QA/QC and Key Category Analysis

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QA/QC

What is Quality Assurance (QA)?

A planned system of review procedures by personnel **not directly involved** in the inventory process.

Performed upon a completed inventory following quality control procedure.

- Verify the data quality objectives were met;
- Ensure that the inventory represents the best possible estimates of emissions and sinks;
- Support the quality control program.

What is Quality Control (QC)?

System of routine technical activities to assess and maintain the quality of the inventory as it is being compiled. **Performed by personnel compiling the inventory**.

Designed to:

- Provide routine and consistent checks to ensure data integrity, correctness, and completeness;
- Identify and address errors and omissions;
- Document and archive inventory material and record all (QC) activities;
- Check data acquisition, calculations, and procedures;
- Document technical reviews of data, methods, and results

Importance of QA/QC

Helps identify areas for improvement!

Builds confidence in national GHG inventories!

General Quality Control Procedures

Apply at category and cross-cutting levels

- Data gathering, input, and handling activities
- Data documentation
- Calculating emissions and checking calculations
- Check overall data has been aggregated properly from lower levels
- *Consider adding quality control procedures relevant to country specific compilation processes (e.g., figure data QC)*

Category-Specific Quality Checks

- Activity data checks
  - Assess quality of data, i.e., understand standards applied in collecting data, data provider QA/QC, etc.
- Emission factor checks
  - Assess background data used for country-specific emission factors for representativeness
  - Comparisons with defaults
  - Comparisons with other countries
- Model Quality Control
- Calculation Quality Control

Procedures to Apply Quality Control

Example: General Quality Control Checks

1. Check that spreadsheets use consistent units, properly labelled
2. Check that estimates are reported for all source categories and for all years
3. Cross-check spreadsheet values to publication values
4. Trend checks (e.g., can be automated, i.e., to check implied emission factor over time series, check for unexplained trends)

Example: Category-Specific Quality Control Checks

1. Energy, Stationary Combustion - Some countries estimate emissions from fuel consumed and the carbon contents of those fuels. In this case, the carbon contents of the fuels should be regularly reviewed.

Document Implementation of Quality Control

Completed checklists should be submitted by leads with final files, and collated in inventory archives upon completion of Inventory

	Item	Check Completed			Corrective Action		Supporting documents (provide reference)
		Date	Individual (first initial, last name)	Errors (Y/N)	Date	Individual (first initial, last name)	
DATA GATHERING, INPUT, AND HANDLING ACTIVITIES: QUALITY CHECKS							
1.	Check a sample of input data (e.g., activity data, emission factors, uncertainty inputs) for transcription errors. Check a random sample of data in each worksheet. (VMT, Aircraft fuel consumption)	1/24 3/24	S Brown L O'Rourke S. Johnson	N N N			
2.	Review spreadsheets with automatic checks and/or quality check reports. Perform a random check of cell formulas to assure that the formula is correct in each source sheet.	12/23 3/24	S Brown T Atwood L O'Rourke	Y	12/23 3/24	T Atwood L O'Rourke S Brown	Corrections made to change proxy formulas to refer to new data available

Where to Apply Quality Control

General quality control (QC) checks are applicable to **all inventory categories and all types of data**

Questions to consider for prioritizing your QC process:

1. Is the source/sink a key category?
2. Has a category's methodology or data changed?
3. Is there a high level of uncertainty for the category?
4. When was the last time this category went through the QC check?

Some categories need more QA/QC than others!

When to Apply the Quality Control

What level of quality control is needed annually?

- Appy general checks to a sample of data and calculations from each category each year
- Quality control (QC) should be performed prior to any peer review
- Apply if you update data prior to finalizing inventory

Some quality control is needed only periodically.

- Category-specific procedures may only be applied every other year, and can be prioritized for key categories
- Emission factors/activity data QC may only need to be implemented when there are changes (e.g., in activity, data sources, or science)

Quality Assurance Procedures

- Expert peer review (should)
  - Provide an objective review of methods, data and results and ensure it is reasonable/technically sound
  - Involve reviewers or experts not involved in preparing the inventory
  - Can focus on whole report and/or parts
    - Prioritize key categories and areas with methodological refinements
- Audits
  - Provide an in-depth analysis of the procedures taken to develop an inventory, based on the documentation available

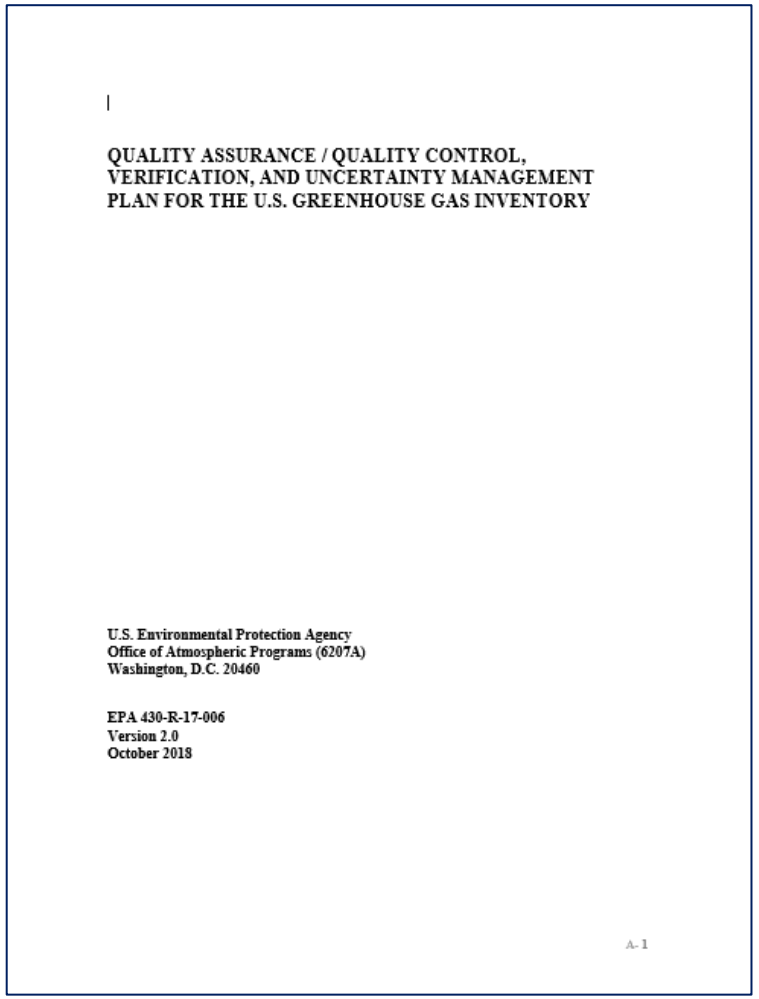
QA/QC PLAN VS. GENERAL PROCEDURES

QA/QC Plan

- Includes data quality objectives (e.g. TACCC, timeliness and continuous improvement)
- Describes QA/QC arrangements
- Outlines the QA/QC and verification activities implemented
  - **General quality control (QC) procedures (part of the QA/QC plan)**
  - Other QC procedures (category-specific QC, likely includes calculation)
  - QA procedures
  - Verification procedures
  - Feedback mechanisms, etc.

QA/QC Plan

- *Quality Assurance / Quality Control, Verification, and Uncertainty Management Plan for the U.S. Greenhouse Gas Inventory* (in place since 2002)
- Provides a rigorous set of procedures for maximizing the quality of the inventory
- Plan includes forms and checklists to standardize QA/QC application and documentation
- Plan closely adheres to IPCC guidance and good practices
- Reflects EPA's Guidance for Data Quality Assessment and EPA's Peer Review Handbook
- *Update in progress with aim to finalize in 2024 (last update in 2018)*



QUALITY ASSURANCE / QUALITY CONTROL,
VERIFICATION, AND UNCERTAINTY MANAGEMENT
PLAN FOR THE U.S. GREENHOUSE GAS INVENTORY

U.S. Environmental Protection Agency
Office of Atmospheric Programs (6207A)
Washington, D.C. 20460

EPA 430-R-17-006
Version 2.0
October 2018

A-1

Quality Control Bottom Line

- Check your work i.e., implementing and documenting QA/QC steps assures inventory quality and builds confidence in national data
- Start with general quality control (QC) checklist included in IPCC guidance
- Consider a team peer QC process
- Identifies areas for improvement (beyond identifying basic errors)
- Develop a basic QC plan to check all estimates, and add additional checks prioritizing more significant categories (i.e., key categories)
    - Assign roles/responsibilities (e.g., a QA/QC coordinator to implement and maintain QA/QC plan)
    - Consider if you can include additional QC checks for key categories
    - Communicate plan and outputs to inventory compilation team
    - Establish a process and schedule for QA

Verification

Verification refers to the collection of activities and procedures conducted during the planning and development, or after completion of an inventory that can help to establish its reliability.

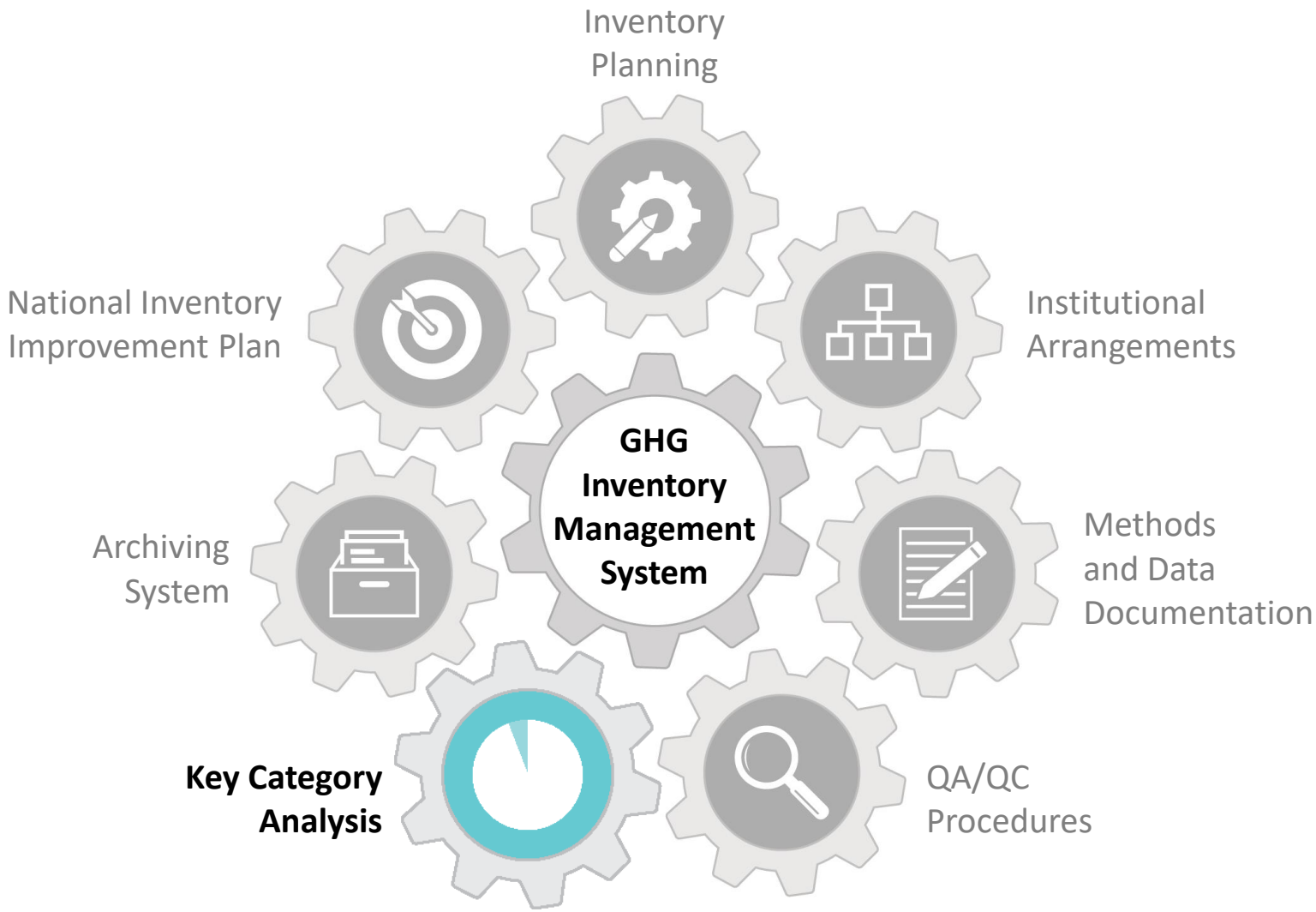
Includes comparisons with emission or removal estimates prepared by other bodies and comparisons with estimates derived from fully independent assessments.

Example from 2006 IPCC Guidelines

The IPCC provides potential outside verification checks in the national level CO_2 emissions estimates compiled by the International Energy Agency (IEA)

Key Category Analysis (KCA)

Key Category Analysis



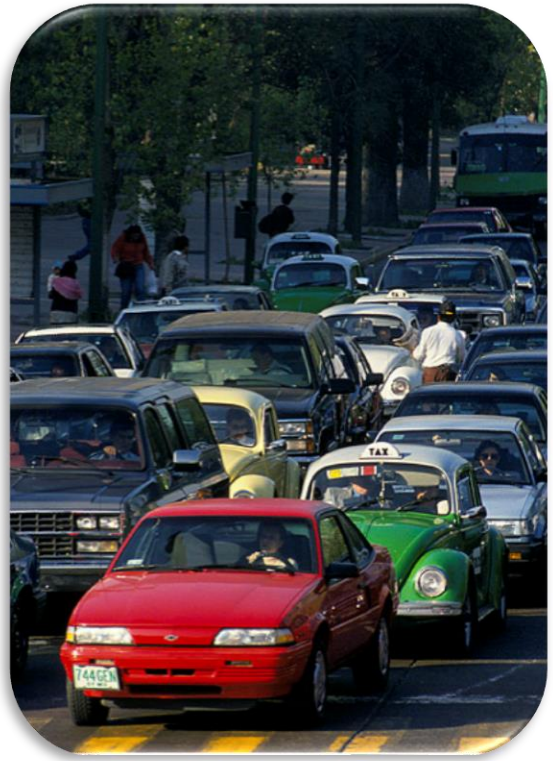
What is a Key Category?

2006 IPCC Volume 1, Chapter 4

A category 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.**

Example Key Source and Sink Categories

Absolute level contribution to total emissions

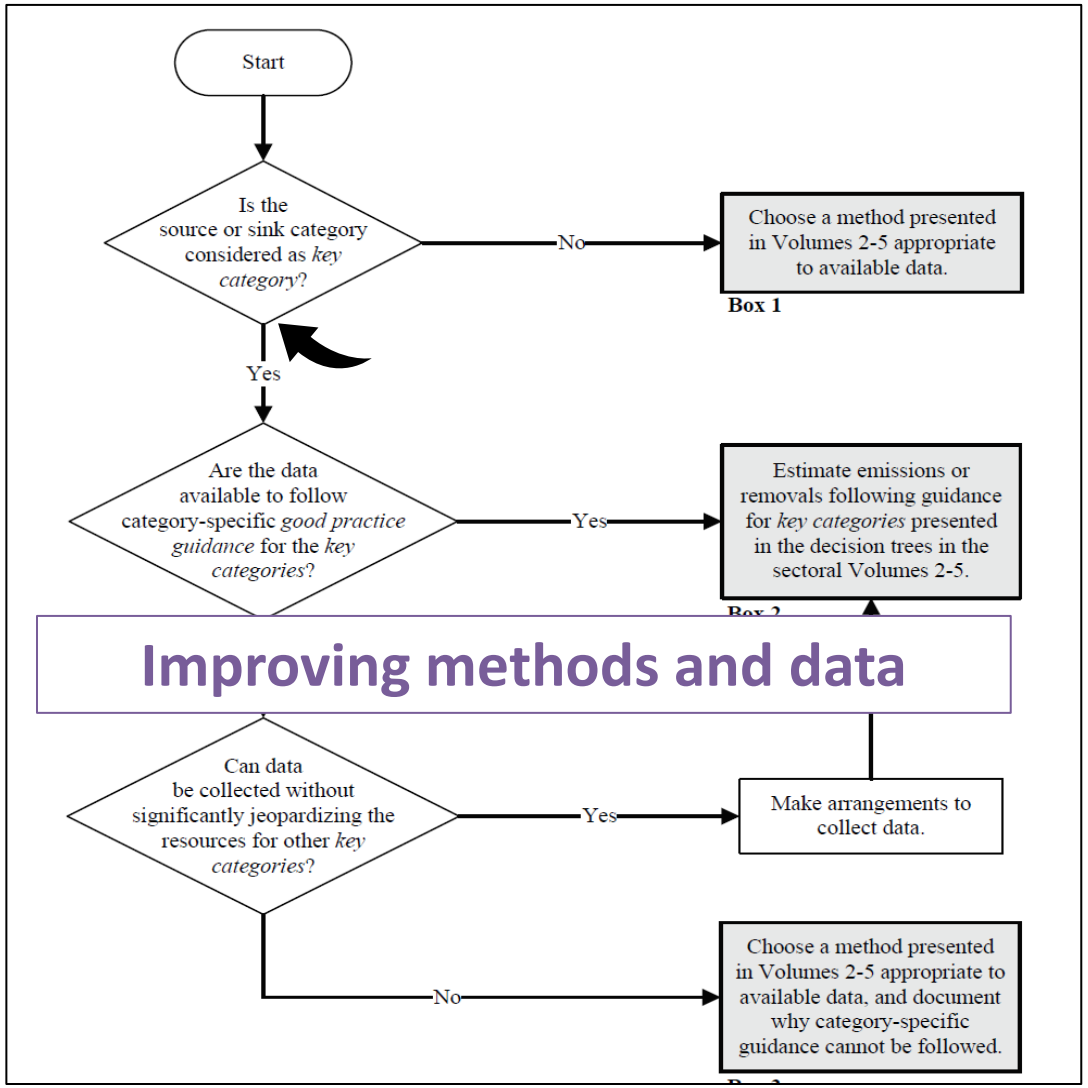


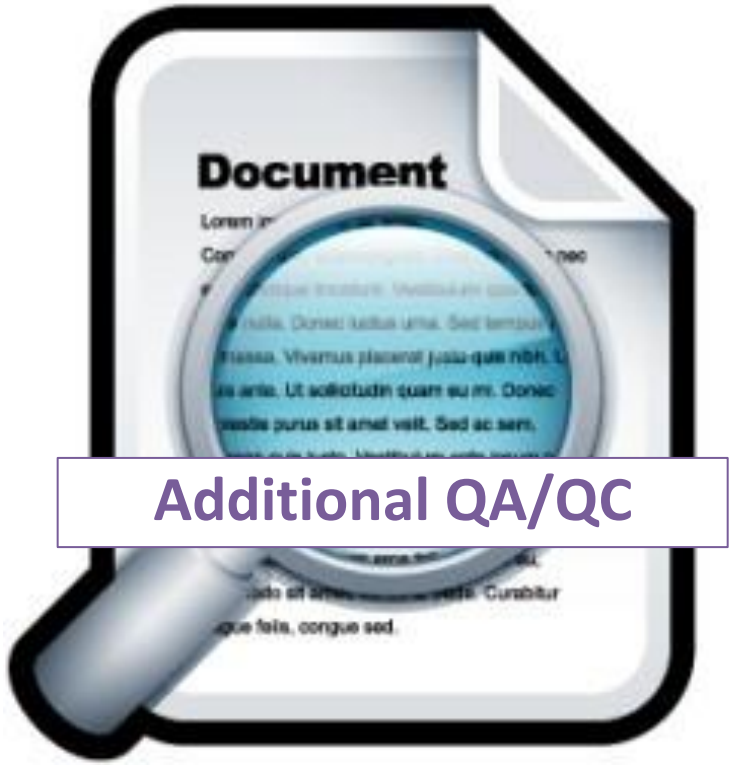
Trend: High growth rate in emissions

Uncertainty in emissions or removals

Why prioritize Key Categories in Inventories?

Figure 4.1 Decision Tree to choose a Good Practice method





How to Identify Key Categories

Quantitative Approaches	Qualitative Approaches
• Use emission and sink estimates and uncertainty analysis results to analyze actual category contribution to both overall emissions and sinks and uncertainty.	• Completeness: If there are known categories that are excluded from the inventory, consider qualitive criteria to identify any additional key categories. • Other qualitative criteria include expected growth, lack of quantified uncertainty assessment, and mitigation effects

Quantitative Assessment for Identifying Key Categories

- ✓ **Approach 1:** sorts and ranks source and sink categories according to absolute contribution to total emissions and removals. Identifies categories that collectively contribute **95%** of total national emissions and removals
  - ✓ "Level assessment" looks at a particular year
  - ✓ "Trend assessment" looks at the category trend relative to national trend in emissions and removals
- ✓ **Approach 2**: sorts and ranks category estimates according to their absolute contribution weighted by **uncertainty,** and identifies categories that collectively contribute **90%** of uncertainty weighted total national emissions and removals

Note: In the IPCC Inventory Software, quantitative KCA is performed automatically by the software as data is entered

Quantitative Assessment: Conducting an Approach 1 Level Assessment (w/LULUCF)

Step 2) Sort in descending order by contribution to total emissions (absolute values)

Emission Category	Gas	Gg CO_2 eq.
Energy Industries (solid fuel)	CO_2	300
Forest Land Remaining Forest Land	CO_2	-190
Road Transport	CO_2	110
Enteric Fermentation	CH_4	100
Iron and Steel Production	CO_2	90
Manure Management	N_2O	80
Rice Cultivation	CH_4	50
Cement Production	CO_2	30
Croplands Remaining Croplands	CO_2	6
Product Uses as ODS Substitutes (Aerosols)	HFC&PFC	4
Iron and Steel Production	CH_4	1

Quantitative Assessment: Conducting an Approach 1 Level Assessment (w/LULUCF)

Step 2) Sort in descending order by contribution to total emissions (absolute values)

Emission Category	Gas	Gg CO_2 eq.	Cumulative %
Energy Industries (solid fuel)	CO_2	300	
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Road Transport	CO_2	110	
Enteric Fermentation	CH_4	100	
Iron and Steel Production	CO_2	90	
Manure Management	N_2O	80	
Rice Cultivation	CH_4	50	
Cement Production	CO_2	30	
Croplands Remaining Croplands	CO_2	6	
Product Uses as ODS Substitutes (Aerosols)	HFC&PFC	4	
Iron and Steel Production	CH_4	1	

Quantitative Assessment: Conducting an Approach 1 Level Assessment

Step 3) Sum cumulative contribution of sources and sinks in absolute, descending order until you reach 95%

Emission Category	Gas	Gg CO_2 eq.	Cumulative %
Energy Industries (solid fuel)	CO_2	300	31%
Forest Land Remaining Forest Land	CO_2	190	51%
Road Transport	CO_2	110	62%
Enteric Fermentation	CH_4	100	73%
Iron and Steel Production	CO_2	90	82%
Manure Management	N_2O	80	91%
Rice Cultivation	CH_4	50	96%
Cement Production	CO_2	30	99%
Croplands Remaining Croplands	CO_2	6	99%
Product Uses as ODS Substitutes (Aerosols)	HFC&PFC	4	99.9%
Iron and Steel Production	CH_4	1	100%

TOTAL : 961

Quantitative Assessment: Conducting an Approach 1 Level Assessment (w/LULUCF)

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Croplands Remaining Croplands	CO_2	6	99%
Product Uses as ODS Substitutes (Aerosols)	HFC&PFC	4	99.9%
Iron and Steel Production	CH_4	1	100%

Sum to 95%

These are key categories identified by the approach 1 level assessment (including LULUCF) for the latest reported year

Quantitative Assessment: Conducting an Approach 1 Level Assessment

Step 3) Sum cumulative contribution of sources and sinks in absolute, descending order until you reach 95%

Emission Category	Gas	Gg CO_2 eq.	Cumulative %
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Sum to 95%

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Product Uses as ODS Substitutes (Aerosols)	HFC&PFC	4	99.9%
Iron and Steel Production	CH_4	1	100%

ETF reporting guidelines provide flexibility for developing countries, in light of their capacities, to instead use a threshold of no lower than 85% to allow focus on improving fewer categories

Qualitative Assessments to Conducting Key Category Analysis

- Mitigation techniques and technologies applied
- Expected emission growth
- Uncertainties not yet quantified, but presumed high (e.g., LULUCF)
- Not yet included in inventory (i.e., completeness)

Recap: Why Do a Key Category Analysis?

Perform Key Category Analysis

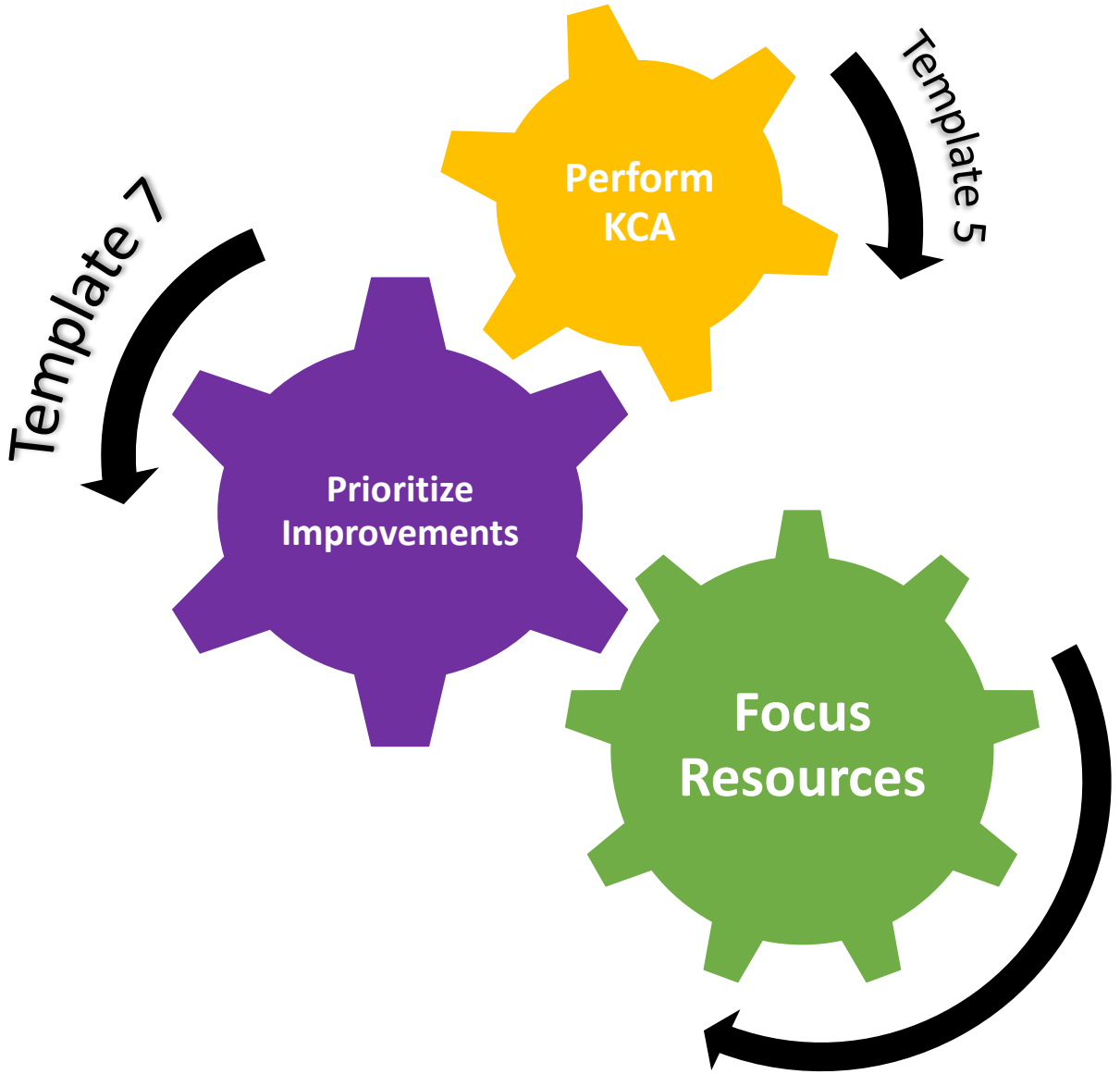
↓

Identify categories to prioritize in inventory planning and National GHG inventory improvement plan

↓

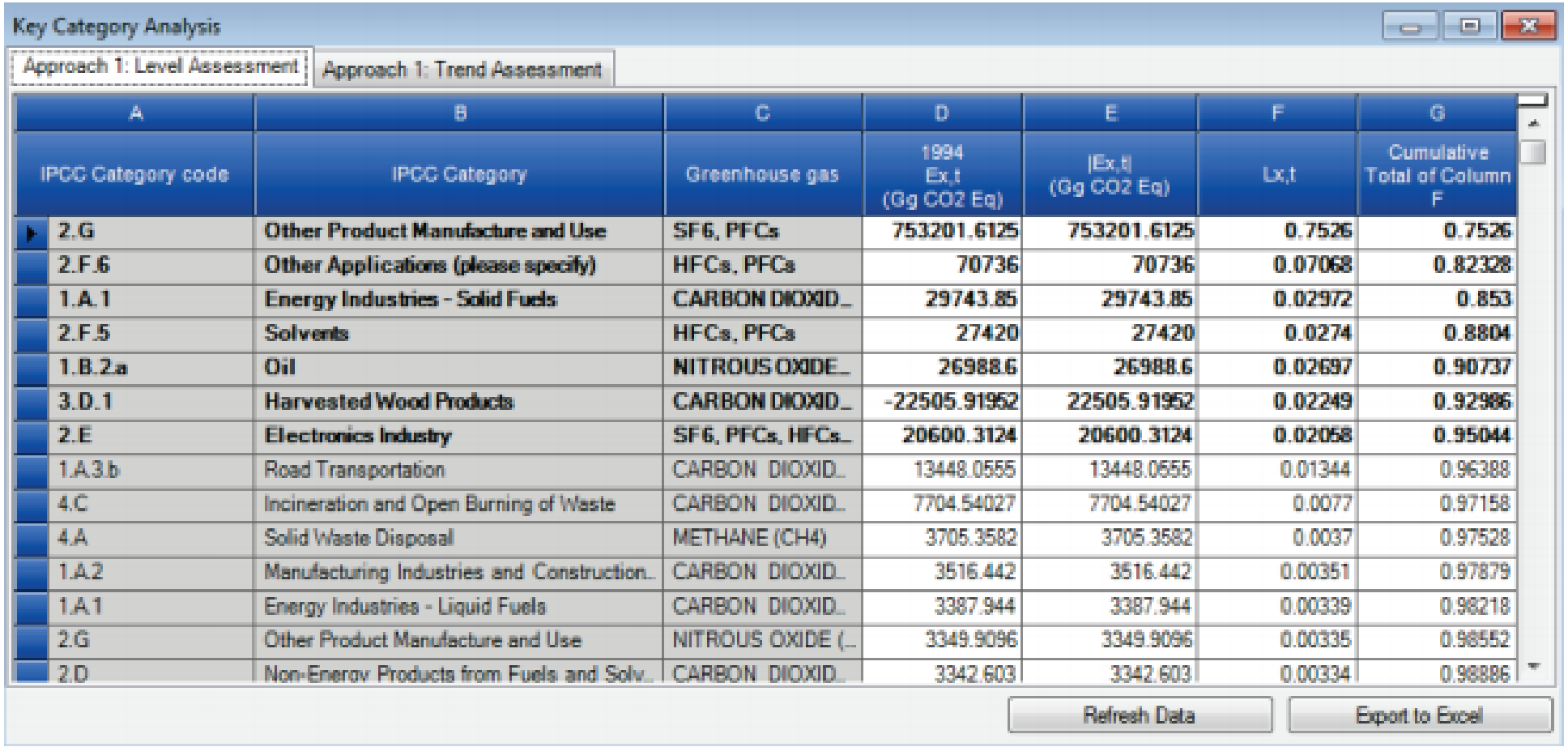
Focus Improvement Efforts on Key Categories

- Choose higher-tiered methods (Tier 2, 3)
- Obtain improved activity data
- Improve/establish institutional arrangements
- Focus QA/QC, etc.



IPCC Inventory Software

Automates preparing a quantitative KCA analysis



A	B	C	D	E	F	G
IPCC Category code	IPCC Category	Greenhouse gas	1994 Ex,t (Gg CO2 Eq)	|Ex,t| (Gg CO2 Eq)	Lx,t	Cumulative Total of Column F
2.G	Other Product Manufacture and Use	SF6, PFCs	753201.6125	753201.6125	0.7526	0.7526
2.F.6	Other Applications (please specify)	HFCs, PFCs	70736	70736	0.07068	0.82328
1.A.1	Energy Industries - Solid Fuels	CARBON DIOXID...	29743.85	29743.85	0.02972	0.853
2.F.5	Solvents	HFCs, PFCs	27420	27420	0.0274	0.8804
1.B.2.a	Oil	NITROUS OXIDE...	26988.6	26988.6	0.02697	0.90737
3.D.1	Harvested Wood Products	CARBON DIOXID...	-22505.91952	22505.91952	0.02249	0.92986
2.E	Electronics Industry	SF6, PFCs, HFCs...	20600.3124	20600.3124	0.02058	0.95044
1.A.3.b	Road Transportation	CARBON DIOXID...	13448.0555	13448.0555	0.01344	0.96388
4.C	Incineration and Open Burning of Waste	CARBON DIOXID...	7704.54027	7704.54027	0.0077	0.97158
4.A	Solid Waste Disposal	METHANE (CH4)	3705.3582	3705.3582	0.0037	0.97528
1.A.2	Manufacturing Industries and Construction...	CARBON DIOXID...	3516.442	3516.442	0.00351	0.97879
1.A.1	Energy Industries - Liquid Fuels	CARBON DIOXID...	3387.944	3387.944	0.00339	0.98218
2.G	Other Product Manufacture and Use	NITROUS OXIDE (...	3349.9096	3349.9096	0.00335	0.98552
2.D	Non-Energy Products from Fuels and Solv...	CARBON DIOXID...	3342.603	3342.603	0.00334	0.98886

Where to Obtain the Key Category Analysis Tool

Available Online at

https://www.epa.gov/ghgemissions/toolkit-building-national-ghg-inventory-systems

5. Key Category Analysis (KCA)

This template identifies the sources and sinks that make the greatest contribution to national GHG emissions and removals. With this analysis of key categories, a GHG inventory team can prioritize over time the resources needed to implement the more impactful improvements to a national GHG inventory.

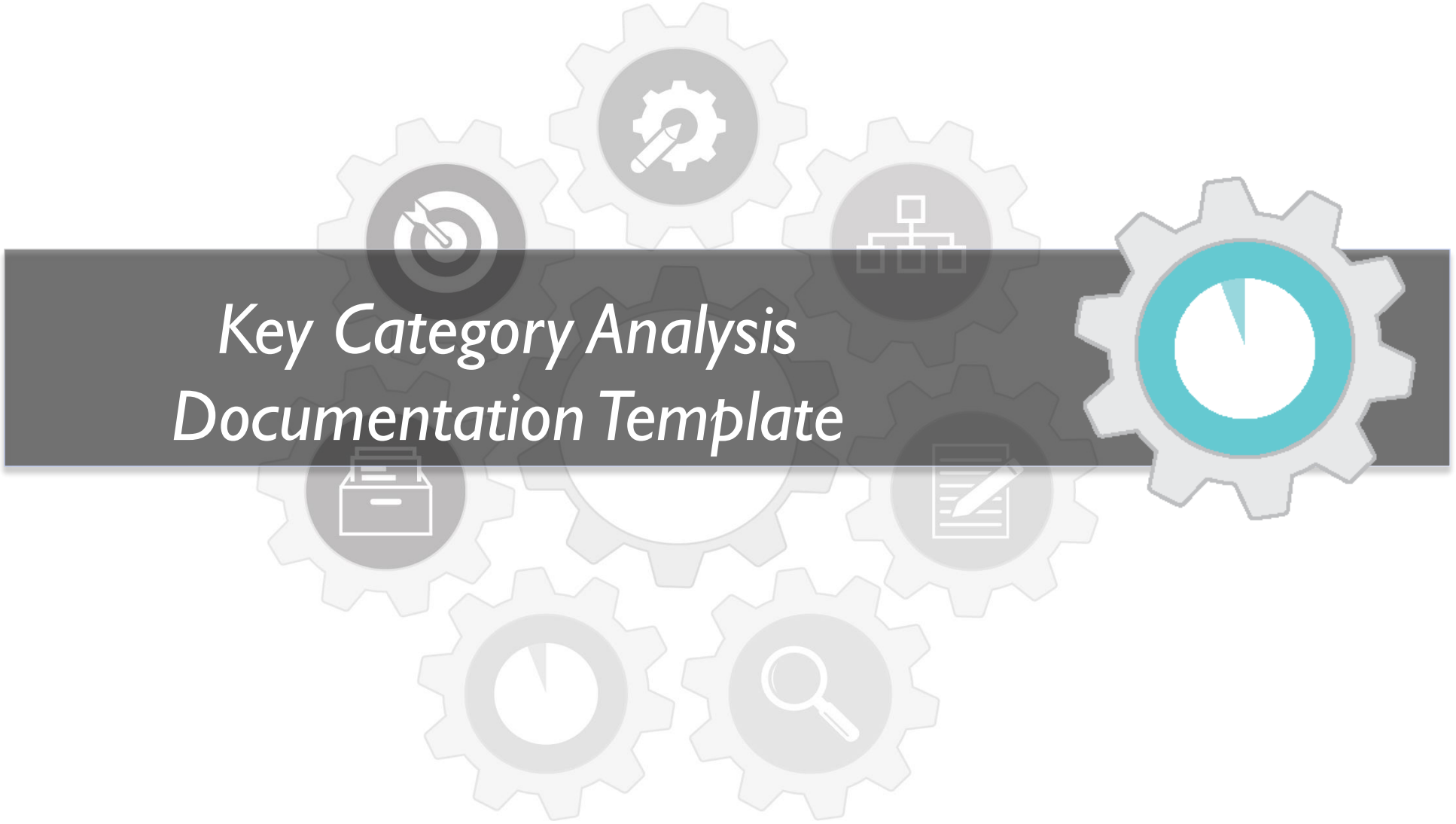
- Key Category Analysis (12 pp, 124 K)
- Key Category Analysis (PDF) (12 pp, 486 K)

Supporting Tool: The **Key Category Analysis Tool** enables a GHG inventory team to determine key categories of GHG emissions and removals from GHG inventory estimates.

- Key Category Analysis Tool (MB)

Top of Page

Key Category Analysis Documentation Template



Key Category Analysis Tool and Template helps

- Identify, document, and summarize all key categories identified using latest Inventory based on approaches available
  - Approach 1
  - Approach 2 (reflects uncertainty)
  - Qualitative criteria
- Document inventory improvements for the future

Step 1: Level Assessment (Current Year)

Approach 1 Level Assessment (Current Year)

Table 5.1: Key Categories Based on Contribution to Total National Emissions in Current Year [year, e.g., 2019, excluding LULUCF]

IPCC Category Code	IPCC Category	Gas	Current Year Emissions (Gg CO_2 Eq.)	Contribution to National Emissions	Cumulative Per Cent of National Emissions
1A1	Fuel Combustion Activities - Energy Industries (Gaseous Fuel)	CO_2	7,500	30%	30%
1A3e	Fuel Combustion Activities - Transport - Other Transportation	CH_4	5,000	20%	50%
2C3	Metal Industry -Aluminum Production	PFC	4,800	19%	69%
1A3a	Fuel Combustion Activities - Transport - Domestic Civil Aviation	CO_2	1,000	3%	72%
3C1	Biomass Burning	N_2O	700	3%	75%
…	…	…	…	…	…

Who completes this table: Key Category Analysis Lead

Steps 2-7: Key Categories from Conducting Level Assessment for Base Year, Trend Assessment using Approach 1 (Approach 2 if feasible) and Qualitative Criteria

- Repeat process in remaining tables within template to list key category identified from each assessment
  - Approach 1
    - Level Analysis (current year)
    - Level Analysis (base year)
    - Trend Analysis
  - Approach 2
    - Level Analysis (current year)
    - Level Analysis (base year)
    - Trend Analysis
  - Qualitative

Table 5-2: Key Categories Based on Contribution to Total National Emissions in Base Year [year, e.g., 2000]

IPCC Category Code	IPCC Category	Gas	Base Year Emissions ($Gg\ CO_2$ Eq.)	Contribution to National Emissions	Cumulative Per Cent of National Emissions
1A1	Fuel Combustion Activities - Energy Industries (Gaseous)	CO2	7,200	32%	32%

Approach 1 Level Assessment (Base Year)

Table 5-3: Key Categories Based on Contribution to Overall Trend in Net National Emissions

IPCC Category Code	IPCC Category	Gas	Base Year Emissions ($Gg\ CO_2$ Eq.)	Current Year Emissions ($Gg\ CO_2$ Eq.)	Contribution to Trend	Cumulative Contribution to Trend
1A1	Fuel Combustion Activities - Energy Industries (Gaseous)	CO2	7,200	7,500	31%	31%

Approach 1 Trend Assessment

Who completes this table: Key Category Analysis Lead

Step 8: Key Category Analysis Summary

Table 5-8: Summary of Key Categories Identified and Methodology

IPCC Category Code	IPCC Category	Greenhouse Gas (CO_2, CH_4, etc)	Identification Criteria (L1, T2, Q, etc)	Comments
1A1	Fuel Combustion Activities - Energy Industries (Gaseous)	CO2	L1, T1	None

Who completes this table: Key Category Analysis Lead

Step 9: Improvements to GHG Inventory

Table 5-9: Improvements to the GHG inventory

Improvement #	Sector	Source Category and IPCC Tier Used	Potential Improvement	Steps Needed to Implement This Improvement
1	Energy	Transport-Railways (CO2, CH4, N2O)	Currently no estimates, need to include	Find source for activity data and if available, data on uncertainty
2	IPPU	Cement Production (CO2)– Tier 1	Move to Tier 2 because this category is a key category	Establish IA with data provider for clinker production data
3	IPPU	Aluminum Production (PFCs)	Apply and document category-specific QC and send to expert for additional QA	Select applicable category specific QC procedures (e.g., comparing AD to other available data, comparing EFs to defaults and those for production in region, if available). Collect relevant data Conduct comparisons Prepare documentation outline

Who completes this table: Key Category Analysis Lead

Thank You For Your Attention!

For questions & more information, email:

ghgi.transparency@epa.gov

Toolkit for Building National GHG Inventory Systems

https://www.epa.gov/ghgemissions/toolkit-building-national-ghg-inventory-systems