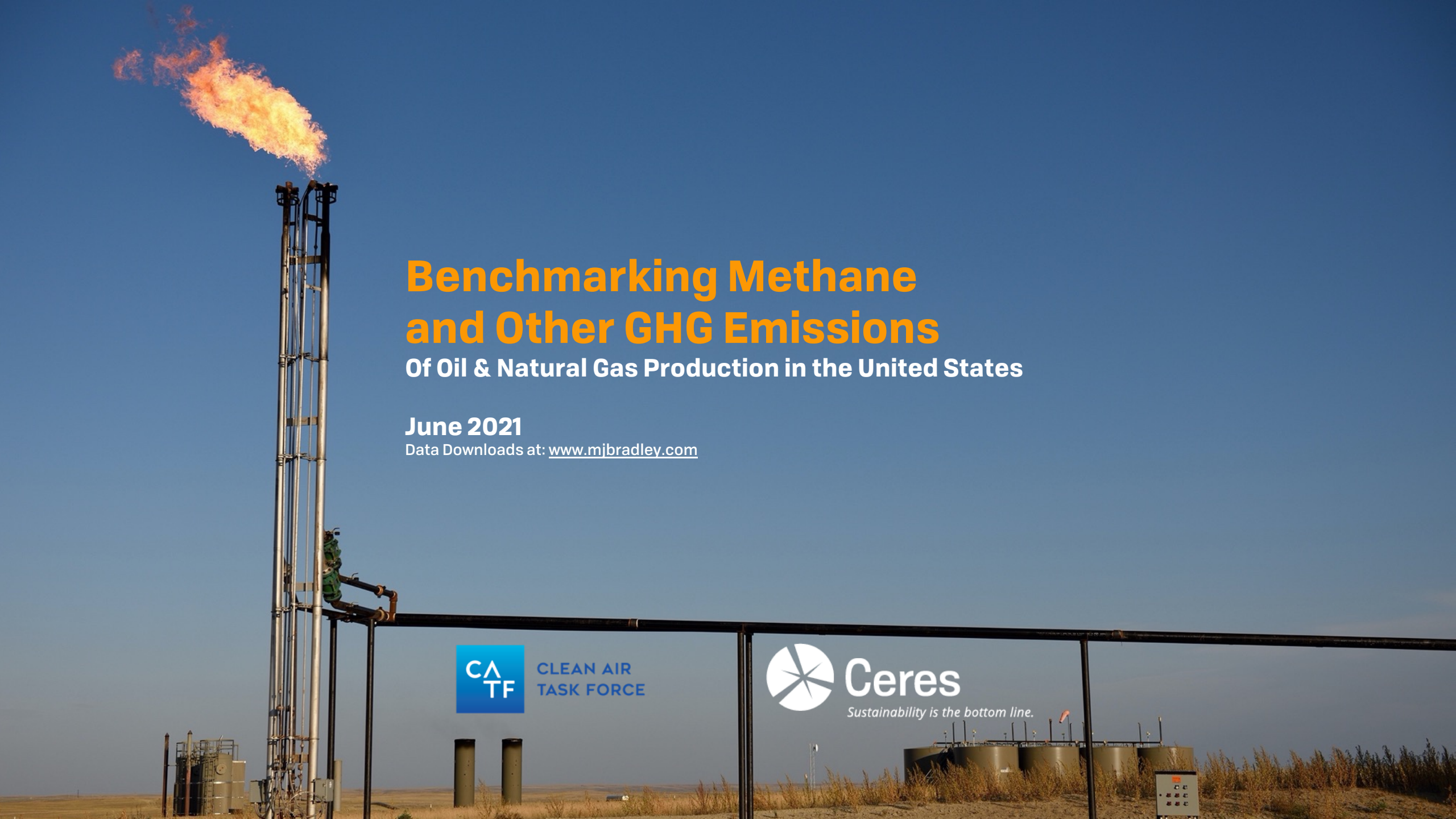

Benchmarking Methane and Other GHG Emissions

Of Oil & Natural Gas Production in the United States

June 2021

Data Downloads at: www.mjbradley.com

Acknowledgements

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Data used in this report can also be accessed via an interactive data platform hosted at www.mjbradley.com.

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Clean Air Task Force (CATF) is a non-profit organization working to safeguard against the worst impacts of climate change by catalyzing the rapid global development and deployment of low-carbon energy and other climate-protecting technologies. This is accomplished through research and analysis, public advocacy leadership, and partnership with the private sector. With nearly 25 years of nationally and internationally recognized expertise on clean air policy and regulations and a fierce commitment to fully exploring all potential solutions, CATF is an environmental advocacy group with the bold ideas needed today to solve the climate crisis. CATF is headquartered in Boston, with staff working virtually around the U.S. and abroad. For more information, visit www.catf.us

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Key Findings

- Of 295 oil and natural gas producers with reported data, the top 100 oil and gas producers by total energy were responsible for nearly 80% of total reported methane and GHG emissions in 2019. While most top 100 producers are also among the top 100 emitters, production rank does not correspond to emissions rank.
- Hydrocarbon production and associated GHG emissions are concentrated in a small number of basins. In 2019, the five largest basins by total oil and gas production were responsible for 66% of total reported natural gas production, 80% of total reported oil production, 51% of total reported methane emissions, and 78% of total reported CO_2 emissions.
- The methane emissions intensity of natural gas production and the GHG emissions intensity of oil and gas production varies dramatically across producers. Natural gas producers in the highest quartile of methane emissions intensity have an average emissions intensity that is nearly 22 times higher than natural gas producers in the lowest quartile of methane emissions intensity. Oil and gas producers in the highest quartile of GHG emissions intensity have an average emissions intensity that is nearly 10 times higher than oil and gas producers in the lowest quartile.
- Pneumatic controllers were the largest source of total reported production-segment methane emissions, making up 54% of total reported methane emissions.
- Fuel combustion equipment, such as engines and heaters, were the largest source of total reported production-segment CO_2 emissions, responsible for 49% of total reported CO_2 emissions.
- In oil-heavy basins, associated gas venting and flaring can be a significant component of GHG emissions. In the Permian basin, for example, this source contributes 25% of total GHG emissions. In gas-heavy basins, associated gas is limited or non-existent; for example, there was no reported associated gas venting and flaring in the Appalachian basin. Across all basins, associated gas venting and flaring was responsible for 19% of total reported production-segment GHG emissions.
- While the Greenhouse Gas Reporting Program does not capture all GHG emissions from the oil and gas industry, the data reported to EPA provide a consistent methodology for estimating emissions and a valuable framework for comparing performance across companies.

Benchmarking Methane and Other GHG Emissions

Of Oil & Natural Gas Production in the United States

Download detailed data from the 2021 Benchmarking GHG Emissions report at: www.mjbradley.com

Oil & Gas Production in the United States

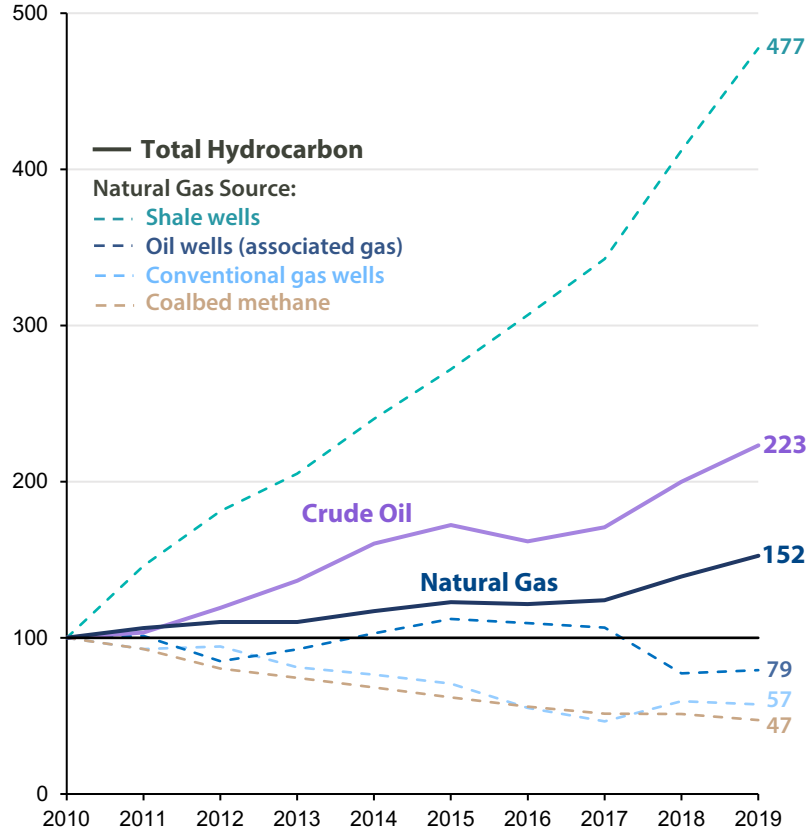
The oil and gas production sector in the United States includes a wide array of companies that produce hydrocarbons from diverse geographies and geological formations. Producers range from large publicly-traded corporations with thousands of wells to small private companies operating a single well. For 2019, companies reported to EPA information on over 477 thousand onshore wells which together produced approximately 32 trillion cubic feet of natural gas and 3 billion barrels of oil.

Background

Concern over climate change has brought increased focus on methane and greenhouse gas emissions associated with oil and gas production. These emissions, especially methane emissions, can diminish the greenhouse gas benefits of using gas in place of coal and represent a significant source of climate pollution. In addition, a growing body of research indicates that methane emissions associated with oil and natural gas production are substantially higher than those reported in official inventories. A wide range of stakeholders, including policymakers, fuel purchasers, environmental organizations, and financial institutions, are interested in better understanding industry-wide and company-specific emissions trends. Oil and gas companies that minimize and most effectively manage their emissions will be best positioned for a low-carbon future.

Stakeholder engagement with the industry—and the industry's ability to benchmark its own performance—has been stymied by a lack of clear and consistently calculated metrics, forcing stakeholders and companies to rely on voluntary metrics reported by companies that are often incomplete or non-comparable. The 2021 Oil & Gas Benchmarking Report is a collaborative effort using publicly available data to develop comparable metrics that highlight the GHG performance of onshore oil and gas producers in the U.S. The report uses data reported to EPA under Subpart W of the Greenhouse Gas Reporting Program (GHGRP) and data calculated from assumptions in EPA's annual Greenhouse Gas Inventory (GHG Inventory).* The report focuses on the onshore oil and natural gas production segments and does not include emissions or production from offshore operations, gathering & boosting facilities, or other midstream or downstream segments of the oil and gas supply chains. All of the information presented in this report is based on 2019 production and emissions data.

U.S. Hydrocarbon Production
(Indexed; 2010 = 100)



* For simplicity, the emissions captured in this report are referred to as "reported emissions"

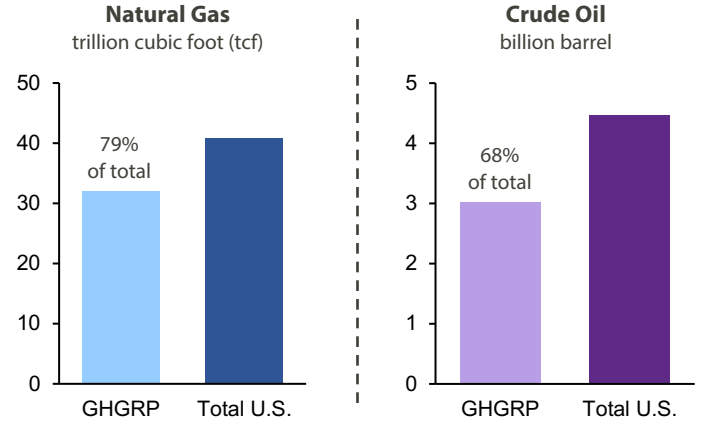
Introduction and Overview of Oil & Gas Data

Data on U.S. oil and gas production and air emissions are available to the public through several databases maintained by state and federal agencies. Publicly-traded and privately-held oil and gas producers are required to report production and GHG emissions data under EPA's GHGRP for any basin in which their annual GHG emissions exceed 25,000 metric tons of carbon dioxide equivalent (CO_2e). In this report, these data are combined for companies operating in multiple basins and presented such that company-level comparisons can be made across U.S. onshore production operations.

The Oil & Gas Benchmarking Report facilitates the comparison of emissions performance by using reported production and emissions data to calculate methane and GHG emissions intensities and presenting this information and source data in a graphical format that aids in understanding and evaluating the data. The report is intended for a wide audience, including oil and gas industry executives, oil and gas operators, environmental advocates, financial analysts, investors, journalists, and public policymakers.

The methane and GHG emissions included in this report do not capture total emissions from the onshore production segment. Most importantly, the GHGRP's methodology does not properly account for emissions from infrequent, high-emitting occurrences and therefore underestimates emissions from sources covered by the program. In addition, emissions from facilities below the GHGRP reporting threshold are not included. Further, the GHGRP does not require all production segment emission sources (i.e., equipment or processes) to report emissions. As result of these factors, actual emissions from the production segment are higher than the numbers reported to EPA.

2019 Hydrocarbon Production
GHGRP vs. Total U.S.[1]



[1] Source: U.S. EIA

Relative Scope of Data Analyzed

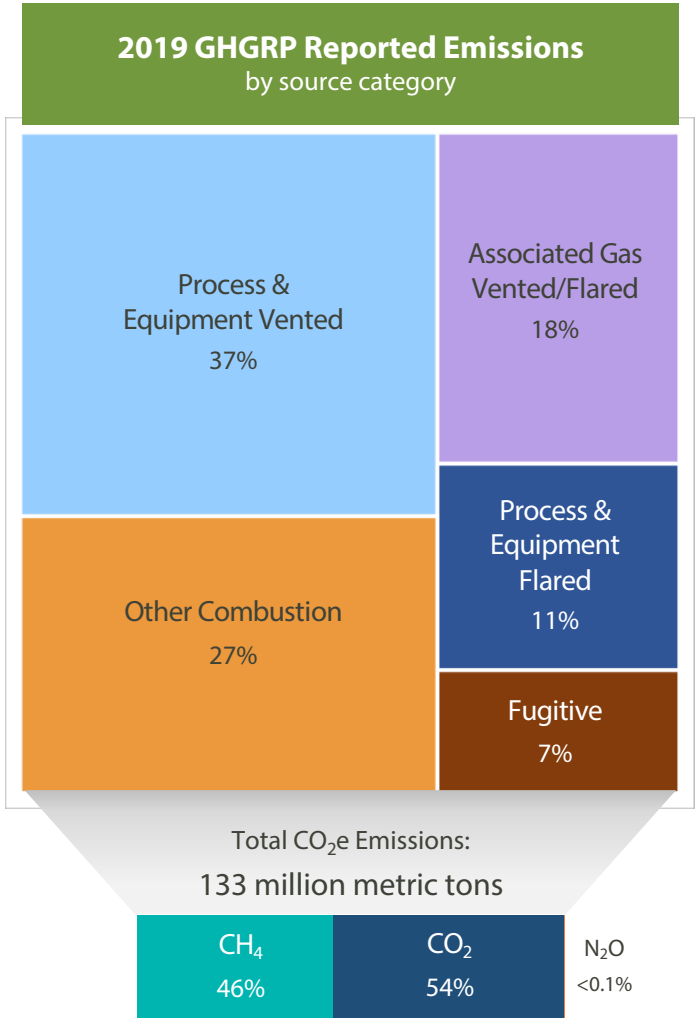
- Onshore oil & gas production reported to GHGRP represents 68% of total U.S. annual oil production and 79% of total U.S. annual gas production
- Reported onshore production segment methane represents 49% of total methane reported under Subpart W
- Reported onshore production segment CO_2e represents 47% of total CO_2e reported under Subpart W
- Reported onshore production segment methane emissions represent 53% of total U.S. onshore production segment methane emissions estimated in the GHG Inventory

Types of Emissions Associated with Oil & Gas Production

The GHGRP includes reporting on emissions from 17 emission sources (see page 50). In addition, this report attributes emissions associated with six additional sources that are estimated at the national level by EPA in the GHG Inventory, but not included in GHGRP (see page 51). The relative contribution of GHG emissions from oil and gas production can vary widely by both type of gas and emissions source. Factors influencing the relative contribution of emissions include geology, targeted hydrocarbons (e.g., dry gas vs. wet gas), available infrastructure, and company policies and practices.

For purposes of comparison within this report, emission sources are grouped into five categories:

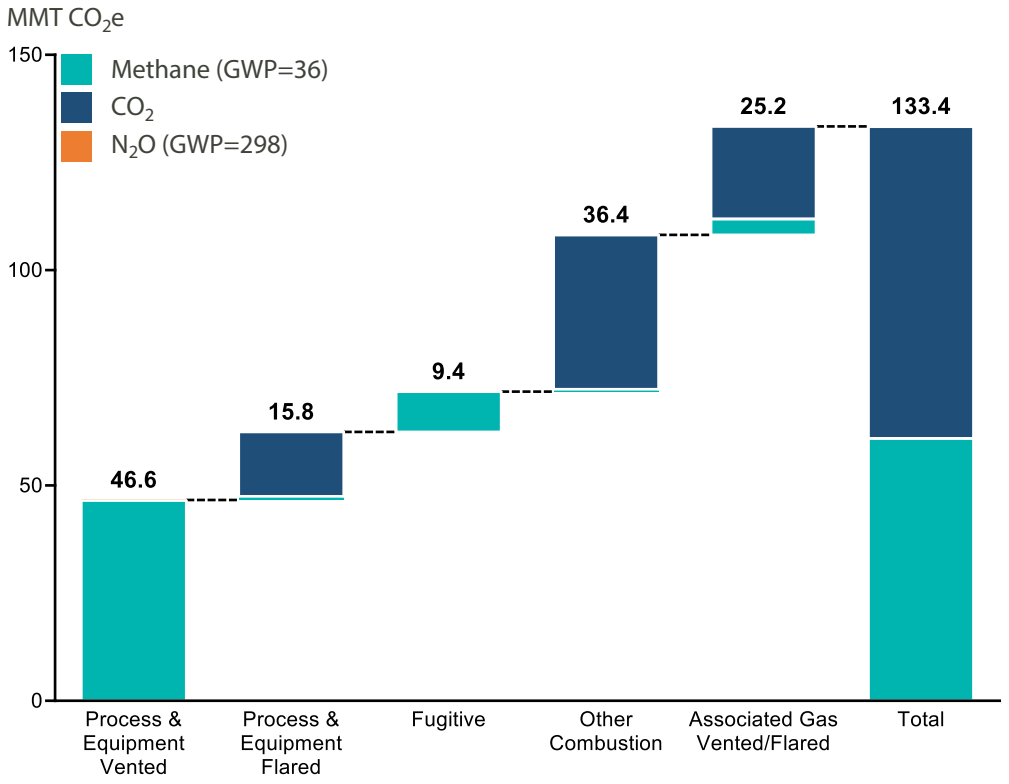
- **Process & Equipment Vented** Vented emissions are intentional releases of natural gas from equipment and processes. Common sources of vented emissions include gas-driven pneumatic devices, compressor seals, tanks, and liquids unloading.
- **Process & Equipment Flared** Flared emissions consist primarily of CO_2 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 CO_2 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.



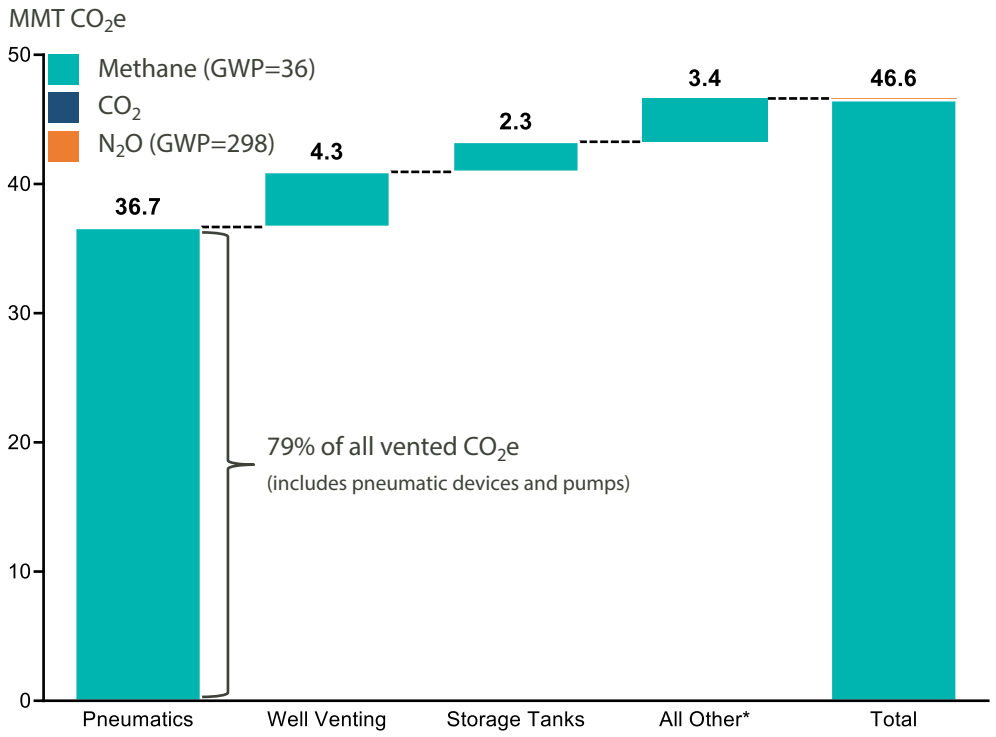
Sources of Methane Emissions

Process & equipment vented and fugitive methane emissions make up approximately 92% and 44% of the total methane and GHG emissions, respectively, reported across all sources included in this report.

2019 Reported Production Emissions, by Source Category
million metric ton CO_2e (MMT CO_2e)



Process & Equipment Vented Emissions, by Source
million metric ton CO_2e (MMT CO_2e)



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

Challenges Associated with Estimating Oil & Gas Emissions

Underestimating Actual Emissions
Research on GHG emissions from oil and gas production has shown that emissions estimates that rely primarily on emission factors and activity counts – including the GHGRP – significantly underestimate actual emissions.* Even when emission factors and activity assumptions have been updated using in-field measurements, inventories that measure actual emissions from one or more sites at various scales (e.g. single well pad to entire production basin) continue to record higher emissions than emission and activity factor-based inventories. The primary driver of this mismatch is a relatively small number of high-emitting abnormal process conditions. These emission sources have random spatial and temporal distributions and have proven to be difficult to account for using equipment emission factors. As a result, the GHGRP underestimates aggregate total actual emissions from facilities captured by the program.

Research to better characterize methane emissions from oil and gas sources is a major focus of industry, environmental organizations, and academia.

* See Alvarez et al. "Assessment of methane emissions from the U.S. oil and gas supply chain". Science 13 Jul 2018: Vol. 361, Issue 6398, pp. 186-188.

The GHGRP represents the most robust and comprehensive inventory of company-level GHG emissions from the oil and gas industry. By applying a uniform emissions calculation methodology across all reporting companies, it creates a dataset that is useful for the direct comparison of company-level data. As noted above, the emissions in this report also include sources that are not included in the GHGRP but that can be estimated based on the GHG Inventory. However, there are important limitations users should keep in mind when reviewing the data:

- **Default emission factors do not represent actual emissions**. The use of emission factors to estimate total emissions relies on the emissions factor being representative of average emissions for a given activity. This approach can be effective where there is robust data on emissions per unit of activity. For example, automobile emissions are routinely and reliably estimated using emission factors despite the fact that emissions from a single vehicle may be different than predicted by an emission factor. With a diversity of emission sources and the presence of low frequency, high emission events, the use of emission factors is significantly less reliable in the oil and gas sector, and typically underestimates actual emissions (see box).
- **Emissions from facilities below GHGRP reporting threshold.** Emissions from facilities below the GHGRP's reporting threshold of 25,000 metric tons CO_2e/year are not included in this analysis. Because the GHGRP does not capture facilities responsible for nearly one third of oil production and one quarter of gas production, emissions associated with that portion of oil and gas production activities are not reported to EPA or included in this analysis.
- **Emissions from sources not covered by GHGRP.** Companies are not required to report emissions from certain equipment and processes. Estimated emissions from some of these sources are included in this analysis by applying GHG Inventory emission factors to GHGRP reported activity data, as described in the Appendix.
- **Emission reduction activities not included.** Many producers implement work practices to reduce emissions and, in some cases, separately report these reductions to EPA through voluntary programs. However, unless the practices result in the use of a lower emissions factor or changes in activity data, these reductions are not incorporated into reported GHGRP data and are not accounted for in this analysis.
- **Abandoned infrastructure not included.** Research has highlighted that abandoned oil and gas wells are a significant source of methane emissions. These sources are not reported under the GHGRP and represent another source of the industry's GHG emissions that are not accounted for in this report. As a result, if companies are responsible for significant amounts of abandoned infrastructure, emissions from that infrastructure will not be captured in this report.

Using Public Data to Compare Producer Performance

Despite the challenges of estimating emissions from oil and gas sources, the application of a uniform emissions calculation methodology across the industry allows for direct comparison of company-level data. Normalizing these emissions by reported production data allows for calculation of emissions intensities that can be used to directly compare company methane and GHG emissions performance per unit of energy produced. While intensity metrics provide a straightforward way to compare the performance of operators of different sizes, it is important to note that absolute emissions can increase even as emissions intensity declines. Users are encouraged to consider total GHG emissions as well as emissions intensity when reviewing company data.

This report uses two emissions intensity metrics to compare producer performance. The first is the Edison Electric Institute and American Gas Association Natural Gas Sustainability Initiative (NGSI) protocol for calculating methane emissions intensity. 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 metric provides insight to investors and gas purchasers interested in evaluating the methane performance of the natural gas value chain separate from the oil value chain. The NGSI methane emissions intensity is expressed as a percent (%).*

The second metric, total GHG emissions intensity, is calculated as total production-segment GHG emissions in kilograms of carbon dioxide equivalent (CO_2e) divided by total hydrocarbon production in barrel of oil equivalent (BOE). The GHG emissions intensity is expressed as kilograms CO_2e per BOE.

*The NGSI methane emissions intensity metric is different than a methane leak rate calculated as total methane divided by total produced gas as it allocates emissions between oil production and natural gas production on a produced energy basis, and uses the emissions attributed to natural gas to calculate intensity as a percentage of total methane content of the produced natural gas. It does not include emissions assigned to oil production. Additional details on the NGSI metric are available on EEI's website.

NGSI Methane Emissions Intensity

$$\frac{CH_4 \text{ Emissions (MT)} * \text{Gas Ratio}}{\text{Produced Gas (mcf)} * \text{Methane Content} * (0.0192 \text{ MT/mcf})}$$

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

$$\frac{CH_4 \text{ Emissions (kg } CO_2e) + CO_2 \text{ Emissions (kg } CO_2e) + N_2O \text{ Emissions (kg } CO_2e)}{\text{Produced Gas (BOE)} + \text{Oil Sales (BOE)}}$$

where:

CO_2e = CO_2-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

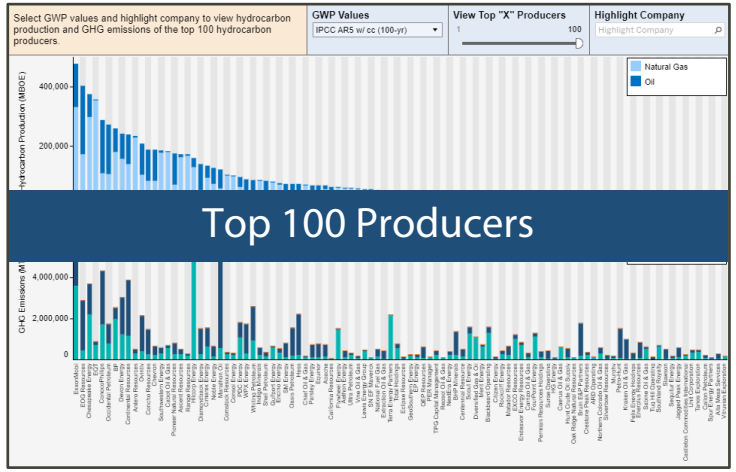
Benchmarking Analytical Resources

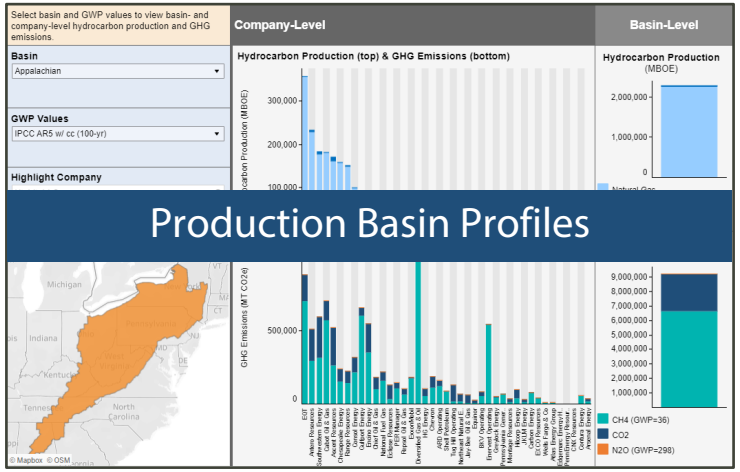
The Oil & Gas Benchmarking Report includes a series of interactive, web-based dashboards to further visualize GHG emissions from oil and gas producers and production basins in the United States. These tools provide insight into how company- and basin-level emissions and emissions intensity vary as well as information on the types of sources contributing to GHG emissions.

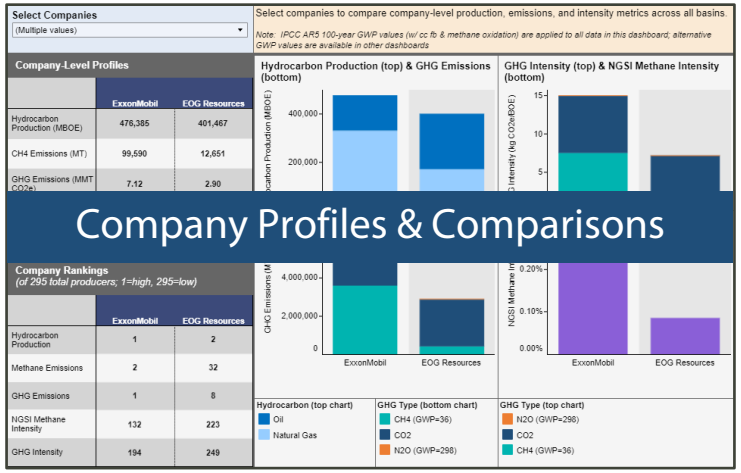
The online resources include data for all companies and basins in the GHGRP database, including those not highlighted in this report. Data dashboards include:

- **Top 100 Producers:** Oil & gas production, source-specific emissions, and emission intensities of the top 100 hydrocarbon producers with additional company rankings of other key metrics
- **Production Basin Profiles:** Production, detailed emissions, and emission intensities by basin and companies that operate within selected basins
- **Company Profiles & Comparisons:** Production, detailed emissions, and emission intensities at a company- and basin-level with the ability to select and directly compare companies

These tools are available at www.mjbradley.com.



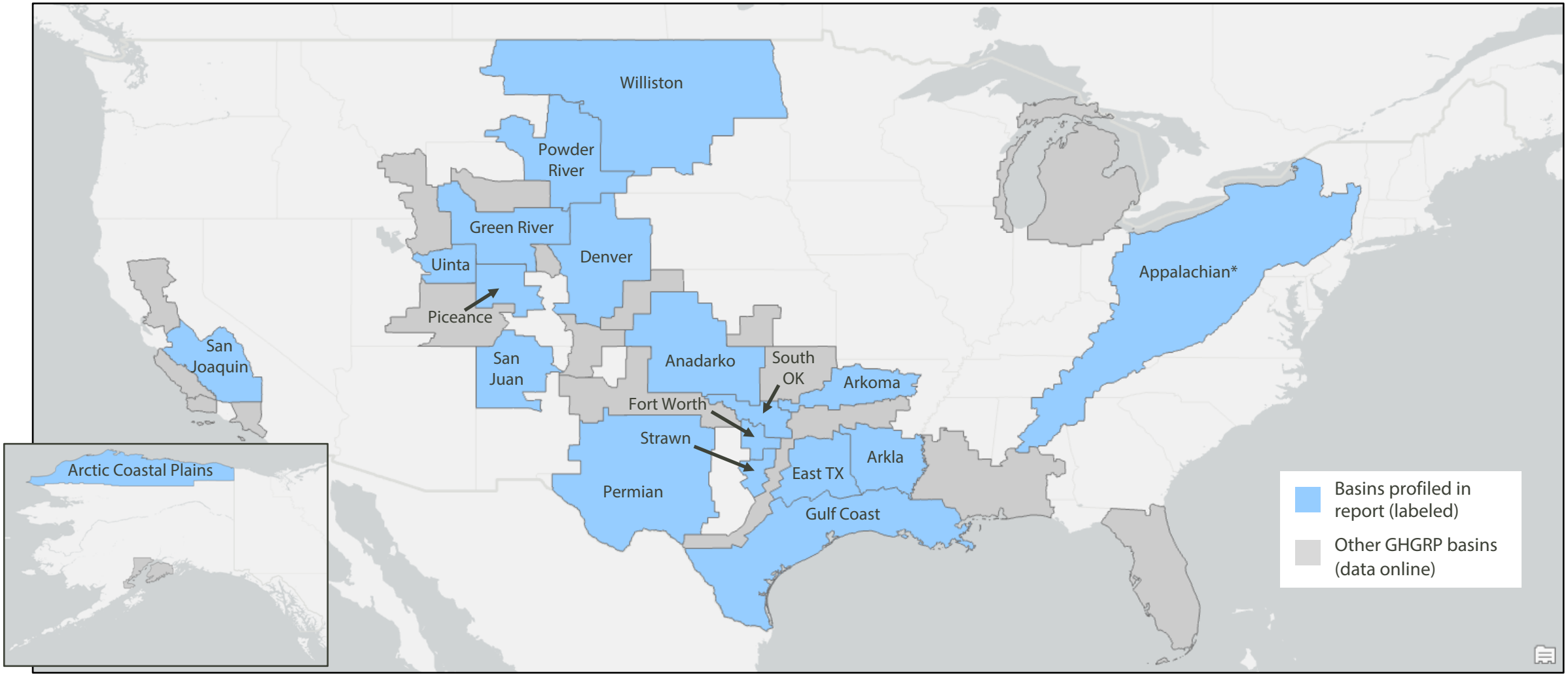




Basin-Level Summary Data

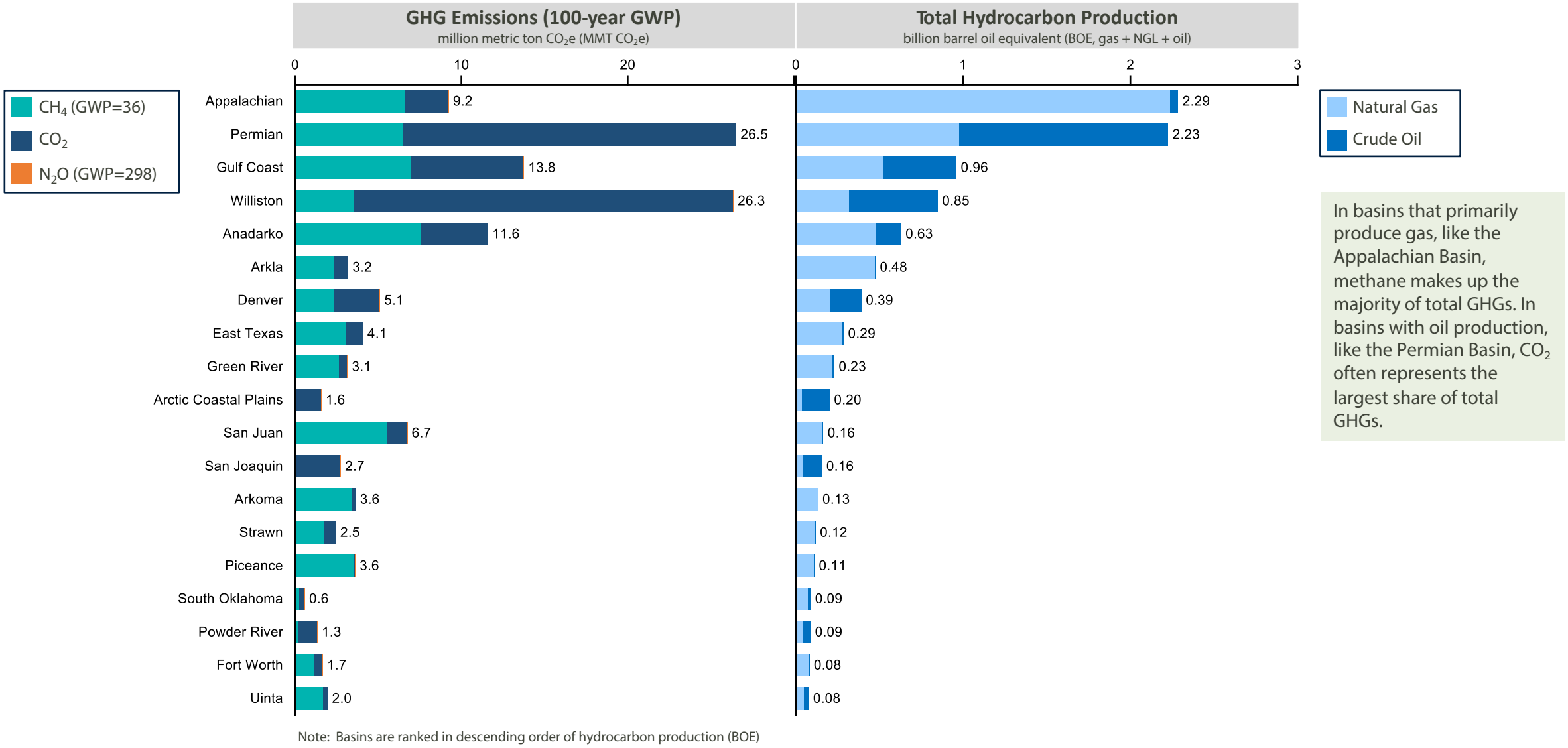
This section provides data on hydrocarbon production, GHG emissions, emissions intensity, and sources of emissions for the 19 largest hydrocarbon production basins in the U.S. by 2019 production volume. Together, these basins represent 98.6% and 99.3% of total 2019 natural gas and oil production in the EPA data, respectively.

GHGRP Basins



* GHGRP data contain two distinct Appalachian basins (160 & 160A). This analysis combines data reported across both basins and presents them as a single basin.
Note: Basin boundaries defined by geologic provinces published by the American Association of Petroleum Geologists; data provided by U.S. EPA.

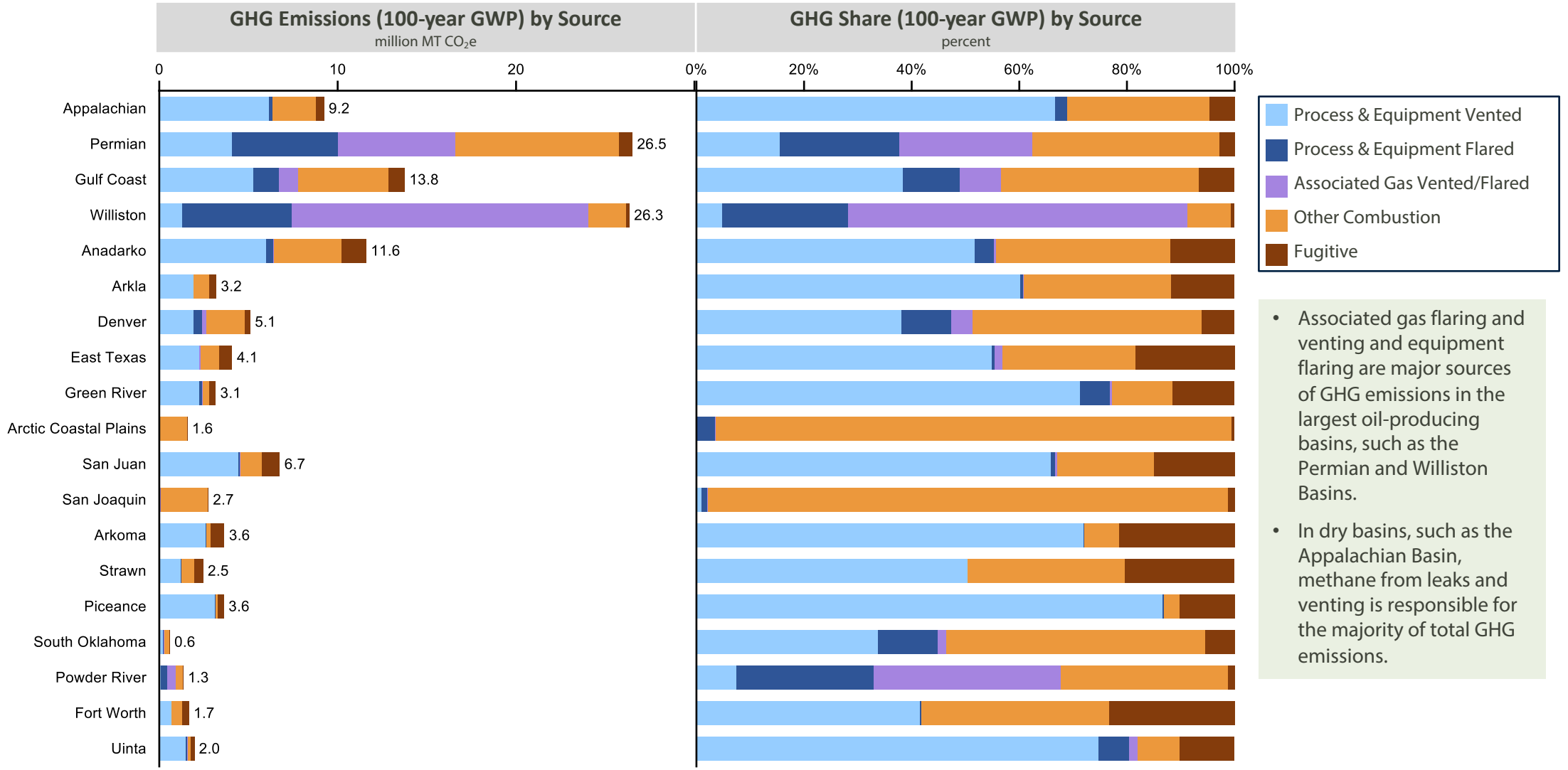
GHGRP Basin Production & Emissions



In basins that primarily produce gas, like the Appalachian Basin, methane makes up the majority of total GHGs. In basins with oil production, like the Permian Basin, CO_2 often represents the largest share of total GHGs.

Note: Basins are ranked in descending order of hydrocarbon production (BOE)

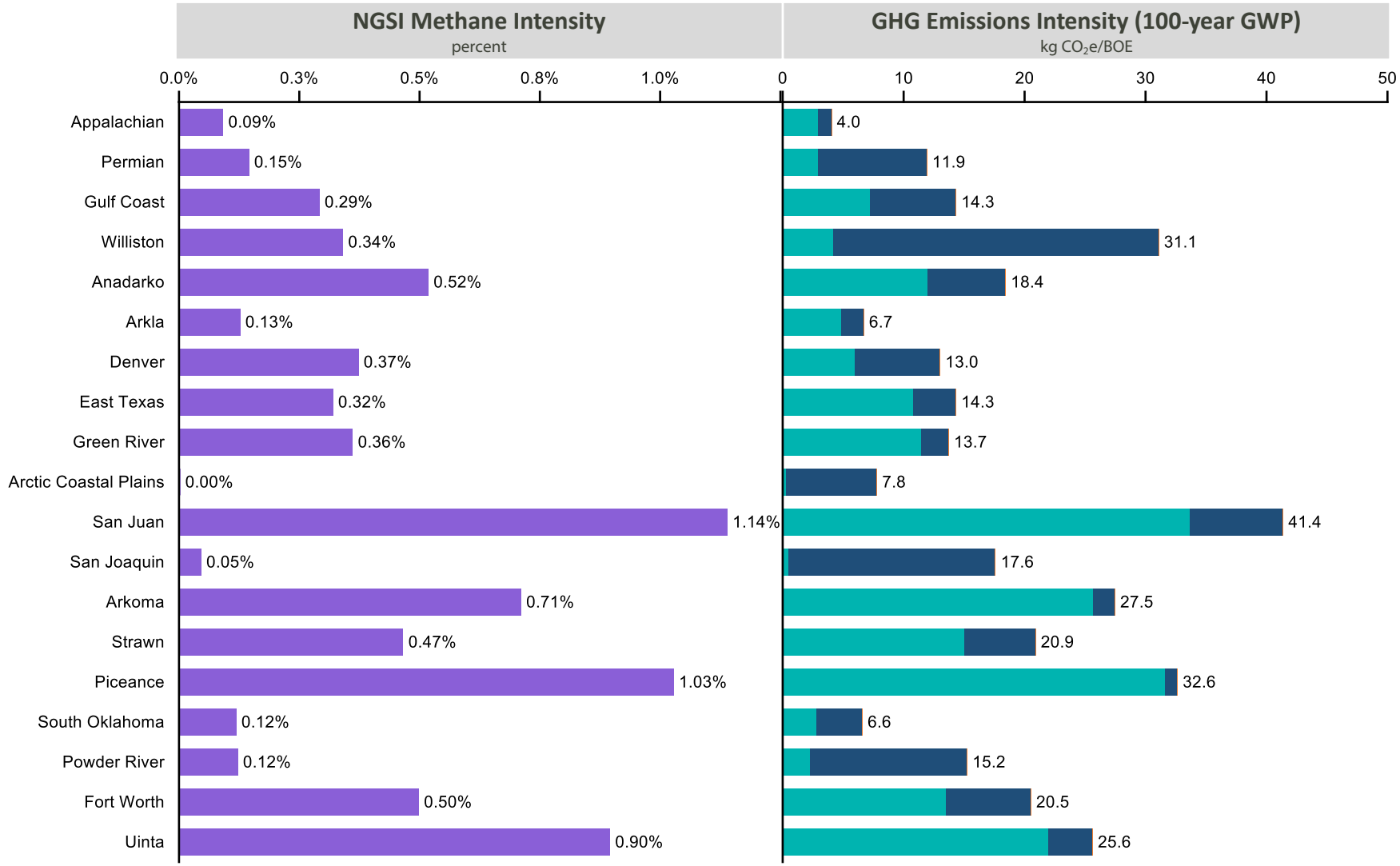
GHGRP Basin Emissions by Source



- Associated gas flaring and venting and equipment flaring are major sources of GHG emissions in the largest oil-producing basins, such as the Permian and Williston Basins.
- In dry basins, such as the Appalachian Basin, methane from leaks and venting is responsible for the majority of total GHG emissions.

Note: Basins are ranked in descending order of hydrocarbon production (BOE)

GHGRP Basin Methane & GHG Intensity



- Methane and GHG emission intensities vary substantially across basins.
- Ranking in methane intensity does not always correspond to the same GHG intensity rank, reflecting the higher contribution of CO_2 to total emissions in some basins.
- Differences in emission intensities can be driven by operator practices, type of hydrocarbon production, and infrastructure age.

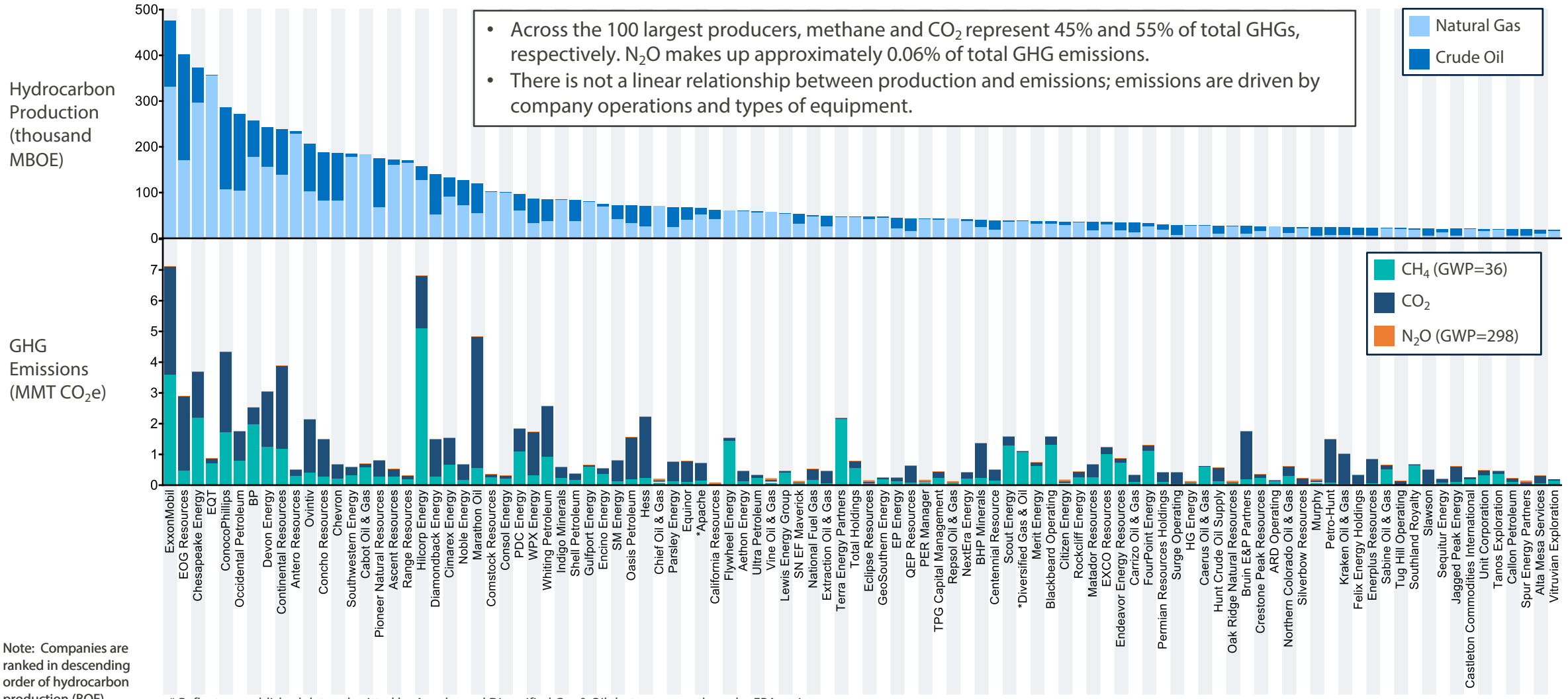
Note: Basins are ranked in descending order of hydrocarbon production (BOE)

Company-Level Summary Data

This section summarizes data on hydrocarbon production, GHG emissions, emissions intensity, and sources of emissions for the 100 largest hydrocarbon producers in the U.S. Additional graphics show the relative distribution of hydrocarbon production, GHG emissions, and methane and GHG emission intensities across the 100 largest producers. Detailed tables list the data and associated rankings for the primary metrics included in this analysis for each of the 100 companies.

Top 100 Hydrocarbon Producers

Hydrocarbon Production & Emissions (100-year GWP)

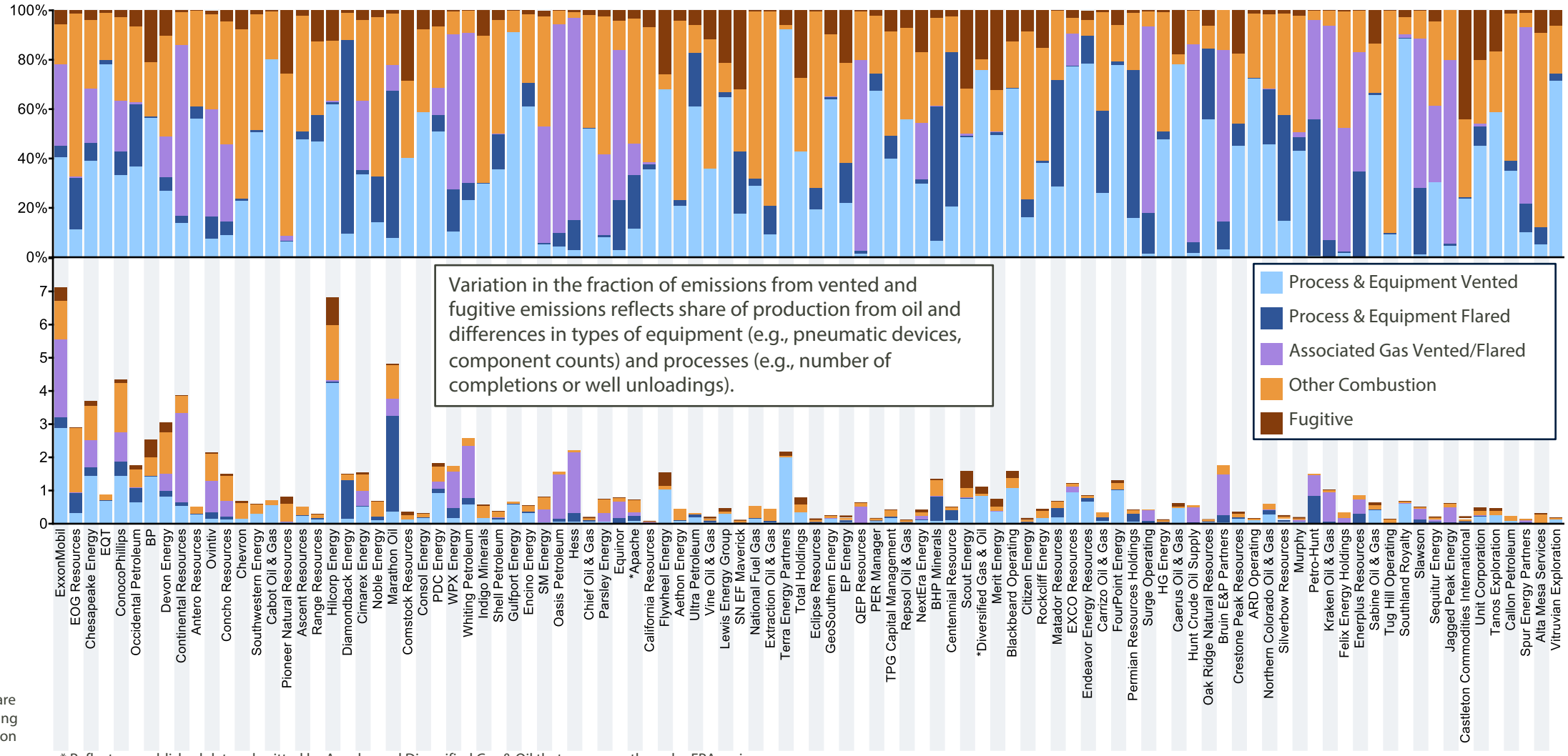


Note: Companies are ranked in descending order of hydrocarbon production (BOE)

* Reflects unpublished data submitted by Apache and Diversified Gas & Oil that are currently under EPA review

Top 100 Hydrocarbon Producers

GHG Emissions by Source (100-year GWP)

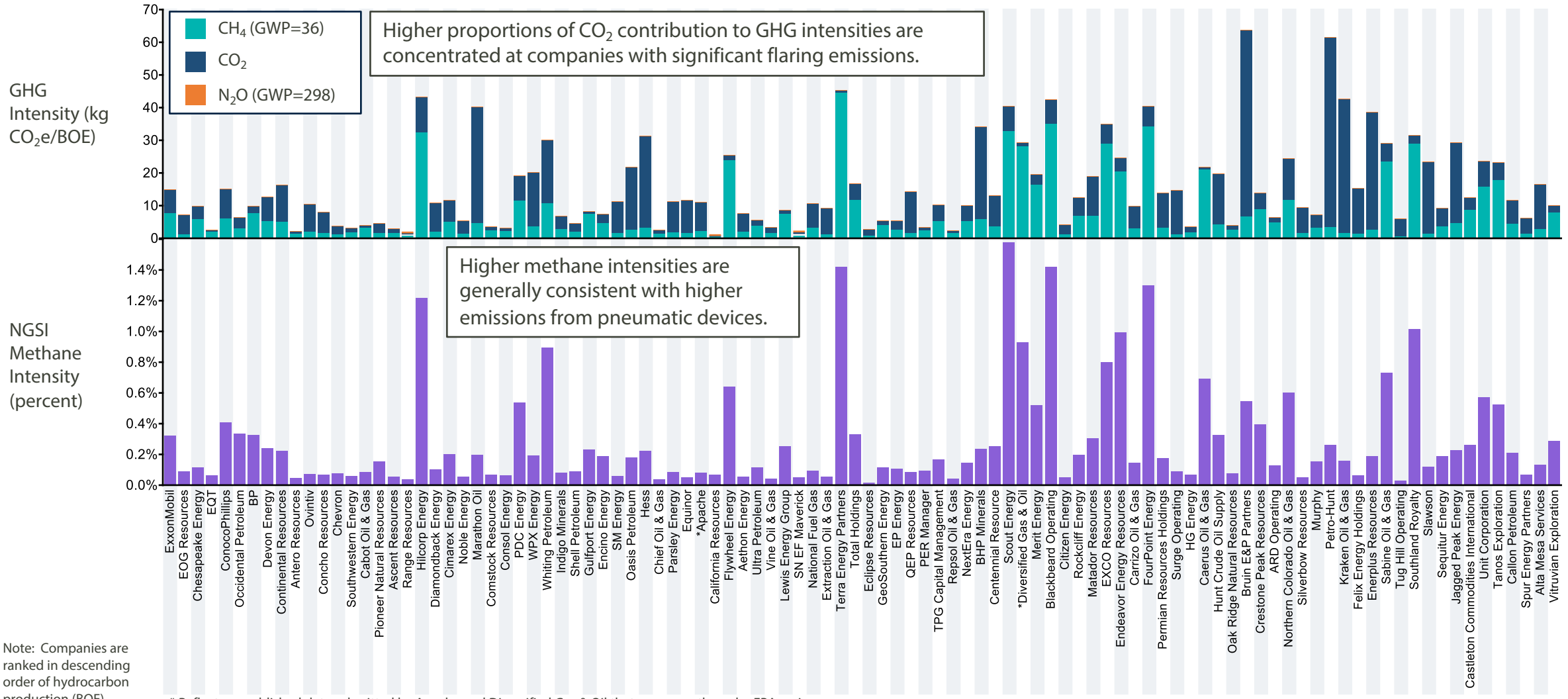


Note: Companies are ranked in descending order of hydrocarbon production (BOE)

* Reflects unpublished data submitted by Apache and Diversified Gas & Oil that are currently under EPA review

Top 100 Hydrocarbon Producers

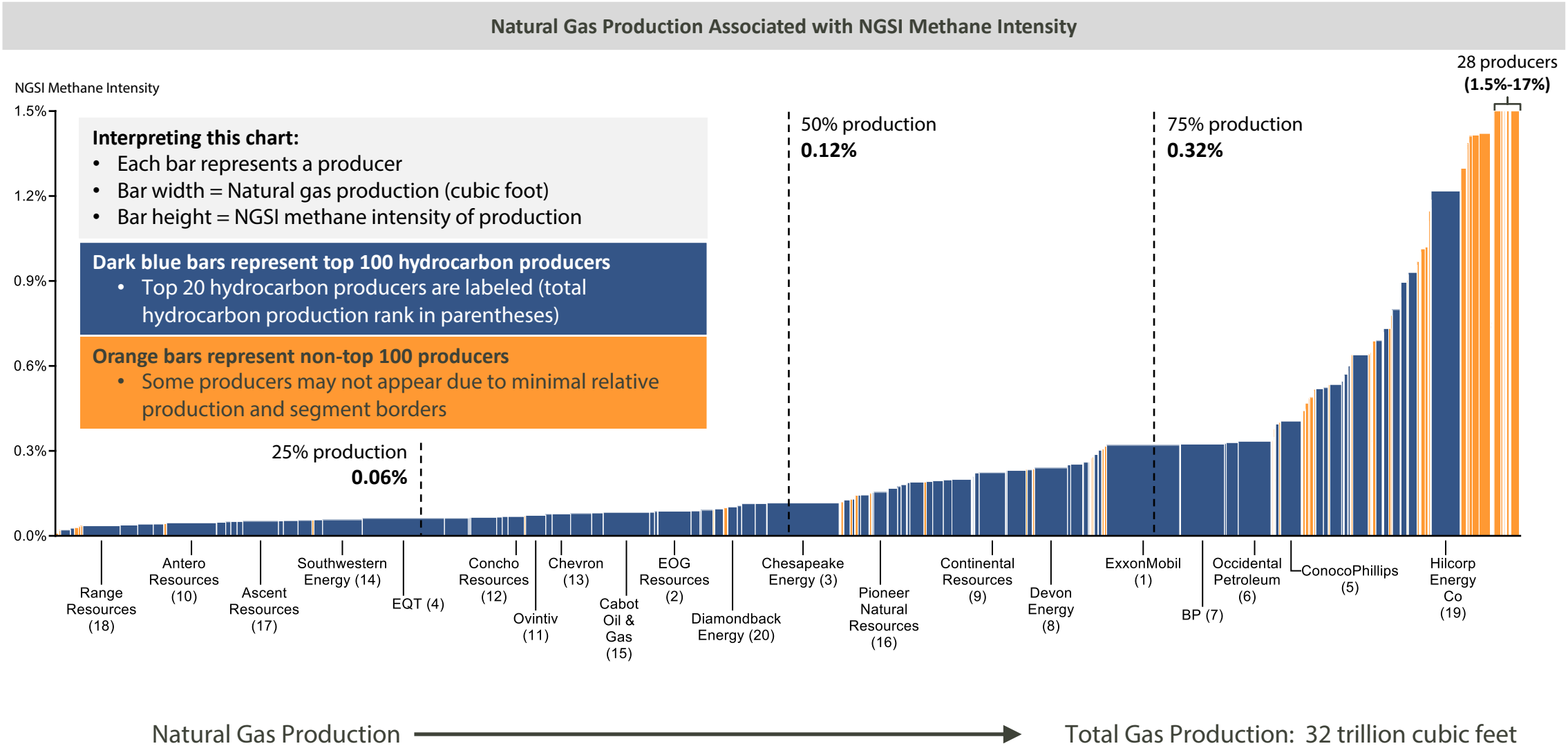
Methane & GHG Intensity (100-year GWP)



Note: Companies are ranked in descending order of hydrocarbon production (BOE)

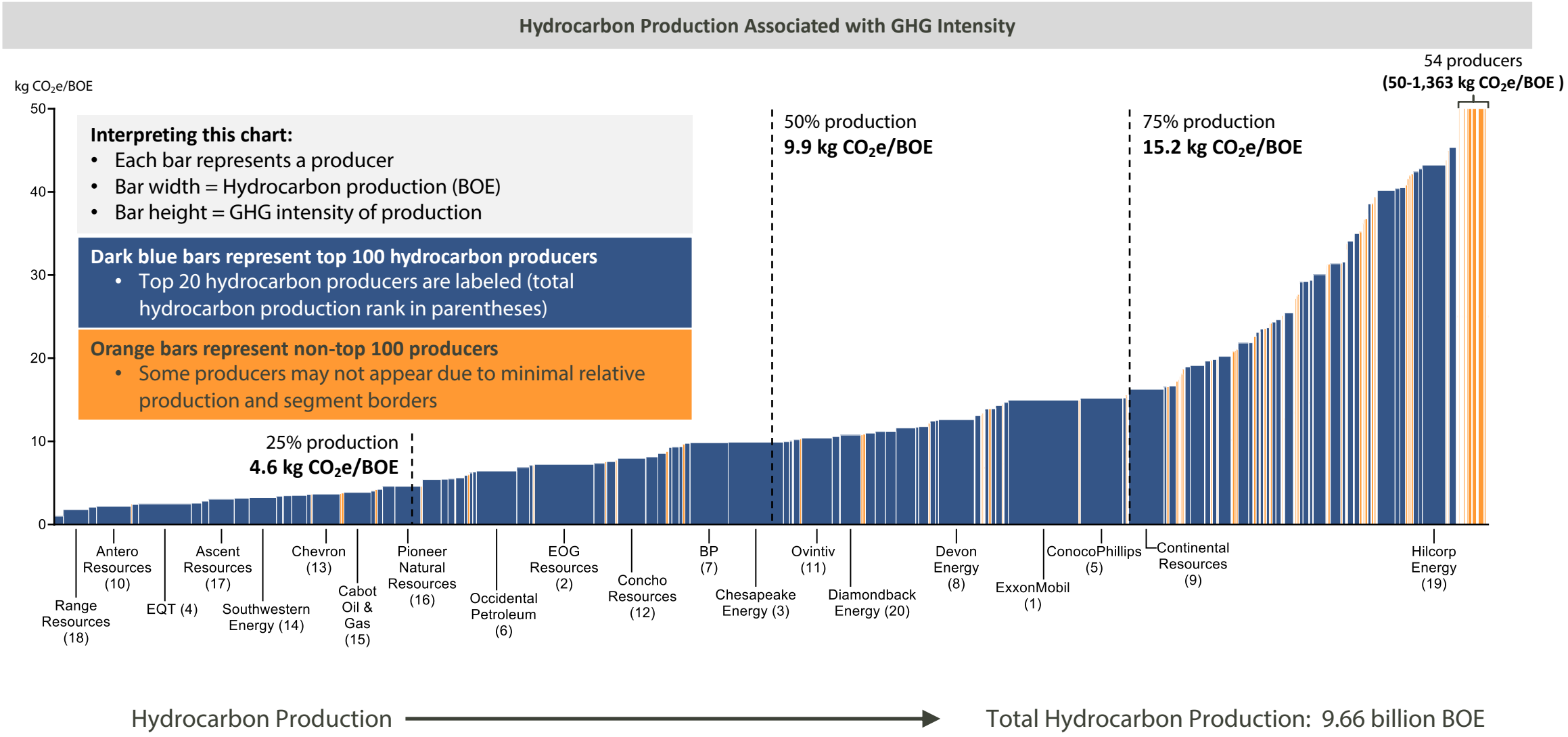
* Reflects unpublished data submitted by Apache and Diversified Gas & Oil that are currently under EPA review

Total GHGRP Natural Gas Production, by Methane Intensity

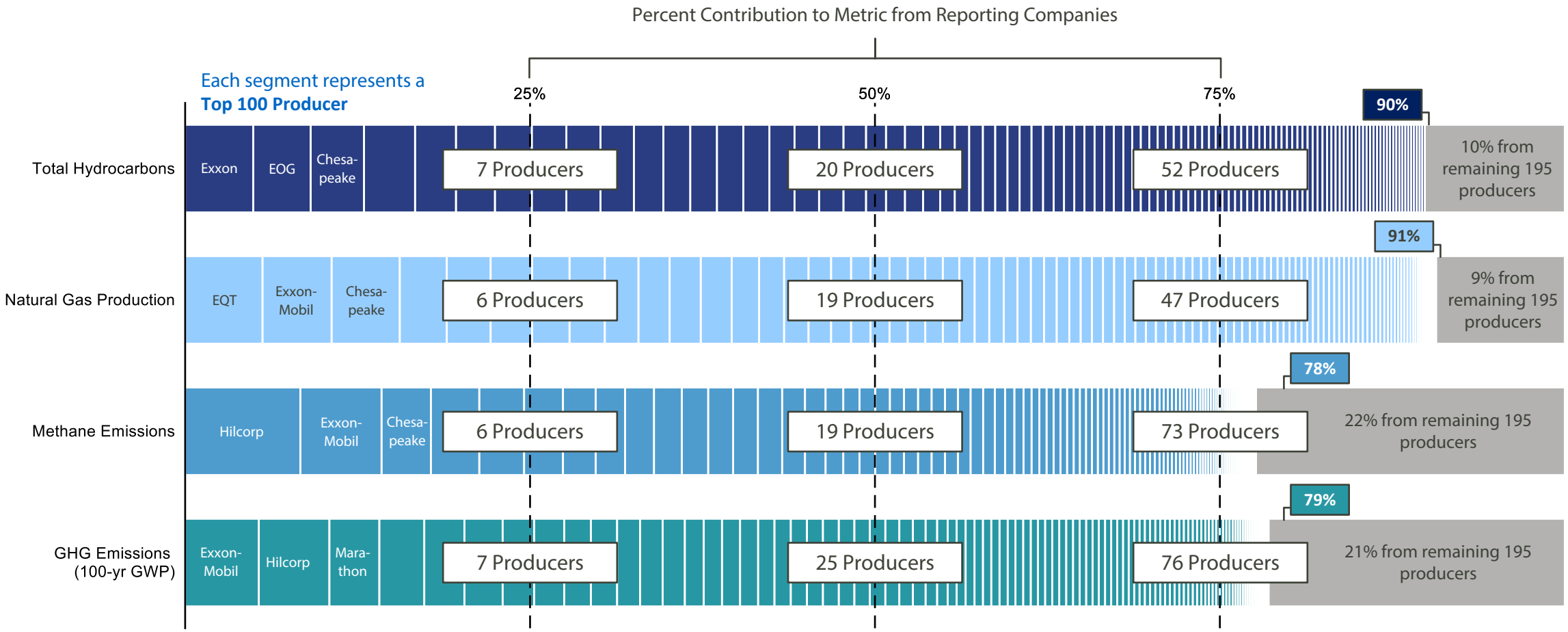


Natural Gas Production → Total Gas Production: 32 trillion cubic feet

Total GHGRP Hydrocarbon Production, by GHG Intensity



GHGRP Hydrocarbon Production & Emission Contributions



Hydrocarbon production and absolute GHG emissions reported to EPA are highly concentrated among a small number of companies. 25% of total reported hydrocarbons produced and methane emitted are by seven and six companies, respectively. However, the 195 companies that fall outside the top 100 are responsible for 22% of reported methane emissions compared to 10% of total hydrocarbon production.

Emissions & Emissions Intensities of the Top 100 Producers

		Production		Emissions		Intensity		Metric Rank (among top 100 producers) 1=highest, 100= lowest				
Rank	Company	Total MBOE	Gas (bcf)	MT CH4	MT GHG	NGSI Intensity	GHG Intensity	Gas (bcf)	CH4 Emissions	GHG Emissions	NGSI Intensity	GHG Intensity
1	ExxonMobil	476,385	1,608	99,590	7,122,557	0.32%	14.95	2	2	1	26	37
2	EOG Resources	401,467	726	12,651	2,901,845	0.09%	7.23	10	29	8	67	69
3	Chesapeake Energy	373,341	1,586	60,514	3,695,066	0.12%	9.90	3	3	6	58	58
4	EQT	357,125	1,801	19,336	877,467	0.06%	2.46	1	19	31	83	95
5	ConocoPhillips	286,177	452	47,723	4,345,323	0.40%	15.18	18	6	4	20	36
6	Occidental Petroleum	272,545	721	21,736	1,751,974	0.33%	6.43	12	17	16	22	72
7	BP	257,919	965	54,987	2,536,090	0.32%	9.83	6	5	10	25	59
8	Devon Energy	242,135	724	34,143	3,052,082	0.24%	12.60	11	10	7	33	43
9	Continental Resources	238,306	580	32,357	3,876,096	0.22%	16.27	14	11	5	37	34
10	Antero Resources	233,420	1,095	8,088	511,286	0.05%	2.19	4	37	58	94	97
11	Ovintiv	206,567	442	11,360	2,147,859	0.07%	10.40	19	30	13	75	54
12	Concho Resources	187,937	355	7,544	1,496,363	0.07%	7.96	24	40	25	76	66
13	Chevron	186,724	407	5,832	682,497	0.08%	3.66	22	54	44	73	85
14	Southwestern Energy	184,554	872	8,649	593,751	0.06%	3.22	7	35	52	84	90
15	Cabot Oil & Gas	182,855	1,020	15,797	704,807	0.08%	3.85	5	25	41	70	84
16	Pioneer Natural Resources	174,878	293	7,617	803,344	0.15%	4.59	31	39	35	51	80
17	Ascent Resources	172,007	784	7,267	518,329	0.05%	3.01	9	41	57	89	92
18	Range Resources	170,777	821	5,084	305,371	0.04%	1.79	8	56	79	98	99
19	Hilcorp Energy	157,815	638	141,274	6,819,164	1.22%	43.21	13	1	2	5	4
20	Diamondback Energy	139,660	208	7,206	1,500,718	0.10%	10.75	42	42	24	62	52
21	Cimarex Energy	132,660	424	17,976	1,541,085	0.20%	11.62	20	20	21	40	48
22	Noble Energy	126,544	306	4,408	684,266	0.05%	5.41	29	61	43	86	79
23	Marathon Oil	120,183	233	15,349	4,828,517	0.19%	40.18	39	27	3	42	9
24	Comstock Resources	101,730	569	6,775	354,948	0.07%	3.49	15	43	73	79	87
25	Consol Energy	100,794	526	5,905	318,553	0.06%	3.16	16	53	77	82	91
26	PDC Energy	95,829	257	30,325	1,831,493	0.53%	19.11	35	13	14	17	30
27	WPX Energy	86,165	139	8,417	1,741,797	0.19%	20.21	57	36	17	43	27
28	Whiting Petroleum	85,841	129	25,202	2,578,351	0.89%	30.04	60	16	9	9	15
29	Indigo Minerals	85,103	465	6,560	582,459	0.08%	6.84	17	46	53	72	71
30	Shell Petroleum	83,045	195	4,284	380,339	0.09%	4.58	45	62	71	66	81
31	Gulfport Energy	80,778	410	16,627	656,416	0.23%	8.13	21	23	46	35	65
32	Encino Energy	74,393	309	9,620	545,857	0.19%	7.34	28	33	55	44	68
33	SM Energy	72,539	189	3,223	812,270	0.06%	11.20	48	68	34	85	49
34	Oasis Petroleum	71,763	116	4,938	1,565,697	0.18%	21.82	65	58	20	47	26

Emissions & Emissions Intensities of the Top 100 Producers

		Production		Emissions		Intensity		Metric Rank (among top 100 producers)				
								1=highest, 100= lowest				
Rank	Company	Total MBOE	Gas (bcf)	MT CH4	MT GHG	NGSI Intensity	GHG Intensity	Gas (bcf)	CH4 Emissions	GHG Emissions	NGSI Intensity	GHG Intensity
35	Hess	70,804	95	6,294	2,219,454	0.22%	31.35	75	49	11	38	14
36	Chief Oil & Gas	70,510	386	2,730	180,912	0.04%	2.57	23	75	88	97	94
37	Parsley Energy	67,742	107	3,211	756,979	0.08%	11.17	71	69	38	69	50
38	Equinor	67,430	195	2,745	792,355	0.05%	11.75	44	74	37	93	46
39	Apache*	66,471	246	3,878	729,998	0.08%	10.98	37	65	40	71	51
40	California Resources	61,701	122	735	60,490	0.07%	0.98	63	98	100	78	100
41	Flywheel Energy	60,301	340	40,048	1,534,451	0.64%	25.45	25	7	22	13	19
42	Aethon Energy	59,618	321	3,187	450,967	0.05%	7.56	27	70	65	87	67
43	Ultra Petroleum	58,741	295	6,181	329,233	0.11%	5.60	30	50	76	60	76
44	Vine Oil & Gas	56,944	338	2,540	196,379	0.04%	3.45	26	78	85	96	88
45	Lewis Energy Group	54,968	265	11,207	469,223	0.25%	8.54	32	31	62	31	64
46	SN EF Maverick	52,611	137	1,553	109,479	0.05%	2.08	59	87	97	91	98
47	National Fuel Gas	50,186	260	4,466	530,474	0.09%	10.57	34	60	56	64	53
48	Extraction Oil & Gas	48,497	109	1,428	451,065	0.05%	9.30	68	89	64	88	62
49	Terra Energy Partners	48,017	245	59,364	2,176,534	1.42%	45.33	38	4	12	2	3
50	Total Holdings	47,742	261	15,519	794,779	0.33%	16.65	33	26	36	23	32
51	Eclipse Resources	47,090	211	822	131,205	0.02%	2.79	41	95	93	100	93
52	GeoSouthern Energy	46,357	250	5,149	252,269	0.11%	5.44	36	55	81	59	78
53	EP Energy	45,143	96	3,117	246,970	0.11%	5.47	74	71	82	61	77
54	QEP Resources	43,655	64	1,816	624,129	0.09%	14.30	84	84	48	68	39
55	PER Manager	42,881	188	2,821	145,891	0.09%	3.40	49	73	92	63	89
56	TPG Capital Management	42,716	204	6,164	435,530	0.17%	10.20	43	51	67	49	55
57	Repsol Oil & Gas	42,120	231	1,795	102,130	0.04%	2.42	40	85	99	95	96
58	NextEra Energy	41,426	184	5,925	412,458	0.14%	9.96	50	52	70	53	57
59	BHP Minerals	39,764	109	6,326	1,354,985	0.23%	34.08	69	47	26	34	12
60	Centennial Resource	39,023	71	3,911	510,594	0.25%	13.08	82	64	59	32	42
61	Scout Energy	38,941	152	35,475	1,576,842	1.58%	40.49	53	9	19	1	7
62	Diversified Gas & Oil*	38,171	194	29,694	1,114,736	0.93%	29.20	46	14	29	8	17
63	Merit Energy	37,864	167	17,165	743,970	0.52%	19.65	52	22	39	19	29
64	Blackbeard Operating	37,228	150	36,063	1,578,848	1.42%	42.41	54	8	18	3	6
65	Citizen Energy	35,913	125	1,099	151,706	0.05%	4.22	62	91	91	90	82
66	Rockcliff Energy	35,578	190	6,699	442,625	0.20%	12.44	47	44	66	41	45
67	Matador Resources	35,532	70	6,666	673,546	0.30%	18.96	83	45	45	27	31

* Reflects unpublished data submitted by Apache and Diversified Gas & Oil that are currently under EPA review

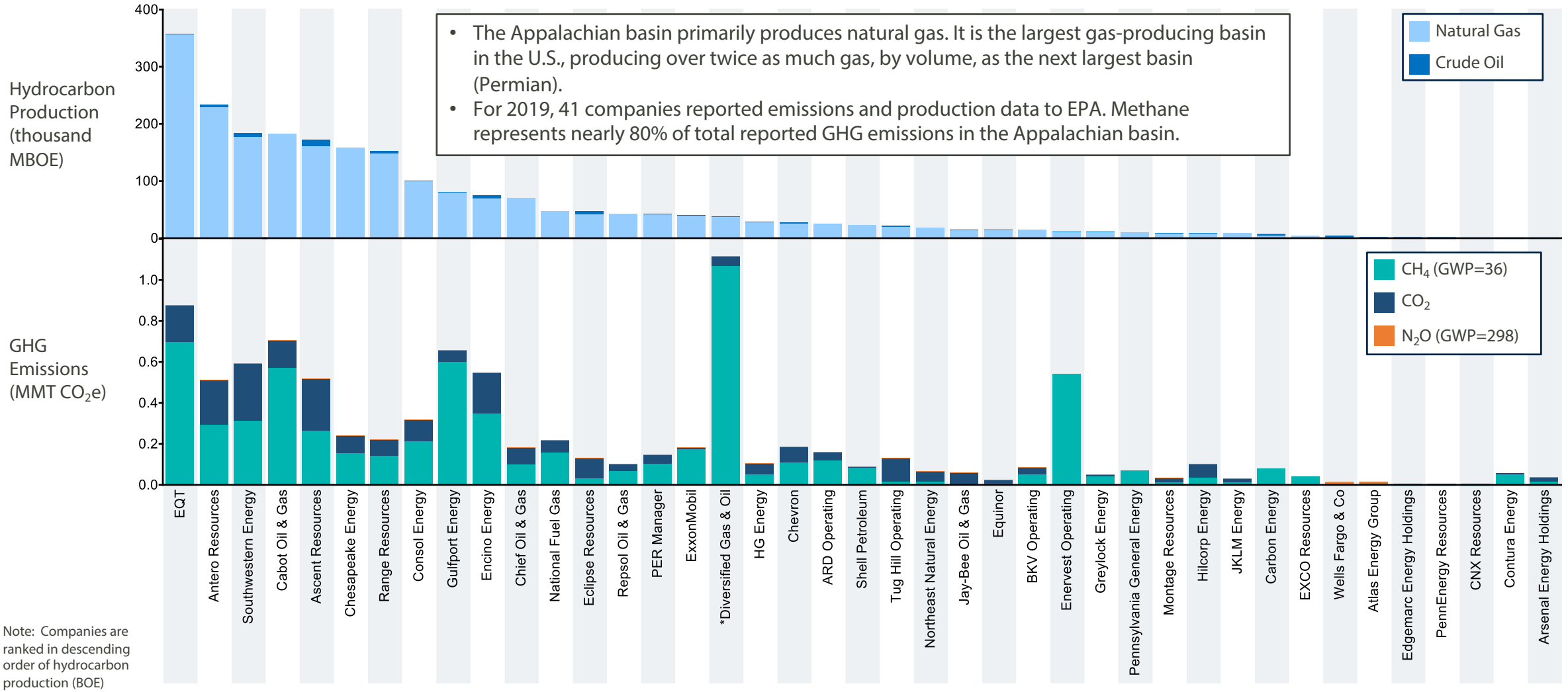
Emissions & Emissions Intensities of the Top 100 Producers

		Production		Emissions		Intensity		Metric Rank (among top 100 producers) 1=highest, 100= lowest				
Rank	Company	Total MBOE	Gas (bcf)	MT CH4	MT GHG	NGSI Intensity	GHG Intensity	Gas (bcf)	CH4 Emissions	GHG Emissions	NGSI Intensity	GHG Intensity
68	EXCO Resources	35,138	173	28,098	1,229,113	0.80%	34.98	51	15	28	10	11
69	Endeavor Energy Resources	35,078	74	19,794	863,206	0.99%	24.61	80	18	32	7	20
70	Carrizo Oil & Gas	34,255	55	2,853	334,213	0.14%	9.76	86	72	75	54	60
71	FourPoint Energy	32,382	121	30,633	1,307,724	1.30%	40.38	64	12	27	4	8
72	Permian Resources Holdings	29,853	76	2,677	415,438	0.17%	13.92	79	76	69	48	40
73	Surge Operating	29,196	29	902	428,464	0.09%	14.68	92	94	68	65	38
74	HG Energy	28,868	128	1,414	104,592	0.07%	3.62	61	90	98	77	86
75	Caerus Oil & Gas	28,390	141	16,500	620,074	0.69%	21.84	55	24	49	12	25
76	Hunt Crude Oil Supply	28,164	40	3,291	558,572	0.33%	19.83	89	66	54	24	28
77	Oak Ridge Natural Resources	27,985	139	1,950	112,084	0.08%	4.01	56	83	96	74	83
78	Bruin E&P Partners	27,640	35	4,991	1,761,620	0.55%	63.73	90	57	15	16	1
79	Crestone Peak Resources	25,620	72	6,315	355,732	0.39%	13.89	81	48	72	21	41
80	ARD Operating	25,141	138	3,266	158,726	0.13%	6.31	58	67	90	56	73
81	Northern Colorado Oil & Gas	24,887	48	8,071	605,589	0.60%	24.33	87	38	50	14	21
82	Silverbow Resources	24,814	112	987	232,008	0.05%	9.35	66	93	83	92	61
83	Murphy	24,559	29	2,215	174,376	0.15%	7.10	93	81	89	52	70
84	Petro-Hunt	24,486	30	2,322	1,504,639	0.26%	61.45	91	80	23	29	2
85	Kraken Oil & Gas	23,764	24	997	1,015,774	0.16%	42.74	97	92	30	50	5
86	Felix Energy Holdings	22,496	27	766	342,254	0.06%	15.21	94	97	74	81	35
87	Enerplus Resources	22,310	22	1,577	860,050	0.19%	38.55	99	86	33	46	10
88	Sabine Oil & Gas	22,113	112	14,337	644,560	0.73%	29.15	67	28	47	11	18
89	Tug Hill Operating	22,016	87	375	130,193	0.03%	5.91	76	100	94	99	75
90	Southland Royalty	21,726	96	17,414	685,687	1.01%	31.56	73	21	42	6	13
91	Slawson	21,335	18	818	501,519	0.12%	23.51	100	96	60	57	23
92	Sequitur Energy	20,894	56	2,081	193,482	0.19%	9.26	85	82	86	45	63
93	Jagged Peak Energy	20,612	25	2,603	605,383	0.23%	29.37	96	77	51	36	16
94	Castleton Commodities International	20,391	108	4,870	255,195	0.26%	12.51	70	59	80	30	44
95	Unit Corporation	20,274	79	8,809	479,462	0.57%	23.65	78	34	61	15	22
96	Tanos Exploration	20,107	105	9,888	464,519	0.52%	23.10	72	32	63	18	24
97	Callon Petroleum	19,689	24	2,394	230,440	0.21%	11.70	98	79	84	39	47
98	Spur Energy Partners	19,562	26	676	121,124	0.06%	6.19	95	99	95	80	74
99	Alta Mesa Services	18,620	47	1,455	307,804	0.13%	16.53	88	88	78	55	33
100	Vitruvian Exploration	18,462	79	4,014	184,908	0.29%	10.02	77	63	87	28	56

Company- & Basin-Level Summary Data

This section summarizes company-level data on hydrocarbon production, GHG emissions, emissions intensity, and sources of emissions for each of the following basins: Appalachian, Permian, Gulf Coast, and Williston. Additional data show the distribution of methane and GHG emission intensities by volume in each basin.

Hydrocarbon Production & Emissions (100-year GWP)



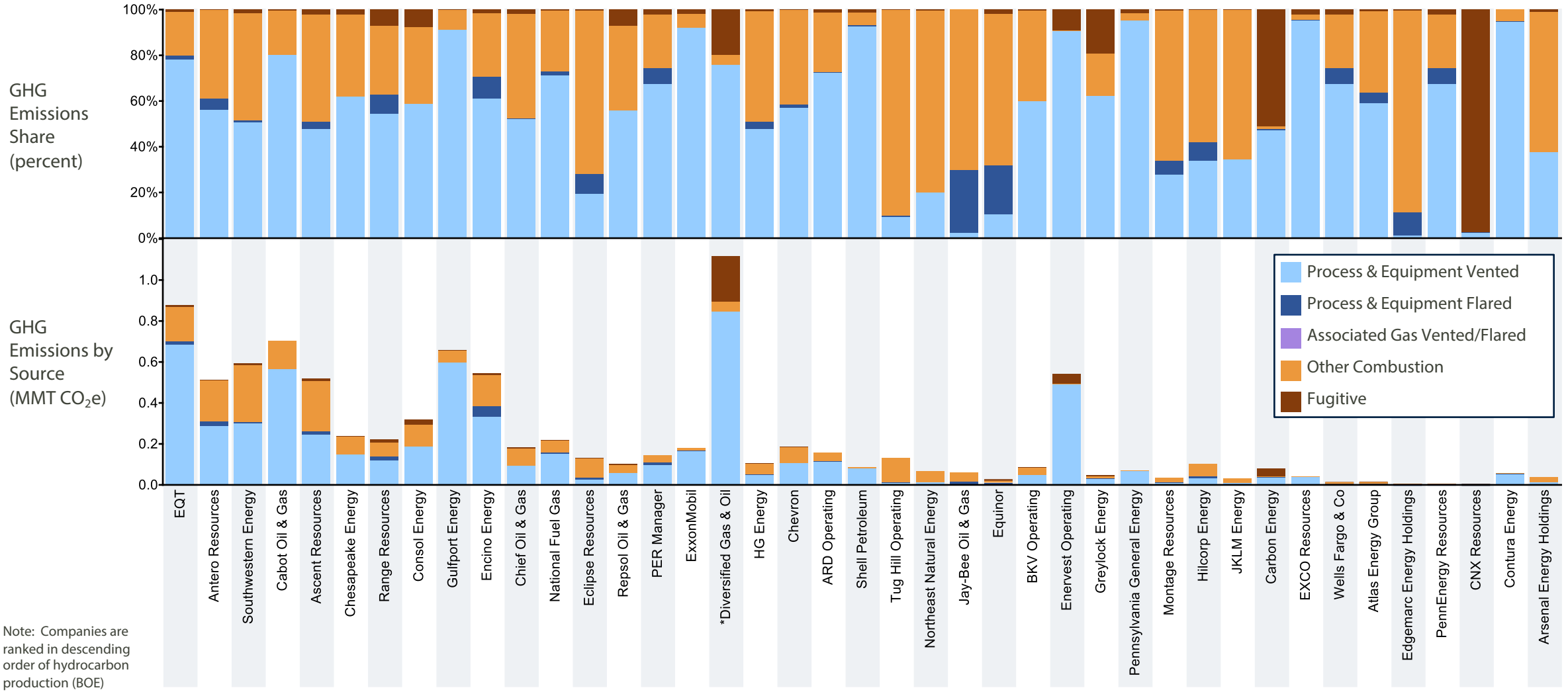
- The Appalachian basin primarily produces natural gas. It is the largest gas-producing basin in the U.S., producing over twice as much gas, by volume, as the next largest basin (Permian).
- For 2019, 41 companies reported emissions and production data to EPA. Methane represents nearly 80% of total reported GHG emissions in the Appalachian basin.

Note: Companies are ranked in descending order of hydrocarbon production (BOE) within basin

* Reflects unpublished data submitted by Diversified Gas & Oil that are currently under EPA review

Appalachian Basin Producers

GHG Emissions by Source (100-year GWP)

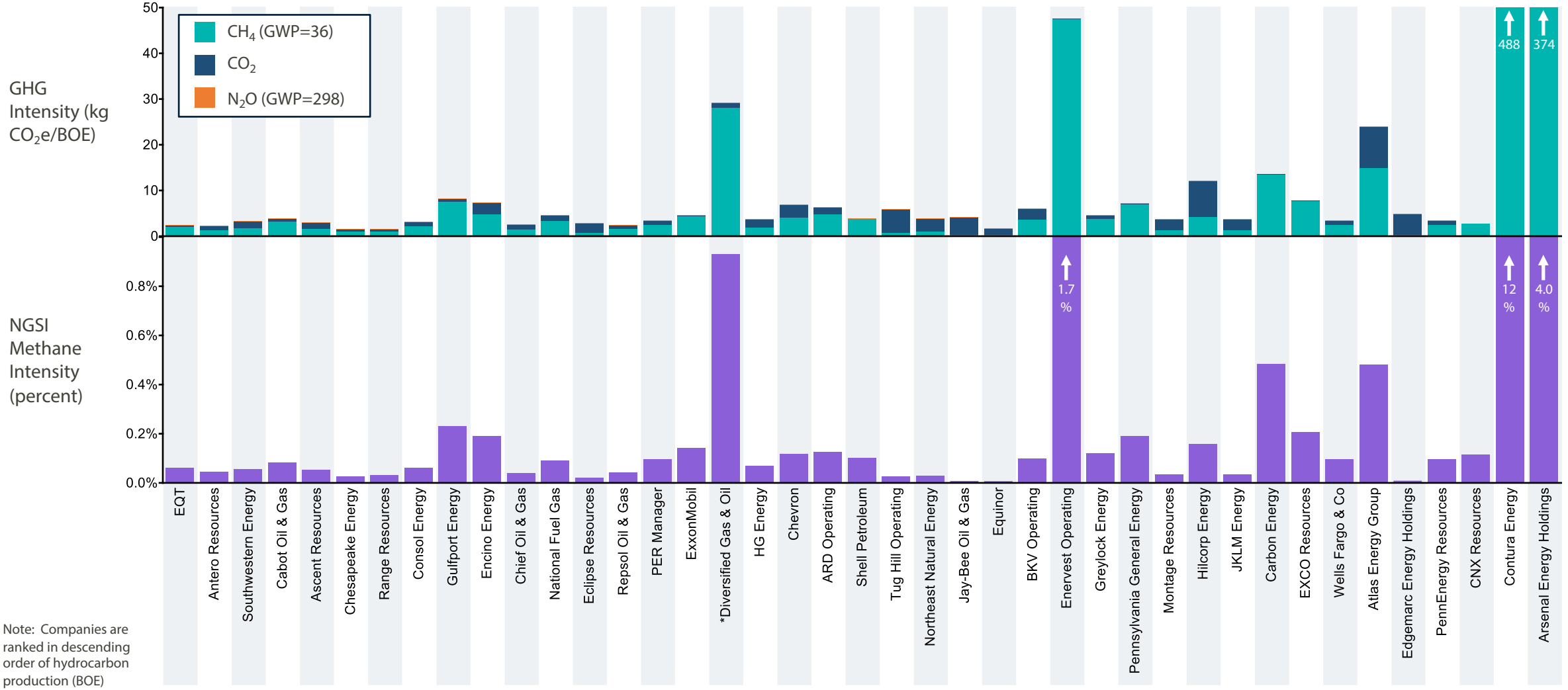


Note: Companies are ranked in descending order of hydrocarbon production (BOE) within basin

* Reflects unpublished data submitted by Diversified Gas & Oil that are currently under EPA review

Appalachian Basin Producers

Methane & GHG Intensity (100-year GWP)

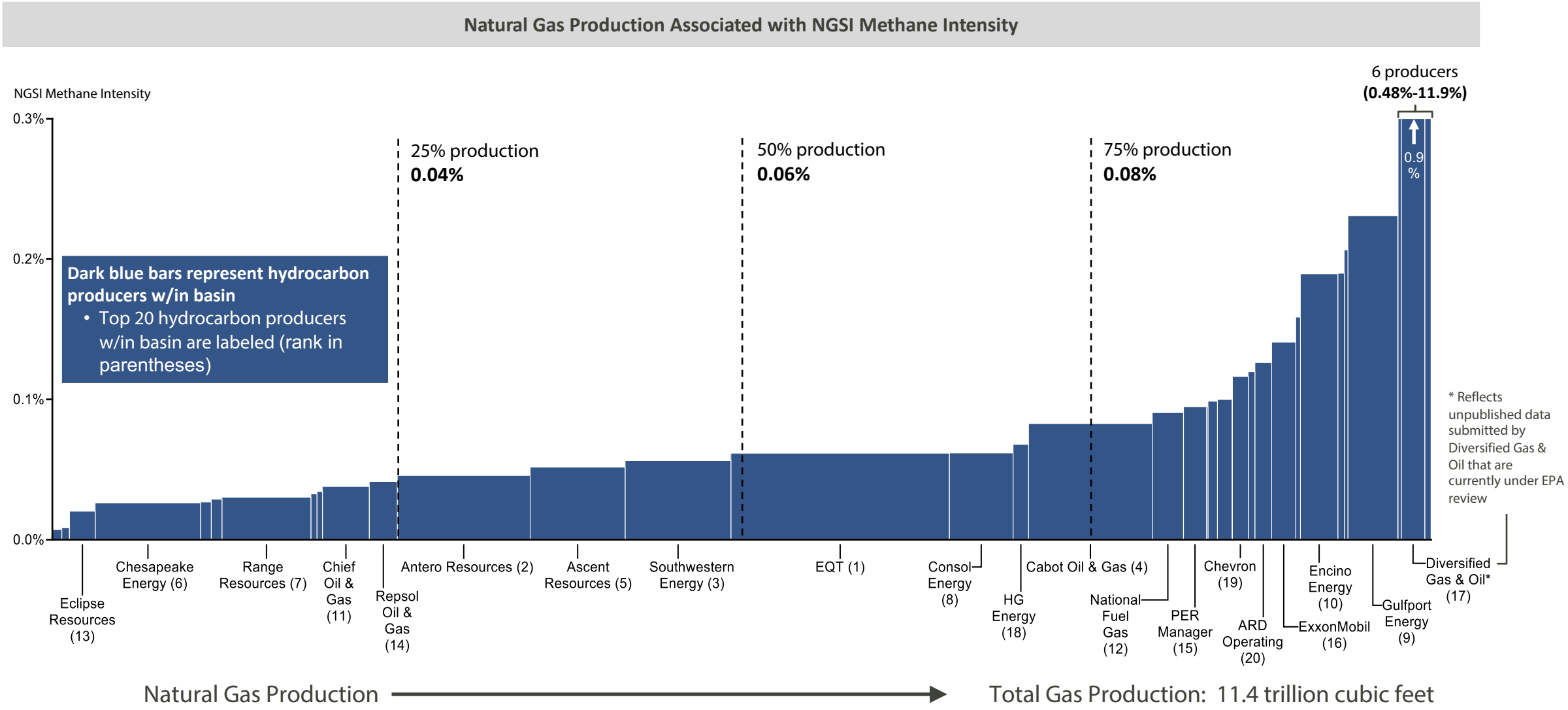


Note: Companies are ranked in descending order of hydrocarbon production (BOE) within basin

* Reflects unpublished data submitted by Diversified Gas & Oil that are currently under EPA review

Appalachian Basin Producers

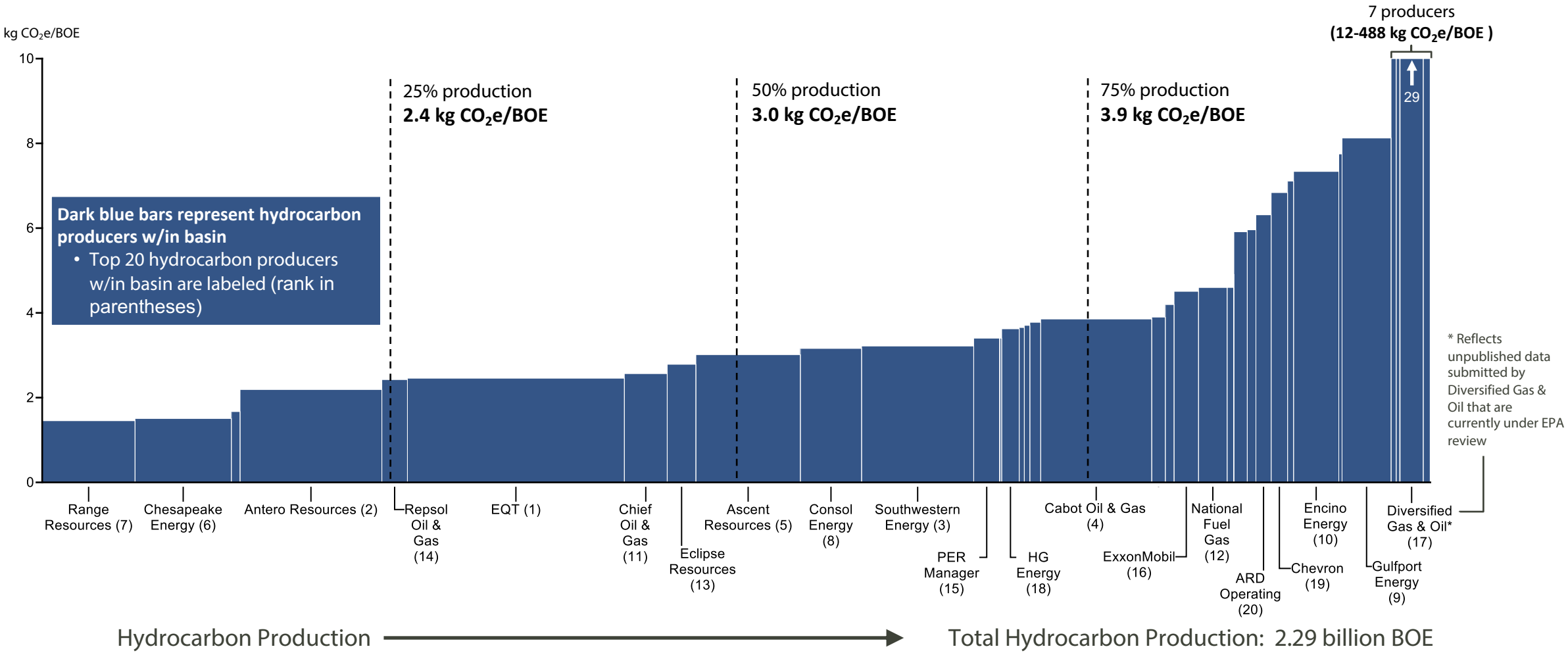
Total GHGRP Natural Gas Production, by Methane Intensity



Appalachian Basin Producers

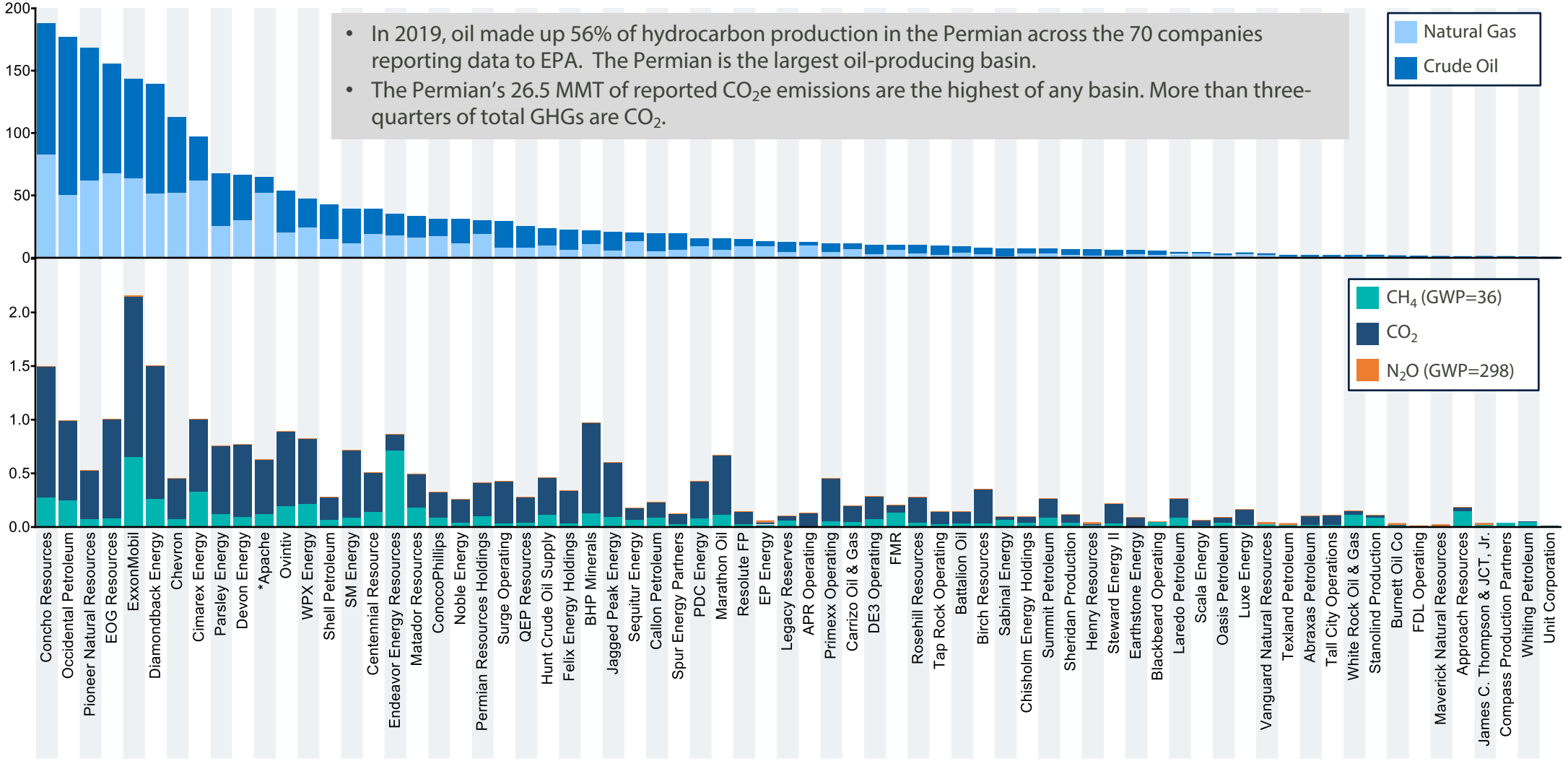
Total GHGRP Hydrocarbon Production, by GHG Intensity

Hydrocarbon Production Associated with GHG Intensity



Hydrocarbon Production & Emissions (100-year GWP)

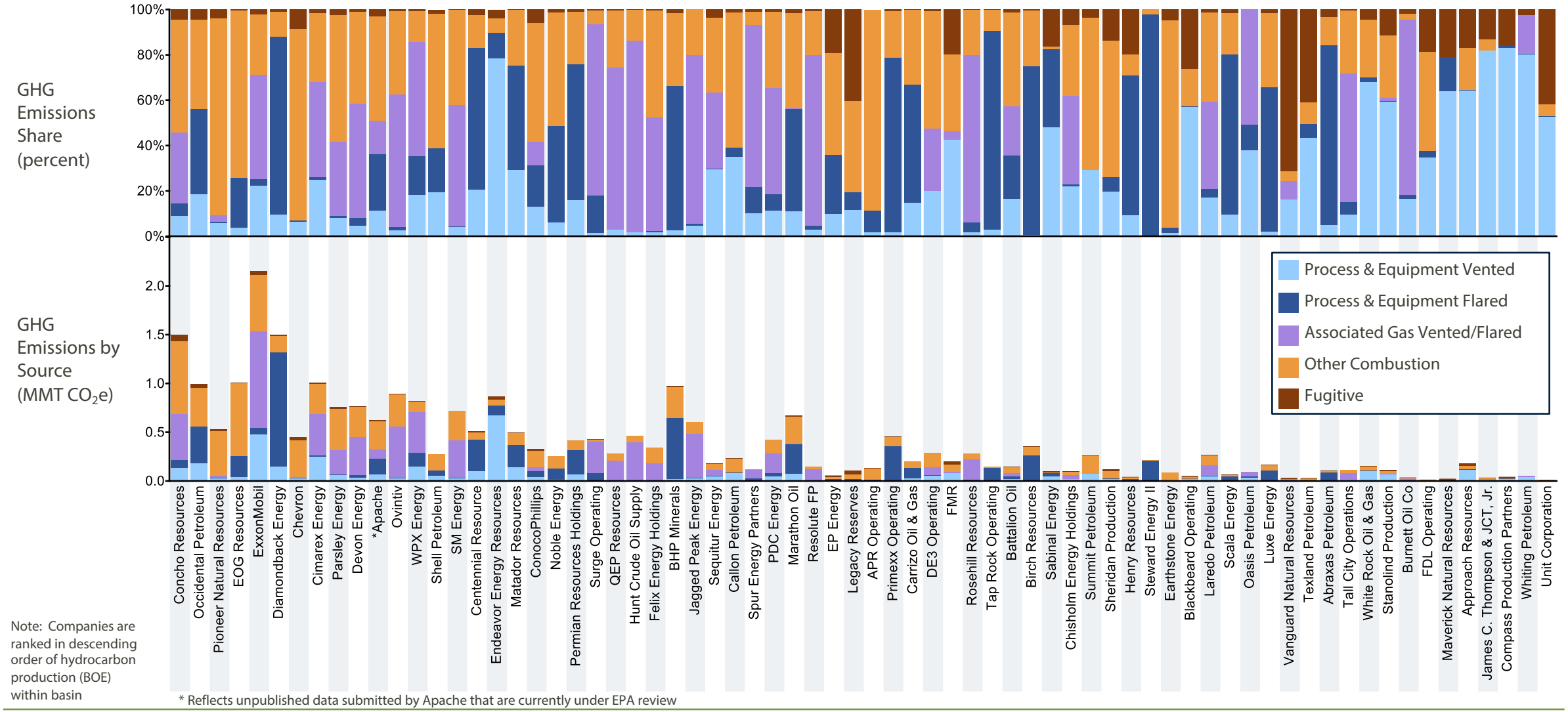
- In 2019, oil made up 56% of hydrocarbon production in the Permian across the 70 companies reporting data to EPA. The Permian is the largest oil-producing basin.
- The Permian's 26.5 MMT of reported CO_2e emissions are the highest of any basin. More than three-quarters of total GHGs are CO_2.



Note: Companies are ranked in descending order of hydrocarbon production (BOE) within basin

* Reflects unpublished data submitted by Apache that are currently under EPA review

GHG Emissions by Source (100-year GWP)



Note: Companies are ranked in descending order of hydrocarbon production (BOE) within basin

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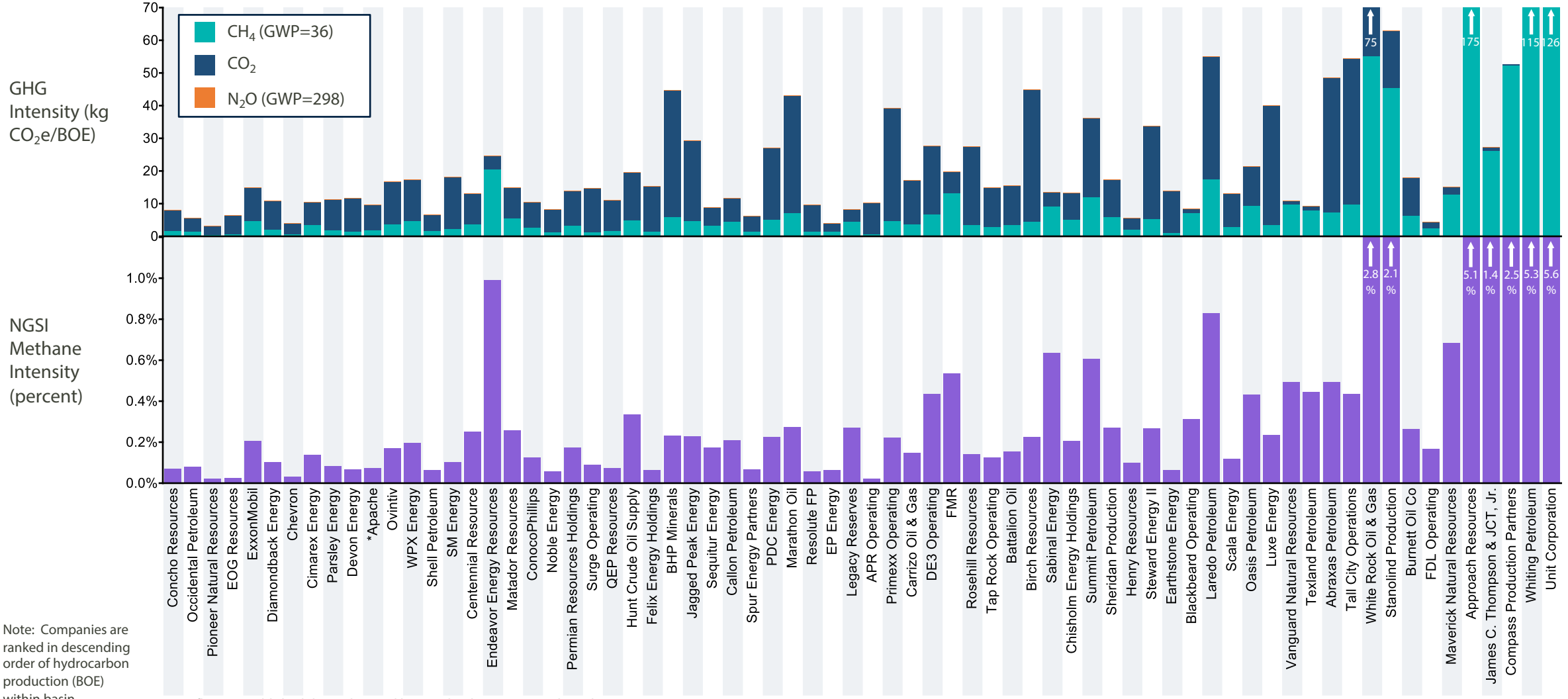
Permian Basin Producers

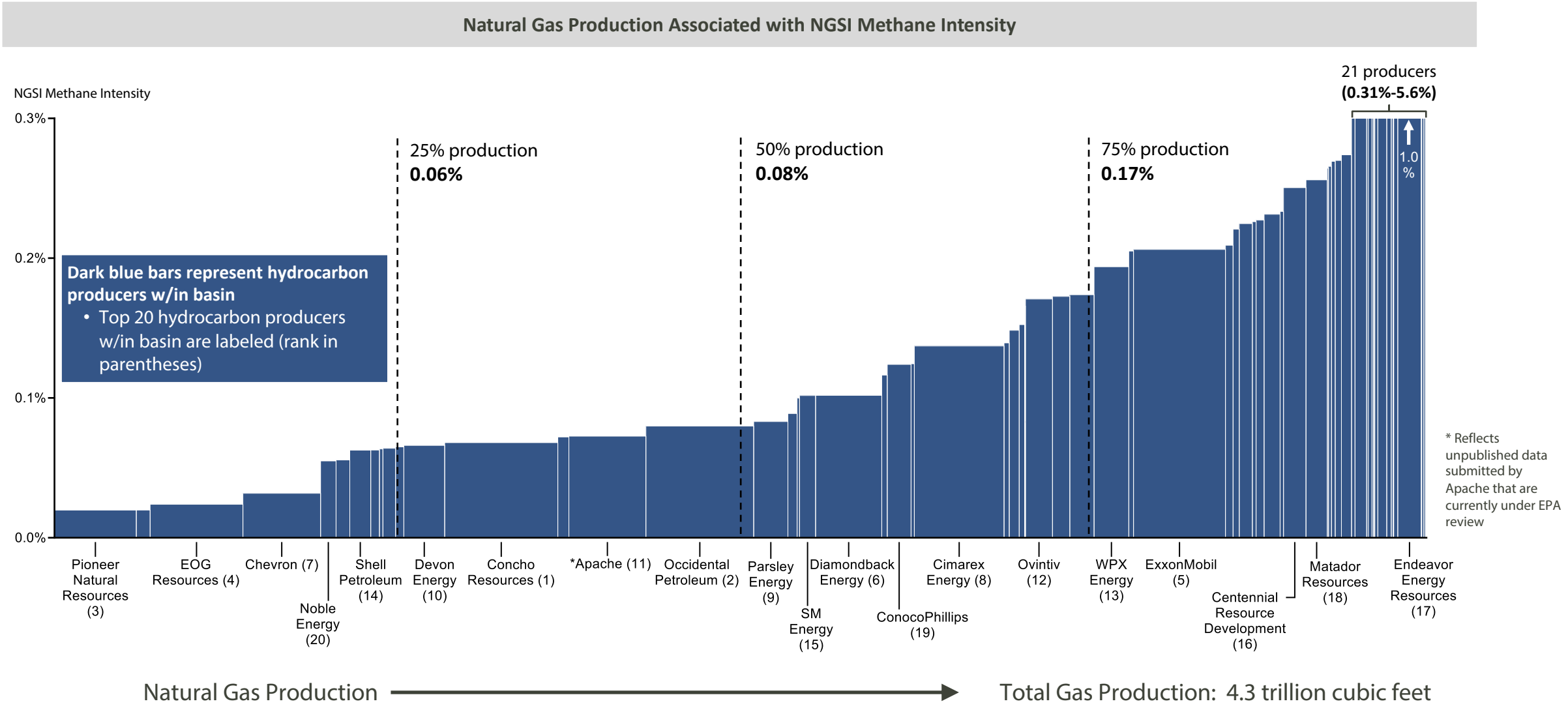
Methane & GHG Intensity (100-year GWP)



Note: Companies are ranked in descending order of hydrocarbon production (BOE) within basin

* Reflects unpublished data submitted by Apache that are currently under EPA review

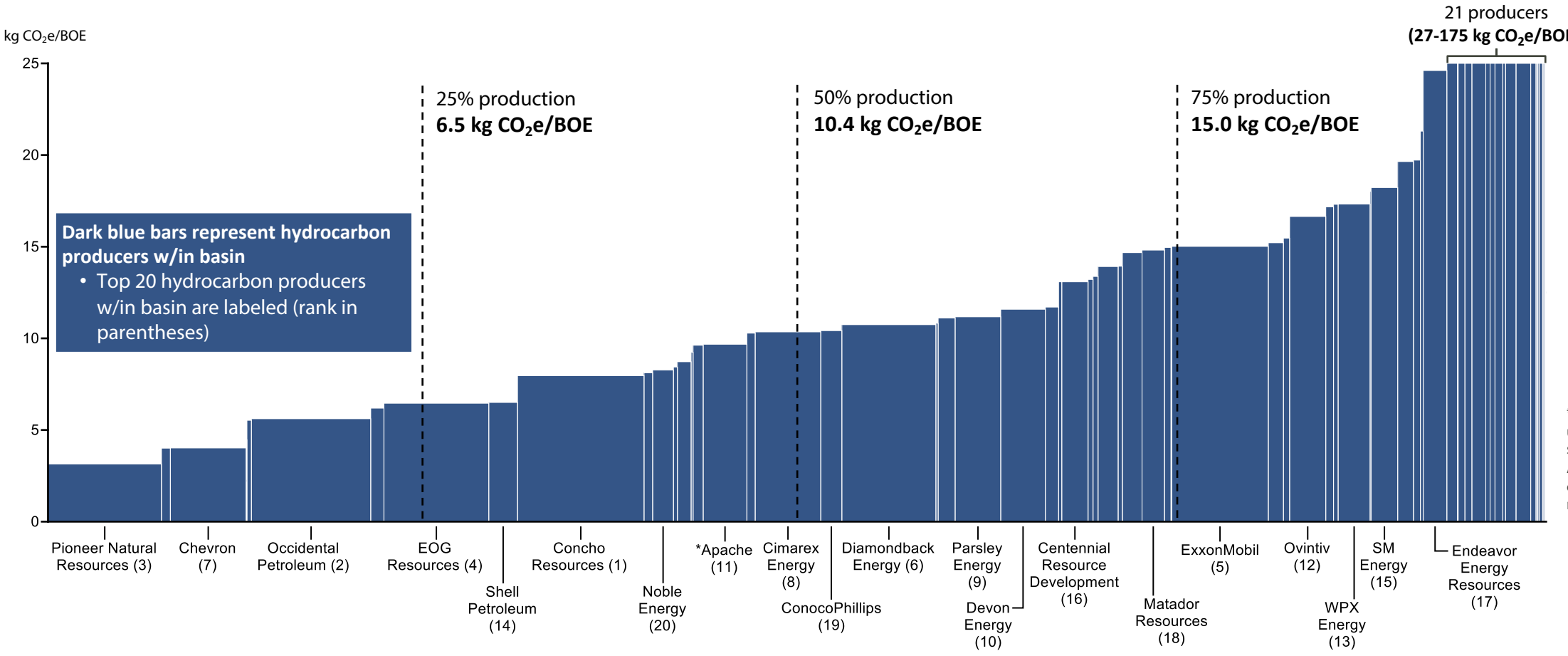
Total GHGRP Natural Gas Production, by Methane Intensity



Permian Basin Producers

Total GHGRP Hydrocarbon Production, by GHG Intensity

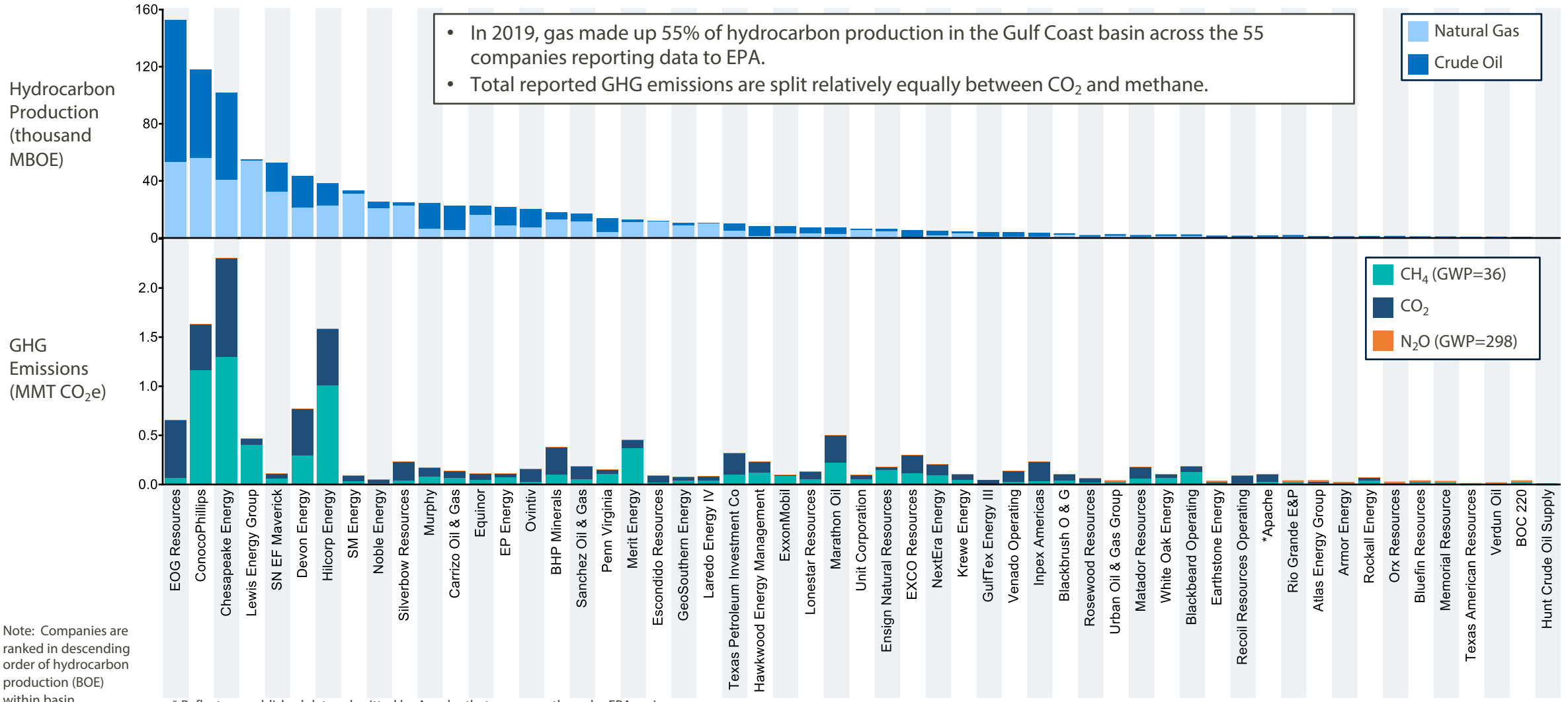
Hydrocarbon Production Associated with GHG Intensity



* Reflects unpublished data submitted by Apache that are currently under EPA review

Hydrocarbon Production → Total Hydrocarbon Production: 2.23 billion BOE

Hydrocarbon Production & Emissions (100-year GWP)

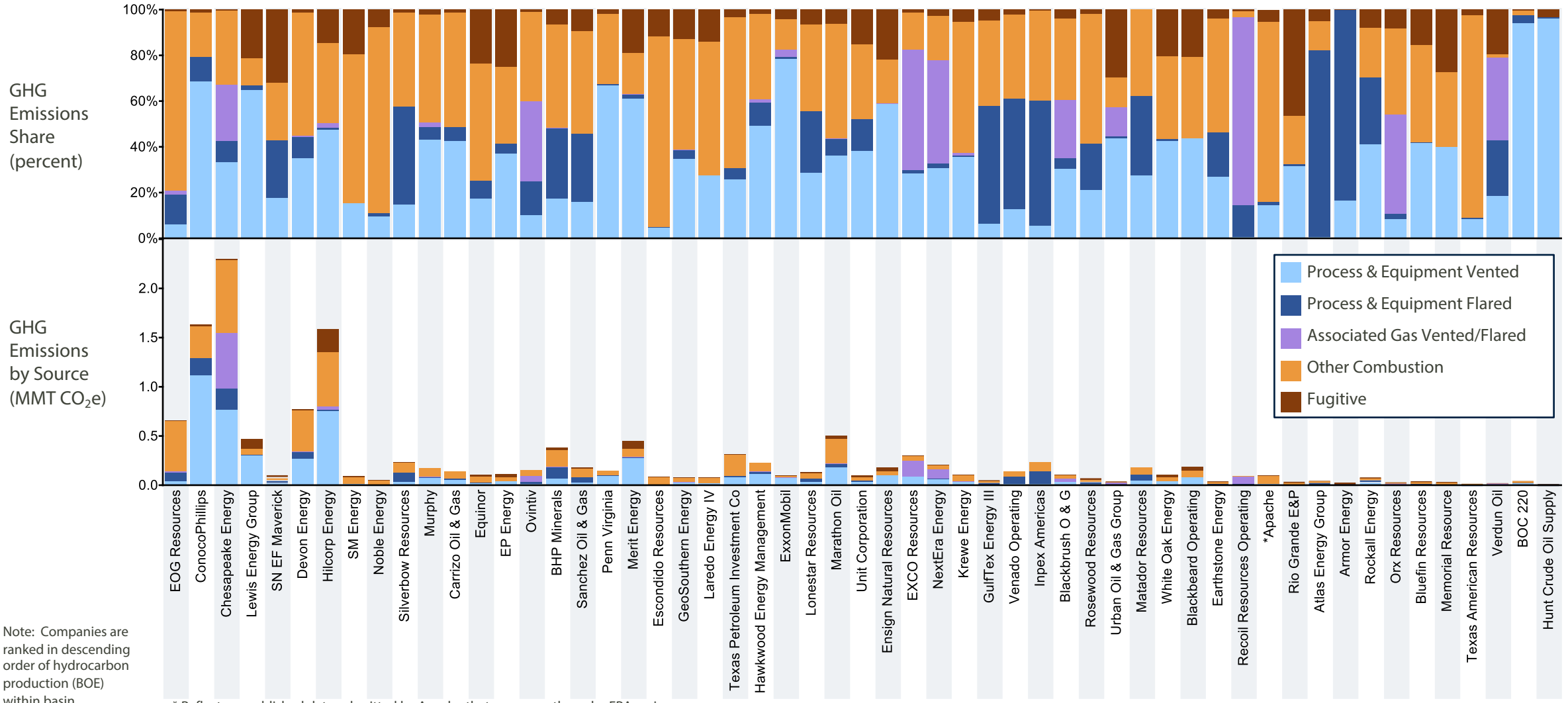


Note: Companies are ranked in descending order of hydrocarbon production (BOE) within basin

* Reflects unpublished data submitted by Apache that are currently under EPA review

Gulf Coast Basin Producers

GHG Emissions by Source (100-year GWP)

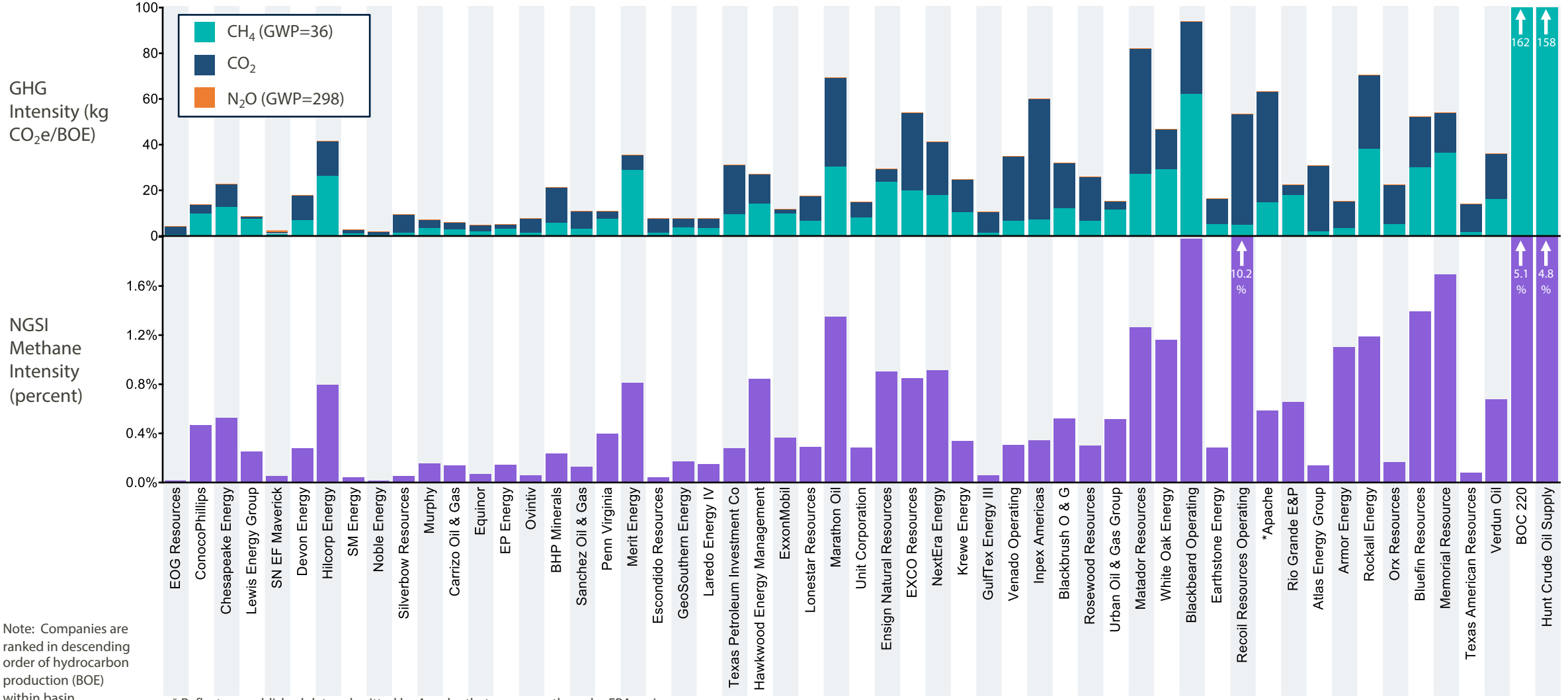


Note: Companies are ranked in descending order of hydrocarbon production (BOE) within basin

* Reflects unpublished data submitted by Apache that are currently under EPA review

Gulf Coast Basin Producers

Methane & GHG Intensity (100-year GWP)

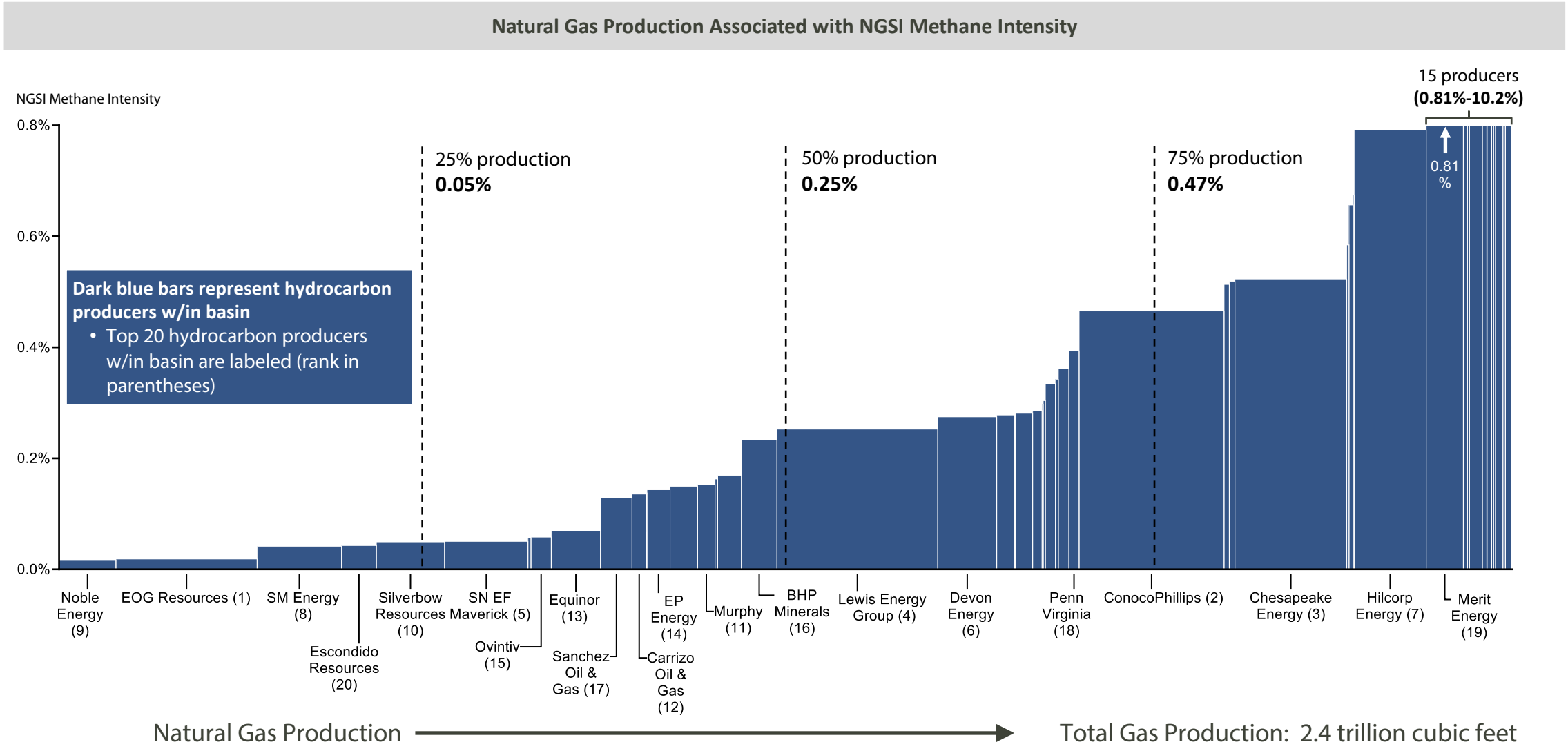


Note: Companies are ranked in descending order of hydrocarbon production (BOE) within basin

* Reflects unpublished data submitted by Apache that are currently under EPA review

Gulf Coast Basin Producers

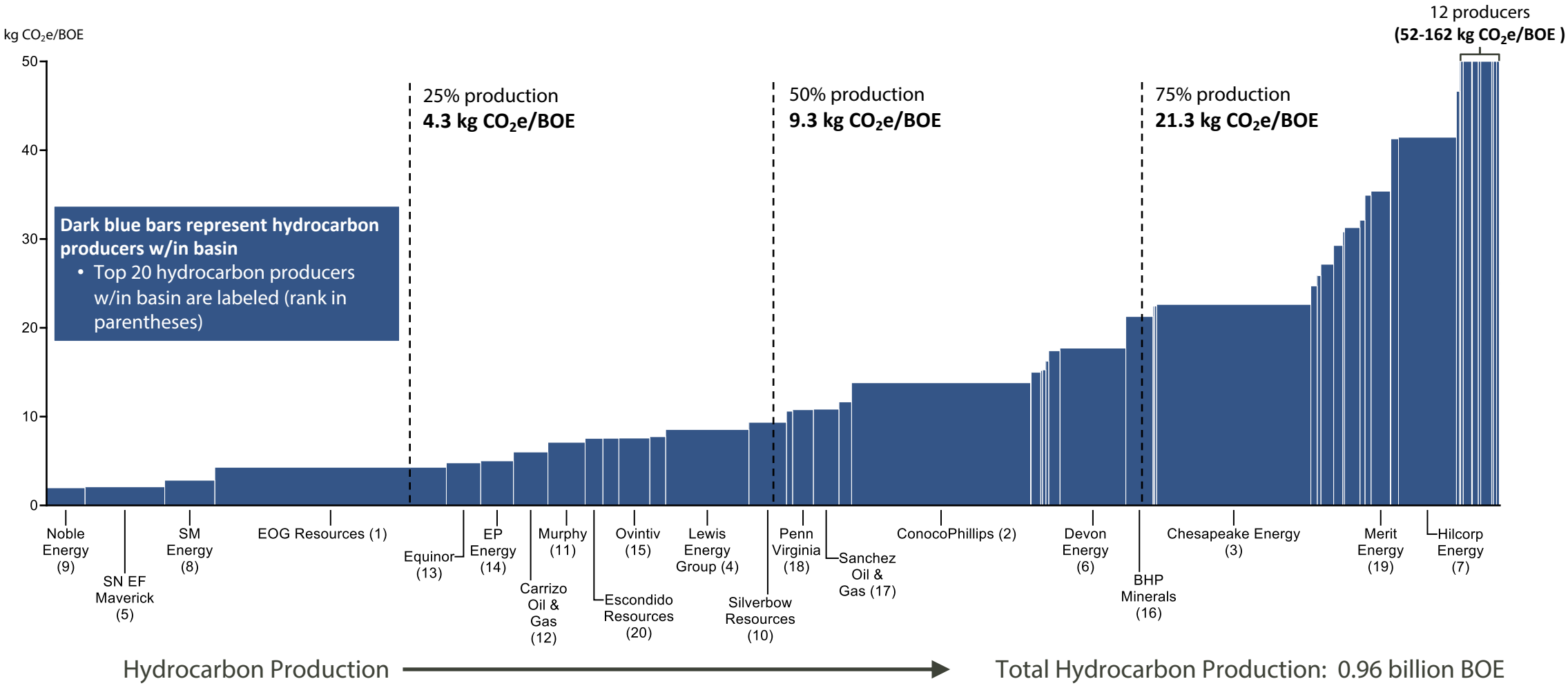
Total GHGRP Natural Gas Production, by Methane Intensity



Gulf Coast Basin Producers

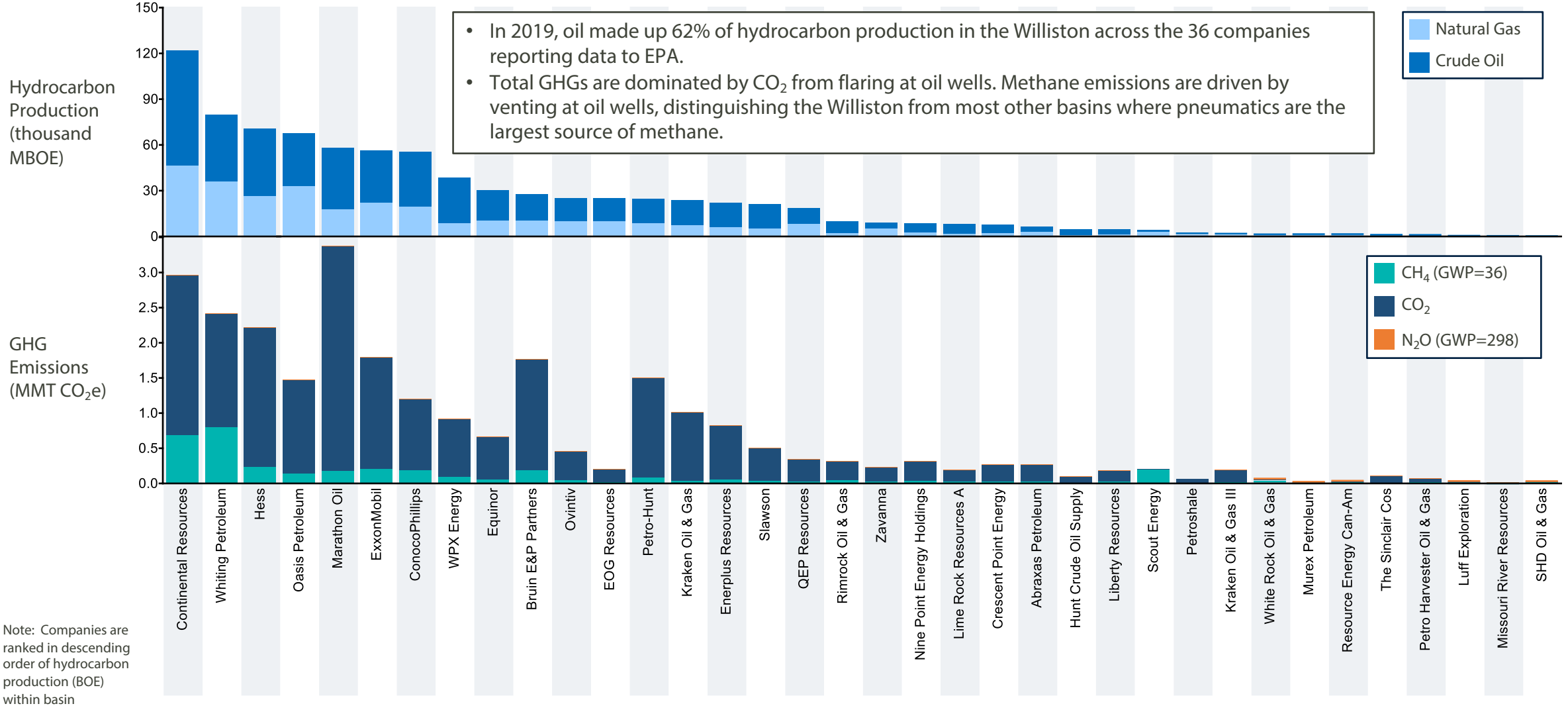
Total GHGRP Hydrocarbon Production, by GHG Intensity

Hydrocarbon Production Associated with GHG Intensity



Hydrocarbon Production & Emissions (100-year GWP)

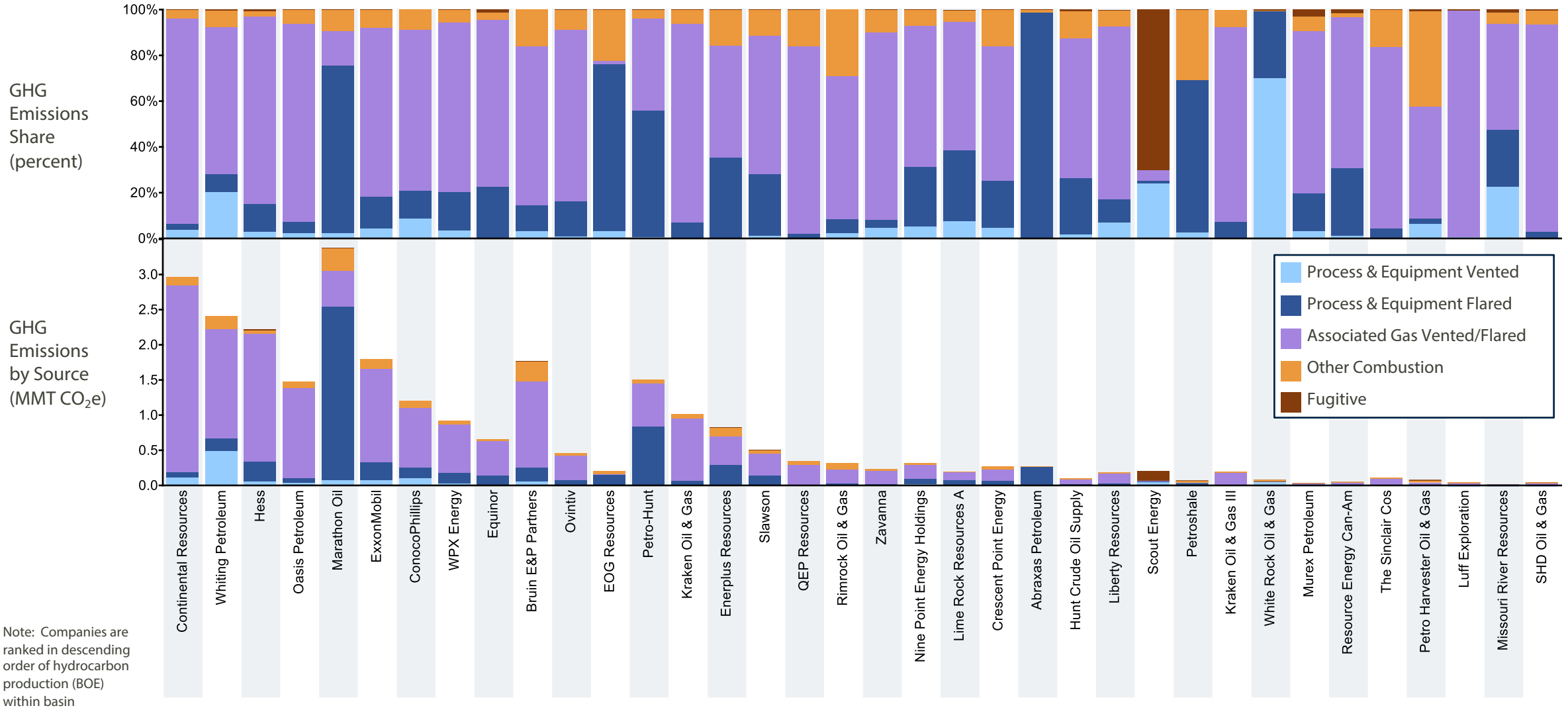
- In 2019, oil made up 62% of hydrocarbon production in the Williston across the 36 companies reporting data to EPA.
- Total GHGs are dominated by CO_2 from flaring at oil wells. Methane emissions are driven by venting at oil wells, distinguishing the Williston from most other basins where pneumatics are the largest source of methane.



Note: Companies are ranked in descending order of hydrocarbon production (BOE) within basin

Williston Basin Producers

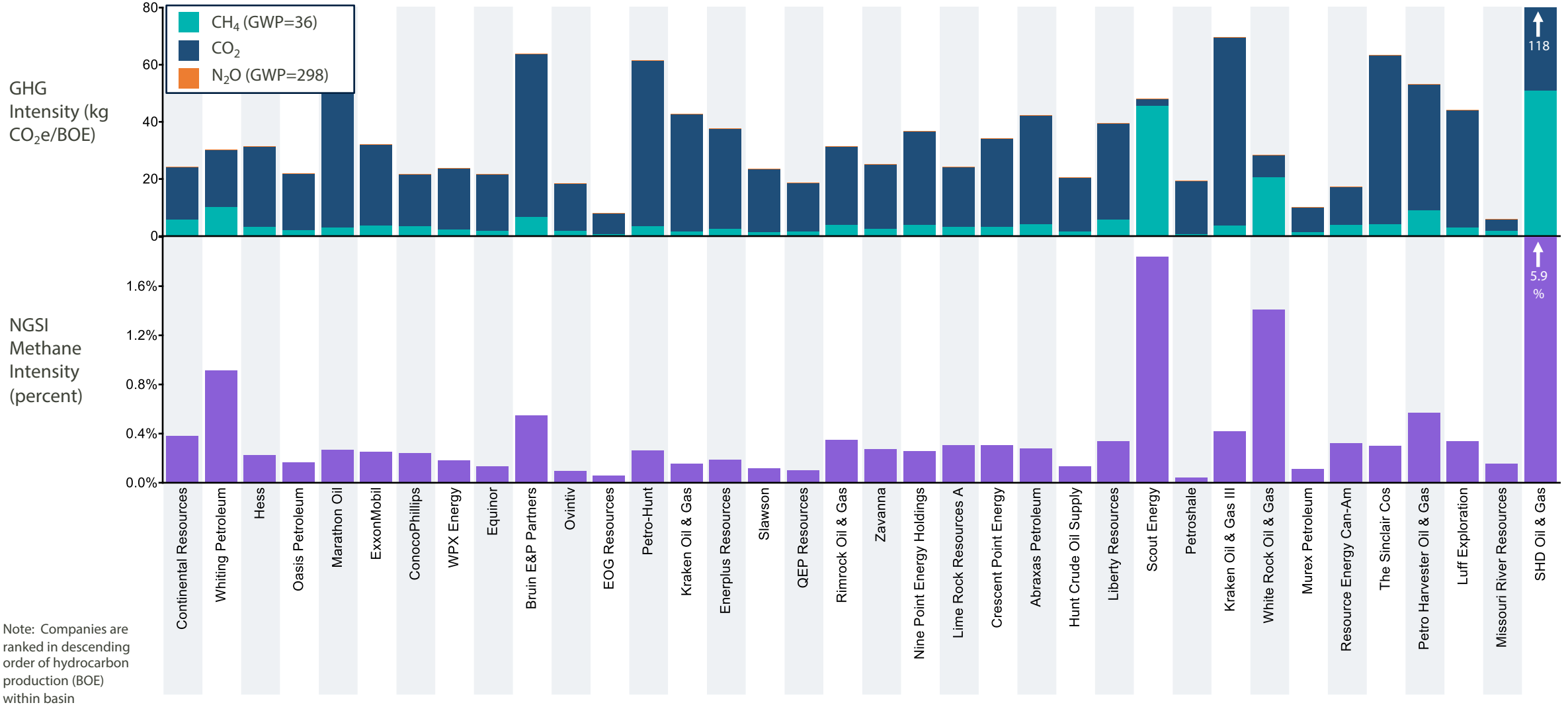
GHG Emissions by Source (100-year GWP)



Note: Companies are ranked in descending order of hydrocarbon production (BOE) within basin

Williston Basin Producers

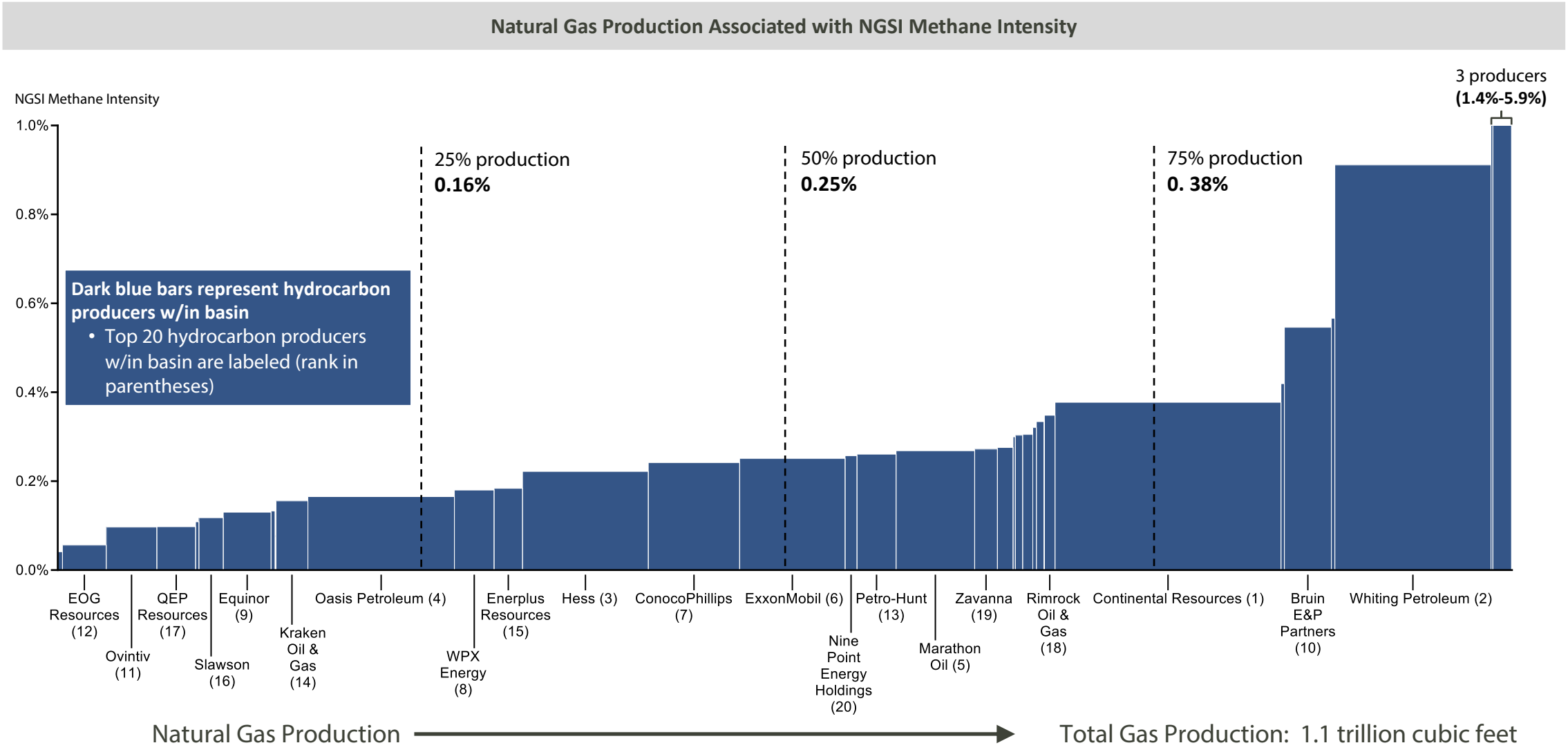
Methane & GHG Intensity (100-year GWP)



Note: Companies are ranked in descending order of hydrocarbon production (BOE) within basin

Williston Basin Producers

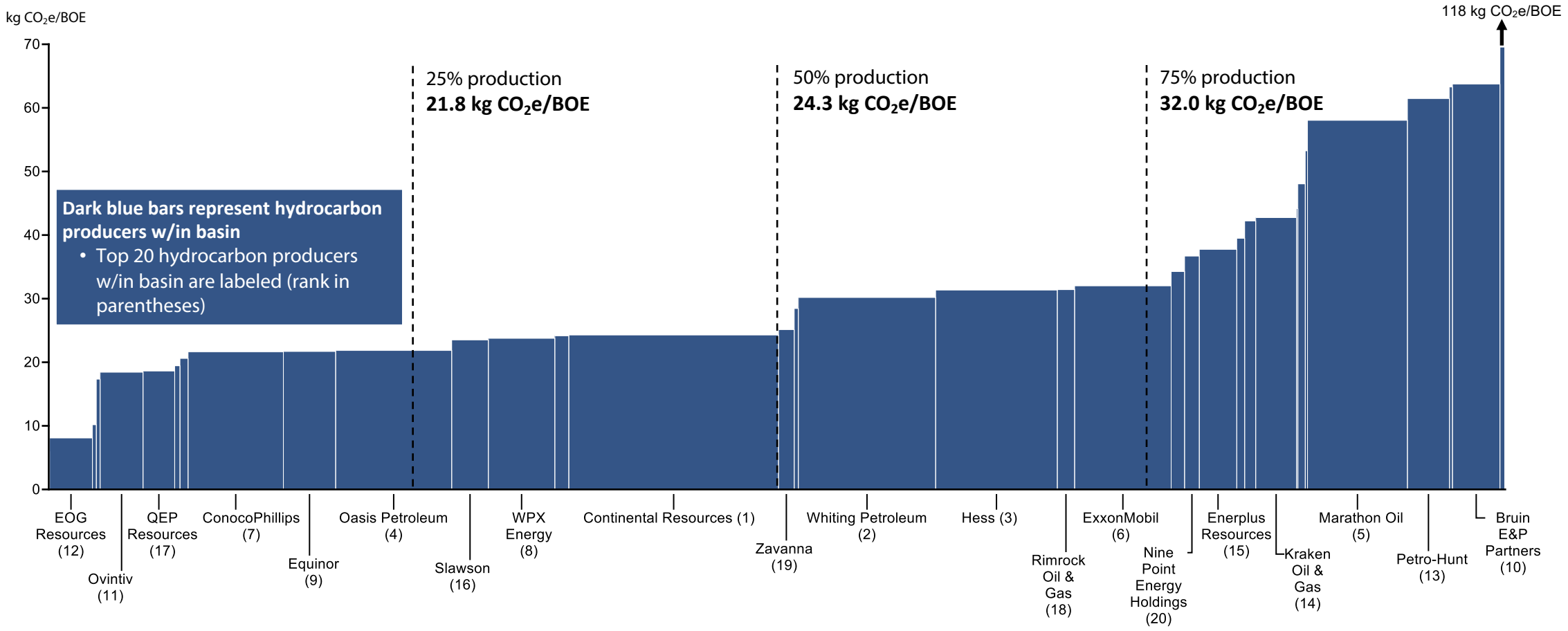
Total GHGRP Natural Gas Production, by Methane Intensity



Williston Basin Producers

Total GHGRP Hydrocarbon Production, by GHG Intensity

Hydrocarbon Production Associated with GHG Intensity



Data Sources & Methodology

This section describes the data sources and methodology used in this study. The methodology was developed by MJB&A with support from Ceres and CATF as part of a scoping study funded by the Bank of America Foundation in 2020. The scoping study included the development of a framework and methodology for using publicly available data, including GHG emissions data reported to and published by the U.S. EPA, to benchmark the production-segment methane and GHG emissions intensity of U.S. oil and natural gas producers.

As part of the scoping study, MJB&A engaged with and sought feedback from a Producer Review Panel composed of leading oil and gas companies with operations in the U.S. In addition to verifying the approaches and metrics used in the analysis, the Producer Review Panel provided valuable context on the data reported to EPA and recommendations on approaches for presenting the data in clear and meaningful ways. Final decisions on the methodology and the presentation of data were made by MJB&A.

Data Sources Used in this Analysis

U.S. EPA Greenhouse Gas Reporting Program (GHGRP)

EPA's GHGRP is the primary data source for this analysis. The GHGRP requires facilities with GHG emissions greater than 25,000 metric tons CO_2e per year to report these emissions and other data to EPA annually (note that EPA uses a GWP of 25 for methane in its threshold calculation). Subpart W of the GHGRP covers most segments of the oil and natural gas supply chains and requires reporting of methane, carbon dioxide, and nitrous oxide. Most emissions are calculated under Subpart W by multiplying company activity data by default emission factors that are applied to all companies; some emissions are based on direct measurements or company-specific emission factors derived from direct measurements.

This report includes emissions reported to EPA under Subpart W from facilities in the oil and gas production segment. Oil and gas production facilities are defined by EPA at the basin level for the purposes of GHGRP. All equipment on or associated with well pads within a production basin that are under common control by a company are considered a single facility. Under this framework, a given company has one production facility per basin, even if it operates hundreds of wells within that basin.

This report does not include emissions from sources in the gathering & boosting segment. Production and gathering & boosting infrastructure may be collocated, and different companies may classify equipment differently in their Subpart W reporting; equipment that one company reports in the production segment another company may report in the gathering & boosting segment.

Subpart W data reported by EPA's Envirofacts database accounts for all of the production data analyzed in this report, 99.4 percent of the methane data, more than 99.998 percent of the CO_2 data, and all of the N_2O data. The remainder is based on sources not included in the GHGRP but estimated based on the GHG Inventory, as described in page 51. This report uses the following 2019 Subpart W Envirofacts files:

- "EF_W_EMISSIONS_SOURCE_GHG"
- "EF_W_FACILITY_OVERVIEW"
- "EF_W_EQUIP_LEAKS_ONSHORE"
- "EF_W_ACIDGASREMOVAL_UNITS"
- "EF_W_CENTRIF_COMP_ONSHORE"
- "EF_W_RECIP_COMP_ONSHORE"

Data Sources Used in this Analysis (continued)

U.S. EPA Greenhouse Gas Inventory

EPA's GHG Inventory is an annual report that estimates total GHG emissions from the U.S. economy. The GHG Inventory is not a reporting program and does not estimate emissions from individual companies. Instead, it estimates emissions from major industries, including the oil and natural gas sectors. EPA calculates GHG Inventory estimates using national activity data and default emission factors.

The GHG Inventory estimates emissions from a number of sources that are not included in Subpart W reporting. This analysis calculates company emissions from these sources and adds them to emissions reported under Subpart W using activity data from Subpart W and emission factors from the GHG Inventory. Not all of the GHG Inventory emissions sources that are additional to Subpart W can be included due to lack of corresponding activity data in Subpart W (e.g., the GHG Inventory has a produced water emission factor, but Subpart W does not require reporting of the applicable activity factor).

For some of these sources, the GHG Inventory lists different emission factors for natural gas and oil wells. Subpart W does not distinguish between natural gas and oil wells. This report uses the natural gas emission factor for these sources. The GHG Inventory emission factors are used in conjunction with activity data reported under Subpart W to calculate approximately 0.6 percent of the methane emissions and 0.002 percent of the CO_2 emissions analyzed in this report. The GHG Inventory data used in this report are available in the natural gas and petroleum systems methodology annex files:

https://www.epa.gov/sites/production/files/2021-02/2021_ghgi_natural_gas_systems_annex36_tables.xlsx
https://www.epa.gov/sites/production/files/2021-02/2021_ghgi_petroleum_systems_annex35_tables.xlsx

EIA Data

As described in the Methodology section below, EIA data on regional natural gas liquid (NGL) production is used to estimate the non-methane and non-CO_2 composition of reported natural gas production. The ratio of NGL production for each region reported to EIA is applied to the unknown component of gas composition for gas produced in corresponding regions. EIA Natural Gas Plant Field Production file is the source of these data:

https://www.eia.gov/dnav/pet/pet_pnp_gp_dc_r10_mbbl_m.htm

Where available or provided, company-specific data were used to estimate the non-methane and non-CO_2 composition of reported natural gas production.

EIA natural gas and oil production data are used in this report to compare hydrocarbon production reported under Subpart W to total U.S. production:

https://www.eia.gov/dnav/ng/ng_prod_sum_a_EPG0_FGW_mmcf_m.htm
https://www.eia.gov/dnav/pet/pet_crd_crpdn_adc_mbbl_a.htm

Methodology

Greenhouse Gas Reporting Program Data

This report assigns production and emissions data to individual companies based on the facility owner/operator listed in the GHGRP's "Reported Parent Companies" database. These data are reported at the basin level; the national level data in this report are calculated by summing basin level data across basins using parent companies listed in the GHGRP. For production facilities with multiple owners/operators, production and emissions are allocated based on each company's percent ownership of the facility.

GHGRP data are based on facility ownership or operating control, not ownership of hydrocarbons. A company's equity share of emissions and hydrocarbons may therefore be higher or lower than reported to EPA and calculated in this analysis. Although most companies report equity production and a growing number report equity GHG emissions, publicly available data do not allow for the application of a uniform equity-based methodology to all of the producers in the GHGRP data set.

Production Segment Sources and GHGs Covered by Subpart W

Source	CH_4	CO_2	N_2O
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 (continued)

GHG Inventory Data

The table at right provides details on the assumptions for calculating emissions from sources using GHG Inventory emission factors, which were used for sources not reported to GHGRP. For compressor blowdowns, compressor starts, pressure release valve upsets, well drilling, and acid gas removal units, emissions are calculated by multiplying the GHG Inventory emission factor by the activity count reported under Subpart W. Only methane emissions are calculated for acid gas removal units as CO_2 emissions are captured in Subpart W.

The number of vessels are not reported under Subpart W. To calculate emissions from vessel blowdowns, the GHG Inventory assumption on the number of vessels located at each well is first applied. This number is multiplied by the reported well count to estimate the number of vessels and this product is then multiplied by the GHG Inventory emission factor to estimate emissions. Emissions from sources calculated using GHG Inventory emission factors are small and generally account for a small percentage of total emissions from a company or basin.

Emissions Source	GHG Inventory CH_4 Emission Factor	GHG Inventory CO_2 Emission Factor	Activity Factor
Vessel Blowdowns (applies to separators, heater-treaters, dehydrators, and in-line heaters)	**1.6 kg/vessel**	**0.18 kg/vessel**	**Well count from GHGRP; 0.87 vessels/well as per GHG Inventory**
Compressor Blowdowns	**76.9 kg/compressor**	**8.6 kg/compressor**	**Compressor count from GHGRP**
Compressor Starts	**172 kg/compressor**	**19.3 kg/compressor**	**Compressor count from GHGRP**
Pressure Relief Valve Upsets	**0.7 kg/valve**	**0.08 kg/valve**	**Valve count from GHGRP**
Well Drilling	**51 kg/well**	**6.6 kg/well**	**Gas wells completed from GHGRP**
Acid Gas Removal Units	**598 kg/AGRU**	**Captured in GHGRP**	**AGRU count from GHGRP**

Methodology (continued)

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 CO_2 molar content of produced gas but does not include information on other components of the gas. Because the percentage of methane and CO_2 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 CO_2 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	39%	35%	11%	5%	10%
PADD 2	IN, IL, & KY	28%	44%	10%	10%	8%
	MN, WI, ND, & SD	21%	40%	18%	5%	16%
	OK, KS, & MO	41%	32%	11%	6%	11%
PADD 3	LA (Gulf)	38%	33%	11%	7%	10%
	N. LA & AR	28%	26%	11%	9%	26%
	NM	41%	32%	10%	7%	11%
	TX (Inland)	43%	31%	10%	6%	10%
PADD 4 (Rocky Mountain)		25%	37%	14%	7%	16%
PADD 5 (West Coast)		0%	17%	16%	21%	46%

Methodology (continued)

Global Warming Potentials

Global warming potential (GWP) is used to quantify the climate impact of individual GHGs relative to CO_2 to allow for the comparison of different gases over different timescales. After conversion using GWPs, emissions are expressed using a standard metric, carbon dioxide equivalent (CO_2e).

This report uses the 100-year GWPs for methane and N_2O emissions from the Fifth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC AR5), which reflect the most recent scientific understanding of the climate impacts of individual GHGs. Both 100-year GWPs include the impact of climate-carbon feedbacks, and the methane GWP includes the impact of CO_2 from methane oxidation. The table at right also includes the AR5 GWP values without climate-carbon feedbacks and without methane oxidation.

This report's online database allows users to select from a range of GWPs under both 20- and 100-year time scales.

GHG	Additional Mechanisms	20-year GWP	100-year GWP
Methane (CH_4)	No climate-carbon feedbacks	84	28
	With climate-carbon feedbacks	86	34
	With climate-carbon feedbacks and methane oxidation	87	36
Nitrous oxide (N_2O)	No climate-carbon feedbacks	264	265
	With climate-carbon feedbacks	268	298

Source: https://www.ipcc.ch/site/assets/uploads/2018/02/WG1AR5_Chapter08_FINAL.pdf

Methodology (continued)

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 emission sources to source categories.

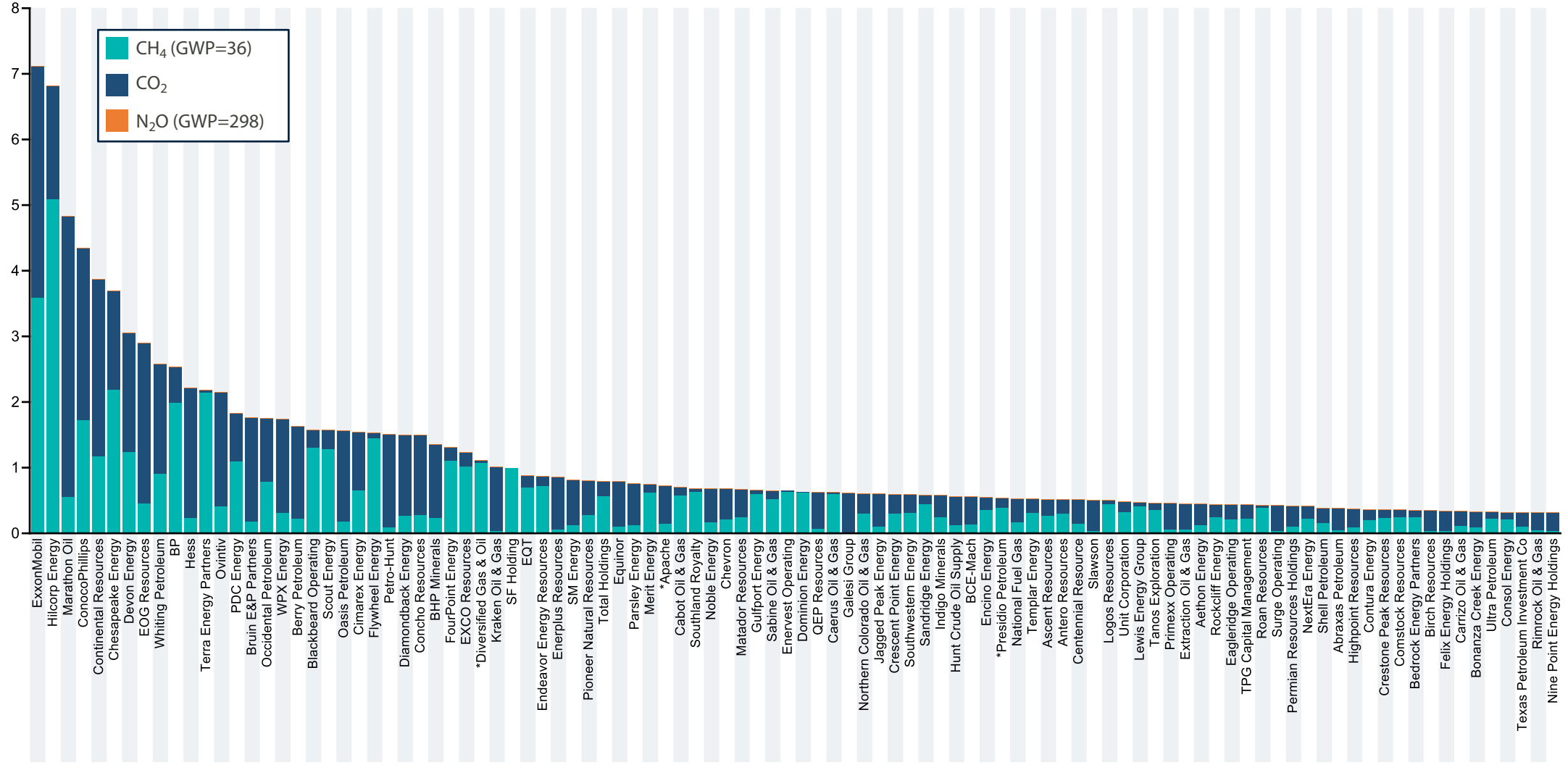
Emissions data on individual sources and their relative contribution to total emissions, by both individual GHG and total CO_2e, are available at the national, basin, and company level on the Oil and Gas Benchmarking interactive data website.

Source	CH_4 & N_2O 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

Appendix

Top 100 GHG Emitters

GHG Emissions (100-year GWP)

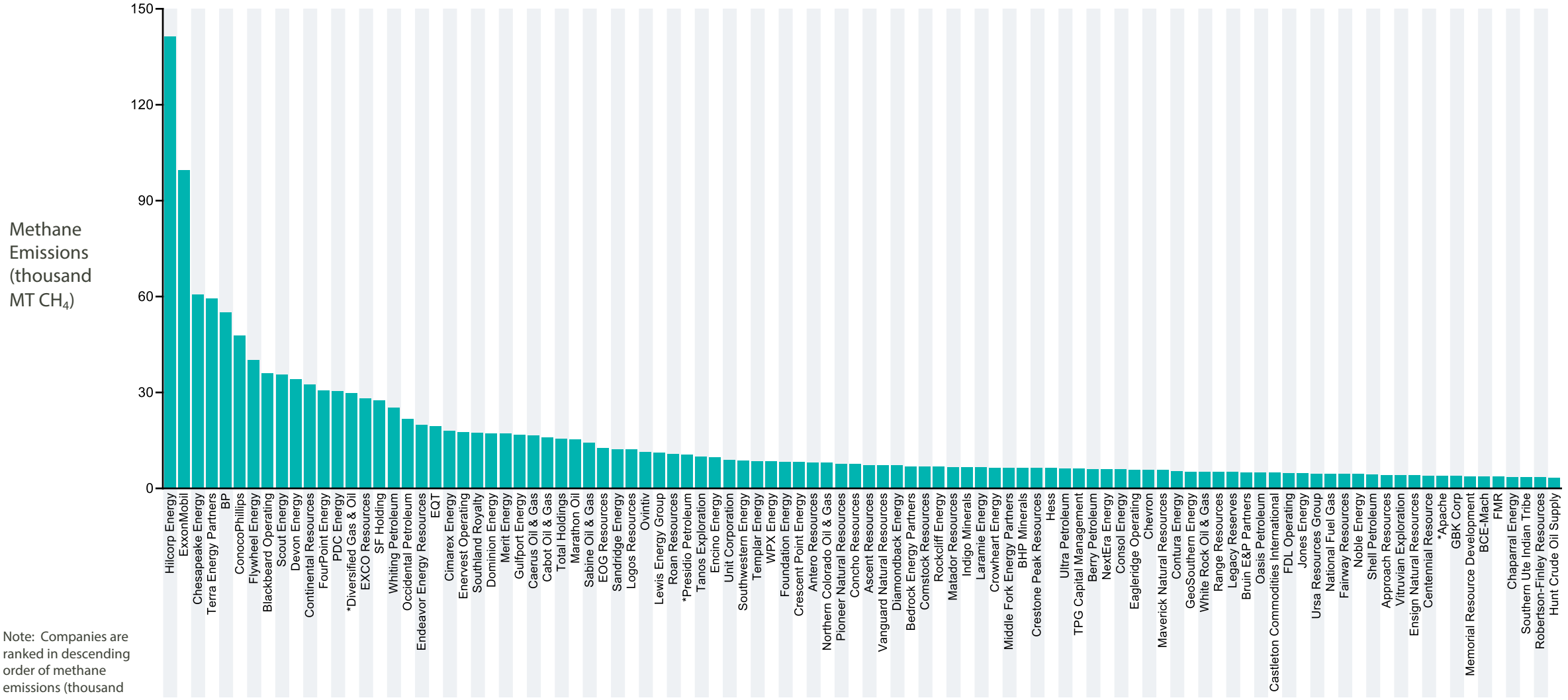


Note: Companies are ranked in descending order of GHG emissions (MMT CO_2e)

* Reflects unpublished data submitted by Apache and Diversified Gas & Oil that are currently under EPA review; Presidio Petroleum represents assets sold in 2019 that were allocated to Apache in the current EPA data set

Top 100 Methane Emitters

Methane Emissions

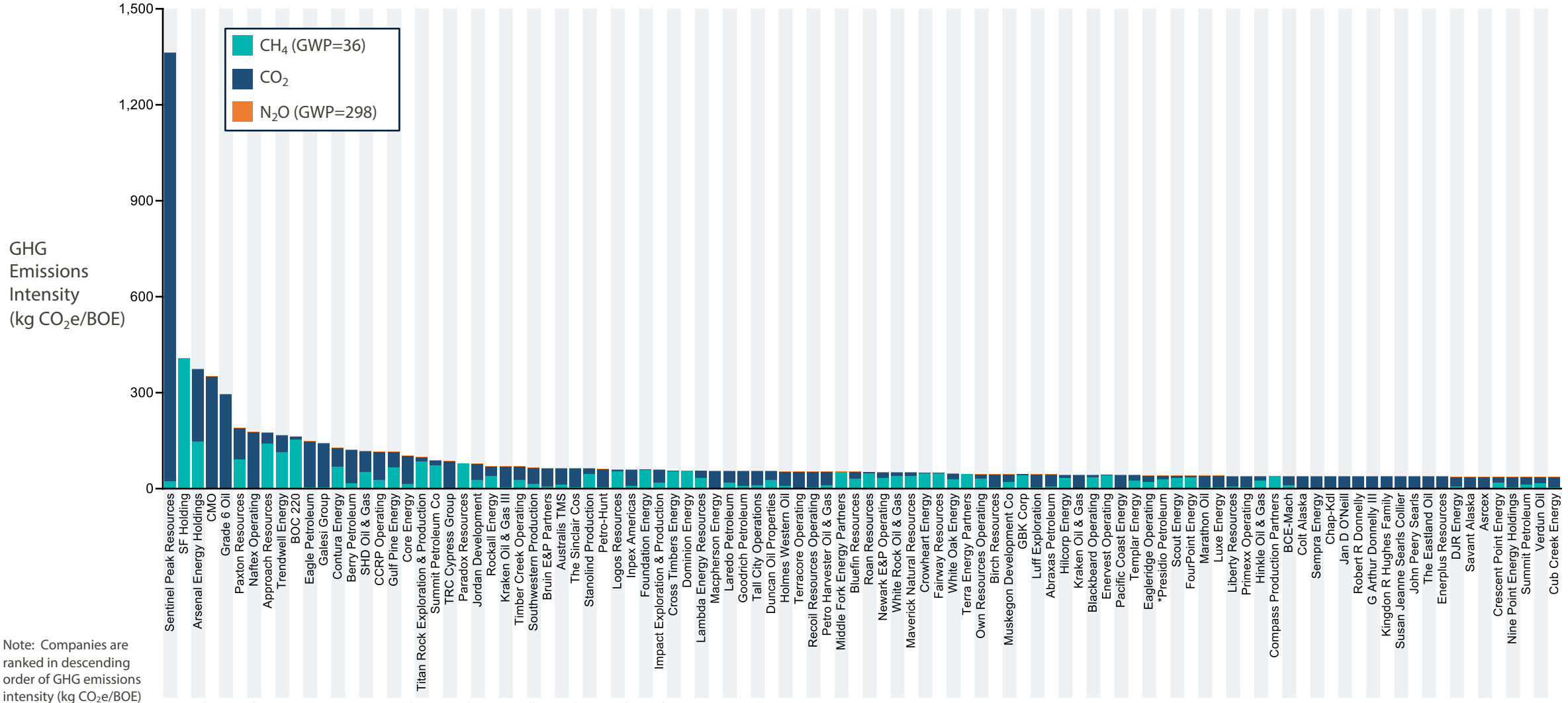


Note: Companies are ranked in descending order of methane emissions (thousand MT CH_4)

* Reflects unpublished data submitted by Apache and Diversified Gas & Oil that are currently under EPA review; Presidio Petroleum represents assets sold in 2019 that were allocated to Apache in the current EPA data set

Top 100 Highest GHG Emissions Intensities

GHG Emissions Intensity

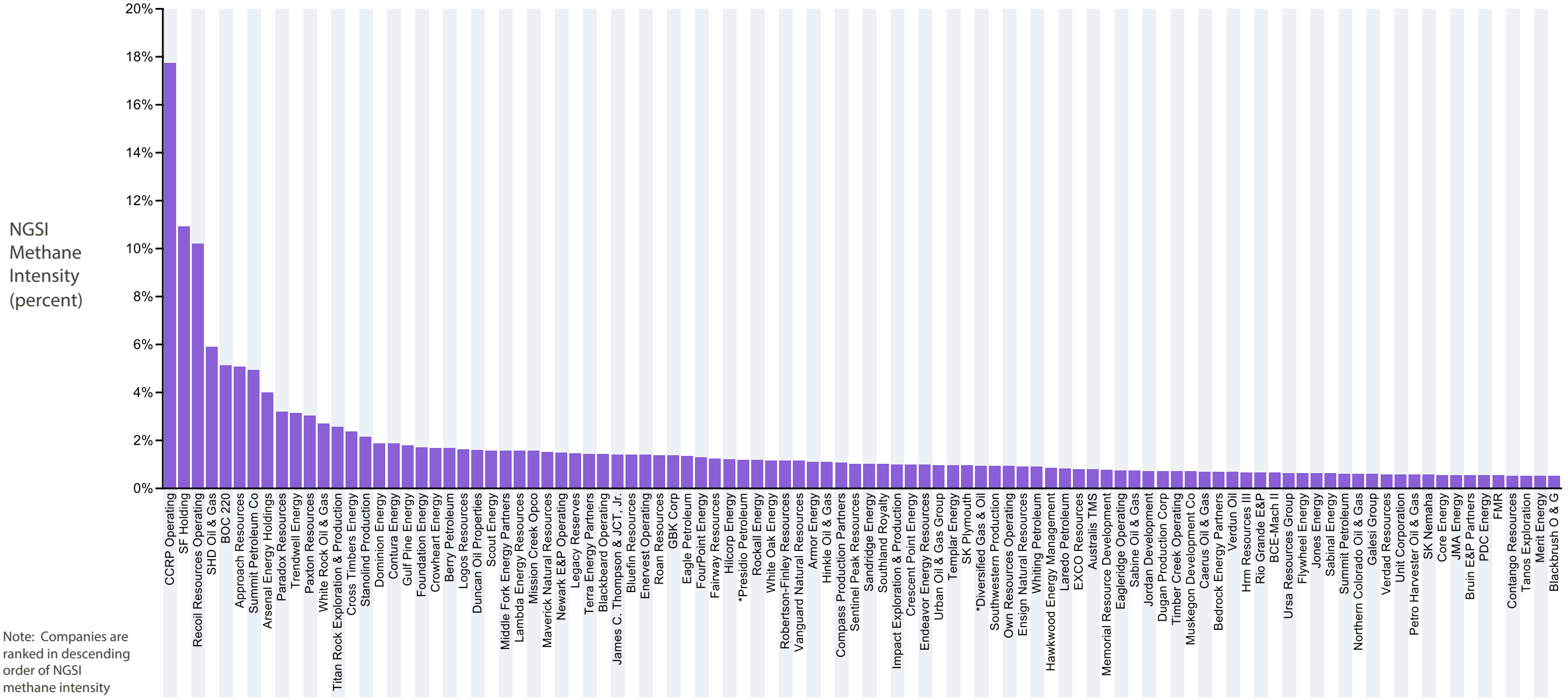


Note: Companies are ranked in descending order of GHG emissions intensity (kg CO_2e/BOE)

* Presidio Petroleum represents assets sold in 2019 that were allocated to Apache in the current EPA data set

Top 100 Highest NGSI Methane Intensities

Methane Intensity

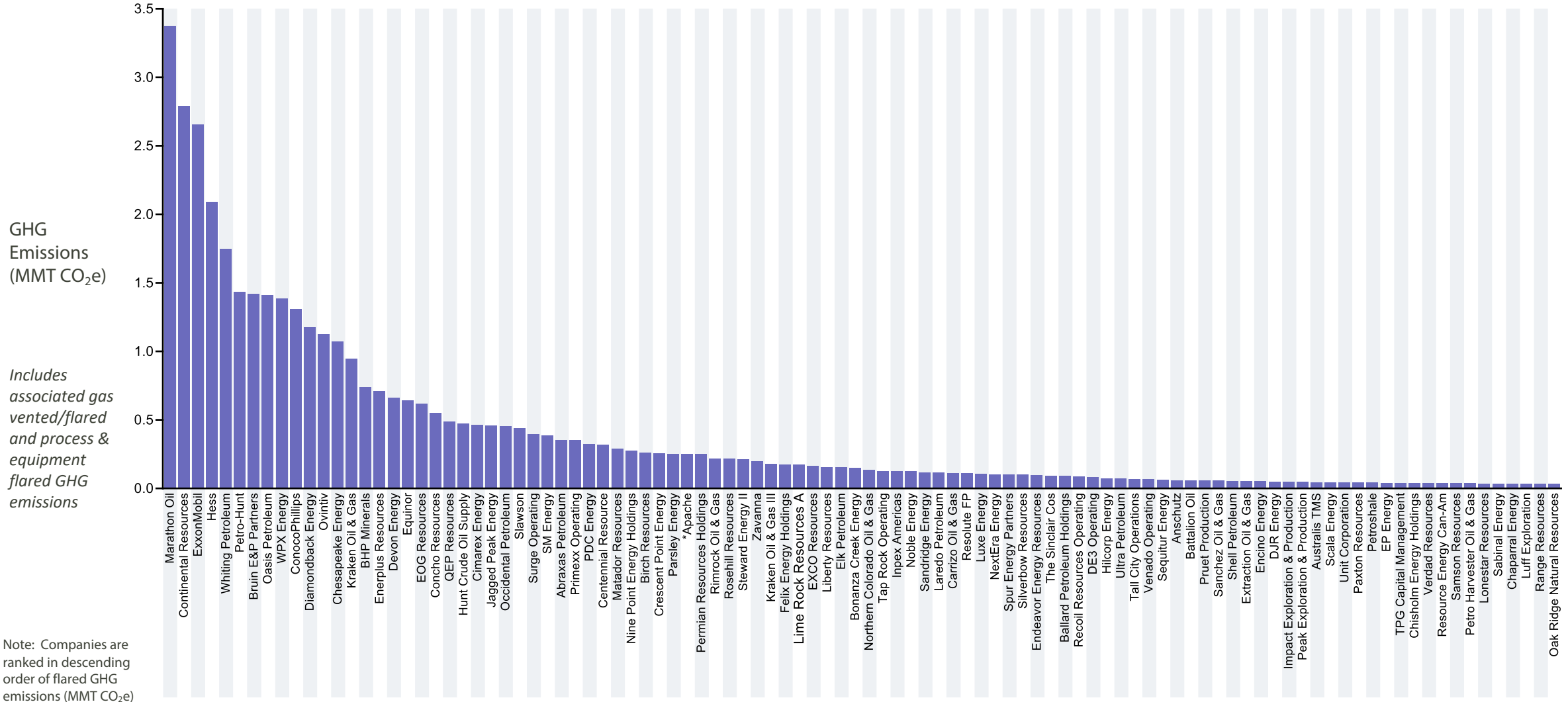


Note: Companies are ranked in descending order of NGSI methane intensity (percent)

* Reflects unpublished data submitted by Diversified Gas & Oil that are currently under EPA review; Presidio Petroleum represents assets sold in 2019 that were allocated to Apache in the current EPA data set

Top 100 Flared GHG Emissions

Associated Gas Venting/Flaring and Other Flaring GHG Emissions (100-year GWP)



Includes associated gas vented/flared and process & equipment flared GHG emissions

Note: Companies are ranked in descending order of flared GHG emissions (MMT CO_2e)

* Reflects unpublished data submitted by Apache that are currently under EPA review