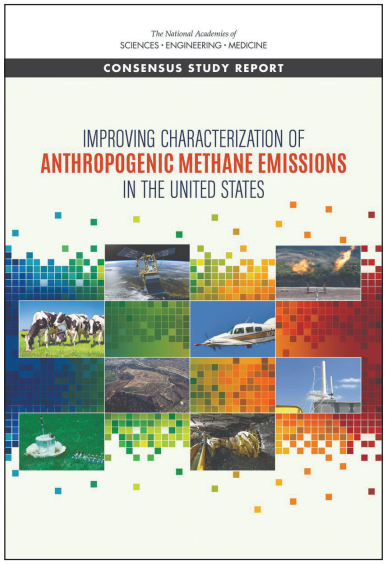
Consensus Study Report

March 2018

HIGHLIGHTS

# Improving Characterization of Anthropogenic Methane Emissions in the United States




*Tracking emissions of methane to the atmosphere from human and natural sources is essential to informing decisions that affect the climate, economy, and human health and safety. Discrepancies between different emissions estimates have fueled discussion about how to characterize methane emissions more accurately. This report recommends strengthening measurement, monitoring, and inventories of methane emissions; developing a gridded inventory as a mechanism to integrate approaches; and launching a nationwide research effort to address knowledge gaps.*

Methane, the primary component of natural gas, is a potent greenhouse gas that is second only to carbon dioxide in its contribution to rising global average temperatures. Current levels of methane in the atmosphere are unprecedented over the past century as measured by direct observations, and over the past two millennia as measured from ice cores. Methane has a diversity of human caused sources in the United States, including petroleum and natural gas systems, cattle and manure management, landfills, and coal mines. Natural methane sources include wetlands, coastal oceans, wildfires, and geologic sources (see Figure 1).

Being able to accurately quantify methane emissions from specific sources is critical for evaluating climate change policy proposals aimed at limiting greenhouse gases, as well as for a variety of health, safety, and economic reasons. Because methane is flammable and can be dangerous at high concentrations, it is monitored in mines and

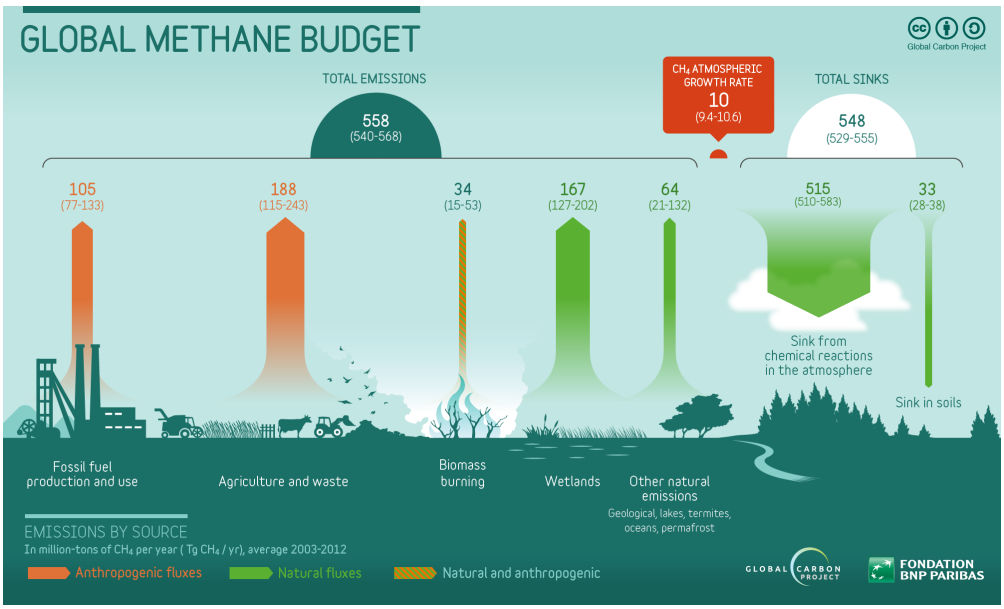



**Figure 1** This schematic depicts global sources and sinks of methane. Source: Global Carbon Project, http://www.globalcarbonproject.org/.

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at landfill sites to protect the safety of workers. Given methane's value as the main component of natural gas, monitoring in the energy, agriculture, and waste sectors is aimed at reducing losses or enhancing recovery of methane.

## MEASUREMENT APPROACHES FOR ESTIMATING METHANE EMISSIONS

There are two main approaches for estimating methane emissions. Bottom-up (or inventory development) estimates measure emissions at the scale of individual methane emitters, such as natural gas wells or cattle farms. Methane inventories are developed for a variety of purposes and use a combination of activity data (the number of emitters) and emission factors (the amount of methane per emitter), which then are extrapolated to regional and national scales. In the United States, the Greenhouse Gas Inventory (GHGI) is the main inventory of human-caused greenhouse gas emissions. The GHGI is also submitted to the United Nations (UN) as part of treaty obligations under the UN Framework Convention on Climate Change.

Top-down estimates use observations of atmospheric methane concentrations and models that account for transport from the emitter to the observation location to estimate how much emissions must have occurred. Such measurements are made via aircraft, surface, and tower and satellite remote sensing.

Bottom-up and top-down approaches each have strengths and limitations. Bottom-up methods provide information about emissions from specific sources but may not account for all sources and may use uncertain or inaccurate activity data and emissions factors. In contrast, top-down estimates include emissions from all sources, both natural and anthropogenic, but may have difficulty in attributing emissions to specific sources or source categories. In some cases, the estimates produced by these two methods differ significantly, leading to re-examination of the measurements. Ideally, top-down and bottom-up approaches can be tested against each other to improve the application of both approaches.

## MEETING THE CHALLENGES OF CHARACTERIZING METHANE EMISSIONS

The traceable attribution of methane emissions to specific sectors, processes, and components is a key output of bottom-up inventories, which are thus uniquely suited for applications in the sphere of mitigation and societal interests. Currently, however, the GHGI cannot be independently tested against top-down measurements, as both spatial and temporal attributes are missing and thus expected atmospheric concentrations cannot be inferred.

Building a strong link between observed atmospheric methane concentrations and methane emission inventories has many benefits, including the discovery of missing sources or processes, improved confidence in the basic data that enter into decisions by companies and governments, and better capability to detect trends with time. Interlinking top-down and bottom-up approaches involves strengthening both approaches as well as developing a mechanism to integrate across these approaches, as outlined in the following recommendations.

### Strengthening Atmospheric Methane Observations and Modeling

Atmospheric observations are the foundation for understanding changes in methane concentrations. However, the current network of atmospheric methane observation sites is sparse and cannot capture the full spatial and temporal variability of methane emissions.

The models used in top-down approaches can also introduce uncertainties. In particular, it is challenging to use current global atmospheric transport models with relatively coarse spatial resolution to "invert" observed methane concentrations to estimate emissions from small-scale processes. To make atmospheric transport models more accurate, it will likely be necessary to develop simulations with finer spatial and temporal resolution.

Long-term observations of background methane levels are critical to detect trends in methane emissions. On regional scales, sustaining current observational networks and expanding them to multi-scale observational strategies will be necessary to make high quality long-term observations.

One of the primary challenges in using top-down analyses is attributing emissions to specific sources. Atmospheric molecular and isotopic species can provide information about methane sources, and global monitoring observations are available for certain atmospheric trace species that may be helpful for understanding the methane budget.

**Recommendation #1: NOAA and NASA should continue and enhance current atmospheric methane observations and advance models and assimilation techniques used by top-down approaches.**

### Gridded Methane Emissions Inventories

As the most frequently updated inventory of human-caused methane emissions in the United States, the GHGI is used by diverse communities for an array of scientific and policy purposes. Increasingly, it is being used for purposes for which it was not designed. For example, the GHGI has been used to verify top-down atmospheric emission estimates to make the estimates more applicable to policy needs. However, comparing the two sets of data is challenging because they are collected at different spatial and temporal scales.

Gridded inventories combine estimates of the quantity of methane emitted with data about the location and timescale of the emission-generating activities. On national scales, spatially and temporally resolved gridded

inventories of national methane emissions provide significant value to the scientific community to better characterize and compare inventories and test against top-down emissions estimates. Further, gridded inventories have the potential to inform mitigation activities at spatial scales relevant to policy makers, industry, and other stakeholders.

**Recommendation #2: EPA, in collaboration with the scientific research community, DOE, NOAA, USDA, and NASA should establish and maintain a fine scale, spatially and temporally explicit (e.g. gridded) inventory of U.S. anthropogenic methane emissions that is testable using atmospheric observations and update it on a regular basis.**

## Incorporating new science into inventory methodologies

The measurement, modeling, and underlying science contributing to understanding of methane emissions estimates has improved substantially during the past two decades and is still improving from year to year. These new methods and understanding can help make methane inventories more accurate and precise. However, the Intergovernmental Panel on Climate Change (IPCC) Guidelines on inventory methodologies, which are widely used in the GHGI development, have not been updated since 2006, and thus predate the last decade of field measurements and modeling. To keep track of new advances, a sustainable process to regularly review U.S. methane inventory methodologies and incorporate the latest science into the GHGI is needed.

For each methane source, there are uncertainties associated with emission estimates. For many sources, emission factors are outdated; for example, the current methodology for estimating emissions from landfills relies on 20-40-year-old assumptions and does not include the two major drivers for emissions: site-specific climate and operational factors. For other sources, there is a scarcity of data on the magnitude of the specific activities that produce methane. For example, in the petroleum and natural gas sector, there are numerous emissions sources, yet relatively sparse activity data on which to develop emissions estimates.

Reducing these uncertainties will involve collecting and reporting activity and emissions data in a consistent and comprehensive manner, although this will be challenging because of cost, time, and technical limitations.

Incorporating the wealth of methane studies from the past decade into the GHGI to improve the estimates is challenging. In recent years, EPA has periodically convened stakeholder webinars and workshops to discuss possible changes to the methane GHGI. Establishing

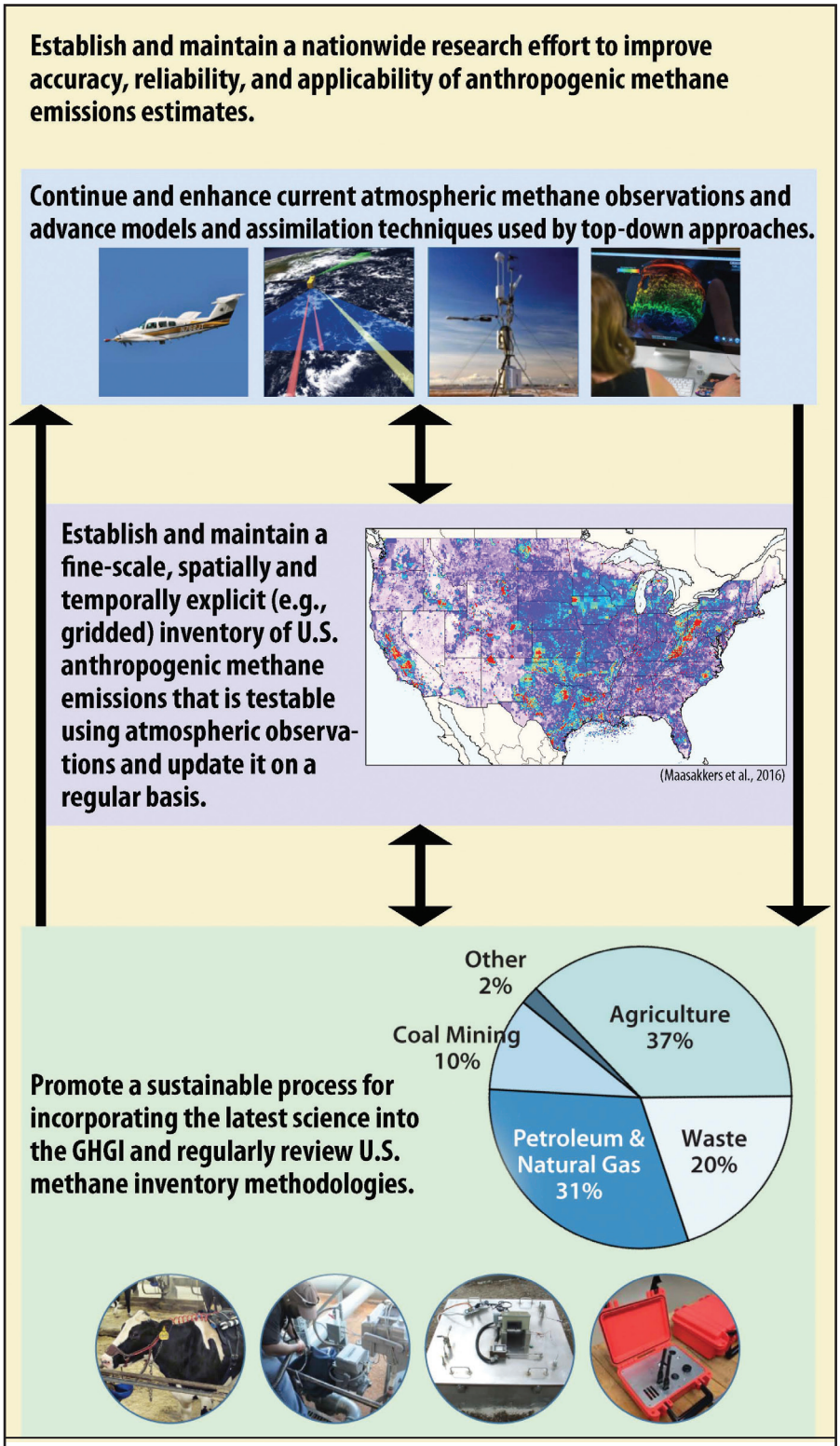


**Figure 2** This schematic summarizes the report's four major recommendations for improving quantification of anthropogenic methane emissions in the United States.

a smaller, more formal advisory group could improve the methane portion of the GHGI by facilitating timely improvements in activity data and enhance characterization of emissions sources and quantities.

**Recommendation #3: EPA, DOE, NOAA, and USDA should promote a sustainable process for incorporating the latest science into the U.S. Greenhouse Gas Inventory and regularly review U.S. methane inventory methodologies.**

## Research for Improving Characterization of Anthropogenic Methane Emissions

Maximizing improvements in the accuracy and precision of methane emission estimates will require a coordinated nationwide research effort that facilitates the complementary use of both top-down and bottom-up measurements and links estimates to field-validated models at appropriate scales. Such a national research effort should include results from atmospheric observations, sustained spatial and temporal characterization of methane emissions for key sectors in the United States, and improvements in estimation techniques.

Coordinated, contemporaneous top-down and bottom-up measurement campaigns, conducted in a variety of source regions for anthropogenic methane emissions, are crucial for identifying knowledge gaps and prioritizing emission inventory improvements. To date, only a limited number of highly coordinated campaigns utilizing both types of methodological approaches have been performed, mainly in regions dominated by emissions from petroleum and natural gas sources.

One challenge is that the accuracy of the measurement methods is not always clearly communicated to policymakers. When presenting results on methane emissions, clarity on the scope, and spatial and temporal boundaries is essential to enable potential users of the data to interpret the results.

**Recommendation #4: The United States should establish and maintain a nationwide research effort to improve accuracy, reliability, and applicability of anthropogenic methane emissions estimates at scales ranging from individual facilities to gridded regional/national estimates.**

## COMMITTEE ON ANTHROPOGENIC METHANE EMISSIONS IN THE UNITED STATES: IMPROVING MEASUREMENT, MONITORING, PRESENTATION OF RESULTS, AND DEVELOPMENT OF INVENTORIES

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For More Information . . . This Consensus Study Report Highlights was prepared by the Board on Atmospheric Sciences and Climate based on the Consensus Study Report *Improving Characterization of Anthropogenic Methane Emissions in the United States* (2018). The study was sponsored by the Department of Energy, Environmental Protection Agency, National Aeronautics and Space Administration, and National Oceanic and Atmospheric Administration. Any opinions, findings, conclusions, or recommendations expressed in this publication do not necessarily reflect the views of any organization or agency that provided support for the project. Copies of the Consensus Study Report are available from the National Academies Press, (800) 624-6242; http://www.nap.edu or via the Board on Atmospheric Sciences and Climate web page at http://www.nationalacademies.org/basc.

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