

# Introduction to GHG Inventory and Planning



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Republic of Maldives

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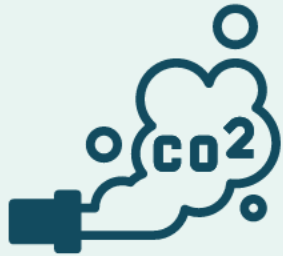
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# What are greenhouse gases



**Carbon dioxide  
( $\text{CO}_2$ )**



**Methane  
( $\text{CH}_4$ )**



**Nitrous Oxide  
( $\text{N}_2\text{O}$ )**



**Fluorinated  
Gases**



**Water Vapor  
( $\text{H}_2\text{O}$ )**

## Pre-Industrial Greenhouse Effect

## Human-Enhanced Greenhouse Effect

Some heat escapes into space.

The Earth's atmosphere reflects some heat into space.

Less heat escapes into space.

GHGs retain the Sun's heat in the Earth's atmosphere.

More GHGs retain heat in the Earth's atmosphere,

GHGs

Earth's surface reflects heat from the sun.

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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.

# 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**





# 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**

# 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



# 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.





# 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



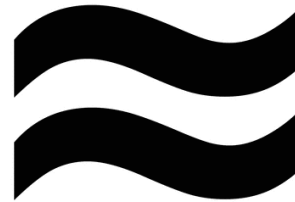
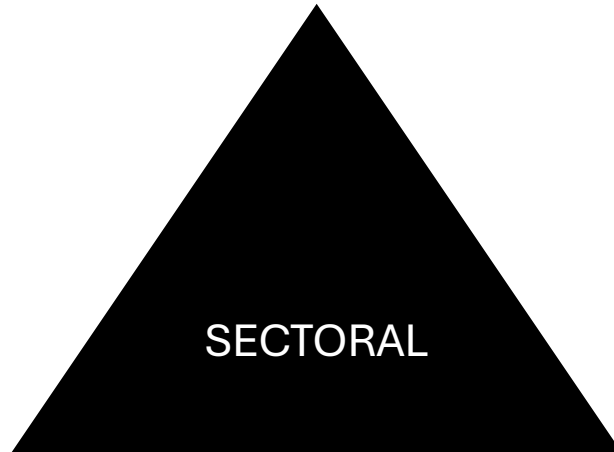
# GHG Inventory Concepts (others)

- **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.

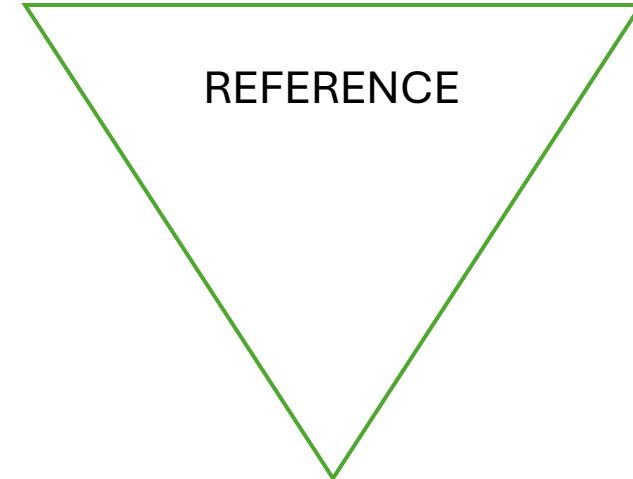


# Reference Approach vs Sectoral approach

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



With in 5%



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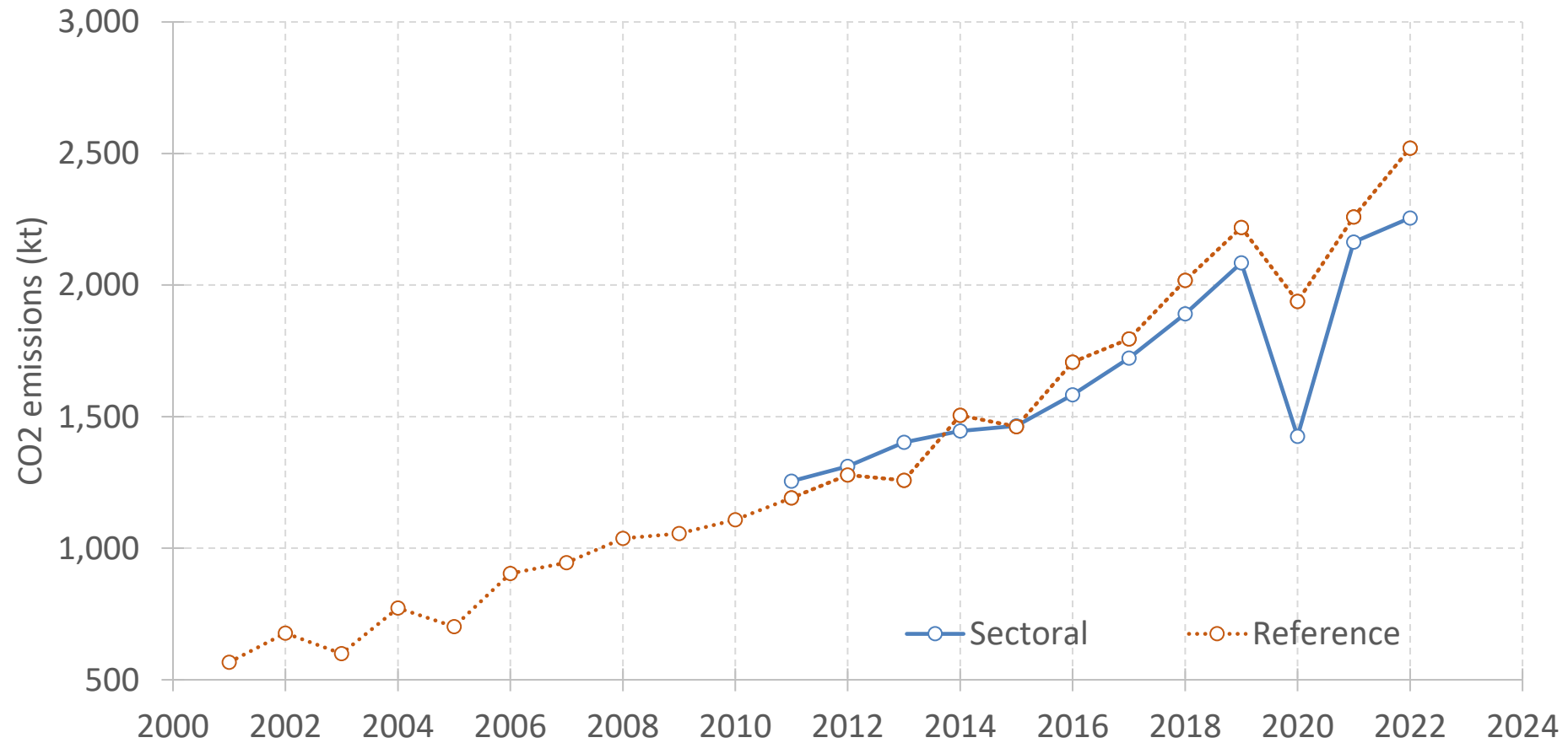


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# REFERENCE APPROACH VS SECTORAL APPROACH



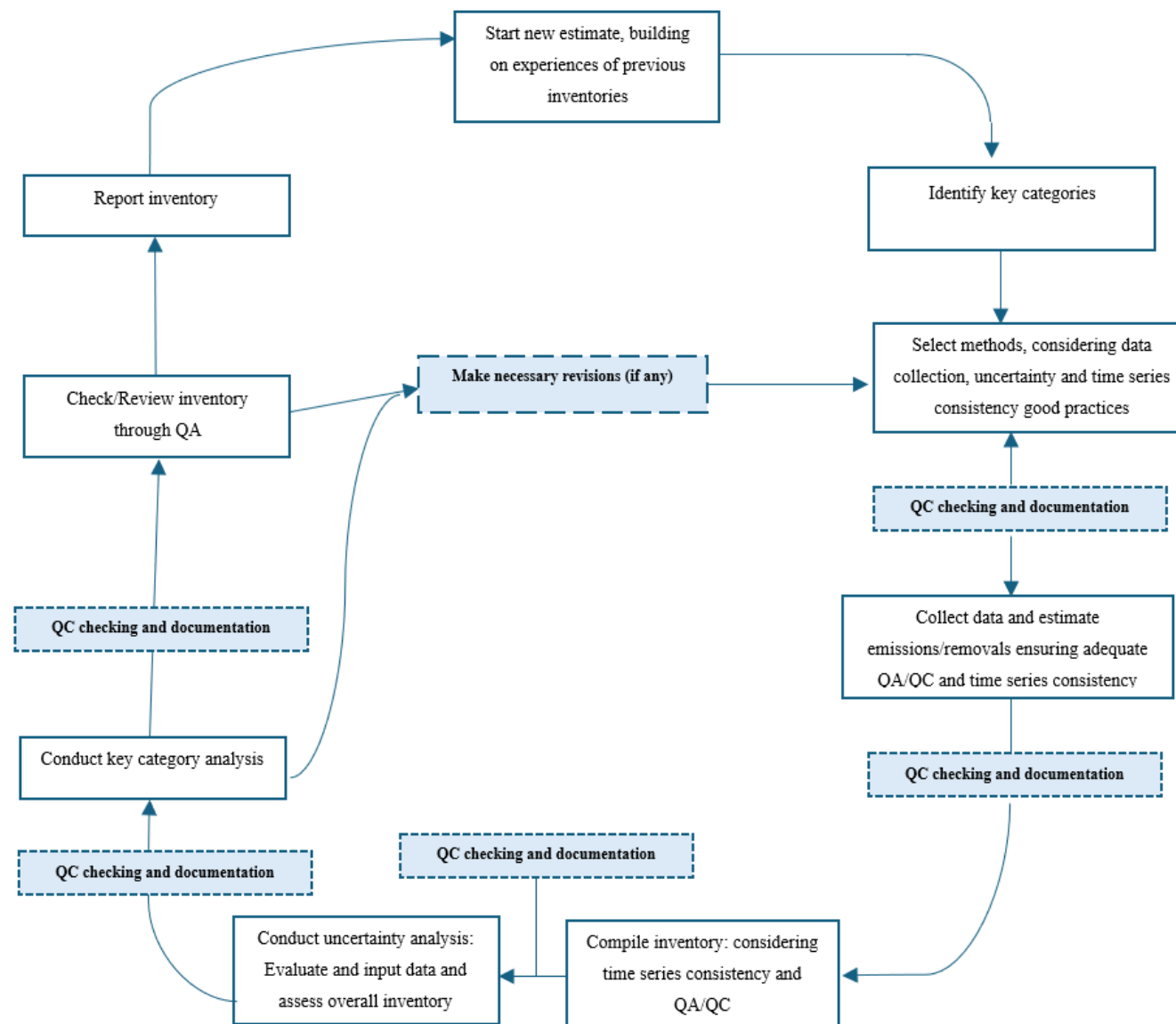
# TACCC principles

- **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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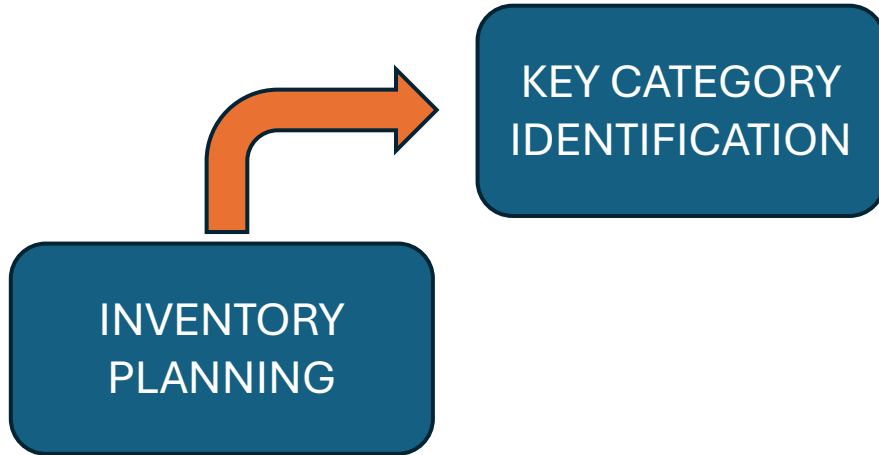


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# Key Categories

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 maybe 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.



# 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





# Qualitative Criteria for Key Category Analysis

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

## Mitigation Impact

- Prioritize categories where emissions have decreased or removals increased due to mitigation efforts, ensuring transparency in assessment methods.

## Anticipated Growth

- Identify categories likely to see rising emissions or declining removals, using expert judgment as needed.

## Uncertainty Reduction

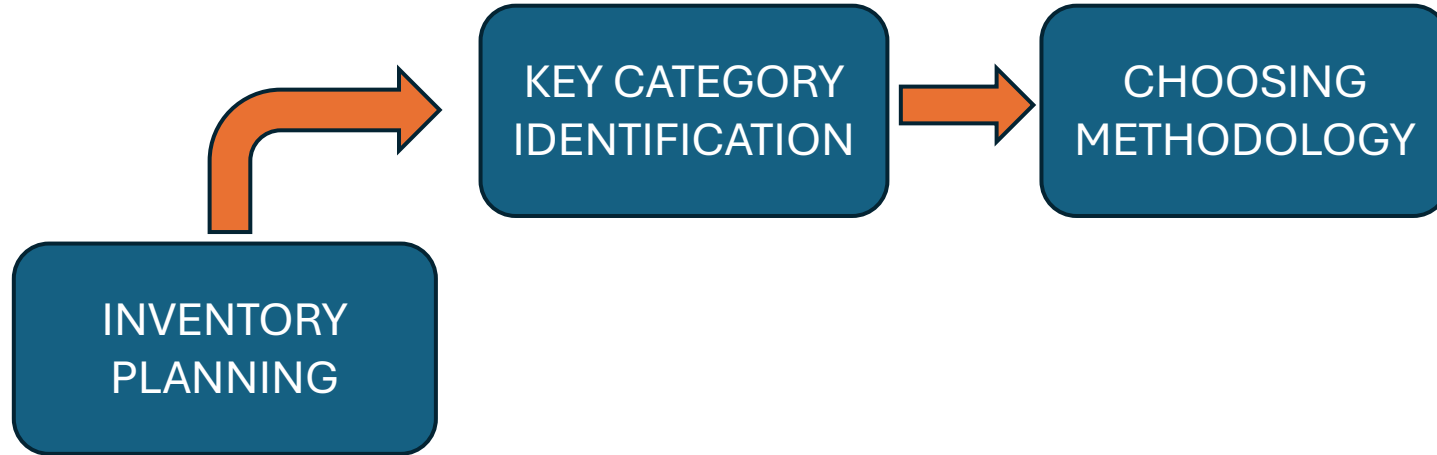
- Focus on categories with significant uncertainty, even if not using Approach 2. Improving estimates in high-uncertainty areas will enhance inventory accuracy.

## Completeness Assurance

- For incomplete inventories, assess key categories qualitatively, prioritize data collection based on preliminary estimates, and consult inventories of similar countries for guidance.



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# Choosing Methodologies

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

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

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

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

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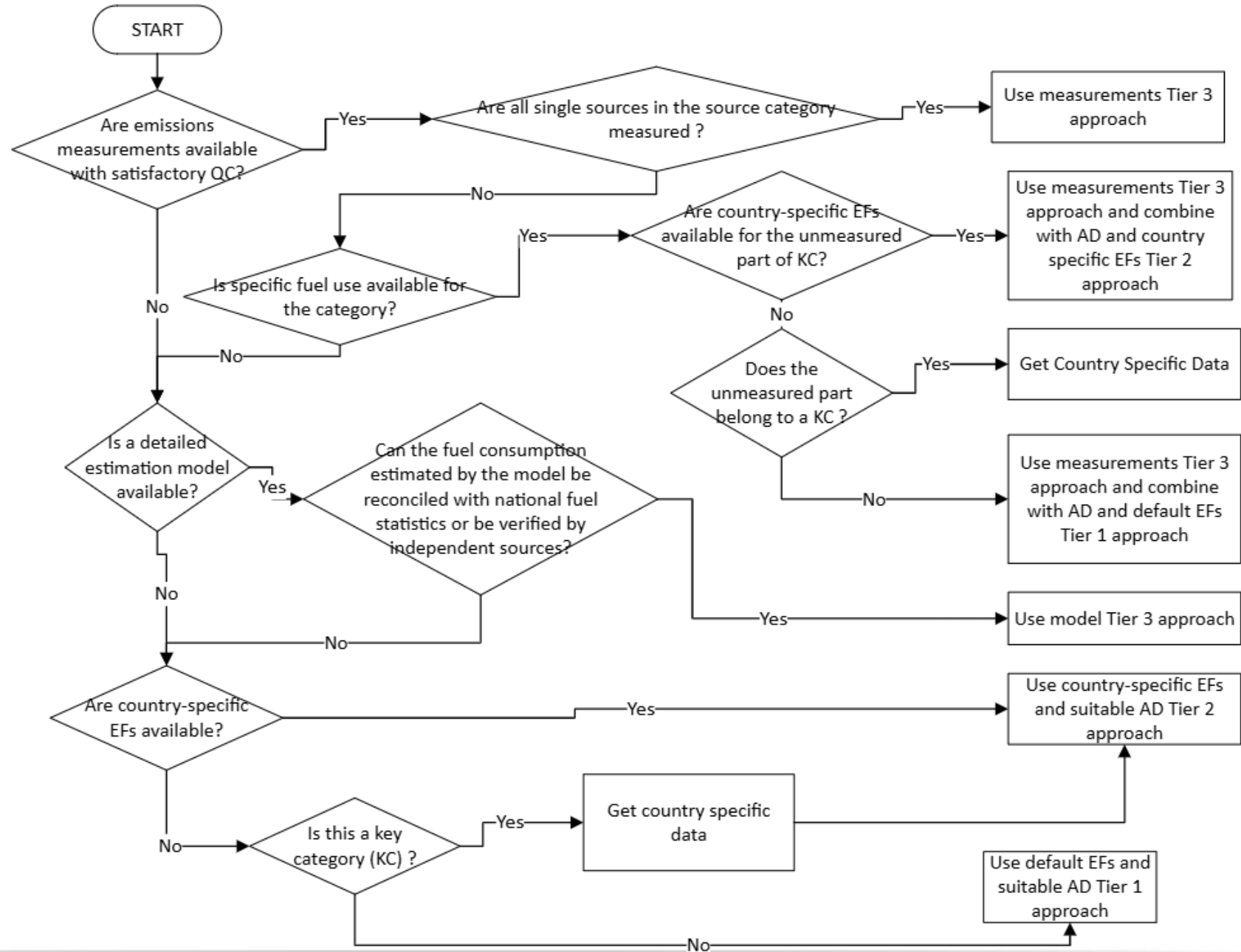


# Methodological Tiers

	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

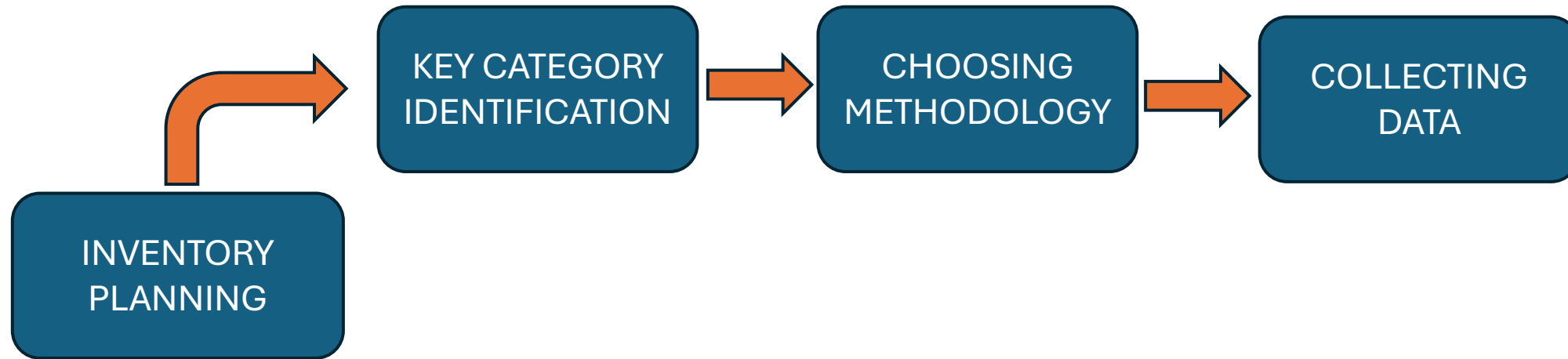


## The step-by-step guide to choosing the right methodology (Tier)





# INVENTORY PROCESS



# 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.



# 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



# 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



# 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





# 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**

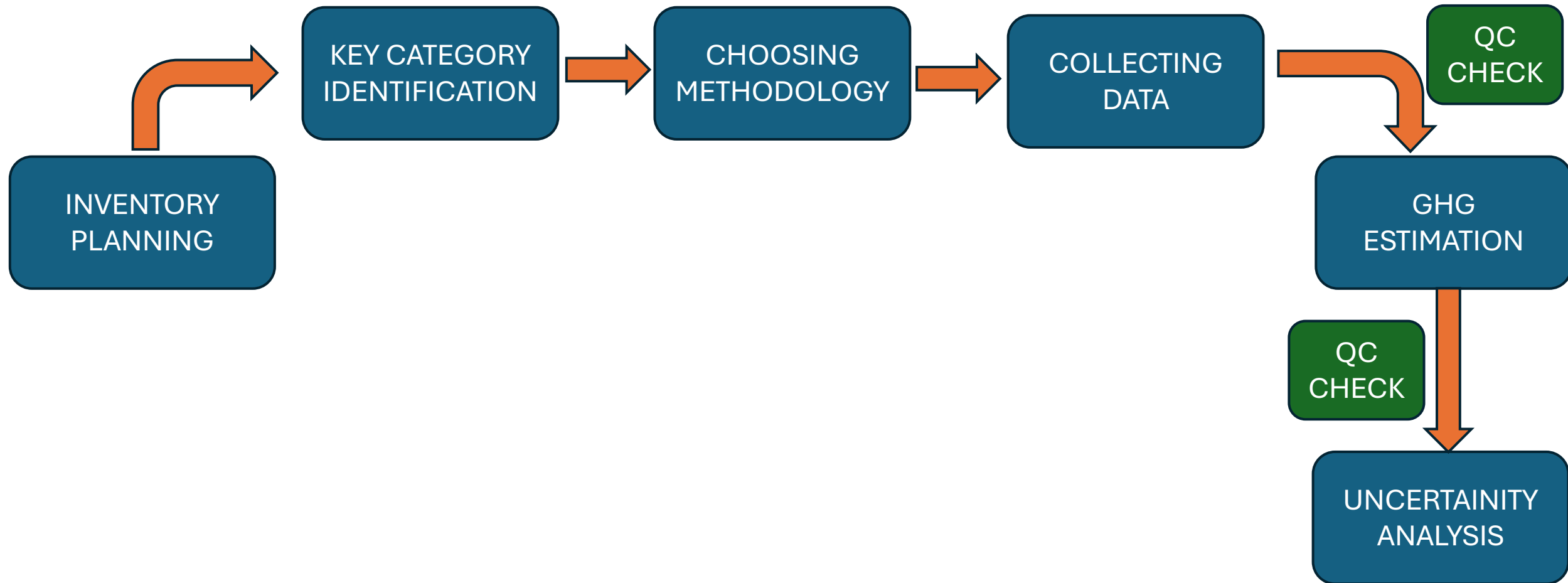
- When new and improved data is available allowing higher tier estimated

- **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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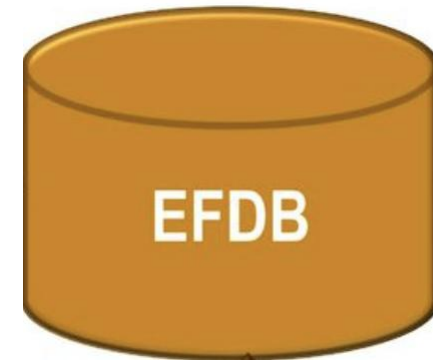


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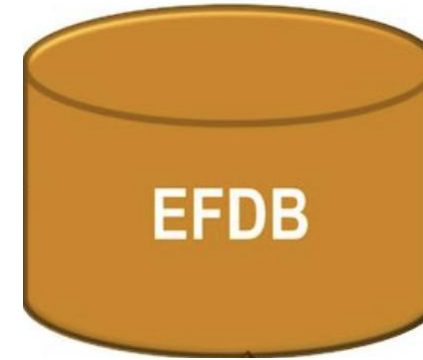


# Basis GHG Estimation

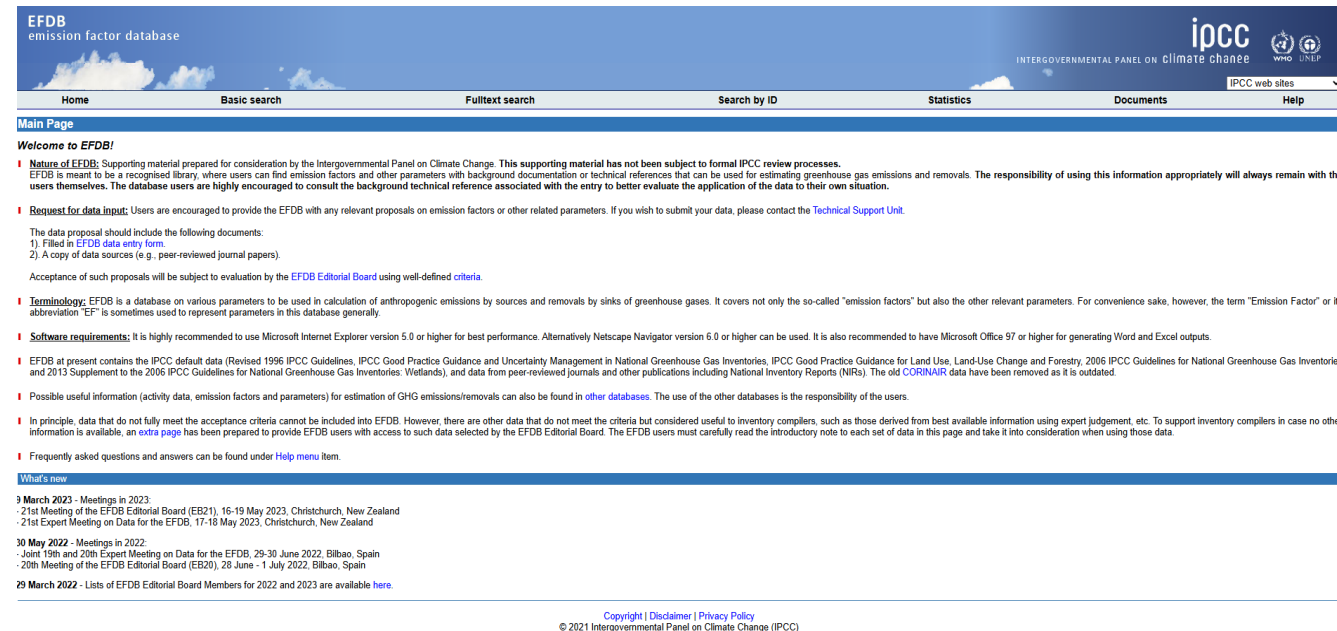
$$\text{Emissions} = \text{Activity Data (AD)} \times \text{Emission Factors (EF)}$$



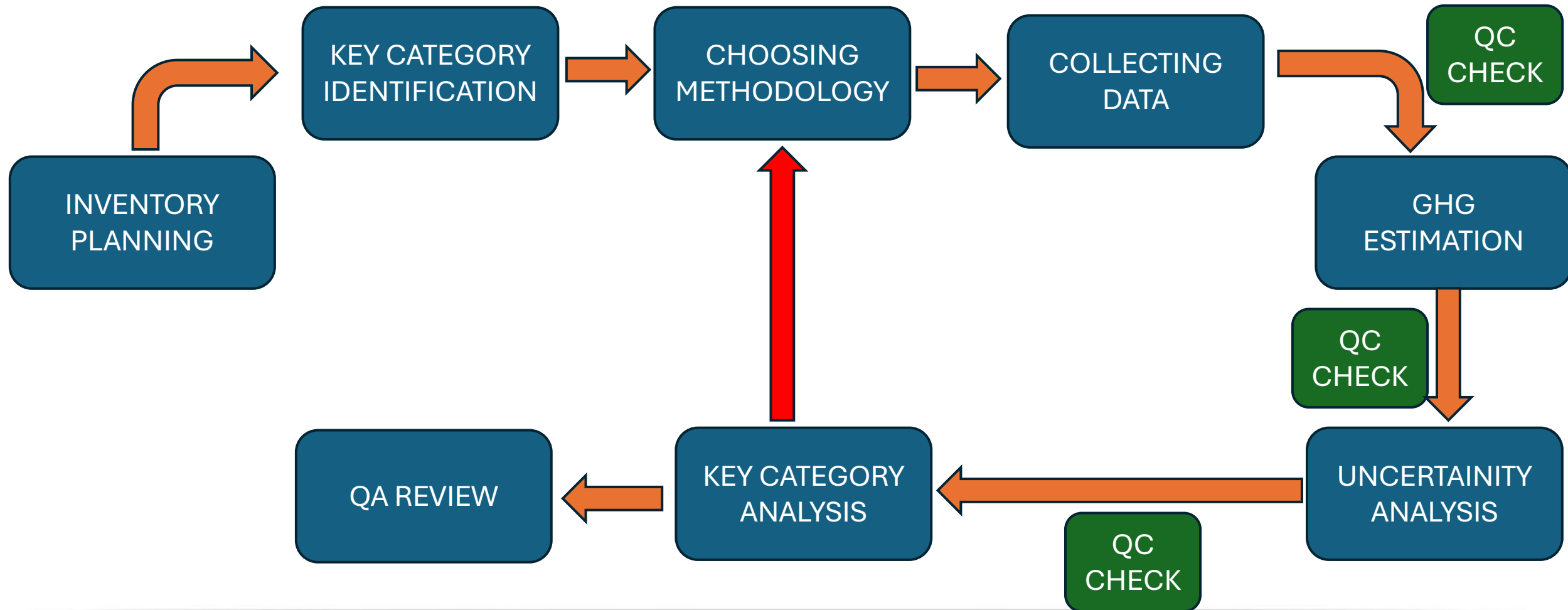
# Choosing Emission Factors



- 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.



# INVENTORY PROCESS



# 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.





# 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.

- **CO2 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:**

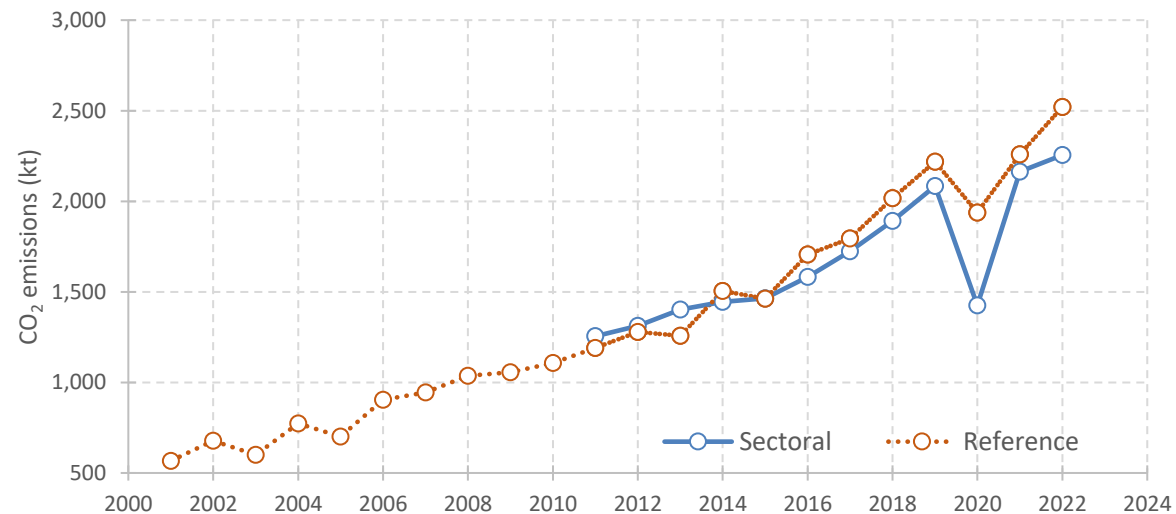
- All conversion factors used to convert data from original units to the chosen reporting units should be documented transparently.



# QA review: Completeness check (time series)

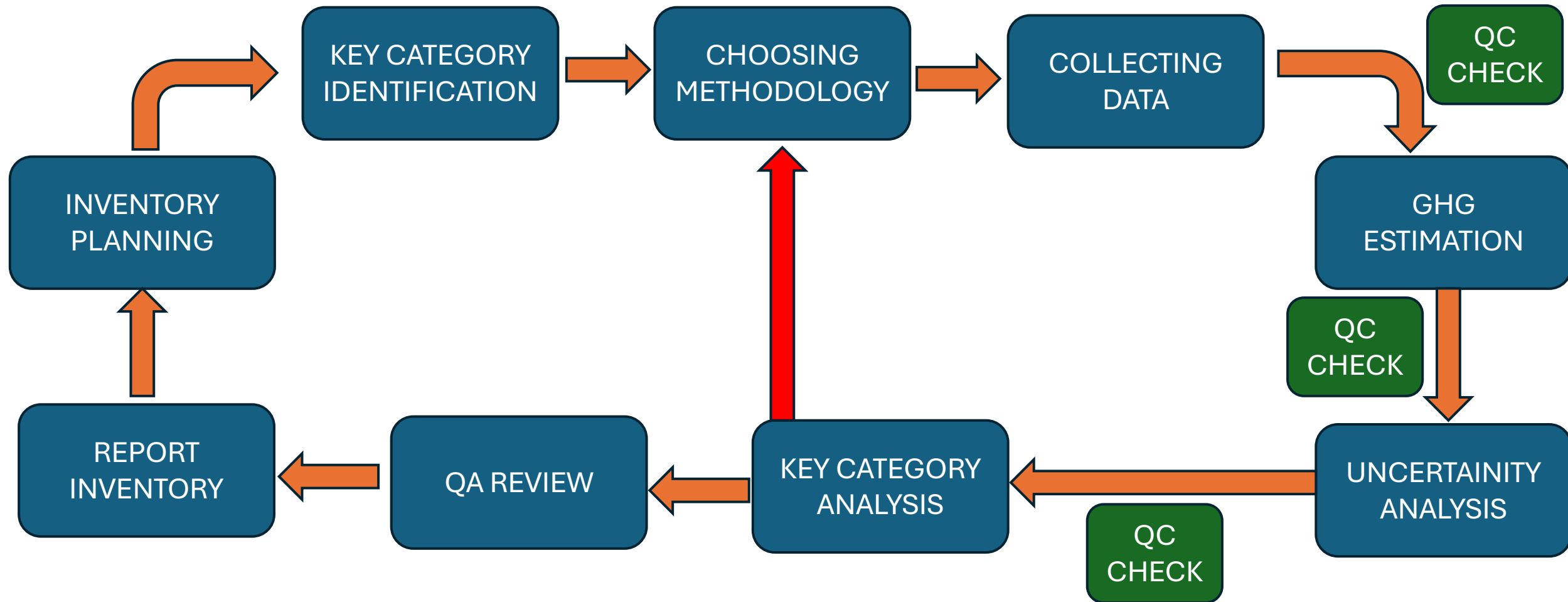
- It is **considered good practice to ensure that all reporting tables are complete for each year** including
  - Summary table,
  - Sectoral table, and
  - cross-sectoral tables
- **Create trend tables/graphs** that summarize aggregated inventory data from different years.

Example





# INVENTORY PROCESS



- 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

Sectoral Background TablesSectoral Report TablesSummary / Cross-sectoral / Trends Tables

# 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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