Methane emissions from liquids unloading and their implications for quantifying and mitigating emissions

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Natural gas wells can accumulate water and other fluids in the wellbore that restrict gas flow and inhibit gas production. In response, operators perform "liquids unloading" to clear fluids and restore production. Wells can be unloaded manually when an operator temporarily switches gas flow to a storage tank instead of the gathering pipeline. This switch pushes liquids out the wellbore into the tank but also can vent gas to the atmosphere, resulting in methane (CH_4) emissions. Some wells are equipped with plunger lift systems that use pressure build-up to remove liquids, but these systems can vent either automatically or manually if there is insufficient pressure to lift the plunger.

Liquids unloading is responsible for a considerable fraction of oil and gas (O&G) industry CH_4 emissions. In their annual greenhouse gas inventory report, the U.S. Environmental Protection Agency estimates 2017 liquids unloading emissions are 117 Gg CH_4, 1.4% of O&G supply chain CH_4 emissions.[1] There are large regional differences in liquids unloading with three basins accounting for 60% of reported emissions to the EPA Greenhouse Gas Reporting Program (GHGRP): the Arkoma (Fayetteville Shale), San Juan, and Appalachian (Marcellus Shale).[2] The vast majority of reported emissions are estimated with EPA's engineering equations, which are often inaccurate for quantifying individual events, but previous research has reported that the method has low bias overall and therefore should be relatively accurate for estimating national emissions.[3]

Manual unloading events typically occur during working daytime hours since they are started and stopped by operator field staff. In the Fayetteville Shale, where manual unloadings are common, liquids unloading emissions vary by time of day with highest emissions in the midday.[4] Researchers were able to reconcile their bottom-up emission inventory with top-down aerial mass balance estimates by accounting for the fact that the aircraft measured emissions during this period of peak emissions, which should not be directly compared with the annual average inventory estimates.[5] There have been suggestions that similar temporal misalignment of measurement data could cause emissions to be overestimated in other basins when relying solely on top-down data. Although this effect is important in the Fayetteville, where over ~3% of wells unload at any one time, manual unloadings are reported to be much less common in other basins and therefore the impact should be minor.[6]

Zaimes et al. 2019, a recently published, peer-reviewed paper led by researchers at the U.S. Department of Energy National Energy Technology Laboratory, developed a bottom-up, probabilistic model to estimate liquids unloading emissions in 18 U.S. basins.[7] They determine that the GHGRP underestimates emissions by a factor of 5.4, which suggests total U.S. emissions are approximately 630 Gg CH_4 in 2018. The authors state that liquids unloading is an alternative explanation for the "abnormal process conditions" invoked in Alvarez et al. 2018 to explain the difference in emission estimates based on

empirical, site-level data and traditional, source-level approaches.[6] For O&G production sites, there are ~4,400 Gg CH_4 of uncategorized emissions, which means their upward revision for liquids unloading could only account for about 11% of these emissions. It is possible that this fraction is higher if there are systematic issues with the underlying data being used to estimate liquids unloading, such as inaccurately reported unloading type due to a currently inadequate reporting framework.[7] Given the lack of other alternative explanations, a larger fraction of the uncategorized emissions are due to other issues such as equipment malfunctions, poor engineering, or human error. Importantly, even intentional emission sources like liquids unloading often can be mitigated with cost-effective solutions, so uncertainty over the exact source of emissions should not impede efforts to reduce emissions.

References

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