



Methane in the Inventory of U.S. Greenhouse Gas Emissions and Sinks

U.S. Environmental Protection Agency
Office of Atmospheric Programs, Climate Change Division

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Overview



- EPA Inventory of U.S. GHG Emissions and Sinks
- EPA Greenhouse Gas Reporting Program
- Updating EPA GHG Estimates
- Considerations for Top-Down Studies



Inventory of U.S. Greenhouse Gas Emissions and Sinks

U.S. Greenhouse Gas Emissions Inventory



- Official U.S. estimate of greenhouse gas emissions for reporting to United Nations Framework Convention on Climate Change (UNFCCC)
 - Annual national-level inventory submissions to the UNFCCC since 1994
- EPA leads Inventory development, working with several agencies
 - e.g. input data on forestry from USFS, data on energy from EIA
- Sectors Covered
 - Energy, Industrial Processes, Agriculture, Land-Use Change and Forestry, and Waste
- Gases Covered
 - CO₂, CH₄, N₂O, HFCs, PFCs, SF₆
 - Reported in Gg of each gas, and as global warming potential (GWP)-weighted CO₂e emissions
 - Inventories up to and including current use SAR GWP of 21 for CH₄
 - Future inventories will use AR4 GWP of 25
- Record of emissions trends over time
- Each year, Inventory undergoes expert review, public review, and UNFCCC review

GHG Inventory: Methods

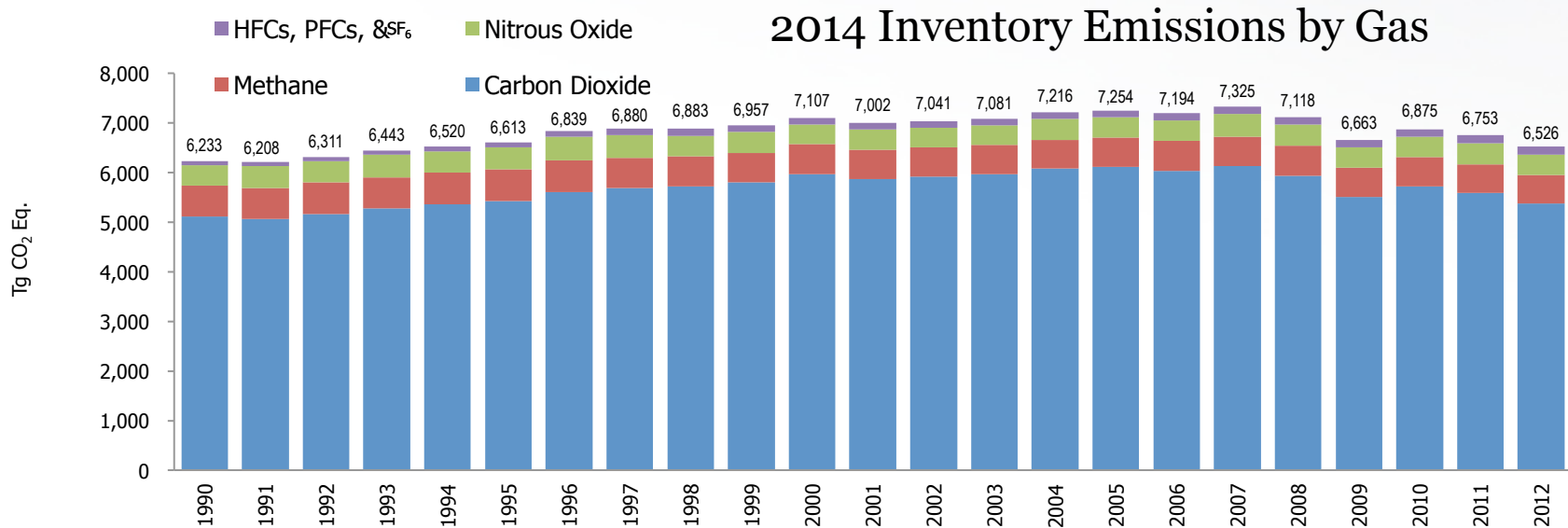


- UNFCCC Reporting Guidelines
- IPCC Guidelines
 - Internationally agreed methods
 - Bottom-up inventories
 - Tiered methods
- U.S. application of guidance
 - General use of higher tiers and 2006 IPCC Guidance
 - National or regional statistics for activity data
 - e.g. input data on forestry from USFS, data on energy from EIA
 - Country-specific models and emission factors
 - Emission factors typically developed from direct measurement
 - Use of facility-level reporting program data (GHGRP)

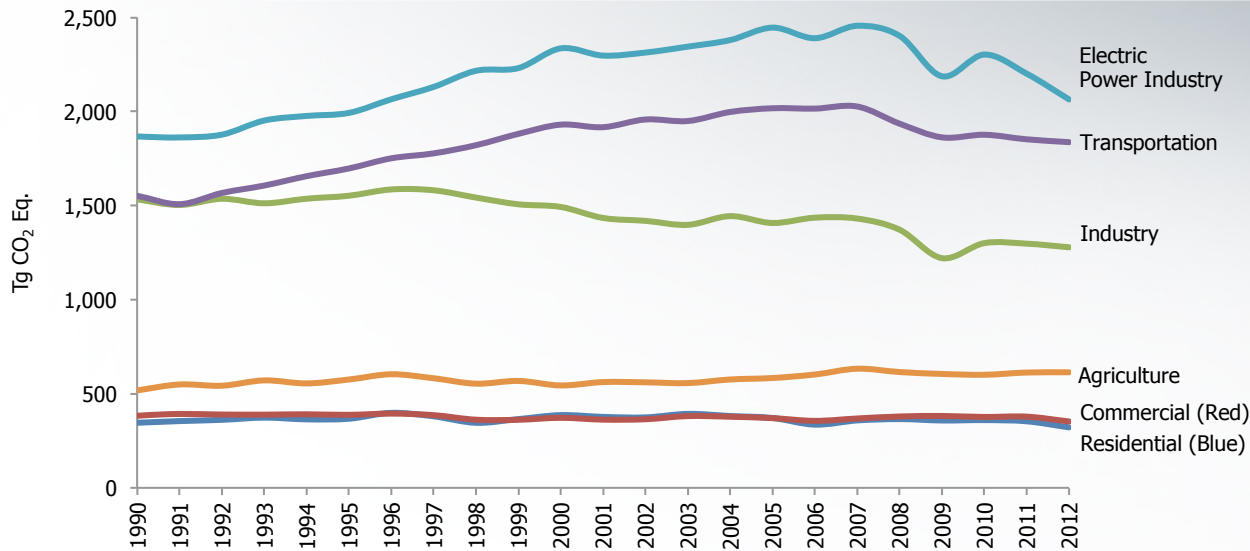
2014 Inventory Results Overview



- US GHG emissions declined 3.4% from 2011 to 2012
 - Increase of 4.7% from 1990, decrease of 10% from 2005
- CO₂ from fuel combustion dominate emissions and trends
 - Major contributors to the 2011-2012 decrease in emissions were decrease in energy consumption across all sectors in the U.S. economy, and decreases in carbon intensity for electricity generation due to fuel switching from coal to natural gas

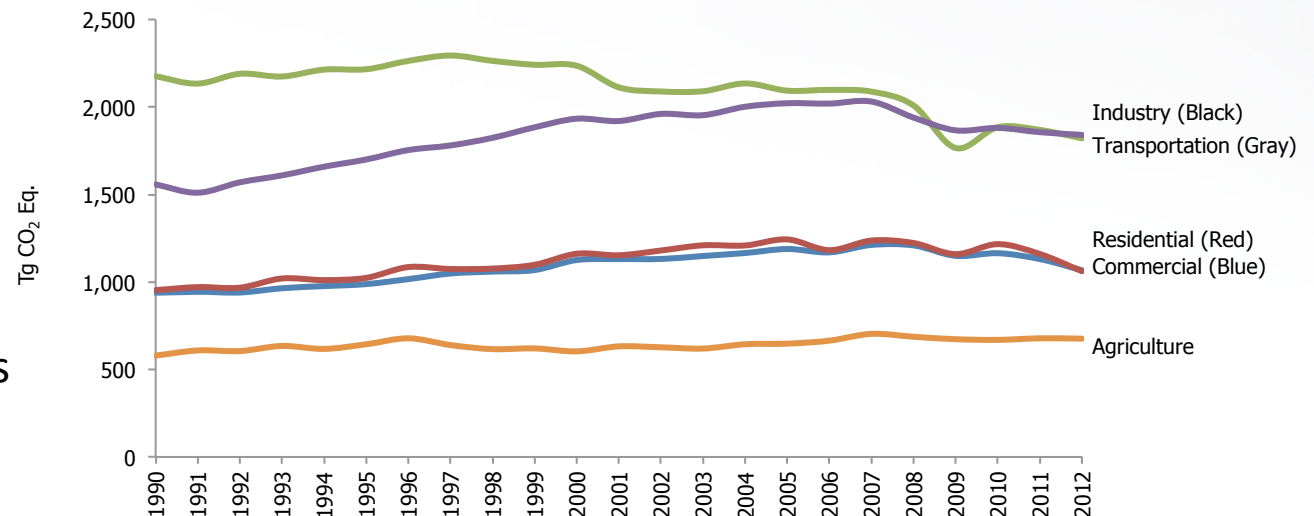


2014 Inventory by Economic Sector

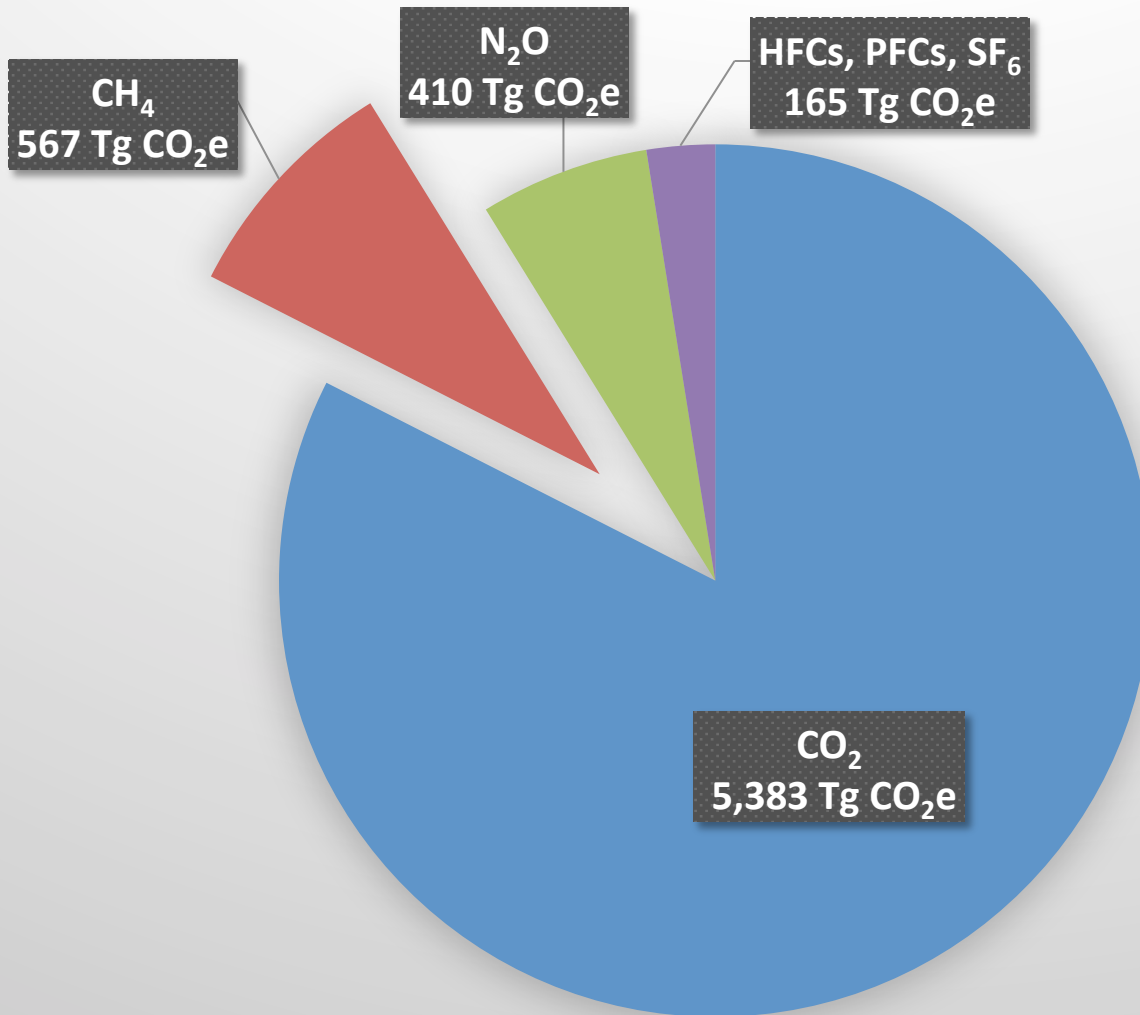


With electric power industry as a separate sector

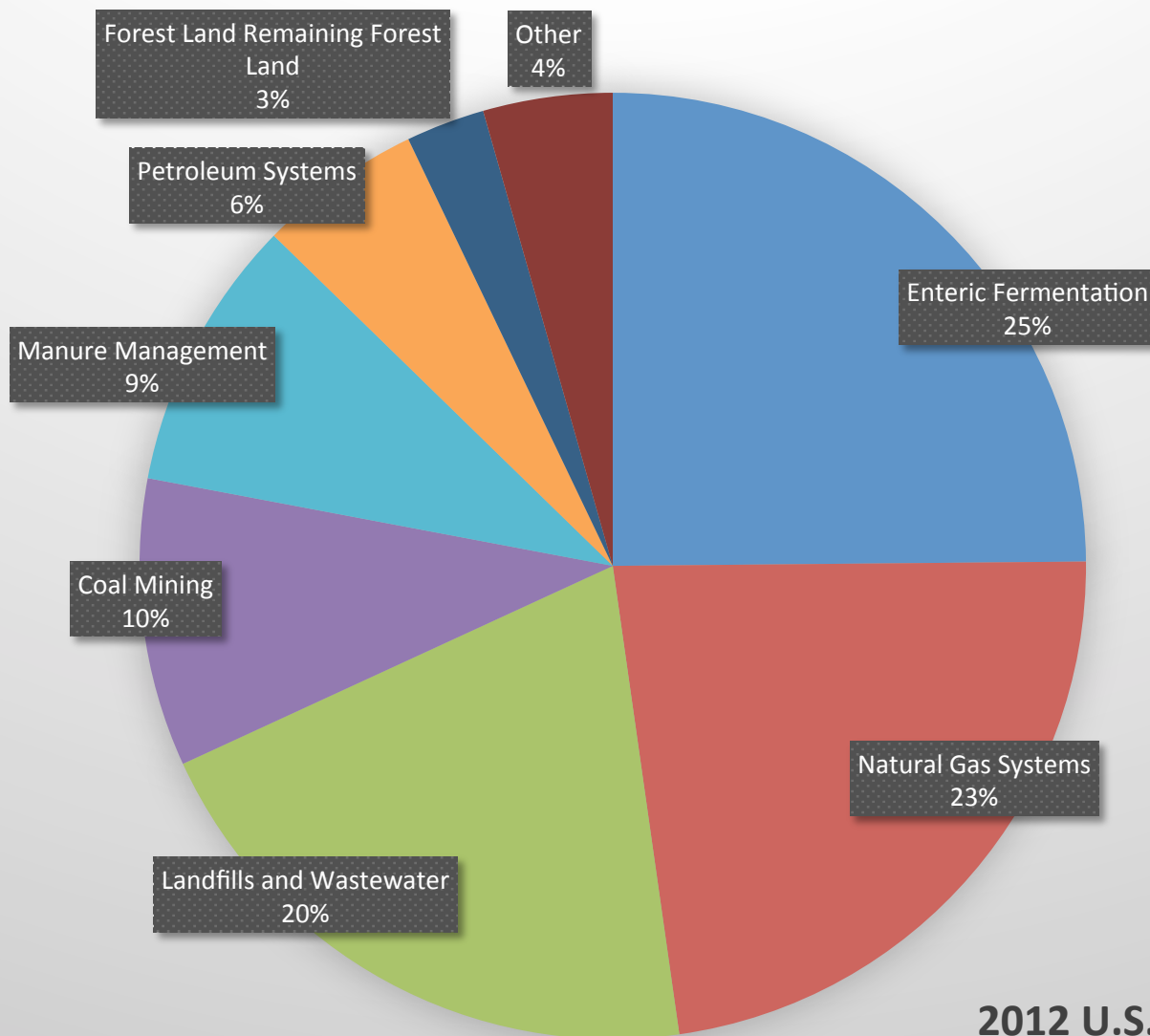
With electric power industry emissions allocated to other sectors by electricity use



2012 Emissions by Gas



2012 Methane in GHG Inventory

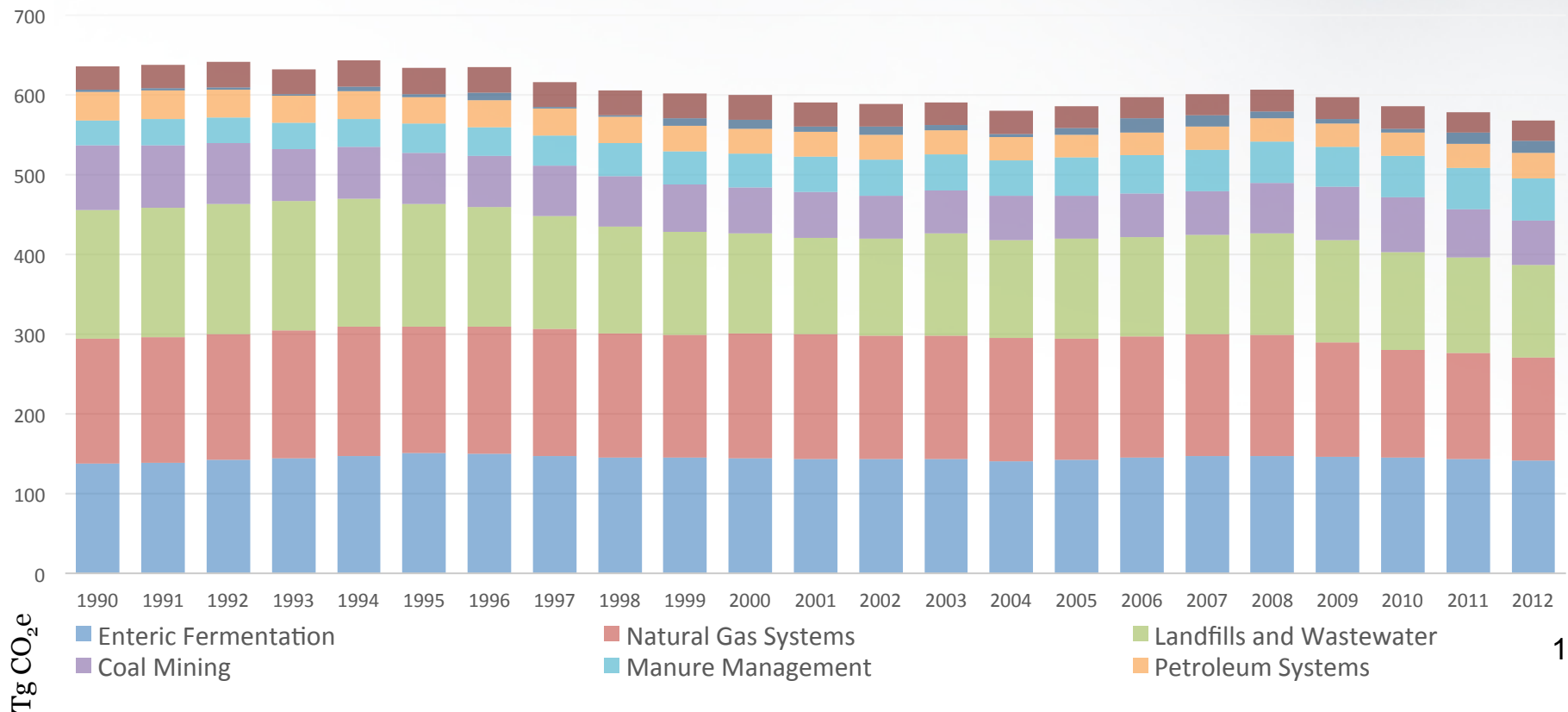


2012 U.S. CH₄ Emissions

Methane Trends 1990-2012



- Decrease of 11% from 1990-2012
 - Driven mostly by decrease in landfill emissions
- Decrease of 3% from 2005-2012
 - Driven mostly by decrease in natural gas emissions

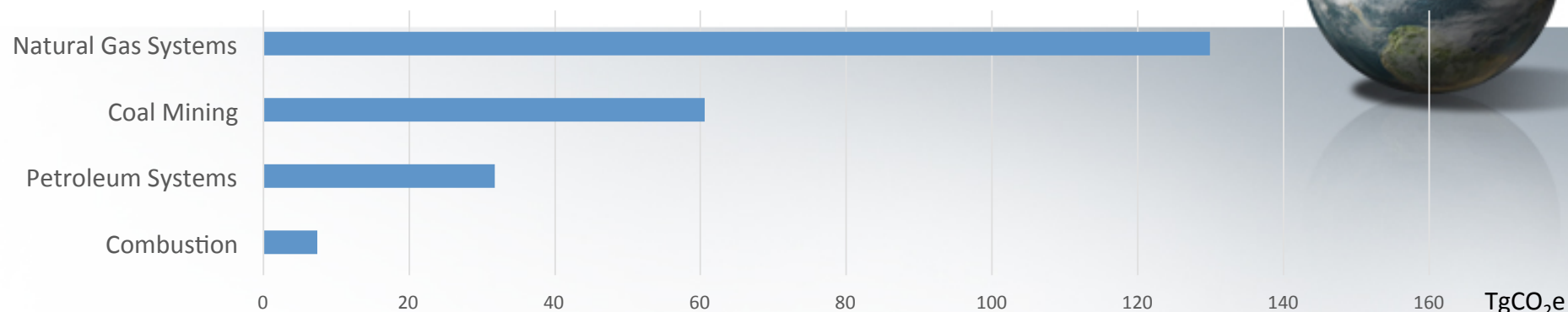


Increasing Stakeholder Interest in CH₄



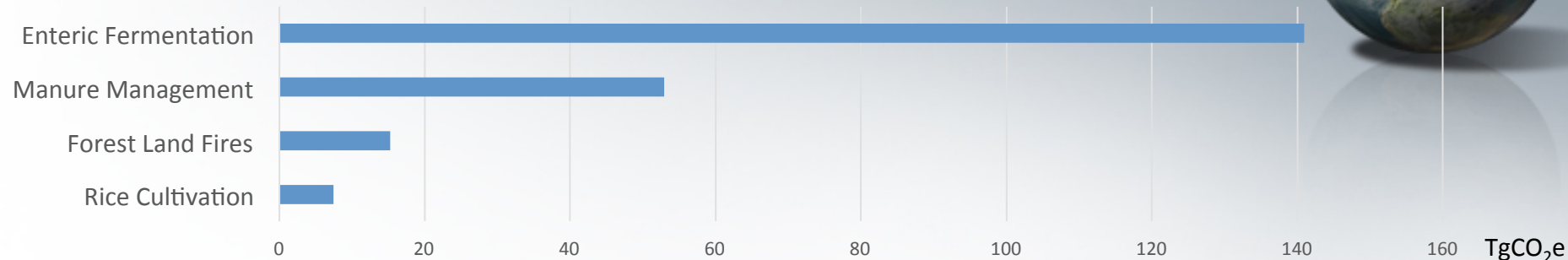
- Interest in EPA estimates
 - Many changes in natural gas industry practices in recent years
 - e.g. hydraulic fracturing; control technologies
 - General interest in role of short-lived climate forcers
 - Fuel-switching implications
 - e.g. power and transport sectors
- Increased EPA engagement with stakeholders
 - Expert and public review processes of the GHG Inventory
 - Stakeholder workshops and webinars September 2012
 - External studies
 - IPCC meeting
- Stakeholder data and information has led to recent improvements in GHG Inventory estimates

Energy CH₄ Sources



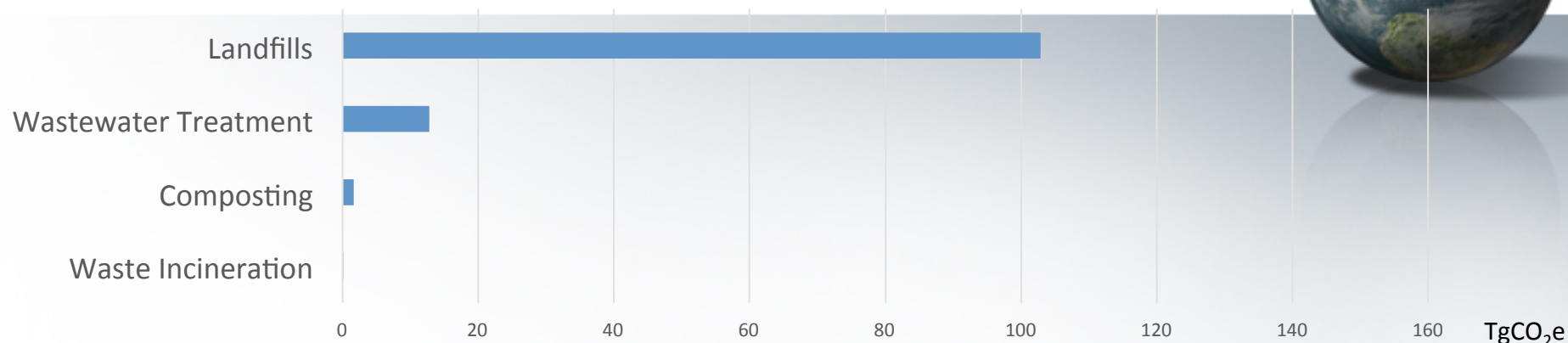
Source	Method/Emission Factors	Activity Data
Natural Gas and Petroleum Systems	Emission factors for 100s of sources, emissions reductions data, GHGRP data	Well counts, equipment counts, practice frequency, miles of pipeline types, etc.
Coal Mining	Use of MSHA emissions data by mine, GHGRP, state agency gas collection data, emission factors for surface and post-mining, decline curve for abandoned mines	EIA coal production data, number of abandoned mines

Agricultural and Land Use CH₄ Sources



Source	Method/Emission Factors	Activity Data
Enteric Fermentation	Model tracks animal growth and diets to develop country-specific (Tier 2) emission factors (cattle); IPCC default factors (other livestock)	Detailed data on animal characteristics, population, management, and diet (cattle); population data (other livestock)
Manure Management	Country-specific emission factors based on annual state climate, type/performance and temperature (liquid systems); IPCC default factors (dry system)	Volatile solids excretion rate (output of enteric model for cattle); waste management system usage (based on correlation with farms population size); typical animal mass
Forest land remaining forest land	Application of CH ₄ emission factor to total C released from forest fires	Area burned, carbon density and combustion factor

Waste Sector CH₄ Sources



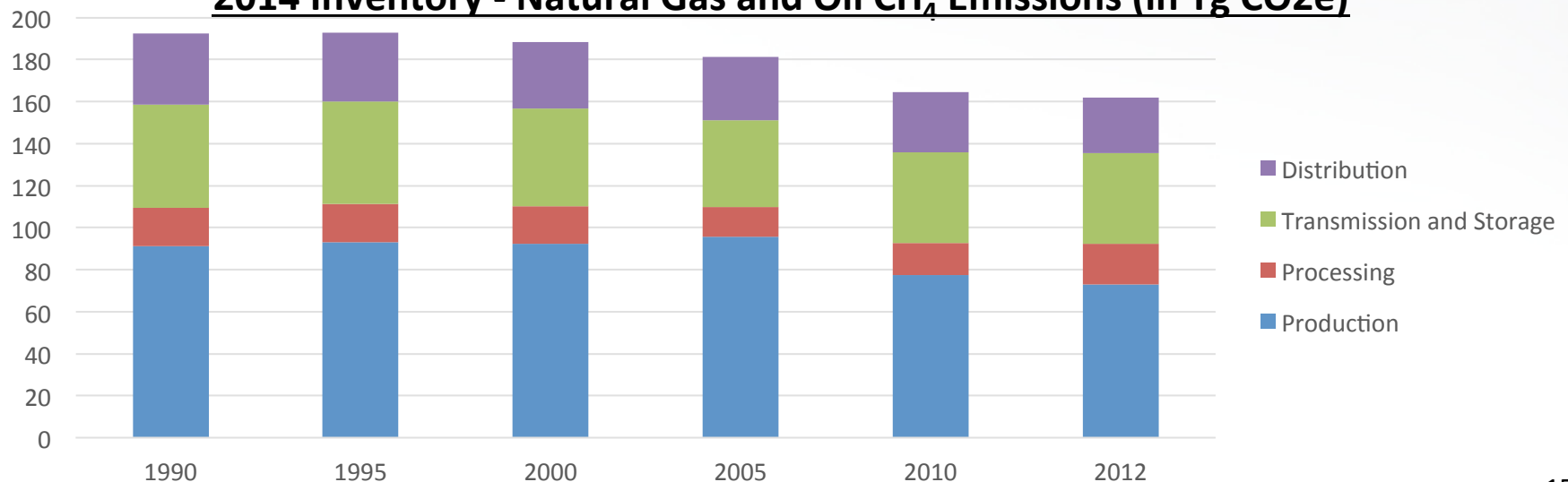
Source	Method/Emission Factor	Activity Data
Landfills	First order decay method, climate-specific decay rate, soil oxidation rate, gas recovery data	Waste in place, rainfall
Wastewater treatment	CH ₄ produced per BOD/COD	Population, fraction of population using each treatment system type, wastewater generation rate
Composting	IPCC emission factor	Mass of organic waste composted

Oil and Gas Emission Estimates in the US GHG Inventory



- Oil and gas CH₄ account for 2% of total U.S. GHG emissions, and 29% of U.S. CH₄ emissions
- 162 Tg CO₂e total CH₄ emissions from natural gas systems
 - 73 Tg CO₂e from oil and gas production segments
 - 19 Tg CO₂e from processing segment
 - 43 Tg CO₂e from transmission and storage segment
 - 26 Tg CO₂e from distribution segment
- Emissions decreased 31 Tg CO₂e, or 16%, from 1990-2012
- EPA continues to update estimates to reflect best available information

2014 Inventory - Natural Gas and Oil CH₄ Emissions (in Tg CO₂e)



Calculations for Oil and Gas



- Oil and gas in inventory covers hundreds of sources
 - Largest emissions from pneumatic controllers, compressors, pipelines
- Oil and gas estimates in the inventory based on EPA/GRI (1996)
 - Comprehensive assessment of CH₄ emissions across the entire oil and gas sector
 - Based on typical emission rates per activity or equipment from 1992
 - Used engineering judgment and measurements
- Considerations for updating from EPA/GRI
 - Time series



Example: Calculation of National Emissions

- Approach uses GRI/EPA study with detailed equipment counts, emissions measurements, and development of emission factors, updates with recent survey data

Calculation of National Emissions

Step 1. Calculate Potential Methane

- Collect activity data on production and equipment in use and apply emission factors (i.e., scf gas per unit or activity)

Step 2. Compile Reductions Data

- Calculate the amount of the methane that is not emitted, using data on voluntary action and State regulations

Step 3. Calculate Net Emissions

- Deduct methane that is not emitted from the total methane potential estimates to develop net CH₄ emissions

Example: 2012 Emissions from pneumatic devices in transmission sector (2014 Inventory)

Activity Data (# of pneumatics)	Emission Factor (Scf/device)	Calculated Potential (Tg CO ₂ e)	Reductions (Tg CO ₂ e)	Emissions (Tg CO ₂ e)
70,827	x 162,197	= 4.7	- 0.3	= 4.4

Updating Estimates for Future GHG Inventories



- Enhancing the US Greenhouse Gas Inventory is a key part of the Climate Action Plan Strategy to Reduce Methane Emissions
 - Incorporation of GHGRP
 - Work with USDA and DOE
 - Promoting transparency and stakeholder input
- Evaluation of updates to estimates key to maintaining GHG Inventory quality
 - Continuous improvement - if better data become available, IPCC good practice and UNFCCC obligates its consideration
 - Emphasis on improving estimates and devoting resources to large sources, or rapidly changing sources (“Key Sources”)
 - Annual reassessment of methodologies and refinements for each source category
- EPA notes updates under consideration in “Planned Improvements” section of Inventory

Example: Recent Updates to GHG Inventory for Oil and Gas



Inventory Year	Update to GHG Inventory Natural Gas Systems Estimate
Inventories through 2010	GHG estimates for all activities were based on a 1996 GRI/EPA study (1992 data)
2011/2012 Inventories	<p>EPA updated the natural gas production sector estimates</p> <ul style="list-style-type: none">• Updated estimates of liquids unloading using engineering calculations• Included hydraulically fractured gas well completions/workovers
2013 Inventory	<p>EPA updated the natural gas estimates for the production sector based on new data</p> <ul style="list-style-type: none">• Further improvements to liquids unloading estimates using API/ANGA study• Updated hydraulic fracturing gas well completions/workovers estimates
2014 Inventory	<ul style="list-style-type: none">• Update to approach for estimating emissions from hydraulically fractured gas well completions/workovers• Use of 4 practice-specific emission factors

Example: Planned Oil and Gas Improvements for Future Inventories



- Continued review of GHGRP data
- Continued review of external studies (e.g. EDF, GTI)
- Updates to uncertainty analysis
- Gas STAR reductions
- Gas well completion and workover counts
- HF oil well completions and workovers
- Pneumatic devices
- Petroleum refineries

Quantifying Uncertainty in GHG Inventory



Source	Uncertainty Range
Enteric Fermentation	-11% to +18%
Natural Gas Systems	-19% to +30%
Landfills	-56% to +47%
Coal Mining	-12% to +16%
Manure Management	-18% to +20%
Petroleum Systems	-24% to +149%
Forest Land Fires	-82% to +176%
Wastewater Treatment	-27% to +21%
<u>National CH₄</u>	<u>-10% to +18%</u>
<u>National Total GHG</u>	<u>-1% to +5%</u>

- Uncertainty is calculated for each source
- Development of probability density functions, and use of Monte Carlo simulations
- Rather small for well-monitored source categories, e.g. fossil fuel combustion (-2% to +5%)
- Higher for CH₄ and N₂O from area sources, e.g. agricultural soils (-21% to +57%)
- IPCC guidance notes limitations



Greenhouse Gas Reporting Program

Overview of GHG Reporting Program



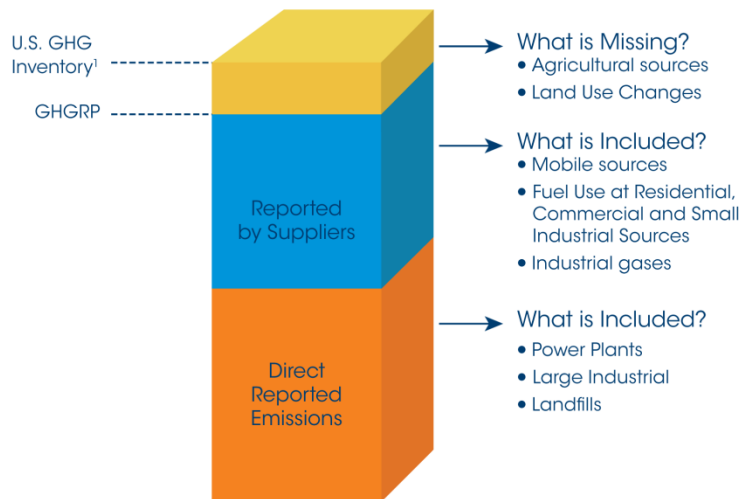
- Launched in response to FY 2008 Consolidated Appropriations Act
- Annual reporting of GHGs by 41 source categories
 - 33 types of direct emitters
 - 6 types of suppliers of fuel and industrial GHGs
 - Facilities that inject CO₂ underground for geologic sequestration, enhanced oil recovery, or any other purpose
- Most source categories began collecting data in 2010, with first annual reports submitted to EPA in September 2011
 - An additional 12 source categories began collecting data in 2011, with first annual reports submitted to EPA in September 2012
 - We now have published 3 years of data for 29 source categories and 2 years of data for 12 source categories
- Facilities use uniform methods prescribed by EPA to calculate GHG emissions, such as direct measurement, engineering calculations, or emission factors derived from direct measurement
 - In some cases, facilities have a choice of calculation methods for an emission source
- Direct reporting to EPA electronically
- EPA verification of GHG data

GHG Reporting Program vs. US GHG Inventory



- Inventory of U.S. Greenhouse Gas Emissions and Sinks (Inventory) tracks total annual U.S. emissions across all sectors of the economy using national-level data
- GHGRP collects detailed emissions data from large greenhouse gas emitting facilities in the United States
 - GHGRP covers most, but not all, U.S. GHG emissions
 - GHGRP does not include agriculture, land use, and small sources

GHGRP Covers the Majority of U.S. GHG Emissions



¹ Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990–2011, April 2013.

Task	Inventory	Greenhouse Gas Reporting Program
Find total U.S. emissions	✓	
Review trend data for the past 20 years	✓	
Browse a map to find largest emitters in your area		✓
Compare facility emissions across an industrial sector		✓
Find <u>reported</u> emissions by state		✓



Methane Sources in GHGRP



- Top reported CH₄ sources
 - Landfills and industrial wastewater
 - Oil and gas
 - Coal mines
- Considerations for comparing GHGRP and GHG Inventory
 - Sources covered: GHGRP does not contain data for agriculture and forestry CH₄ emissions
 - Definitions: Definitions of sectors and industry groupings in the Inventory and GHGRP may not be the same
 - Threshold: Generally, GHGRP requires facilities that emit greater than 25,000 metric tons CO₂e per year to report
 - Methods: Use of U.S.-national factors in Inventory versus facility-level emissions calculated with direct measurement, engineering calculations, and/or emissions factors

Petroleum and Natural Gas Systems in GHGRP (Subpart W)



Production and Processing

1. Onshore Production
- 2a, 2b. Offshore Production
3. Gathering and Boosting (not covered by Subpart W)
4. Natural Gas Processing



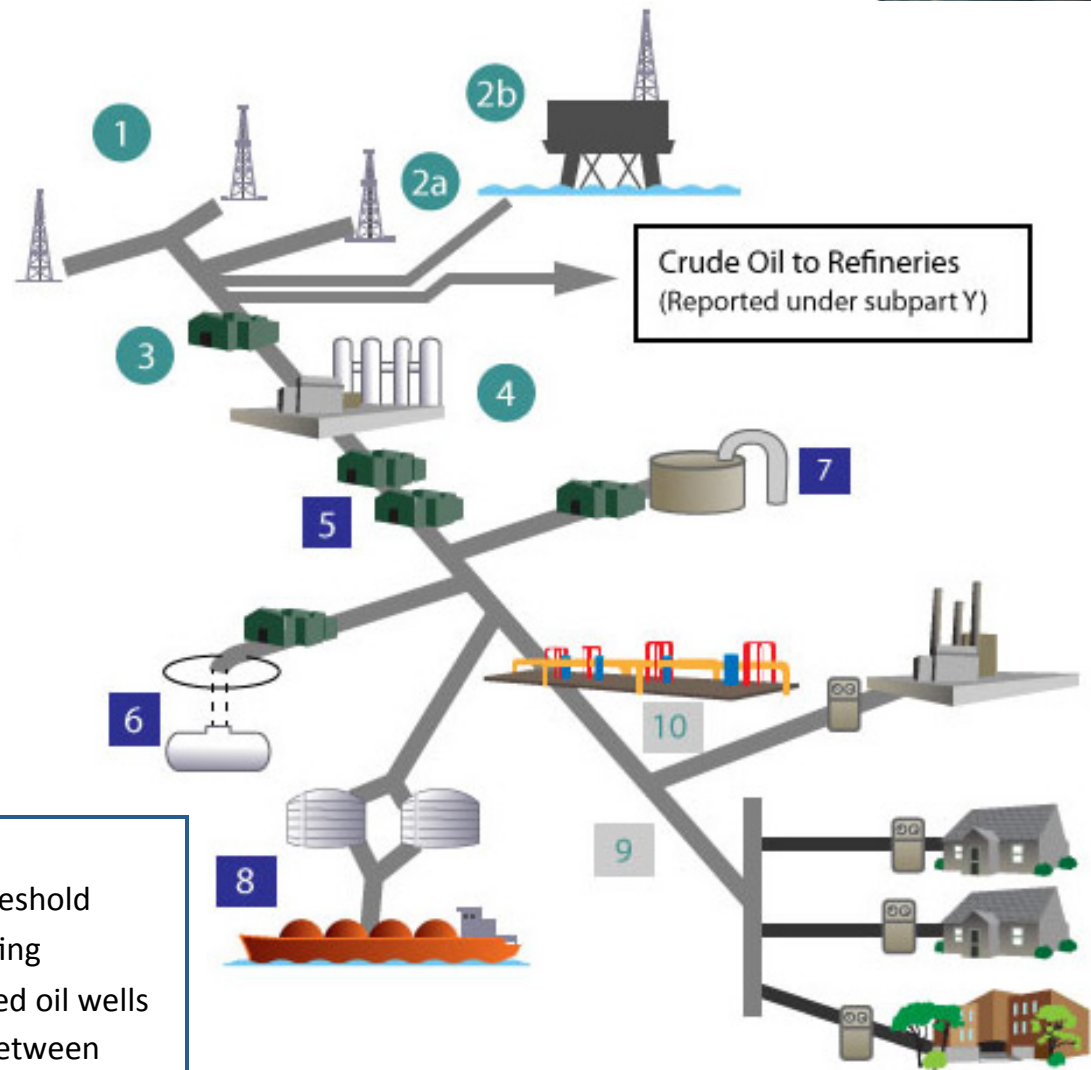
Transmission and Storage

5. Natural Gas Transmission
6. Underground Natural Gas Storage
7. LNG Storage
8. LNG Import-Export



Distribution

- 9, 10. Natural Gas Distribution



Not Covered

- Emissions below 25,000 metric ton CO₂e threshold
- Process emissions from gathering and boosting
- Vented emissions from hydraulically fractured oil wells
- Process emissions from transmission lines between compressor stations

Figure adapted from AGA and Natural Gas STAR

Example: Oil and Gas GHGRP data in GHG Inventory



- QC of key updates
 - Data from GHGRP used to check Inventory updates under consideration
 - Liquids unloading update to 2013 Inventory
 - 2012 Inventory total emissions significantly higher than GHGRP results
 - GHGRP data used to validate a new data sources and updated emissions totals
- Use of GHGRP data to update methods
 - Hydraulic fracturing update to 2014 Inventory
 - 2013 Inventory total emissions higher than GHGRP total emissions
 - GHGRP data show more RECs and flaring than GHG Inventory
 - GHGRP data show similar activity data (# of completions)
 - 2014 Inventory used GHGRP data to update HF emissions methodology with practice-specific factors instead of potential factor
- Future use of GHGRP
 - Petroleum refineries and review of other sources
 - Activity data available in 2015

Methane Measurement Studies



- Several recent studies have measured CH₄ emissions at the national or regional level, with estimates that differ from EPA's emissions estimate
 - Some studies compare to EPA inventory; some to other bottom-up data
- EPA is considering how such measurement studies can be used to update Inventory estimates
 - Verification tool?
 - Prioritizing sources for improvement?
 - Incorporation into inventory?
- Some factors for consideration
 - Attribution—including calculations and assumptions regarding natural sources of emissions and other emissions that are not the target of the study
 - How such measurements can inform emission factors and activity data used to calculate a time series for national emissions

Attribution Considerations (1 of 2)



Sources not included in GHG Inventory

- Non-anthropogenic emissions not included in GHG Inventory
 - Natural sources include both fossil (e.g. geological seepage) and biological sources of carbon (e.g. wetlands)
 - Likely large sources in U.S. include wetlands, geological seepage, and termites
 - Global estimates (EPA 2010 and IPCC 2013) ~40% of total global CH₄ from non-anthropogenic activities
 - Wetlands (60-80%), geological seepage (~20%), and smaller amounts from lakes, termites and wild animals
- Anthropogenic emissions not included in GHG Inventory
 - Abandoned oil and gas wells

Attribution Considerations (2 of 2)



Regional and seasonal considerations

- Livestock
 - Livestock populations and production practices vary greatly regionally
 - Population size varies with production cycle
 - Emissions from manure management systems temperature-dependent
- Waste
 - Waste management practices vary by region
 - Landfill emissions impacted by precipitation
- Oil and gas
 - Practices and emissions can vary regionally (e.g. formation types, regulations)

Informing Emission Factors and Activity Data



- Activities taking place at the time of measurement
 - General operating conditions
 - High-emission venting events
 - Maintenance schedule
- Regional versus national factors
- Controlled versus uncontrolled
- Super emitters
 - Where do they occur (e.g. which processes or equipment)?
 - How common are they?
- Corresponding activity data
 - Is national data available?

How to Access GHG Inventory Oil and Gas Emissions Data



- Detailed source descriptions, methodologies, emissions data and activity data available at
 - Energy Chapter of GHG Inventory (pages 3.54-3.75)
 - <http://www.epa.gov/climatechange/Downloads/ghgemissions/US-GHG-Inventory-2014-Chapter-3-Energy.pdf>
 - Annex 3 of GHG Inventory (pages A.175-A.208)
 - <http://www.epa.gov/climatechange/Downloads/ghgemissions/US-GHG-Inventory-2014-Annex-3-Additional-Source-or-Sink-Categories.pdf>
- Data tables
 - <http://www.epa.gov/climatechange/ghgemissions/usinventoryreport.html>

How to Access GHGRP Data on Petroleum and Natural Gas Systems



- EPA has several data portals to access data collected by the GHGRP on Petroleum and Natural Gas Systems
- EPA's easy-to-use Facility Level Information on GreenHouse gas Tool (FLIGHT) allows users to view GHG data from Petroleum and Natural Gas Systems in a variety of ways
 - View GHG data reported by individual facilities
 - Aggregate reported emissions based on industry segment or geographic level
 - Search for facilities by name, location, corporate parent, or NAICS code
 - Visit FLIGHT: <http://ghgdata.epa.gov>
- Detailed non-CBI data is available through Envirofacts
 - Access GHG data on Envirofacts:
<http://www.epa.gov/enviro/facts/ghg/customized.html>