

Benchmarking Methane and Other Greenhouse Gas Emissions

Of Oil & Natural Gas Production in the United States

June 2024

Data downloads at: www.erm.com



CLEAN AIR
TASK FORCE



At Ceres our mission is to transform the economy to build a just and sustainable future for people and the planet. To truly do this, we must acknowledge the deeply traumatic history of colonialism against Indigenous people and their land.

We acknowledge that our office headquarters is in Boston and is on the traditional land of the Massachusett People.



Benchmarking Methane and Other Greenhouse Gas Emissions

Of Oil & Natural Gas Production in the United States

June 2024

Data downloads at: www.erm.com



CLEAN AIR
TASK FORCE



Speakers



Lesley Feldman

Research and Analysis Manager,
Methane Pollution Prevention
Clean Air Task Force



Andrew Logan

Senior Director,
Oil and Gas, Climate and Energy
Ceres



Luke Hellgren

Principal Technical Consultant
ERM



Methodology overview



Methodology – GHG Reporting Program Sources

EPA's publicly available GHGRP Subpart W data set is the primary source of information for this report. All hydrocarbon production data and over 99% of emissions data are sourced from EPA GHGRP.

The GHGRP requires facilities that emit more than 25,000 metric tons of CO₂e per year to report emissions. Subpart W defines an onshore production segment facility as all production-related equipment under common ownership or operating control within a hydrocarbon production basin. Onshore production facilities are therefore made up of many individual well pads and associated equipment.

For the onshore production segment, facilities are required to report emissions for 17 individual source categories; emissions are calculated using a variety of methodologies, including default emission factors and engineering calculations.

Production Segment Sources and GHGs Covered by Subpart W

Source	CH ₄	CO ₂	N ₂ O
Acid Gas Removal Units		✓	
Associated Gas Venting/Flaring	✓	✓	✓
Atmospheric Storage Tanks	✓	✓	✓
Centrifugal Compressors	✓	✓	
Combustion Equipment	✓	✓	✓
Completions/Workovers w/ Hydraulic Fracturing	✓	✓	✓
Completions/Workovers w/o Hydraulic Fracturing	✓	✓	✓
Dehydrators	✓	✓	✓
EOR Hydrocarbon Liquids		✓	
EOR Injection Pumps		✓	
Equipment Leak Surveys/Population Counts	✓	✓	
Flare Stacks	✓	✓	✓
NG Pneumatic Devices	✓	✓	
NG-Driven Pneumatic Pumps	✓	✓	
Reciprocating Compressors	✓	✓	
Well Testing	✓	✓	✓
Well Venting (Liquids Unloading)	✓	✓	

Methodology – GHG Inventory Sources

The report captures six additional emission sources that are not reported under GHGRP. Emissions from these sources are calculated using EPA GHG Inventory emission factors and activity data reported under GHGRP.

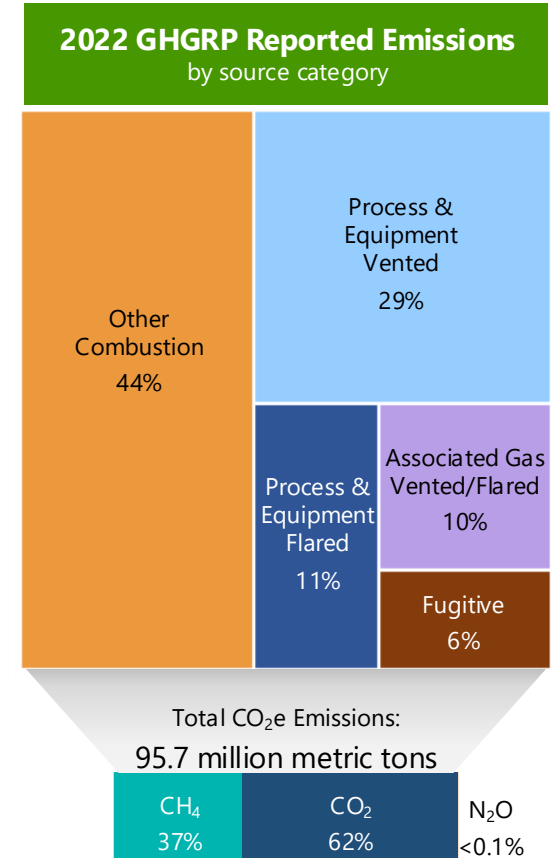
Emissions from these sources represent a small fraction (<1%) of total emissions included in the report.

Emissions Source	GHG Inventory CH ₄ Emissions Factor				GHG Inventory CO ₂ Emissions Factor				Activity Factor (unit)
	2018	2019	2020	2021/ 2022*	2018	2019	2020	2021/ 2022*	
Vessel Blowdowns (applies to separators, heater-treaters, dehydrators, and in-line heaters)	1.6	1.6	1.6	1.6	0.2	0.2	0.2	0.2	Well count from GHGRP; 0.87 vessels/well as per GHG Inventory (kg/vessel)
Compressor Blowdowns	76.8	76.7	76.6	76.6	8.5	8.5	8.6	8.6	Compressor count from GHGRP (kg/compressor)
Compressor Starts	171.7	171.6	171.4	171.4	19.0	19.1	19.2	19.2	Compressor count from GHGRP (kg/compressor)
Pressure Relief Valve Upsets	0.7	0.7	0.7	0.7	0.1	0.1	0.1	0.1	Valve count from GHGRP (kg/valve)
Well Drilling	51.3	51.2	51.2	51.2	6.7	6.7	6.7	6.7	Gas wells completed from GHGRP (kg/well)
Acid Gas Removal Units	598.3	598.3	598.3	598.3	Captured in GHGRP				AGRU count from GHGRP (kg/AGRU)

Types of Emissions Associated with Oil & Gas Production

For purposes of comparison within this report, the 23 individual emission sources (17 from GHGRP, 6 from GHG Inventory) are grouped into five categories:

- **Process & Equipment Vented** Vented emissions are intentional releases of natural gas from equipment and processes. Common sources of vented emissions include gas-driven pneumatic devices, compressor seals, tanks, and liquids unloading.
- **Process & Equipment Flared** Flared emissions consist primarily of CO₂ from the combustion of gas that is captured from equipment and processes. Flaring also results in methane emissions from uncombusted gas that escapes through the flare stack.
- **Associated Gas Vented & Flared** Associated gas vented and flared emissions occur at oil wells that do not capture a portion or any of the gas that is produced alongside oil. The gas is directly released to the atmosphere or combusted in a flare rather than captured for sale, on-site use, or reinjection.
- **Fugitive** Fugitive emissions are unintentional releases, or leaks, of natural gas. These emissions are often caused by faulty or worn-out equipment. Sources of fugitive emissions include seals and cracks on equipment such as tanks and piping, and leakage from infrastructure components such as valves and connectors.
- **Other Combustion** Non-flaring combustion is a significant source of CO₂ emissions from oil and gas production. Diesel and natural gas engines used to power equipment and provide electricity represent the largest source of other combustion emissions. Other combustion also includes methane emissions from uncombusted gas.



Intensity Metrics

This report uses two emissions intensity metrics to compare producer performance.

- **Methane Intensity.** Calculated using the Edison Electric Institute and American Gas Association Natural Gas Sustainability Initiative (NGSI) protocol. This approach focuses on the natural gas value chain and calculates intensity as methane emissions assigned to natural gas on an energy basis divided by the total methane content of produced natural gas. This methane intensity is expressed as a percentage.
- **GHG Intensity.** Calculated as total production-segment GHG emissions in kilograms of carbon dioxide equivalent (CO₂e) divided by total hydrocarbon production in barrel of oil equivalent (BOE). The GHG emissions intensity is expressed as kilograms CO₂e per BOE.

NGSI Methane Emissions Intensity

$$\frac{\text{CH}_4 \text{ Emissions (MT)} * \text{Gas Ratio}}{\text{Produced Gas (mcf)} * \text{Methane Content} * (0.0192 \text{ MT/mcf})}$$

where:

Gas Ratio = Energy content of produced gas / Energy content of total hydrocarbons
Methane Content = Molar fraction of methane in produced gas

Greenhouse Gas Emissions Intensity

$$\frac{\text{CH}_4 \text{ Emissions (kg CO}_2\text{e)} + \text{CO}_2 \text{ Emissions (kg CO}_2\text{e)} + \text{N}_2\text{O Emissions (kg CO}_2\text{e)}}{\text{Produced Gas (BOE)} + \text{Oil Sales (BOE)}}$$

where:

CO₂e = CO₂-equivalent of gases adjusted by GWP
Produced Gas (BOE) + Oil Sales (BOE) = Hydrocarbons as barrel oil equivalent

Note that the NGSI methane intensities in this report may differ slightly from those calculated by companies due to assumptions made in this analysis and its use of publicly reported data.



Thank you

Contact

Luke Hellgren

luke.Hellgren@erm.com

Benchmarking Report

Key Findings and Conclusions

June 2024



CLEAN AIR
TASK FORCE

2022 Reported Emissions: Considerations

- Important to recognize the gap between **reported** emissions and **measured** emissions. A big portion of this gap is the result of large release events (aka “super-emitters”). Thus, **reported** emissions are an underestimate of actual emissions and not all sources are accurately captured in reports.
- Nevertheless, these **reported** emissions provide a useful starting place to compare companies and their practices.

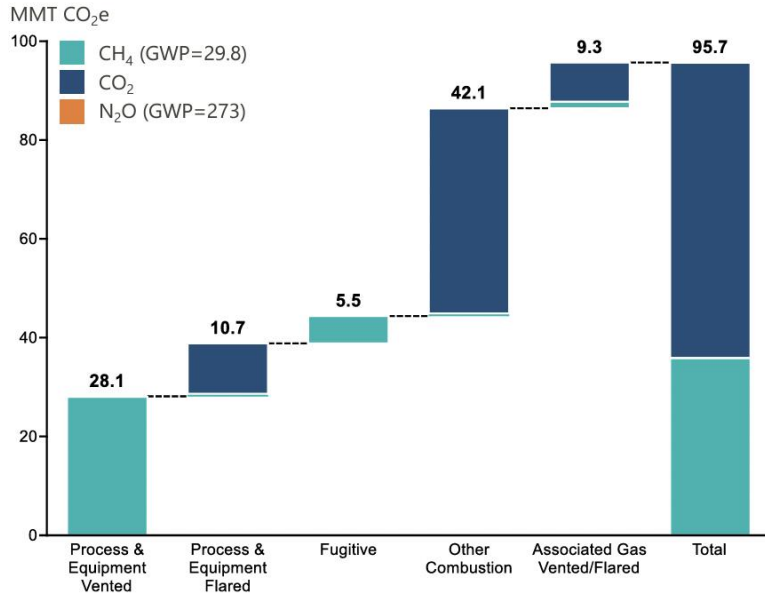
2022 Reported Emissions: Key Findings

- The **reported** methane emissions intensity of natural gas production and the GHG emissions intensity of oil and gas production varies dramatically across producers.
- The highest emitting oil and gas companies had a **reported** methane emissions intensity nearly 32 times that of the lowest emitting companies (up from 26x in 2021)
- Emissions intensity varies even between similarly-sized operators in the same geographic area, according to the data, largely due to different equipment choices and operational practices.
- Pneumatic controllers were the largest source of **reported** production-segment methane emissions, making up 67% of the total.
- Fuel combustion equipment, including engines and heaters, was the largest source of total reported production-segment CO₂ emissions, responsible for 61% of all reported CO₂ emissions.
- Venting and flaring are significant contributors in oil-heavy basins.

Sources of Emissions

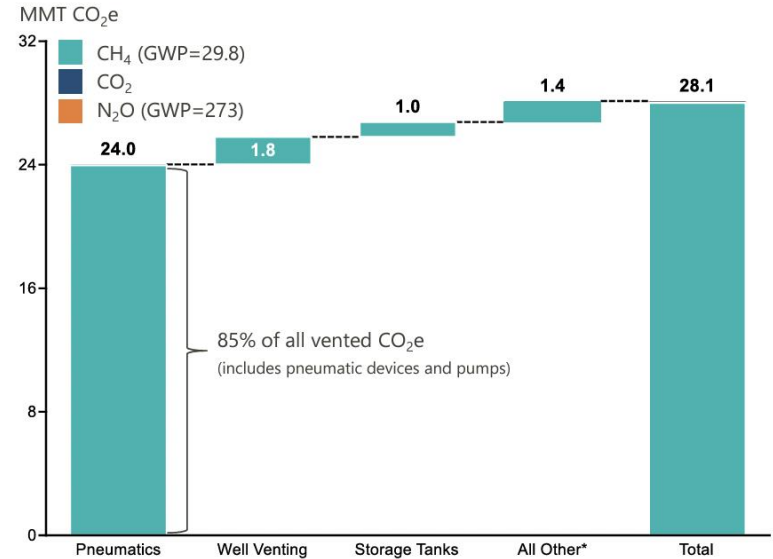
2022 Reported Production Emissions, by Source Category

million metric ton CO₂e (MMT CO₂e)



2022 Reported Process & Equipment Vented Emissions, by Source

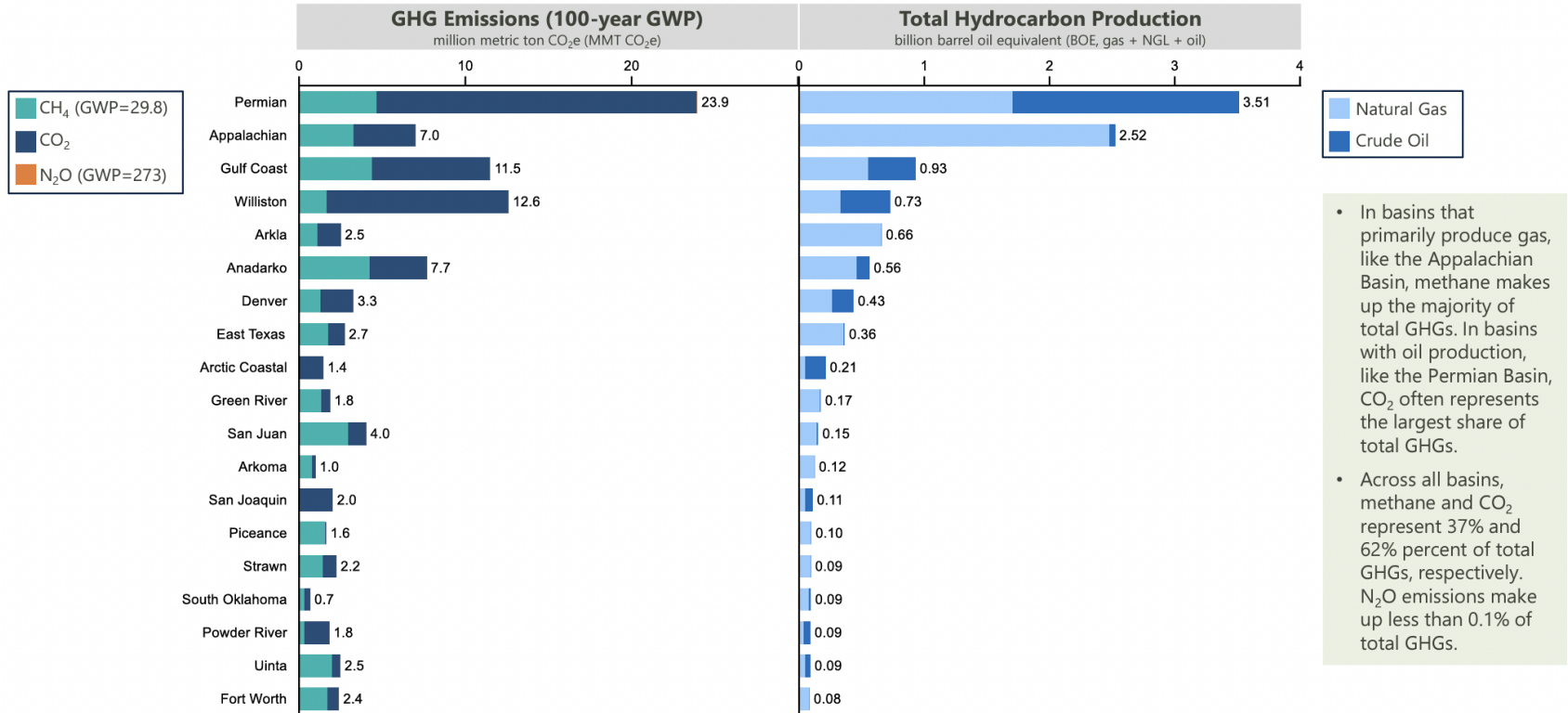
million metric ton CO₂e (MMT CO₂e)



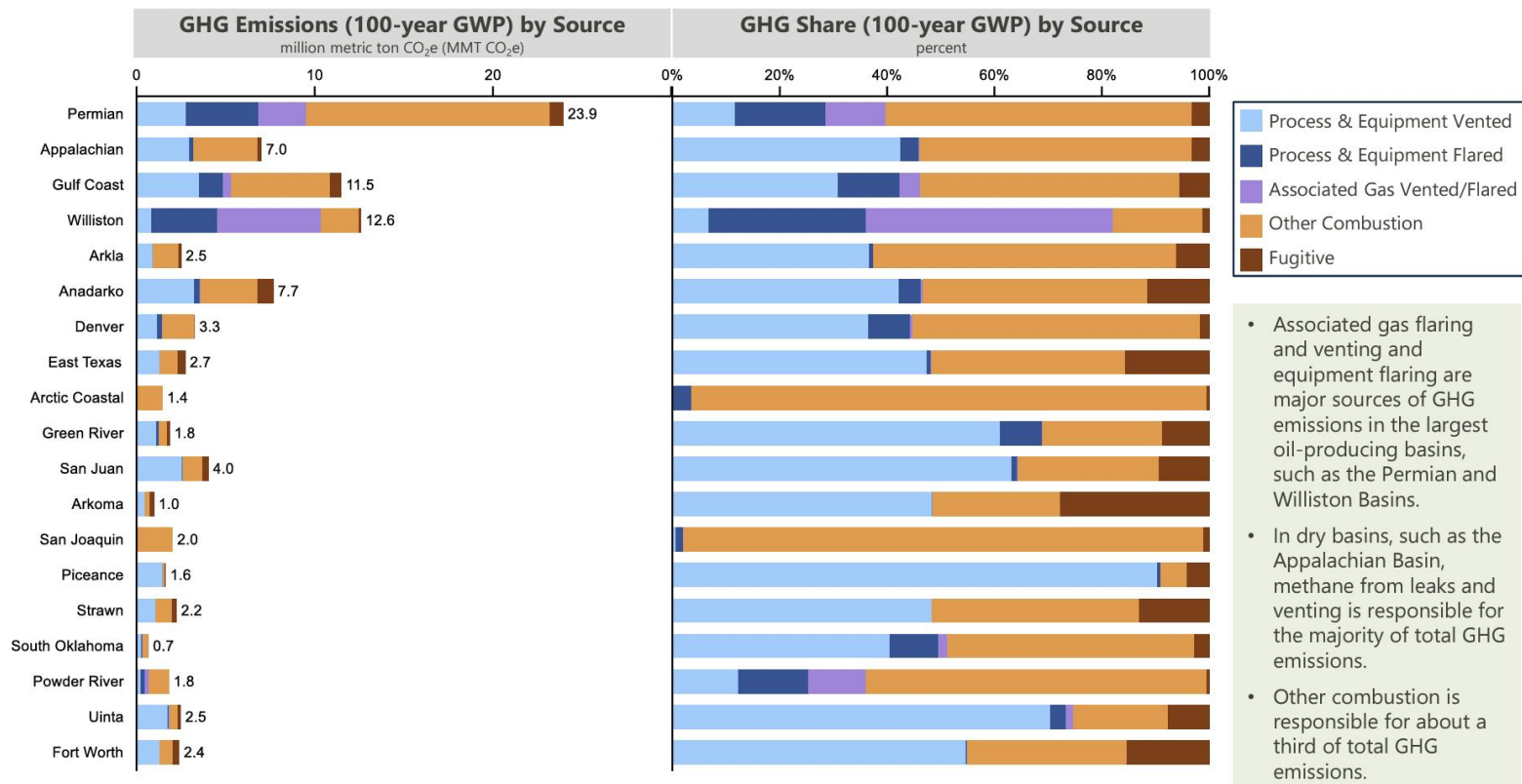
*Includes: Centrifugal compressors, Completions/workovers, dehydrators, reciprocating compressors, compressor blowdowns and starts, well drilling, pressure relief valves, well testing, and acid gas removal units

Basin Level Results

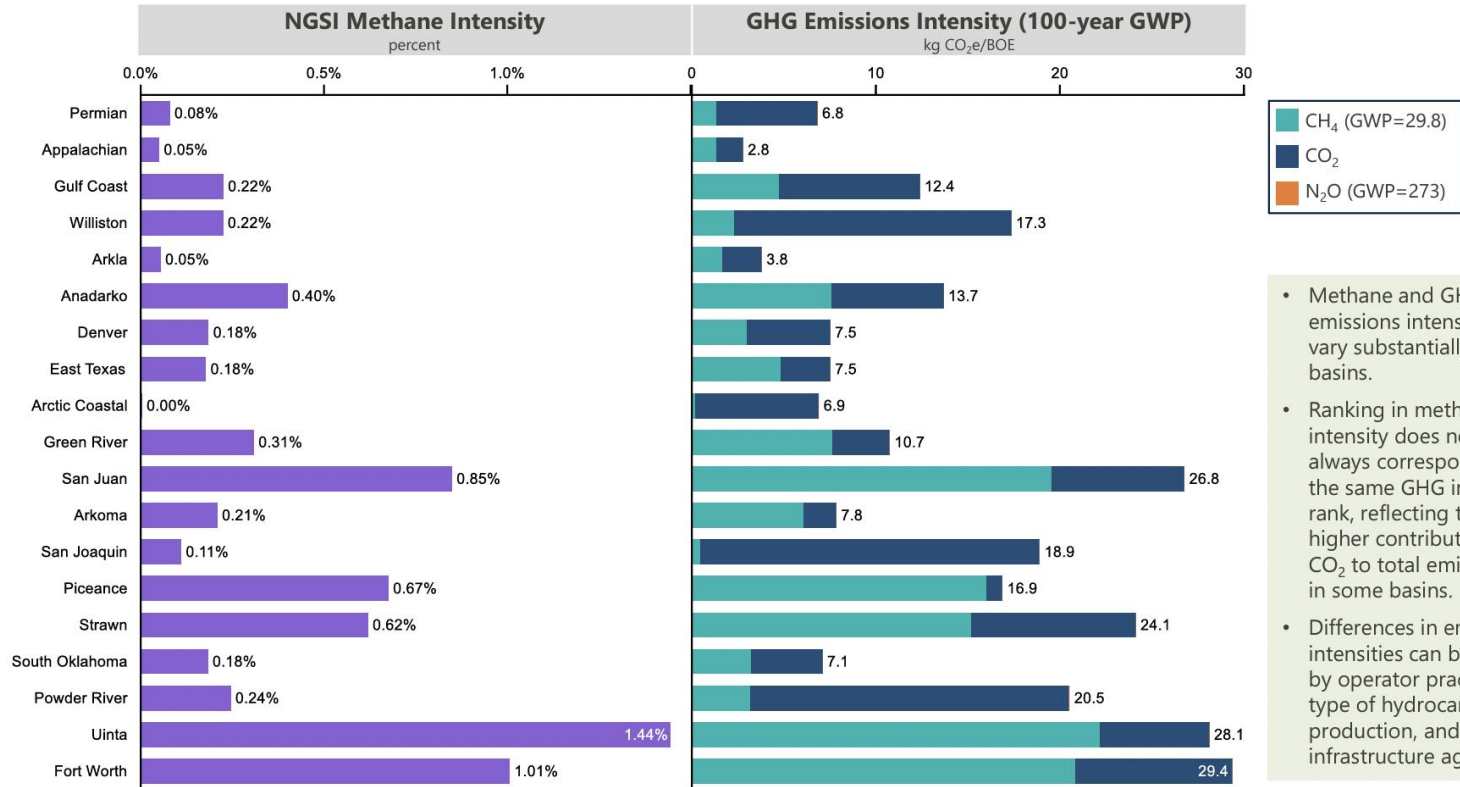
— GHGRP Basin Production & Emissions



— GHGRP Basin Emissions by Source



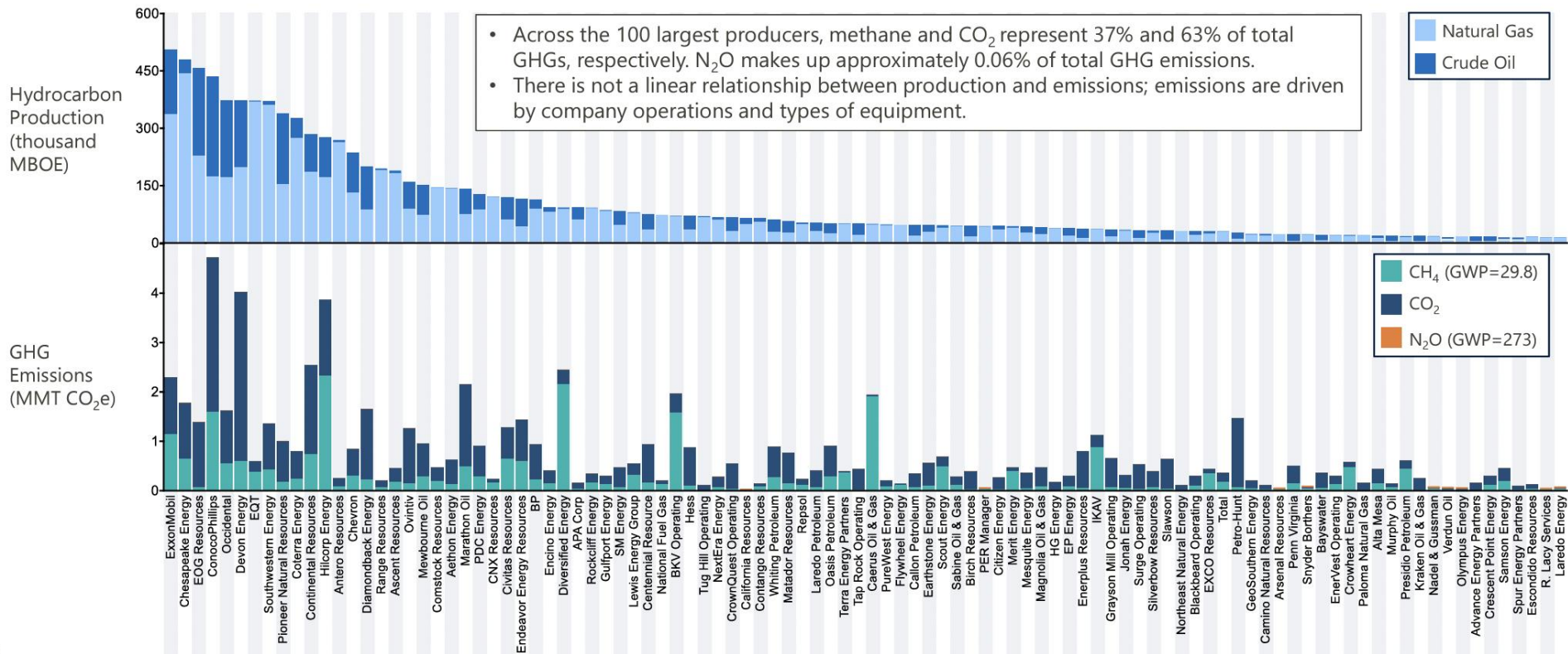
— GHGRP Basin Methane & GHG Intensity



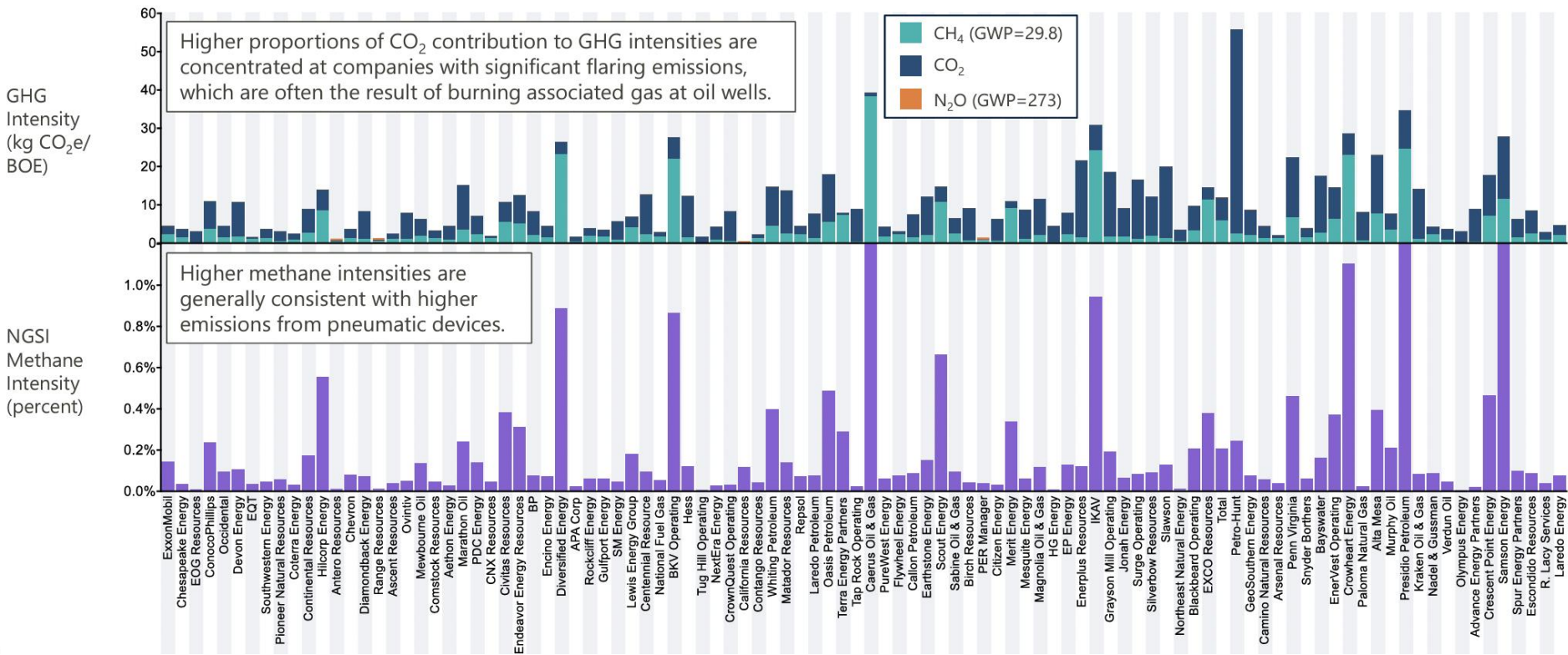
- Methane and GHG emissions intensities vary substantially across basins.
- Ranking in methane intensity does not always correspond to the same GHG intensity rank, reflecting the higher contribution of CO₂ to total emissions in some basins.
- Differences in emissions intensities can be driven by operator practices, type of hydrocarbon production, and infrastructure age.

National Company Level Results

Hydrocarbon Production & Emissions



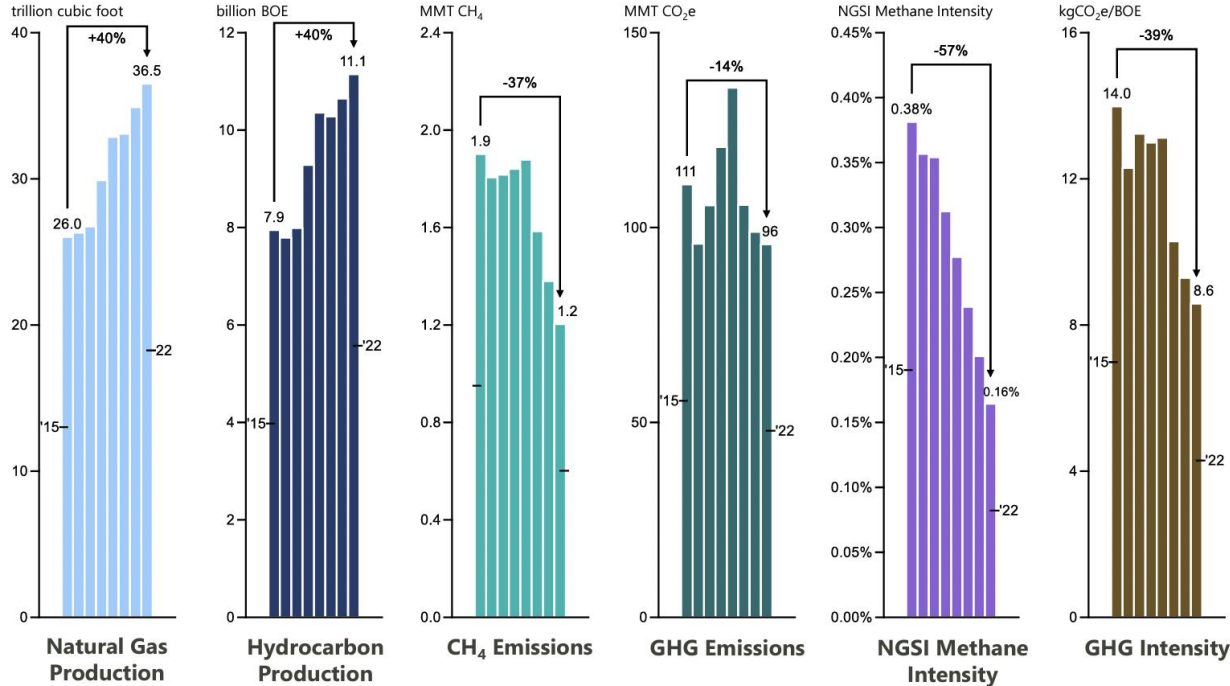
Methane & GHG Intensity



National Trends

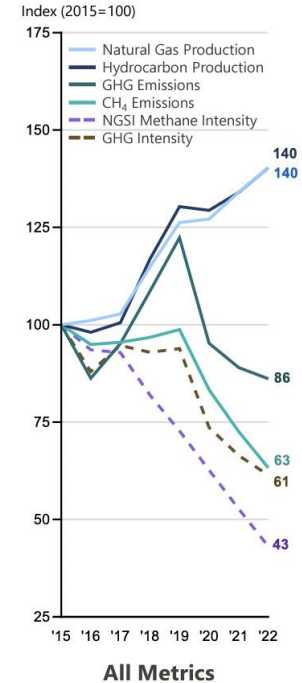
2015-2022 Trends Analysis

GHGRP Data Trends, 2015-2022

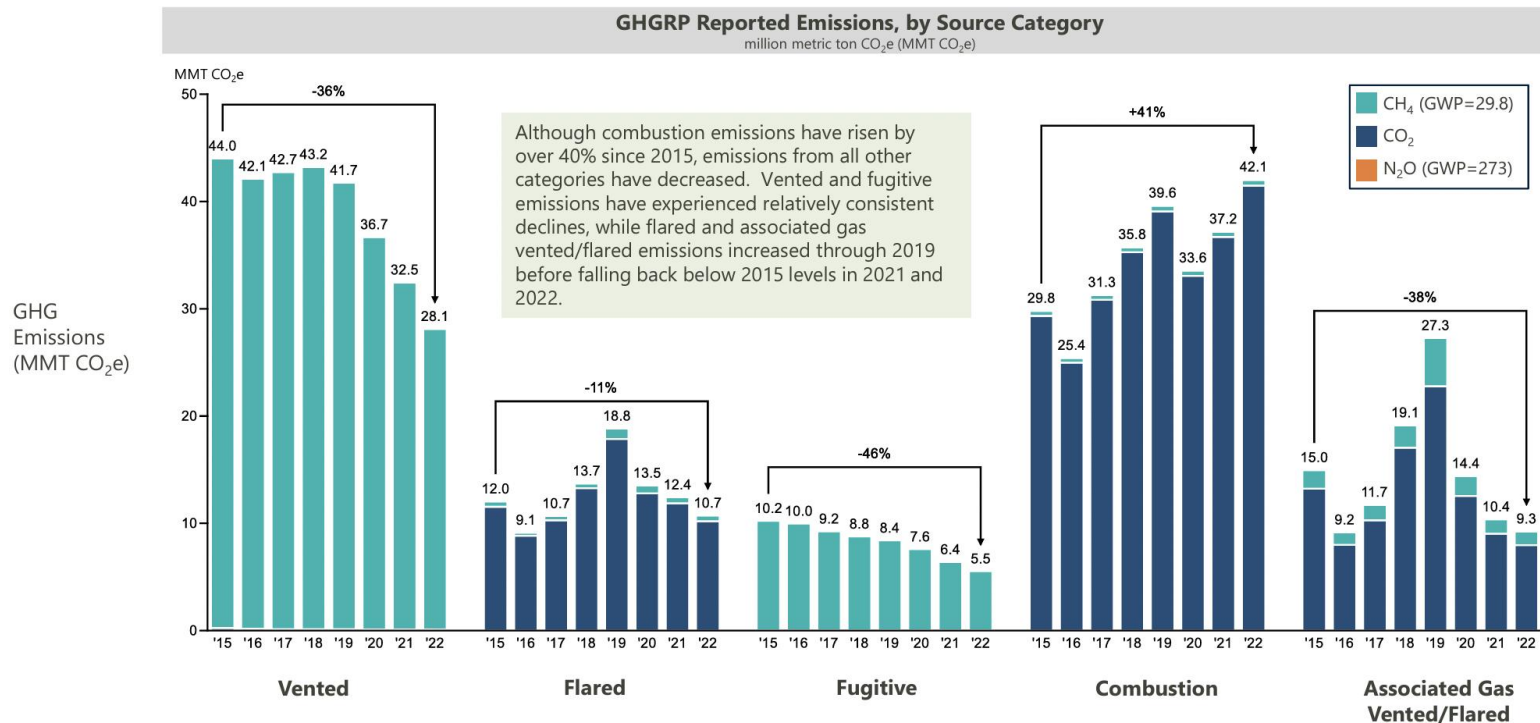


Combined Data Metrics

Indexed; 2015 = 100



2015-2022 Trends Analysis, detail



Impacts of Previous Rulemaking

The **reported** emissions levels and calculated emissions intensities must be viewed in the context of the broader regulatory landscape in the U.S. Compliance with these regulations has led to emissions reductions. For example:

- Each year, as old wells are retired and new wells are drilled and reworked, a larger portion of the nation's reported oil and gas production and associated equipment become subject to the 2016 OOOOa New/Modified Source rules;
- Requirements for reduced emissions completions are driving down emissions from well completions and workovers;
- Requirements to replace or prohibit new high-bleed pneumatic are lowering pneumatic controller emissions;
- Leak detection and repair (LDAR) requirements leading to lower fugitive emissions rates.
- Regulations that put limits on flaring volumes or prohibit routine venting and flaring of associated gas have likely lowered CO₂ and CH₄ emissions from associated gas venting and flaring in some basins.

Impacts of Previous Rulemaking (cont)

However, it is difficult to separate the impact of regulatory compliance from other factors:

- GHGRP reporting basins do not fall within one state, complex to isolate the impact of state-level regulatory actions;
- As of 2024, EPA regulations only apply to new/modified facilities, not feasible to separate in the reported GHGRP data;
- If a company sells assets in a basin to small firms that are not required to report to GHGRP, reported changing;
- GHGRP reported data does not accurately capture LDAR emissions because of abnormal process conditions
- Companies may choose to invest in lower emissions equipment (such as zero-emitting pneumatic controllers) prior to full implementation of the recently finalized 2024 OOOOb New/Modified Source requirements, the OOOOc Existing Source Guidelines, or the Waste Emissions Charge;
- An increase in new (and productive) wells reduces emissions intensity, regardless of voluntary/regulatory actions;
- Voluntary company actions may play a role but are difficult to document and quantify.

New Rulemaking Across the U.S.

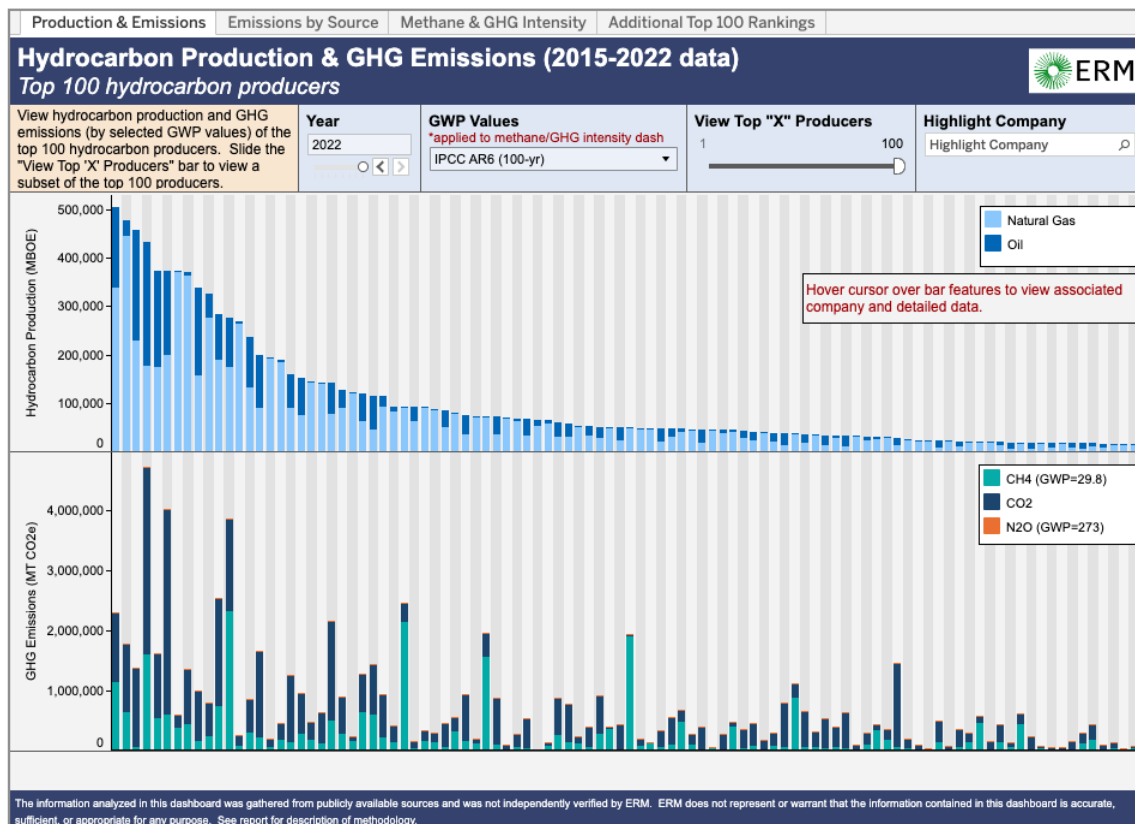
- A number of new laws and regulations will soon be finalized and implemented across the U.S., significant impact on both **reported** and actual methane emissions in the coming years.
- In 2022, Congress passed the Inflation Reduction Act (IRA), which included the Methane Emissions Reduction Program (MERP).
 - Requires EPA to impose and collect an annual methane waste emissions charge (WEC) on methane emissions that exceed emissions intensity thresholds.
 - Will first be imposed in 2025 and calculated using 2024 reporting year emissions data.
- In March 2024, EPA finalized its New/Modified Source Standards (OOOO_b) and Existing Source Guidelines (OOOO_c), (Section 111 rules).
 - New/Modified Source Standards effective in 2024 (or within 1-2 years for some sources)
 - For Existing Source Standards, states have until March 2026 to develop own regulations at least as stringent as in OOOO_c. States must ensure fully implemented by March 2029.

Thank you!

Contact:

Lesley Feldman
lfeldman@catf.us

Online data tool





Thank you

Contact

Luke Hellgren

luke.Hellgren@erm.com

Questions and Answers



Benchmarking Methane and Other Greenhouse Gas Emissions

Of Oil & Natural Gas Production in the United States

June 2024

Data downloads at: www.erm.com



CLEAN AIR
TASK FORCE





Thank you!

Follow us on X @CeresNews or LinkedIn @Ceres-org
Sign up to get our news: ceres.org/subscribe





Your feedback is important.
Please complete this survey.



Freedom to Invest

Special interests are working to ban investors and companies from considering all material financial risks—including climate change—in decision-making.

Join leading private and public sector leaders in calling on policymakers to protect the freedom to invest and operate responsibly.



Visit: [**freedomtoinvest.org**](https://freedomtoinvest.org) or scan QR code to learn more.



ceres.org/climateweek

Ceres at Climate Week NYC

CLIMATE
WEEK **NYC**
CLIMATE GROUP

Main events at



in the Javits Center | September 25-26, 2024

Join us for Ceres 35th Anniversary Gala

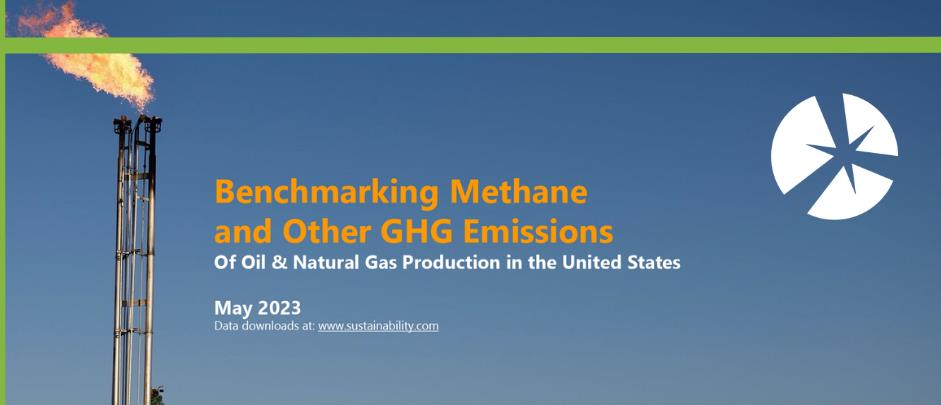
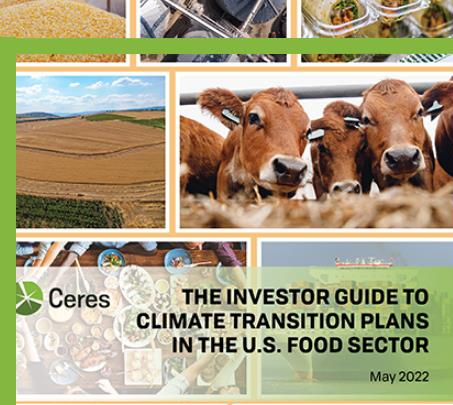
October 23, 2024

Pier Sixty · New York City

ceres.org/gala

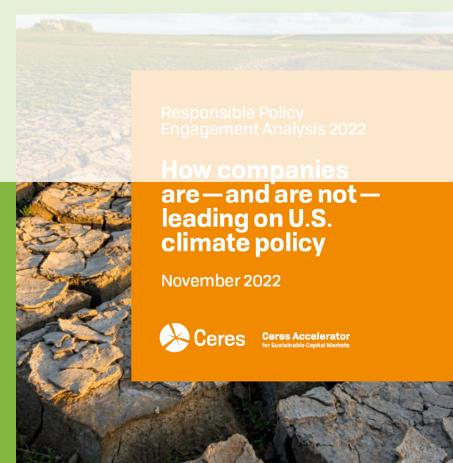


Forward. Together.



Read the latest sustainability research.

CERES.ORG/REPORTS





See all our upcoming events at:
ceres.org/events

Appendix



Methodology – Emissions Source Categories

Emissions sources in this report are grouped into five categories: process and equipment vented (“vented”), process and equipment flared (“flared”), associated gas vented and flared, fugitive, and other combustion. The table to the right shows the assignment of individual emissions sources to source categories.

Emissions data on individual sources and their relative contribution to total emissions, by both individual GHG and total CO₂e, are available at the national, basin, and company level on the Oil and Gas Benchmarking interactive data website.

Source	CH ₄ & N ₂ O Emissions Category	CO ₂ Emissions Category
Acid Gas Removal Units	Vented	Vented
Associated Gas Venting/Flaring	Associated Gas Vented/Flared	Associated Gas Vented/Flared
Atmospheric Storage Tanks	Vented	Flared
Centrifugal Compressors	Vented	Flared
Combustion Equipment	Combustion	Combustion
Completions/Workovers w/ Hydraulic Fracturing	Vented	Flared
Completions/Workovers w/o Hydraulic Fracturing	Vented	Flared
Dehydrators	Vented	Flared
EOR Hydrocarbon Liquids	NA	Vented
EOR Injection Pumps	NA	Vented
Equipment Leak Surveys/Population Counts	Fugitive	Fugitive
Flare Stacks	Flared	Flared
NG Pneumatic Devices	Vented	Vented
NG-Driven Pneumatic Pumps	Vented	Vented
Reciprocating Compressors	Vented	Flared
Well Testing	Vented	Flared
Well Venting (Liquids Unloading)	Vented	Vented
Vessel Blowdowns	Vented	Flared
Compressor Blowdowns	Vented	Vented
Compressor Starts	Vented	Vented
PRV Upsets	Vented	Vented
Well Drilling	Vented	Flared

Methodology – NGL Content

EIA Natural Gas Liquids Data

Companies in the oil and gas sector produce oil and natural gas as well as NGLs. NGLs include ethane, propane, butane, isobutane, and natural gasoline. These hydrocarbons are separated from oil and natural gas after production during processing and refining. In the production stage, NGLs are entrained with oil and natural gas and can impact the energy content of the produced hydrocarbons, as they have an energy content that is higher than natural gas but lower than oil.

For the purposes of the calculations in this report, the energy content of the reported natural gas production is adjusted to include the energy content of produced NGLs. The natural gas production data reported under Subpart W includes information on the methane and CO₂ molar content of produced gas but does not include information on other components of the gas. Because the percentage of methane and CO₂ does not add up to 100 percent, a portion of the gas content is unknown. NGLs are commonly coproduced with natural gas and oil and in most cases represent some of the unknown gas composition. This analysis assumes the unknown portion of gas composition is made up of NGLs and allocates it to five individual NGLs based on EIA regional NGL production data. Each NGL is allocated a share of the

unknown percentage based on its regional production share. This approach recognizes the energy content of non-oil and non-methane hydrocarbons; because methane emissions are allocated to the natural gas value chain using an energy-weighted gas ratio, the allocation of NGLs affects company methane emissions and methane intensity. This impact is minor for most companies and only significantly impacts companies that report low methane and CO₂ molar fractions.

The regional NGL percentages applied to the unknown gas component are shown in the table to the right. Company-specific data were used where available or provided. It is important to note that nitrogen is also a common component of natural gas and represents a portion of the unknown gas component. However, little public data is available on the nitrogen molar fraction of natural gas produced across the U.S. This analysis assumes that produced gas contains no nitrogen and fills the missing gas component entirely with NGLs. This conservative approach slightly increases the amount methane emissions allocated to the natural gas value chain and methane intensity for most companies.

Region	Area	Ethane	Propane	Butane	Isobutane	Natural Gasoline (pentane plus)
PADD 1	East Coast	0%	33%	67%	0%	0%
	Appalachian	41%	34%	10%	5%	10%
	IN, IL, & KY	36%	41%	8%	9%	6%
PADD 2	MN, WI, ND, & SD	30%	36%	15%	5%	14%
	OK, KS, & MO	41%	31%	10%	6%	12%
	LA (Gulf)	39%	33%	12%	6%	10%
PADD 3	N. LA & AR	19%	30%	13%	11%	28%
	NM	39%	32%	12%	5%	12%
	TX (Inland)	44%	30%	11%	5%	10%
PADD 4 (Rocky Mountain)		32%	35%	14%	6%	14%
PADD 5 (West Coast)		0%	11%	27%	12%	49%