Xpansiv

Digital Fuels Program

2022-2023 Methane Emissions Benchmark

DIGITAL FUELS PROGRAM:

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This annex to the **Quantification Framework for Digital Natural Gas and Methane Performance Certificates** ("Quantification Framework", originally published in June, 2021 and updated October 2021) provides an updated benchmark for Xpansiv's Digital Fuels Program to contextualize methane emissions intensities for specific units of natural gas production.

In Section 3 of the 2021 Quantification Framework, an average "baseline" methane emissions rate from natural gas production was estimated based on the most recent U.S. Greenhouse Gas Inventory submitted by the U.S. government as part of the United Nations Framework Convention on Climate Change (UNFCCC) and corresponding levels of natural gas production reported by the U.S. Energy Information Administration (EIA). As described in Section 5 of that document, that average methane emission rate is used in calculating the number of Methane Performance Certificates associated with a specific volume of produced natural gas from an individual production facility.

With release of the 2022 U.S. Greenhouse Gas Inventory, Xpansiv is updating the average, baseline methane emissions rate from natural gas production, using the methodology provided in Section 3 of the Quantification Framework, replicated below with the most recently available information.

Equation #1. Baseline rate of upstream methane emissions from natural gas

$$BER_{CH4,U} = \frac{AME_{NG} * ER_{NG} * 1000}{MK_{NG} * \rho_{CH4}}$$

WHERE		UNITS
BER_{CH4}	Baseline rate of upstream methane emissions in natural gas production	%
AME_{NG}	Aggregate U.S. methane emissions from production of natural gas	kts
ER_{NG}	Energy ratio of produced natural gas relative to the energy content of total hydrocarbons produced with natural gas	%
ρ_{CH4}	Density of methane	MT/MCF
MK_{NG}	Marketed U.S. production of natural gas	MMCF

Values for the parameters used for Equation #1 are listed in Table 1.

Table 1. Parameter Values for Equation #1

PARAMETER	VALUE	SOURCE
2020 methane emissions from production of natural gas ($AME_{NG, U}$) including gathering and boosting	5,012	See Equation #2
Energy ratio (ER_{NG})	0.59	See Equation #3
2020 Marketed U.S. natural gas production(MK_{NG})	36,202,446 MMCF	EIA: 2020 *Natural Gas Gross Withdrawals and Production*[2], Marketed Production Data Series, Annual Million Cubic Feet
Density of Methane (ρ_{CH4})	0.0192 MT/MCF	US EPA GHGRP, 40 CFR 98.233 (u)(2)(v)

Equation #2 Aggregate methane emissions from production of natural gas

$$AME_{NG} = ME_{NGS} + ME_{PS}$$

WHERE		UNITS
ME_{NGS}	Aggregate U.S. methane emissions from natural gas systems	kts
ME_{PS}	Aggregate U.S. methane emissions from petroleum systems	kts

Values for the parameters used for Equation #2 are listed in Table 2.

Table 2. Parameter Values for Equation #2

PARAMETER	VALUE	SOURCE
2019 methane emissions from natural gas systems (ME_{NGS})	3748 kts	*Inventory of U.S. Greenhouse Gas Emissions and Sinks 1990-2019, Table 3-64.*[9] Natural gas production includes onshore and offshore production and gathering and boosting. Emissions from processing and exploration are not included.
2019 methane emissions from petroleum systems (M_{EPS})	1508 kts	*Inventory of U.S. Greenhouse Gas Emissions and Sinks 1990-2019, Table 3-39**. Petroleum production includes: pneumatic controllers, offshore production, gas engines, equipment leaks, produced water, associated gas flaring, other sources.

Equations #3 and #4 provide derivations for the energy ratio of natural gas.

[2]https://www.eia.gov/dnav/ng/ng_prod_sum_a_EPG0_FGW_mmcf_a.htm
[3]EPA (2021) Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2020. Published May 2022

Equation #3. Energy Ratio

$$ER_{NG} = \frac{(P_{NG} * 1000 * EC_{NG})}{TEC_{NGHC}}$$

WHERE		UNITS
P_{NG}	2019 U.S. natural gas production	MCF
EC_{NG}	Energy content of natural gas	MMBtu/MCF
TEC_{NGHC}	Total energy content of all US hydrocarbon production	MMBtu

Values for the parameters used for Equation #3 are listed in Table 3.

Table 3. Parameter Values for Equation #3

PARAMETER	VALUE	SOURCE
Energy intensity of natural gas in the U.S. (EC_{NG})	1.146 MMBtu/MCF	Energy Information Administration, U.S. Department of Energy, *Monthly Energy Review, May 2021*, Table A4.[4]
Total Energy Content of all US hydrocarbon production (TEC_{NGHC})	78,350,226,015 MMBtu	See Equation #4

Equation #4. Total energy content of all US hydrocarbon production

$$TEC_{NGHC} = (P_{CO} * 1000 * EC_{CO}) + (P_{NG} * 1000 * EC_{NG}) + (P_{LC} * 10^{6} * EC_{LC}) + (P_{NGL} * 10^{6} * EC_{NGL})$$

WHERE		UNITS
P_{CO}	2020 U.S. crude oil production	MBBL
EC_{CO}	Energy content of crude oil	MMBtu/BBL
P_{NG}	2020 US natural gas production	MMCF
EC_{NG}	Energy content of natural gas	MMBtu/MCF
P_{LC}	2020 U.S. production of lease condensate	MMBBL
EC_{LC}	Energy content of lease condensate	MMBtu/BBL
PN_{GL}	2020 U.S. production of natural gas plant liquids	MMBBL
EC_{NGL}	Energy content of natural gas plant liquids	MMBtu/BBL

[4]EPA (2021) Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2019. Published May 2021

Table 4. Parameter Values for Equation #4

PARAMETER	VALUE	SOURCE
2020 U.S. crude oil production (P_{CO})	4,129,563 MBBL	Energy Information Administration, U.S. Department of Energy[5]
Energy content of crude oil (EC_{CO})	5.691 MMBtu/BBL	Energy Information Administration, U.S. Department of Energy, *Monthly Energy Review, April 2022,* Table A2.[6]
2020 U.S. Natural Gas Production (P_{NG})	40,613,767 MMCF	Energy Information Administration, U.S. Department of Energy[7]
Energy Content of natural gas (EC_{NG})	1.146 MMBtu/MCF	Energy Information Administration, U.S. Department of Energy, *Monthly Energy Review, April 2022*, Table A4[8]
2020 U.S. production of lease condensate (P_{LC})	308 MMBBL	Energy Information Administration, U.S. Department of Energy[9]
Energy content of lease condensate (EC_{LC})	4.638 MMBtu/BBL	Energy Information Administration, U.S. Department of Energy, *Monthly Energy Review, April 2022*, Table A1, Natural Gasoline (Pentanes Plus)[10]
2020 U.S. production of natural gas plant liquids (P_{NGL})	1,914 MMBBL	Energy Information Administration, U.S. Department of Energy[11]
Energy content of natural gas plant liquids (EC_{NGL})	3.593 MMBtu/BBL	Energy Information Administration, U.S. Department of Energy, *Monthly Energy Review, April 2022*, Table A2[12]

Using Equation #1, a baseline rate of methane emissions (BER_{CH4}) associated with natural gas production for 2020 in the U.S. yields:

$$BER_{CH4} = 0.428\%$$

For present purposes, the baseline emission calculation does not include midstream sources of methane emissions including transmission, storage and distribution; these other segments are being added in future DNG-derived products.

As noted in the 2021 Quantification Framework, this is only one of potentially multiple approaches that could be used to compute the baseline for upstream methane emissions from natural gas production.

[5]https://www.eia.gov/dnav/pet/pet_crd_crpdn_adc_mbbl_a.htm
[6]https://www.eia.gov/totalenergy/data/monthly/pdf/mer.pdf
[7]https://www.eia.gov/dnav/ng/ng_prod_sum_a_EPG0_FGW_mmcf_a.htm
[8]https://www.eia.gov/dnav/ng/ng_prod_lc_s1_a.htm
[9]https://www.eia.gov/totalenergy/data/monthly/pdf/mer.pdf
[10]https://docs.google.com/spreadsheets/d/1vBMEgiQwgHNIR_9jHaRawzlQh_nDjx7n/edit#gid=1485512482

For example, a recent collaboration of industry stakeholders reported a methane emissions “benchmark” of 0.12% (MJ Bradley, 2021), based on “Subpart W” data reported to the U.S. EPA under the Agency’sGreenhouse Gas Reporting Program (GHGRP) from facilities with GHG emissions greater than 25,000 metric tonnes CO2e per year. Emissions are estimated by individual facilities using default activity and emission factors.Facilities used various methods prescribed by the EPA to calculate GHG emissions, such as direct measurement, engineering calculations, or emission factorsspecified in the regulation (Subpart W, 40 CFR 98.232).

The value for methane emissions from natural gas production used in Equation #1 is the aggregated value representing natural gas production, as reported in the 2022 U.S. Inventory of Greenhouse Gas Emissions and Sinks(GHGI).The U.S. GHGI, which includes data from the GHGRP, is submitted on an annual basis by the United States to comply with existing commitments under the United Nations Framework Convention on Climate Change (UNFCCC). In addition to representing smaller natural gas production facilities, the aggregated methane emissions value used in Equation #1 includes the gathering and boosting segment which is part of the natural gas production category in the U.S. GHGI.

Other baselines or “benchmarks” for methane emission rates could be determined to be more applicable for particular geographies, types of production, or other variables.For any calculation based on existing reporting frameworks, data may under-represent the influence of the small number of “super-emitting” sources, or infrequent peak events (liquid unloading) that can account for a disproportionately large fraction of total methane emissions. A 5-year meta-analysis of ground-level and air monitoring data from 16 studies coordinated by the Environmental Defense Fund, involving over 40 institutions and 50 natural gas companies, found that methane leaks from natural gas systems were approximately 60% higher than what is reported to the U.S. EPA.[11] Additional information would be needed to assess whether adjustments to estimated baselines would provide a more accurate estimate of an average emissions rate.

[11]Alvarez, R.A., et al. (2018) Assessment of methane emissions from the U.S. oil and gas supply chain.Science361:186-188