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# Introduction

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## Suggested Citation

M. Desai, W. Irving, A. Fawcett, J. Lou, R. Cui, and N. Hultman. (2026). Chapter 1. Introduction. In Desai et al., *Greenhouse Gas Inventory and Analysis for the United States: 1990-2024* (pp. 1-1 to 1-8). Center for Global Sustainability, University of Maryland, College Park.

# Chapter 1. Introduction

## 1.1 Background

### Overview

A greenhouse gas inventory (GHGI) is a fundamental component of an overall strategy to plan, manage, implement, and assess greenhouse gas (GHG) mitigation efforts. A national GHGI identifies the magnitude of individual sources and sinks within a country in a single year, and tracks changes over time, so that it is possible to compare source and sink strengths and trends.

This chapter provides an overview of the *Greenhouse Gas Inventory and Analysis for the United States (GHGIA)*, including descriptions of the institutional arrangements and methodological approaches used. Additional information on the methodological approach and results for individual categories of emissions is presented in subsequent chapters on a sector-by-sector basis (energy; industrial processes and product use; agriculture; land use, land-use change and forestry [LULUCF]; and waste). Supplementary information published with this *GHGIA* for download include all the tables presented across the *GHGIA* and its annexes.

### Use of This Report

The U.S. government previously submitted a national GHGI to the United Nations Framework Convention on Climate Change (UNFCCC) annually following its ratification in 1992 until 2024. The annual inventory submission fulfilled an obligation under Article 4.1 of that Agreement, while also serving other important functions, including the following:

- Informing domestic policy development
- Facilitating international comparisons
- Supporting subnational inventory development
- Serving as a technical reference for methods, emission factors, and activity data.

This *GHGIA* is not an official national inventory nor is it an official inventory submission in the context of the UNFCCC. However, the information presented in this *GHGIA* has been grounded in standard inventory practices that enable continuity in comparing it to the previous U.S. official reports, and can support continued understanding of U.S. emissions for scientific and policy communities:

- It adheres to international standards for transparency, accuracy, completeness, comparability, and consistency.
- It is consistent with good practice as defined by the Intergovernmental Panel on Climate Change (IPCC).

- It builds from and improves upon recent versions of the U.S. Environmental Protection Agency's (EPA's) *Inventory of U.S. Greenhouse Gas Emissions and Sinks*.

## 1.2 Institutional Arrangements

### Coordinating Organization

This *GHGIA* was coordinated and compiled by the Center for Global Sustainability (CGS) at the University of Maryland. CGS has overall responsibility for preparing emission and removal calculations, in addition to methodological choice, uncertainty assessment, quality assurance/quality control (QA/QC) processes, and improvement planning. CGS also serves as the official point of contact for data and report publication, communication, and partnerships.

Other organizations contributed to this first non-governmentally based *GHGIA* report as documented in the supplemental information. As part of an evolving institutional arrangement process, CGS will explore additional technical discussion and collaboration across the U.S. and international scientific communities for future development, particularly in areas where rapidly evolving technological and scientific tools are becoming available to improve GHG data quality (e.g., methane, agriculture, forestry, and other land use).

The report makes use of several publicly available datasets provided by the U.S. government, including information from the U.S. Department of Agriculture, the U.S. Forest Service, the Energy Information Administration, the National Oceanic and Atmospheric Administration (NOAA), the U.S. Geological Survey, the Federal Highway Administration, the Department of Transportation, the National Aeronautics and Space Administration (NASA), and the Department of Commerce.

For more information on the use of datasets from specific data providers and statistical compilers, see the individual category write-ups in the sectoral chapters.

### Inventory Preparation Process

Following usual practice, this *GHGIA* presents inventory information following sequential steps, specifically: review of methods and the improvement plan, identification of priority improvements and updates (e.g., change and/or refine methods/data), compilation of source- and sink-level estimates, compilation of overall inventory database including uncertainty, and cross-cutting analytical work (e.g., trends, recalculations). The *GHGIA* then communicates the latest inventory findings at the cross-cutting, sector, and source levels. Consistent with IPCC good practice, CGS provides additional technical documentation to enhance transparency of methods and underlying data for more involved estimation methods.

# Archiving

A cloud-based management system, maintained within by the *GHGIA* coordinator, provides a platform for facilitating (1) collaboration on inventory preparation during each compilation phase and (2) the efficient storage and archiving of electronic document and data files each annual cycle.

## Consideration and Approval of the *GHGIA*

CGS is currently considering options for engaging experts and the scientific community, along with the broader public, as part of planning and publishing future versions of this report.

## Methodologies and Data Sources

The methodologies used in this report are the same as those used to compile recent versions of the *Inventory of U.S. Greenhouse Gas Emissions and Sinks* by EPA (EPA, 2025). The methodologies and data tables described in these recent EPA reports are generally transparent and, in most cases, it was possible to apply them in the same manner for this *GHGIA*. In specific cases identified in the sectoral chapters, the estimates for the most recent year (2024) were based on extrapolation techniques consistent with IPCC good practice, rather than full utilization of the previous EPA methodology.

Future versions of the *GHGIA* may reflect recalculated 2024 estimates using the full methodology where possible, and will explore alternative approaches where previous data and models used by EPA are no longer available or where there is no information on future availability (e.g., facility-level data through the Greenhouse Gas Reporting Program). Consistent with IPCC good practice, future versions of this *GHGIA* will also identify and implement methodological improvements to approaches previously used by EPA.

## Key Categories

Key categories are those that individually, or as a group, are prioritized because their estimates have the greatest influence on the quality of a country's GHGI. Specifically, key categories are those that have the largest contribution to the absolute level, the trend, or overall uncertainty in the level or trend. Identifying key categories helps inventory teams to allocate time and resources efficiently to methodological and data improvements that matter the most.

This *GHGIA* uses the two quantitative approaches for identifying key categories as described by the IPCC. The IPCC also describes a qualitative approach, which was not used in this *GHGIA*. The three approaches are as follows:

- **Quantitative Approach 1:** Identifies key categories based on their contribution to the total level of emissions and to the overall trend of emissions. Emission and removal categories are ranked individually according to this impact and then summed. The key categories are those that cumulatively account for 95 percent of the total.

- **Quantitative Approach 2:** This approach is similar to Approach 1 but incorporates the evaluated statistical uncertainty of the results. Incorporating uncertainty can identify additional key categories that merit attention and resources from inventory compilers. Emission and removal categories are ranked individually according to their impact on the overall level and trend, weighted by their uncertainty estimates. Key categories are those that cumulatively account for 90 percent of total uncertainty. This approach has not been updated for this *GHGIA* but will be included in future annual reports.
- **Qualitative Approach:** The IPCC also provides inventory compilers with the flexibility to identify categories as key even if they do not meet Quantitative Approach 1 or 2 quantitative thresholds. An example would be a small category that is the subject of ambitious mitigation measures. Improving the methodology for the category would make it possible to reflect the results of mitigation more rigorously.

The basic Approach 1 “level” assessment identified 32 categories in this *GHGIA*, accounting for 95 percent of gross emissions, with four categories making up more than 50 percent. These four categories are as follow:

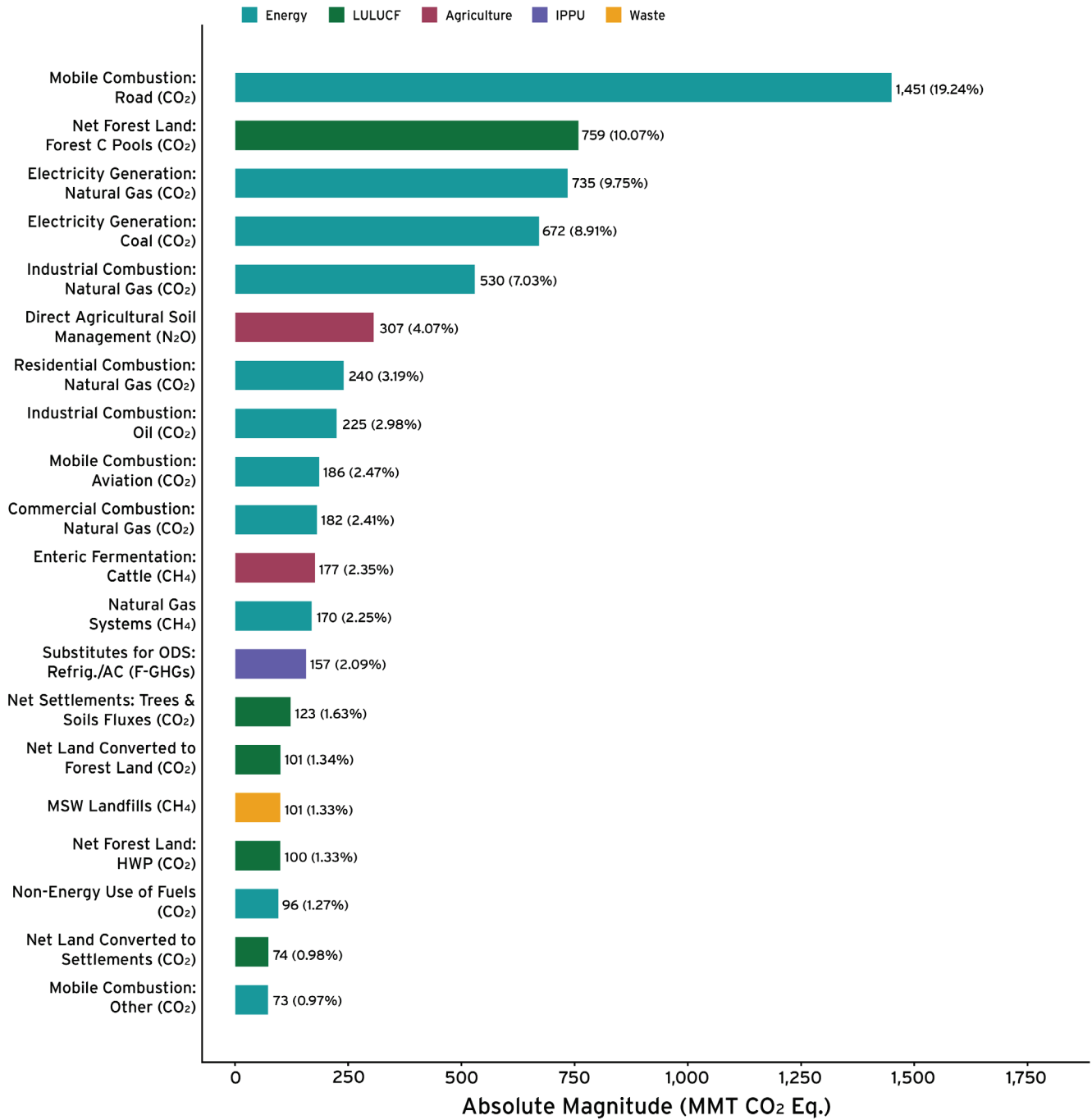
- Carbon dioxide (CO<sub>2</sub>) emissions from mobile combustion (road)
- CO<sub>2</sub> emissions from stationary combustion of natural gas (electricity production)
- CO<sub>2</sub> emissions from stationary combustion of coal (electricity production)
- CO<sub>2</sub> emissions from stationary combustion of natural gas (industry)

Including LULUCF brought in an additional eight categories, including changes in the amount of carbon stored in existing forests (“forest land remaining forest land”) and in urban and suburban areas (“settlements remaining settlements”). Figure 1-1 shows the 2024 key categories identified by the Approach 1 level assessment—including the LULUCF sector—in descending order of absolute magnitude.

The Approach 1 “trend” assessments, with and without LULUCF, identified additional categories: smaller sources that have trends that differ significantly from the overall trend, including fluorochemical productions, stored carbon in croplands (e.g., soil carbon in “cropland remaining cropland”), and stored carbon in landfills (e.g., yard trimmings and food waste).

Please see Annex 1 to this *GHGIA* for more detailed technical information on the implementation of key category analysis.

**Figure 1-1: Top 20 Key Categories Using Approach 1, Including LULUCF in 2024 (Absolute Magnitude, MMT CO<sub>2</sub> Eq.)**



Note: MMT CO<sub>2</sub> Eq. = million metric tons of CO<sub>2</sub> equivalent.

# Quality Assurance/Quality Control

General QA/QC checks were conducted that were consistent with Volume 1, Chapter 6 of the *2006 IPCC Guidelines for National Greenhouse Gas Inventories* and its *2019 Refinement* (IPCC, 2006, 2019). CGS will explore development of a customized QA/QC plan for future reports.

## Uncertainty Assessment

Conducting an uncertainty assessment provides invaluable information to inventory compilers on the quality of results. It can also inform the efficient use of time and resources by targeting them on those improvements with the biggest potential impacts.

The IPCC provides two quantitative approaches for combining the uncertainty of inputs and estimates. The first approach—error propagation—gives a good general indication of uncertainty but is not well-suited for handling strong correlations or non-normally distributed (e.g., skewed, bimodal) data. The second approach—Monte Carlo analysis—is more data- and computationally-intensive but also better able to accommodate correlations and non-normal datasets.

Although this version of the *GHGIA* does not include new Monte Carlo uncertainty analyses, future versions will incorporate this information on a rolling basis, beginning with key categories. Given that the methodologies and input data are largely consistent with previous EPA reports, the previous EPA-estimated Monte Carlo results reflect the best available uncertainty assessments and are presented in this *GHGIA*.

The combined total uncertainty of net U.S. emissions is estimated to be 6 percent below to 5 percent above in 1990 and 5 percent below to 6 percent above in 2024. When the LULUCF sector is excluded from the analysis (i.e., gross emissions) the uncertainty of U.S. emissions is slightly lower, at 2 percent below to 4 percent above in 1990 and 2 percent below to 4 percent above in 2024.

Additionally, this *GHGIA* provides a qualitative discussion of the uncertainty for each category, along with assessments of areas of additional uncertainty introduced by using proxy data or drivers for the most recent year (2024) where historical datasets, facility-level data, or models were not available.

## Completeness

This *GHGIA* is intended to be comprehensive and includes the vast majority of emissions and removals identified as anthropogenic. In general, sources or sink categories not accounted for in this *GHGIA* are excluded because they are not occurring in the United States, its territories, and tribal lands; because data are unavailable to develop an estimate; and/or because the categories were determined to be insignificant in terms of overall national emissions.

CGS will provide a list of sources and sink categories not included and more information on the significance of these categories following publication of this *GHGIA*.

# Metrics

A global warming potential (GWP) estimates the globally averaged radiative forcing impacts of emissions of a particular GHG over time relative to a reference gas (i.e., the total radiative forcing over a specific time frame due to emitting 1 kilogram [kg] of the gas, relative to that of the reference gas CO<sub>2</sub>) (IPCC, 2021). GWP-weighted emissions are measured in CO<sub>2</sub> equivalent (CO<sub>2</sub> eq.).<sup>1</sup> GWP values allow for a comparison of the impacts of emissions and reductions of different gases.

Consistent with GHGs from other countries, this *GHGIA* uses 100-year GWP (GWP<sub>100</sub>) values from Table 8.A.1 in Appendix 8.A of the *IPCC Fifth Assessment Report (AR5)* for calculating CO<sub>2</sub> eq. emissions (IPCC, 2013). Key GWP<sub>100</sub> values include methane (CH<sub>4</sub>; GWP<sub>100</sub> = 28), nitrous oxide (N<sub>2</sub>O; GWP<sub>100</sub> = 265), and high-impact compounds such as sulfur hexafluoride (SF<sub>6</sub>; GWP<sub>100</sub> = 23,500) and nitrogen trifluoride (NF<sub>3</sub>; GWP<sub>100</sub> = 16,100). The values for the main GHGs are presented in Table 1-1 below. Detailed data and methodological notes can be found in AR5.

**Table 1-1: 100-Year Global Warming Potentials for Greenhouse Gases**

Greenhouse Gas	GWP <sub>100</sub> (AR5)
Carbon dioxide (CO <sub>2</sub> )	1
Methane (CH <sub>4</sub> )	28
Nitrous oxide (N <sub>2</sub> O)	265
HFC-23 (CHF <sub>3</sub> )	12,400
HFC-32 (CH <sub>2</sub> F <sub>2</sub> )	677
HFC-134a (CH <sub>2</sub> FCF <sub>3</sub> )	1,300
Sulfur hexafluoride (SF <sub>6</sub> )	23,500
Nitrogen trifluoride (NF <sub>3</sub> )	16,100
Perfluoromethane (CF <sub>4</sub> )	6,630
Perfluoroethane (C <sub>2</sub> F <sub>6</sub> )	11,100

Source: IPCC, 2013.

Future inventories may include estimates for short-lived gases with radiative forcing impacts such as carbon monoxide (CO), tropospheric ozone, ozone precursors (e.g., NO<sub>x</sub>, and non-methane volatile organic compounds), and tropospheric aerosols (e.g., sulfur dioxide [SO<sub>2</sub>] products and carbonaceous particles). Unlike well-mixed and relatively long-lived GHGs, it is difficult to quantify such gases' global radiative forcing impacts using GWP values.

<sup>1</sup> Carbon comprises 12/44<sup>ths</sup> of carbon dioxide by weight.

# References

Intergovernmental Panel on Climate Change (IPCC). (2013). *Climate change 2013: The physical science basis: Contribution of Working Group I to the fifth assessment report of the Intergovernmental Panel on Climate Change* (T. F. Stocker, D. Qin, G.-K. Plattner, M. Tignor, S. K. Allen, J. Boschung, A. Nauels, Y. Xia, V. Bex, & P. M. Midgley, Eds.). Cambridge University Press.

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