone Secretariat under Art. 7 of the Montreal Protocol? • Who is responsible for collecting this data? • Which quality checks/controls do you perform
Is the import and export of pre-charged refrigerating/cooling equipment monitored? (e.g. refrigerant contained in refrigerators, moveable ACs, split ACs, small commercial equipment, vehicles, transport refrigeration systems)	• Which equipment is covered? • Who is responsible for collecting this data? • How often is the data set updated?

Status Quo: Summary of Guiding Questions

Standardised products	
Are refrigerating/cooling appliances registered? For what reason? Is the data used for monitoring? Monitoring of what? Is registering a pre-condition for putting it on the market?	• What is the legislative/regulatory basis for the registration? • Which equipment is covered? • What parameters are recorded? • How is this done?
Is the entry into the market of refrigerating/cooling equipment monitored? (e.g. split ACs, refrigerators, etc.)The number of those put on the market could be determined by recoding production, import and export numbers.	• What is the legislative/regulatory basis for the registration? • Which equipment is covered? • How is this done?
Is there any monitoring of the number of appliances in use? Are there exclusions within the subsectors such as not-in-kind technologies, or a limit in data collected from specific capacities, within the subsector?	• What is the legislative/regulatory basis for the registration? • Which equipment is covered? • How is this done?
What kind of statistics are available to deduct the number of appliances in use?	• Number of households? • Income strata of households? • Energy use per household?

Status Quo: Summary of Guiding Questions

Custom-made products	
Is there any monitoring of the number of appliances in use? For which purpose? Monitoring or registration?	• Which equipment is covered? • Is the reporting mandatory or voluntary? • What parameters are recorded?
What kind of statistics are available to deduct the number of appliances in use? How often are they updated? By whom?	• Floorspace of cooled office buildings? • Number of supermarkets? • Refrigerants used?

Waste streams	
Are refrigerants or refrigerating/cooling appliances collected for recycling/ reclamation/destruction? Is the amount of ODS/HFC that enters the waste stream per year monitored? Is the amount of destruction of the ODS/ HFC monitored?	• Which equipment is covered? • Is the reporting mandatory or voluntary? • What parameters are recorded? • Who is responsible for the data collection on waste?

Quasi-constant parameters	
Are there appliance-specific statistics about average runtime, product life, refrigerant emission factors?	How are they determined? How often?

Step 4: Analysis of Collected Data

The results of the status quo analysis can be used to do a gap analysis, which is intended to inform the development of the final structure of the MRV system. The decision trees provide an orientation on useful questions and steps, depending on the envisioned scope. The decision trees are described in detail here. For the assessment of the data, the following course of action is recommended:

- Verify if the data already exists, e.g. through online research of available data.
- Verify if existing data can be used for MRV, e.g. if the quality requirements are met and data is collected often enough.
- Contact ministries to access non-published data.
- Use national statistics that can act as proxies to determine required data.
- Use international reports from the MLF, IPCC, GIZ, UNEP, World Bank or market studies (e.g. JARN) to get data, especially on technical parameters, if these are not available in the country. Ascertain whether the data in international third-party reporting is updated regularly before relying on it.

The summary matrix (as shown below) is to be filled in, enabling a quick overview on information gathered during step 3 and its analysis. Data sources and gaps as well as potential recommended data sources are to be discussed in a stakeholder workshop.

The following matrix is to be filled out per subsector.

If there is no data available, please note this down. If the data point is not applicable to the subsector, please note N/A. Empty fields are considered as still being worked on. Potential data sources are any data sets that contain useful information, but are not yet used for the RAC sector MRV. Mostly, such data can be used to deduct installed refrigeration capacities or the number of appliances in use. These can be statistical data of household numbers, income strata, populated areas per climatic region (if applicable), as well as hotel beds/rooms, office spaces or food production statistics. Often, certain assumptions need to be taken in order to calculate appliance numbers. Also consider obtaining easily accessible information that is not just collected, such as data sets collected by associations. The MRV blueprint contains further information.

Matrix for collecting existing data sources

Existing data sources	Data source	Data availability (years)	Collection routine & data flow	QA/QC: Why do you think the data source is reliable? Which cross checks are reliable? Which problems/ limitations exist with this data?	Responsibilities and ownership	Information source (website, contact person, study/report, etc.)
Stock						
Sales						
Lifetime						
Refrigerant distribution						
Runtime hours						
Refrigerant emission factors (manufacturing, servicing, end-of life)						
Average cooling capacity or cooling capacity per appliance						
Average energy use/ energy efficiency per appliance						
Average charge size per unit						

Matrix for collecting potential data sources

Potential data sources	Data source	Data availability (years)	Collection routine & data flow	QA/QC: Why do you think the data source is reliable? Which cross checks are reliable? Which problems/ limitations exist with this data?	Responsibilities and ownership	Information source (website, contact person, study/report, etc.)
Stock						
Sales						
Lifetime						
Refrigerant distribution						
Runtime hours						
Refrigerant emission factors (manufacturing, servicing, end-of life)						
Average cooling capacity or cooling capacity per appliance						
Average energy use/ energy efficiency per appliance						
Average charge size per unit						

Step 5: Recommendations Regarding Data Sources and Implementation as well as Institutional Set-up and Final Structure

Preliminary results have to be discussed in an evaluation workshop with all relevant stakeholders. The results of this workshop are part of the final recommendations. The objectives of the workshop are to combine further information from stakeholders, determine the scope for communication with other stakeholders, and set first steps towards developing a roadmap for implementation.

The structure of the MRV system should be defined for each RAC application. Based on the scope, data gaps per application system and potential sources are to be identified. The MRV structure is linked to reporting requirements under the Montreal Protocol and the UNFCCC.

Recommendations should be stratified per subsector. The format of the recommendations is determined by the stakeholders. An example is provided in the Annex. The recommendations should form the basis for a roadmap towards the implementation of a RAC sector MRV. The decision trees might be of help again at this point.

Information should include the following as well as all additional necessary information to set up an institutionalised sector-MRV.

Note down if:

- Data source is existing or potential
- Recommendations on how to establish collection routine and data flow if this is not established yet
- Existing or potential QA/QC procedure
- Recommendations on data responsibilities and ownership – if necessary, also recommendations on legal proceedings to establish data source
- Participation in expert technical committee. Tasks of the expert technical committee, such as annual data verification, regular (e.g. 3-5 years) determination of quasi-constant parameters such as product lifetimes and refrigerant emission factors
- Steps towards implementation, including timeline and responsibilities
- Ranking of the recommendations based on importance of the subsector, necessary effort, and expected use of data

Further Steps: Implementation Procedures and Recurrent Data Collection

Use the recommendations to develop an implementation plan based on the MRV roadmap. It is important to develop clear responsibilities and quality requirements for each data set to be collected. Regular meetings and updates should be agreed upon by the management team. Ideally, the implementation plan is linked to international reporting requirements.

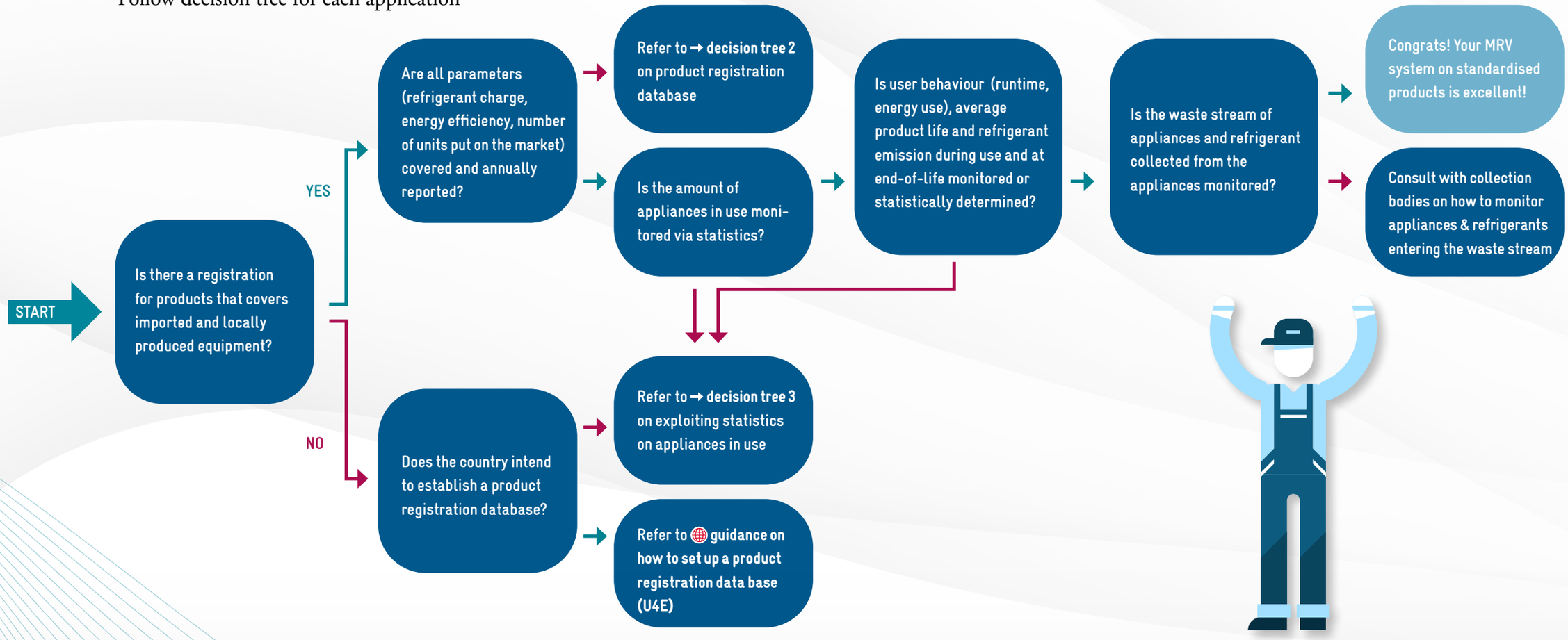
3.2 Decision Trees: Finding Your Way Through the MRV Jungle

In this sub-chapter, we provide you with decision trees that help you analyse your status quo and provide you with feedback on next steps.

- **Decision Tree 1**: Overview – For Standardised Products
- **Decision Tree 2**: Product Registration Database – For Standardised Products
- **Decision Tree 3**: Exploiting Statistics on Appliances in Use – For Standardised Products
- **Decision Tree 4**: Overview – For Custom-made Products
- **Guidance on How to Set Up a Product Registration Database (U4E)**

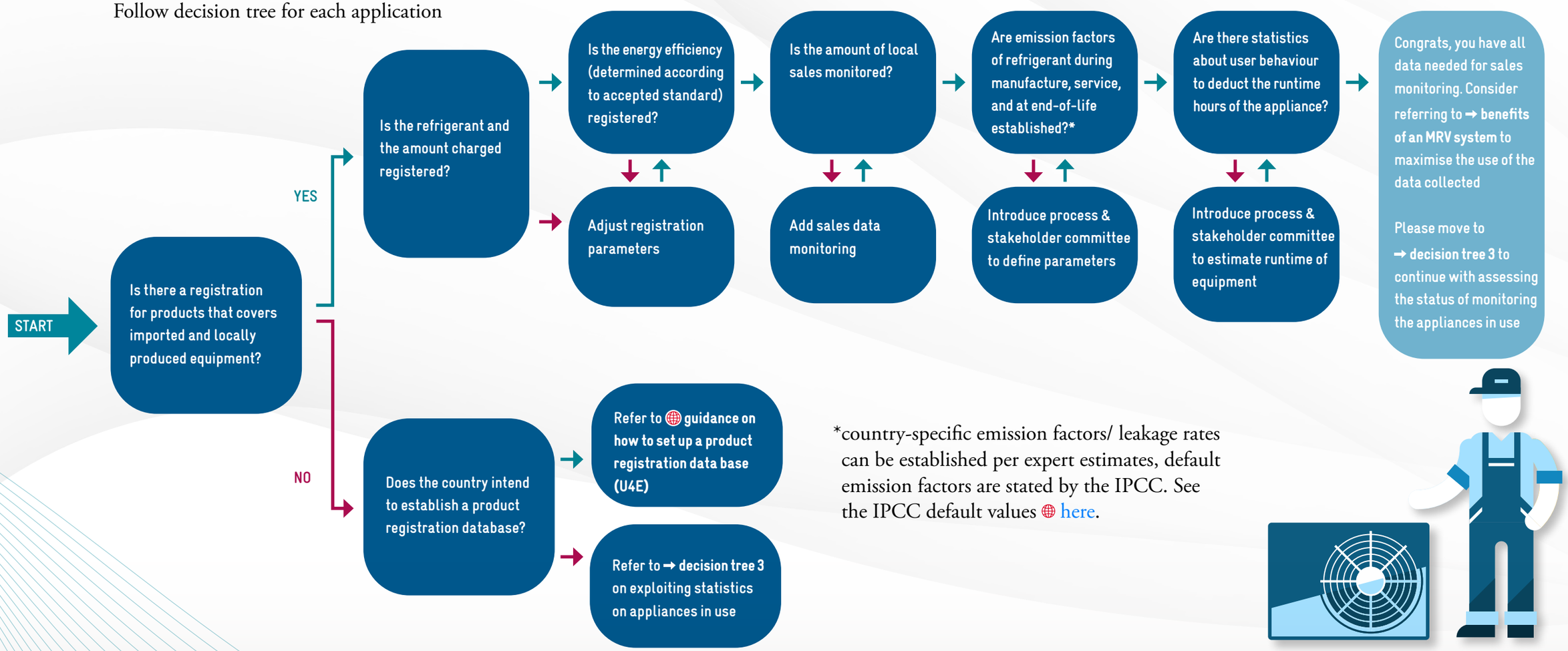
Decision Tree 1: Overview – For Standardised Products

Follow decision tree for each application



Decision Tree 2: Product Registration Database – For Standardised Products

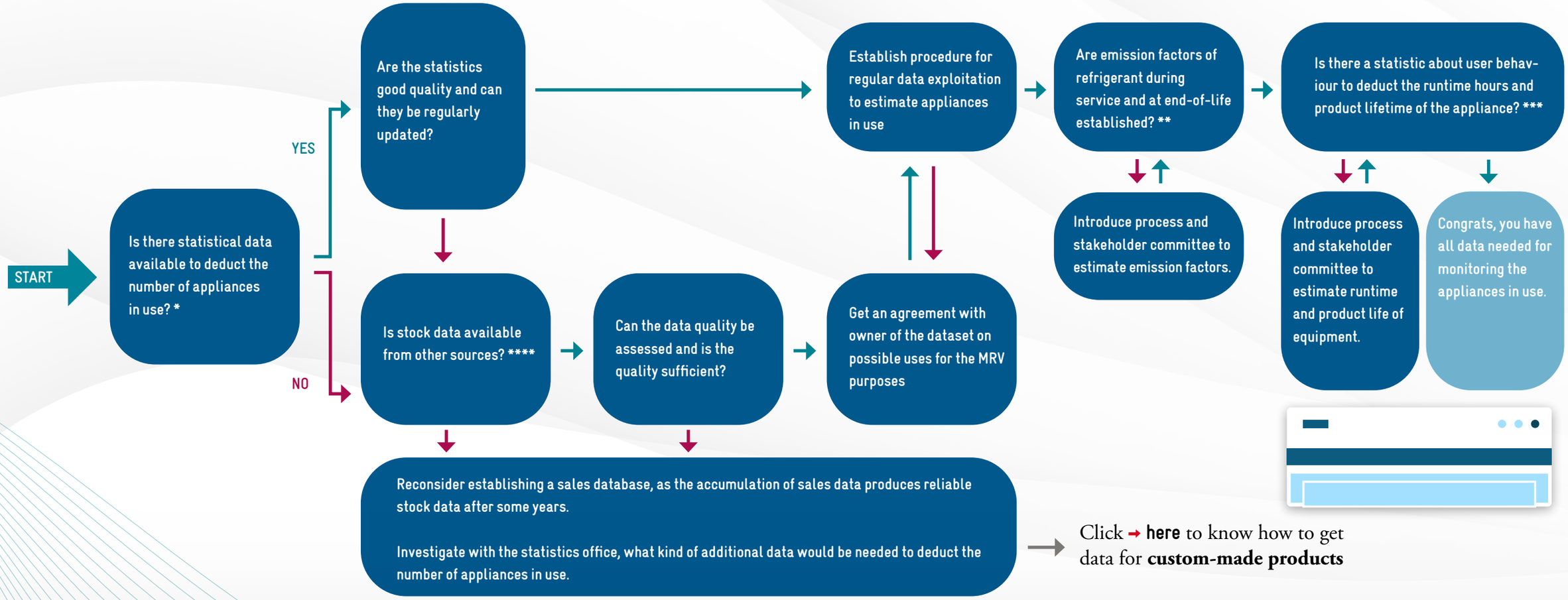
Follow decision tree for each application



*country-specific emission factors/ leakage rates can be established per expert estimates, default emission factors are stated by the IPCC. See the IPCC default values here.

Decision Tree 3: Exploiting Statistics on Appliances in Use – For Standardised Products

Follow decision tree for each application



Click → **here** to know how to get data for **custom-made products**

Decision Tree 3: Exploiting Statistics on Appliances in Use – For Standardised Products

* Search the national statistics office database for data and ask representatives from the statistics office to see unpublished data. Make good use of available statistics and talk to sector experts about the number of appliances per statistical unit. This can be cooled floor space or number of shops for certain goods.

It might be appropriate to conduct a representative study of the number of appliances per statistical unit. Such representative studies could be repeated every 5 years to monitor development. Such a study can also take up the following questions:

- Common refrigerant contained in the appliance
- Average energy efficiency of appliances per income group
- Average runtime hours
- Average product life

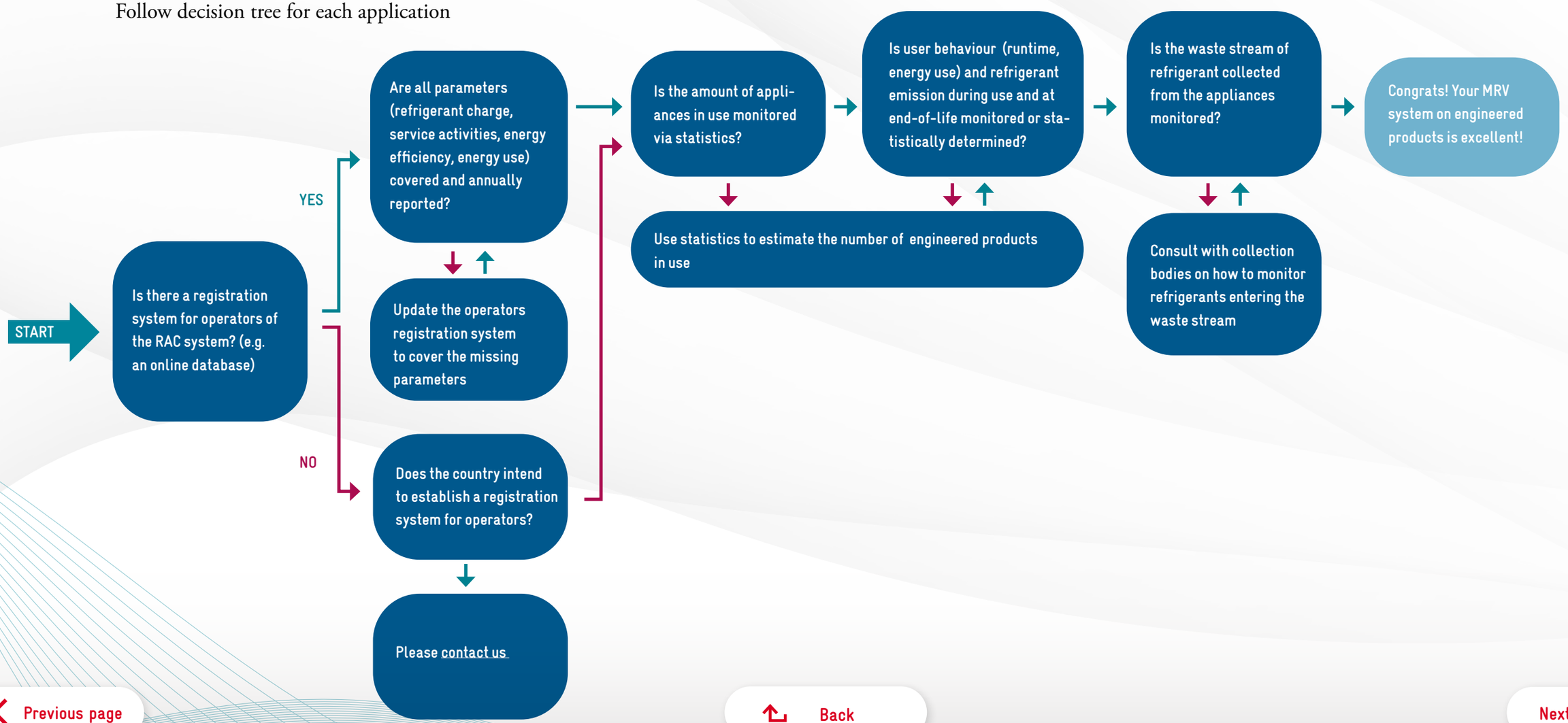
**Country-specific emission factors can be established per expert estimates, default emission factors are stated by the IPCC. See the IPCC default values here.

*** If a study on those parameters is not possible due to limited resources, gather experts estimates and document the assumptions.

**** National industry associations often have a good market overview
Also international studies might be available, search JARN, BSRIA and others.
Also talk to the responsible persons of the HPMP to find out who the national experts are.

Decision Tree 4: Overview – For Custom-made Products

Follow decision tree for each application



Product Registration Database - United for Efficiency (U4E)

For standardized products, it is recommended to count the sales via a product database and/or to estimate the stock via a statistical approach. In order to streamline various initiatives that deal with the RAC sector, some elements of the blueprint are built upon **U4E's product registration work**. U4E receives support from the Global Environment Facility (GEF) and Kigali Cooling Efficiency Program (K-CEP) to develop a prototype registration system and support countries and regions in its implementation. It's aims are fivefold:

- Enable developing and emerging economies to monitor which products are sold in their markets to ensure compliance with national policies.

- Foster an exchange of information and experiences so that the countries can learn from each other and pursue proactive policy revisions as their markets evolve.

- Reduce barriers to trade and compliance complexity for importers and manufacturers.
- Develop a globally applicable prototype (informed by existing systems) that can be used to monitor various products, with an initial focus on refrigerators and air conditioners.

- Provide capacity building support to countries to implement the prototype within a national or regional framework.

Click here for **guidance on How to Set Up a Product Registration Database.**

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Annex

Annex: Guiding Questions to Assess the Current Status of a National RAC Sector MRV system for standardised products

1	Tier 1	Import, export, and consumption of HCFC and HFC have to be reported to the Montreal Protocol in kg/t of substance and CO_2eq. Describe how this data is assembled, using the following questions for guidance.	Comments	Self-contained ACs	Split ACs	Refrigera-tors	Stand-alone units	Cars with AC	Large vehicles with AC (busses, trucks)	Reference, source
1.1	What data is used for reporting to the Ozone Secretariat under Art. 7 of the Montreal Protocol?									
	Who is collecting the data? Who is the responsible ministry/department/contact person?									
	Based on which laws/regulations?									
	Who is collecting what data? Which occasions/ locations?									
	Who is reporting?									
	How often is data collected/aggregated?									
	How is the data stored and processed? (on paper, excel-based, other?)									
	What is the data flow? Please provide flowchart if possible.									
	What quality checks/controls do you perform?									

Annex: Guiding Questions to Assess the Current Status of a National RAC Sector MRV system for standardised products

1.2	Is the import and export of pre-charged refrigerating/cooling equipment monitored? E.g. refrigerant contained in refrigerators, moveable ACs, split ACs, small commercial equipment, vehicles, transport refrigeration systems		Comments	Self-contained ACs	Split ACs	Refrigerators	Stand-alone units	Cars with AC	Large vehicles with AC (busses, trucks)	Reference, source
	If yes:	What equipment is covered? How is the scope defined?								
		Who is responsible? (which Ministry, which department, contact person)								
		What is the legislative/regulatory basis for the monitoring?								
		Who is collecting what data? What occasions/locations?								
		Who is reporting?								
		How often is the dataset updated?								
		Where is the data stored? In which format?								
		What is the data flow? Please provide flowchart if possible.								
		Is the reporting mandatory or voluntary?								
		What review/QA/QC procedures are applied?								

Annex: Guiding Questions to Assess the Current Status of a National RAC Sector MRV system for standardised products

2	Tier 2 - standardised products									
2.1	Are refrigerating/cooling appliances registered?For what reason? Is the data used for monitoring? Monitoring of what? Is registering a pre-condition for putting on the market?		Comments	Self-contained ACs	Split ACs	Refrigera-tors	Stand-alone units	Cars with AC	Large vehicles with AC (busses, trucks)	Reference, source
	If yes:	What is the legislative/regulatory basis for the registration?								
		What equipment is covered? How is the scope defined?								
		What parameters are recorded?								
		Who is responsible? (which Ministry, which department, contact person)								
		Who is collecting what data at what occasions/ locations?								
		Where is the data stored? In which format?								
		Who is reporting?								
		Is the reporting mandatory or voluntary?								
		How often is the dataset updated?								
		What review/QA/QC procedures are applied? Is there any monitoring done on registered equipment? E.g. random testing? Other checks? How often? Where?								

Annex: Guiding Questions to Assess the Current Status of a National RAC Sector MRV system for standardised products

2.2	Is refrigerating/cooling equipment monitored when put on the market? E.g split ACs, refrigerators, ...Number of those put on the market could be determined by recording production, import and export numbers.		Comments	Self-contained ACs	Split ACs	Refrigera-tors	Stand-alone units	Cars with AC	Large vehicles with AC (busses, trucks)	Reference, source
	If yes:	What is the legislative/regulatory basis for monitoring?								
		What equipment is covered? How is the scope defined?								
		Is the reporting mandatory or voluntary?								
		Who is overall responsible? (which Ministry, which department, contact person)								
		Who is reporting?								
		Who is collecting what data? What occasions/locations?								
		Where is the data stored? In which format?								
		What is the data flow? Please provide flowchart if possible.								
		How often is the dataset updated?								
		What parameters are recorded?*								
		If EER and/or SEER are recorded, which standard is applied to define them?								
		What review/QA/QC procedures are applied?								

* Possible parameters: Price, Refrigerant used, Charge size (Refrigerant content on import), Cooling Capacity/Rated Capacity EER, SEER, Label class (if existing)

Annex: Guiding Questions to Assess the Current Status of a National RAC Sector MRV system for standardised products

2.3	Is the number of appliances in use monitored?		Comments	Self-contained ACs	Split ACs	Refrigera-tors	Stand-alone units	Cars with AC	Large vehicles with AC (busses, trucks)	Reference, source
	If yes:	What is the legislative/regulatory basis for the monitoring?								
		What equipment is covered? How is the scope defined?								
		Is the reporting mandatory or voluntary?								
		Who is responsible overall? (which Ministry, which department, contact person)								
		Who is reporting?								
		Who is collecting what data at what occasions/locations?								
		Where is the data stored? In which format?								
		How is the data flow? Please provide flowchart if possible.								
		How often is the dataset updated?								
		What parameters are recorded?								
		If EER and/or SEER are recorded, which standard is applied to define them?								
		What review/QA/QC procedures are applied?								

Annex: Guiding Questions to Assess the Current Status of a National RAC Sector MRV system for standardised products

2.4	What kind of statistics are available to deduct the number of appliances in use? How often are they updated? By whom?	Comments	General	Reference, source
	Number of households			
	Income strata of households			
	Living area of households			
	Building material of houses			
	Number of vehicles on the road by passenger car, bus, truck, etc.			
	Electrification			
	Urbanisation			
	Energy use per household			
	Number of refrigerators per household			
	Number of ACs per household			
	Average runtime of ACs			
	Refrigerants used (year of introduction in different sectors)			
	Average EER/SEER (time series development)			
	What review/QA/QC procedures are applied?			

Annex: Guiding Questions to Assess the Current Status of a National RAC Sector MRV system for custom-made products

3	Custom-made (engineered products)							
3.1	Is there any monitoring for the number of appliances in use? For which purpose? Monitoring or registration? E.g. customs, energy monitoring, refrigerant use monitoring, etc.		Comments	Large AC installations	Commercial refrigeration installation	Industrial refrigeration installation	Refrigerated trucks	Reference, source
	If yes:	What is the legislative/regulatory basis for the monitoring?						
		What equipment is covered? How is the scope defined?						
		Is the reporting mandatory or voluntary?						
		Who is responsible overall? (which Ministry, which department, contact person)						
		Who is reporting?						
		Who is collecting? What occasions/locations?						
		What parameters are recorded?						
		Where is the data stored? In which format?						
		What is the data flow? Please provide flowchart if possible.						
		How often is the dataset updated?						
		Is refrigerant use recorded?						
		If EER and/or SEER are recorded, which standard is applied to define them?						
		Is there a recording of energy used per year?						
		What review/QA/QC procedures are applied?						

Annex: Guiding Questions to Assess the Current Status of a National RAC Sector MRV system for custom-made products

3.2	What kind of statistics are available to deduct the number of appliances in use? How often are they updated? By whom?	Comments	General	Reference, source
	Floor space of cooled office buildings			
	Food production			
	Trade			
	Tourism (number of hotel beds, hotel categories)			
	Number of supermarkets			
	Number of refrigerated trucks			
	Energy use per sector			
	Refrigerants used (year of introduction in different sectors)			
	Average EER/SEER (time series development)			

Annex: Guiding Questions to Assess the Current Status of a National RAC Sector MRV system for custom-made products

4	Waste streams				
4.1	Are refrigerants or refrigerating/cooling appliances collected for recycling/ reclamation/destruction?		Comments	General	Reference, source
	If yes:	Are any of those activities monitored?			
		What is the legislative/regulatory basis for the monitoring?			
		Is the reporting mandatory or voluntary?			
		What equipment is covered? How is the scope defined?			
		Who is responsible overall? (which Ministry, which department, contact person)			
		Who is reporting?			
		Who is collecting what data? What occasions/locations?			
		Where is the data stored? In which format?			
		What is the data flow? Please provide flowchart if possible.			
		How often is the dataset updated?			
		What parameters are recorded?			
		Is the amount of collected refrigerant recorded?			
		Is the number of collected appliances recorded?			
		What review/QA/QC procedures are applied?			

Annex: Guiding Questions to Assess the Current Status of a National RAC Sector MRV system for standardised products

5	Quasi-constant parameters for standardised products	Comments	Self-contained ACs	Split ACs	Refrigera-tors	Stand-alone units	Cars with AC	Large vehicles with AC (busses, trucks)	Reference, source
	Are there appliance-specific statistics for average runtime, product life, refrigerant emission factors? How are they determined? By whom? How often? What are they used for?								
	Who are the stakeholders/experts that might know this? If possible, give names of sector experts who can provide realistic estimates of country-specific estimates								

Annex: Guiding Questions to Assess the Current Status of a National RAC Sector MRV system for custom-made products

6	Quasi-constant parameters for custom-made products	Comments	Large AC installations	Commercial refrigeration installation	Industrial refrigeration installation	Refrigerated trucks	Remarks, Reference source
	Are there appliance-specific statistics for average runtime, product life, refrigerant emission factors? How are they determined? By whom? How often? What are they used for?						
	Who are the stakeholders/experts that might know this? If possible, give names of sector experts who can provide realistic estimates of country-specific estimates						

Annex: Guiding Questions to Assess the Current Status of a National RAC Sector MRV system

7	Other	Comments	General	Reference, source
	Who is responsible for the F-gas reporting to the UNFCCC (Ministry, department, contact person)			
	What approach is taken?			
	What QA/QC procedures are followed?			

Glossary

AC	Air Conditioner
BSRIA	Building Services Research and Information Association
CO2	Carbon Dioxide
CO2-EQ	Carbon Dioxide equivalent
CFC	Chlorofluorocarbons
COP	Coefficient of Performance
EE	Energy Efficiency
EER	Energy Efficiency Ratio
EOL	End of Life
ERL	Energy Rating Label
F-GAS	Fluorinated Greenhouse Gas
GEF	Global Environment Facility
GHG	Greenhouse Gas
GIZ	German Corporation for International Cooperation
GWP	Global Warming Potential
HCFC	Hydrochlorofluorocarbons
HFC	Hydrofluorocarbons
HPMP	Hydrofluorocarbons Phase Out Management Plan
IEA	International Energy Agency
IEC	International Electrotechnical Commission
IPCC	Intergovernmental Panel on Climate Change
IPLV	Integrated Part Load Value
ISO	International Organization for Standardization
K-CEP	Kigali Cooling Efficiency Programme
KEMCO	Korean Energy Management Cooperation
MEPS	Minimum Energy Performance Standard
MLF	Multilateral Fund
MKE	Ministry of Knowledge Economy, Korea
MRV	Measurement, Reporting, Verification
MP	Montreal Protocol
NAMA	Nationally Appropriate Mitigation Action
NDC	Nationally Determined Contributions

Glossary

NOU	National Ozone Unit
NZ	New Zealand
ODP	Ozone Depletion Potential
ODS	Ozone Depleting Substance
PA	Paris Agreement
QA	Quality Assurance
QC	Quality Control
RAC	Refrigerant and Air Conditioning
SEER	Seasonal Energy Efficiency Ratio
TOR	Terms of Reference
U4E	United 4 Efficiency
UAC	Unitary Air Conditioning
UNEP	United Nations Environment Programme
UNDP	United Nations Development Programme
UMPE	Unidad de Planeación Minero Energética, Colombia
UNFCCC	United Nations Framework Convention on Climate Change
VRF	Variable Refrigerant Flow

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