Mass-Balance Analysis of Oil and Gas Methane Emissions in California MethaneSAT Data

EDF used MethaneSAT emissions data, API gravity data from CalGEM, and production data from Enverus to estimate the share of methane emissions in the San Joaquin region that stem from wells producing heavy oil. We build a dataset of 2024 active production wells via Enverus. We analyze 2024 CalGEM monthly production reports to assess the average API gravity of oil at wells; we average API gravity for all months where a nonzero API gravity is reported, and then merge the API gravity data with Enverus data via well API number. We use spatial data on well location from Enverus to reduce the dataset to wells enclosed in the MethaneSAT study area of the San Joaquin Valley.

This analysis is based on the adjusted methane loss rates from marginal and nonmarginal wells from Omara et al. 2022. The study finds average methane loss rates at nonmarginal and marginal wells as 1.5% and 13% respectively. The authors also estimate a kg/hr site level emissions rate at nonmarginal and marginal wells as 1.7 kg/site and 0.8 kg/site respectively.

We apply these assumptions to all gas wells and light oil wells with API gravity greater than or equal to 20. We compare these emissions to MethaneSAT's regional total oil and gas emissions to estimate the share of heavy oil emissions enclosed within the study area.

Scenario A: Estimated Emissions Share from Heavy Oil using Omara et al. 2022 Loss Rates

Omara et al. Loss Rates, unadjusted	Total (Loss Rate)	Non-Marginal (Loss Rate)	Marginal (Loss Rate)
		1.50%	13%
Units	MT/h	MT/h	MT/h
Light Oil Wells: Enverus Well Type Oil and API Gravity >=20	5.9	1.8	4.1
Gas Wells	0.0	0.0	0.0
Oil Wells without CalGEM API Gravity Data (categorized as light oil based on higher gas production)	1.0	0.1	0.9
MethaneSAT O&G Total Emissions	**18**		
Heavy Oil Wells: Enverus Well Type Oil and API Gravity < 20	***11.1***	**62%**	

Under these assumptions, about 62% of the region's oil and gas methane emissions must stem from heavy oil wells.

Scenario B: Estimated Emissions Share from Heavy Oil using Omara et al. 2022 Site Level Emissions Rates

Omara et al. site level emissions rates, unadjusted	Total (EF)	Non-Marginal (EF)	Marginal (EF)
EF		1.7 kg/site	0.8 kg/site
Units	MT/h	MT/h	MT/h
Light Oil Wells: Enverus Well Type Oil and API Gravity >=20	8.8	2.9	5.9
Gas Wells	0.1	0.0	0.1
Oil Wells without CalGEM API Gravity Data (categorized as light oil based on higher gas production)	1.8	0.2	1.6
MethaneSAT O&G Total Emissions	**18**		
Heavy Oil Wells: Enverus Well Type Oil and API Gravity < 20	***7.3***	**40%**	

Under these assumptions, about 40% of the region's oil and gas methane emissions must stem from heavy oil wells.

We also consider the emissions reductions achieved by current state LDAR programs. CARB' s three most recent annual LDAR reports find that the average percentage of emissions reduced annually through LDAR is 19%. assume that light oil wells and gas wells are performing regular leak detection and repair surveys pursuant to COGR and adjust loss rates downward by 19%, then apply the loss rates to light oil wells and gas wells in the study area.

Scenario C: Estimated Emissions Share from Heavy Oil: CARB 2020-2022 LDAR Reductions (mean 19% reduction) Applied to Omara et al. 2022 Loss Rates for Light Oil and Gas Wells

CARB 2020-2022 LDAR Reductions (19%) Applied to Omara et al. 2022 Loss Rates	Total (Loss Rate)	Non-Marginal (Loss Rate)	Marginal (Loss Rate)
%		1.22%	11%
Units	MT/h	MT/h	MT/h
Light Oil Wells: Enverus Well Type Oil and API Gravity >=20	4.8	1.4	3.3
Gas Wells: Enverus Well Type Gas	0.1	0.0	0.1
Oil Wells without CalGEM API Gravity Data (categorized as light oil based on higher gas production)	0.8	0.1	0.8
MethaneSAT O&G Total Emissions	18		
Heavy Oil Wells: Enverus Well Type Oil and API Gravity < 20	***12.3***	**68%**	

Under these assumptions, about 68% of the region's oil and gas methane emissions must stem from heavy oil wells. **In this scenario, for heavy oil wells to contribute negligible emissions as previously modelled by CARB[1], the state's nonmarginal light oil and gas wells would need to emit 11% of their production.**

We propagated uncertainty by running 10,000 Monte Carlo simulations in which each of the four emission rate parameters was independently drawn from a uniform distribution spanning 50% below to 50% above its baseline value. The resulting 95% confidence interval on heavy oil's share of total observed oil and gas methane emissions was 17-65% under the emissions factor model and 45-77% under the loss rate model. While considerable uncertainties exist, these results place the heavy oil share at roughly half of total oil and gas methane emissions. Heavy oil remains a substantial contributor to methane emissions across all scenarios.

[1] See Page 4 of CARB's 2018 LDAR Report