FUGITIVE EMISSIONS FROM FLARING

Flares vastly underperform, leading to a five-fold increase in their climate impact

MITIGATION OPPORTUNITY

Both inefficient and unlit natural gas flares emit large quantities of methane.

Current estimates of flaring's climate impact generally assume flares are always lit and destroy methane (the primary component of natural gas) with 98% efficiency. Neither assumption is founded in real-world observations.

Researchers conducted an airborne survey that directly measured flare performance across the three areas responsible for >80% of flaring in the U.S. They combined these observations with unlit flare prevalence surveys. They found that both unlit flares and inefficient combustion contribute comparably to ineffective methane removal, with flares effectively destroying on average only 91.1% of methane.

This means that nearly five times more methane is released to the atmosphere from flares than presently assumed, which, if mitigated, would be equivalent to removing ~2.9 million cars from the road. This finding highlights a previously underappreciated methane source and mitigation opportunity. Increasing flare efficiency, reducing the number of unlit flares, and reducing flare volume overall would all be effective interventions.

WHY IS NATURAL GAS FLARED?

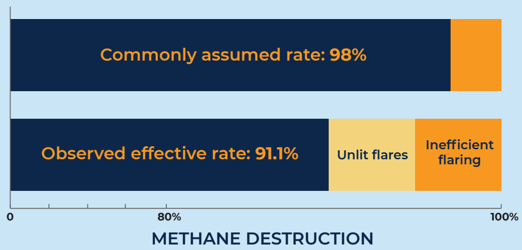
Flaring occurs for a number of safety, infrastructure, regulatory, and economic reasons in the extraction and processing of hydrocarbon fuels.

The bulk of persistent flaring occurs both in the processing of hydrocarbons and with associated gas produced during oil production.

The primary reason for drilling and extraction is oil, but when harvesting oil, natural gas is often produced as a by-product known as associated gas. If there isn't infrastructure to capture and/or it isn't economic to capture at low volumes, this associated gas is then flared in many jurisdictions.

IMPROVE FLARE PERFORMANCE TO REDUCE EMISSIONS

Unlit flares and inefficient flares contribute a comparable volume of emissions



Field data measures massive uncounted emissions

5X

Real-world observations find that unlit flares and inefficient combustion result in ineffective methane destruction, destroying only 91.1%. Using basin-specific measurements for the U.S. (0.49 Tg observed emissions), this represents a **five-fold increase** over present calculations, which assume only 2% (0.1 Tg) is emitted, while 98% is destroyed.

Three interventions can mitigate fugitive emissions

- Reduce the total volume of flaring activity
- Increase flare efficiency
- Reduce the number of unlit flares

F³UEL Flaring & Fossil Fuels: Uncovering Emissions & Losses

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BACKGROUND

Whether due to economic or safety considerations, if an excess of natural gas is present that cannot be captured, the combustion process of flaring converts this methane-heavy waste product to carbon dioxide and water. This flaring process aims to reduce the climate impacts that would result from venting methane which has a greater global warming potential than CO_2, directly into the atmosphere. Flaring also releases nitrogen oxides (NO_X) and other hazardous air pollutants. The assessment of NO_X emissions and air quality implications will be the subject of forthcoming work.

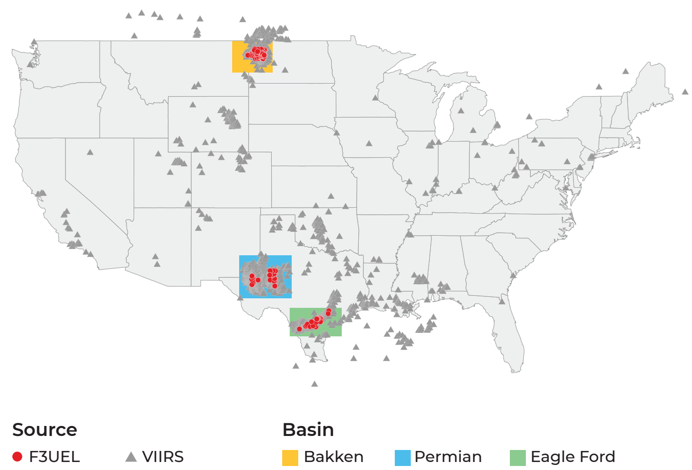
The U.S. ranks among the top five nations globally for flaring activity. Accounting of flare-related emissions is based on the assumption that 98% of the CH_4 within the flare gas is destroyed through combustion. This assumption stems not from measurements of real-world flare operations, but rather from a limited controlled study conducted in the 1980s.

In addition to the efficiency of combusting flares, the prevalence of unlit flares (i.e., directly venting hydrocarbon gas to the atmosphere due to the flame extinguishing or never being lit) must also be considered to understand the full impact of flaring activities on CH_4 emissions.

Despite a growing body of research highlighting the important role unlit flares play in methane emissions, the importance of unlit flares compared to inefficient combustion has been unknown. Studies of the efficiency of real-world flares have been limited. More complete knowledge is needed to determine efficient and effective mitigation efforts. This new research helps fill those gaps.

KEY FINDINGS

- **Both inefficient combustion and unlit flares contribute to substantial methane emissions that greatly exceed standard estimates for flaring.**
- **Mitigation efforts that address either combustion efficiency or unlit flares** (such as operational practices on flare maintenance), or reducing the usage of flares altogether (with alternatives such as re-injection or small-scale gas capture technology) would provide significant methane emission benefits.
- **DRE values are skewed.** Destruction removal efficiency (DRE) characterizes how well a flare's combustion destroys CH_4 in the waste gas. The majority of flares function close to expected performance, with DRE values near 98%. However, across all basins, a relatively modest number of poorly performing flares (with DRE values as low as 60%) were observed to cause a significant drop in average performance.
- **Unlit flares directly vent unburned gas to the atmosphere due to the flame being extinguished or never properly ignited, resulting in an additional impact on the flaring CH_4 budget.** Given, based on observations, that ~3-5% of flares are unlit, the relative contribution of both poorly combusting and unlit flares to total CH_4 flaring emissions is similar.
- **Observed DRE combined with rate of unlit flares results in effective flare efficiencies that are considerably lower than the expected 98% across all three basins.** The average observed DRE across the three regions of study is 95.2% and the average total effective DRE after accounting for unlit flares is 91.1%. These emissions estimates are ~5x larger than if assuming 98% DRE for all flares quantified by VIIRS and no occurrences of unlit flares (0.10 Tg CH_4/year). This indicates that flaring activities are a much larger part of the CH_4 O&G footprint than previously estimated.
- **Our U.S. average effective 91.1% DRE is similar to the International Energy Agency's new 92% global efficiency estimate, which estimates 8 Tg CH_4 emissions in 2020--a magnitude similar to the worlds ultra-emitters and equal to 8-11% of total global oil and gas emissions.**



In 2020, more than 85% of U.S. gas volumes flared or vented occurred in North Dakota and Texas, overwhelmingly within the Permian Basin, the Eagle Ford Shale, and the Bakken Formation. The F3UEL project targets these areas of primary flaring activity. To investigate flare performance at the basin scale, researchers deployed a Scientific Aviation Mooney aircraft, sampling flares in the three basins over 12 dedicated research flights, each four to five hours in length.

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ABOUT THE PROJECT

This research is part of the Flaring and Fossil Fuels: Uncovering Emissions and Losses (F3UEL) project, which aims to enhance public and scientific understanding of environmental impacts of offshore energy production and natural gas flaring. The project is funded by the Alfred P. Sloan Foundation with additional support from the Environmental Defense Fund, Scientific Aviation, and the University of Michigan.

F3UEL Flaring & Fossil Fuels: Uncovering Emissions & Losses