Hands-on training Workshop on National GHG Inventory Preparation and Reporting under the ETF: Agriculture, IPPU and Waste Sector

Introduction to National GHG Inventory Planning and Methods

Data Collection, QA/QC, Inventory Planning, Time Series Consistency

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Belize

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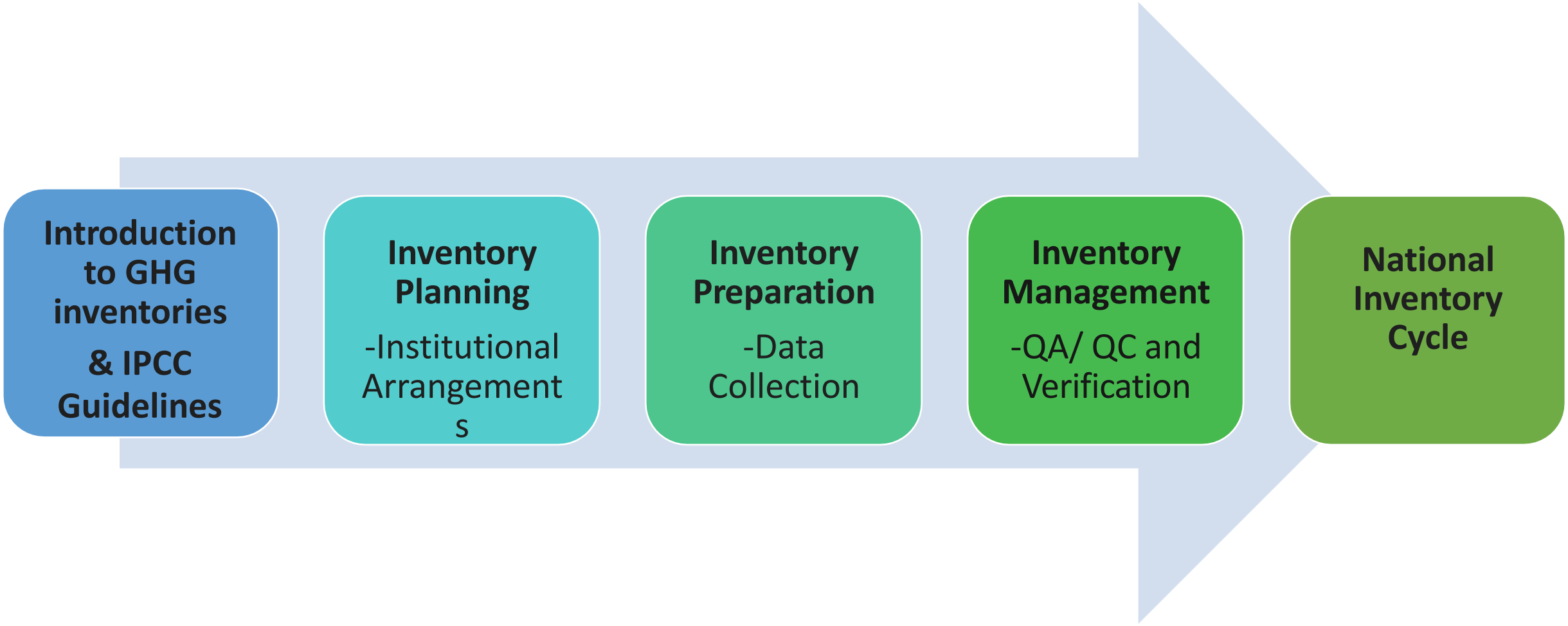
Session overview



Why do we care about GHG inventories?

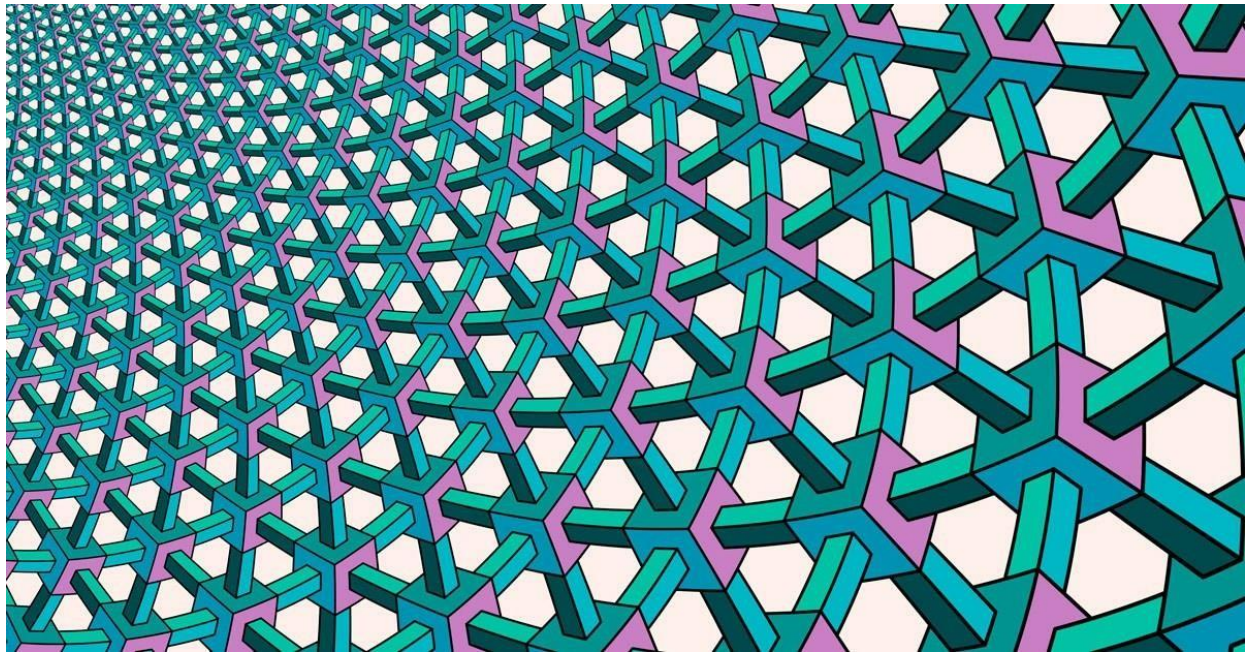
You can't manage what you don't measure

- What are the **main drivers of your emissions and removals**?
- What are the **past trends** of emissions and removals?
- What are the **effects of existing and planned policies** and measures (including policies that may aggravate emissions)?
- What information is lacking **to support political decisions**?
- Does the GHG inventory fulfill specific **reporting** requirements (e.g., under the UNFCCC)?
- What activities, industries, companies, or policies have **been responsible** for significant increases or decreases in GHG emissions or removals?
- How to **quantify and get credit** for activities that reduce emissions or sequester carbon?
- What are the priorities for **research** and measurement?

Policies depend on reliable emissions data

GHG Emissions Inventory

An **GHG emission inventory** attempts to quantify and organize information about GHG emissions based on common standards and protocols, and to attribute emissions correctly to a project, facility, company, nation, or other entity.



GHG Inventory Categories

CO_2

Fossil Fuel Combustion

Natural Gas Flaring

Cement Manufacture

Lime Manufacture

Limestone and Dolomite Use

Soda Ash Manufacture and Consumption

Carbon Dioxide Consumption

Waste Combustion

Titanium Dioxide Production

Aluminum Production

Iron and Steel Production

Ferroalloys

Indirect CO_2 Emissions

Ammonia Manufacture

Land-Use Change and Forestry (Sink)

International Bunker Fuels

CH_4

Stationary Sources

Mobile Sources

Coal Mining

Natural Gas Systems

Petroleum Systems

Petrochemical Production

Silicon Carbide Production

Enteric Fermentation

Manure Management

Rice Cultivation

Agricultural Residue Burning

Landfills

Wastewater Treatment

International Bunker Fuels

N_2O

Stationary Source

Mobile Sources

Adipic Acid

Nitric Acid

Manure Management

Agricultural Soil Management

Agricultural Residue Burning

Human Sewage

Waste Combustion

International Bunker Fuels

HFCs, PFCs, NF_3 and SF_6

Substitution of Ozone Depleting Substances

Aluminum Production

HCFC-22 Production

Semiconductor Manufacture

Electrical Transmission and Distribution

Magnesium Production and Processing

Major Sources of Anthropogenic GHG Emissions

Greenhouse gas	Sources
Carbon dioxide (CO_2)	Burning of **fossil fuels** and organic matter (i.e., wood, dung, crops residues); **Forest land conversion** to other uses; Disturbances to and losses of soil from **mismanagement**; Forest and peat land fires; **Incineration** and open burning of waste
Methane (CH_4)	**Decomposition** of organic matter; **Enteric fermentation** by livestock; Livestock **manure management**; **Rice cultivation**
Nitrous oxide (N_2O)	Application of nitrogen-based **fertilizers**; Livestock **manure management**
Perfluorocarbons (PFCs)	Released in **manufacturing** of fluorinated gases; **By-product** of aluminum and magnesium production; released in electronics manufacturing

IPCC Guidelines

Cornerstone for all work on GHG inventories since early 1990s

Task Force on National GHG Inventories

Maintains IPCC Emission Factor Database (EFDB)

1994	1996	2000	2003	2006	2019
IPCC Guidelines for National Greenhouse Gas Inventories	*Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories*	*Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories*	*Good Practice Guidance for Land Use, Land-Use Change and Forestry*	***2006 IPCC Guidelines for National Greenhouse Gas Inventories***	***2019 Refinement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories***

Considerations for structuring a GHG inventory

- **Time series**
- **Choice of methods (IPCC)**
- **Reporting format (UNFCCC)**

IPCC Guidelines (Methods)

https://www.ipcc-nggip.iges.or.jp/public/2006gl/

https://www.ipcc-nggip.iges.or.jp/public/2019rf/index.html

UNFCCC Reporting

https://unfccc.int/national-reports-from-non-annex-i-parties

Volume 1 General Guidance and Reporting

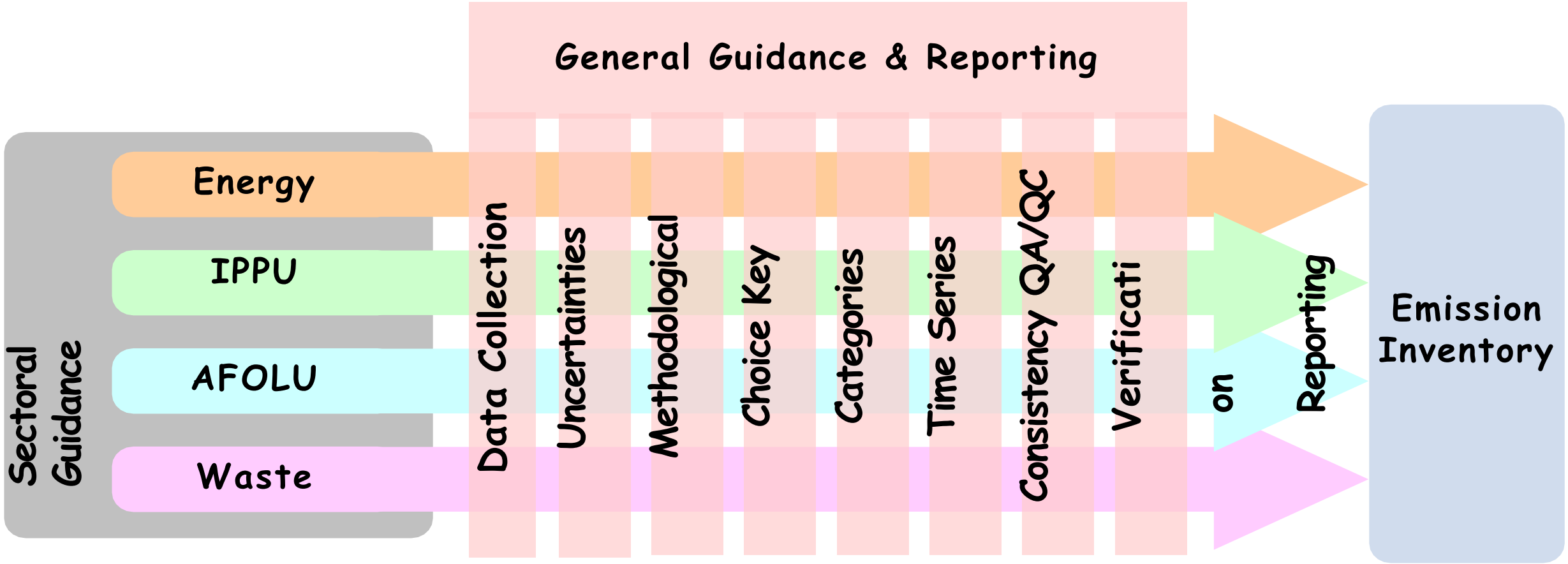
Volume 2 Energy

Volume 3 Industrial Processes and Product Use

Volume 4 Agriculture, Forestry and Other Land Use

Volume 5 Waste

What topics within the IPCC guidelines are “cross cutting”?



What is Climate Change MRV?

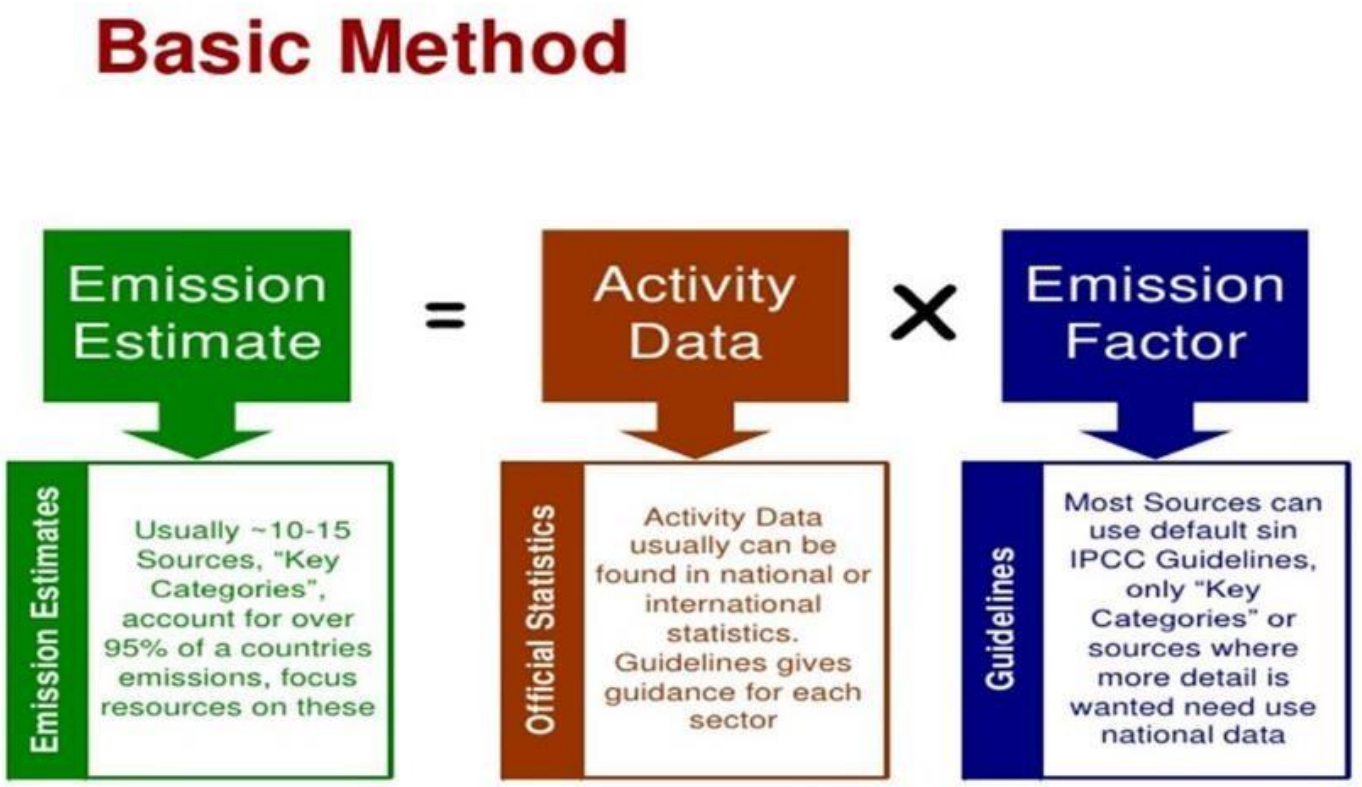
MRV: Systems that support collection, management, analysis, use, and assurance of climate change-related data (mitigation, adaptation, finance, capacity building, tech transfer).

Measure: **Direct** or **estimated** calculations following strict guidance and protocols. Sometimes called “monitoring”.

Report: **Documentation** intended to inform interested parties.

Verify: Specific procedures or expert review used to **verify** the quality of the data.

Emissions = AD * EF



Emissions = AD * EF

An inventory is characterized by the following parameters:

① Set of chemical or physical identity of pollutants
② Institutional entities, activities or sectors covered
③ Geographic area covered
④ Time period over which emissions are estimated

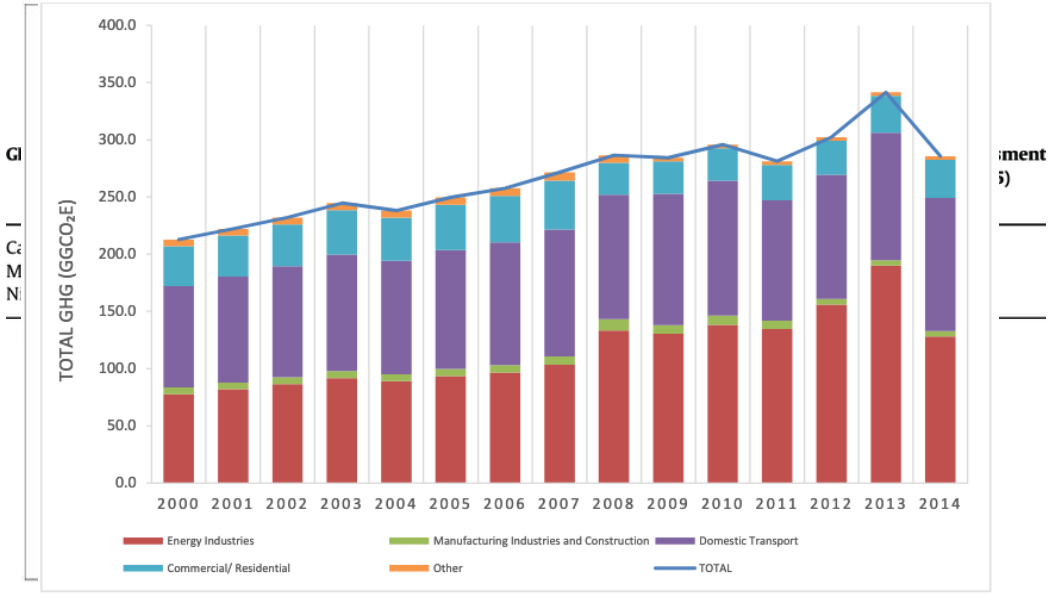


Figure 17-Time series displaying emissions from the Energy Sector.

Managing the Inventory Cycle

The three main stages:

- Planning

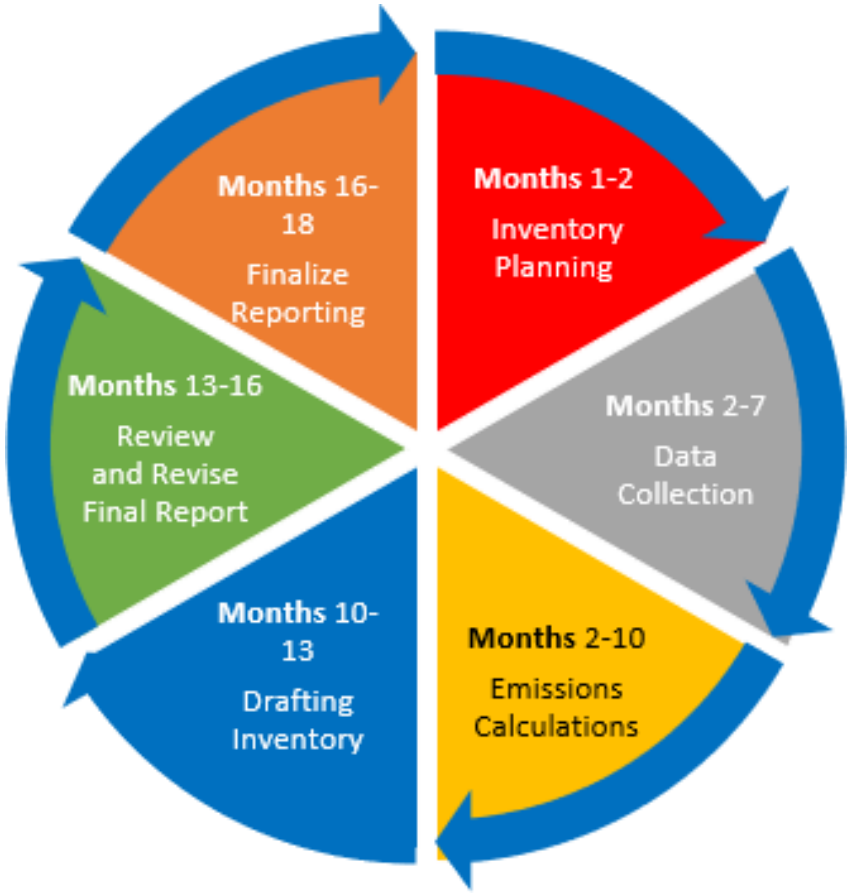
(e.g. agreements, work plan)

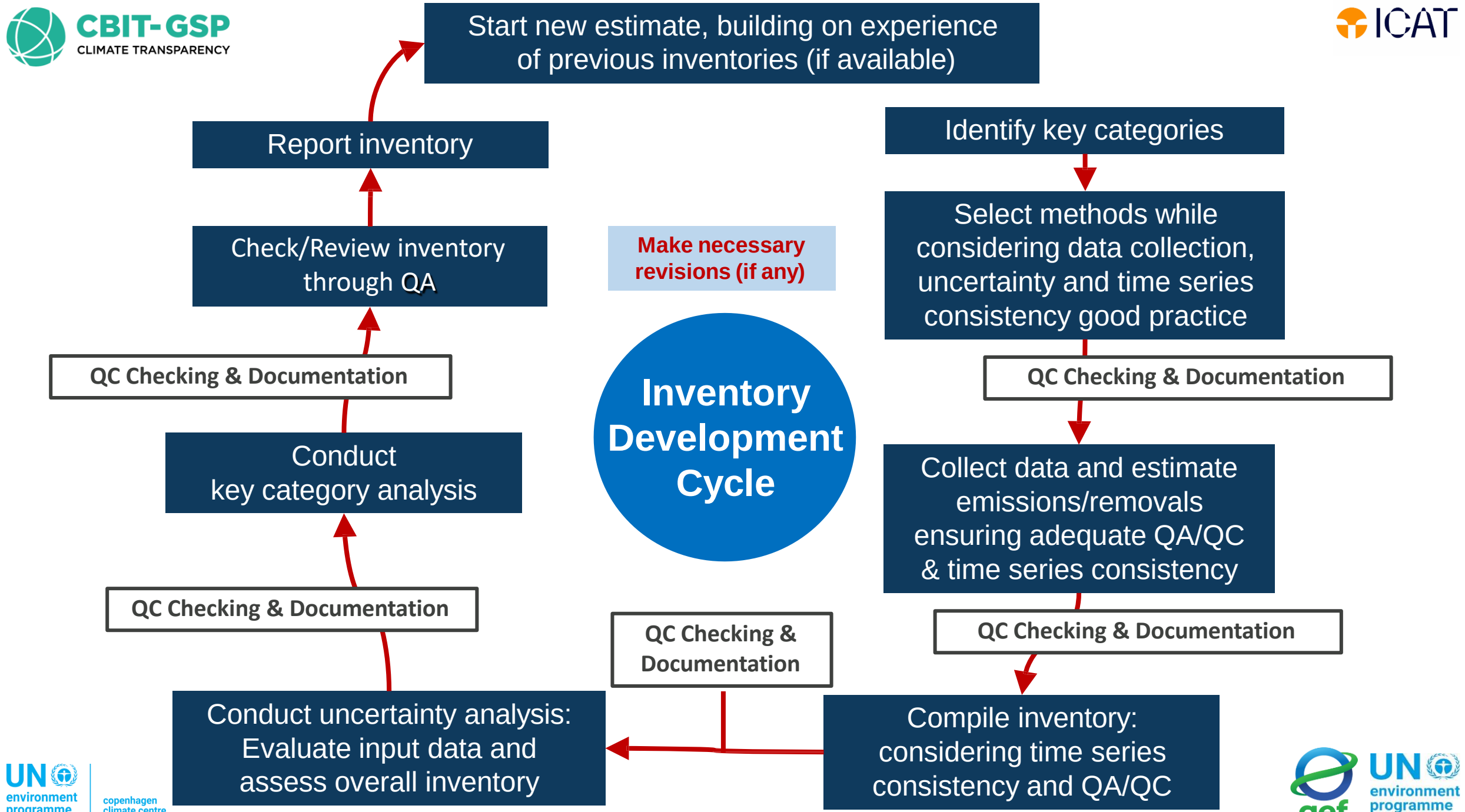
- Preparation

(e.g. data collection, GHG estimation)

- Management

(e.g. reporting, documenting, archiving)




Start new estimate, building on experience of previous inventories (if available)
Report inventory
Check/Review inventory through QA
QC Checking & Documentation
Conduct key category analysis
QC Checking & Documentation
Conduct uncertainty analysis: Evaluate input data and assess overall inventory
QC Checking & Documentation
Compile inventory: considering time series consistency and QA/QC
QC Checking & Documentation
Collect data and estimate emissions/removals ensuring adequate QA/QC & time series consistency
QC Checking & Documentation
Select methods while considering data collection, uncertainty and time series consistency good practice
QC Checking & Documentation
Identify key categories
Make necessary revisions (if any)
Inventory Development Cycle

Planning: Inventory Management

Stage	Overview of Tasks
Inventory Planning	• Prioritize and plan, taking into account inventory improvement plan • Select methods based on preliminary key category analysis, begin to identify AD, EFs • Inception memo • Review and update Institutional Arrangements • Kick-off meeting with inventory team/stakeholders

Inventory Planning

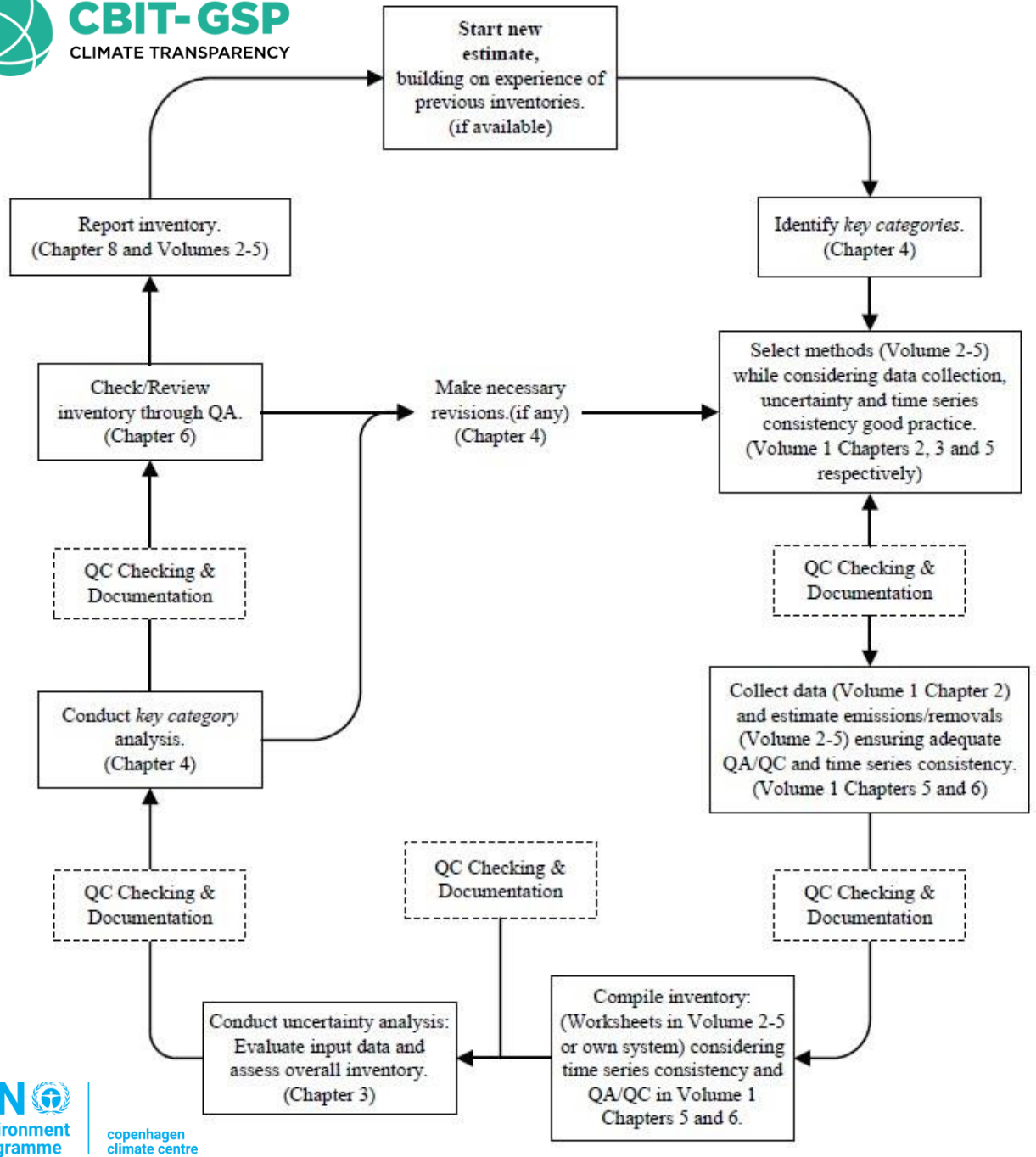
- Define and allocate responsibilities for inventory development (inventory compiler, sector leads, QA/QC responsibilities, relationships with data providers).

- Establish any necessary formal or informal agreements among ministries,
  data providers, national institutions and industries.

- Establish written procedures for inventory development, including data sources and timelines, and submission to the UNFCCC.
  - Consider how to follow up to questions raised from the public, external review processes, etc.
- Develop a QA/QC plan

- Develop an inventory improvement plan

Discussed further under the discussion of QA/QC

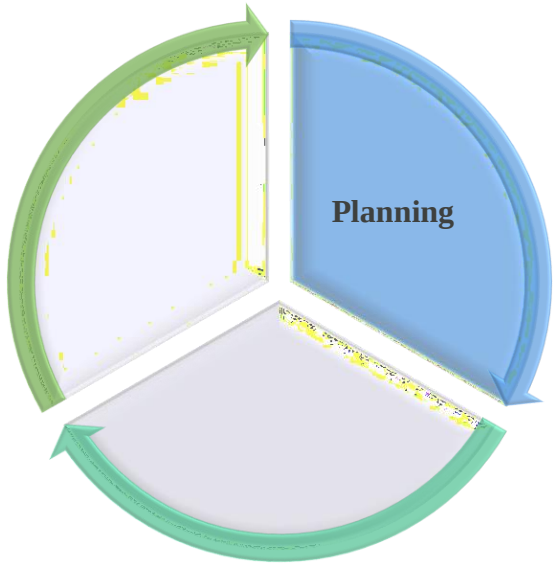


Inventory Development is an Iterative Process

- Establish the necessary relationships (institutional arrangements) and data management system to enable your system to develop.
- Availability of data will increase over time
- Relevant emissions sources may change over time.
- Not all categories are equally important.
- Do not “reinvent the wheel”. Much data and experience already exists.

Establishing Written Procedures

For each step, in inventory development, it is important to elaborate and document a timeframe and to identify and link it to the people involved in that stage of the process, as well as the outcomes



What are institutional arrangements?

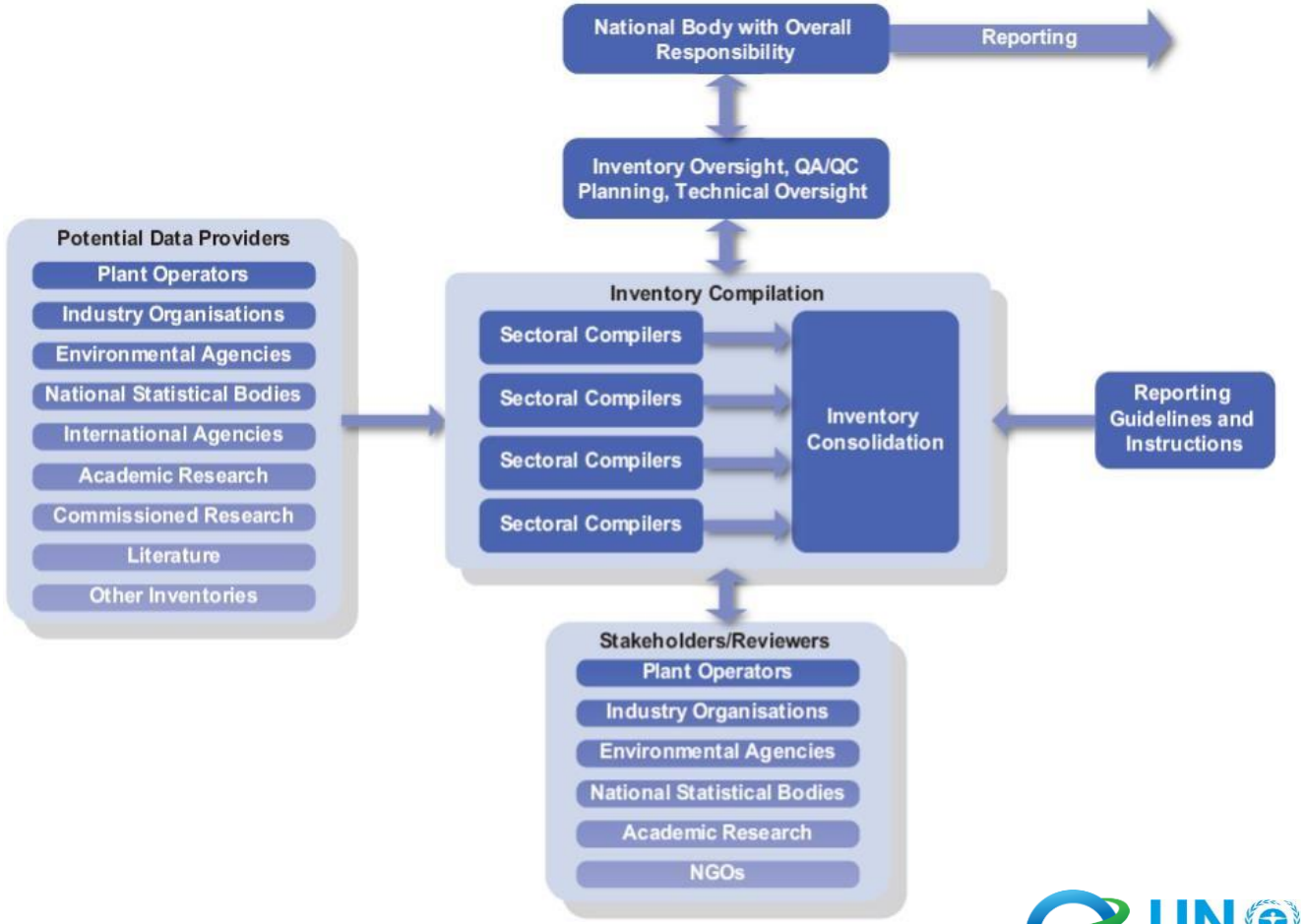
The legal, institutional, and procedural elements needed to estimate, report, and archive GHG emissions and sinks. This includes the description of the procedures for preparing GHG inventories and the documentation of data sources, methodological choice, and assumptions.

Institutional arrangements, by definition, are country-specific.

Arrangement between who, what, when?

- National decision makers or policy advisors
- Management and coordinators
- Experts
- Data suppliers

Documentation: Role, Name, Organization, Contact Information, Categories, Type of Arrangement



Why Establish Institutional Arrangements?

Allows for timely and continuous development and reporting of high-quality GHG information

- It is time consuming, expensive and in-effective to develop a "one-time" report every two years. Establishing institutional arrangements puts the necessary procedures in place to produce higher quality information more effectively.
- Allows a country to continually build on, and improve, what was there and implement IPCC principles.

Gives ownership to the country

- Embedding the systems in national institutions, supplemented by industry, universities, and external institutions and experts enhances the ability of the country to engage domestically and internationally in the climate discussion.

Necessary to organize a complex process

- Climate change and GHG emissions reporting impacts the entire economy; clear roles, responsibilities and procedures are needed to organize the large number of individuals and data sources involved.

Documentation of Institutional Arrangements

- **Templates "1: Institutional Arrangements" and "4: Description of Archiving System"** are part of a series of templates in the EPA's "Improving a National GHG Inventory System Workbook" that can be a useful tool.

- **The purpose of the templates include to**:
  - Document parties and key contacts involved, and their roles and arrangements by secto
  - Aid current and future inventory compilers in their compilation effort as they can understand previously used data, methodologies, structures, processes, etc. Increase sustainability of the National Inventory System and its improvement over time
  - Increase transparency of reporting under the UNFCCC, e.g. for NCs and BURs, as well as for reporting under the Paris Agreement.

- **Not all documentation needs to be reported**

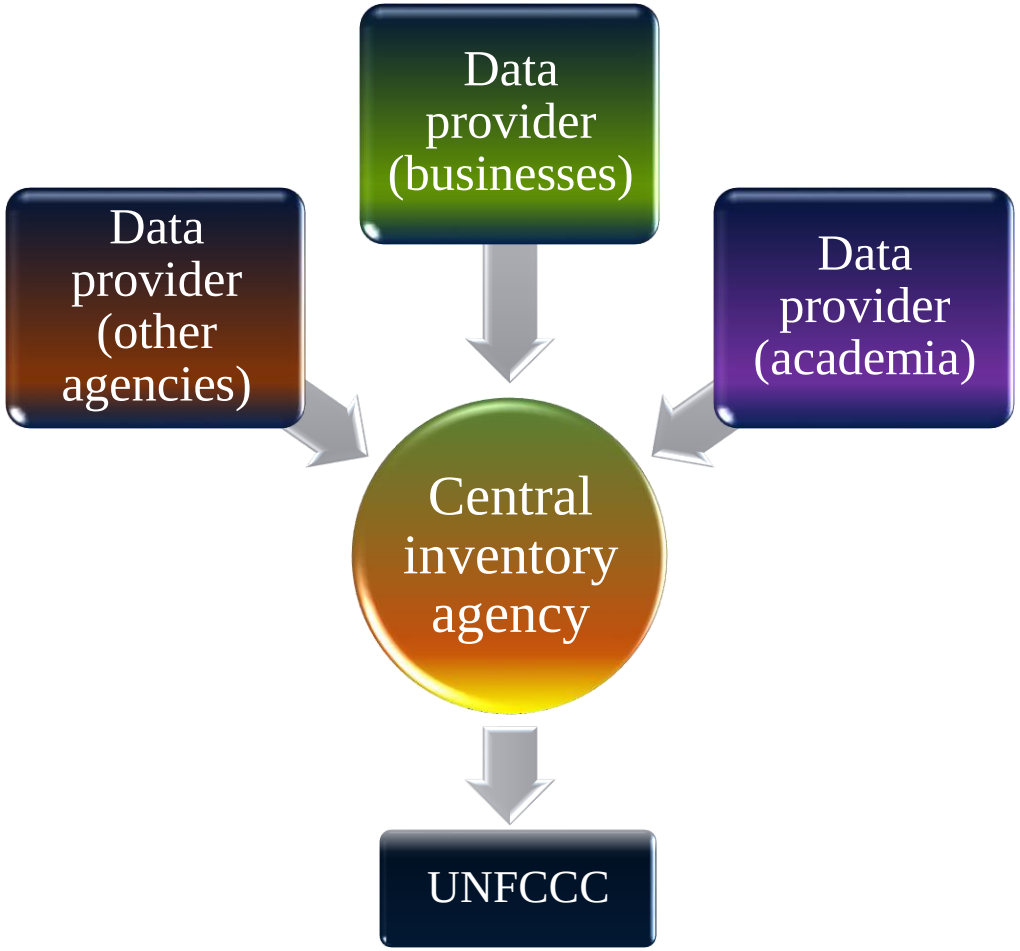
- Link to EPA Template 1 and Template 4

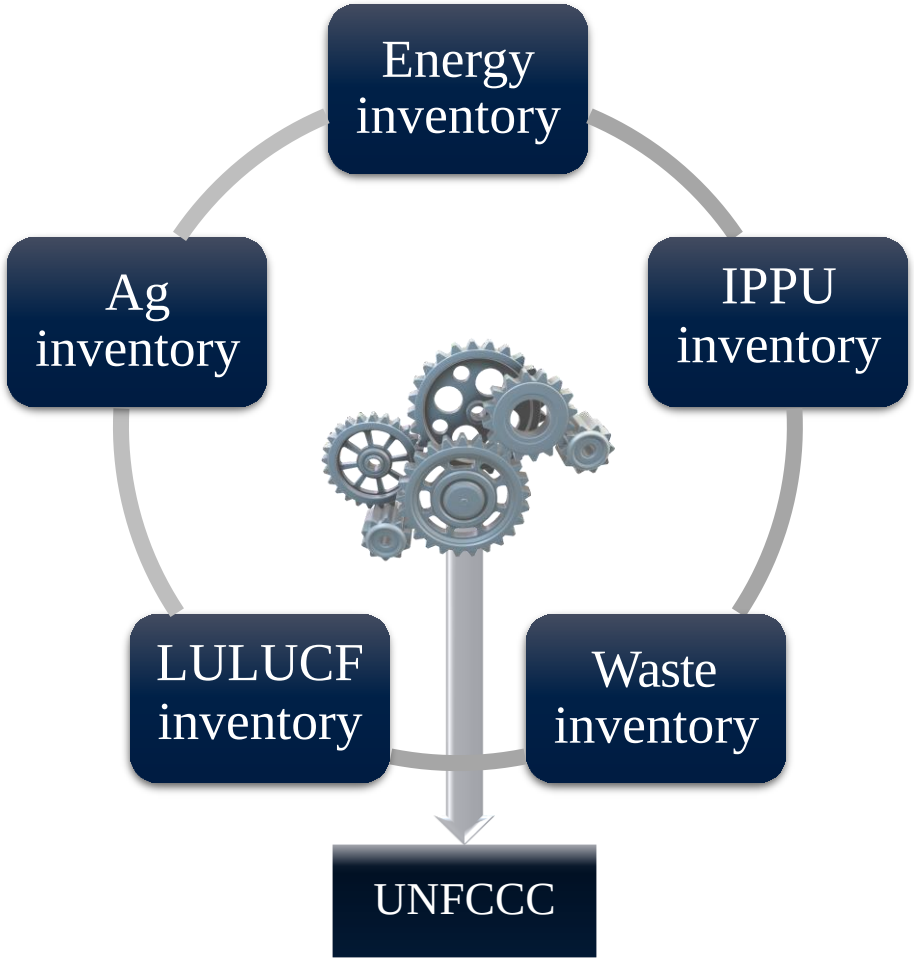
Reporting on Institutional Arrangements

- **Reporting requirements on institutional arrangements is generally guided by program requirements.**
  - *"Non-Annex I Parties may provide a description of existing institutional arrangements relevant to the preparation of their national communications on a continuous basis."*
  - *"Non-Annex I Parties are encouraged to describe procedures and arrangements undertaken to collect and archive data for the preparation of national GHG inventories, as well as efforts to make this a continuous process, including information on the role of the institutions involved."*

- **Think about the big picture of the steps discussed above under inventory planning, preparation and management.**
  - Who is involved?
  - What do they do?
  - When do they do it?
  - How may procedures be improved in the future? Constraints and gaps?
  - Capacity building needs?

Models of Institutional Arrangements





Centralized approach ← **Decentralized approach**

Beyond Meeting Reporting Requirements

The information generated from the arrangements is of interest to a wide range of stakeholders:

- Decision makers and policy advisors
- International climate change community
- Provincial and local agencies
- The public and interest groups
- Businesses
- Scientists

Integration of GHG Inventory with SDGs

Useful as a tool for developing strategies for national planning and decision-making

Preparation: Inventory Management

Data Collection	• Communicate and coordinate with data providers • Incorporate collected AD, EFs, assumptions, uncertainty information, sources in data collection templates • Conduct initial quality control (QC) activities
Emissions Calculations	• Prepare emissions estimates [using IPCC software][and other relevant tools]. • Check key category analysis based on calculated emissions • Conduct uncertainty analysis • Conduct QC on calculated estimates, to the extent possible

Inventory Preparation

- Identify **key categories**
- **Calculate GHG emissions** estimates using agreed upon Guidelines (including methods, collection of AD, EFs and other parameters).
- Calculate **uncertainty**
- **Prepare and report recalculations** in accordance with the 2006 IPCC Guidelines and relevant reporting formats
- Report emissions using **agreed upon formats**
- **Implement QA/QC procedures** according to your plan and the 2006 IPCC GL
- **Documentation** (see templates in “Data collection”, “QA/QC”)

Building Blocks of a Data Collection Strategy

Remember that inventory development is an iterative process

Data collection strategy for each category should consider TACCC

Prioritize data collection for key categories

Establish relationships with data providers, (formal if possible)

Consider multiple data sources: local, national, international, private and public

Collect new data

Prioritize Data Collection for Key Categories

The purpose of a key category analysis is to prioritize inventory development to enhance accuracy and ensure most efficient use of resources.

Still want to strive for completeness of GHG Inventory, but may use lower tiers for less significant sources.

Do not forget to qualitatively assess key categories; can be particularly important in early years where it is difficult to quantitatively assess a category.

Data acquisition: Dealing with restricted data and confidentiality

- It is good practice to engage data suppliers in the process of inventory compilation and improvement

- Data providers might restrict access to information because it is confidential, unpublished, or not yet finalized.

- Find solutions to overcome these concerns by:
  - explaining the intended use of the data,
  - agreeing, in writing, to the level at which it will be made public,
  - identifying the increased accuracy that can be gained through its use in inventories,
  - offering cooperation to derive mutually acceptable data sets,
  - and/or giving credit/acknowledgement in the inventory to the data provided.

Reference: UNFCCC CGE Training material

Collection of data: General guidance for gathering existing data – Important Steps

- Begin with screening of available data
  - Iterative process where details of available data are built up
  - Slow and requires questioning until final judgment about usefulness of a data set for the inventory can be made e.g. consider the original intent for data source

- Refining data requirements
  - Formal specification and data request (i.e. knowing what to ask for, from whom, and when)
  - Specifications include the following:

Reference: UNFCCC GGE materials

Gathering existing data: Possible sources of country-specific data

National

- National statistics Agencies
- Sectoral experts, stakeholder organisations
- Other national experts
- Reference libraries (National Libraries)
- National Inventory Reports from Parties to the United Nations Framework Convention on Climate Change

International

- IPCC Emission Factor Database (EFDB)
- International organisations publishing statistics e.g., United Nations, Eurostat or the International Energy Agency, OECD, FAO and the IMF (which maintains international activity as well as economic data)
- Other international experts

Other

- Scientific and technical articles in environmental books, journals and reports
- Universities
- Web search for organisations & specialists

Reference: UNFCCC CGE Training material

Establishing Relationships with Data Providers

- It is good practice to engage data suppliers in the process of inventory compilation and improvement from the beginning.
  - They will better understand your data needs.
  - Establish a formal memorandum of understanding or other mechanism to acquire data in a timeframe appropriate for the GHG Inventory on a continual basis.
- Communicate with clear data requirements and specifications
- Involve them in the QA / QC process
- Acknowledge them in the final GHG inventory report.

Data Arrangements

Types

Formal Data Arrangements

- Legal, legislative
- Legal, policy mandate or directive
- Enforcement or regulative authority
- Contractual

Informal Data Arrangement

- Memo of Understanding
- Informal, task force, committee

Handling Confidential Information

- For some activities – particularly fuel consumption by the military and industrial activities – data providers might not allow or restrict access to information because it is considered classified, confidential, or may be unpublished, or not yet finalized.

- Confidential data may be used; report at a higher level of aggregation to avoid divulging confident information.

- Use of confidential data involves establishing strong relationships with data providers:

  - Ensure they understand the use of the data; how data will be treated and who will have access (e.g., during a technical analysis of the BUR, could confidential data be made available?)
  - Put in place appropriate and well documented procedures to handle confidential information
  - Offer the option to data providers to do the emissions calculations themselves and provide you with an aggregate figure to be used for the inventory or to have a third party aggregate data (establish specific QA/QC procedures for this).

- Make sure agreed upon procedures for handling of confidential material are included in the archived GHG inventory documentation.

Confidentiality challenges

Procedures needed to ensure that data confidentiality is respected

Despite best efforts, it is possible to face situations where access to data required for the GHG inventory is blocked.

Talk to all people involved and understand their specific confidentiality concerns.

Then dissolve any misconceptions about the inventory process. If that fails…

- Develop custom confidentiality protection provisions to address their concerns.
- Get yourself 'authorized' by senior members in the organization (e.g., CEO, secretary, minister etc.) to access the data
- Collect data on your own
- Use surrogate data to approximate the information needed for the GHG inventory (e.g., missing activity data)

Collect all Available Data: Multiple Sources

National
Official statistics and databases
Universities
Industry, environmental groups, other national experts
Trade Associations
National Library
Published literature and expert judgement
Census and surveys, one-time studies

International
International organizations (UN, International Energy Agency, FAO, OECD, U.S. EIA, U.S. Geologic Survey, World Bank)
IPCC Emission Factor Database
GHG inventories from other countries
Published literature and expert judgement
Web

In general,

√ **National data better than International**

√ **Peer reviewed data better than non-peer reviewed**

√ **Direct data better than surrogate**

√ **Public data better than confidential**

Adapting data for inventory use

Examples of "adapting data" for the GHG inventory include:

- Correcting data for calendar year use
- Avoiding multi-year averaging
- Ensuring population statistics represent the time animals live
- Using "splicing" techniques to ensure time series consistency (e.g., extrapolation, interpolation)
- Using regionally collected data in country and aggregate to national level.
- Using surrogate data to complete gaps
- GHG Inventories should be consistent across time
- Adapting data includes filling data gaps for one or more years or to ensure complete national coverage.

Goal:
To ensure the level of detail and coverage of the data, including sectors, processes, abatement, match the location, land type, compound and years included.

Adapting data for inventory use

Strategies for Addressing Data Gaps in Greenhouse Gas Inventories

Types of Data Gaps:

Filling Gaps in Periodic Data:

Examples: Infrequent surveys (e.g., national forest inventories).

Methods: Inference, splicing, extrapolation (Chapter 5: Time Series Consistency).

Time Series Revision:

Use of modeling and. assumptions by statistical organizations for the most recent year.

Refinement in the following year with further data processing.

Integration of revised data into the inventory

Incorporating Improved Data:

Challenges when recent data improvements are not suitable for earlier years.

Addressing inconsistencies in time series with detailed new data (e.g., emission factors for modern vs. older plants)

Stratification using expert judgment or surrogate data

Compensating for Deteriorating Data:

Use of splicing techniques for managing deteriorating data sets.

Deterioration due to changing priorities, economic restructuring, or diminishing resources.

Consideration of international data sources for relevant activity data.

Incomplete Coverage:

Usage of available data even when incomplete (e.g., measurements for a subset of plants or partial survey data).

Combination with other data sets for calculating national estimates.

Recommendations for expert judgment and data combination with considerations for time series consistency.

Eliciting expert judgment?

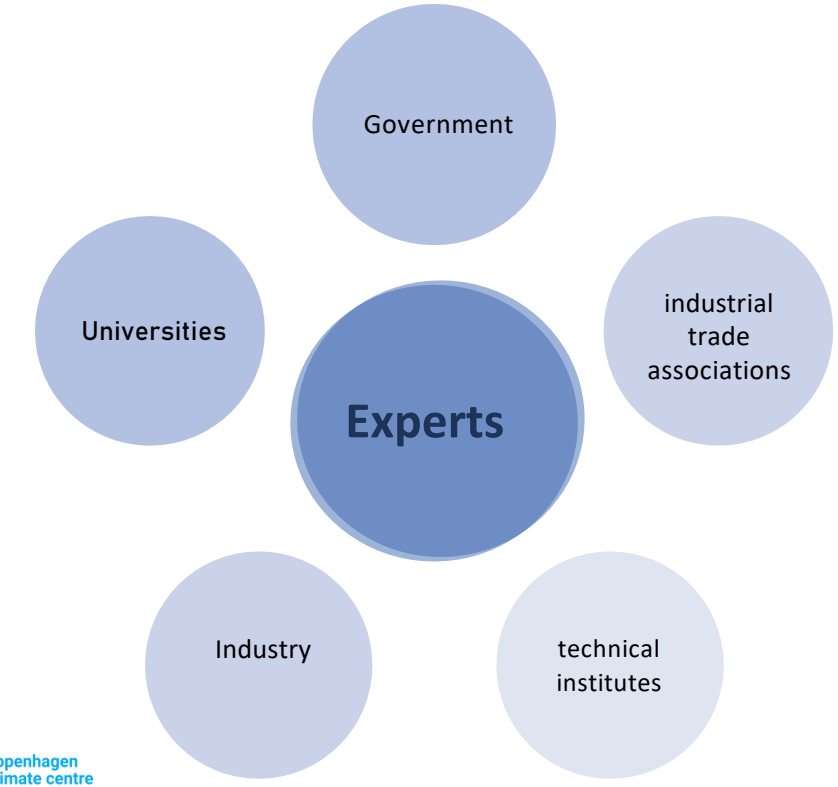
In some cases, an appropriate protocol is especially important. For example, to fill gaps in the available data, to select data from a range of possible values or make judgments about uncertainty ranges.

- Motivating: establish a rapport; describe the context
- Structuring: define the quantities for which judgements are to be sought (e.g. the year and country, the source/sink category, the structure of the inventory model, etc).
- Conditioning: work with the expert to identify and record all relevant data, models, and theory relating to the formulation of the judgements.
- Encoding: encoding is the process of converting an expert's judgement regarding uncertainty into a quantitative PDF (see Vol 1. Chapter 3).
- Verification: analyze the expert's response and provide the expert with feedback. Is what has been encoded really what the expert meant? Are there inconsistencies in the expert's judgement?

Expert judgement

Expert judgment, a fundamental component of inventory development, refers to the well-informed conclusions and selections made by subject-matter experts. It acts as a pillar for managing information gaps and making important choices.

Expert judgment forms the basis of all inventory development efforts. Sector specialists play a crucial role in providing insights and filling gaps in data where necessary.



Assist

- selecting methodologies
- parameter values
- activity data
- ensuring a comprehensive approach

After you have data, what next?
Emissions Estimations

- Templates and resources available for developing countries
- The specific methodologies will be explained during the sessions tomorrow (Sector lessons)

Preparing for the BTR submission: Documents to consider

There are many helpful guidance and reference documents available to inventory compilers for developing national GHG inventories and a national GHG inventory system. These include:

- UNFCCC Non-Annex 1 Guidelines on National Communications and BURs;
- ETF Handbook v2 (2023)
- 2006 IPCC Guidelines;
- UNDP's Managing the National GHG Inventory Process Guidance;
- EPA's Developing a national GHG inventory system: template workbook;
- GIZ's BUR template
- Examples of other Parties

Management: Inventory Management

Drafting Inventory	• Inventory coordinator, or designee drafts general sections of report (e.g. introduction, overview of trends, key category analysis, institutional arrangements, etc.) • Sector experts to draft narrative GHG report to communicate category level emissions estimates, including sources and values of AD, EFs and assumptions, results, and an explanation of trends.
Review and Revise Inventory	• Conduct QC of draft inventory report • Conduct expert QA, if time permits • Revise draft pending outcome of review
Finalize Reporting Cycle	• Finalize draft inventory • Submit to the UNFCCC • Submit materials to the archive • Ensure planned improvements are documented, as appropriate

Inventory Management

- Archiving of relevant information for the entire time series
  - Disaggregated AD, EFs, documentation
  - Calculation spreadsheets
  - QA/QC procedures and results
  - Planned improvements
- How is system organized ?
  - Electronic versus hard copy
  - Security
  - Handling of confidential information
- Have procedures in place for allowing viewing of documentation by external Parties (e.g. during a technical analysis)

Quality Assurance/ Quality Control (QA/QC) and Verification

Quality Control (QC)

-**Routine** technical activities

-Conducted **during compilation**

- Performed by **inventory team**

-**Document and archive** inventory material and record all QC activities

Quality Assurance (QA)

-Planned **system of review procedures**

-Performed by **personnel not on the inventory team**

<u>Reviews verify that:</u>

-measurable objectives were met,

-inventory represents the best possible estimates

-support the effectiveness of the QC program

Verification

Collection of activities and procedures conducted during the planning and development, or after completion of an inventory that can help **to establish its reliability** for the intended applications of the inventory

Criteria for Achieving Data Quality Objectives

Transparency

- There is sufficient and clear documentation such that all involved can understand how the inventory was compiled and can assure themselves that it meets the good practice requirements for national GHG emissions inventories.

Consistency:

- Estimates for different inventory years, gases and categories are made in such a way that differences between years and categories reflect real differences in emissions. Inventory annual trends, as far as possible, should be calculated using the same method and data sources in all years.

Comparability:

- The national GHG inventory can be compared with national GHG inventories for other countries. This comparability should be reflected in appropriate identification of key categories; in the use of the reporting guidance and tables; and use of the classification and definition of categories of emissions and removals.

Completeness

- National, calendar year estimates are reported for all sources and sinks, and gases. Where elements are missing their absence should be clearly documented together with a justification for exclusion.

Accuracy:

- National GHG inventories should contain neither over- nor under-estimates so far as can be judged. This means making all endeavours to remove bias from the inventory estimates.

TACCC PRINCIPLES

Transparency, accuracy, completeness, consistency, and comparability are **key IPCC principles in preparing and reporting GHG inventories** and are also indicators of inventory quality.

Why develop a QA/QC System & Plan?

Establishing and implementing a QA/QC system is fundamental to delivering a GHG inventory you can trust

- A QA/QC and verification system contributes to the objectives of good practice in inventory development, namely to improve transparency, consistency, comparability, completeness, and accuracy of national greenhouse gas inventories.

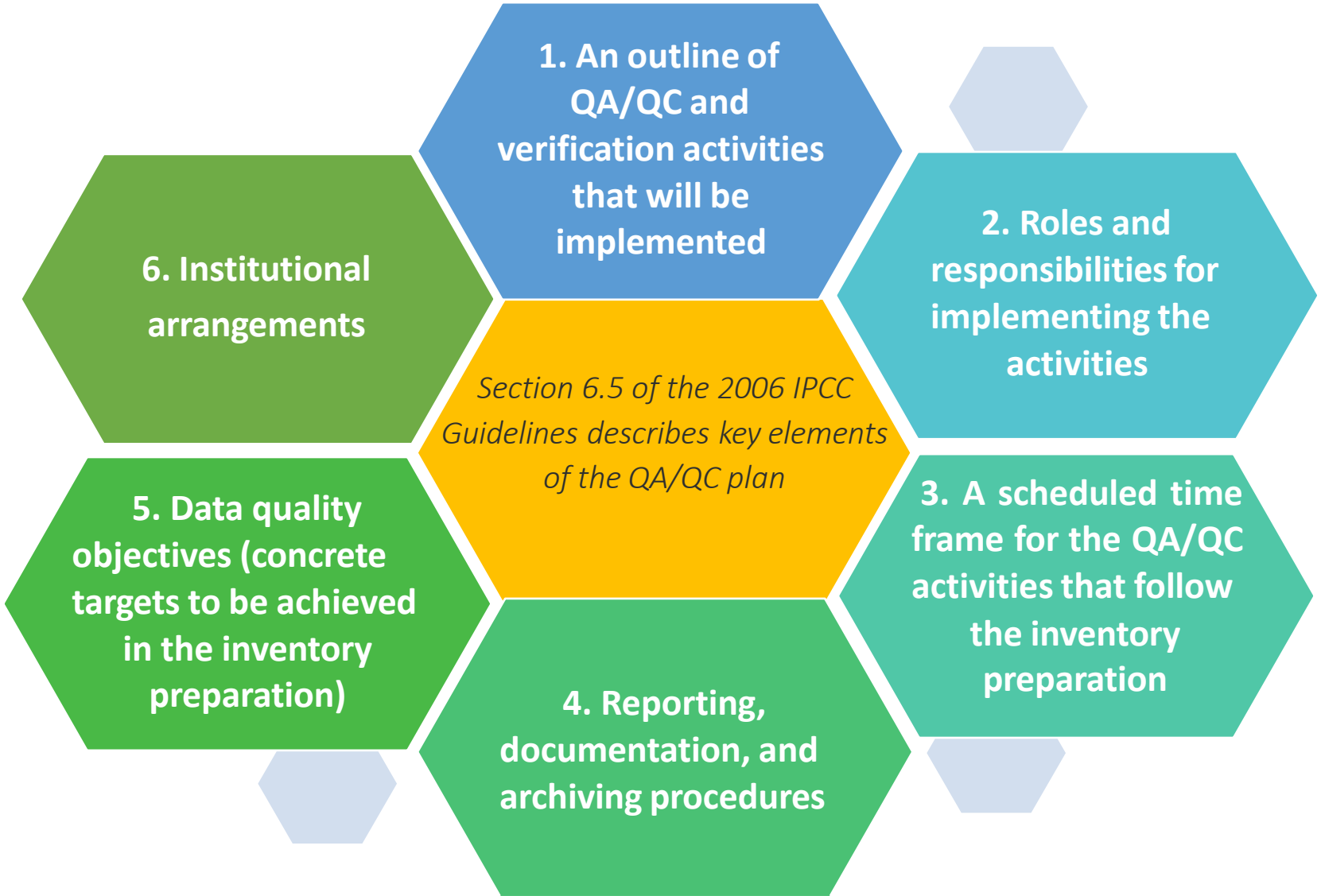
A QA/QC plan is an integral part of the process to help improve the inventory over time

- The outcomes of QA/QC and verification may result in a reassessment of inventory or category uncertainty estimates and to subsequent improvements in the estimates of emissions or removals.

Elements of the QA/QC System

1. Identified roles and responsibilities
    - Inventory compiler and/or quality management coordinator coordinates QA/QC activities and defines roles
2. A QA/QC plan
3. General QC procedures
4. Category-specific QC procedures for all inventory categories
5. Focus on key categories
6. QA and review procedures
7. QA/QC integration with uncertainty assessment
8. Verification activities
9. Reporting, documentation, and archiving procedures

Key elements of the QA/QC & verification plan



Structural Organization of Belize's QA/QC System

a. The National Climate Change Office/ Manager of the QA/QC Manual

- The QA/QC Plan can be modified if inventory processes change or on the recommendation of reviewers.

b. Inventory Coordinator

- Highly specialised experts with in-depth knowledge of UNFCCC and IPCC methodologies
- Responsible for collecting activity data and analysing it before calculating GHG estimates for the reported sectors

c. Sector Leads

- The NCCO and other government entities collect data used in sectoral emissions estimations. It is expected that focal persons within the different government entities verify the product before its finalised and published.

d. QA/QC Lead/Coordinator

- Directs the overall implementation of QA/QC Plan, supervises sector QA/QC leads, oversees expert reviews, and is responsible for ensuring the full and adequate implementation of QA/QC elements
- Main person responsible for implementing the QA/QC Plan.

Structural Organization of Belize's QA/QC System

Annex II: General QC checklist

Date: _____

Inventory Year	
Category/Categories included in checks	
QC expert (name, date and signature)	
QA/QC manager (name, date and signature)	

INSTRUCTIONS FOR COMPLETING THIS FORM

This form is used as a guide ***in every GHG inventory cycle*** and provides a record of any corrective actions taken. The form is based on the checks contained in the 200 QA/QC, focusing on those checks most relevant for Belize at the current time

Table A.3: Category-specific QC checklist

QC Activity	Task Completed		Corrective Measure Tak
	Name/ Initials	Date	Supporting Documents (List Document Name)
Definitions used for categories, AD and assumptions are consistent with the corresponding definitions in the 2006 IPCC Guidelines			
Where IPCC default EFs are used, are the conditions under which the default EF were developed similar to conditions in the country?			
Where country-specific EFs are used, a data quality investigation of the generation of the country-specific EF has been undertaken to ensure appropriateness for national circumstances and use in the GHG inventory, including comparison with the IPCC defaults			
Where direct measurements are used (e.g. for emissions, AD and EF) have measurements been undertaken in a way that is consistent with national and/or international standards?			
Alternative methods are used to cross-check results of inventory calculations (e.g. higher and/or lower tier)			
Evaluate the QC checks undertaken by data providers or other third parties to ensure consistency with the procedures outlined in this QA/QC plan			
Review uncertainty calculations; adjust any default uncertainties pending the outcome of other QC checks			
Verify AD, EFs and/or emissions/removals estimates by comparing estimates to other national or international estimates at the national, gas, sector, or sub-sector level, as available			
Other (please specify)			

Checklists for Sector Leads to consider while entering AD, and estimating emissions, and drafting report

Quality Control (QC) Procedures

General QC procedures are followed each consecutive inventory cycle for all categories to ensure that basic standards of quality are met. These standards focus on the processing, handling, documenting, archiving, and reporting procedures common to all categories.

Responsible: QC Coordinator/ GHG Inventory Coordinator
When to fill Checklist: At the stage of Draft Sector report
Checked and confirmed by: QA/QC Lead

Category-specific QC procedures complement general inventory QC procedures and are directed at specific types of data used in calculating GHG emissions for individual source or sink categories. These procedures require knowledge of the specific category.

Responsible: Sector Lead for each sector

When to fill Checklist: At the stage of Draft Sector report

Checked and confirmed by: QA/QC Lead

The 2006 IPCC Guidelines refer to two types of Quality Assurance activities: expert review and audits

The objective of expert peer review is to ensure that the inventory's results, assumptions, and methods are reasonable as judged by those knowledgeable in the specific category

Review processes may raise technical problems regarding the selection and implementation of methods, AD and EFs, and identify potential improvements to the inventory.

Issues raised are incorporated into The Bahamas' current inventory process, to the extent possible, and where not feasible incorporated into the NIIP for the next or subsequent GHG inventory development cycles.

Summary of the review processes undertaken for the current GHG inventory:

•**UNFCCC voluntary peer review:** : In April 2018, Belize volunteered to have its NC3 subjected to a peer review, lead by the UNFCCC

•**Regional or bilateral reviews**

•**Other Expert QA process:** Currently, a "validation session" is held after a draft report is submitted to NCCO. Representatives from academia, NGOs, government and the private sector are invited to review the accuracy and completeness of Belize's GHG inventory

•**UNFCCC International Consultation and Analysis (ICA) Process: Belize** submitted its first BUR in 2021 was subject to a technical analysis by an international technical team of experts (TTE) in accordance with decision 2/CP.17, annex IV. Findings identified by the TTE will be included in the inventory improvement plan, in particular with a goal to identify those improvements which can be implemented before the BTR submission in 2024.

•**Audits:** Conducted by an independent expert. Currently audits are not a part of Belize's QA/QC plan.

Quality Assurance (QA)

Due to the comprehensive and costly nature of QA activities, these procedures are only applied for selected categories and selected years, and generally only for key categories. Experts to conduct review processes can be selected by the NCCO and early in the inventory planning process.

The approach to QA is to prioritize: key categories, issues listed in the inventory improvement plan, categories with major recalculations, issues identified by experts, and to a lesser extent, based on the uncertainty of the emissions estimates.

Verification Procedures

Refers specifically to those methods that are external to the inventory and apply independent data, including comparisons with inventory estimates made by other bodies or through alternative methods.

Verification activities are typically directed at specific categories, and their application will depend on the availability of independent estimation methodologies and/or data that can be used for comparison.

The results broadly, provide inputs to improve inventories, build confidence in emissions estimates and trends, and improve scientific understanding.

QA/QC of GHG Inventory:

- Verify sector-specific calculations
- IPCC default emission factors
- Applying lower-tier methods
- Horizontal methodological shifts (e.g., between Xa and Xb methods)
- Comparisons with independently compiled estimates

In the context of measurement, reporting, and verification (MRV):

- Verification is addressed at the international level through International Consultation and Analysis of BURs
- In the near future, BTR analysis and review will provide additional opportunities for the verification

Documenting and Archiving: What to Include?

- **Responsibilities, institutional arrangements, and procedures** for the planning, preparation, and management of the inventory process.
- **Assumptions and criteria** for the selection of activity data and emission factors.
- **Emission factors and other estimation parameters used**, including references to the IPCC document for default factors or to published references or other documentation for emission factors used in higher tier methods.
- **Activity data or sufficient information to enable activity data** to be traced to the referenced source.
- **Information on uncertainty** associated with activity data and emission factors.
- **Rationale** for choice of methods.
- **Methods used**, including those used to estimate uncertainty and those used for recalculations.
- **Changes in data inputs or methods** from previous inventories (recalculations).
- **Identification of individuals providing expert judgment** for uncertainty estimates and their qualifications to do so.
- **Details of electronic databases or software** used in the production of the inventory, including versions, operating manuals, hardware requirements and any other information required to enable their later use.
- **Worksheets and interim calculations** for category estimates, and aggregated estimates and any recalculations of previous estimates.
- **Final inventory report** and any analysis of trends from previous years.
- **QA/QC plans and outcomes** of QA/QC procedures.
- **Secure archiving of complete datasets**, to include shared databases that are used in inventory development. This is particularly important for categories that rely on the multi-step development of emissions from a large set of primary data from outside sources.

2006 IPCC Guidelines on Documenting and Archiving:

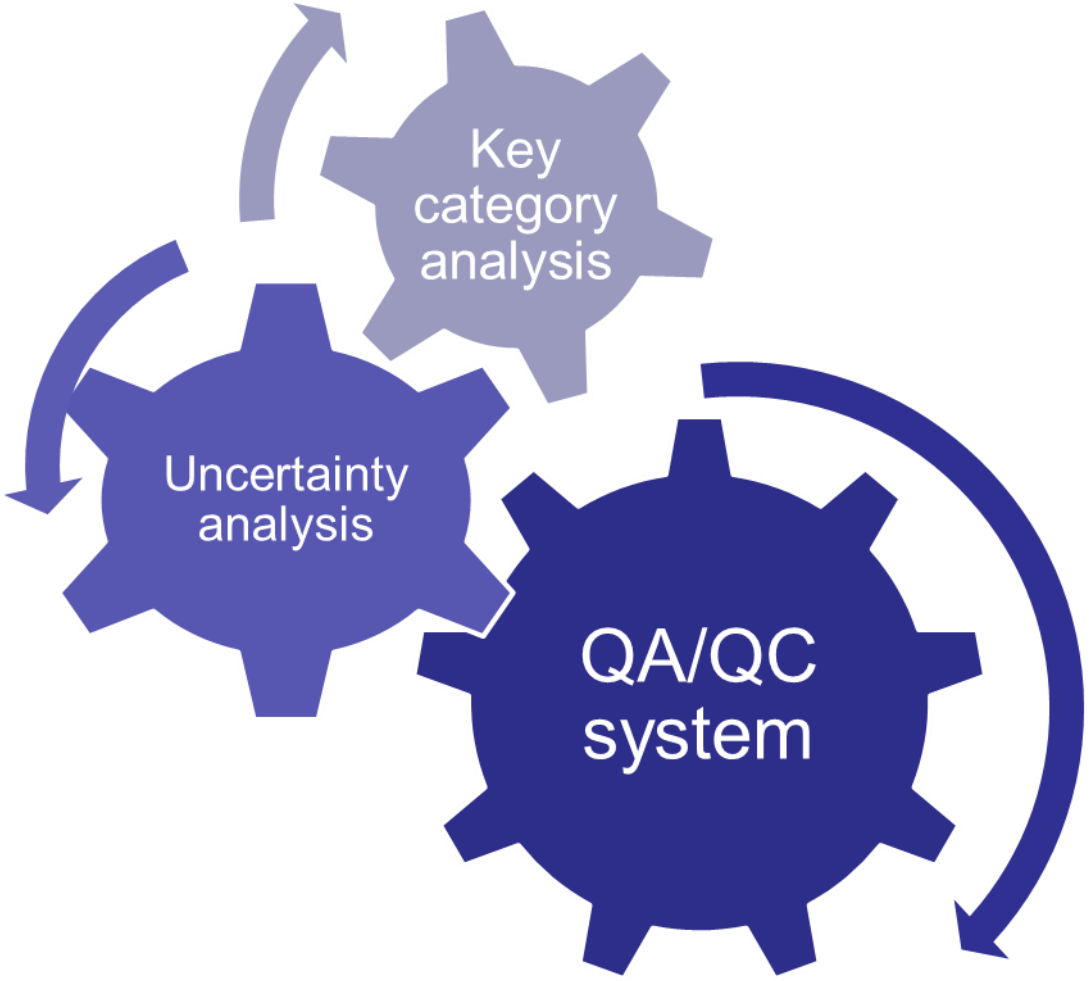
According to the 2006 IPCC Guidelines (volume 1, chapter 6, section 6.11.1) when conducting these QAQC checks, the following aspects are reviewed:

- Internal documentation to ensure it is detailed enough to support the inventory estimates and allows for the reproduction of the emission, removal and uncertainty estimates;
- Archive and storage of inventory data, supporting data and inventory records to allow for detailed reviews;
- Closure and security of the archived data once inventory is completed;
- Integrity of data archiving arrangements of outside organizations involved in inventory preparation.

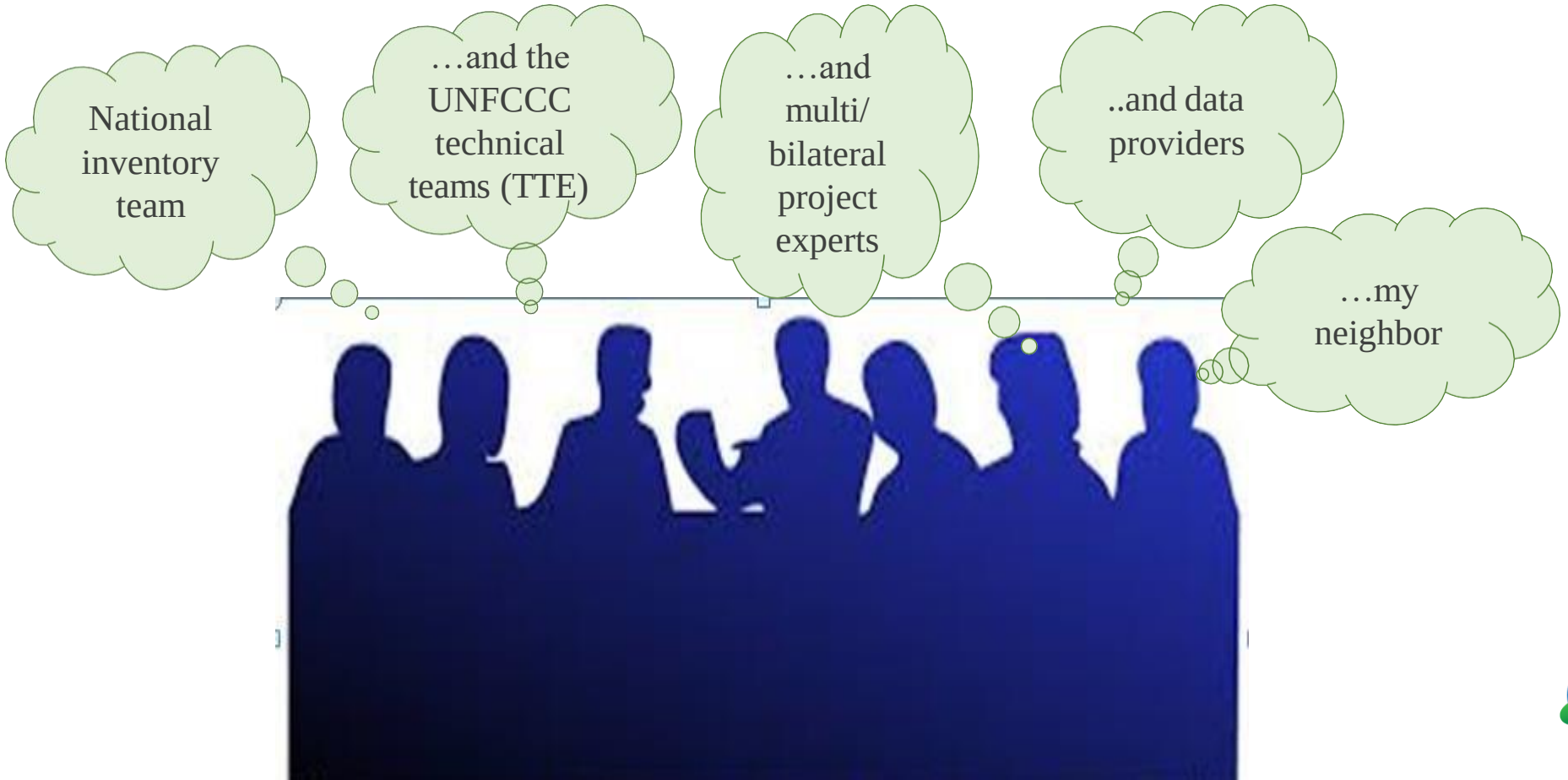
- For Belize, **Archiving** of all data, expert judgement, QA/QC checklists, Calculation files, reports are in its **National MRV System.**
- **Final published reports** are made public in its **CRIS**

As it relates to Reporting, the 2006 IPCC Guidelines (volume 1, chapter 6, section 6.11.2), it is good practice to report a summary of implemented QA/QC activities and key findings as a supplement to a submission of a country's National GHG Inventory in its NC, BTR or NIR.

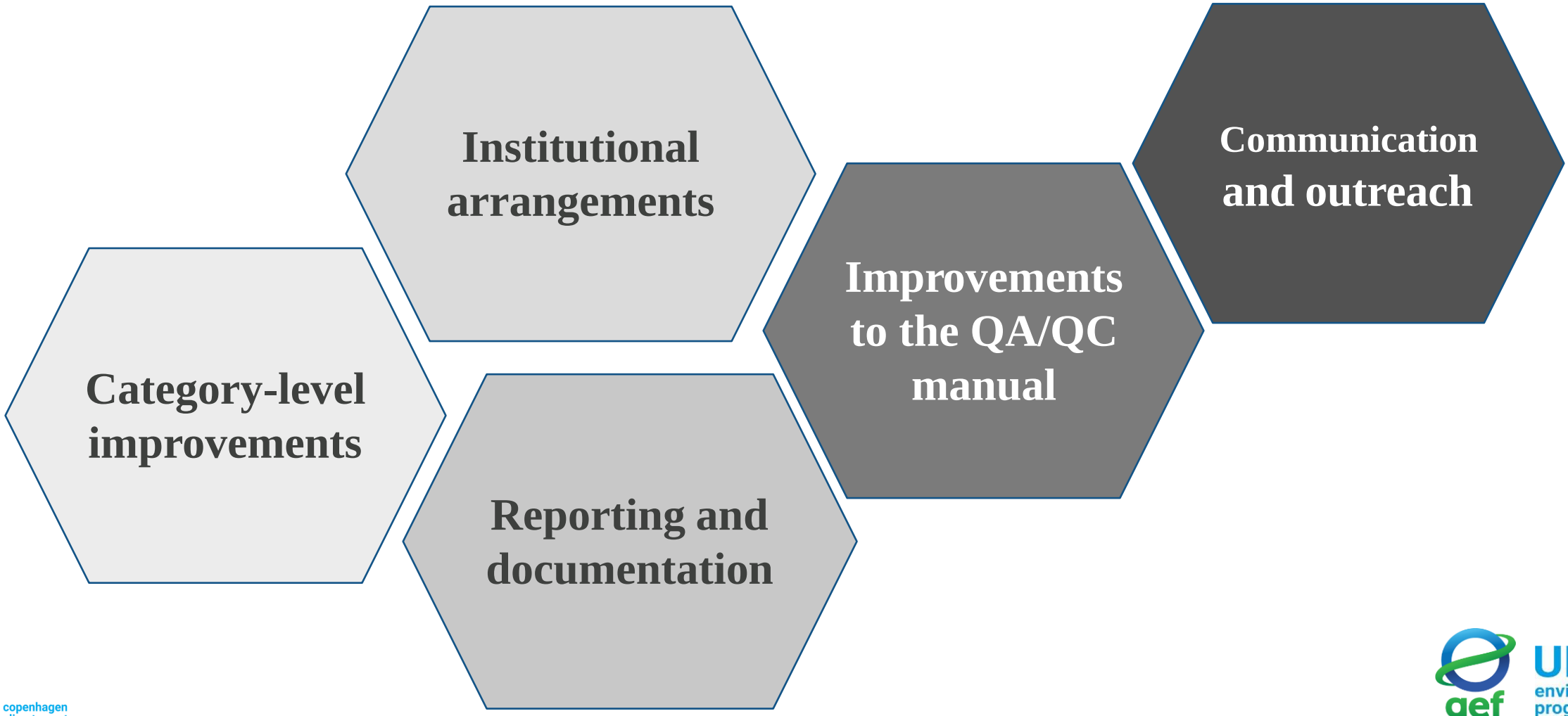
QA/QC and Improving the National GHG Inventory



Who Identifies Inventory Improvements?



Areas for Improvement in the Inventory



Reporting on the Inventory Improvement Plan

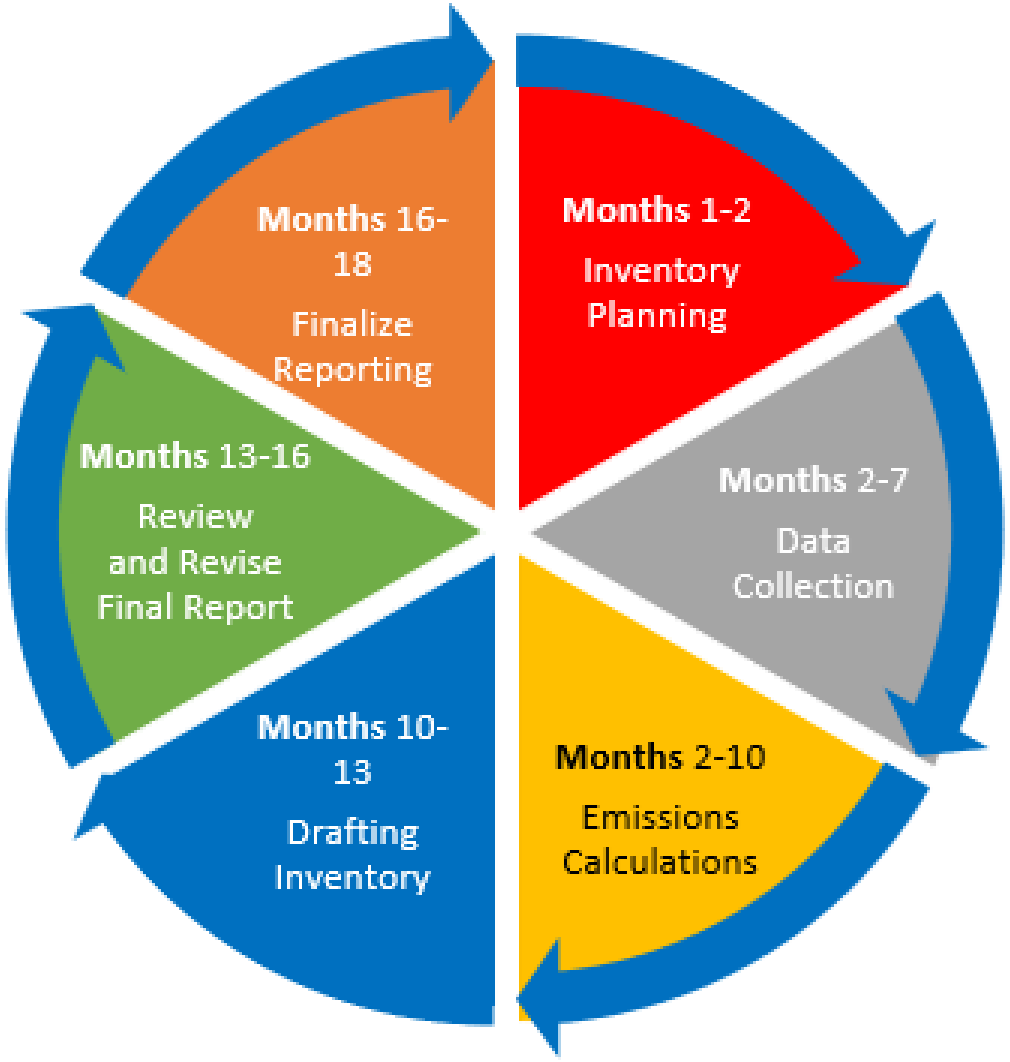
- The inventory improvement may be an internal document, containing internal information on prioritization and timelines.
- The inventory should describe the general approach to identifying and incorporating inventory improvements.
- Specific improvements, where applicable, should be provided at the category level, with a discussion of the planned improvement, any issues affecting implementation of the improvement.

Belize's Inventory Improvement Plan

Table 5.1 Gaps and constraints

Sector		Constraints and Gaps
Energy	i.	Disaggregated data on fuel consumption, by fuel type, is not available.
	ii.	There is lack of data on heavy duty equipment used in the construction industry.
	iii.	Disaggregated data on marine transport is not available.
	iv.	There is a lack of data on fugitive emissions from oil and gas activities.
IPPU	i.	The lack of accurate and reliable data continues to be a constraint for this sector.
	ii.	Reluctance of producers to provide data
	iii.	Challenge in obtaining data from privately owned companies
AFOLU	i.	Through the REDD+ Readiness project, improvements have been made under the FOLU sector in improving data availability and accuracy, however, there is more to be done in the in terms of data collection in the Agriculture sector.
Waste	i.	This sector has benefited from recent solid waste studies done on waste characterization and composition. Nonetheless, there is lack of data in areas such as open burning of waste, and total volume of wastewater produced by industry.
	ii.	Incomplete data available on domestic and commercial wastewater.
	iii.	There is lack of data from the industrial sector, as there is no formal reporting on the generation of liquid waste from shrimp culture and other small industries.

Where is Belize in this Inventory Cycle?



Consider:

What is your role in the current National Inventory Cycle?

Time Series Consistency & Recalculations

Overview

- Why is TSC important?
- Various techniques to create a consistent time series
  - Overlap method
  - Surrogate method
  - Interpolation
  - Extrapolation
- QA/QC checks to ensure a consistent time series
- Reporting on time series consistency in the inventory report

Time Series Consistency (TSC) means

All emissions estimates in a time series should be estimated consistently, which means that as far as possible, the time series should be calculated using the same method and data sources in all years.

The 2006 IPCC Guidelines provides good practice for what to do when the same sources are not available across the time series.

Why Care about TSC?

Inventory is not one year, but multiple years

- Want time series presented to reflect real changes in emissions and not be an artifact of different methods/ data sources

Data improve over time; new sources become available; new sources become key

- Encouraged to use updated data. Sometimes those data are not available historically and methods need to be applied to ensure new data can be applied, without negatively impacting time series

Better track progress of national actions

“Splicing” to Make the Time Series Consistent?

Splicing: combining or joining of more than one method or data series to form a complete time series

-Methodological change and refinement

-Data gaps

- The 2006 IPCC Guidelines provide several splicing techniques
  - Overlap
  - Surrogate
  - Interpolation
  - Extrapolation
- Selecting a technique requires an evaluation of the specific circumstances and a determination of the best option for the particular case

Overlap Method

- You previously used tier 1, but now apply tier 2. The overlap can be used for the years in which you have both data sets to try to apply new method across time series.

- Develop a time series based on the relationship between multiple data sets.

Figure 5.1 Consistent overlap

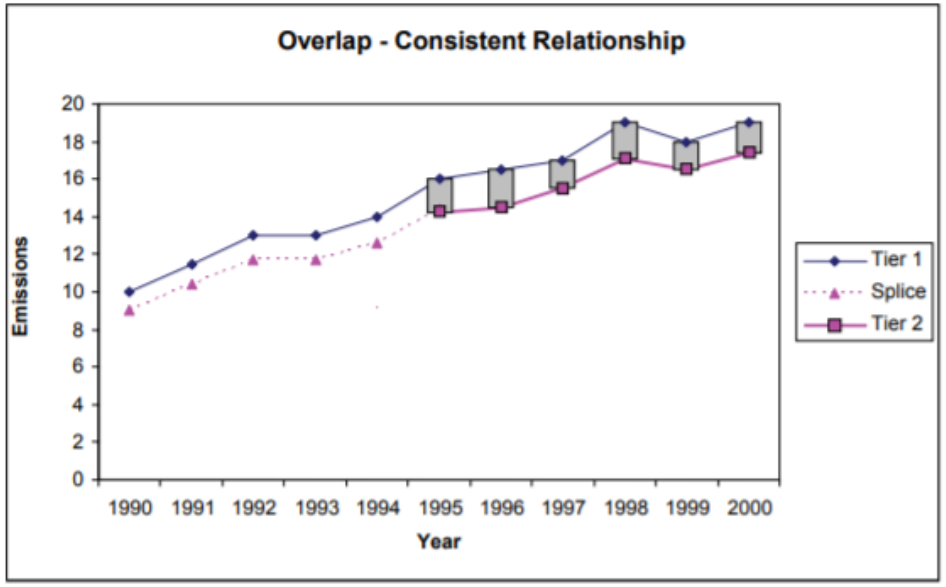
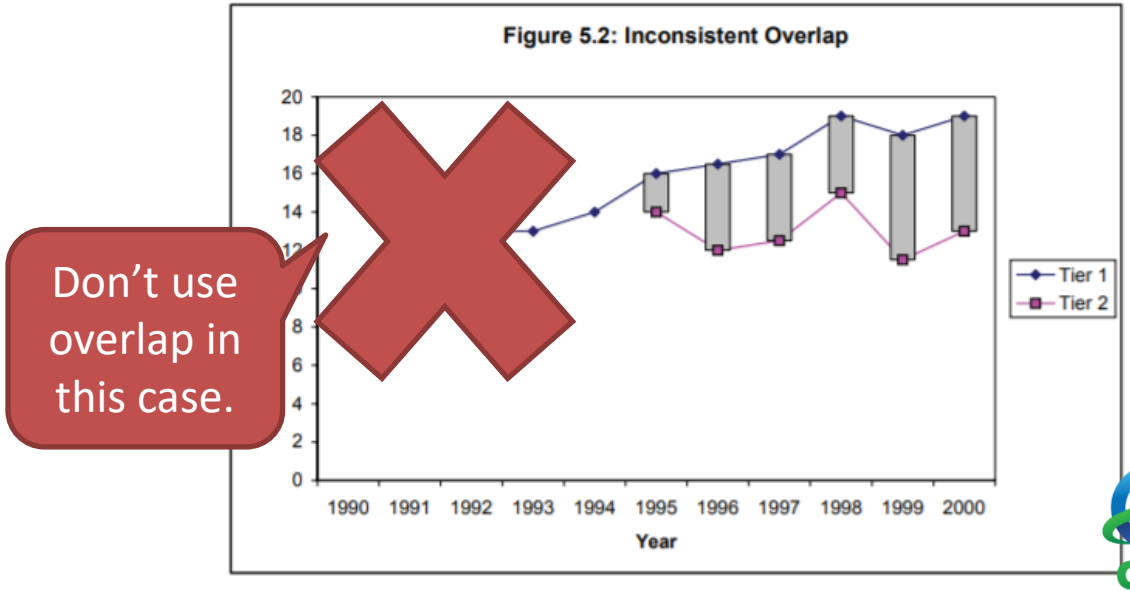


Figure 5.2 Inconsistent overlap



Overlap Method: An Example

EQUATION 5.1
RECALCULATED EMISSION OR REMOVAL ESTIMATE COMPUTED USING THE OVERLAP METHOD

$$y_0 = x_0 \bullet \left(\frac{1}{(n-m+1)} \bullet \sum_{i=m}^{n} \frac{y_i}{x_i} \right)$$

Where:

y_0 = the recalculated emission or removal estimate computed using the overlap method

x_0 = the estimate developed using the previously used method

y_i and x_i are the estimates prepared using the new and previously used methods during the period of overlap, as denoted by years m through n

Step 1

	2007	2008	2009	2010	2011	2012	2013
Tier 1	100	125	130	145	170	200	230
Tier 2			140	160	180	215	244
Ratio Tier 2/tier 1			1.077	1.103	1.059	1.075	1.061

Step 2

	2007	2008	2009	2010	2011	2012	2013
Tier 1	100	125	130	145	170	200	230
Tier 2	107.5	134.38	140	160	180	215	244
Ratio Tier 2/tier 1			1.077	1.103	1.059	1.075	1.061

Calculate std deviation 0.018

$$Y_0 = X_0 \times \left(\frac{1}{2013-2009+1} \times \sum_{2009}^{2013} \left(\frac{140}{130}\right) + \left(\frac{160}{145}\right) + \left(\frac{180}{170}\right) + \left(\frac{215}{200}\right) + \left(\frac{230}{244}\right) \right)$$

$$Y_0 = X_0 \times \left(\frac{1}{5} \times \sum_{2009}^{2013} (1.077) + (1.103) + (1.059) + (1.075) + (1.061) \right)$$

$$Y_0 = X_0 \times \left(\frac{1}{5} \times 5.375 \right)$$

$$Y_0 = X_0 \times 1.075$$

1. Make sure there is a reasonable / consistent relationship between the two methods

2. Consider specific circumstances of category, possible that earlier years in the time series would be expected to be different and so not logical that the relationship stays the same.

Surrogate Data Method

EQUATION 5.2

EMISSION/REMOVALS TREND ESTIMATES USING SURROGATE PARAMETERS

$$y_0 = y_t \bullet (s_0 / s_t)$$

Where:

y = the emission/removal estimate in years 0 and *t*

s = the surrogate statistical parameter in years 0 and *t*

- Relates emissions or removals to underlying AD or other indicative data.

- Must have indicative underlying data.
  - Good examples are trends in vehicle KMT and mobile source emissions, emissions from domestic wastewater and population, and chemical manufacturing and production.

	2007	2008	2009	2010	2011	2012	2013
Reported value: CO_2 emissions from road transport (kg)	?	?	3400	2000	3800	4100	4200
vehicle km travelled	15000	16000	16500	10000	18900	20000	22000

Average ratio = 0.20

	2007	2008	2009	2010	2011	2012	2013
Reported value: CO_2 emissions from road transport (kg)	3009.084	3209.689	3400	2000	3800	4100	4200
vehicle km travelled	15000	16000	16500	10000	18900	20000	22000
Based on data, ratio observed was:			0.21	0.20	0.20	0.21	0.19

Based on national, peer reviewed study, you know that the average kg CO_2 per km travelled is 0.2

Multiply vehicle km in year in missing year by ratio to estimate emissions.

Interpolation

- In some cases it may be possible to apply a method only intermittently throughout the time series. Years are missing in the middle
  - Best if have a longer time series and trends are identifiable and stable
  - If information on the trends or underlying parameters are available, the surrogate method may be preferable.

Table 8 Total Nitrogen Fertilizers in kgs.

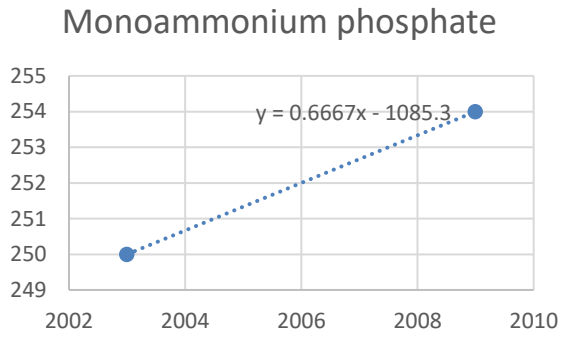
Fertilizer Type	2003	2006	2009
Urea	36020,700	2,066,209	9,105,733
Ammonium Sulphate	644,684	473,243	334,136
Ammonium Sulphate solution	531,854	360,504	405,222
Ammonium Nitrate	4,162,866	1,454,656	696,577
Diammonium phosphate	7,228,518	7,243,236	7,695,840
Nitrogenous Fertilizer	268,524	183,239	370,095
NPK Fertilizers	8,748,492	2,633,062	1,902,602
Fertilizer Mixes	9,497,189	2,071,549	1,812,897
Monoammonium phosphate	250		254
Ammonium carbonate	540	671	2131

Source: Third National Greenhouse Gas Inventory Report, 2015

Basic Example: Belize AD for Monoammonium phosphate

Note: Scenario is not ideal as there is not a longer term trend, but in the absence of other data it could be used.

Y= 0.6667(2006) – 1085.3
Y = 252.1 kg monoammonium phosphate in 2006



$$Y = 250 + (2006 - 2003) * \frac{(254 - 250)}{(2009 - 2003)}$$

Interpolation: How to Use Excel

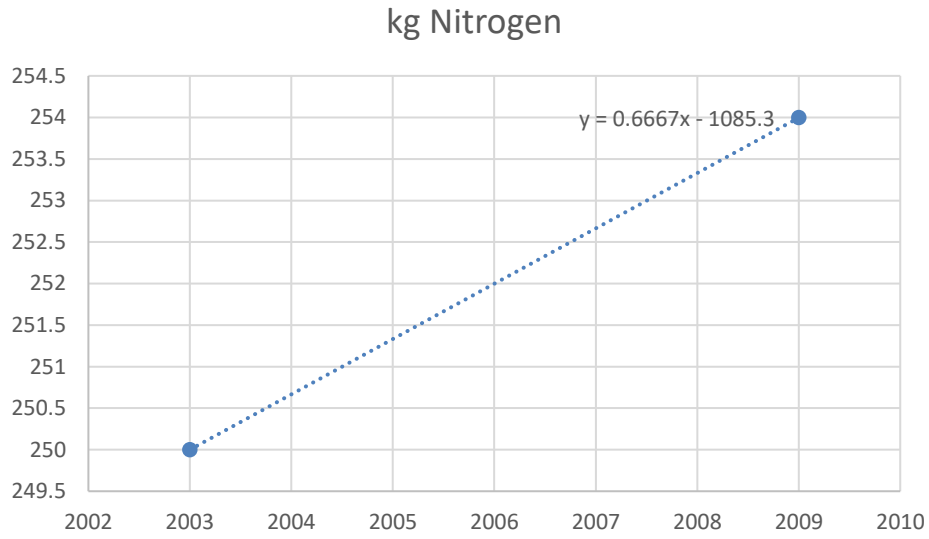
1. Enter data

	kg Nitrogen
2003	250
2006	
2009	254

2. Plot your data in a scatter plot.

3. Select one data point to “Add a trendline” to the graph

4. Display the equation on the chart



5. Use this equation (Y = 0.6667x – 1085.3) where X is the missing year, to find the missing Y value.

Extrapolation

- Can be used when data are not available for the first or last year(s). Should not be used for more than a couple of years.
- Should only be used if there is an observable trend.
- Can be linear or non-linear (e.g. exponential) but should justify choice.

Table 5: Livestock Production 2000-2009

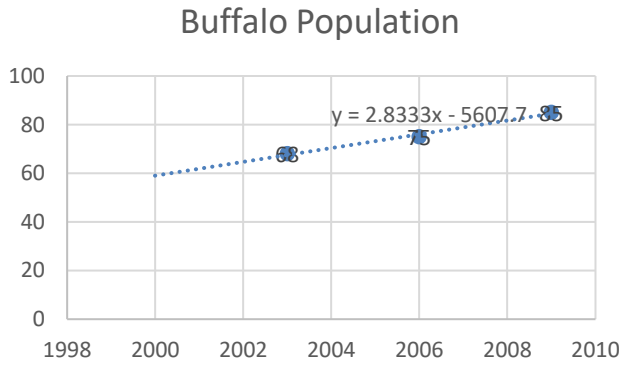
Livestock	2000	2003	2006	2009
Beef	63655	54250	67611	91,129
Dairy	1858	3550	7728	3,877
Swine	14712	21224	14533	17,038
Sheep	4000*	6265	7770	13,018
Goat		620	685	750
Buffalo		68	75	85
Poultry	1,000,000	11,061,544	11133634	12,140,498

Source: Third National Greenhouse Gas Inventory Report, 2015

Basic Example: Buffalo AD

Note: Scenario is not ideal as multiple years missing (2000-2002)

= 2.8333 (2000) – 5607.7
= 59.0 Buffalo estimated for 2000



Time Series Consistency and Reporting

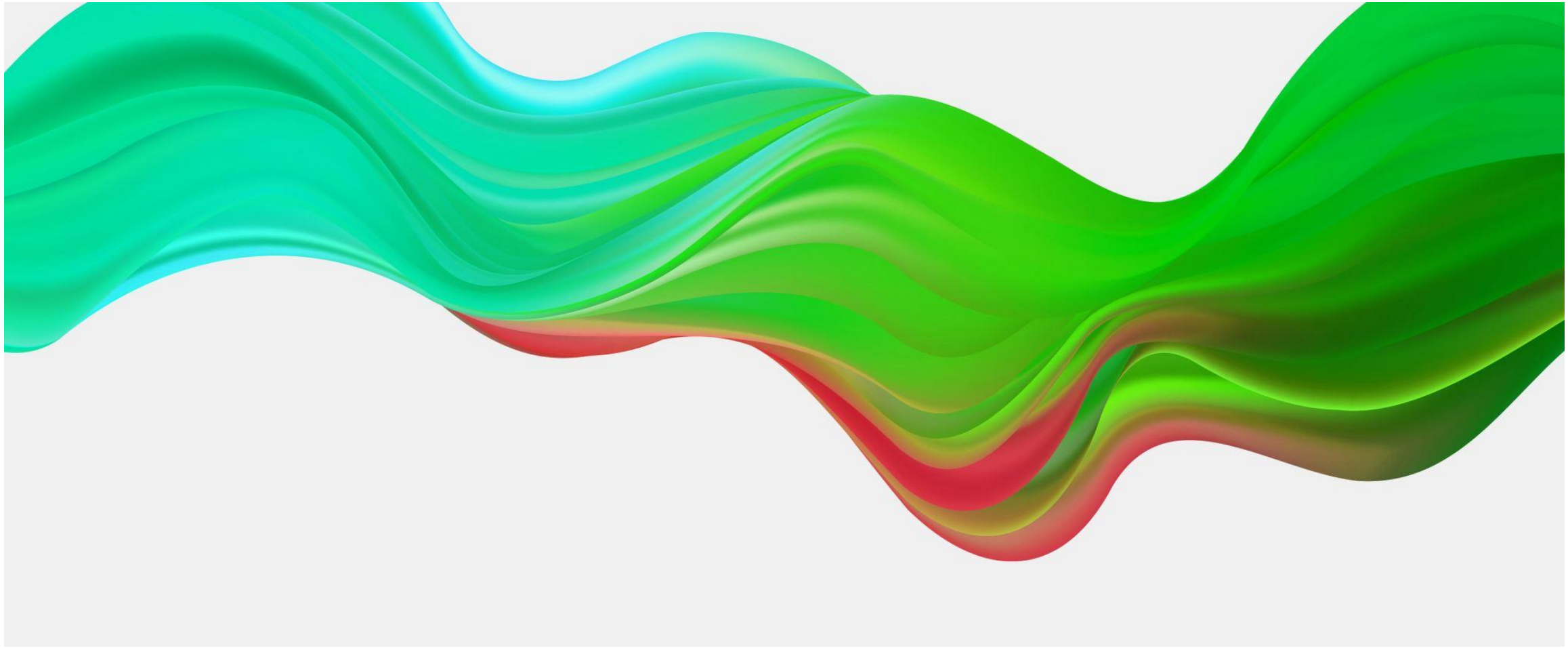
- It is always important to explain trends in your GHG inventory, considering all parameters (AD, EFs and emissions) and explaining how the time series is consistent.
- **Any time you recalculate previously reported estimates**, either because you have updated your AD, EFs, emissions, or because you have used one of these splicing techniques, **you should describe this in the inventory report.**
- The discussion should be qualitative and quantitative and evaluate the impact on the overall trend.

TABLE 5.2
CATEGORY-SPECIFIC DOCUMENTATION OF RECALCULATIONS

Category/Gas	Emissions and Removals (Gg)										
	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Previous Data (PD)											
Latest Data (LD)											
Difference in percent =100•[(LD–PD)/PD]											

Documentation (reason for recalculation):

Exercises: Time Series Consistency



For Discussion

1. Which scenario does NOT lead to an inconsistent time series?
   A. AD are missing for 2014 and 2015, so you use AD from 2013 to report for 2015.
   B. A new reporting program is put in place for a chemical manufacturer, so you start reporting emissions in 2010. Emissions prior to 2010 are not estimated.
   C. You have installed abatement technology on a nitric acid facility so there is a sharp drop in emissions in 2010.
   D. You use two different data sets, one for 1990-2010 and one for 2010 onwards.

2. Give two reasons why extrapolation/interpolation might not be the best splicing technique?

Any Questions?

www.climate-transparency-platform.org

Thank you for your attention !

CBIT-GSP
CLIMATE TRANSPARENCY

Please reach out to us for any question, comments or suggestions!

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