

Synapse
Energy Economics, Inc.

Onshore Oil and Natural Gas Operations on Federal and Tribal Lands in the United States

Analysis of Emissions and Lost Revenue

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Report Outline

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- Project Overview
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Executive Summary

- Synapse calculated the royalty value of gas lost due to venting, flaring, and leaks from natural gas operations on federal and tribal lands in 2019.

| Type of lost gas | Emissions Volume (Bcf) | | | Royalties (millions, 2022\$) | | | |
|------------------|------------------------|---------------|--------------|------------------------------|----------------|----------------|----------------|
| | Total | Federal | Tribal only | Total | Federal | Tribal | State |
| Total | 162.65 | 106.97 | 55.68 | \$63.60 | \$21.33 | \$21.77 | \$20.50 |
| Flared | 87.50 | 38.43 | 49.07 | \$34.22 | \$7.66 | \$19.19 | \$7.36 |
| Vented | 0.36 | 0.33 | 0.02 | \$0.14 | \$0.07 | \$0.01 | \$0.06 |
| Leaked | 74.79 | 68.21 | 6.58 | \$29.24 | \$13.60 | \$2.57 | \$13.07 |

- Synapse also calculated the lost state revenue from taxes collected on natural gas operations on federal lands in the top six states with the highest volume of wasted gas. These states (NM, ND, WY, UT, PA, and CO) had a combined total of 157 Bcf of wasted gas from federal and tribal lands. The lost state revenue from wasted gas on federal lands for these six states totaled \$18.8 million.
- The potential sales revenue of wasted natural gas on federal and tribal lands in 2019 was \$509 million, which could have met the yearly needs of 2.2 million households.

Project Overview

Project Overview

- Calculate and categorize natural gas and methane emissions volumes from venting, flaring, and leaks in the production segment on federal and tribal lands
- Determine the value of gas lost due to venting, flaring, and leaks from federal and tribal lands in 2019
 - Value lost in revenue from federal and tribal royalties
 - \$63.6 million, with \$21.3 million as lost federal revenue, \$21.8 as lost tribal revenue, and \$20.5 as lost state revenue
 - Value lost in state revenue from taxes
 - \$18.8 million from the top six states with the highest volume of gas lost
 - Value lost from wasted natural gas
 - \$509 million, or enough natural gas to meet the yearly needs of 2.2 million households

Background

Background

- During oil and natural gas production, natural gas is often vented (released) or flared (burned off) for various reasons. Additionally, natural gas leaks (resulting in fugitive gas) can occur throughout the production and transport process, resulting in wasted gas that could otherwise be sold.
- Venting, flaring, and leaks not only result in wasted gas and lost revenue, but also in methane emissions into the atmosphere. Methane is a potent greenhouse gas, and methane emissions contribute to climate change.
- This analysis assesses the amount and value of wasted natural gas that occurred in 2019 from venting, flaring, and leaks on federal and tribal lands.

Background: Rulemakings

- The U.S. Federal Government is proposing new actions to reduce wasted gas and address methane emissions from natural gas production.
 - Bureau of Land Management (BLM) proposed rulemaking: “Waste Prevention, Production Subject to Royalties, and Resource Conservation”
 - Environmental Protection Agency (EPA) supplementary proposal to proposed rulemaking: “Standards of Performance for New, Reconstructed, and Modified Sources and Emissions Guidelines for Existing Sources: Oil and Natural Gas Sector Climate Review”

Background: BLM Rulemaking

- BLM proposed the rulemaking “Waste Prevention, Production Subject to Royalties, and Resource Conservation” on November 30, 2022.
- This proposed rule seeks to reduce the waste of natural gas from venting, flaring, and leaks during oil and gas production activities on Federal and Indian leases through:
 1. Technology requirements;
 2. Leak detection plans;
 3. Waste minimization plans and conditions on applications for permits to drill; and
 4. Monthly limits on royalty-free flaring.

Background: EPA Rulemaking

- EPA issued a supplementary proposal to update the proposed rulemaking “Standards of Performance for New, Reconstructed, and Modified Sources and Emissions Guidelines for Existing Sources: Oil and Natural Gas Sector Climate Review” on November 11, 2022.
- This proposed rule seeks to reduce emissions of methane from new and existing sources in the oil and natural gas industry through:
 1. Requiring routine leak monitoring;
 2. Preventing emissions at abandoned and unplugged wells;
 3. Creating a super-emitter response program;
 4. Strengthening flaring requirements;
 5. Requiring pneumatic pumps and controllers to have zero emissions; and
 6. Updating proposed requirements for compressors.

Background: Federal and Tribal Royalties

- Federal and tribal governments collect royalties for natural gas produced on leased federal and tribal lands. Royalties are assessed at the point-of-sale, according to the sales price of the gas.
- The royalty rate for a given lease is established before leases are auctioned for sale:
 - The Mineral Leasing Act of 1920 established a minimum royalty rate of 12.5%. BLM can charge a higher rate in the terms of individual leases.
 - Future leases will have higher royalty rates due to the Inflation Reduction Act and other potential future rulemakings.
- For royalties collected on federal land, 51% of that revenue is allocated to the federal government and 49% is allocated as revenue to the state in which the gas was produced.
- Natural gas that is vented, flared, or leaked before the point-of-sale often results in lost royalty revenues due to inconsistent application of the current regulations on avoidably lost gas and an uptick in royalty-free flaring requests in recent years.

Background: State Royalty and Tax Revenue

- In addition to their share of the federal royalties generated from gas production within their borders, states collect severance taxes on natural gas produced within their borders, including gas from federal lands. Severance taxes do not apply to gas from tribal lands.
- Severance tax rates vary by state (see slide 18) but are usually a percentage of the market value of the gas.
- Some states also collect other taxes on natural gas extraction.
 - New Mexico, Wyoming, and Utah collect conservation taxes in addition to their severance taxes.
 - New Mexico also collects an emergency school tax and processor's tax.
- Like severance taxes, local property taxes on natural gas producers are usually based on the value of gas extracted. This analysis does not include local taxes.
- Natural gas that is vented, flared, or leaked before the point-of-sale results in lost potential state revenues from taxes, as the emissions are not included in the sales volume on which taxes are assessed.

Background: Value of Wasted Natural Gas

- Natural gas provides energy for various uses, such as heating, cooling, cooking, and combined heat and power systems.
- Venting, flaring, and leaks waste a resource that could be used productively for these purposes.
- Wasted natural gas either results in increased gas production to compensate for leaks, which leads to additional production costs, or results in lower supply relative to demand, which increases prices.
- The value of lost natural gas can be measured through the market price of natural gas.

Methodology

Methodology: Overview

- This analysis examines wasted natural gas in 2019 because it is the most recent year available that is most reflective of the industry.
 - 2020 and 2021 data are available but are not reflective of the industry and were an aberration due to the COVID-19 pandemic.
- All values are presented in 2022 dollars.
- Data sources:
 - Henry Hub price data is from the U.S. Energy Information Administration (EIA) Natural Gas Spot and Futures Prices (NYMEX)
 - Natural gas consumption data for residential customers is from EIA's Natural Gas Consumption by End Use data series
 - U.S. EPA Greenhouse Gas Reporting Program data
 - Enverus well and production data
 - VIIRS satellite data

Methodology: Volume of Wasted Gas - Leaked and Vented

EDF provided natural gas volumes from leaks, venting, and flaring on federal and tribal lands for the production segment for 2019. To estimate leaked and vented methane emissions, EDF used its Synthesis model based on Alvarez et al. 2018. This model uses well pad data from Enverus and production-dependent emission factors to estimate site-level total methane emissions. EPA GHGRP data and a statistical model are used to estimate vented emissions at the well-pad-level. To get the volumes of emissions on federal and tribal lands, EDF used GIS shapefiles from BLM (oil and gas leases), USFS (mineral rights), and BIA (surface ownership) to extract just those well pads on federal and tribal lands. As there is not a comprehensive databased of tribal mineral ownership, surface ownership was used as a proxy for determining wells on tribal lands.” to extract just those well pads on federal and tribal lands. EDF converted methane emissions to volumes of natural gas assuming an 80% methane content in natural gas in the production segment.

Note: This analysis does not include any emissions from AK, MI, NE, IL, and IN, though we would expect some level of emissions due to reported production on BLM leases in those states. Emissions in AK are challenging to estimate because most gas is reinjected. For MI, NE, IL, and IN, data limitations prevent direct estimation of emissions, but we expect fugitive and vented natural gas volumes to be less than 0.1 BCF based on the number of wells on federal and tribal lands in those states.

Methodology: Volume of Wasted Gas - Flared

For flared volumes, EDF used location-specific flaring volumes from the VIIRS satellite [Elvidge, C.D.; Zhizhin, M.; Baugh, K.; Hsu, F.-C.; Ghosh, T. 2016. “Methods for Global Survey of Natural Gas Flaring from Visible Infrared Imaging Radiometer Suite Data.” *Energies*, 9, 14. <https://doi.org/10.3390/en9010014>]. We overlaid these flared volumes with the same GIS shapefiles to extract flared volumes just on federal and tribal lands.

Note: We estimate uncertainties in the extracted VIIRS flared volumes on federal/tribal lands to be +15%/-25% due to coarse spatial location accuracy of the VIIRS satellite.

Methodology: Lost Royalty Revenue from Federal and Tribal Lands

- Synapse used the prior 2019 royalty rate of 12.5% to reflect historical revenues.
 - 12.5% was the minimum royalty rate prior to the passage of the Inflation Reduction Act.
 - Royalty rates can vary on tribal lands. Following interviews with federal staff, EDF, TCS, and Synapse decided that 12.5% is the most appropriate royalty rate to use for tribal lands.
- Synapse calculated the sales price of gas lost from federal lands using the historical Henry Hub price for 2019, which is \$3.01 per MMBtu (2022 dollars).
- Lost federal and tribal royalties from wasted gas is equal to the royalty rate times the sales price of gas lost from venting, flaring, and leaks, as this gas is emitted before it could be sold and assessed for royalties.
 - The federal government receives 51% of this royalty revenue, and the remaining 49% goes to the states.

Methodology: Lost State Tax and Royalty Revenue

- Synapse calculated the amount of revenue that state governments lost in 2019 as a result of wasted natural gas from public lands for the six states with the largest quantities of wasted gas: New Mexico, North Dakota, Wyoming, Utah, Pennsylvania, and Colorado.
- See Slide 18 for a summary of the tax rates in each state. Note that state severance taxes apply to federal lands only (not tribal lands).
 - Lost state tax revenue from wasted gas is equal to the Synapse assumption for the state's tax rate times the sales price of gas lost from venting, flaring, and leaks for states with a market-value-based tax. For states with a volume-based tax, lost tax revenue is equal to the Synapse assumption for the state's tax rate times the volume of gas lost from venting, flaring, and leaks.
 - For states whose severance taxes allow for federal royalty deductions, Synapse calculated the deduction using the 2019 BLM rate of 12.5%.
- Lost state revenue also includes each state's share of federal royalties. States receive 49% of the federal royalties collected on natural gas extraction from federal lands within their borders.

Methodology: Lost State Tax Revenue

| State | Tax Rate | Synapse Assumption | Allows Federal Royalty Deduction |
|-------|---|---|----------------------------------|
| NM | Severance tax: 3.75% of taxable value Conservation tax: 0.0019% of taxable value Emergency school tax: 4% of taxable value Processor's tax: Base rate of \$0.0065 per MMBtu multiplied by an adjustment factor equal to the average value of natural gas from the preceding calendar year divided by \$1.33. | 7.7519% composite tax rate plus \$20,360 per Bcf processor's tax | Yes |
| ND | Severance tax rate changes annually based on producer price index for gas. | \$78,650 per Bcf of natural gas (average of FY19 and FY20 prices) | No |
| WY | Severance tax: 6% of fair market value Conservation tax: 0.05% of fair market value | 6.05% composite tax rate | No |
| UT | Severance tax: tiered rate (3-5%) Conservation tax: 0.2% of taxable value | 4.24% composite tax rate | Yes |
| PA | Impact fee/unconventional gas well fee (fee assessed on per-well basis) | None, state revenue does not depend on volume of gas extracted | n/a |
| CO | Severance tax: tiered rate (2-5%) Conservation levy: \$0.0015 per dollar of gas sold | 3.65% composite tax rate | No |

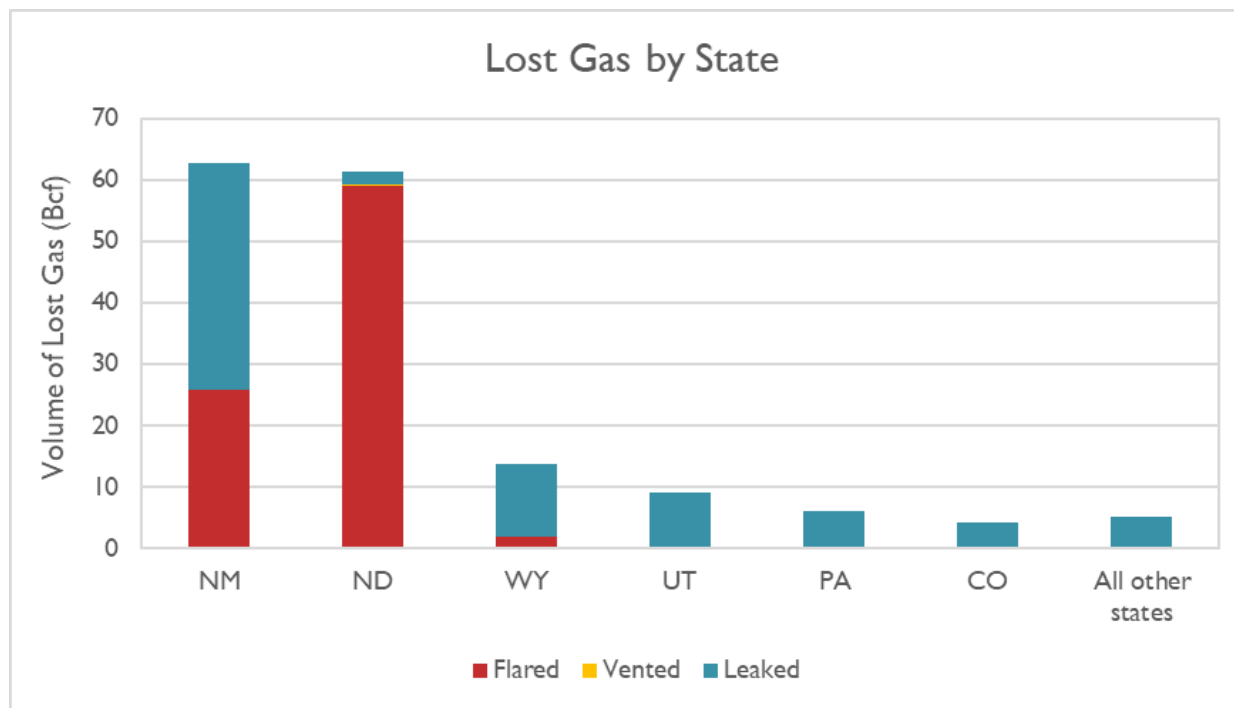
Methodology: Lost Value of Wasted Natural Gas

- Synapse calculated the value of the wasted natural gas lost from federal and tribal lands using historical Henry Hub gas price data from the Energy Information Administration.
- To estimate the number of households whose needs could be met with that wasted natural gas, Synapse used EIA's natural gas consumption data for natural gas consumed by residential consumers and divided that by the number of residential consumers to get the average amount of gas consumed per household.
- This value is the lost value of the gas to society, as it is not being used productively.

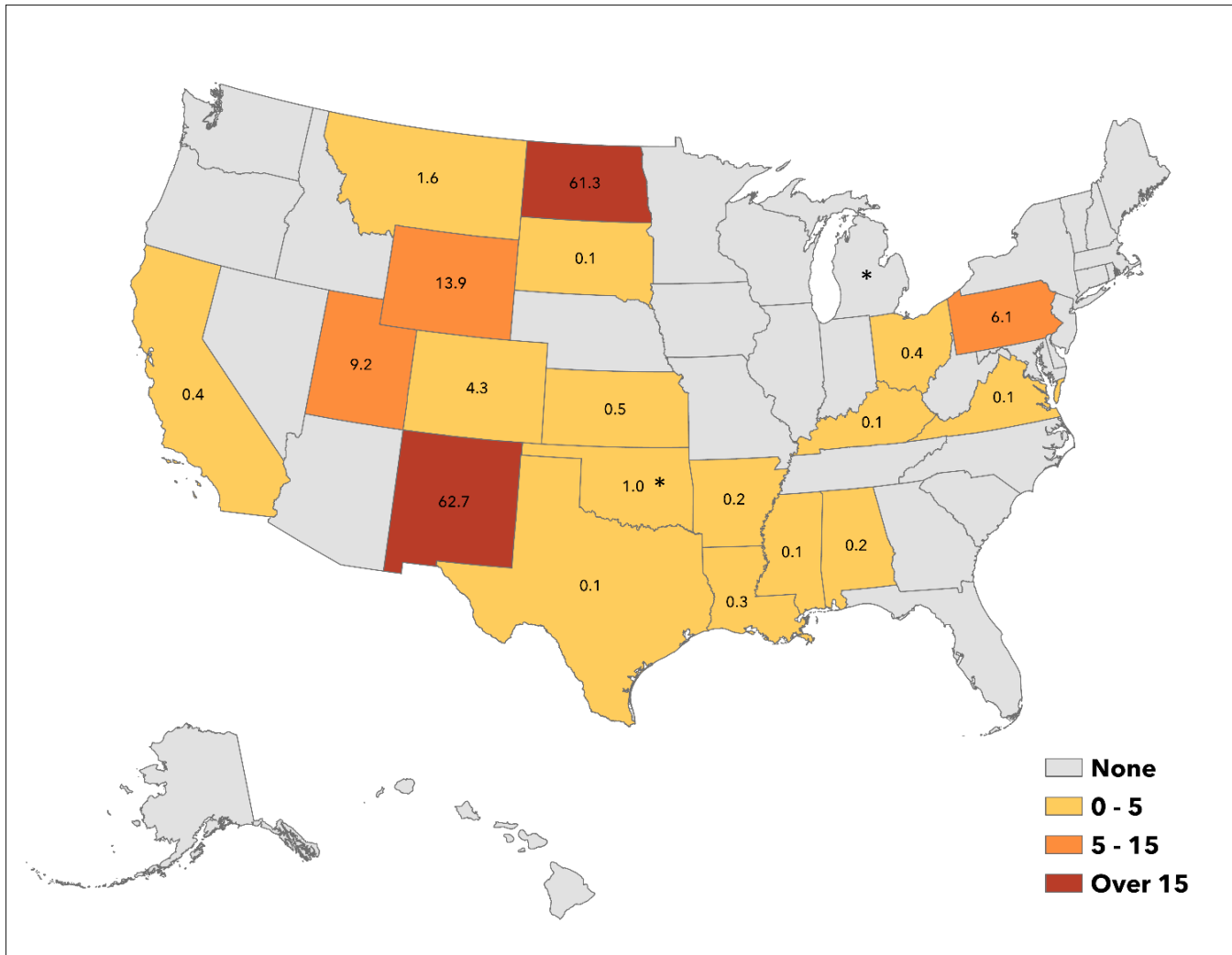
Results and Findings

Results and Findings: Volume of Lost Gas from Federal and Tribal Lands

- In 2019, leaks accounted for 46% of lost gas, flaring for 54%, and venting for less than 1%.
- The six states with the highest volume of gas lost from federal and tribal lands are New Mexico, North Dakota, Wyoming, Utah, Pennsylvania, and Colorado.

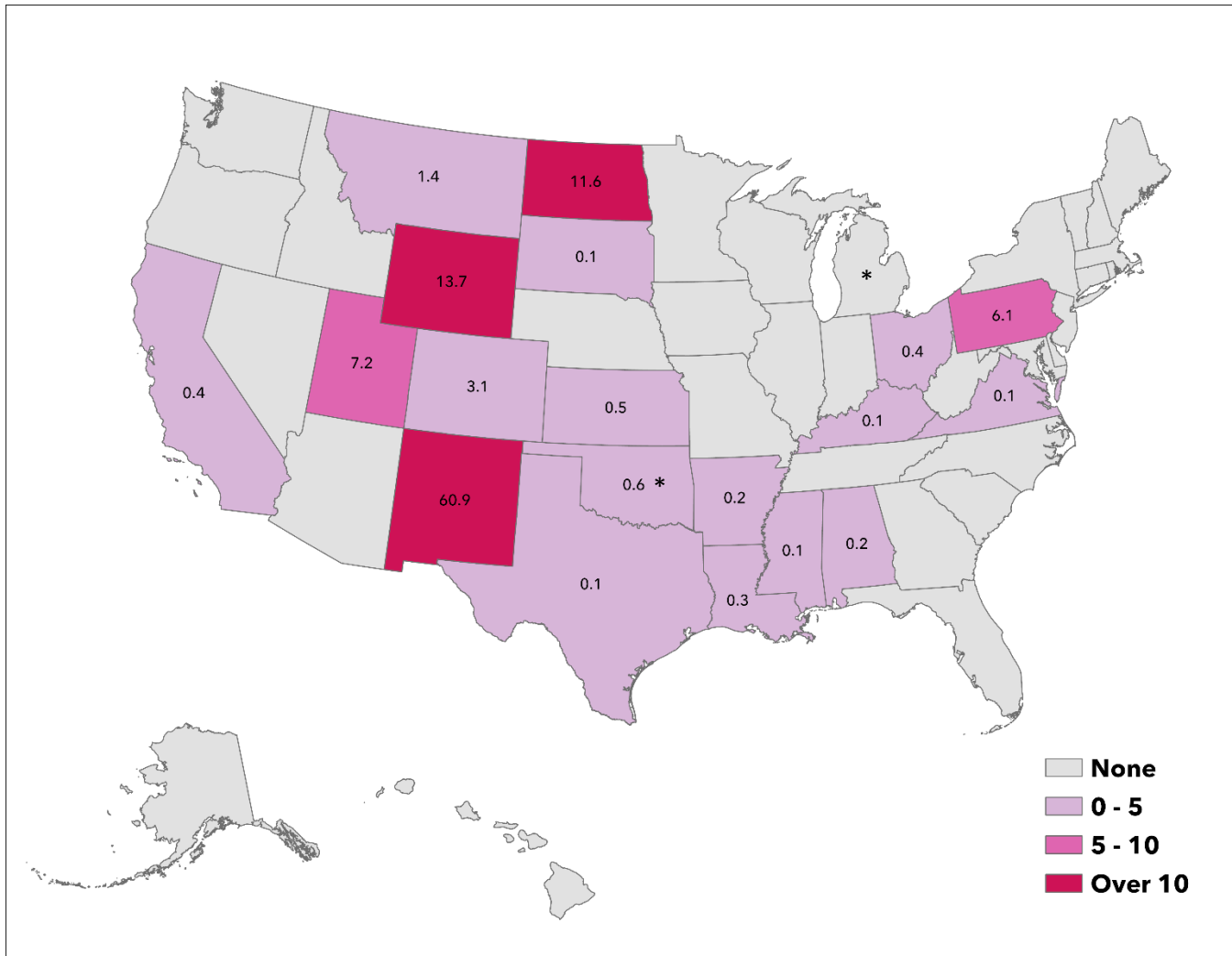


Results and Findings: Vented, Flared, and Leaked Gas from Federal and Tribal Lands (Bcf)



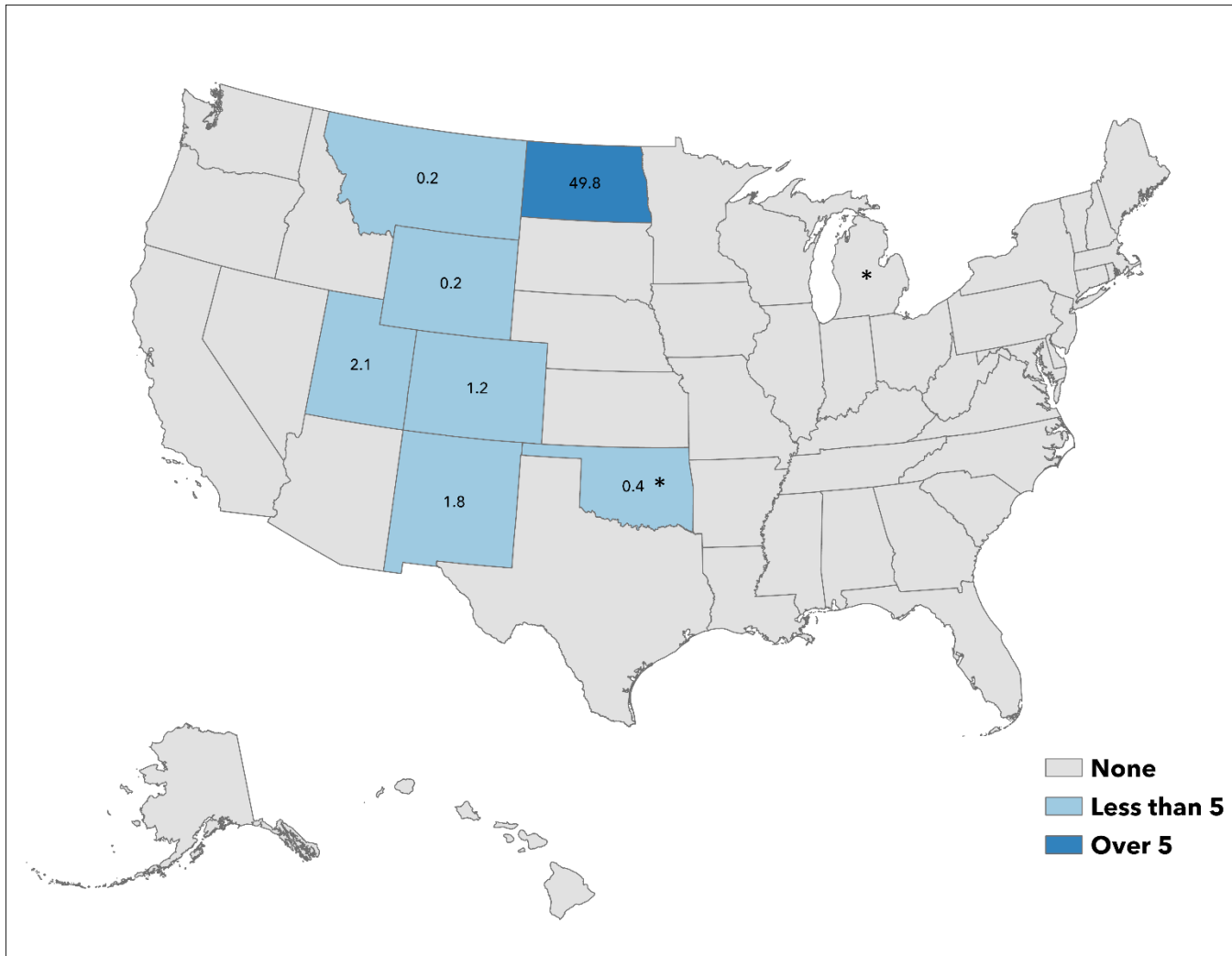
* These are likely underestimates due to data limitations and will be updated in the future

Results and Findings: Vented, Flared, and Leaked Gas from Federal Lands (Bcf)



* These are likely underestimates due to data limitations and will be updated in the future

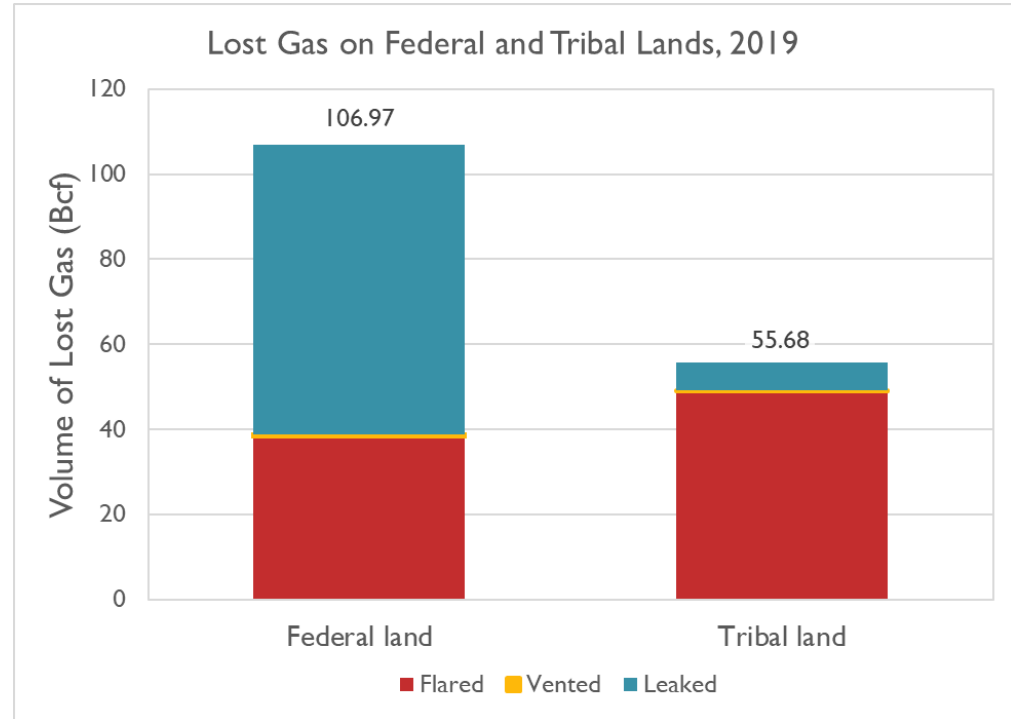
Results and Findings: Vented, Flared, and Leaked Gas from Tribal Lands (Bcf)



* These are likely underestimates due to data limitations and will be updated in the future

Results and Findings: Lost Gas from Federal and Tribal Lands

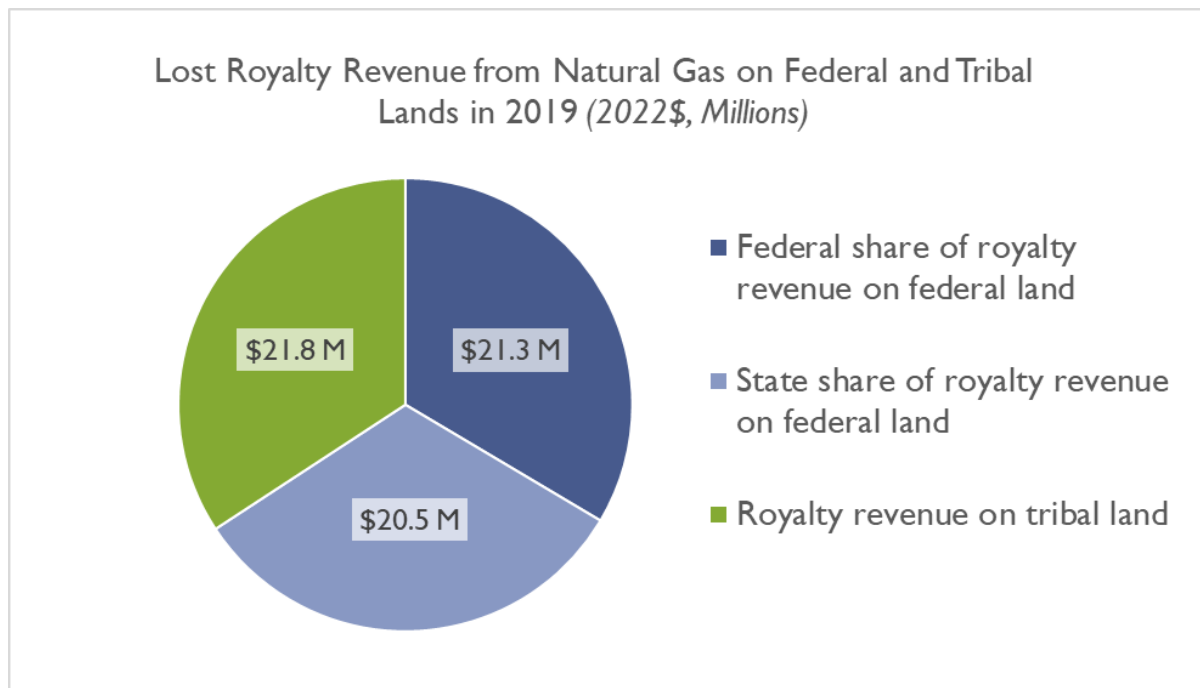
- On federal land, the majority of lost gas is leaked.
- On tribal land, the majority of lost gas is flared.



| Lost gas on federal & tribal lands in 2019 (Bcf) | Total | Federal only | Tribal only |
|--|---------------|---------------|--------------|
| Total | 162.65 | 106.97 | 55.68 |
| Flared gas | 87.50 | 38.43 | 49.07 |
| Vented gas | 0.36 | 0.33 | 0.02 |
| Leaked gas | 74.79 | 68.21 | 6.58 |

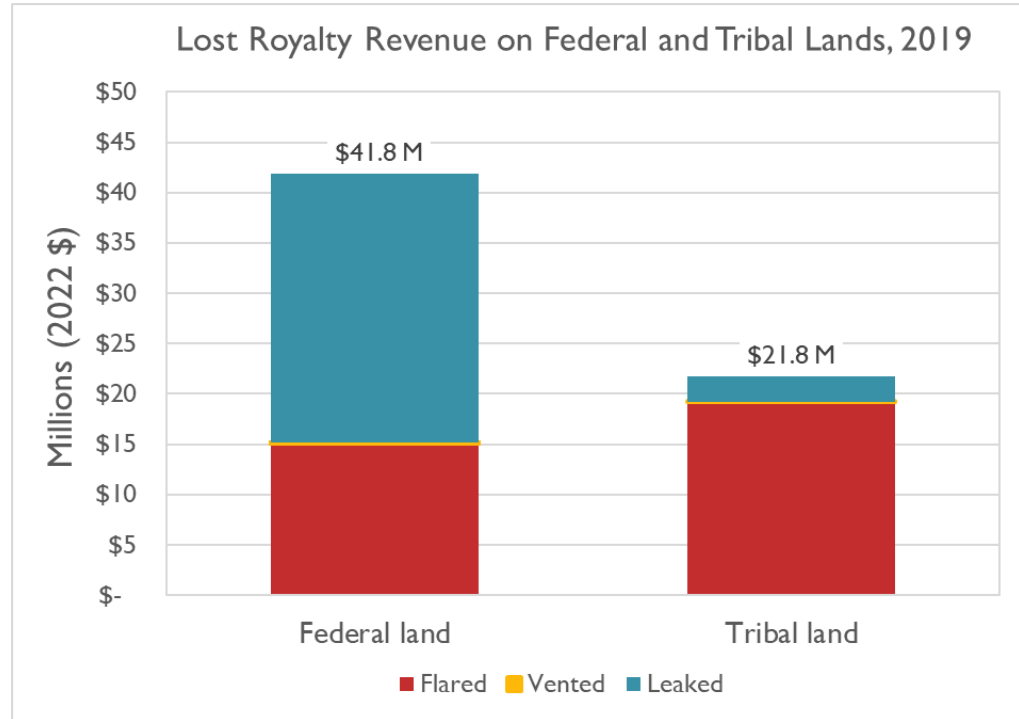
Results and Findings: Lost Royalty Revenue from Federal and Tribal Lands

- Using the historical rate of 12.5%, the total lost royalty revenue from natural gas produced on federal and tribal lands in 2019 was \$63.6 million (2022 dollars).
 - Of this, 34% of lost royalty revenues (\$21.8 million) was from natural gas lost on tribal land.
 - Royalty revenues from gas lost on federal land (\$35.6 M) is split between the federal (51%) and state government (49%).



Results and Findings: Lost Royalty Revenue from Federal and Tribal Lands

- In total, flaring accounts for 53.8% of lost revenues on tribal and federal land, leaks for 46%, and venting for 0.2%.



| Lost royalty revenues on federal & tribal lands in 2019 (2022\$) | Total | Federal only | Tribal only |
|--|---------------------|---------------------|---------------------|
| Total | \$63,600,000 | \$41,830,000 | \$21,770,000 |
| Flared gas | \$34,220,000 | \$15,030,000 | \$19,190,000 |
| Vented gas | \$138,900 | \$130,700 | \$8,200 |
| Leaked gas | \$29,240,000 | \$26,670,000 | \$2,570,000 |

Results and Findings: Lost State Tax and Royalty Revenue

- The six states with the highest volume of wasted gas from public lands lost a combined \$18.8 million in state tax revenue and \$19.6 in federal royalty revenue in 2019.

| State | Volume of wasted gas from federal and tribal lands* (Bcf) | Lost state revenue from state taxes (millions 2022\$) | Lost state revenue from federal royalties (millions 2022\$) |
|--------------|---|---|---|
| NM | 62.7 | \$14.2 | \$11.7 |
| ND | 61.3 | \$0.908 | \$2.21 |
| WY | 13.9 | \$2.59 | \$2.63 |
| UT | 9.24 | \$0.833 | \$1.37 |
| PA | 6.06 | - | \$1.16 |
| CO | 4.29 | \$0.355 | \$0.596 |
| Total | 157 | \$18.8 | \$19.6 |

**Note that lost state revenue is based on the portion of this gas that is from federal lands only.*

Results and Findings: Lost Value of Wasted Natural Gas

- The total volume of wasted natural gas on federal and tribal lands in 2019 was 162.65 billion cubic feet, which is worth \$509 million (2022\$), based on the Energy Information Administration's 2019 Henry Hub gas price.
- This is enough natural gas to meet the yearly needs of 2.2 million households, nearly as many households as New Mexico, North Dakota, Utah, and Wyoming combined.

| Lost value of natural gas in 2019 (2022\$) <i>Federal & Tribal lands</i> | |
|--|----------------------|
| Total lost value from emissions | \$508,790,000 |
| Flared gas | \$273,720,000 |
| Vented gas | \$1,110,000 |
| Leaked gas | \$233,950,000 |

Conclusions

1. Strengthening rules that reduce methane waste from natural gas production has the potential to provide federal, state, and tribal government with significant revenue that is currently being wasted.
2. Flared and leaked gas comprises the vast majority of wasted gas, and actions that address these types of emissions will provide the most benefit and the most saved revenue.
3. Reducing wasted natural gas would mean millions of households could be powered without the need for additional natural gas drilling, saving money and resources.