



**Ministry of Tourism and Environment**  
Republic of Maldives

**Training Report on**

# **Hands-on Training for Estimating Greenhouse Gas Emissions from Non- Energy Sectors in Maldives**

Consultancy Services for a GHG Inventory Expert

**July 2025**

**CBIT Maldives**

Capacity Building for Improved Transparency  
of Climate Change Mitigation and Adaptation  
Actions in the Maldives



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# Report on Hands-on Training for Estimating Greenhouse Gas Emissions from Non-Energy Sectors in Maldives

15 July 2025 | Malé, Maldives

*Consultancy Services for a GHG Inventory Expert*

**Linked Project Deliverables:**

- Deliverable 1.2.5 – Workshop 4 of 4
- Deliverable 1.4.3 – Training 3 of 3

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Climate Change Mitigation and Adaptation Actions in  
the Maldives Project**





Ministry of Tourism and Environment

Capacity Strengthening for Improved  
Transparency of Climate Change Mitigation  
and Adaptation Actions in the Maldives  
Project (CBIT Maldives)



This document was developed under the project “Capacity Strengthening for Improved Transparency of Climate Change Mitigation and Adaptation Actions in the Maldives (CBIT Maldives)”, financed by the Global Environment Facility (GEF).

The project is executed by the Ministry of Tourism and Environment, with implementation support from the United Nations Environment Programme (UN Environment).

July 2025

Consultant:

Development Advisory Services Pvt Ltd

## Contents

<b>Executive Summary .....</b>	<b>4</b>
<b>1 Introduction .....</b>	<b>5</b>
<b>2 Objectives.....</b>	<b>6</b>
<b>3 Training Sessions .....</b>	<b>6</b>
3.1 Session 1 .....	6
3.2 Session 2 .....	6
<b>4 Participant Engagement &amp; Feedback .....</b>	<b>7</b>
<b>ANNEX 1: AGENDA .....</b>	<b>8</b>
<b>ANNEX 2: PARTICIPANT LIST .....</b>	<b>13</b>
<b>ANNEX 3: TRAINING MATERIALS FOR HAND-ON TRAINING FOR ESTIMATING GREENHOUSE GAS EMISSIONS OF NON-ENERGY SECTORS IN MALDIVES .....</b>	<b>16</b>
<b>ANNEX 4: PHOTOS OF HAND-ON TRAINING FOR ESTIMATING GREENHOUSE GAS EMISSIONS OF NON-ENERGY SECTORS IN MALDIVES .....</b>	<b>70</b>



## *Executive Summary*

As part of a consultancy project to develop guidelines and protocols for Greenhouse gas emission inventory, a hands-on-training workshop on GHG estimation for non energy sectors was held on 15<sup>th</sup> July 2025. The main objective of the workshop was to provide training on the use of guidelines and protocols for GHG emission estimation for non-energy sub-categories, including essential aspects such as data collection, emission calculation, and quality assurance and control (QA/QC) procedures.

The workshops were facilitated by GHG Inventory Expert, Mr. Zammath Khaleel. A total of 20 participants (12 Female and 8 Male) attended the workshop on hands-on training for estimating GHG emissions from non-Energy. Participants included representatives from the Maldives Bureau of Statistics, Utility Regulatory Authority, Maldives Customs Services, Maldives Water and Sewerage Company (MWSC), and the Waste Management Corporation (WAMCO). In addition, officials from the Climate Change Department, Ozone Unit, Air Quality Unit, Waste and Pollution Control Department, and Water and Sanitation Department of the Ministry also took part in the training.

The workshops were conducted in an interactive manner with presentations, sample calculations followed by hands on exercises. The sessions were designed to inform the audience on the data requirements for GHG estimation using the guidelines, protocols and tools and clarify any issues in regards to data collection, calculation and GHG inventory compilation.

This training workshop collectively fulfills the following project deliverables of the project;

- Deliverable 1.2.5: Four (4) workshop reports on GHG inventory compilation and maintenance of the database management system.
  - This workshop fulfilled the fourth and final of the four required workshops under this deliverable.
  - The first two workshops were conducted from 22nd to 24th January 2025, covering GHG inventory compilation and reporting (Day 1 and Day 2), and the third workshop was held on 14th July 2025.
- Deliverable 1.4.3: Three (3) training workshop reports on QA/QC plans
  - This workshop fulfilled the third and final of the three required QA/QC training workshops.
  - The first QA/QC training was conducted on Day 3 of the workshop held from 22nd to 24th January 2025, and the second was delivered on 14th July 2025.

# 1 Introduction

The Capacity Building Initiative for Transparency (CBIT) project of Maldives is aimed to strengthening institutional capacity for tracking mitigation and adaptation actions and establishing climate finance tracking system in the Maldives. It aims to establish and enhance the Maldives' transparency system, in line with Enhanced Transparency Framework (ETF) of Paris Agreement.

As part of the Maldives CBIT project, Development Advisory Services Pvt Ltd was recruited as consultants to Develop Guidelines and Protocols for Preparation of GHG inventory for Maldives. The main objective of the assignment is to develop nationally appropriate guidelines and toolkits to report GHG emissions in line with the Enhanced Transparency Framework (ETF) of the Paris Agreement.

The hands-on training on estimating GHG emissions from non-Energy was on 15th July 2025 to train key stakeholders of GHG estimation in non-energy sectors on the data requirements and estimating GHG emissions. This training covers data collection, data adaptation, emission calculation and compilation and reporting together with Quality Assurance and Quality Control process. Training workshop was divided into two sessions with hand-on exercises to ensure that the audience grasp and apply the highly technical knowledge included in the guideline.

The training began with opening remarks from Mr. Ali Shareef, Special Climate Envoy from Presidents office. In the hands-on training on estimating GHG for non-energy sector session 1 focused on general provisions of the GHG estimation guidelines while session 2 focused on non-energy categories relevant to Maldives which included 2 focused presentations and hands on exercise on industrial processes and product use and waste sectors. The sessions concluded with handing training completion certificates to the participants and closing statement from the Minister of State for Tourism and Environment, Mr. Ibrahim Mimrah.

This report is aimed to archive training material given on the workshop and record the feedback from the stakeholders. This report outlines as the following;

- **Objectives of the workshop:** the section includes the objectives of training workshop will be described.
- **Training sessions:** this section describes the training method and materials provided during the training period..

- **Engagement and Feedback:** this section captures the main discussions and recommendations made by the participants on the training sessions and materials

## 2 Objectives

The main objective of the training was to inform and build capacity of key stakeholders that would be engaged in estimating GHG emissions for non-energy sectors in Maldives, particularly emissions from use F-Gas as a substitute for Ozone depleting substances, solid waste management and waste water. The focused audience would be primary data providers, data aggregators and key sectoral agencies. The training would also serves to build awareness among the data providers and aggregators on how their data will be used in GHG estimation and reporting.

## 3 Training Sessions

The main focus of the workshop was to cover key aspects of estimating GHG emissions in key non-energy categories relevant to Maldives. The training was split into 2 sessions. The agenda for the training is included in annex

### 3.1 Session 1

Session 1 was focused on introducing the guideline with a focus on emission calculation and compilation. The presentation introduced GHG emissions and the importance of compiling national GHG inventory. The session introduced key concepts of GHG inventory including IPCC definitions of various emissions, main IPCC sectors, Global Warming Potentials (GWPs) and TACCC principles. Furthermore, the presentation goes over step by step on the inventory process of GHG inventory compilation introducing key processes like Key Category Analysis, data collection best practices. The presentation is included in the annex.

### 3.2 Session 2

This session was split into two presentations, estimating emissions from IPPU and estimating emissions from Waste. In the IPPU sector main focus was given on subcategory pertaining to use F-Gas as a substitute for Ozone depleting substances in refrigeration and cooling sector in Maldives. In waste, Municipal Solid Waste and Domestic Wastewater in different waste management streams were the focus of the presentation. Each presentation was followed by hands on exercise. The presentation covers introduction to subcategories to be reported under Enhanced Transparency Framework, including the relevance of

categories to the national context of Maldives. The training includes key definitions, emission sources, different methodological approaches for estimation and guidance on preparation of emissions inventory for reporting with a particular focus on reporting requirements under the Paris Agreement. More guidance was provided on potential data sources including proxy data and appropriating available data for use in emission calculation to improve completeness of the GHG inventory. Furthermore, detail guidance on data quality control for each subcategory of energy combustion and method and guidance on where to report different emission sources in accordance with the IPCC definitions. Training focused on differences in QC processes in different sectors and a need to have expert group for each main category for QC. The step-by-step example was provided to illustrate the emission calculation and reporting for ease of understanding. The hands on exercise for IPPU focused on the use of IPCC tool to calculate F-Gas emissions for a blended refrigerant. Exercise also entailed estimating emissions of individual F-Gases and aggregating the gases in CO<sub>2</sub> equivalent. The hands on exercise for waste sector centered around carrying out emissions calculation from waste generation to management. In both the hands-on activities the key focus was adapting the activity data for emission estimation and use of the IPCC tools and methods in estimating emissions from different sub-categories. For each hands-on exercise 1 hour were given to the participants followed by discussing the final results. The presentations and materials for hands on exercise is included in the annex.

## 4 Participant Engagement & Feedback

The participants were enthusiastically engaged with the information provided and clarified their understanding on the IPCC subcategories and definitions which differs from national definitions. The participants appreciated the local examples of data sources and step by step calculations and hands-on exercises as it allowed them to practically apply the guideline in actual GHG estimation. The key feedback on improvement future improvement of the training includes, further simplifying the concept descriptions, and including more examples of GHG calculation using local data and more guidance on use of IPCC software and ETF tool. In addition, participants also suggested additional data sources and possible ways to improve emission estimates which could be considered in the future GHG inventory. This includes improving factors used waste generation rate in Maldives and activity data sources for F-Gases uses.

## ANNEX 1: AGENDA



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### Hand-on training for estimating greenhouse gas emissions of non-energy sectors in Maldives

Date: 15th July 2025 | Venue: Meeruma

#### Overview and Objectives of the training

Estimating a greenhouse gas (GHG) inventory is crucial for the Maldives, a nation particularly vulnerable to climate change due to its low-lying geography. A comprehensive and accurate inventory enables policymakers to assess emissions sources, track progress towards climate commitments, and design effective mitigation strategies. Given the Maldives' commitment to international climate action, precise estimation ensures transparency, supports informed decision-making, and strengthens resilience against environmental changes.

Estimation tools play a key role in this process, providing structured methodologies for data collection, calculation, and reporting. These tools enhance efficiency, standardization, and accuracy in GHG inventory assessments, ensuring consistency with internationally accepted guidelines such as those of the Intergovernmental Panel on Climate Change (IPCC). Their application in the Maldives fosters data-driven climate policies and strengthens national capacity for emissions tracking. The estimation tools for this workshop covers key non-energy sources of greenhouse gases, namely Industrial Processes and Product Use and Waste sectors occurring in Maldives.

Furthermore, this workshop aligns with the United Nations Framework Convention on Climate Change (UNFCCC) Enhanced Transparency Framework (ETF), which emphasizes systematic reporting, verification, and improvement of national climate data. By mastering estimation tools, participants will contribute to the Maldives' ability to fulfil its reporting obligations under the Paris Agreement, thereby enhancing the credibility and effectiveness of national climate action.

A critical aspect of this training is the data collection, handling, quality control and assurance, GHG estimation and archiving for non-energy sectors. Proper management of inventory data ensures accuracy, accessibility, and continuity of information, which is essential for long-term climate planning. During hands-on exercises, participants will gain practical experience in collecting, processing (including QA/QC), estimating GHG and safeguarding data, ensuring it remains useful for future assessments and reporting.

This training workshop will provide both theoretical knowledge and practical application of tools used in GHG inventory estimation for Maldives. **The participants of the training are required to bring their laptop with the IPCC software and Microsoft Excel installed.** The IPCC software can be downloaded from the official website: [Inventory Software - IPCC-TFI](#). Participants who complete all sessions will receive a certificate of participation.

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Page 1 of 5





## Agenda

Participants Arrival and Registration	08:45 – 09:00
Opening Ceremony	09:00 – 09:10
<b>Group photo and Tea / Coffee break</b>	09:10 – 09:30
<b>Session 1: Introduction to GHG inventory process</b>	09:30 – 12:00
<ul style="list-style-type: none"> <li>• General guidelines, including IPCC methodologies</li> <li>• Introduction to IPCC inventory tools</li> <li>• Key category analysis for emission sources</li> </ul>	
Questions and Answers	
<b>Lunch</b>	
<b>Session 2: Non-Energy Sectors</b>	13:00 – 16:00
<ul style="list-style-type: none"> <li>• <b>Industrial Processes and Product Use (IPPU)</b> (Refrigerants)</li> <li>• Hands-on exercise: <i>HFC/PFC emission calculations including QA/QC</i></li> <li>• <b>Waste Sector</b> (waste combustion, wastewater)</li> <li>• Hands-on exercise: Solid waste and Methane emissions including QA/QC</li> </ul>	
Closing Ceremony	
<ul style="list-style-type: none"> <li>• Certificate Distribution</li> <li>• Closing Remarks</li> </ul>	
<b>Tea</b>	16:15

## Participants

1. Climate Department, Ministry of Tourism and Environment
2. Waste and Pollution Control Department, Ministry of Tourism and Environment
3. Ozone Unit, Ministry of Tourism and Environment
4. Water and Sanitation Department, Ministry of Tourism and Environment
5. Tourism Statistics Section, Ministry of Tourism and Environment
6. Water section of Utility Regulatory Authority (URA)
7. Ministry of Fisheries Marine Resources and Agriculture
8. National Bureau of Statistics
9. Maldives Customs Services
10. Waste Management Corporation
11. MWSC

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Page 2 of 5



## Background of the CBIT Maldives Project

Anthropogenic climate change is widely accepted as the most significant environmental challenge faced by the world in the 21st century. The Fifth Assessment Report (AR5) (2014) and the Global Warming at 1.5 °C (2018) special report by the Intergovernmental Panel on Climate Change (IPCC) confirm that climate change is an existential threat for low lying coral islands like Maldives. The Maldives is one of the most vulnerable countries for adverse impacts of global climate change.

Maldives' Nationally Determined Contribution (NDC) highlights food security, critical infrastructure, public health, water security, coastal protection, and coral reef biodiversity as key vulnerabilities of the country. In addition to these vulnerabilities, Maldives, like other Small Island Developing States (SIDS), face specific developmental challenges. They include high transportation and logistical costs, exploitation of natural resources, poor management of waste and pollution, and a small population leading to unsustainable economies of scale for different development agendas.

The 21st Conference of the Parties (COP21) was a key milestone for the international climate negotiations due to adoption of the Paris Agreement (PA), which came into force in 2016. Maldives was among the first countries to sign and ratify the PA in April 2016. One of the unique aspects of the PA is the contribution of both Annex 1 Parties and non-Annex 1 Parties in climate change mitigation and adaptation efforts in the form of NDCs. Article 13 of the PA outlines the transparency framework relating to the transparency of action and support. The main purpose of the transparency framework is to improve mutual accountability amongst the Parties in terms of their efforts for emissions reduction, adaptation efforts and support needed and received for addressing climate change.

Parties to the United Nations Framework Convention on Climate Change (UNFCCC) agreed on the Katowice climate package during the 24th Conference of the Parties (COP24) held in Katowice in December 2018. The Katowice climate package included eight guiding principles for the modalities, procedures and guidelines (MPGs) of the Enhanced Transparency Framework (ETF) under the PA, these include 1) Building on and enhancing the transparency arrangements under the Convention, recognizing the special circumstances of the Least Developed Countries (LDCs) and Small Island Developing States (SIDS), and implementing the transparency framework in a facilitative, non-intrusive, non-punitive manner, respecting

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Page 3 of 5



national sovereignty and avoiding placing undue burden on Parties; 2) The importance of facilitating improved reporting and transparency over time; 3) Providing flexibility to those developing country Parties that need it in the light of their capacities; 4) Promoting transparency, accuracy, completeness, consistency and comparability; 5) Avoiding duplication of work and undue burden on Parties and the secretariat; 6) Ensuring that Parties maintain at least the frequency and quality of reporting in accordance with their respective obligations under the Convention; 7) Ensuring that double counting is avoided; and 8) Ensuring environmental integrity. Furthermore, the ETF requires all Parties to compile national greenhouse gas (GHG) inventories and to report on the implementation of mitigation actions (tracking of NDC implementation) on a regular basis.

The Maldives is committed to meet the requirements of the ETF, despite of the flexibility provided for SIDS. There is need, therefore, for the Maldives to (i) establish a permanent institutional arrangement for GHG inventory compilation and tracking of NDC commitments, (ii) develop a centralized climate data management system for GHG data, tracking of mitigation actions, adaptation actions and support received and needed and (iii) develop tools and train experts to meet the enhanced transparency framework under the Paris Agreement.

This CBIT project has been developed with the objective of strengthening institutional capacity for tracking mitigation and adaptation actions and establishing climate finance tracking system in the Maldives. It aims to establish and enhance the Maldives' transparency system, in line with ETF of the PA. To achieve this objective, the following efforts are needed:

- (i) strengthening and formalizing long-term institutional arrangements.
- (ii) systemizing data collection and processing.
- (iii) developing indicators and advancing methodologies, as well as improving the overall data quality and management procedures, for preparing GHG inventories, tracking mitigation and adaptation actions and climate finance in an integrated manner. The final goal is to inform the national decision-making process as well as regularly report to the UNFCCC process.



The project includes two components:

- Component 1: The Maldives' National Greenhouse Gas (GHG) Inventory System improved.
- Component 2: The Maldives' Transparency Framework for mitigation and adaptation actions and resilience building, including tracking support for implementation.

Component 1 is designed to enable Maldives to meet the GHG inventory reporting requirements under the Modalities, Procedures and Guidelines (MPGs) outlined under the ETF of PA. Particularly, Chapter II of the MPGs contained in the annex of decision 18/CMA.1.

Component 2 is designed to meet the NDC tracking requirements of MPGs and both components are aimed to enable Maldives to submit the Biennial Transparency Reports (BTRs) in a timely and regular manner.

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Page 5 of 5



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Signing Sheet

Hands-on Training for Estimating Greenhouse Gas Emissions from Non - Energy Sector in Maldives  
Date: 15th July 2025

#	Institution	Name	Designation	Signature
1	Ozone Unit, <i>Air Quality Unit</i> Ministry of Tourism and Environment	Aminath Maiha Hameed	Senior Air Quality Management Officer	
2	Ozone Unit, Ministry of Tourism and Environment	Aishath Shuaila	Project Officer	
3	Waste and Pollution Control Department, Ministry of Tourism and Environment	Fathimath Siba	Program Officer	
4	Waste and Pollution Control Department, Ministry of Tourism and Environment	Fathimath Shamra	Senior Environment Analyst	
5	Waste and Pollution Control Department, Ministry of Tourism and Environment	Aishath Rashfa	Assistant Director	
6	Waste and Pollution Control Department, Ministry of Tourism and Environment	Fathimath Shafa-ath	Environmental Engineer	





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7	Water and Sanitation Department, Ministry of Tourism and Environment	Aishath Nafua	Environment Research Officer	
8	Climate Department, Ministry of Tourism and Environment	Ahmed Masoon	Programme Officer	
9	Climate Department, Ministry of Tourism and Environment	Juruath Abdulla Nafiz	Programme Officer	
10	Climate Department, Ministry of Tourism and Environment	Fathimath Raufa Moosa	Project Technical Coordinator	
11	Tourism Statistics Section, Ministry of Tourism and Environment	Aishath Maazza Fuad	Research Officer	
12	Tourism Statistics Section, Ministry of Tourism and Environment	Mohamed Sinan	Environment officer	
13	National Bureau of Statistics	Mariyam Shadeena	Deputy Statistician	
14	National Bureau of Statistics	Aishath Aniya	Statistical Officer	
15	Utility Regulatory Authority	Aminath Fizna	Senior Environment Analyst	
16	Utility Regulatory Authority	Afnan Ahmed	Environment Analyst	



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17	Male' Water & Sewerage Company (MWSC)	Ibrahim Akram	Regional Manager	
18	Male' Water & Sewerage Company (MWSC)	Mohamed Shaulan Sadiq	Water & Environmental Engineer	
19	Maldives Customs Services	Ali Tholhath	Chief Customs Officer	
20	Maldives Customs Services	Abdulla Hameed	Senior Customs Officer Grade 2	
21	Maldives Customs Services	Mohamed Ilyas	Senior Customs Officer Grade 1	
22	Waste Management Corporation	Aminath Shafrath Adam	Environment & Social Safeguard Specialist	
23	Waste Management Corporation	Ali Huzam Saeed	Manager	
24	Waste Management Corporation	Ibrahim Sinan	Senior Operations Officer	
25	Wameco	Ishaq Mohamed	Env. social Safeguard Officer	
26				

## ANNEX 3: TRAINING MATERIALS FOR HAND-ON TRAINING FOR ESTIMATING GREENHOUSE GAS EMISSIONS OF NON-ENERGY SECTORS IN MALDIVES

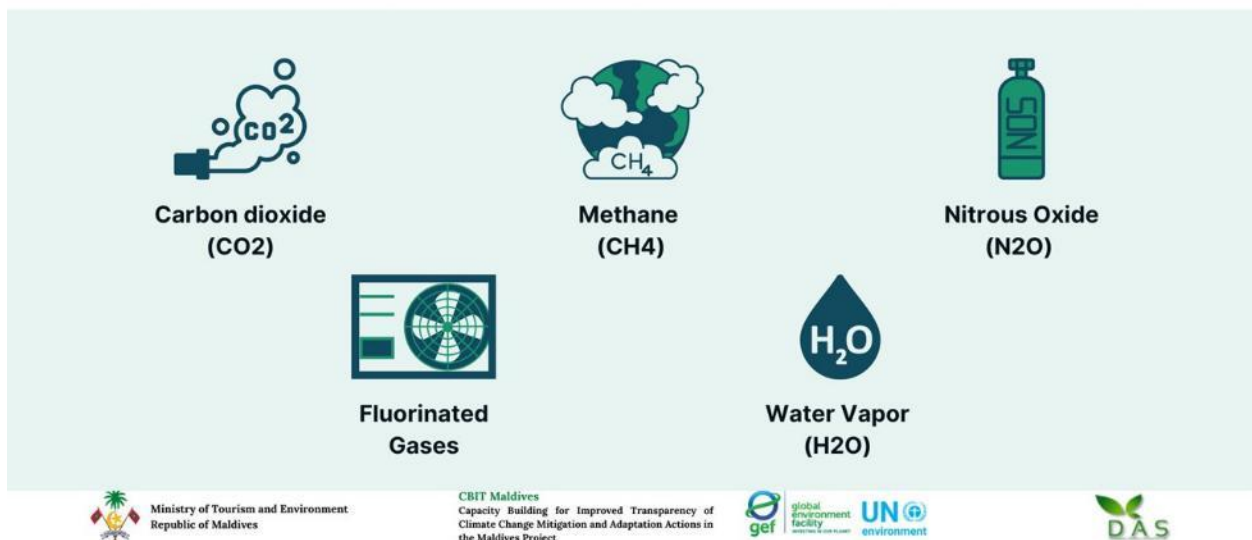
# Introduction to GHG Inventory and Planning



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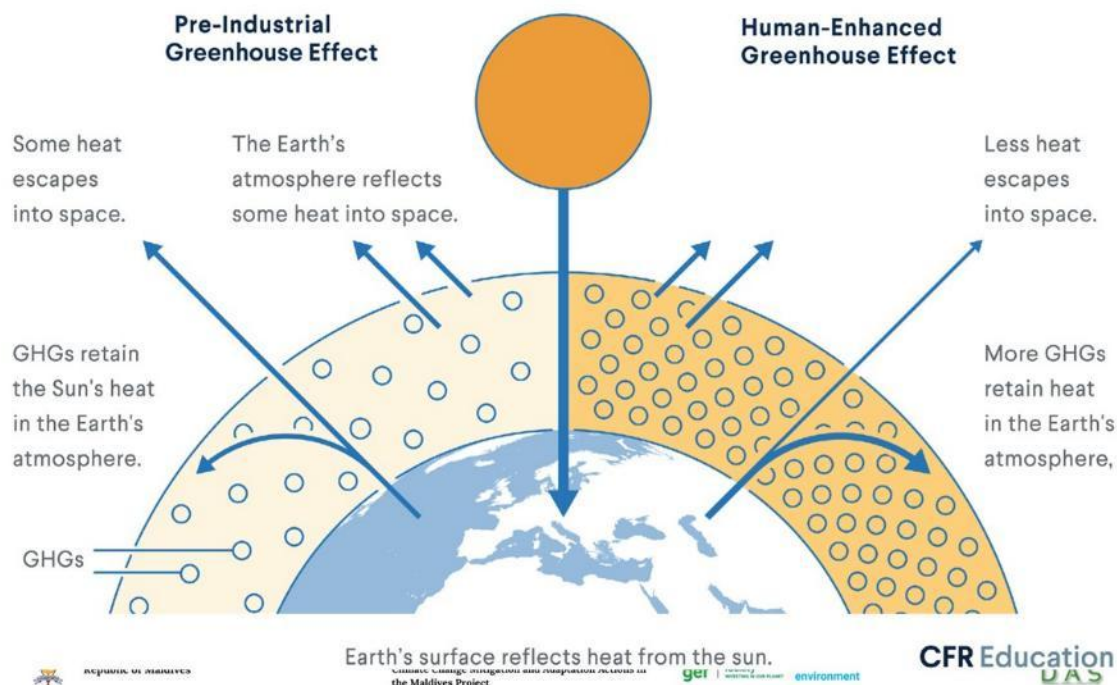


## What are greenhouse gases



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## What are the key sources of GHGs?



**Fossil Fuel Use** – Burning coal, oil, and gas for electricity, heating, and transportation releases CO<sub>2</sub> and other GHGs.



**Industrial Production** – Energy-intensive industries like steel, cement, and chemical production emit significant GHGs.



**Agriculture** – Livestock farming, deforestation, and synthetic fertilizers release CH<sub>4</sub> and N<sub>2</sub>O.



**Deforestation** – Clearing forests reduces carbon sinks while releasing stored CO<sub>2</sub> into the atmosphere.



**Waste Management** – Landfills produce CH<sub>4</sub> from decomposing organic waste, while incineration emits CO<sub>2</sub> and pollutants.



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# Why are GHG inventories important for the Maldives?



- Reporting obligations under the UNFCCC
  - Meet requirements of the Enhanced Transparency Framework (ETF) of the Paris Agreement
  - National Inventory Report
  - Track Progress of NDC
- Emissions reduction and carbon markets
  - Carbon Budget submission

Important Tool Planning and informed decision making



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## Existing Methodologies and Guidances



- 1996 IPCC Guidelines
- Revised 1996 IPCC Guidelines
- IPCC GPG 2000
- GPG-LULUCF
- **2006 IPCC Guidelines**
- IPCC Wetlands Supplement
- IPCC KP supplement
- **2019 Refinement Guidelines**



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# GHG Inventory concepts

- **Anthropogenic emissions and removals:** These are greenhouse gas emissions and removal processes, stemming from human activities.
- Anthropogenic activities that emit GHGs to the atmosphere in the Maldives include (not limited to):
  - Combustion of fossil fuels to produce energy.
  - Agricultural activities such as farming and crop production.
  - Deforestation.
  - Burning of waste and decomposition of organic waste in landfills.
- Although not entirely relevant to the context of the Maldives, some anthropogenic interventions that can remove carbon dioxide from the atmosphere include:
  - Afforestation
  - Reforestation
  - Carbon Capture and Storage



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# GHG Inventory concepts

- **Greenhouse Gases:** The greenhouse gases covered depend on the national context and key category analysis. Based on previous inventories and assessments, the following three gases are the most relevant to the Maldives:
  - Carbon dioxide (CO<sub>2</sub>)
  - Methane (CH<sub>4</sub>)
  - Nitrous oxide (N<sub>2</sub>O)
  - F-Gases
- **Sectors and Categories:** Greenhouse gas emission and removal estimates are categorized into primary sectors, each encompassing related processes, sources, and sinks [1]. These sectors are:
  - Energy
  - Industrial Processes and Product Use (IPPU)
  - Agriculture, Forestry, and Other Land Use (AFOLU)
  - Waste
  - Other (e.g., indirect emissions from nitrogen deposition originating from non-agricultural sources)
- Each sector includes individual categories (e.g., transport) and sub-categories (e.g., cars). Inventories are typically built starting from the sub-category level, following IPCC methodologies, and aggregated to calculate national totals.
- Emissions from international transport (ships and aircraft) are reported separately and not included in national totals.



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## GHG Inventory concepts

- **Global Warming Potential (GWPs):** GWP is a metric that compares the radiative forcing of a metric ton of a particular greenhouse gas over a specified time-period (e.g., 100 years) to the radiative forcing of a metric ton of CO<sub>2</sub> over the same period [1].

Global Warming Potential (GWP <sub>100</sub> )		
CO <sub>2</sub>	CH <sub>4</sub>	N <sub>2</sub> O
1	28	265



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## GHG Inventory Concepts (others)

- **National Territory:** GHG emissions and removals reported in the national inventory must occur within the national territory.
- **Inventory Year and Time Series:** National inventories report GHG estimates for the year of emissions or removals. In cases of incomplete data, estimation methods like averaging or extrapolation can be used. Countries are encouraged to maintain consistent time series data.
- **Inventory Reporting:** A national inventory report consists of two components: standardized reporting tables covering all relevant gases, categories, and years, and a written report detailing the methodologies and data used to generate estimates. The ETF's Common Reporting Formats (CRFs) must be followed to meet Paris Agreement obligations.



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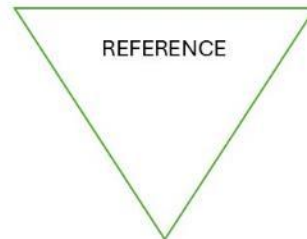


## Reference Approach vs Sectoral approach

Bottom-up approach, which gives a Breakdown emissions by specific sectors (e.g., transportation, industry).



Top-down Approach, using a country's energy supply data to calculate emissions



Within 5%



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## REFERENCE APPROACH VS SECTORAL APPROACH

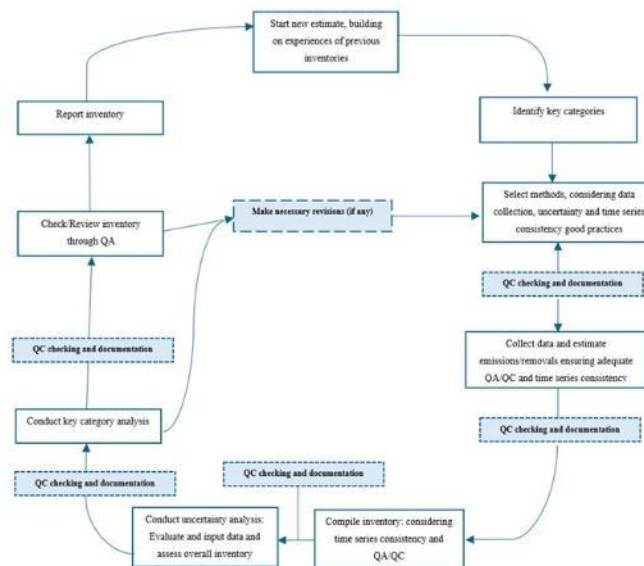


12

# TACCC principles

- **Transparency:** Assumptions and methodologies should be clearly explained and documented
- **Accuracy:** Emission and removal estimates should be neither over nor under the true values
- **Consistency:** Inventories should be internally consistent with previous years' inventories
- **Completeness:** Inventories should be complete
- **Comparability:** Inventories should be comparable

## Overall Inventory Development Process



# INVENTORY PROCESS



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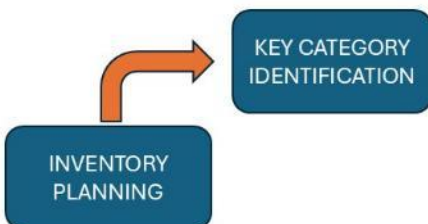


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# INVENTORY PROCESS



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# Key Categories

A key category is one that is prioritized within the national inventory system because its estimate has a significant influence on a country's total inventory of greenhouse gases in terms of the absolute level, the trend, or the uncertainty in emissions and removals. Whenever the term key category is used, it includes both source and sink categories.

- For a new inventory, make rough estimates based on previous knowledge of activities, emission sources, and experience with similar inventories.
- For continuing inventories, use the last national inventory to carry out Key category analysis
- Where quantitative analysis is not feasible, due to incomplete data, qualitative assessments may be done
- The IPCC provides **two approaches** to conduct key category analysis: both focused on identifying key categories based on their contributions to the **absolute level** and **trend** of emissions and removals.



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## Key category analysis

### Level assessment

Key categories are the ones that, when added together in descending order of magnitude, account for 95 percent of the total level of emissions and removals.

### Trend assessment

Key categories are those whose trend most significantly diverges from the overall trend

IPCC code	Category	Greenhouse gas	2011 Level	2022 Level	2022 Trend
1.A.4	Other Sectors - Liquid Fuels	CO <sub>2</sub>	X	X	X
1.A.1	Energy Industries - Liquid Fuels	CO <sub>2</sub>	X	X	X
1.A.3.d	Water-borne Navigation - Liquid Fuels	CO <sub>2</sub>	X	X	X
1.A.3.b	Road Transportation - Liquid Fuels	CO <sub>2</sub>	X	X	X
1.A.3.a	Civil Aviation - Liquid Fuels	CO <sub>2</sub>	X	X	X
1.A.3.e	Other Transportation - Liquid Fuels	CO <sub>2</sub>	-	-	X
4.C	Incineration and Open Burning of Waste	CH <sub>4</sub>	X	X	X



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# Qualitative Criteria for Key Category Analysis

Where quantitative analysis is not feasible, due to incomplete data, qualitative assessments may be done

<b>Mitigation Impact</b>	<ul style="list-style-type: none"><li>• Prioritize categories where emissions have decreased or removals increased due to mitigation efforts, ensuring transparency in assessment methods.</li></ul>
<b>Anticipated Growth</b>	<ul style="list-style-type: none"><li>• Identify categories likely to see rising emissions or declining removals, using expert judgment as needed.</li></ul>
<b>Uncertainty Reduction</b>	<ul style="list-style-type: none"><li>• Focus on categories with significant uncertainty, even if not using Approach 2. Improving estimates in high-uncertainty areas will enhance inventory accuracy.</li></ul>
<b>Completeness Assurance</b>	<ul style="list-style-type: none"><li>• For incomplete inventories, assess key categories qualitatively, prioritize data collection based on preliminary estimates, and consult inventories of similar countries for guidance.</li></ul>



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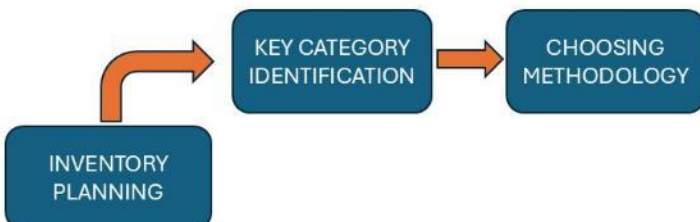


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# Choosing Methodologies

There are **three methodological tiers (Tier 1, Tier 2 and Tier 3)** that may be used for GHG inventories

A tier **represents the level of complexity and effort required to estimate GHG emissions** and removals.

Higher-tier methodologies generally provide more accurate estimates, but they require detailed and high-quality data, which can be resource-intensive to collect.

The **choice of tier is dependent on the country context, availability of resources and data.**



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## Methodological Tiers

	Estimation Method	Example of Data collection required
Tier 1 - Basic	Emissions = Default Emission factor x National Activity data (aggregated)	Total Fuel combusted for electricity generation
Tier 2 - Intermediate	Emissions = Country Specific emission factor x Specific activity data	Fuels combusted for electricity generation together with the average combustion rates of the technology used
Tier 3 - Advanced	Emission measurements or models to estimate emissions accurately	Stack emissions for all the power houses

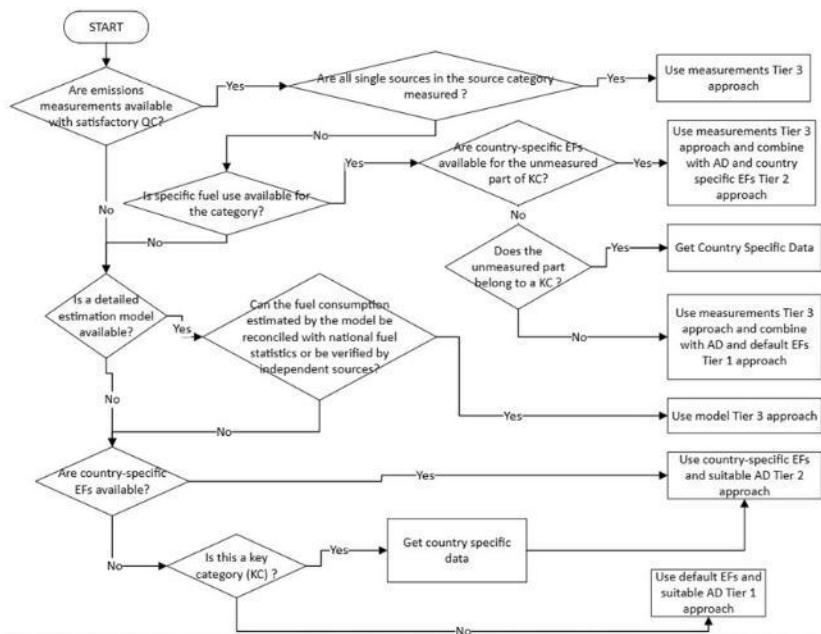


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The step-by-step guide to choosing the right methodology (Tier)



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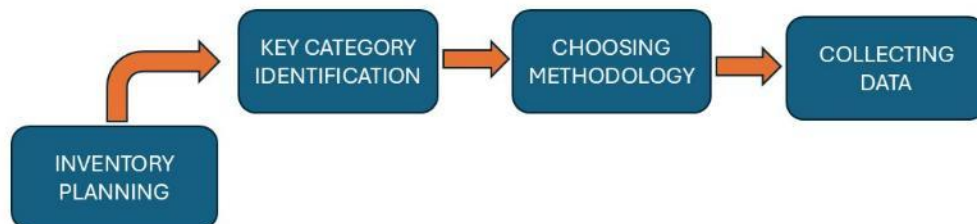


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# Best Practices in Data collection

- Prioritize **collecting data that enhances estimates for the most significant key categories**, considering their contribution, potential for change, and uncertainty.
- Choose data collection methods that **progressively enhance inventory quality**, aligning with data quality goals.
- Establish data collection practices (such as resource allocation, planning, documentation) that **continuously enhance the inventory data**.
- Gather **data at an appropriate level of detail** based on the chosen method.
- **Regularly review data collection activities** and methodological requirements to drive ongoing and efficient inventory improvement.
- **Establish agreements with data providers** to ensure consistent and continuous information flow.



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## Collecting data

- Recommended existing data source prioritization
  - National Statistical Agencies – Maldives Bureau of Statistics, MCS
  - Sectoral Experts/Government Agencies – URA, MOT, MPL . . .
  - Other National Experts –consultants
  - IPCC EFDB
  - International Organizations – World Bank, FAO
  - Historical references – FNC, SNC, BUR, Carbon Audit 2009
  - Academia – MNU
  - Inventory Reports of other similar countries

Source	Type of Activity Data
Maldives Customs Services	Fuel import/export data
State Trading Organization (STO)	Fuel import/export/stock data
Fuel Supply Maldives	Fuel import/export/stock data
Maldives Gas	Fuel import/export/stock data
Villa Hakatha	Fuel import/export/stock data
Villa Gas	Fuel import/export/stock data
Hawks Pvt Ltd	Fuel import/export/stock data
Meridiam Services	Fuel import/export/stock data
Asian Gas and Oil and Coastal Blocks	Fuel import/export/stock data
Hakatha One	Fuel import/export/stock data
Fuel Express Maldives	Fuel import/export/stock data
Maldives Airports Company Limited	Fuel stock/consumption data
Regional Airports	Fuel stock/consumption data
STELCO	Fuel Consumption Data
FENAKA	Fuel Consumption Data
MWSC	Fuel Consumption Data
Utility Regulatory Authority (Previously MEA)	Fuel Consumption data
Resorts	Fuel Consumption data and bed-nights or occupancy data
MIFCO	Fuel Consumption Data
MPL including Regional Ports	Fuel Consumption Data
MNDF/MPS	Fuel Consumption Data
Horizon Fisheries	Fuel Consumption Data
Ministry of Transport/ Transport Authority	Vehicle/vessel registry data
Ministry of Fisheries	Data on fishing trips/vessels
Ministry of Tourism	Bed nights/occupancy rates
Maldives Bureau of Statistics	Demography and socio-economic data/indices



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## Collecting data

- Conduct an **initial screening of existing data** sources through a literature review
- If officially published data is unavailable, **formal requests should be sent to relevant agencies and stakeholders**, clearly specifying requirements to ensure the data meets expectations
- These **requirements** include:
  - **Define the data set** including the disaggregation, time series, details about sectors and sub-sectors, national coverage, requirements for uncertainty data, emission factors, and units of activity data
  - **Define the format** (e.g., spreadsheet) and the structure of the data set
  - Include **descriptions of the assumptions** made in the data sets
  - **Specify how often the data set is updated** and which elements are updated
  - Documentation and QA/QC Procedures
  - Contact Information



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## Generating new data

- Generating new data may become necessary **when representative emission factors, activity data, or other estimation parameters are unavailable**
- To optimize resources, **new data should be generated as an extension of existing programs rather than through entirely new initiatives.**
  - Example rather than have an independent survey incorporate new question into existing surveys like HIES, Census, Waste Accounting etc
- Before deciding on a new survey, three key steps should be taken



### Review Available Data

- Assess existing data systems
- Identify planned surveys
- Published data usually stem from detailed datasets that can be restructured for inventory purposes

### Explore Administrative Sources

- Consider using administrative records, which can be adapted to inventory purpose on a lower cost

### Incorporate New Questions or Modules into existing surveys

- Adding questions to existing surveys is often more cost effective than launching standalone surveys



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# Adapting data for Estimation

- **Filling Gaps in Periodic Data**
  - When data collection intervals not aligning with annual inventory cycle (example waste audit data)
- **Time Series Revision**
  - when the data provider revises their historical data (example: data reconciliation process leading historical value revisions)
- **Incorporating Improved Data**
  - When new and improve data is available allowing higher tier estimated
- **Incomplete Coverage**
  - When data do not fully represent the entire country. Proxy data can be used to extrapolate (example use of bed nights to estimate fuel use in resorts)



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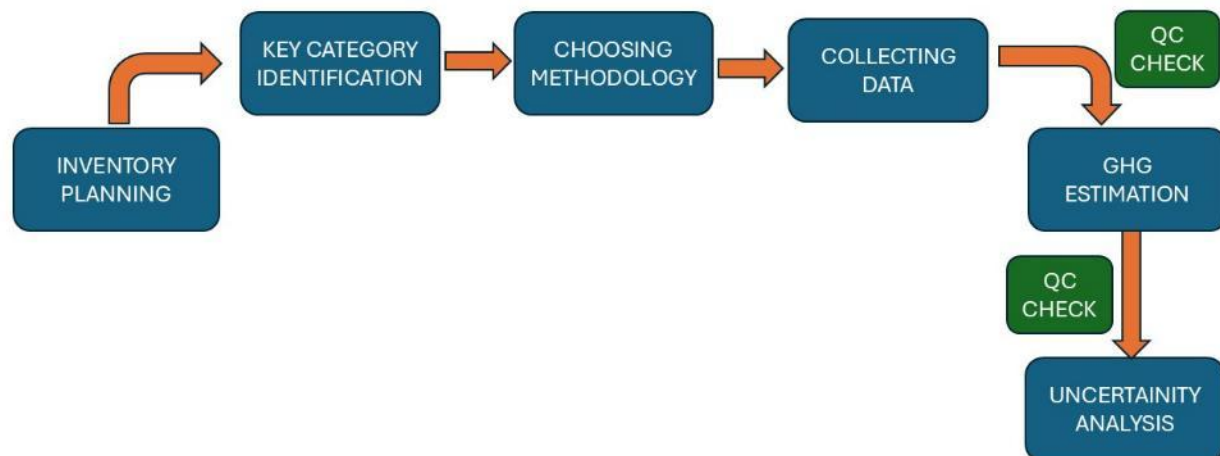
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# Basis GHG Estimation



$$\text{Emissions} = \text{Activity Data (AD)} \times \text{Emission Factors (EF)}$$



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## Choosing Emission Factors



- In the absence of country-specific peer-reviewed studies in the Maldives, IPCC default emission factors and Tier 1 methods are appropriate for estimating greenhouse gas emissions.
- The **Emission Factor Database (EFDB)** is a continuously updated web-based platform that facilitates information exchange on emission factors and related parameters.
- Experts and researchers can access the EFDB via the IPCC or IPCC-NGGIP websites, or directly at <http://www.ipcc-nggip.iges.or.jp/EFDB/main.php>.
- The platform enables experts to share new emission factors globally, enhancing collaboration and improving inventory assessments.

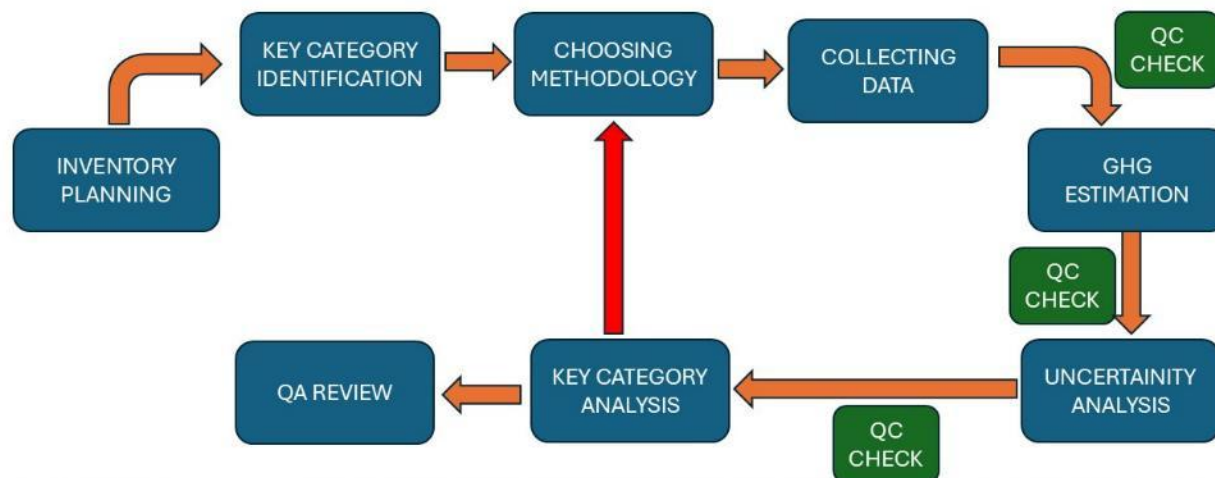


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## QA Review: Completeness check (Notation Keys)

- Notation keys **provide essential information on emission estimates** or removals that are incomplete, partial, or need clarification
- They **enhance the transparency** and help stakeholders **interpret the data, ensuring that specific emissions or removal are understood within their context**

Notation Key	Definition
NO	(Not occurring) for activities or processes in a particular source or sink that do not occur within a country
NE	(Not estimated) for existing emissions by sources and removals by sinks of greenhouse gases which have not been estimated.
NA	(Not applicable) for activities in a given source/sink category that do not result in emissions or removals of a specific gas.
IE	(Included elsewhere) or emissions by sources and removals by sinks of greenhouse gases estimated but included elsewhere in the inventory instead of the expected source/sink category. Where "IE" is used in an inventory, the country should indicate, using the CRF completeness table (CRT 9?) where in the inventory the emissions or removals from the displaced source/sink category have been included and explain why they have placed these emissions or removals in a different category.
C	(Confidential) for emissions by sources and removals by sinks of GHGs where the reporting would involve the disclosure of confidential information
FX	(Flexibility) for cells where data are not available or reported because of a flexibility provision applied by a country that needed flexibility in the light of its capacity.



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## QA Review: Completeness check (Units)

- **Consistency of Units:**
  - Emissions and removals should be expressed in mass units consistently within each sector.
- **Preferred Unit:**
  - Generally, emissions in summary and sectoral tables are expressed in gigagrams (Gg), but other SI mass units may be used for increased transparency.
- **Appropriate Significant Digits:**
  - The number of significant digits in reported values should be appropriate to their magnitude. A precision of 0.1 percent of the national total is considered adequate for each gas.
- **CO<sub>2</sub> Equivalents:**
  - For certain gases specified in individual sector tables, emissions and removals should be reported in terms of carbon dioxide equivalents (CO<sub>2</sub>e), which accounts for their global warming potential.
- **Transparency in Conversion Factors:**
  - All conversion factors used to convert data from original units to the chosen reporting units should be documented transparently.



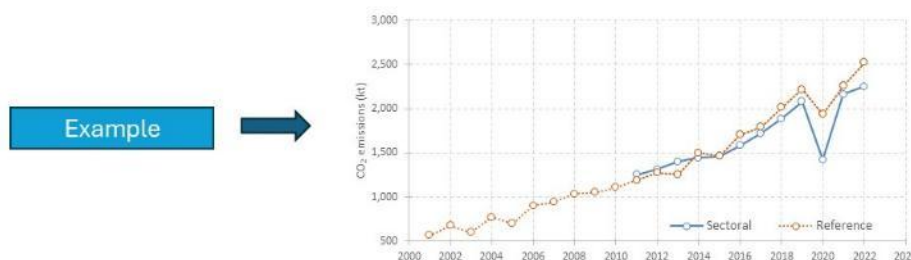
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## QA review: Completeness check (time series)

- It is **considered good practice to ensure that all reporting tables are complete for each year** including
  - Summary table,
  - Sectoral table, and
  - cross-sectoral tables
- **Create trend tables/graphs** that summarize aggregated inventory data from different years.



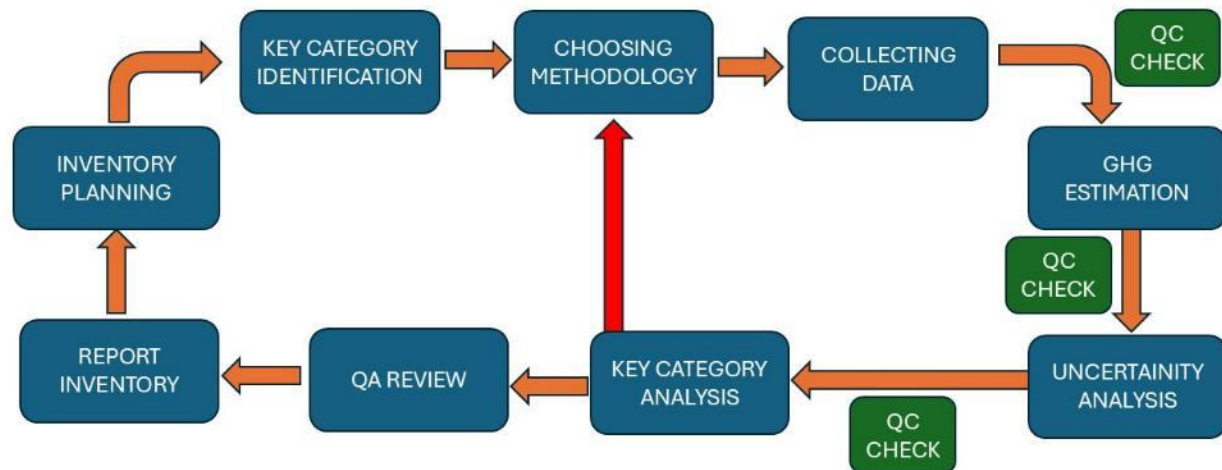
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## GHG Inventory Reporting: CRT Tables

- CRT tables are a set of tables that all Parties to the Paris Agreement will be required to use, starting in 2024, to report their national GHG inventories to the UNFCCC

The image displays three sample CRT tables. The first table, 'Sectoral Background Tables', is an orange-colored table with multiple columns and rows. The second table, 'Sectoral Report Tables', is a green-colored table with multiple columns and rows. The third table, 'Summary / Cross-sectoral / Trends Tables', is a blue-colored table with multiple columns and rows.



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# GHG Inventory Reporting – Archiving

- **Use of IPCC Inventory Software:**

- The inventory is established using the IPCC inventory software, which ensures standardized and consistent calculations. This software also includes data backup features, contributing to data security.

- **Excel Sheets for Data Storage:**

- sector-specific data, raw and processed data are stored in Excel sheets.

- **Documentation and Comments:**

- the commenting feature in the IPCC software is utilized to input remarks in relevant fields. These comments serve as a valuable resource for maintaining continuity and improving the inventory in the future.

- **Centralized Data Storage:**

- all datasets used for inventory preparation are centrally archived at the Ministry

- **Cloud Storage for Redundancy:**

- This ensures data integrity and minimizes the risk of data loss.



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# ESTIMATING EMISSIONS – INDUSTRIAL PROCESSES & PRODUCT USE

JANUARY 23, 2025  
PREPARED BY: DEVELOPMENT ADVISORY SERVICES



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## INTRODUCTION

- The Industrial Processes and Product Use (IPPU) sector accounts for greenhouse gas emissions generated through industrial activities.
- Source categories under IPCC
  - 2A. Mineral Industry
  - 2B. Chemical Industry
  - 2C. Metal Industry
  - 2D. Non-Energy Products from Fuels and Solvent Use
  - 2E. Electronic Industry
  - 2F. Product Uses as Substitutes for Ozone Depletion Substances (ODS)
  - 2G. Other Product Manufacture and Use
- **Most relevant to Maldives is Product Uses as Substitutes for Ozone Depletion Substances (ODS)**
- Hydrofluorocarbons (HFCs) have are widely used in refrigeration and air conditioning equipment
- HFCs are commonly used as alternatives to ozone-depleting substances (ODS) in cooling systems across our resorts, residential buildings, and fish processing facilities



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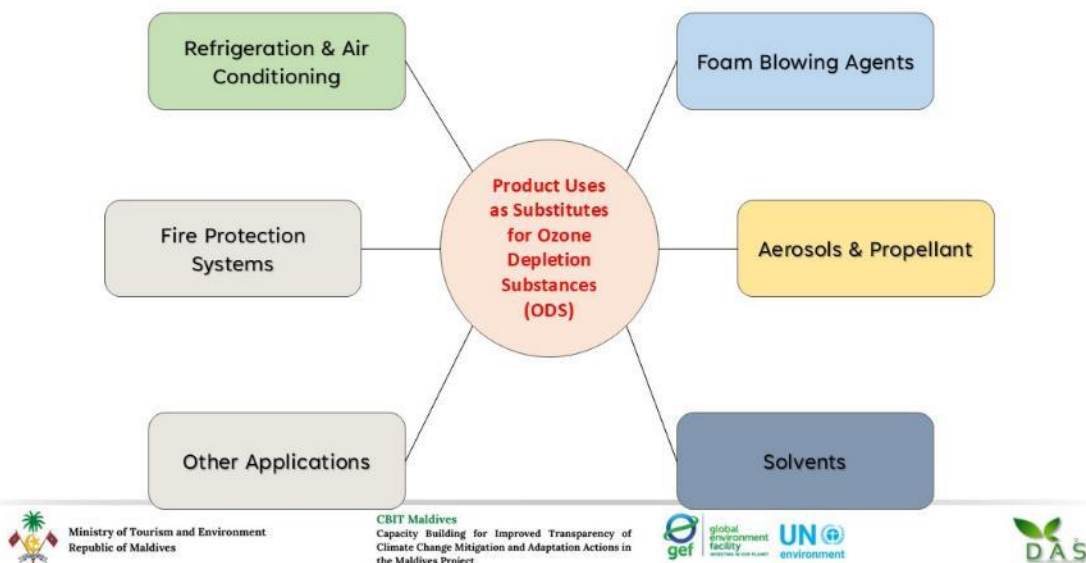


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## INTRODUCTION



## METHODOLOGICAL APPROACHES

- Two approaches, Emissions Factor approach and Mass Balance approach
- Mass Balance approach - based on the principle of conservation of mass, where the total amount of a chemical entering a system must equal the amount stored, consumed, or emitted.
- This method follows the chemicals from their import into the country through their life cycle in various equipment and systems.
  - Chemical Consumption: Tracking the amount of chemicals (e.g., HFCs, PFCs) purchased or produced.
  - Equipment Stocks: Monitoring changes in the inventory of equipment that contains these chemicals (e.g., air conditioners, refrigerators, or industrial systems).
  - Emissions Calculation: Emissions are derived by accounting for the difference between the chemicals added to the system and those stored or destroyed. For example, if a certain amount of refrigerant is added to equipment but not recovered during maintenance or disposal, the difference is assumed to have been emitted

## METHODOLOGICAL APPROACHES

- Emission Factor approach - calculate emissions by combining data on quantity of chemical stored in equipment (chemical bank) and predefined emission factors, which represent the rate at which these chemicals are released into the atmosphere
- Chemical Banks: Estimating the total amount of chemicals stored in equipment or products (e.g., refrigerants in air conditioners, foam blowing agents in insulation). Banks are the amounts of chemical that have accumulated throughout the lifecycle, either in supply chains, products, equipment or even waste streams but which, as of the end of the most recent year, has not been emitted.
- Emission Factors: Using predefined factors that describe the fraction of the chemical bank emitted annually. These factors are often based on empirical data, such as leakage rates from equipment or release rates during product use or disposal.
- Emissions Calculation: Emissions are calculated by multiplying the size of the chemical bank by the appropriate emission factor. For example, if a country has 1,000 tons of HFCs stored in refrigeration systems and the emission factor is 5% per year, the annual emissions would be 50 tons.



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## CHOICE OF TIERS

- Three Tier approaches available
- **Tier 1** approach uses aggregated data and simpler calculations, making it suitable for countries with limited data availability.
- **Tier 2** method requires detailed, disaggregated data for more precise calculations
- **Tier 3** involves direct measurement of emissions from point source which is rarely carried in ODS.
- In more practical terms, **Tier 1** and **Tier 2** are **commonly used**



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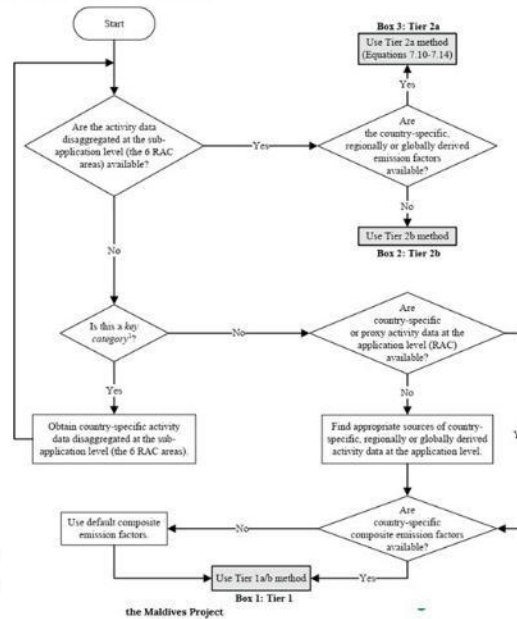


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## DECISION TREE FOR TIERS



## COMPARISON OF APPROACH AND TIER

### Data requirements for both approaches

	Approach A (emission-factor approach)	Approach B (mass-balance approach)
<b>Tier 1 (emission estimation at an aggregated level)</b>	<ul style="list-style-type: none"> <li>Data on chemical sales by application [country-specific or globally/regionally derived]</li> <li>Emission factors by application [country specific or (composite) default]</li> </ul>	<ul style="list-style-type: none"> <li>Data on chemical sales by application [country-specific or globally/regionally derived]</li> <li>Data on historic and current equipment sales adjusted for import/export by application [country-specific or globally/regionally derived]</li> </ul>
<b>Tier 2 (emission estimation at a disaggregated level)</b>	<ul style="list-style-type: none"> <li>Data on chemical sales and usage pattern by sub-application [country-specific or globally/regionally derived]</li> <li>Emission factors by sub-application [country-specific or default]</li> </ul>	<ul style="list-style-type: none"> <li>Data on chemical sales by sub-application [country-specific or globally/regionally derived]</li> <li>Data on historic and current equipment sales adjusted for import/export by sub application [country-specific or globally/regionally derived]</li> </ul>

## TIER 1 APPROACH

- Tier 1 method is simpler and looks at emission estimates carried out at the application level rather than the individual products or equipment or at sub-application level.
- Tier 1 is sometimes used as Tier 1a and Tier 1b approaches or as a combination of both depending on the data availability
- The following formula can be used

$$\text{Annual Emissions} = \text{Net Consumption} \times \text{Composite EF}$$

- If banked chemical information is used, it can be modified as follows

$$\text{Annual Emissions} = \text{Net Consumption} \times \text{Composite EF}_{FY} + \text{Total banked chemical} \times \text{Composite EF}_B$$

- Where:

$$\text{Net Consumption} = \text{Production} + \text{Imports} - \text{Exports} - \text{Destruction}$$

Composite  $\text{EF}_{FY}$  is composite emission factor for the application for first year

Total banked chemical is the bank of the chemical for the application

Composite  $\text{EF}_B$  is composite emission factor for the application of bank



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## TIER 2 APPROACH

- Tier 2 approaches analyze emissions for specific chemicals and equipment types within each sub-application category
- This approach requires to establish a comprehensive consumption baseline for emission calculations by monitoring chemical use in distinct applications such as household refrigerators, various stationary cooling equipment, foam materials in appliances, building insulation panels, pipe insulation systems, and other relevant product categories
- Emissions are estimated through one of two methodologies:
- The emissions factor approach (Tier 2a), applies specific emission factors that account for the distinctive release patterns associated with different processes, products, and equipment types.
- Alternatively, mass balance approach (Tier 2b) method employs a mass-balance approach that incorporates detailed information about new equipment installations and retiring units at the sub-application level to track the movement of chemicals throughout their lifecycle



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## TIER 2 APPROACH

- In the Tier 2a, emissions calculations breaks down emissions into multiple phases: initial filling (installation), annual leakage during operation, losses during maintenance (servicing), and releases when equipment reaches end-of-life (decommissioning).
- Each of these stages can have its own specific emission factor, making this approach much more detailed and reflective of real-world conditions. It also explicitly tracks the 'bank' — the amount of gas already installed in equipment from prior years — to account for legacy emissions.
- This method, while more complex, provides a more accurate long-term emissions estimate, especially for equipment with long service lives
- In the Tier 2b, emissions are calculated based on the net amount of gas consumed during the year and applies a single, representative annual emission factor (leak rate) for each product type.
- This approach assumes that all equipment of a certain type leaks at the same average rate, combining installation, operational, servicing, and disposal leaks into a single value
- **Using a Tier 2a approach is the recommended method for Maldives**



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## CHOICE OF EMISSION FACTORS

- Choice of emission factor depends on how similar the products are within each category, the calculation method being used, how local practices affect leakage rates, how chemicals accumulate over time, and any unique national circumstances
- Since Tier 1 methods work at the broader application level, they require composite emission factors. These can be created by taking weighted averages of known emission factors from more specific sub-categories, or by using tested estimation approaches (country specific or default)
- For Tier 2 methods, it is vital to understand the specific conditions affecting the countries sub-applications.
- While products and equipment may be similar worldwide, emission factors can vary significantly throughout a product's lifetime due to climate differences, building practices, regulations, and especially servicing methods.
- Particularly important is how products are disposed of at the end of their useful life, since this can dramatically impact total emissions - equipment may still contain 90% or more of the original chemical when discarded. Different applications have their own specific emission factor considerations.
- Currently Maldives does not have country specific emissions factors and therefore default factors are used



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## ACTIVITY DATA COLLECTION

- Data required for the emissions from ODS can be from national Customs statistics.
- Maldives only imports HFCs in cylinders, small canisters and in pre-charged equipment
- No exports
- Higher tier, it would be good practice to obtain data from users or industrial to get information about the leakage rates, lifetimes and storage information
- Chemical used annually within a specific application, sub-application, or even at a more detailed level, such as by equipment or product type is required for Tier 2
- Main focus is given on the following

Refrigeration and Air-Conditioning (RAC)

2.F.1.a – Refrigeration and Stationary Air-Conditioning

2.F.1.b – Mobile Air-Conditioning



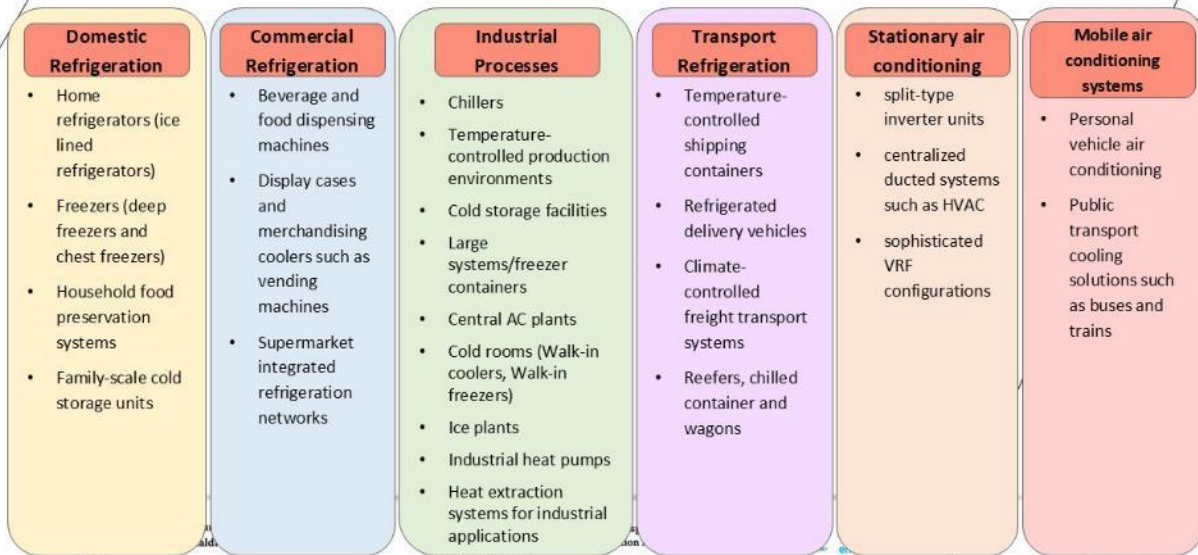
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## REFRIGERATION & AIR CONDITIONING (RAC) IN MALDIVES

- As per IPCC, RAC) systems can be organized into as many as six distinct sub-application categories



## HFC USES IN MALDIVES

Sector	Type of HFCs and HFC blends							HCs
Domestic Refrigeration	R-134a	R-404a						HC-600a
Commercial Refrigeration	R-134a	R-404a	R-507a	R-23				
Industrial Refrigeration	R-134a	R-404a	R-407c	R-410a	R-507a	R-23	R-438a	
Mobile Air Conditioning	R-134a							
Transport refrigeration	R-134a	R-404a						
Residential and Commercial Air Conditioning	R-134a	R-407c	R-410a	R-417a	R32			HC- 290



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## BLENDS, HFC RATIOS AND GWP

Refrigerant	Components and Percentages	Component GWPs (AR5)	Composite GWP
R-32	Pure compound (100% HFC-32)	HFC-32: 677	677
R-134a	Pure compound (100% HFC-134a)	HFC-134a: 1,300	1,300
R-407C	23% HFC-32, 25% HFC-125, 52% HFC-134a	HFC-32: 677, HFC-125: 3,170, HFC-134a: 1,300	1,624
R-410A	50% HFC-32, 50% HFC-125	HFC-32: 677, HFC-125: 3,170	1,924
R-404A	44% HFC-125, 52% HFC-143a, 4% HFC-134a	HFC-125: 3,170, HFC-143a: 4,800, HFC-134a: 1,300	3,943
R-438A	8.5% HFC-32, 45% HFC-125, 44.2% HFC-134a, 1.7% HC-600, 0.6% HC-601a	HFC-32: 677, HFC-125: 3,170, HFC-134a: 1,300, HC-600: 4, HC-601a: ~4	2,059
R-417A	46.6% HFC-125, 50% HFC-134a, 3.4% HC-600	HFC-125: 3,170, HFC-134a: 1,300, HC-600: 4	2,127
R-507A	50% HFC-125, 50% HFC-143a	HFC-125: 3,170, HFC-143a: 4,800	3,985
R-23	Pure compound (100% HFC-23)	HFC-23: 12,400	12,400
R-22	Pure compound (100% HCFC-22)	HCFC-22: 1,760	1,760
R-401A	53% HCFC-22, 13% HFC-152a, 34% HCFC-124	HCFC-22: 1,760, HFC-152a: 138, HCFC-124: 527	1,182
R-290	Pure compound (100% HC-290) Propane	HC-290: 3	3
R-600	Pure compound (100% HC-600) Butane	HC-600: 4	4



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## TYPICAL PRE-CHARGE AMOUNTS

Mobile AC (all R134a)							
Cars	Vans	Pickup	Lorry	Trucks	Cranes	Forklifts	Excavators
0.6	0.6	0.6	0.6	0.9	1	0.6	1
Domestic refrigeration							
R134a	R404a						
0.13	0.18						
Commercial refrigeration							
R134a	R404a	R507	R23				
0.32	1.15	1.15	0.1				
Residential and Commercial ACs							
R410a	R407C	R417A	R134a	R32			
2.08	5.56	3.13	3.13	4.51			
Industrial refrigeration							
R134a	R404a	R407	R410	R507C	R23	R438	
4	26	26	26	26	4	4	
Transport							
R134a	R404a						
0.28	6.5						



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## EMISSION ESTIMATION

- To estimate emissions, the most accurate way would be to collect blend agents and chemical use from the sector. However, this would be a difficult data to collect.
- Import data should be used. Import data needs to be broken down to application and sub-application level. It also needs to be segregated to which industries they are used in.
- One blend type might be used in several sectors.
- For example, R-134a is used in many sectors (almost all sectors). But how much of the imported amount is used by the sectors needs to be determined by a survey. Similarly, R-507a is used in commercial refrigeration and industrial refrigeration. But from the imported amount, how much is used in these sectors must be estimated.



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## EMISSION ESTIMATION (USING TIER 1)

- Disaggregated level of information is not available, a hybrid approach of Tier 1 (Tier 1 a/b) could be undertaken according to the IPCC guidelines
- The following data would be minimally required:
  - Sales of a specific refrigerant in the year to be reported
  - Year of introduction of the refrigerant
  - Growth rate in sales of new equipment (usually assumed linear across the period of assessment)
  - Assumed percentage of new equipment imported
  - Import/export data of chemical agent (in tonnes)
- The following assumptions are made.



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## EMISSION ESTIMATION (USING TIER 1)

- The following assumptions are made.
- Refrigerant-containing systems operate for 3 years after installation before any service is performed.
- Refrigerant banks experience an annual emission rate of 15% across the entire refrigeration and air conditioning sector
- The average lifetime of refrigeration and air conditioning equipment is assumed to be 15 years, which is estimated as a weighted average across all sub-applications.
- A 10-year time frame is required for a complete transition to a new refrigerant technology. For a single chemical in a single country, this assumption is believed to be valid based on past experience.



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## EMISSION ESTIMATION (USING TIER 1)

- For Tier 1 the following IPCC interface could be used. Columns for data entry are the first 3 columns.

The screenshot shows the IPCC interface for Tier 1 emission estimation. The left pane displays a tree view of categories, with '2.F.1.a - Refrigeration and Stationary Air Conditioning' selected. The main window shows a table for 'Chemical's Data' with columns for Year, Agent production, Agent export, Agent import, Total new agent to domestic market, Retired agent at end-of-life, Destruction of agent in retired equipment, Release of agent from retired equipment, Bank, Emissions from installed equipment, Total Emissions (tonnes), Total Emissions (Gg), and Agent for servicing. The table includes data for 2019, 2020, and 2021.



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## EMISSION ESTIMATION (USING TIER 1)

- Addition of subdivision and gases

The screenshot shows the 'Chemical's Data' dialog box in the IPCC interface. The dialog box contains fields for Country/Territory (Maldives), Category (2.F.1.a - Refrigeration and Stationary Air Conditioning), Subdivision (Unspecified), Gas (HFC-134a (CH2FCF3)), Year of Introduction (2006), Growth Rate in New Equipment Sales (GR) (1.00%), Assumed Equipment Lifetime (years) (15), Emission Factor from installed base (EF) (15.00%), and % of Gas Destroyed at End of Life (X) (0.00%).



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## EMISSION ESTIMATION (USING TIER 2A)

Addition The Tier 2a method takes the following into account.

- Incorporates the scheduled elimination or gradual reduction of CFCs and HCFCs according to Montreal Protocol timelines and applicable national or regional regulatory frameworks, enabling the determination of appropriate refrigerant selections across all applications.
- It specifies the typical refrigerant charge (the amount of refrigerant used in a system) and the equipment lifetime for each sub-application. This information helps estimate refrigerant demand and emissions over time, tailored to specific uses like commercial refrigeration, industrial cooling, or residential air conditioning.
- It establishes emission factors for different stages of a refrigerant's lifecycle:
  - Refrigerant charge: Emissions during initial filling of the system.
  - During operation: Emissions from leaks or normal system operation.
  - At servicing: Emissions during maintenance, repairs, or refilling.
  - At end-of-life: Emissions when equipment is decommissioned or disposed of.



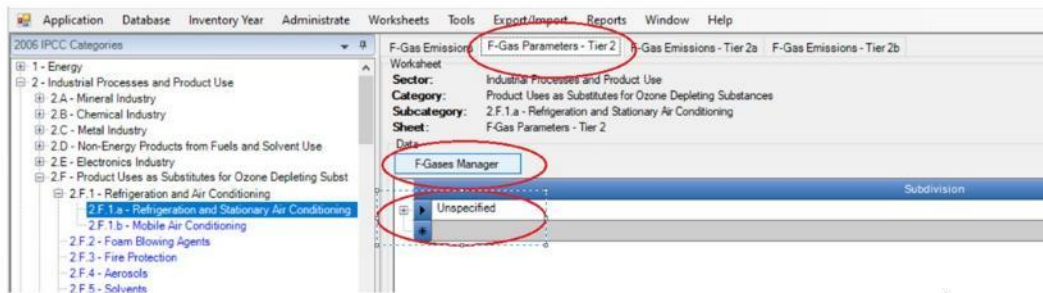
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## EMISSION ESTIMATION (USING TIER 2A)

- Tier 2 data entry needs to set up the sub-application level and F-Gases.



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## EMISSION ESTIMATION (USING TIER 2A)

- Management of blends and F-gases to prepare for use of Tier 2

F-Gases Manager - 2.5.1.a

Chemicals and Blends - applicability at IPCC Category level

Chemical group	Chemical	Formula	Consumed and/or Exported at category level
HFCs			
HFCs listed in Table 2.1	HFC-23	CHF <sub>3</sub>	<input checked="" type="checkbox"/>
	HFC-32	CH <sub>2</sub> F <sub>2</sub>	<input checked="" type="checkbox"/>
	HFC-125	CHF <sub>3</sub>	<input checked="" type="checkbox"/>
	HFC-134a	CH <sub>2</sub> F <sub>2</sub>	<input checked="" type="checkbox"/>
	HFC-152a	CH <sub>3</sub> CHF <sub>2</sub>	<input checked="" type="checkbox"/>
	HFC-143a	CH <sub>3</sub> CF <sub>3</sub>	<input checked="" type="checkbox"/>
PFCs			
SF <sub>6</sub>			<input checked="" type="checkbox"/>
NF <sub>3</sub>			<input checked="" type="checkbox"/>
Ethers and Halogenated Ethers			<input checked="" type="checkbox"/>
Other GHGs			<input checked="" type="checkbox"/>
Blends			
Blends referenced in section 7.5.1 of the 2006 GL	R-410A	HFC-32/HFC-125 (50/50.0)	<input checked="" type="checkbox"/>
	R-404A	HFC-125/HFC-143a/HFC-134a (44.052/04.0)	<input checked="" type="checkbox"/>
	R-407C	HFC-32/HFC-125/HFC-134a (23.025/052.0)	<input checked="" type="checkbox"/>
	R-507A	HFC-125/HFC-143a (50/50.0)	<input checked="" type="checkbox"/>
Other blends	R-417A	HFC-32/HFC-134a/HFC-600 (48.6/50.0/1.4)	<input checked="" type="checkbox"/>
	R-417A	HFC-125/HFC-134a/HFC-600 (48.6/50.0/1.4)	<input checked="" type="checkbox"/>
User-defined blends	R-408A	HFC-32/HFC-125/HFC-134a/HFC-600a/HFC-507a (8.54...)	<input checked="" type="checkbox"/>

Chemicals at country level    Blends at country level    Done



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## EMISSION ESTIMATION (USING TIER 2A)

- Default factors to create the sub-divisions

F-Gas Emissions Worksheet

Sector: Industrial Processes and Product Use

Category: Product Uses as Substitutes for Ozone Depleting Substances

Subcategory: 2.F.1.a - Refrigeration and Stationary Air Conditioning

Sheet: F-Gas Parameters - Tier 2

2021

Data

F-Gases Manager

Sub-application	Lifetime of equipment (years)	Emission factor for filling (production/manufacturing) of new equipment (% initial charge/yr)	Emission factor for equipment operation (leakage/servicing) (% initial charge/yr)	Recovery efficiency of charge (to be reclaimed/recycled) remaining at end of life in retired equipment (%)	Share of initial charge remaining at the end of life (%)
Domestic Refrigeration	12 ≤ d ≤ 20	0.2 ≤ k ≤ 1	0.1 ≤ x ≤ 0.5	0 < nrec.d < 70	0 < p < 80
Stand-alone Commercial Applications	10 ≤ d ≤ 15	0.5 ≤ k ≤ 3	1 ≤ x ≤ 15	0 < nrec.d < 70	0 < p < 80
Medium & Large Commercial Refrigeration	7 ≤ d ≤ 15	0.5 ≤ k ≤ 3	10 ≤ x ≤ 35	0 < nrec.d < 70	50 < p < 100
Transport Refrigeration	6 ≤ d ≤ 9	0.2 ≤ k ≤ 1	15 ≤ x ≤ 50	0 < nrec.d < 70	0 < p < 50
Industrial Refrigeration including Food Processing and Cold Storage	15 ≤ d ≤ 30	0.5 ≤ k ≤ 3	7 ≤ x ≤ 25	0 < nrec.d < 90	50 < p < 100
Chillers	15 ≤ d ≤ 30	0.2 ≤ k ≤ 1	2 ≤ x ≤ 15	0 < nrec.d < 95	80 < p < 100
Residential and Commercial A/C, including Heat Pumps	10 ≤ d ≤ 20	0.2 ≤ k ≤ 1	1 ≤ x ≤ 10	0 < nrec.d < 80	0 < p < 80



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## EMISSION ESTIMATION (USING TIER 2A)

- Data entry to Tier 2a. If available data should be entered to C,D,E,F,G

F-Gas Emissions - Tier 2a

Worksheet: F-Gas Emissions - Tier 2a

Sector: Industrial Processes and Product Use

Category: Product Uses as Substitutes for Ozone Depleting Substances

Subcategory: 2.F.1.a - Refrigeration and Stationary Air Conditioning

Sheet: F-Gas Emissions - Emission Factor Approach - Tier 2a

Data

Subdivision: Refrigeration

Sub-application: Domestic Refrigeration

Gas: HFC-134a (CH2FCF3)

Intro Year: 2006

EFc [%]: 15

EFk [%]: 1

p [%]: 80

D [%]: 0

η(rec,d) [%]: 0

I. Total Chemical Agent Inputs (across the time series) (ΣF + ΣH)

II. Total Chemical Agent in new equipment exported (across the time series) (ΣG)

III. Total Chemical Agent in equipment in use (last year of the time series) (Bank#)

IV. Total Chemical Agent Emissions (across the time series) (ΣV)

V. Total Chemical Agent Recovered/Destroyed/Exported from equipment at end-of-life (across the time series) (ΣQ + ΣS + ΣT)

Year	Amount in the bank on January 1st of year t (kg)	Domestically Manufactured Chemical in year t (kg)	Imported in bulk in year t (kg)	Exported in bulk in year t (kg)	Contained in factory-charged imported equipment in year t	Contained in factory-charged exported new equipment in year t	Domestic Sales of new & recovered chemical (in bulk) in year t (kg)	Emitted by containers management (during transfer from bulk to small)	Used to fill domestically manufactured new equipment in year t	Emitted during filling of new equipment in year t (kg)	Contained in new equipment filled in country in year t	Contained in new equipment consumed in year t (kg)	
t	Δ	Bank(t-1)	C	D	E	F	G	H = C + D - E + Q(t-1)	I = H * (EFc / 100)	J = H - I - O	K = J * (EFk / 100)	L = J - K	M = L + F - G
2006		0						0	0	0	0	0	0
2007		0						0	0	0	0	0	0
2008		0						0	0	0	0	0	0

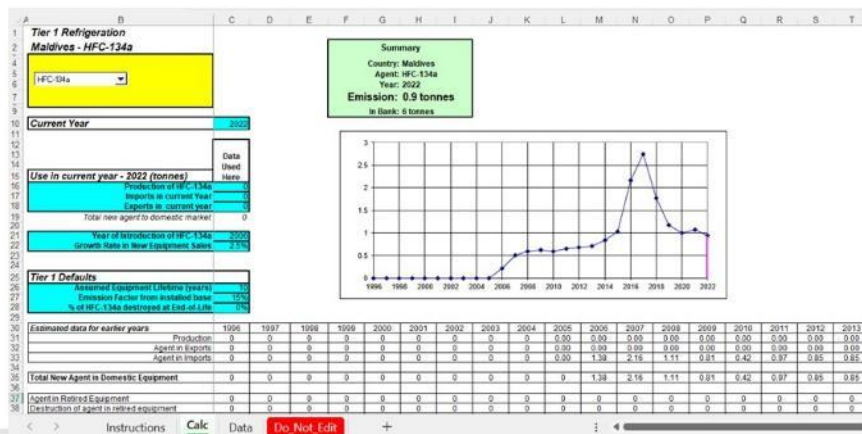
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## USE OF EXCEL TOOL BY IPCC

- IPCC provides two excel sheets (1 for tier 1 and other for Tier 2) to calculate the emissions.
- Tier 1 approach





# ESTIMATING WASTE EMISSIONS

PREPARED BY: DEVELOPMENT ADVISORY SERVICES



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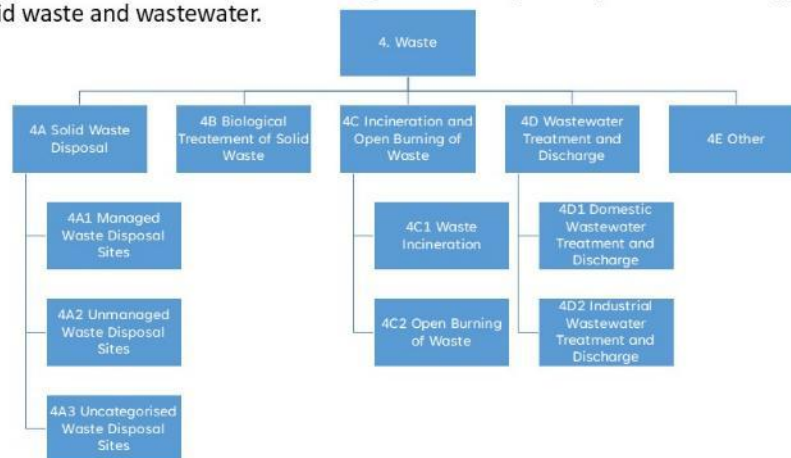


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## INTRODUCTION

The waste sector accounts for emission resulting waste management practices for all types of waste including solid waste and wastewater.



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## KEY TERMS

Wet weight basis

Dry Weight basis

Dry Matter content

Decomposable Organic Carbon (fraction of Organic carbon that decomposes)

Biogenic carbon content / Fossil carbon content

Methane Correction Factor

Methane Generation Rate/Half-Life

Oxidation Factor

BOD

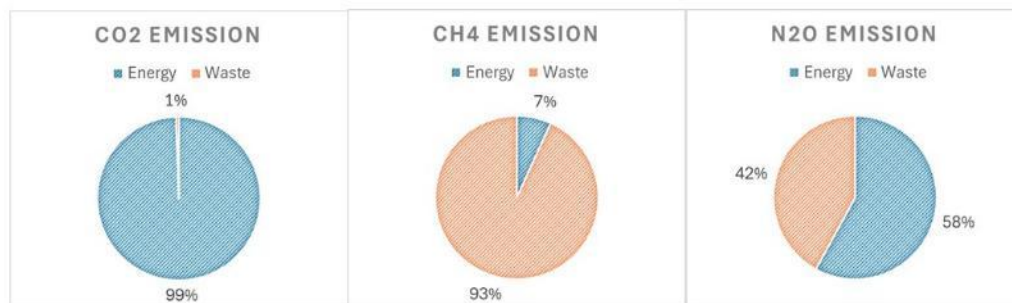


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## NATIONAL CONTEXT - WASTE



Maldives GHG inventory 2022: Waste accounts for majority of CH<sub>4</sub> and significant portion of N<sub>2</sub>O emissions in Maldives

Main method of waste management in Maldives is unmanaged open burning with limited incineration in resorts and dumping biodegradable waste into the sea.



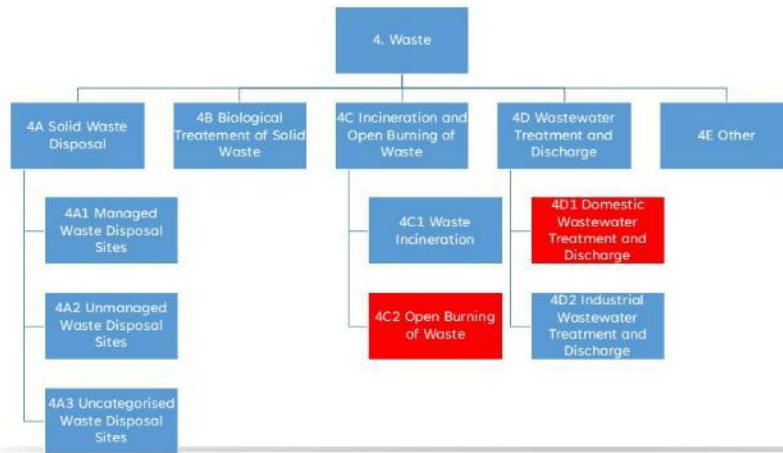
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## NATIONAL CONTEXT - WASTE



Plans for the sector to consider in future inventories

- Waste to Energy Facilities in Thilafushi, Addu and Vandhoo with managed landfill for incinerated waste
- Promoting composting in organic waste
- Phasing out Open burning



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## NATIONAL CONTEXT - WASTE



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## METHODOLOGICAL APPROACH

Step 1: Estimate total solid waste generated - default

*Tier 1 IPCC default*

$$\text{Total Solid Waste} = \frac{\text{Population}}{\text{NBS}} \times \frac{\text{Waste generation rate}}{0.91 \text{ ton per capita per year}}$$



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## METHODOLOGICAL APPROACH

Step 1: Estimate total solid waste generated – country specific

$$\text{Bulk Waste (in tons)} = \text{Waste in Male'} + \text{Waste in Other islands} + \text{Waste in Resorts}$$

$$\text{Waste in Male'} = \frac{\text{Waste Generation Rate}_{\text{Male'}} \times \text{Population}_{\text{Male'}}}{\frac{365}{1000}}$$

2.8 kg per person per day NBS

$$\text{Waste in Other Island} = \frac{\text{Waste Generation Rate}_{\text{Other island}} \times \text{Population}_{\text{Other Island}}}{\frac{365}{1000}}$$

1 kg per person per day NBS

$$\text{Waste in Resorts} = \frac{\text{Waste Generation Rate}_{\text{Resorts}} \times \text{Tourist Bednights}_{\text{Resorts}}}{\text{MTE}}$$

7.2 kg per resort bednight MTE



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## METHODOLOGICAL APPROACH

STEP 2 – composition of Waste – optional for all but 1 category

Waste Type	Default Waste Composition for South Asia (%)
Food Waste	66.1
Garden Waste	0
Paper/Cardboard	9.2
Wood	0
Textiles	1.2
Nappies	0
Rubber/Leather	0.4
Plastic	7
Metal	0.9
Glass	1.5
Other	13.9
Bulk Waste	100



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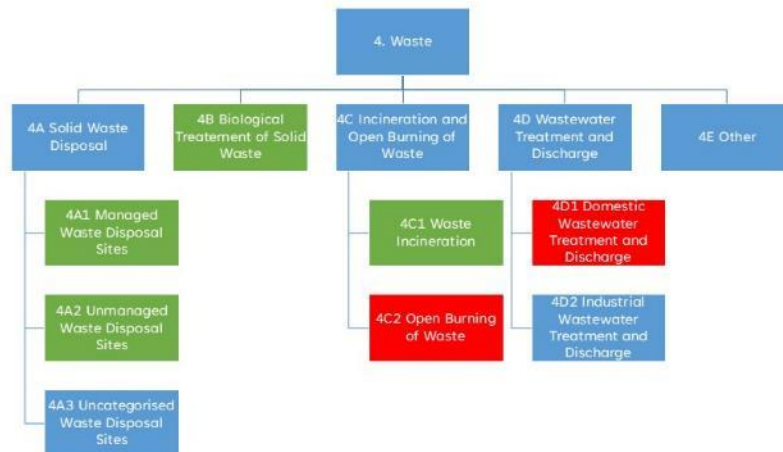


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## METHODOLOGICAL APPROACH



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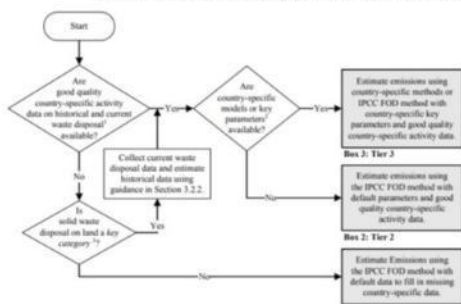
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## SOLID WASTE DISPOSAL SITES

Treatment and disposal of municipal, industrial and other solid waste produces significant amounts of methane ( $\text{CH}_4$ ).

The IPCC methodology for estimating  $\text{CH}_4$  emissions from SWDS is based on the First Order Decay (FOD)



\* A site is considered SWDS for emission calculation if the waste collected at the site remains for more than one year and accumulates over multiple years (2+ years) without transfer or burning

Notes:  
1. Good quality country-specific activity data means country-specific data on waste disposed in SWDS for 10 years or more;  
2. Key parameters mean  $\text{DOC}_{\text{L}}$ ,  $\text{DOC}$ , and half-life time;  
3. See Volume 3 Chapter 4, "Methodological Choice and Identification of Key Categories" (moving Section 4.1.2 on limited resources), for discussion of key categories and use of decision trees.



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## BASICS OF FIRST ORDER DECAY CALCULATION

1:

Estimating Decomposable DOC from waste disposal data

$$DDOC_m = W \times DOC \times DOC_f \times MCF$$

Where

$W$  = mass of waste deposited in Gg or 1000t

$DOC$  = fraction of degradable organic carbon in year of deposition, 0.18 for bulk waste

$DOC_f$  = fraction of DOC that can decompose, 0.5 for Bulk waste

$MCF$  = Methane Correction Factor



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## BASICS OF FIRST ORDER DECAY CALCULATION

2

Estimating Accumulated *DDOCm* for year ending in T

$$DDOCma_T = DDOCm_T + (DDOCma_{T-1} \times e^{-k})$$

Where

*DDOCma<sub>T</sub>* = *DDOCm accumulated at the end of year T*

*DDOCm<sub>T</sub>* = *DDOCm deposited at the end of year T*

*DDOCma<sub>T-1</sub>* = *DDOCm accumulated at the end of year T – 1 (previous year)*

*k* = *Methane Generation rate*



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## BASICS OF FIRST ORDER DECAY CALCULATION

3

Estimating *DDOCm* decomposed at the end of year T

$$DDOCmdecomp_T = DDOCma_{T-1} \times (1 - e^{-k})$$

4

Estimating Methane Generated for year T

$$CH_4\ generated_T = DDOCmdecomp_T \times F \times \frac{16}{12}$$

Where

*F* = *Fraction of Methane by Volume, default is 0.5*

$\frac{16}{12}$  = *CH<sub>4</sub> to Carbon mass number ratio*



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## BASICS OF FIRST ORDER DECAY CALCULATION

5

Estimating Methane emissions

$$CH_4 \text{ emissions} = (CH_4 \text{ generated}_T - R_T) \times (1 - OX_T)$$

Where

$$R_T = \text{Methane recovered in Gg or 1000t}$$



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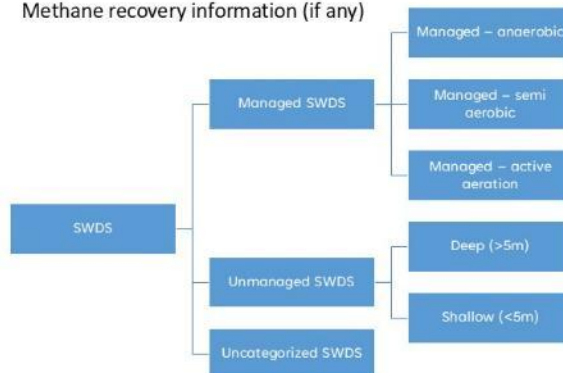


## SOLID WASTE DISPOSAL SITES

Activity Data Required:

percentage of waste deposited at SWDS segregated by type of SWDS (WAMCO)

Methane recovery information (if any)



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## SOLID WASTE DISPOSAL SITE

STEP 3 – Set initial parameters (a must for SWDS emission estimate)

Parameters SWDS Types - Utilization Activity Data Amount Deposited Long Term stored C in SWDS Harvested Wood Products

Country/Territory: Maldives  
Region: Asia - South-Central  
Subdivision: Unspecified  
Climate Zone: Tropical wet

Main parameters and Waste Types for selected Subdivision

Starting year: 1950  
Delay Time (months): 6  
Fraction of methane (F) in developed gas: 0.500  
Conversion Factor, C to CH<sub>4</sub>: 1.333333

Waste Type Parameters for selected Subdivision...

Parameters for HWP (Bulk MSW)

% garden in municipal waste: 0.00 %  
% paper in municipal waste: 0.00 %  
% wood in municipal waste: 0.00 %

Parameters for HWP (Bulk Industrial Waste)

% paper in industrial waste: 0.00 %  
% wood in industrial waste: 0.00 %

Save Waste Type Manager

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## SOLID WASTE DISPOSAL SITE

STEP 3 – Set parameters and EF (a must for SWDS emission estimate)

Waste Type Parameters

Waste Category	Class of decomposability	Waste Type / Industry Type	Use in calculations	DOC (Fraction of wet weight)	Degradable organic carbon which decomposes in SWDS (DOCI) (Fraction)	Methane generation rate constant (k)
Industrial Waste	Bulk waste	Bulk Industrial Waste	<input checked="" type="checkbox"/>	0.15	0.5	0.17
	Highly decomposable waste	Food, beverages and tobacco	<input checked="" type="checkbox"/>	0.15	0.7	
	Less decomposable waste	Construction and demolition	<input checked="" type="checkbox"/>	0.04	0.5	
		Wood and wood products	<input checked="" type="checkbox"/>	0.43	0.5	
	Moderately decomposable waste	Pulp and paper	<input checked="" type="checkbox"/>	0.4	0.5	
Municipal Waste		Textile	<input checked="" type="checkbox"/>	0.24	0.5	
	Bulk waste	Bulk Municipal Waste	<input checked="" type="checkbox"/>	0.18	0.5	0.17
	Highly decomposable waste	Food waste	<input checked="" type="checkbox"/>	0.15	0.7	0.4
		Garden and park	<input checked="" type="checkbox"/>	0.2	0.7	0.17
	Less decomposable waste	Wood	<input checked="" type="checkbox"/>	0.43	0.5	0.035
	Moderately decomposable waste	Disposable nappies	<input checked="" type="checkbox"/>	0.24	0.5	0.17
		Paper and cardboard	<input checked="" type="checkbox"/>	0.4	0.5	0.07
		Textile	<input checked="" type="checkbox"/>	0.24	0.5	0.07
Other waste	Bulk waste	Clinical waste	<input checked="" type="checkbox"/>	0.15	0.5	
		Hazardous waste	<input checked="" type="checkbox"/>		0.5	
Sludge	Highly decomposable waste	Industrial sewage sludge	<input checked="" type="checkbox"/>	0.09	0.5	
		Municipal sewage sludge	<input checked="" type="checkbox"/>	0.05	0.5	

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## SOLID WASTE DISPOSAL SITE

### STEP 3 – Set parameters and EF

SWDS Types - MCF and OX Methane Generated Methane Emissions

Worksheet

Sector: Waste

Category: Methane emissions from Solid Waste Disposal Sites

Subcategory: 4.A.1 - Managed Waste Disposal Sites

Sheet: SWDS Types - Methane Correction Factors and Oxidation Factors

Data

Subdivision: Unspecified

2024

Year	Managed - anaerobic		Managed poorly - semi-aerobic		Managed well - semi-aerobic		Managed poorly - active aeration		Managed well - active aeration	
	MCF (Fraction)	OX (Fraction)	MCF (Fraction)	OX (Fraction)	MCF (Fraction)	OX (Fraction)	MCF (Fraction)	OX (Fraction)	MCF (Fraction)	OX (Fraction)
1950	1	0								
1951	1	0								
1952	1	0								
1953	1	0								
1954	1	0								
1955	1	0								
1956	1	0								
1957	1	0								
1958	1	0								
1959	1	0								
1960	1	0								
1961	1	0								
1962	1	0								
1963	1	0								

Type of Site	MCF Default values
Managed - anaerobic	1
Managed well - semi aerobic	0.5
Managed poorly - semi aerobic	0.7
Managed well - active aeration	0.4
Managed poor - active aeration	0.7
Unmanaged - deep (>5m waste)	0.8
Unmanaged - shallow (<5m waste)	0.4
Uncategorized SWDS	0.6



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## SOLID WASTE DISPOSAL SITE

### STEP 4 – Input methane recovery if any (zero for Maldives)

SWDS Types - MCF and OX Methane Generated Methane Emissions

Worksheet

Sector: Waste

Category: Methane emissions from Solid Waste Disposal Sites

Subcategory: 4.A.1 - Managed Waste Disposal Sites

Sheet: Methane Emissions

Data

Subdivision: Unspecified

SWDS Type: Managed - anaerobic

2024

Year	Methane generated				Total methane generated (Gg)	Methane recovered		Methane oxidised		Methane Emissions (Gg)
	Municipal Waste (Gg)	Industrial Waste (Gg)	Sludge (Gg)	Other waste (Gg)		Flaring (Gg)	Energy use (Gg)	OX (Fraction)	Methane oxidised (Gg)	
	A	B	C	D	E = A + B + C + D	F	G	H	I = (E - F - G) * H	J = E - F - G - I
1950	0	0	0	0	0			0	0	0
1951	0.11139	0	0	0	0.11139			0	0	0.11139
1952	0.20536	0	0	0	0.20536			0	0	0.20536
1953	0.28465	0	0	0	0.28465			0	0	0.28465
1954	0.35154	0	0	0	0.35154			0	0	0.35154
1955	0.40797	0	0	0	0.40797			0	0	0.40797
1956	0.45558	0	0	0	0.45558			0	0	0.45558
1957	0.49574	0	0	0	0.49574			0	0	0.49574
1958	0.52963	0	0	0	0.52963			0	0	0.52963
1959	0.55822	0	0	0	0.55822			0	0	0.55822



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## BIOLOGICAL TREATMENT OF SOLID WASTE

Biological treatment of waste includes composting, anaerobic digestion of organic waste and mechanical-biological treatment of waste.

The primary emissions from these processes considered in this category are Methane and Nitrous Oxide.

National Waste accounts, no waste is recorded as being composted  
Need to collect data on waste composting to report GHG emissions from this sector

?

NBS, Local council, WAMCO



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## BIOLOGICAL TREATMENT OF SOLID WASTE

The CH<sub>4</sub> and N<sub>2</sub>O emissions of biological treatment can be estimated using the following equation

$$CH_4 \text{ emissions} = M \times EF \times 10^{-3} \times R$$

$$N_2O \text{ emissions} = M \times EF \times 10^{-3}$$

Where

*M* = mass of organic waste treated in Gg or 1000 tons

*EF* = relevant emission factor from Table below

*R* = total amount of methane recovered

Type of biological treatment	CH <sub>4</sub> emission factor (g CH <sub>4</sub> / kg waste treated)		N <sub>2</sub> O emission factor (g N <sub>2</sub> O / kg waste treated)	
	Dry weight basis	Wet weight basis	Dry weight basis	Wet weight basis
Composting	10 (0.08 - 20)	4 (0.03 - 8)	0.6 (0.2 - 1.6)	0.24 (0.06 - 0.6)
Anaerobic digestion at biogas facilities	2 (0 - 20)	0.8 (0 - 8)	negligible	negligible



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## BIOLOGICAL TREATMENT OF SOLID WASTE

Biological Treatment of Solid Waste									
Worksheet									
2024									
Sector: Waste									
Category: Biological Treatment of Solid Waste									
Subcategory: 4.B - Biological Treatment of Solid Waste									
Sheet: Emissions from Biological Treatment of Solid Waste									
Data									
Gas: METHANE (CH <sub>4</sub> )									
Equation 4.1.4.2									
Subdivision	Biological Treatment System	Waste Category	Type of Waste	Type of Activity	Waste Amount (kg CH <sub>4</sub> /kg waste treated)	Total Annual Methane Emissions (t/a)	Methane recovered (t/a)	Total Annual Methane Emissions (t/a)	
A1	A2	A3	A4	A5	B	C = (A1*B1) / 1000	D = C * 0.7	E = (C - D) * 1.0	F = E * 1.0
Unspecified	Composting	Municipal	Food waste		2	0.00	0	0.00	0.00
Total					2	0.00	0	0.00	0.00
Waste Type Manager									
Uncertainties									
Time Series data entry									



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## INCINERATION AND OPEN BURNING

Waste incineration is defined as the combustion of solid and liquid waste in controlled incineration facilities.



Open burning of waste can be defined as the combustion of unwanted combustible materials

Relevant gases emitted include CO<sub>2</sub>, methane (CH<sub>4</sub>) and nitrous oxide (N<sub>2</sub>O).



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## INCINERATION AND OPEN BURNING

$$CO_2 \text{ emissions} = \sum (SW \times dm \times CF \times FCF \times OF) \times \frac{44}{12}$$

Where;

SW = total amount of Solid waste of type (wet weight) incinerated or open burnt

Dm = dry matter content in the waste (wet weight)

CF = fraction of carbon in dry matter

FCF = Fraction of fossil carbon in total carbon

OF = Oxidation factor

Waste Type	Default Waste Composition for South Asia (%)	Dry Matter content fraction	Fraction of carbon in dry matter	Fraction of carbon in total carbon
Food Waste	66.1	0.40	0.38	0
Garden Waste	0	0.40	0.49	0
Paper/Cardboard	9.2	0.90	0.46	0.01
Wood	0	0.85	0.50	0
Textiles	1.2	0.80	0.50	0.20
Nappies	0	0.40	0.70	0.10
Rubber/Leather	0.4	0.84	0.67	0.20
Plastic	7	1	0.75	1
Metal	0.9	1	NA	NA
Glass	1.5	1	NA	NA
Other	13.9	0.9	0.03	1
Bulk Waste	100	0.579	0.359	0.213



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## INCINERATION AND OPEN BURNING

Waste incineration Fossil liquid incineration N2O Emissions from Incineration of waste - Tier 3

Worksheet

Sector: Waste

Category: Incineration and Open Burning of Waste

Subcategory: 4.C.1 - Waste Incineration

Sheet: Emissions from Incineration of Waste

2024

Data

Gas: CARBON DIOXIDE (CO2)

Equation 5.1, 5.2

Subdivision	Waste Category	Type of Waste	Total Amount of Waste incinerated (Wet Weight) (Gg Waste)	Dry Matter Content - dm (Fraction)	Fraction of Carbon in Dry Matter - CF	Fraction of Fossil Carbon in Total Carbon - FCF	Oxidation Factor - OF (Fraction)	Fossil CO2 Emissions (Gg)	Amount of total waste of fossil origin (Gg Waste)	Amount of total waste of biogenic origin (Gg Waste)	Biogenic CO2 emissions (Gg)			
Δ ▾	Δ ▾	Δ ▾	Aj	dm	CFj	FCFj	OFj	EFj = Aj * dm * CFj * FCFj * OFj * 44/12	APj = Aj * FCFj or specified	ABj = Aj * (1 - FCFj) or specified	EBj = ABj * dm * CFj * 44/12			
Unspecified	Municipal	Bulk	Specific	100	0.579	0.359	0.213	1	16.233	Calculated	21.3	Calculated	78.7	59.981
Total				100					16.233		21.3		78.7	59.981

Waste Type Manager Uncertainties Time Series data entry...



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## INCINERATION AND OPEN BURNING

$$CH_4 / N_2O \text{ emissions} = \sum (IW \times EF) \times 10^{-6}$$

Where

IW = amount of solid waste of type incinerated in Gg/yr

EF = aggregate CH<sub>4</sub> or N<sub>2</sub>O emission factor

Technology	CH <sub>4</sub> emission factor (kg/Gg waste incinerated)	N <sub>2</sub> O emission factor (kg/Gg waste incinerated)
Open Burning	6500	150 (dry weight basis)
Continuous incineration– Stoker bed	0.2	50
Continuous incineration – Fluidised bed	~0	50
Semi Continuous incineration – Stoker bed	6	50
Semi Continuous incineration – Fluidised bed	188	50
Batch incineration – stoker bed	60	60
Batch incineration – Fluidised bed	237	60
Industrial Waste – all incineration		100
Sewage sludge - incineration		900



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## INCINERATION AND OPEN BURNING

Waste incineration: Fossil liquid incineration: N <sub>2</sub> O Emissions from incineration of waste- Tier 3														
Worksheet														
Sector: Waste														
Category: Incineration and Open Burning of Waste														
Subcategory: 4.C.1 - Waste Incineration														
Sheet: Emissions from Incineration of Waste														
Data Gas: METHANE (CH <sub>4</sub> )														
Equation 5.4														
Subcategory	Waste Category	Type of Waste	Total Amount of Waste Incinerated (Gg Waste)	Emission Factor (kg CH <sub>4</sub> /Gg Waste)	Total Methane Emissions (Gg)	Amount of solid waste of fossil origin (Gg Waste)	Amount of solid waste of organic origin (Gg Waste)	Methane Emissions - Fossil Origin (Gg)	Methane Emissions - Organic Origin (Gg)	Methane Emissions - Total (Gg)	Amount of solid waste of fossil origin (Gg Waste)	Amount of solid waste of organic origin (Gg Waste)	Methane Emissions - Fossil Origin (Gg)	Methane Emissions - Organic Origin (Gg)
Unspecified	Municipal	Bulk Mass	100	0.000	0.000	21.3	78.7	0.000	0.000	0.000	21.3	78.7	0.000	0.000
Total			100			21.3	78.7	0.000	0.000	0.000	21.3	78.7	0.000	0.000
Equation 5.5														
Subcategory	Waste Category	Type of Waste	Total Amount of Waste Incinerated (Gg Waste)	N <sub>2</sub> O Emission Factor (kg N <sub>2</sub> O/Gg Waste)	Total Nitrous Oxide Emissions (Gg)	Amount of solid waste of fossil origin (Gg Waste)	Amount of solid waste of organic origin (Gg Waste)	Nitrous Oxide Emissions - Fossil Origin (Gg)	Nitrous Oxide Emissions - Organic Origin (Gg)	Nitrous Oxide Emissions - Total (Gg)	Amount of solid waste of fossil origin (Gg Waste)	Amount of solid waste of organic origin (Gg Waste)	Nitrous Oxide Emissions - Fossil Origin (Gg)	Nitrous Oxide Emissions - Organic Origin (Gg)
Unspecified	Municipal	Bulk Mass	100	0.000	0.000	21.3	78.7	0.000	0.000	0.000	21.3	78.7	0.000	0.000
Total			100			21.3	78.7	0.000	0.000	0.000	21.3	78.7	0.000	0.000



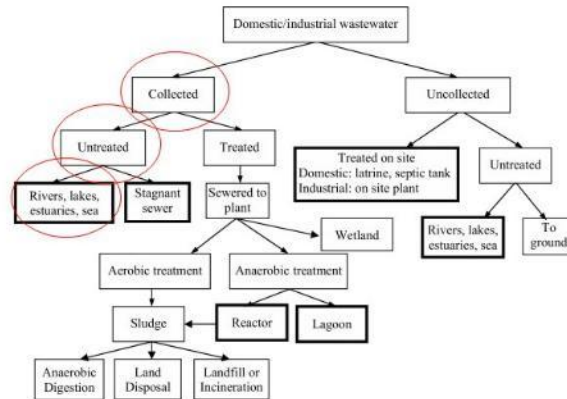
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## WASTEWATER TREATMENT AND DISCHARGE

Wastewater can be a source of methane when treated or disposed anaerobically. It can also be a source of nitrous oxide emissions.



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## WASTEWATER TREATMENT AND DISCHARGE

The activity data for Methane emissions from this source category is the total amount of organically degradable material in the wastewater (TOW).

$$TOW = P \times BOD \times 0.001 \times 365$$

NBS 34 g/person/day

$$TOW_j = TOW * I * U * T$$

where,

$I$  = correction factor for industrial BOD discharged (default for collected system is 1.25)

$U$  = Utilization factor (which is 1 for Maldives)

$T$  = Fraction of population in income group (assumed to be 1 for Maldives)



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## WASTEWATER TREATMENT AND DISCHARGE

The key activity data estimating nitrous oxide emissions from wastewater is the Total Nitrogen ( $TN_{dom}$ ) present in domestic water.

$$TN_{dom} = P_{treatment} \times Protien \times F_{NPR} \times N_{HH} \times F_{NON-CON} \times F_{IND COM}$$

where,

$P_{treatment}$  = share of population served with the treatment pathway, which is 1 for Maldives

$Protien$  = annual per capita protein consumption, kg protein per person per year

$F_{NPR}$  = fraction of nitrogen in protein, default is 0.16 kg N per kg protein

$N_{HH}$  = additional nitrogen from household products added to the wastewater, default is 1.1

$F_{NON-CON}$  = factor for nitrogen in non – consumed protein disposed in system default is 1 for Maldives

$F_{IND COM}$  = factor for industrial and commercial codischarged protein into the system



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## WASTEWATER TREATMENT AND DISCHARGE

Area	Element	Year	Unit	Value
Maldives	Protein supply quantity (g/capita/day)	2010	g/cap/d	115.65
Maldives	Protein supply quantity (g/capita/day)	2011	g/cap/d	115.71
Maldives	Protein supply quantity (g/capita/day)	2012	g/cap/d	115.94
Maldives	Protein supply quantity (g/capita/day)	2013	g/cap/d	118.07
Maldives	Protein supply quantity (g/capita/day)	2014	g/cap/d	116.86
Maldives	Protein supply quantity (g/capita/day)	2015	g/cap/d	114.91
Maldives	Protein supply quantity (g/capita/day)	2016	g/cap/d	116.52
Maldives	Protein supply quantity (g/capita/day)	2017	g/cap/d	101.6
Maldives	Protein supply quantity (g/capita/day)	2018	g/cap/d	99.15
Maldives	Protein supply quantity (g/capita/day)	2019	g/cap/d	95.37
Maldives	Protein supply quantity (g/capita/day)	2020	g/cap/d	93.66
Maldives	Protein supply quantity (g/capita/day)	2021	g/cap/d	97.54
Maldives	Protein supply quantity (g/capita/day)	2022	g/cap/d	101.76

$$Protien = Protein_{supply} \times FPC$$

kg per  
capita per  
year

0.96  
for  
SA



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<http://www.fao.org/faostat/en/#data/FBS/visualize>



## WASTEWATER TREATMENT AND DISCHARGE

$$CH_4 \text{ emissions (in Gg)} = TOW_j \times EF_{CH_4} \times 10^{-6}$$

$$N_2O \text{ emissions (in Gg)} = TN_{dom} \times EF_{N_2O} \times 10^{-6}$$

The Methane emission factor for a wastewater treatment and discharge pathway and system is a function of the maximum  $CH_4$  producing potential (Bo) and the methane correction factor (MCF) for the wastewater treatment and discharge system. The default value for Bo is 0.6 kg  $CH_4$  per kg of BOD. The tier 1 methane correction factor is 0.11 (0.004-0.27).

	EF value
<b>Methane Emission Factor (kg CH<sub>4</sub>/kg BOD)</b>	0.068
<b>Indirect Nitrous Oxide emission factor (kg N<sub>2</sub>O / kg N)</b>	0.005



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## WASTEWATER TREATMENT AND DISCHARGE

CH<sub>4</sub> Emissions Worksheet  
Sector: Water  
Category: Wastewater Treatment and Discharge  
Subcategory: 4.D.1 - Domestic Wastewater Treatment and Discharge  
Sheet: CH<sub>4</sub> Emissions from Domestic Wastewater  
Data

2024

Equation 5.1.5.3

Subdivision (Region, city, etc.)	Weighted Emission Factor (kg CH <sub>4</sub> /kg BOD)	Population (thousands)	Organic waste (kg BOD)	Correction factor for industrial BOD discharged in sewers	Organically degradable material in wastewater (kg BOD)	Sludge removed (kg BOD)	Methane recovered (kg CH <sub>4</sub> )	CH <sub>4</sub> Emission (kg CH <sub>4</sub> )	CH <sub>4</sub> Emission (kg CH <sub>4</sub> )
Unspecified	0.068	100	34	Calculated	1.25	Calculated	1512.5	0	0
Specified	0.068	100	34	Calculated	1.25	Calculated	1512.5	0	0
Total								1512.5	0

Correction factor for industrial BOD discharged in sewers

Type of treatment and discharge pathway or system	Degree of utilization (fraction)	Correction factor for industrial BOD discharged in sewers
See, river and lake discharge	1	Calculated
Unspecified	1	Calculated
Total		1.25

Cancel Save

Weighted Emission Factor

Equation 5.1.6.2

Income Group	Fraction of Population in Income Group (fraction)	Weighted Emission Factor (kg CH <sub>4</sub> /kg BOD)
Upper-high income	1	0.068

Equation 5.1.6.3

Type of treatment and discharge pathway or system	Degree of utilization (fraction)	Maximum methane producing capacity (kg CH <sub>4</sub> /kg BOD)	Methane correction factor for treatment system (fraction)	Emission Factor (kg CH <sub>4</sub> /kg BOD)	Weighted Emission Factor (kg CH <sub>4</sub> /kg BOD)
See, river and lake discharge	1	0.6	0.11	0.066	0.066
Unspecified	1	0.6	0.11	0.066	0.066
Total					

Cancel



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## WASTEWATER TREATMENT AND DISCHARGE

CH4 Emissions CH4 Emissions from Constructed Wetlands Direct N2O Emissions from Treatment Plants **Indirect N2O Emissions** Direct N2O Emissions from Constructed Wetlands

Worksheet  
**Sector:** Waste  
**Category:** Wastewater Treatment and Discharge  
**Subcategory:** 4.D.1 - Domestic Wastewater Treatment and Discharge  
**Sheet:** Indirect N2O Emissions from Wastewater

2024

Data

Equation 6.7, 6.8

Subdivision (Region, city, etc.)	Population (P) (people)	Per capita protein consumption (Protein) (kg/person)	Fraction of nitrogen in protein (Fnpr) (kg N/kg Protein)	Fraction of non- consumption protein (Fnon-con) (-)	Fraction of industrial and commercial co-discharged protein (Find-com)	Nitrogen removed with sludge (Nsludge) (kg)	Total nitrogen in effluent (Neffluent) (kg N/yr)	Nitrogen from Wastewater plants (kg N/yr)	Emission Factor (kg N2O-N/kg N)	N2O Emissions (kg N2O/yr)	N2O Emissions (Gg N2O/yr)				
Δ▽	A	B	C	D	E	F	G = (A*B*C*D* E)-F)	H	I	J = (G - H) * I * 44/28	K = J / 10 <sup>6</sup>				
Unspecified	1000	37.14	0.16	1	1.25	0	7428	0.03977	0.005	58.36254	0.00006				
Total							7428			58.36254	0.00006				



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## QA/QC

- Cross-check country-specific values for MSW generated, industrial waste generated and waste composition against the default IPCC values, to determine whether the national parameters used are considered reasonable relative to the IPCC default values
- Reviewing survey data collection methods and checking the data to ensure that they were collected and aggregated correctly.
- Cross-check the data with previous years to ensure the data are reasonable and are consistent in the time series
- Evaluating secondary data sources and referencing QA/QC activities associated with the secondary data preparation especially check the consistency of the secondary data with the data requirements of greenhouse gas inventory.
- Seek experts review for the selection of values for the parameters
- Compare national emission rates with those of similar countries that have comparable demographic and economic attributes to understand any discrepancies between countries and determine if they represent any source of errors.



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# Hands on Exercise for IPPU

Country imports the blend R-404. Assume that all of these are used in the domestic refrigeration.

## Tasks

1. Use the emissions tool to calculate the emissions of the chemical
2. Calculate the emissions for the individual gases
3. Calculate the total emissions in CO<sub>2</sub>eq



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# Hands on Exercise for Waste

Regional waste management facility caters to 4 southern most atolls (GA, GDh, Fuvahmulah and Addu). The total resident population of these atoll is 56,187 people. These four atoll also host 10 resort islands with a total bed capacity of 2516. The average occupancy rates for these resorts for the years 2022, 2023 and 2024 was 55%, 60% and 62% respectively.

The waste generated are managed in the following methods

- 15% of the waste is composted at household/island level
- 10% of the waste is recovered or recycled
- 14.66 kt, 15.15 kt and 17.52 kt of waste were incinerated at the regional facility in 2022, 2023 and 2024 respectively

## Tasks

1. Conduct a QC of the information provided and identify any potential issues with the information provided
2. Calculate the emission from waste management in the GA, GDh, Fuvahmulah and Addu



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## ANNEX 4: PHOTOS OF HAND-ON TRAINING FOR ESTIMATING GREENHOUSE GAS EMISSIONS OF NON-ENERGY SECTORS IN MALDIVES







