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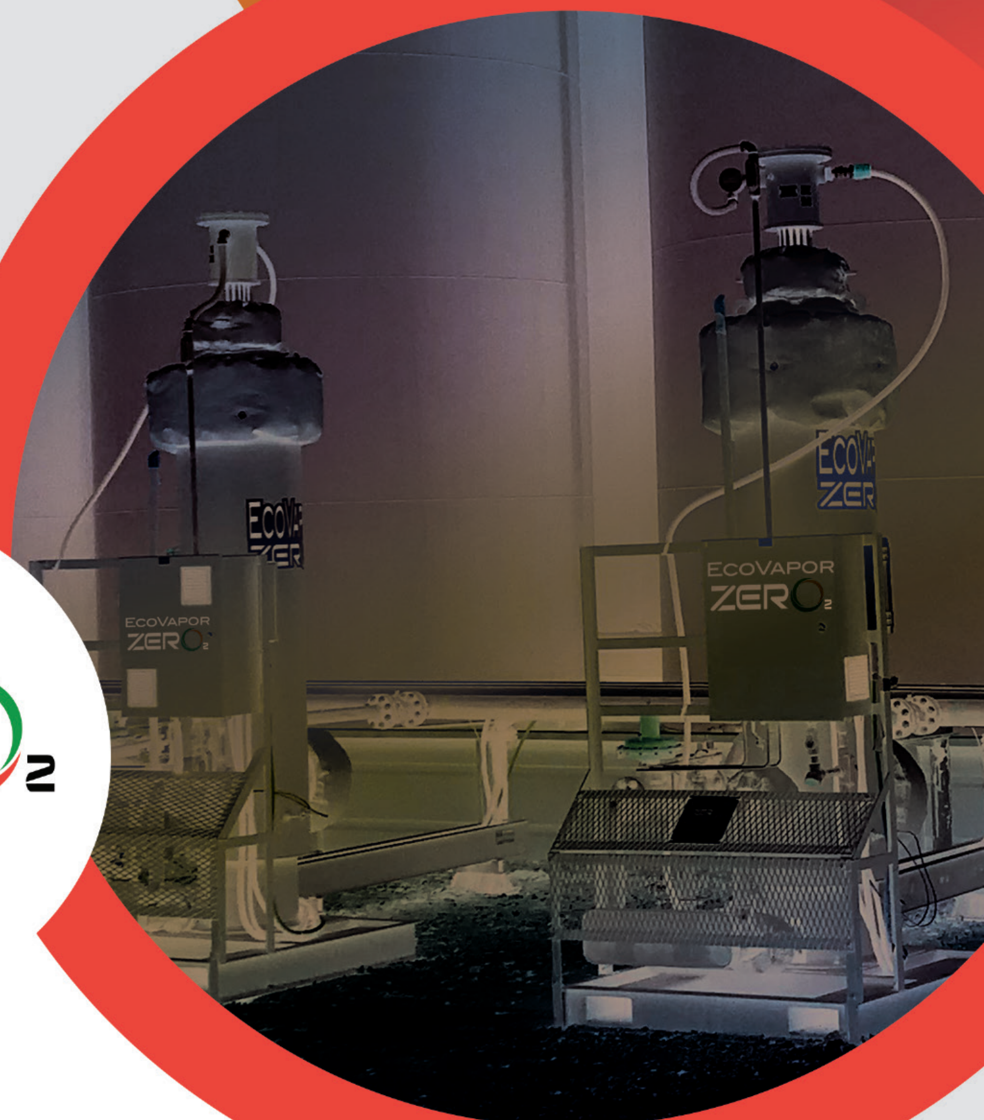


ZERO2

CASE STUDY

INDUSTRY EMISSIONS REDUCTION TARGETS CANNOT BE MET WITHOUT ADDRESSING TANK BATTERY FLARING AND VENTING

February 2022

EXECUTIVE SUMMARY

The U.S. oil & gas industry is under increasing pressure from regulators and key stakeholders to reduce methane emissions, eliminate routine flaring, and decrease overall GHG emissions. Up to now the focus has been on mitigating fugitive methane emissions and eliminating routine flaring of produced gas. More recently, it has been discovered that tank batteries, tank flares and combustors are significant sources of emissions that any serious plan for improving air quality must address.

This paper documents the role of tank batteries using both industry-wide estimates and direct measurements on site, including the differences between these data sources and the implications.

BACKGROUND

The U.S. Environmental Protection Agency (EPA) first established guidelines for tank batteries in 2012 with the advent of standards under the Clean Air Act ("Quad-O"), which mandated larger production sites to reduce emissions by 95%. Since then, the conventional practice to achieve this objective has been to use a vapor recovery tower (VRT) located upstream of the tank battery (to minimize oxygen ingress) and then direct the remaining uncaptured vapor to one or more flare(s).

Flaring, however, has come under intense scrutiny as burning of natural gas produces emissions of both carbon dioxide, a primary GHG, and nitrogen oxides, a precursor of ozone pollution. Inoperable and/or malfunctioning flares also result in vented methane emissions.

Consequently, the investment community led by the World Bank and other large institutions, and state governments are pressuring the industry to improve its ESG performance. Colorado, Pennsylvania and New Mexico have recently implemented new mandates to reduce emissions from oil & gas operations further, and new federal regulations are expected later this year from both the EPA and Department of Interior.

In light of more stringent emissions rules, current operational practices regarding tank venting and flaring are being called into question. The primary issue being – can operators achieve environmental performance goals demanded by Wall Street and/or comply with existing and pending regulations without reductions in tank venting and flaring?

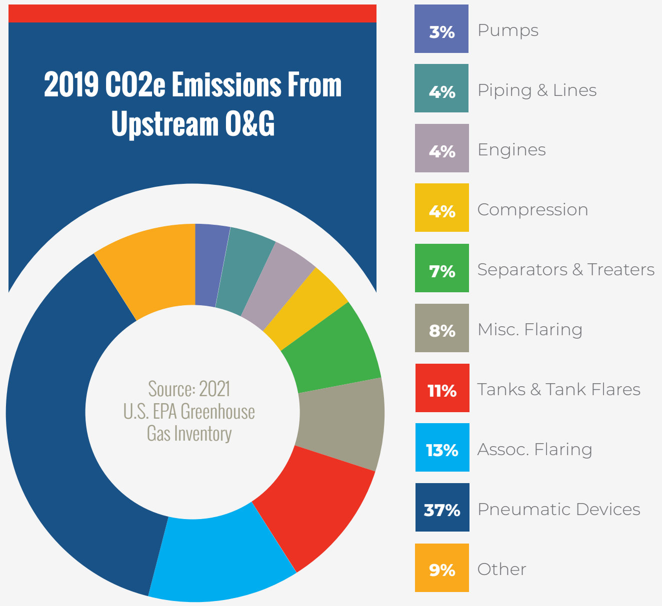
Let's look at the data.

CONTRIBUTION OF GHG EMISSIONS FROM TANKS – NATIONAL ESTIMATES

This chart illustrates GHG emissions sources in the upstream oil & gas sector, as estimated by the EPA from 2019, the most recent year for which information is available.

The emissions volumes are based on the aggregate estimates of methane, CO2, and N2O emissions on a CO2e equivalent basis. **EPA estimates identify tanks and tank flares as the THIRD largest source of emissions after pneumatic devices and routine flaring, accounting for 11% of total upstream GHG emissions**.

Total tank emissions are the result of leaks, tank venting and downstream flaring of the low-pressure vapor from both oil and water storage tanks. In this paper, we focus on flaring.



THE OTHER SOURCE OF ROUTINE FLARING – TANK BATTERIES

Flaring of produced gas at well sites lacking pipeline infrastructure represents the majority of industry emissions associated with flaring, but the flaring of tank vapor itself is a significant and often overlooked source. **Why does tank flaring occur even at well sites connected to natural gas pipelines? VRTs are inefficient and fail to capture all upstream of the tank battery, meaning the remaining low-pressure tank vapor must be flared – and on a routine basis.**

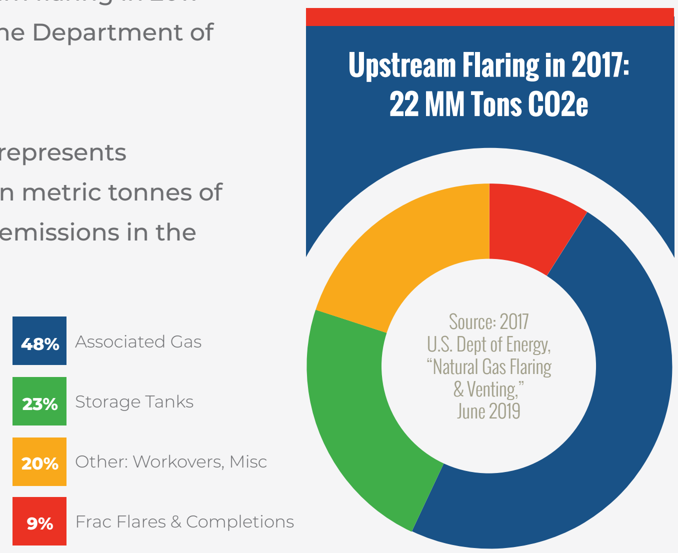
Even for wells connected to natural gas pipelines, routine flaring of tank vapor is unavoidable unless all the site vapor is captured directly from the tank battery. Even in ideal conditions, VRTs typically recover only 70% of total “flash gas” vapor volume. The rest remains entrained in the production stream, only to come out of solution later when oil, condensate and water are stored in tanks for any length of time.

A CLOSER LOOK AT ROUTINE FLARING

The narrow focus on the flaring of associated gas at production sites lacking infrastructure fails to provide the complete picture on emissions, so we must widen our scope to get the full view.

This chart shows sources of upstream flaring in 2017 in terms of CO_2e, as estimated by the Department of Energy.

While the flaring of associated gas represents essentially half of the total 22 million metric tonnes of CO_2e, the second largest source of emissions in the upstream sector is from the tank batteries.



The DoE data demonstrates that current practices for complying with Federal regulations, primarily using VRTs, are inefficient, fail to capture a significant volume of emissions and require oil and gas operators to routinely flare tank vapor gas. The implication is clear – we must focus on the tank battery as an emissions source.

EPA ESTIMATION METHODOLOGY

The EPA's Greenhouse Gas Inventory estimates are just that – best guesses of actual emissions. The EPA emission factors are based on a variety of sources including modeling, surveys, industry panel input, consulting studies, and technical reports. These factors are applied to the frequency of events and activities in the sector to derive a national estimate of industry emissions.

Statistically, the EPA data is useful to policy makers, but it is not specific enough for developing an emissions control plan that will be effective in eliminating all routine flaring and venting at production sites.

DIRECT MEASUREMENT

Leading operators and regulators recognize that emissions control plans based on EPA estimates are not sufficient for eliminating all routine flaring and venting. This becomes evident when standing on a production pad that has obtained all the necessary air permits, yet the tank flare continues to burn.

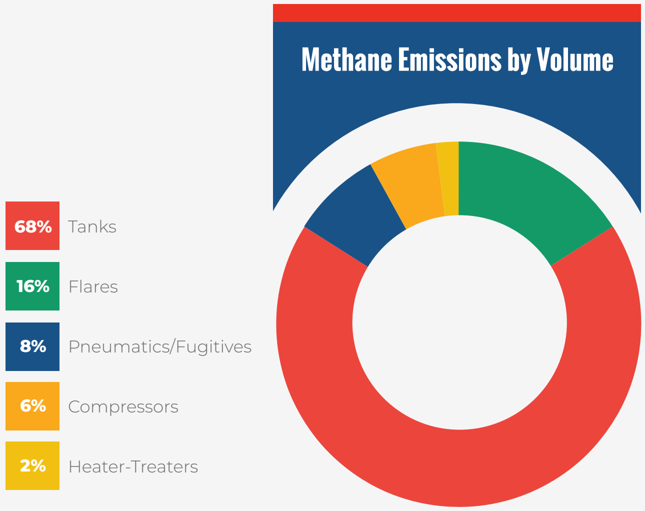
In an attempt to get a boots-on-the-ground view of emissions, operators are increasingly turning to technology-based solutions, including optical gas imaging, continuous monitoring at the fence line, aircraft, drone and satellites to identify and better quantify methane emissions on the well site.

In fact, one upstream producer went so far as to publish the findings of direct measurements of their locations in the Permian Basin. Methane detection commenced in late 2020 in West Texas. The table below summarizes the study, including measurement technologies and the number of sites monitored:

METHOD	SENSOR TYPE	MONITORED
Fixed-wing aircraft	Light Detection & Ranging	25 Central Processing Facilities (CPF)
Drones	Optical Gas Imaging	9 of the Largest Facilities
Truck-mounted	Spectrometer	9 Facilities
Ground, Continuous	Metal Oxide	6 Months at 1 Facility

After several weeks, the operator was surprised to learn that tank batteries were, by a wide margin, the largest source of measured emissions.

The study found that "...component-level emission factors that are used for EPA reporting do a poor job approximating actual emissions." The comparison of the operator's direct measurements and the EPA emissions factors is presented here:



SOURCE	EPA	ACTUAL MEASUREMENTS
Tanks	12%	68%
Flares	2%	16%
Pneumatics	42%	8%
Fugitives	41%	Not meaningful
Compressors	2%	6%
Heaters-Treaters	1%	2%

Key findings from the six-month evaluation include:

- Tanks were the primary emission source and emissions did not correlate with production volumes
- Separators, heater-treaters and their associated equipment represented a small share of overall emissions
- Measured emissions were distributed across both high-rate and low-rate facilities in a relatively uncorrelated manner
- Low oil rate facilities cannot be dismissed as negligible
- The tank vent system and flare were seen as more complex issues, in some cases requiring advanced engineering solutions

Although the results are based on data released from only one operator, the study covered multiple well sites and facilities providing a higher level of confidence that the data is not merely anecdotal.

Additionally, the operator did not provide individual measurements for emissions sources, such as tank venting, leaks and flaring. The company cited the difficulty in diagnosing emissions causes, because of the wide range of problems that create issues at tanks from accidentally leaving thief hatches open, restrictions in vent piping, stuck dump valves, process upsets, scrubber leaks, tank pressure relief valves, etc. In addition to these factors, we would add poorly managed tank pressures, inoperable flares and tank flaring itself.

Importantly, although the levels of total measured emissions from site-to-site varied substantially from standard estimates, the proportions of measured emissions across the sites consistently revealed that tank batteries were the primary sources of methane, VOC, NOx and GHG emissions.

100% DIRECT CAPTURE

There is an economical way to eliminate routine flaring and venting from all sources by focusing on the tank battery, which simultaneously reduces emissions and increases profitability.

Since VRTs operating at full efficiency only capture 70% of flash gas vapor, at least 30% of valuable vapors are sent to the tank where they accumulate in the headspace. Without treating, these tank vapors eventually become contaminated with oxygen, hydrogen sulfide and other elements to levels that exceed pipeline specification, so they are flared.

As a result, even at permitted production sites, the flares intended to be used only in emergencies are routinely burning contaminated tank vapors, which are typically the most valuable on the well site.

Direct capture of vapors from the tanks, both oil and water storage, enables purification of contaminates and converts what was a waste stream into incremental revenue, strengthening returns on investment while simultaneously improving environmental performance.

Direct capture and measurement can also reduce tank venting, by decreasing tank pressures and providing more accurate data to tank management systems.

AN ORDER OF MAGNITUDE

Because tank batteries are prolific sources of emissions, direct tank capture can also have a powerful positive impact on resource conservation, operational efficiency, and the economy.

We estimated that the EcoVapor E300 units operating only in Colorado during 2021 had the capacity to capture enough tank vapor to heat half the homes in Denver and Arapahoe counties combined for a year.

Conserving that magnitude of resource has the real potential to bolster the volumetrics of E&P company reserves, increase severance taxes paid to states, boost royalties paid to mineral owners and extend the life of finite natural resources.

SUMMARY

Direct tank capture of vapors from the tanks, both oil and water, at production sites and facilities is the best practice for reducing emissions and eliminating flaring. The benefits include:

- Reducing emissions from what is typically the largest emissions source – tank batteries.
- Eliminating all routine flaring, not just “most” of it.
- Increasing revenue by converting what was a waste stream into a commercial production stream, typically generating a positive ROI within the first week of installing a vapor purification system.
- Improving well site and facility safety profiles as a result of reducing tank pressures and flaring.
- Conserving significant volumes of valuable, finite natural resources.

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