CARB’s Oil and Gas Methane Regulation
2020 Annual LDAR Summary

November 2023

California Air Resources Board

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A. Key Findings

- At the beginning of the third year of implementation of CARB's Greenhouse Gas Emission Standards for Crude Oil and Natural Gas Facilities[1] (Oil and Gas Methane Regulation, or Regulation), the leak threshold in the Regulation dropped from 10,000 ppmv (in 2018 and 2019) to 1,000 ppmv for 2020 and beyond. In 2020, over 13,000 leaks at or above 1,000 ppmv were identified and repaired during quarterly leak detection and repair (LDAR) surveys of ~2.4 million unique components.
- The ratio of leaks to unique components surveyed was 0.57%.
- The natural gas processing plant sector had the largest ratio of leaks to components surveyed (1.66%), but the second fewest number of components surveyed. The remaining sectors (crude oil production, natural gas production, natural gas storage, natural gas transmission, and natural gas gathering and boosting station) had ratios of leaks to components surveyed ranging from ~0.40% to 1.20%.
- Approximately 10% of the leaks at or above the regulatory threshold of 1,000 ppmv accounted for 50% of the emissions.
- Total emission reductions from LDAR surveys in 2020 were estimated to be ~2,200 metric tons methane, or ~55,000 metric tons CO_2e.[2]
- LDAR surveys in 2020 resulted in a 23% reduction in emissions from components subject to LDAR in the Regulation.

Table 1 shows a comparison between 2020 LDAR data and 2019 LDAR data. The reported number of leaks and number of leaks per component count increased in 2020 because the allowable leak concentration under the Regulation decreased from 10,000 ppmv in 2019 to 1,000 ppmv in 2020. Additionally, in 2020, the natural gas gathering and boosting station and natural gas processing plant sectors were added as reporting sectors on CARB's electronic reporting tool, Cal e-GGRT.[3] A detailed comparison between 2019 and 2020 data is in Section D.

[1] California Code of Regulations, Title 17, Division 3, Chapter 1, Subchapter 10 Climate Change, Article 4. Subarticle 13: Greenhouse Gas Emission Standards for Crude Oil and Natural Gas Facilities.
[2] CO_2e was calculated throughout the report using the 100-year global warming potential (GWP) of methane of 25.
[3] Prior to 2020, facilities in the natural gas gathering and boosting station and natural gas processing plant sectors were included with facilities in both production sectors as well as the natural gas transmission sector.

Table 1: Comparison of 2020 LDAR to 2019

	2019 (10,000 ppmv threshold)	2020 (1,000 ppmv threshold)
Total Count of Components in LDAR Program	2,289,040	2,380,049
Number of Leaks	7,208	13,594
Number of Leaks per Component Count in LDAR Program (%)		
Overall	0.31%	0.57%
Crude Oil Production Sector	0.30%	0.55%
Natural Gas Production Sector	0.29%	0.40%
Natural Gas Storage Sector	0.30%	0.53%
Natural Gas Transmission Sector	0.69%	1.19%
Natural Gas Gathering and Boosting Station Sector	-	0.65%
Natural Gas Processing Plant Sector	-	1.66%
% of Leaks that Accounted for 50% of Emissions	20%	10%
Total Emission Reductions (metric tons methane)	3,000	2,200
% Emission Reductions	12%	23%

B. Background

As an early action measure to achieve the emission reductions required by the California Global Warming Solutions Act (AB 32), CARB adopted the Oil and Gas Methane Regulation to reduce methane emissions from oil and gas production, processing, storage, and transmission compressor stations. CARB's Oil and Gas Methane Regulation was adopted by the Board on March 23, 2017, and went into effect on January 1, 2018. Section 95669 requires owners/operators of oil and natural gas facilities[4] to conduct quarterly LDAR surveys to monitor components for leaks and repair detected leaks within a specified time frame. Quarterly LDAR inspections began on January 1, 2018, and operators are required to submit annual LDAR reports to CARB by July 1 of each calendar year. The following information must be included in operators' annual LDAR reports:

1. Total number of components inspected
2. Total number of leaks identified per leak threshold category (1,000 to 9,999 ppmv, 10,000 to 49,999 ppmv, and 50,000 ppmv or greater)
3. For each leak:
    a. Inspection date
    b. US EPA Method 21 instrument used
    c. US EPA Method 21 instrument calibration date

[4] Including oil and gas production, processing, and storage; natural gas gathering and boosting stations; natural gas underground storage; and natural gas transmission compressor stations.

d. Component type
e. Component ID, if applicable
f. Equipment ID for the equipment the leaking component is on, if applicable
g. Initial leak concentration
h. Repair date
i. Concentration after repair

This Annual LDAR Summary is based on annual reports CARB received from 97 operators for LDAR inspections at 437 facilities during 2020.

The LDAR requirements in CARB's Oil and Gas Methane Regulation do not apply to all components in California; there are two key exemptions. First, components that are subject to local air district LDAR requirements that were in place prior to January 1, 2018 are exempt from LDAR requirements in CARB's Oil and Gas Methane Regulation because the regulation was intended to cover components that were not already subject to district LDAR requirements.[5] Second, components handling crude oil with an API gravity less than 20 are not subject to LDAR requirements due to their very low emissions levels relative to other components found in gas or other liquid service (less than 1% of all emissions from components in the state).[6,7,8,9] Figure 1 shows the fraction of oil and gas components in California that are subject to CARB's regulation, are subject to local air district rules,[10] or handle heavy oil and are exempt from LDAR requirements.[11]

[5] Oil and Gas Methane Regulation, Section 95669(b)(1).
[6] Oil and Gas Methane Regulation, Section 95669(b)(2).
[7] ARB. (2013). Oil and Gas Survey. ARB 2007 Oil and Gas Industry Survey Results, Final Report, revised in October 2013.
[8] CAPCOA. (1999). California Implementation Guidelines for Estimating Mass Emissions of Fugitive Hydrocarbon Leaks at Petroleum Facilities.
[9] 15-Day Notice Attachment 2. https://ww3.arb.ca.gov/regact/2016/oilandgas2016/oilgasatt2.pdf.
[10] There are eight local air districts with LDAR requirements for oil and gas facilities, including Bay Area Air Quality Management District (AQMD), Monterey Bay Air Resources District (ARD), San Joaquin Valley Air Pollution Control District (APCD), San Luis Obispo County APCD, Santa Barbara County APCD, South Coast AQMD, Ventura County APCD, and Yolo-Solano AQMD.
[11] Heavy oil is defined differently in different district rules, e.g., by API gravity, by flash point, by vapor pressure, or by evaporation percentage. For the purposes of Figure 1, heavy oil was defined as < 20 API gravity.

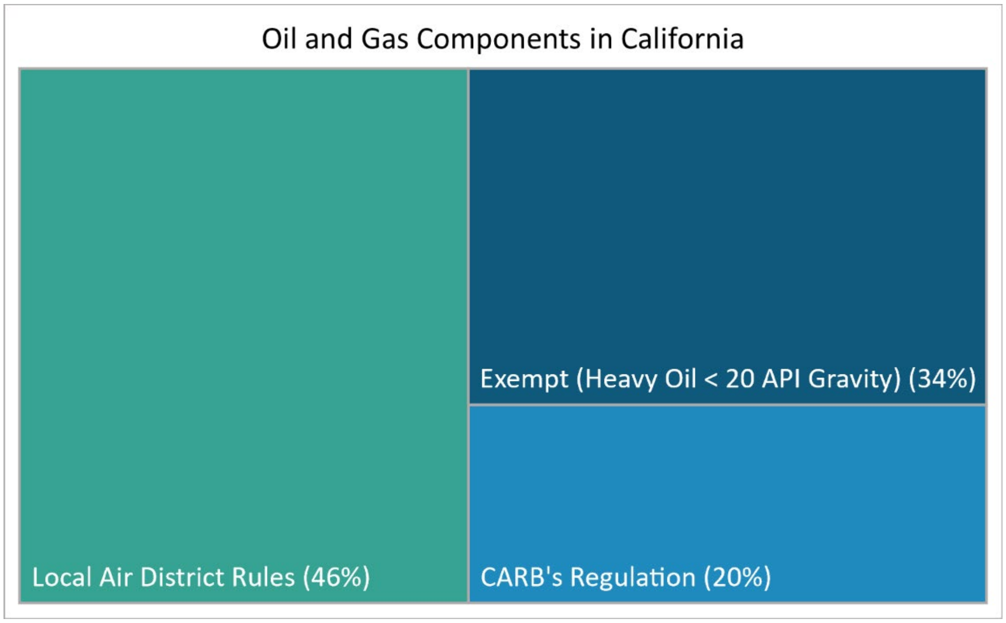

Figure 1: Breakdown of oil and gas components in California. Size of box corresponds to the percent of components in each category (shown in parentheses) based on data from CARB's 2007 oil and gas industry survey and the Oil and Gas Methane Regulation rulemaking.[12,13]

C. Summary of LDAR Data

During 2020 LDAR surveys, 2,380,049 unique components were surveyed[14] and 13,594 leaks were identified as greater than or equal to 1,000 ppmv (the ratio of leaks to components surveyed was 0.57%). Of the leaks found during inspections, 13,447 were repaired or a component was replaced, 127 were designated as critical components[15] and were repaired at the next scheduled shutdown or within 12 months, whichever was sooner, and 20 were approved for delays of repair at the time of reporting and were repaired or replaced within 30 calendar days from the allowed repair time period or by the anticipated repair date stated in the operator's approved delay of repair request. Delay of repair approvals are requested by operators who need to order specific parts or equipment to repair leaking components. CARB staff tracks the delay of repair requests to confirm that repairs are completed according to the allowed timeline.[16]

CARB staff reviewed the data in the 2020 annual reports and found no widespread issues with operators' reported data. Issues encountered were all associated with data entry and include

[12] See footnote 7.
[13] See footnote 9.
[14] Component surveys were repeated quarterly for a total of ~9.5 million component inspections.
[15] A critical component would require the shutdown of a critical process unit if that component was shutdown.
[16] The 147 critical component and delay of repair leaks were included in this report in Tables 1 and 2 and Figures 2 and 3, but not in estimates of emission reductions because those calculations require a concentration after repair that wasn't included at the time annual LDAR reports were submitted.

conflicting inspection dates, conflicting repair dates, conflicting instrument calibration dates, incorrect number of components inspected, incorrect number of leaks found, and incorrect repaired leak concentrations. All discrepancies were corrected by CARB staff after following up with operators. During 2020, 0.26% of the reported leaks had potential errors identified that affected the emissions and emissions reductions calculations and required CARB staff to follow up with operators and make necessary corrections. Of the facilities that reported LDAR data, 7.1% had discrepancies between the number of leaks recorded in the annual LDAR reports' two reporting tables, and 1.8% of all reported quarterly inspections listed incorrect inspection dates (i.e., dates were not in 2020). The validity of the data presented in this report is dependent on the accuracy of the data reported by operators. CARB acknowledges that there are potential limitations with self-reported data; however, CARB staff conducted rigorous quality control checks to ensure the highest level of data integrity possible. There was an increase in the number of facilities with reports that had discrepancies between the number of leaks reported in the two reporting tables; this could be due to the added column to one of the reporting tables for leaks found between 1,000 ppmv and 9,999 ppmv. Other than the discrepancies between the two reporting tables, there were fewer issues identified with 2020 LDAR reporting data compared to 2019, which continues to demonstrate that less follow-up is required by CARB staff as operators gain experience with the regulation.

Table 2 shows the LDAR survey leak distribution for 2020 according to oil and gas sector. On January 1, 2020, the allowed leak threshold decreased from 10,000 ppmv to 1,000 ppmv, as required under the Regulation. The natural gas processing plant sector had the largest ratio of leaks to unique components surveyed (1.66%), but the second fewest number of components surveyed (21,670). The remaining sectors (crude oil production, natural gas production, natural gas storage, natural gas transmission, and natural gas gathering and boosting stations) had ratios of leaks to components surveyed ranging from 0.40% to 1.19%, and crude oil production had the largest number of components surveyed.[17] The natural gas gathering and boosting station sector had the fewest number of components surveyed (3,672).

[17] In general, district LDAR rules cover crude oil production facilities; however, the Oil and Gas Methane Regulation addressed some components that are exempt from district rules, resulting in the large number of components in the crude oil production sector, as shown in Table 2.

Table 2: Components Found Leaking by Sector in 2020

Sector	Total Count of Components in LDAR Program[18]	Number of Leaks in Each Category[19] (Ratio of Leaks to Count of Components in LDAR Program by Sector)			Number of Leaks per Component Count in LDAR Program (%)
		1,000 to 9,999 ppmv	10,000 to 49,999 ppmv	50,000 ppmv or greater	
Crude Oil Production	1,454,667	5,847 (0.40%)	1,806 (0.12%)	375 (0.03%)	0.55%
Natural Gas Production	359,492	825 (0.23%)	443 (0.12%)	171 (0.05%)	0.40%
Natural Gas Storage	410,022	1,495 (0.36%)	474 (0.12%)	221 (0.05%)	0.53%
Natural Gas Transmission	130,526	1,091 (0.84%)	323 (0.25%)	139 (0.11%)	1.19%
Natural Gas Gathering and Boosting Stations	3,672	16 (0.44%)	6 (0.16%)	2 (0.05%)	0.65%
Natural Gas Processing Plants	21,670	230 (1.06%)	130 (0.60%)	0 (0.00%)	1.66%
Total	2,380,049	9,499 (0.40%)	3,182 (0.13%)	908 (0.04%)	0.57%

Figure 2 shows the number of leaks identified in 2020 by component type; connectors and valves had the most leaks of the component types, 5,412 and 4,321, respectively.

[18] Counts include the physical number of components that were surveyed four times throughout the year.
[19] A component could have been found to be leaking during a quarterly inspection and been repaired or replaced within the required time period, and also may have been measured as leaking again during a subsequent quarterly inspection, resulting in one component accounting for more than one leak.

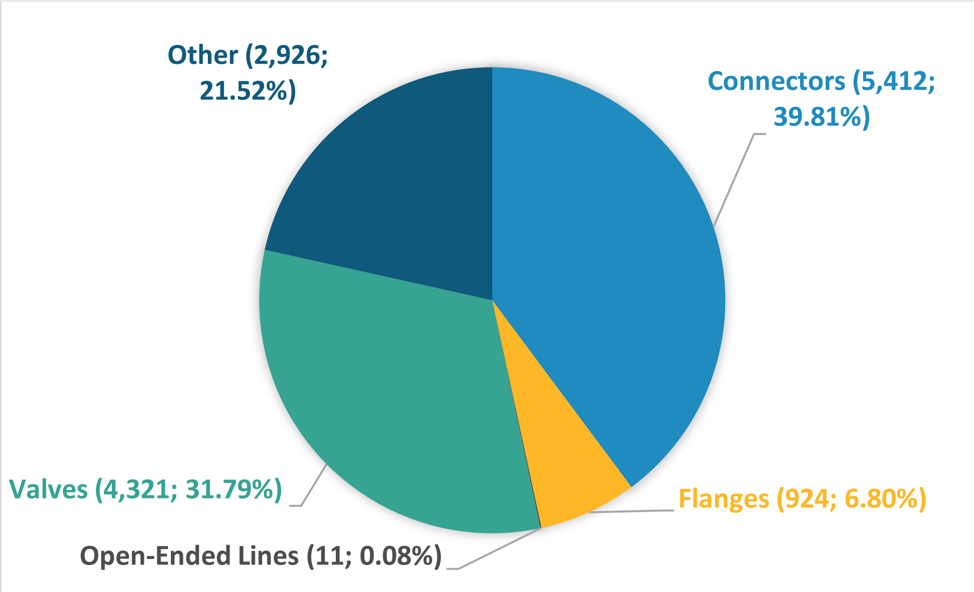

Figure 2: Number of leaks identified in 2020 by component type. The "other" component category includes gas regulators, pressure gauges, pressure relief devices, flow and pressure meter fittings, pneumatic devices, compressor vents, temperature controllers, stuffing boxes, and inactive flare pilots.

CARB staff estimated emissions from the reported leaks using correlation equations developed in a CARB 2019 study.[20] Estimated methane leak rate statistics by component type are shown in Table 3. On average, open-ended lines had the highest leak rate, but only accounted for 11 total leaks. The mean leak rate from all components was 0.019 kg CH_4/hr.

Table 3: Methane Leak Rate Statistics by Component Type[21]

	All Components	Connector	Flange	Open-Ended Line	Valve	Other
Min (kg CH_4/hr)	0.002	0.002	0.002	0.022	0.003	0.005
Max (kg CH_4/hr)	0.500	0.178	0.049	0.275	0.500	0.241
Mean (kg CH_4/hr)	0.019	0.007	0.007	0.134	0.027	0.032
Median (kg CH_4/hr)	0.008	0.004	0.004	0.143	0.014	0.014

[20] Air Resources Board IFB No. 13-414: Enhanced Inspection & Maintenance for GHG & VOCs at Upstream Facilities, Sage ATC Environmental Consulting LLC, revised November 2019.

[21] Leak rates were converted from total hydrocarbons assuming a methane composition of 89.2% based on data from a CARB 2019 study (see footnote 20).

Figure 3 shows the cumulative leak emission distribution from 2020 LDAR data. The distribution shows that ~10% of leaks accounted for 50% of estimated emissions from leaking components. The addition of leaks from 1,000 ppmv to 9,999 ppmv further illustrates that a relatively small number of sources contributed to a significant portion of the emissions from leaking components, as has been demonstrated in previous studies of oil and gas facilities.[22,23]

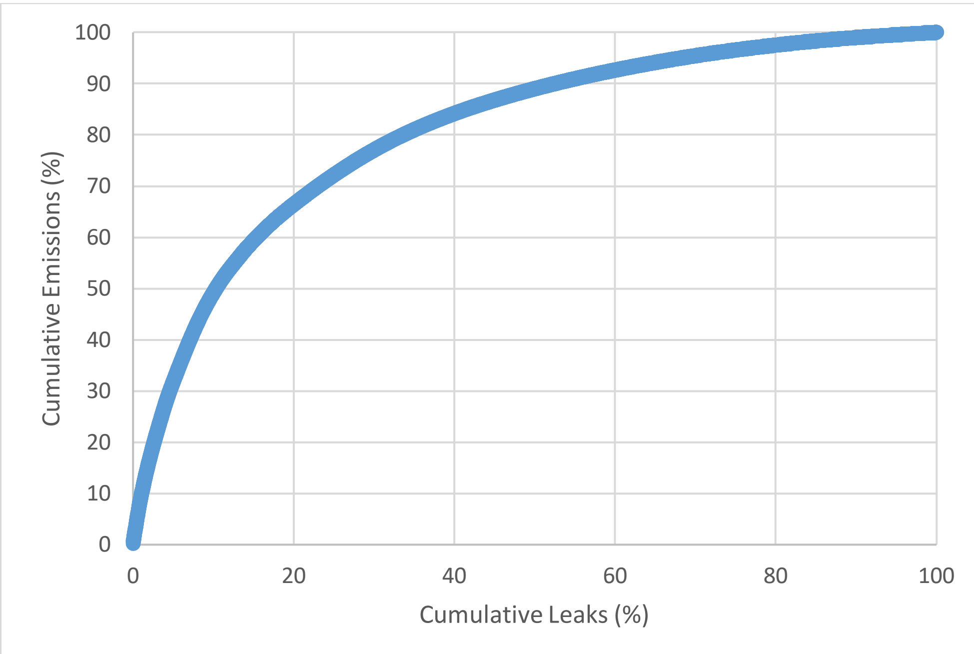

Figure 3: Fraction of cumulative emissions versus cumulative leaks based on LDAR data for 2020.

Emission reductions were estimated by assuming that a leak would have continued unabated for a year without the LDAR program. Total emission reductions from the 2020 LDAR surveys were estimated to be ~2,200 metric tons methane, or ~55,000 metric tons CO_2e.[24] CARB staff also estimated baseline 2020 emissions from all components subject to LDAR in the regulation in order to evaluate the percent emission reductions from 2020 LDAR surveys. Operators are not required to report concentration data for components measured below the leak threshold (1,000 ppmv); therefore, emissions from these "non-leaking" components were estimated by assuming a leak rate equal to the average post-repair leak rate of all leaking components. Similar to an estimate of emission reductions, baseline emissions from leaks were estimated by assuming that leaks would have persisted for a year without the LDAR program. The combined

[22] Allen, D. (2016). Emissions from oil and gas operations in the United States and their air quality implications. *Journal of the Air & Waste Management Association*, 66:6, 549-575. DOI: 10.1080/10962247.2016.1171263.
[23] Brandt et al. 2016. Methane Leaks from Natural Gas Systems Follow Extreme Distributions. *Environmental Science & Technology*, 50:22, 12512-12520. DOI: 10.1021/acs.est.6b04303.
[24] ~160,000 metric tons CO_2e using the 20-year GWP of methane of 72.

total baseline emissions from leaking and "non-leaking" components subject to quarterly LDAR surveys for CARB's Oil and Gas Methane Regulation during 2020 was estimated to be ~9,400 metric tons methane,[25,26] or ~240,000 metric tons CO_2e.[27] Based on these calculations, 2020 LDAR surveys resulted in a 23% reduction in emissions from components subject to LDAR in the regulation.

Leak data broken down by local air district and owner/operator are shown in Appendix A. Figures A-1 and A-3 show emission reductions from each sector (crude oil production, natural gas production, natural gas transmission, natural gas storage, natural gas gathering and boosting stations, and natural gas processing plants), and Figures A-2 and A-4 show the ratios of leaks to components surveyed for each sector.[28] San Joaquin Valley Air Pollution Control District (APCD) had the highest emission reductions, with the majority coming from the crude oil production sector (Figure A-1). Excluding San Joaquin Valley APCD, the transmission sector had the highest ratios of leaks to components surveyed of the six sectors for all local air districts with natural gas transmission facilities (Figure A-2). There were only two districts, San Joaquin Valley APCD and South Coast AQMD, with facilities (4 total) in the processing plant sector that reported LDAR to CARB. The owner/operator with the highest emission reductions was Aera, followed by Pacific Gas & Electric and California Resources Corporation (Figure A-3). The owners/operators with the highest ratios of leaks to components surveyed based on sector were R&R Resources (20%; natural gas production) and Western Metals Corporation (4.50%; natural gas gathering and boosting), while Petrojen Production and Resources Engineering had the third highest ratio of 4.00% for the crude oil production and natural gas production sectors, respectively; no clear trends were observed across sectors (Figure A-4).

D. Comparison to 2019 Data and Conclusions

In 2020, CARB received annual reports for inspections from 97 operators at 437 facilities, whereas in 2019, 94 operators submitted annual reports for inspections at 380 facilities. The number of annual reports increased due to continued improvements in operator compliance with the Regulation during the third year of implementation, via CARB staff follow-up. During 2020 LDAR surveys, operators inspected more unique components (2,380,049 compared to 2,289,040 in 2019). Overall, more leaks were reported (13,594 compared to 7,208 in 2019), but fewer leaks were identified as greater than or equal to 10,000 ppmv (4,090 compared to 7,208

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[25] Converted from total hydrocarbons assuming a methane composition of 89.2% based on data from the Sage study (see footnote 20).

[26] Leaking and "non-leaking" components accounted for ~2,200 and ~7,200 metric tons methane, respectively.

[27] ~680,000 metric tons CO_2e using the 20-year GWP of methane of 72.

[28] The ratio metric in this report should not be compared to the "% of total inspected" metric in Tables 1 and 2 of CARB's Oil and Gas Methane Regulation. Tables 1 and 2 pertain to single inspections of a group of components during district or CARB inspections; the ratios in this report represent four inspections of a group of components during operator inspections. The ratio metric also should not be compared to the loss rate used in Greenhouse Gases, Regulated Emissions, and Energy Use in Transportation (GREET).

in 2019) – continuing the trend from 2018 to 2019. The overall ratio of leaks to unique components surveyed increased from 0.31% in 2019 to 0.57% in 2020. This increase is expected due to the decrease in leak threshold from 10,000 ppmv to 1,000 ppmv, leading to more reported leaks. Table 4 shows the LDAR survey leak distribution comparison between 2020 and 2019 for leaks identified as greater than or equal to 10,000 ppmv. Looking at the four sectors (crude oil production, natural gas production, natural gas storage, and natural gas transmission)[29] that were analyzed in 2019, each sector saw a decrease in ratio of leaks to unique components surveyed. Although the natural gas transmission sector remained the sector with the highest ratio of leaks to unique components surveyed, the leak ratio decreased from 0.69% in 2019 to 0.35% in 2020. The crude oil production sector leak ratio decreased from 0.30% in 2019 to 0.15% in 2020, natural gas production decreased from 0.29% to 0.17%, and natural gas storage decreased from 0.30% to 0.17%.

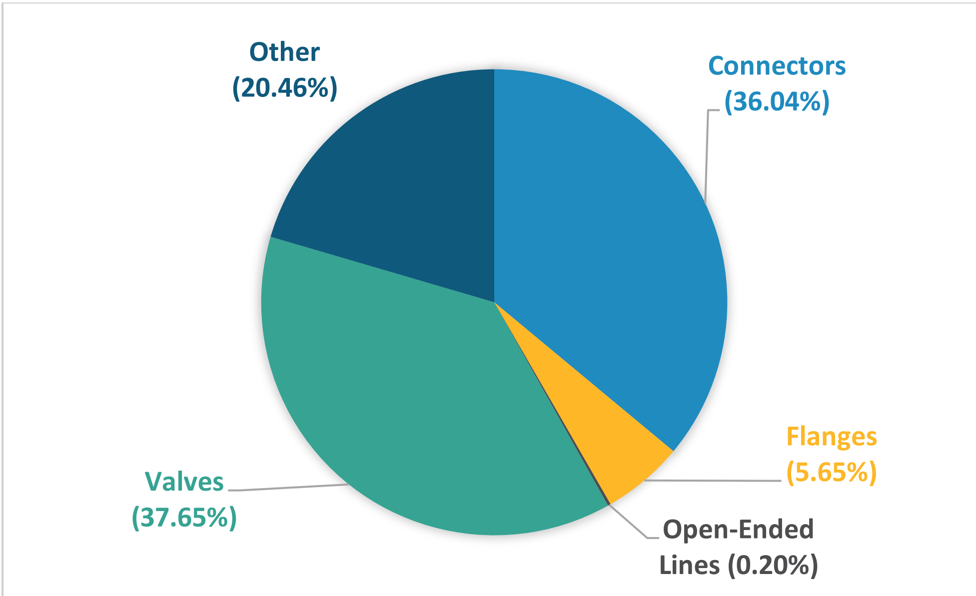
[29] Prior to 2020, facilities in the natural gas gathering and boosting station and natural gas processing plant sectors were categorized in the natural gas transmission sector or were included in their respective production facility reports.

Table 4: Components Found Leaking by Sector in 2020 and 2019

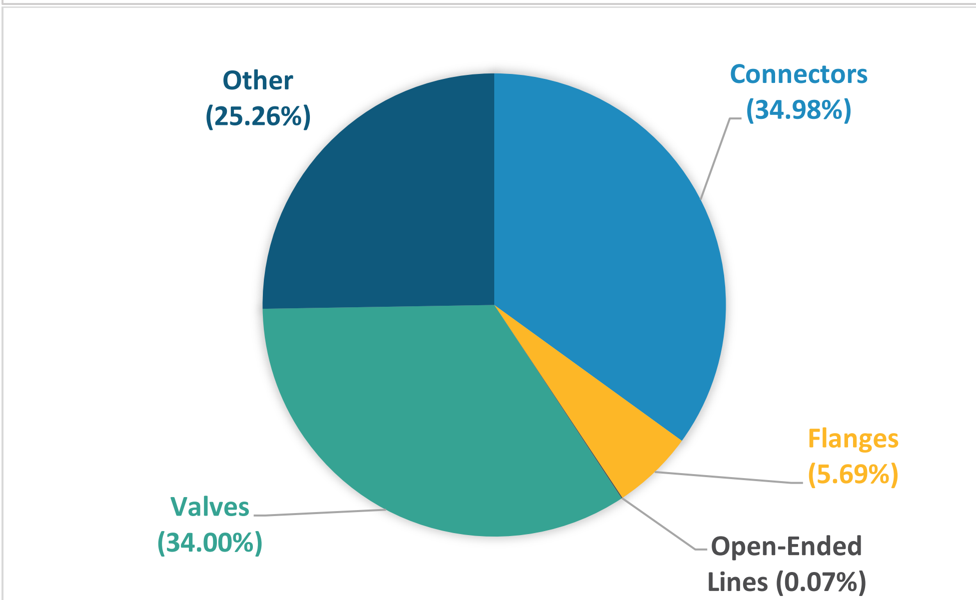
Sector	Total Count of Components in LDAR Program[30] (2020|2019)	Number of Leaks in Each Category[31] (Ratio of Leaks to Count of Components in LDAR Program by Sector)		Number of Leaks per Component Count in LDAR Program (%) (2020|2019)
		10,000 to 49,999 ppmv (2020|2019)	50,000 ppmv or greater (2020|2019)	
Crude Oil Production	1,454,623 | 1,422,282	1,805 (0.12%) | 3,482 (0.24%)	375 (0.03%) | 734 (0.05%)	0.15% | 0.30%
Natural Gas Production	359,536 | 347,614	444 (0.12%) | 985 (0.28%)	171 (0.05%) | 35 (0.01%)	0.17% | 0.29%
Natural Gas Storage	410,022 | 409,719	474 (0.12%) | 781 (0.19%)	221 (0.05%) | 432 (0.11%)	0.17% | 0.30%
Natural Gas Transmission	130,526 | 109,425	323 (0.25%) | 490 (0.45%)	139 (0.11%) | 269 (0.25%)	0.35% | 0.69%
Natural Gas Gathering and Boosting Stations	3,672	6 (0.16%)	2 (0.05%)	0.22%
Natural Gas Processing Plants	21,670	130 (0.60%)	0 (0.00%)	0.60%
Total	2,380,049 | 2,289,040	3,182 (0.13%) | 5,738 (0.25%)	908 (0.04%) | 1,470 (0.06%)	0.17% | 0.31%

Figure 4 shows the percentage of leaks found by component type in 2020 and 2019 for leaks identified as greater than or equal to 10,000 ppmv. Leak counts by component type were similar for 2020 and 2019 with connectors and valves having the most leaks, followed by the "other" category. The percentage of leaks found on connectors increased from 34.98% in 2019 to 36.04% in 2020, leaks found on valves increased from 34.00% to 37.65%, leaks found on components in the "other" category decreased from 25.26% to 20.46%, leaks found on flanges decreased from 5.69% to 5.65%, and leaks found on open-ended lines increased from 0.07% to 0.20%.

[30] These counts include the physical number of components that were surveyed four times throughout the year.
[31] A component could have been found to be leaking during a quarterly inspection and been repaired or replaced within the required time period, and also may have been measured as leaking again during a subsequent quarterly inspection, resulting in one component accounting for more than one leak.



(a)



(b)

Figure 4: Percentages of leaks identified in 2020 (a) and 2019 (b) by component type.

Table 5 displays the methane leak statistics for leaks greater than or equal to 10,000 ppmv in 2020 and 2019. In both years, on average, leaks found on open-ended lines had the highest leak rates but accounted for the fewest leaks total. The mean leak rate from all components remained about the same, at 0.049 kg CH_4/hr in 2019 and 0.046 kg CH_4/hr in 2020.

Table 5: Methane Leak Rate Statistics by Component Type for Leaks Greater than or Equal to 10,000 ppmv in 2020 and 2019[32]

	All Components (2020 | 2019)	Connector (2020 | 2019)	Flange (2020 | 2019)	Open-Ended Line (2020 | 2019)	Valve (2020 | 2019)	Other (2020 | 2019)
Min (kg CH_4/hr)	0.008 | 0.008	0.008 | 0.008	0.008 | 0.008	0.133 | 0.060	0.021 | 0.021	0.029 | 0.029
Max (kg CH_4/hr)	0.500 | 0.877	0.178 | 0.178	0.049 | 0.111	0.275 | 0.165	0.500 | 0.877	0.241 | 0.516
Mean (kg CH_4/hr)	0.046 | 0.049	0.018 | 0.018	0.017 | 0.018	0.171 | 0.140	0.058 | 0.062	0.083 | 0.082
Median (kg CH_4/hr)	0.031 | 0.034	0.016 | 0.014	0.016 | 0.015	0.153 | 0.160	0.050 | 0.051	0.074 | 0.070

Figure 5 shows the cumulative leak distribution for leaks greater than or equal to 10,000 ppmv in 2020 and 2019. The distribution of leaks in 2020 continues to illustrate that ~20% of leaks accounted for 50% of total emissions. Although fewer leaks were identified as greater than or equal to 10,000 ppmv in 2020 (4,090 compared to 7,208 in 2019), the distribution of leaks to emissions remains similar.

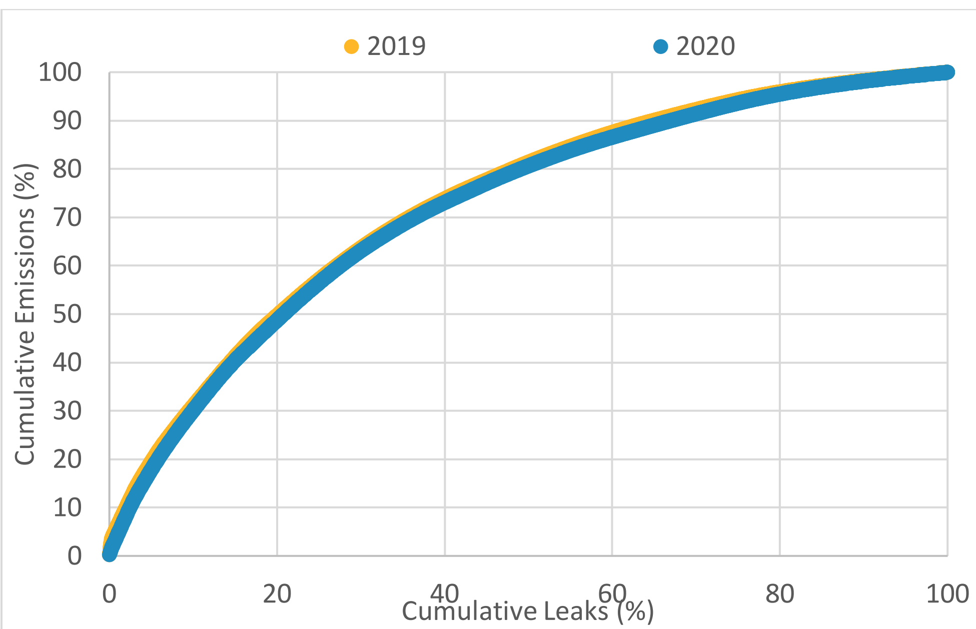


Figure 5: Fraction of cumulative emissions versus cumulative leaks for leaks greater than or equal to 10,000 ppmv based on LDAR data for 2020 and 2019.

[32] Leak rates were converted from total hydrocarbons assuming a methane composition of 89.2% based on data from a CARB 2019 study (see footnote 20).

Table 6 shows a comparison of LDAR emissions and emission reductions between 2020 and 2019. Emission reductions were less in 2020 than in 2019, with reductions of ~2,200 metric tons methane in 2020 compared to ~3,000 metric tons methane in 2019. Looking at the reductions from leaks greater than or equal to 10,000 ppmv, in 2020 those leaks accounted for ~1,600 metric tons methane. The decrease in reductions from leaks greater than or equal to 10,000 ppmv was due to the decrease in the number of leaks identified in 2020. Although the number of components surveyed increased from 2019 to 2020, the baseline emissions from components subject to quarterly LDAR surveys decreased in 2020 relative to 2019. Most of the decrease (76.40%) is seen from "non-leaking" components. This is expected since the emissions from these components were calculated using the average post-repair concentration, which was lower due to the decrease in the allowed leak threshold in 2020 and fewer number of leaks found above 10,000 ppmv. Comparing the baseline emissions from leaks greater than or equal to 10,000 ppmv, the 2020 emissions decreased from ~3,100 metric tons methane in 2019 to ~1,600 metric tons methane in 2020. LDAR surveys in 2020 resulted in a 23% reduction in emissions from components subject to LDAR in the regulation. For leaks greater than or equal to 10,000 ppmv, the emission reductions increased from 12% in 2019 to 17% in 2020; the increase was caused by the decrease in baseline emissions.

Table 6: Comparison of LDAR Emissions and Emission Reductions between 2020 and 2019

<table>
<tr><th></th><th colspan="2">2020</th><th>2019</th></tr>
<tr><td>Baseline Emissions (metric tons methane; "non-leaking" components)</td><td colspan="2">7,200</td><td>21,000</td></tr>
<tr><td>Baseline Emissions (metric tons methane; "leaking" components)</td><td colspan="2">2,200</td><td>3,100</td></tr>
<tr><td>Total Baseline Emissions (metric tons methane)</td><td colspan="2">9,400</td><td>24,100</td></tr>
<tr><td></td><td>1,000 to 10,000 ppmv</td><td>10,000+ ppmv</td><td>10,000+ ppmv</td></tr>
<tr><td>Baseline Emissions (metric tons methane; "leaking" components)</td><td>600</td><td>1,600</td><td>3,100</td></tr>
<tr><td>Total Emission Reductions (metric tons methane)</td><td>600</td><td>1,600</td><td>3,000</td></tr>
<tr><td>% Emission Reductions</td><td>6%</td><td>17%</td><td>12%</td></tr>
</table>

As expected, the decrease in allowed leak threshold from 2019 to 2020 lead to an increase in total number of leaks identified; however, the number of leaks identified as greater than or equal to 10,000 ppmv continued to decrease, suggesting that continued implementation of an LDAR program may reduce the number of leaks over time. The increase in total number of leaks identified also demonstrates that there are a large number of smaller leaks that should not be left unabated. Continued, frequent LDAR surveys is pivotal in mitigating the emissions from not only larger leaks, but also small leaks.

Appendix A: LDAR Data by Local Air District and Owner/Operator

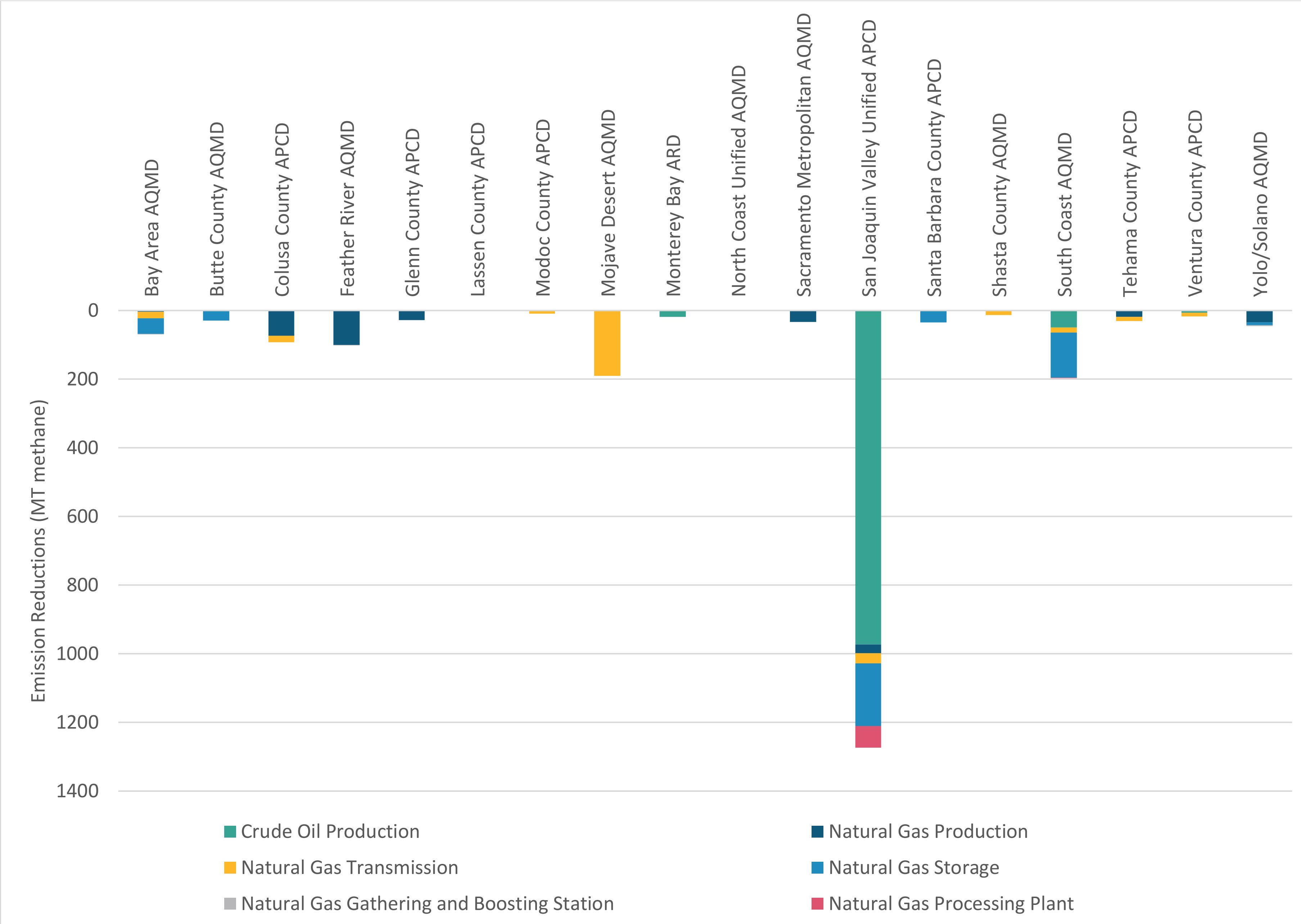


Figure A-1: Emission reductions from each sector by local air district during 2020.

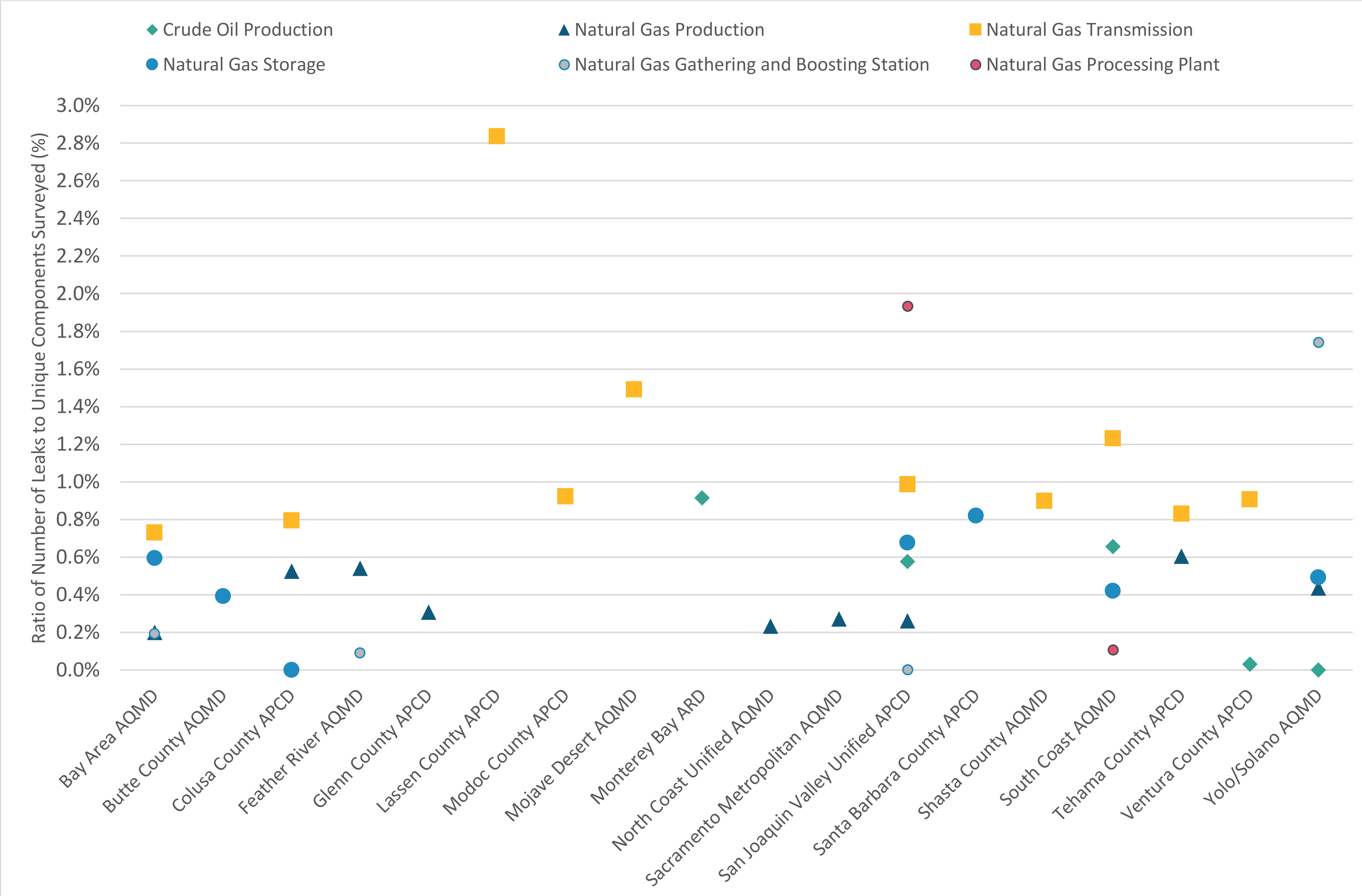


Figure A-2: Ratios of numbers of leaks to numbers of unique components surveyed for each sector by local air district during 2020. Note there are overlapping values: Bay Area AQMD had ratios of 0.20% and 0.19% for natural gas production and natural gas gathering and boosting station, respectively.

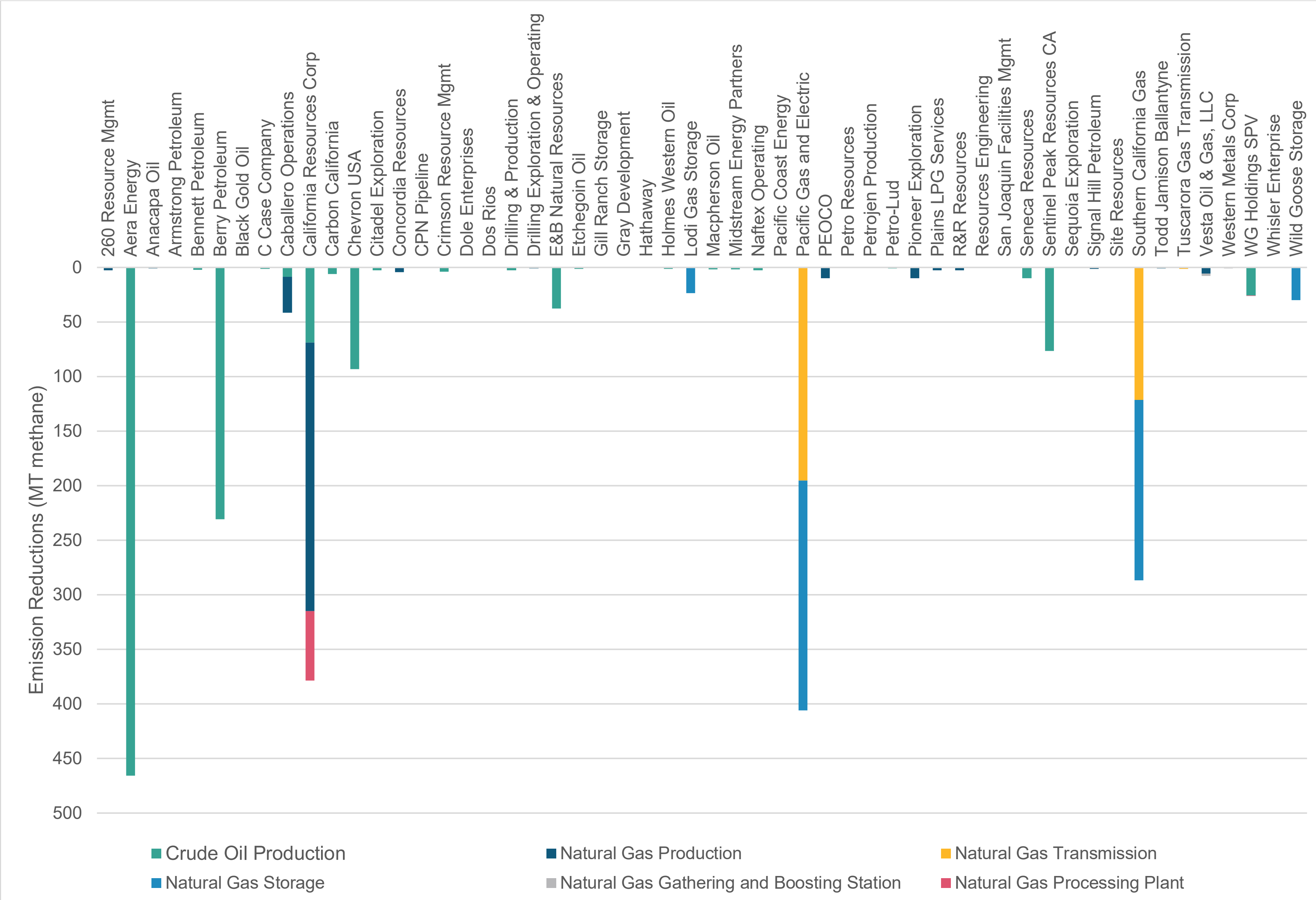


Figure A-3: Emission reductions from each sector by owner/operator during 2020. Of the 97 operators who conducted quarterly LDAR surveys, 43 did not measure any leaks at or above 1,000 ppmv and are therefore not shown here.

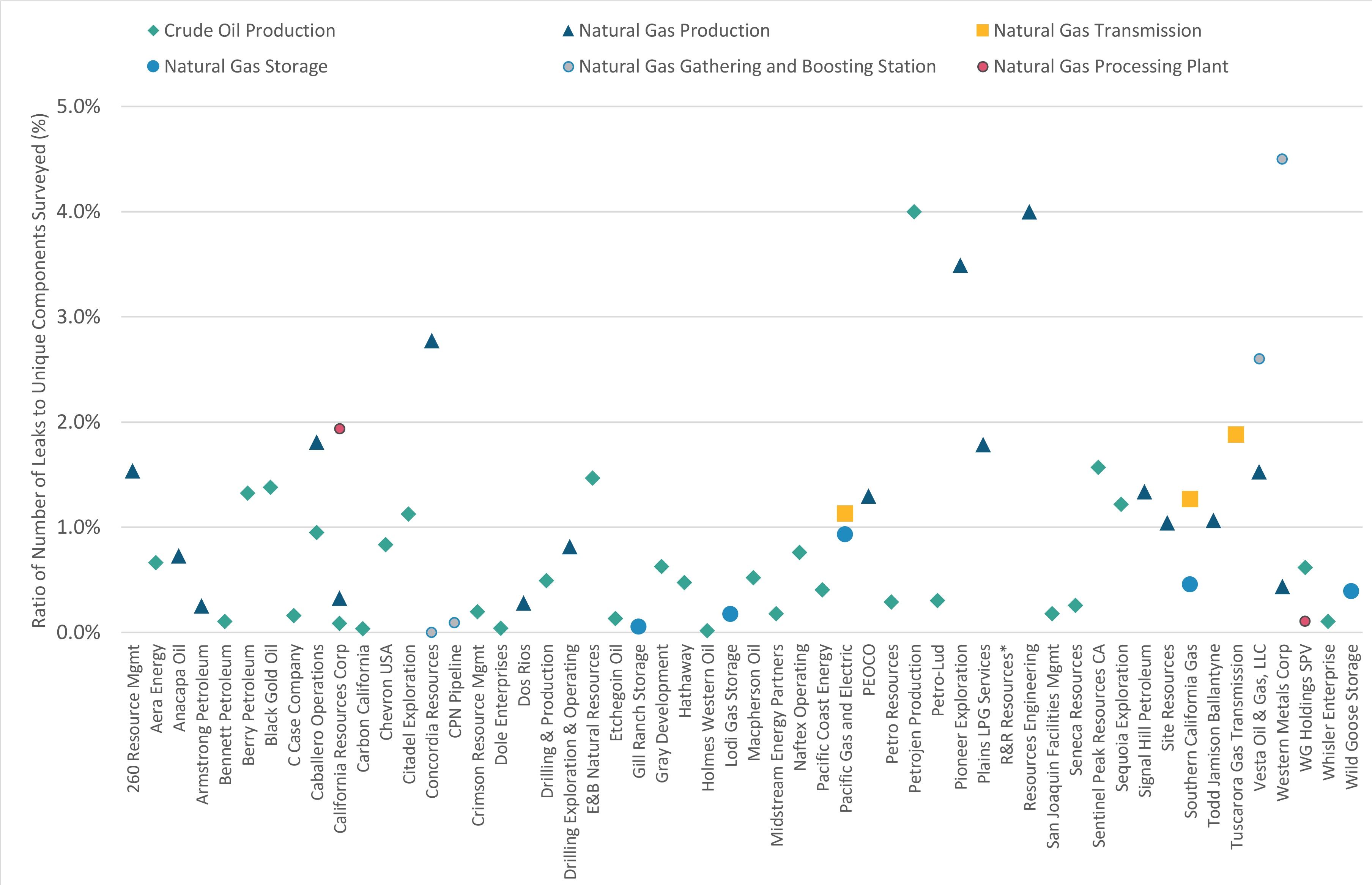


Figure A-4: Ratios of numbers of leaks to numbers of unique components surveyed for each sector by owner/operator during 2020. Of the 97 operators who conducted quarterly LDAR surveys, 43 did not measure any leaks at or above 1,000 ppmv and are therefore not shown here. *R&R Resources had a ratio for natural gas production of 20%, but the y-axis in this figure was limited to 0-5% to better illustrate the variation between the vast majority of operators.