2020 Methane Emissions Management from the Upstream Oil and Gas Sector in Alberta

Alberta

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Alberta Environment and Parks

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Introduction

This information report provides details related to mitigating methane emissions from the upstream oil, bitumen and gas sector in Alberta. This includes all facilities licensed or approved by the Alberta Energy Regulator (AER), including, but not limited to, well sites, oil and gas batteries, gas plants, compressor stations, pipelines, gas gathering systems, oil production sites, and other related facilities; it does not include bitumen mining and upgrading.

The Government of Alberta established a target to achieve a 45% reduction in oil and gas methane emissions from a 2014 baseline by 2025. Provincial methane mitigation requirements and programs have set Alberta on the path towards achieving that target.

Alberta and Canada established an equivalency agreement regarding the reduction of methane emissions from the oil and gas sectors. The Agreement on the Equivalency of Federal and Alberta Regulations Respecting the Release of Methane from the Upstream Oil and Gas Sector in Alberta, 2020 ("equivalency agreement") came into force with the publication of a final order under section 10(3) of the *Canadian Environmental Protection Act* on October 26, 2020. This report meets Alberta's annual reporting requirements included in the agreement. Federal Regulations Respecting Reduction in the Release of Methane and Certain Volatile Organic Compounds (Upstream Oil and Gas Sector) no longer apply in Alberta. Rather, Alberta's Methane Emissions Reduction Regulation and Directive 060: Upstream Petroleum Industry Flaring, Incinerating, and Venting apply.

The equivalency agreement was established in 2020, and the 2020 compliance period is the first annual information report.

Results from 2020 indicate that Alberta on track to achieving the 45% reduction target in 2025. Reported and estimated emissions in 2020 show a 34% reduction in methane emissions from 2014 levels.

Report Information and Structure

The equivalency agreement includes that Alberta provide on an annual basis the following:

A. the number of existing facilities and wells that are subject to the Methane Emission Reduction Regulation (MERR), disaggregated by well type and facility classification, with the average number of dehydrators and compressors at each facility type
B. the number of new facility permits and well permits issued, disaggregated by well type and facility classification
C. the number of closures of facilities and wells, disaggregated by well type and facility classification
D. information respecting an assessment of the implementation and effectiveness of the MERR in reducing methane emissions (in CO_2e), including the methodology (by source), analysis undertaken and results of calculations of emission reductions
E. a summary of compliance verification activities and enforcement or sanctions measures relating to the MERR applied to facilities and wells, segregated by well type and facility classification, including the number of inspections and verifications other than inspections, the number and type of non-compliance events and the orders, penalties, and convictions, and
F. a summary of the annual reports submitted under the MERR including the number of duty holders who submitted annual reports.

This report is organized to align with sections A to F of the equivalency agreement, referenced above. Parts A, B and C of this report summarize data compilation methods respecting the reporting requirements identified previously as A, B and C of the equivalency agreement. Parts D, E and F of this report summarize AER emissions modelling, surveillance program, and OneStop data requirements identified as parts D, E and F of the equivalency agreement.

Methane emission reporting to the AER is done using reporting facility identifiers that are also used for production volumetric reporting. Facility IDs are characterized by type and sub-type as identified in Manual 011: How to Submit Volumetric Data to the AER. Not all facility IDs are required to report under the MERR and Directive 060 Section 8. Facility subtypes that are required to report are listed in Table 4 of Manual 015: Estimating Methane Emissions. All infrastructure in the upstream oil and gas industry can be delineated to one and only one facility ID.

Facilities, wells and pipelines are also authorized for construction and operation through licenses issued by the AER. Some upstream oil and gas sites that do not have wells and do not meet the risk criterion for requiring a facility license may be unlicensed. Pipeline licenses may include multiple installations which have surface equipment. Well licenses and facility licenses may be co-located. Infrastructure capable of emitting methane emissions in the upstream oil and gas industry may be associated with one, multiple or no licenses.

Counts for this report are given as of the dates noted.

Part A - Number of Existing Facilities and Wells

The number of existing facilities and wells that are subject to the MERR in 2020, disaggregated by well type and facility classification, with the average number of dehydrators and compressors at each facility type, are provided in

Table 1 and **Error! Reference source not found.**.

TABLE 1: NUMBER OF EXISTING FACILITIES, DEHYDRATOR AND COMPRESSORS SUBJECT TO THE MERR IN 2020

Facility Type	Facilities[1, 2]	Dehydrators[3]	Compressors[2]
Crude Bitumen Battery	3,542	5	37
Crude Oil Battery	8,521	73	432
Gas Battery	9,509	220	476
Gas Gathering / Compressor Station	6,899	349	1,458
Gas Plant	531	440	1,223
Other[4]	1,935	4	9
Unknown[5]	0	175	0
Total	**30,937**	**1,266**	**3,635**

[1] Includes licensed facilities, licensed wells and unlicensed facilities. A licensed well may consist of more than one well but is counted as one for the purposes of this table.

[2] As of August 5, 2021.

[3] As of July 11, 2021.

[4] "Other" facilities include, but are not limited to Acid Gas Disposal, Disposal, Oil Sands Processing Plants, etc.

[5] Dehydrators are reported under Directive 039, which does require an ID, resulting in many unknown facility types.

TABLE 2: NUMBER OF EXISTING WELLS SUBJECT TO THE MERR IN 2020

Fluid Type	Number of Wells[6]
Coalbed Methane - Shale & Other Sources	43
Coalbed Methane - Coals Only	4,058
Coalbed Methane - Coals & Other Lithology	9,049
Crude Bitumen	3,796
Crude Oil	25,538
Gas	59,332
Helium	2
Shale Gas Only	637
Shale Gas & Other Sources	16
Total	**102,471**

Part B - Number of New Facility and Well Permits Issued

The number of new facility and well permits issued, disaggregated by well type and facility classification in 2020, are shown in Table 3 and Table 4.

TABLE 3: NUMBER OF NEW FACILITY PERMITS ISSUED SUBJECT TO THE MERR IN 2020

Facility Type	Number of New Facility Permits[1,6]
Crude Bitumen Battery	379
Crude Oil Battery	728
Gas Battery	1,127
Gas Gathering / Compressor Station	179
Gas Plant	22
Other[4]	170
Total	**2,605**

[6] As of November 16, 2021.

TABLE 4: NUMBER OF NEW WELL PERMITS SUBJECT TO THE MERR ISSUED IN 2020

Fluid Type	Number of New Well Permits[6]
Coalbed Methane - Shale & Other Sources	6
Coalbed Methane - Coals Only	78
Coalbed Methane - Coals & Other Lithology	53
Crude Bitumen	257
Crude Oil	1,036
Gas	1,477
Helium	2
Shale Gas Only	61
Total	**2,970**

Part C - Number of Closures of Facilities and Wells

The number of closures of facilities and wells, disaggregated by well type and facility classification, are shown in Table 5 and Table 6.

TABLE 5: NUMBER OF FACILITY CLOSURES IN 2020

Facility Type	Number of Facility Closures[1,6]
Crude Bitumen Battery	31
Crude Oil Battery	44
Gas Battery	35
Gas Gathering / Compressor Station	135
Gas Plant	4
Other[4]	10
Total	**259**

TABLE 6: NUMBER OF WELL CLOSURES IN 2020

Fluid Type	Number of Well Closures[6]
Coalbed Methane - Shale & Other Sources	2
Coalbed Methane - Coals Only	26
Coalbed Methane - Coals & Other Lithology	28
Crude Bitumen	170
Crude Oil	1,403
Gas	3,313
Helium	0
Shale Gas Only	1
Water	258
Not Applicable	41
Total	**5,242**

Part D - Implementation and Effectiveness of the MERR

An assessment of the implementation and effectiveness of the MERR was conducted using the Methane Emissions Economic Model of Alberta (MEEMA).

Methane Performance

The emission reduction target set by the Government of Alberta is to achieve a 45% reduction in methane emissions from conventional oil and gas from a 2014 baseline by 2025. New methane requirements have set Alberta on the path towards achieving that target. By the end of 2020, a 34% reduction in methane emissions from 2014 levels has been achieved.

Figure 1 shows the methane emissions (a combination of reported data and estimates) from 2014 to 2020 and forecasts emissions to 2025. These reductions are the result of the requirements of Directive 060 and include early action through programs like the Alberta emissions offsets.

The methane emissions are established through data reported to the AER, estimates and modelling. Modelling and estimates supplement reported data (e.g., 2020 was also a modified year for fugitive emissions surveys due to COVID-19) to allow for an evaluation of the emission reductions achieved to date.

The evaluation excludes oil sands mining and upgrading emissions due to the significant difference in sources (primarily mine face and tailings ponds), control measures and abatement costs. Oil sands mining and upgrading methane emissions are regulated through the Technology Innovation and Emission Reduction (TIER) Regulation.

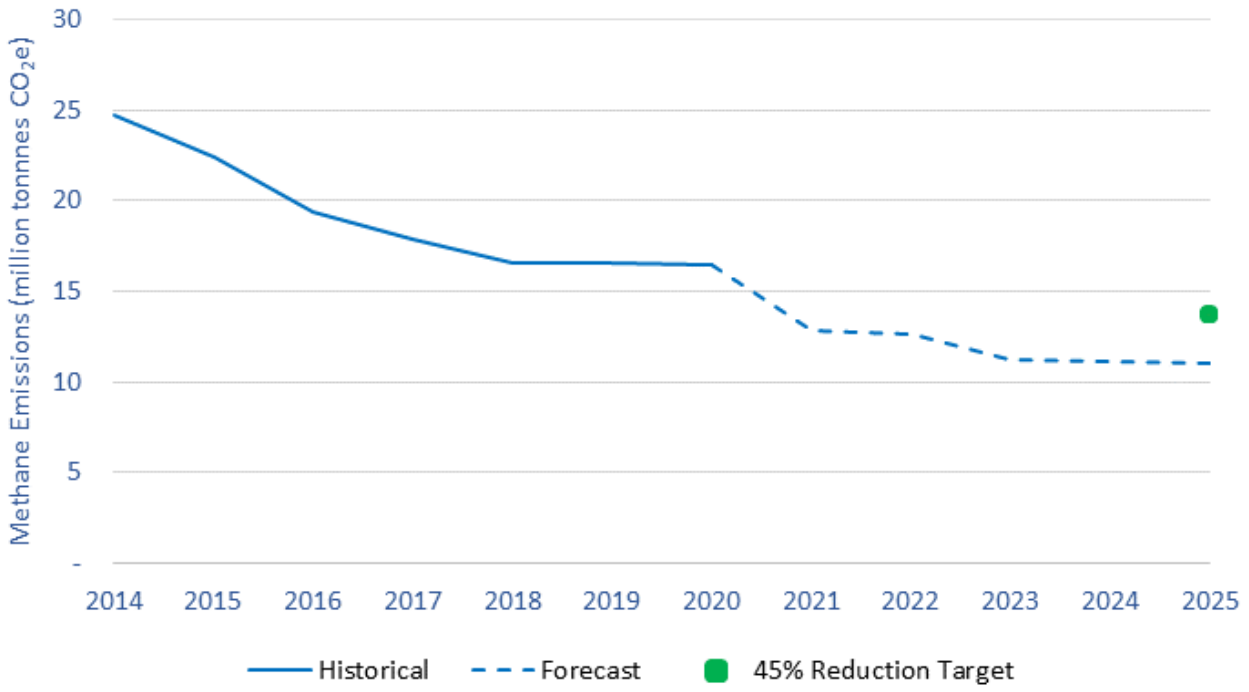

FIGURE 1: METHANE EMISSIONS REDUCTION ESTIMATE AND FORECAST

Methane Emissions Economic Model of Alberta

The Methane Emissions Economic Model of Alberta (MEEMA) was developed to quantify baseline methane emissions from the upstream oil and gas industry and the reductions associated with each requirement. In addition to quantifying emissions, the model quantifies the costs associated with the methane emission reduction requirements, including any measuring, monitoring and reporting (MMR) costs.

The model is based on Microsoft Excel and uses established oil and gas activity modules with customized emissions, technology and requirements modules to estimate methane emissions from Alberta's upstream oil and gas industry.

The model consists of five modules shown in Figure 2 and including:

- Economics module - calculates discounted cash flows and delivers metrics such as net present value, payout, and internal rate of return. The impact of commodity prices on oil and gas drilling activity is implicit in the economics module. The economics module also accounts for additional costs imposed by methane reduction requirements. The cash flows from the economics module inform the oil and gas activity module.
- Oil and gas activity module - simulates industry activity by estimating production forecasts and well counts. There are several parts to industry activity, including activity resulting in new sites, activity of existing sites, and reduced future drilling activities (forgone wells) and shut-in production. The resulting production forecasts and well counts feed into the emissions module to estimate emissions.
- Emissions module - calculates methane emissions from new and existing sites. A 100-year global warming potential of 25 tonnes CO_2e for 1 tonne of methane was used in the model (IPCC 4th Assessment Report, 2007). Assumptions, source data and methodologies were tailored to each emissions source category as summarized in Annex 1.

  When available, industry-reported methane mass emissions are used as they likely provide the most accurate value. When mass emission data are not available, the general approach is to utilize facility counts, component counts, emission factors and an assumed methane content.

- Regulatory requirements module - translates the requirements into formulas to quantify and measure their effect on emission outputs. The requirements module interacts with the technology module since different technologies may be used or purchased to meet the requirements, and these technologies will be deployed differently depending on the stringency of the requirements.
- Technology module - describes the technologies that would be expected to comply with the requirements. Many technologies can be used to mitigate multiple emission source categories, while others are unique to certain emission sources. Different equipment or services may be needed to achieve different levels of emission reduction and costs may vary depending on the equipment or services.

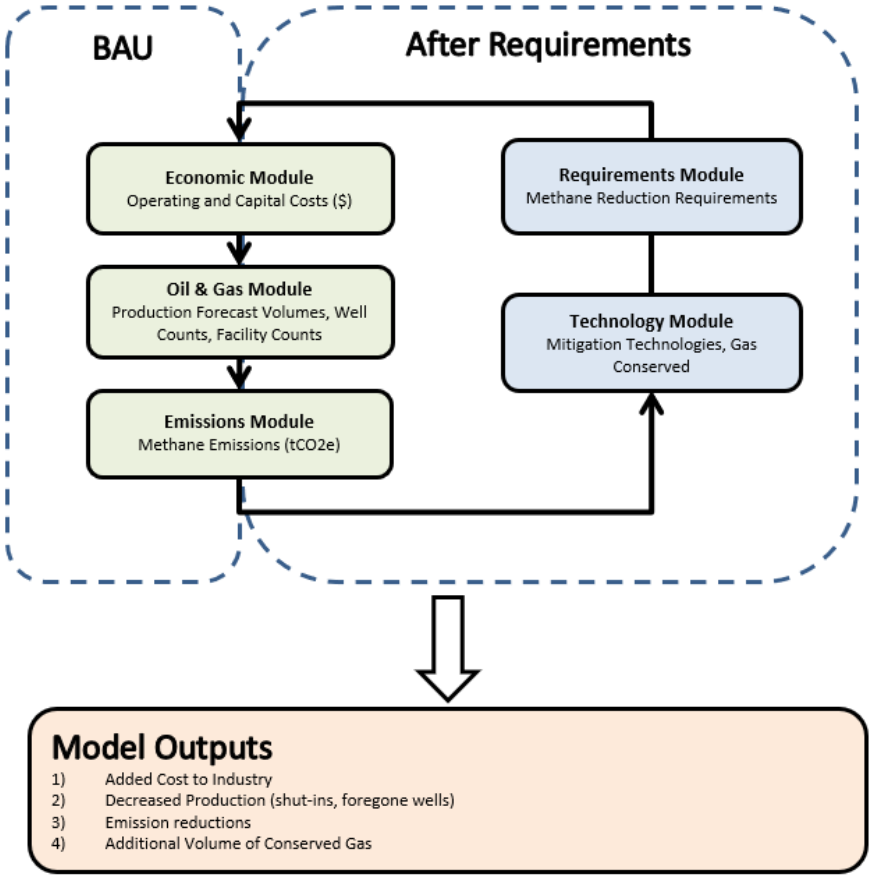

FIGURE 2: AER MEEMA MODEL STRUCTURE

The model delivers methane emissions forecasts, volumes of natural gas conserved, lost wells, and production losses. The model also quantifies incremental capital costs, operating costs, and marginal abatement costs (MAC), which describe the average cost of reducing one tonne of carbon dioxide equivalent (CO_2e). The total methane emissions in 2014 are estimated to be 25 Mt CO_2e.

OneStop Source Specific Emissions

Emissions data reported to the AER through OneStop, as a requirement of the methane emission reduction requirements, provide detail on the source specific contributions to methane emissions. In 2020, total OneStop emissions were 547.1 10^6 m^3 from flaring, incinerating and venting at upstream petroleum industry wells and facilities in Alberta. This includes pipeline installations that convey gas (e.g., compressor stations, line heaters) licensed by the AER in accordance with the *Pipeline Act* (not including Canada Energy Regulator-regulated pipelines) and all schemes and operations approved under section 10 of

the *Oil Sands Conservation Act* (excluding processing plants approved under section 11 of the act and oil sands mining schemes and operations).

Table 7:and Figure 33 show data reported in 2020 by source category and facility subtype. This is the first year the AER required reporting of both vent and fugitive emissions data via OneStop. The data represent most of the facilities that were required to report, however, there were still some data gaps at the time of publication. One data gap is in the fugitive emission category, which was under-reported in 2020 because of requirement adjustments in response to the COVID-19 pandemic.

TABLE 7: 2020 SOURCE SPECIFIC VOLUMES REPORTED TO ONESTOP BY FACILITY SUBTYPE

(in 10^6 m^3) *

Facility Sub Type	DVG	Pneumatic Pumps	Pneumatic Instruments	Reciprocating Compressors	Centrifugal Compressors	Glycol Dehydrators	Fugitive Emissions
Crude Bitumen Battery	41.7	1.1	0.6	0.3	0.0	0.0	10.1
Crude Oil Battery	65.3	20.3	23.3	3.6	0.0	0.5	15.2
Gas Battery	32.5	108.9	96.0	3.3	0.1	4.2	13.8
Gas Gathering / Compressor Station	8.1	3.6	7.9	10.1	0.3	10.6	8.1
Gas Plant	15.2	1.8	3.2	9.6	0.8	1.7	11.9
Other	1.3	0.2	0.4	0.0	0.0	0.4	11.0
Total	**164.1**	**135.9**	**131.4**	**26.9**	**1.2**	**17.4**	**70.1**

*Estimated emissions due to some underreporting through OneStop.

The data in Figure 33 show that gas batteries are the facility subtype with the greatest associated emission volumes, because of the high presence of pneumatic devices at these facility subtypes. Defined Vent Gas (DVG) is the greatest contributing source for both crude oil and crude bitumen batteries, likely due to the presence of hydrocarbon storage tanks at these sites. As the AER continues to evaluate means of improving tank emissions estimation methods, we may see fluctuations in these reported volumes in subsequent years.

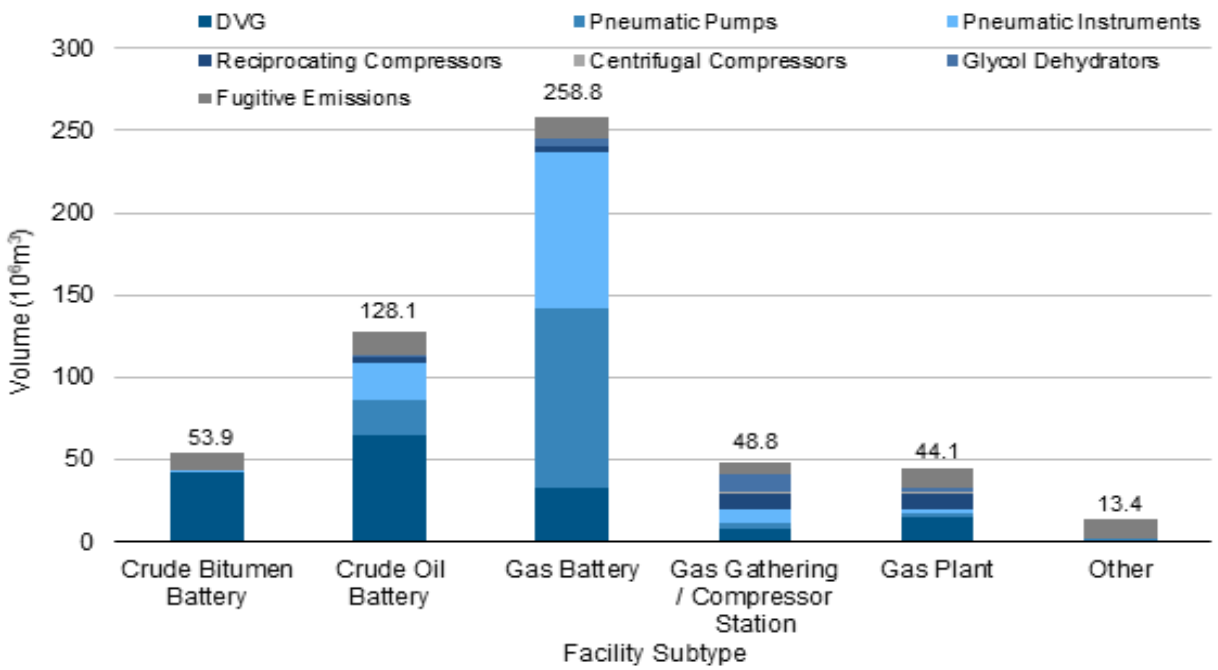

FIGURE 3: REPORTED ONESTOP EMISSION VOLUMES BY SOURCE CATEGORY AND FACILITY SUBTYPE

Defined Vent Gas

Directive 060 includes vent limits for defined vent gas (DVG) that is reported annually to the AER through OneStop. DVG should also be captured within the vent volumes reported to Petrinex. In 2020, DVG emissions reported to OneStop were 164.1 10^6m^3. This represents 30.0% of the total emissions reported to OneStop. The emission volume distribution between battery types does not vary significantly, however, crude oil batteries do contribute the most DVG emissions by volume.

Pneumatic Devices

Directive 060 includes vent limits for vent gas from both pneumatic instruments and pumps. Emissions from pneumatic instruments and pumps are estimated based on a comprehensive inventory and are reported annually to the AER through OneStop. These volumes should also be captured within the vent volumes reported to Petrinex. Pneumatic device inventories are not required to be reported to the AER, so comprehensive device counts are not provided, only emission volumes in Table 7 and Figure 3.

In 2020, emissions reported to OneStop for pneumatic devices (instruments and pumps) were 267.2 10^6m^3. This represents 48.9% of the total emissions reported to OneStop. Gas batteries were the most significant contributor with 76.6% of the total pneumatic emissions. This is a result of a large count of gas batteries and a higher likelihood for gas driven pneumatic devices at these sites, as found in the 2018 Clearstone Engineering Report: Update of Equipment, Component and Fugitive Emission Factors for Alberta Upstream Oil and Gas.

Compressor Seals

Directive 060 includes testing requirements and vent limits for both reciprocating and centrifugal compressor seals. Emissions tested and estimated from these seals are reported annually to the AER through OneStop. These volumes should also be captured within the vent volumes reported to Petrinex.

Directive 060 requires a comprehensive compressor inventory reported annually to the AER through OneStop. Compressors rated at least 75 KW and pressurized greater than 450 hours must be reported individually. For compressors that do not meet those criteria, their associated emissions are reported to compressor seals for that facility, however not to a specific compressor. In 2020, there were 3,433 reciprocating compressors and 202 centrifugal compressors that reported activity.

Emissions associated with compressors, such as compressor blowdowns and engine starts, are reported to the Overall vent gas (OVG) limit.

In 2020, reciprocating compressor seal emissions reported to OneStop were 26.9 $10^6 m^3$. This represents 4.9% of the total emissions reported to OneStop. Centrifugal compressor seal emissions reported to OneStop were 1.2 $10^6 m^3$, a small emission contributor relative to the other sources reported in Table 7 and Figure 3, representing only 0.2% of the total emission reported to OneStop. The most significant contributions came from gas gathering, compressor stations and gas plants. Given the presence of compressors is more likely at these large facility subtypes, it is reasonable that they would have the highest associated volumes.

Glycol Dehydrators

Directive 060 includes vent gas limits for glycol dehydrators. Glycol dehydrator emissions must be reported to the AER through OneStop annually. These volumes should also be captured within the vent volumes reported to Petrinex.

Companies are also required to meet the benzene emission requirements for glycol dehydrators (dehydration and refrigeration) set out in Directive 039: Revised Program to Reduce Benzene Emissions from Glycol Dehydrators. Under Directive 039, licensees must complete and submit to the AER an annual dehydrator inventory list that details the emissions from all their glycol dehydrators.

In 2020, there were 1,266 operating glycol dehydrators in Alberta. Not all dehydrators would be active for the full year but are counted in this inventory if they were operated at all in 2020.

The reporting requirements for glycol dehydrators differ from all other source categories in that the AER only requires the emissions mass to be reported. The data presented Table 7 and Figure 3 reflects a conversion of the reported mass to volume using methane density and an 85% methane concentration estimate. In 2020, glycol dehydrator emissions were calculated to be 17.4 $10^6 m^3$. This represents 3.2% of total emissions reported to OneStop. The most significant contributions came from gas gathering and compressor stations with 61.2% of total emissions.

Fugitive Emissions

Fugitive emissions are unintentional releases of hydrocarbon to the atmosphere and can result from the wear or failure of equipment. Directive 060 includes requirements for screenings and surveys to inspect for and repair fugitive emissions. These emissions are reported to the AER through OneStop annually.

2020 was the first year of implementing prescribed fugitive emission requirements under Directive 060 and the first year for which equipment fugitive emissions data was reported to the AER. This year was also unique, as there were temporary requirement relaxations because of the COVID-19 pandemic. In 2020, fugitive emissions were 70.1 $10^6 m^3$. This represents 12.8% of total emissions reported to OneStop. Though facility counts vary significantly from one facility subtype to the other (see Table 1), the fugitive emission volumes are relatively consistent.

Surface Casing Vent Flows and Gas Migration

A surface casing vent flow (SCVF) is the flow of gas, liquid, or both out of the surface casing or casing annulus of a well. Gas migration (GM) is the flow of detectable gas at the surface outside of the outermost casing string.

Directive 060 requires increased ongoing fugitive emissions surveys at active sites, which will result in more frequent inspections of surface casing vents, as these are identified as mandatory equipment within the scope of a fugitive emission survey.

In 2021, the AER released Directive 087: Well Integrity Management (formerly issued as Interim Directive 2003-01: 1) Isolation Packer Testing, Reporting, and Repair Requirements; 2) Surface Casing Venting Flow/Gas Migration Testing, Reporting, and Repair Requirements; and 3) Casing Failure Reporting and Repair Requirements. Directive 087 complements Directive 060 regarding SCVF management. Directive 060 contains ongoing survey requirements, while Directive 087 contains testing, reporting and repair requirements for isolation packers, SCVFs, gas migration and casing failures. Directive 087 requires companies to report emissions from SCVFs and GM. Over the years, the AER has worked with licensees to ensure proper reporting of SCVFs and GM.

Table 8 shows that in 2020, there were 10,246 unrepaired wells with SCVFs or GM that emitted a total of 65 10^6 m^3 of natural gas.

TABLE 8: EMISSIONS FROM SCVFS AND GM AT UNREPAIRED WELLS

Year	Number of Wells with SCVFs, GM or Both[a]	Annual Natural Gas Emissions (10^6 m^3)[b,c,d]
2010	8,926	95
2011	9,318	92
2012	9,563	88
2013	9,624	89
2014	9,982	84
2015	10,247	86
2016	9,972	81
2017	10,291	83
2018	10,128	65
2019	10,324	66
2020	10,246	65

[a] For wells that have SCVF flow rates that are too small to measure and wells where a GM flow rate cannot be determined, a flow rate of 1 m^3/day was used.

[b] The flow rates reported are from a single point in time and are extrapolated to determine annual emissions. Flow rates for SCVFs and GM can fluctuate significantly over a period of time.

[c] Typically, the methane content of natural gas in SCVFs and GM is between 95 and 99 per cent.

[d] If no emissions type (e.g., natural gas, saline water, or non-saline water) is provided, an SCVF or GM is assumed to be natural gas and have a flow rate equal to the average of all other reported natural gas SCVFs or GM.

The age, construction and operation of a well affect the rates of SCVFs or GM.

As a result, these SCVF or GM rates differ throughout the well's lifecycle.

Table 9: shows the percentage of wells with an SCVF or GM in 2020, both repaired and unrepaired, based on the status of the well. For all wells that were not abandoned, 7.6% had a reported SCVF or GM.

TABLE 9: PERCENTAGE OF WELLS WITH AN SCVF, GM OR BOTH BY WELL STATUS IN 2020

Well Status	Number of Wells	Number of Wells that Reported SCVFs or GM	Percentage of Wells with SCVFs, GM or Both (%)
New Drills[a]	666	5	0.8
Active[b]	159,140	8,363	5.3
Inactive[c]	97,243	11,249	11.6
Total	**257,049**	**19,617**	**7.6**

[a] New drills are wells that have been recently drilled and for which licensees are required to test and report any SCVF or GM.

[b] Active wells are those that are currently producing or injecting and reporting volumetric activity on Petrinex.

[c] Under Directive 013: Suspension Requirements for Wells, inactive wells are those that have not reported any volumetric activity for either 6 or 12 months, depending on the well's risk classification. The number of inactive wells shown in this table also includes wells that are not covered by Directive 013, such as observation wells and training wells.

Improving Performance

The methane reduction requirements are a significant change to how industry manages and reports methane. To improve understanding and ensure compliance, the following activities are carried out:

- remote sensing pilots – details below
- inspections and audits - details below, and
- industry education.

The AER has invested in methane detection equipment to better its understanding of emissions, detect potential non-compliances and help drive better industry performance. The detection equipment used includes: optical gas imaging cameras used by methane field inspectors across the province; truck-mounted methane sensors; drones with gas imaging cameras that can monitor methane plumes; and vent gas metering equipment.

Remote Sensing Pilots

In 2020, AER conducted its second remote sensing pilot that used technologies such as satellite-, airplane- and truck-mounted methane sensors as emissions compliance tools. The objective of the pilot was to determine if there are technologies available that could serve as regional surveillance tools for emissions compliance.

For the 2020 pilot program, an airplane-mounted methane sensor was used over 1435 km^2 and approximately 3000 facilities to collect site-level methane data primarily within the areas surrounding Grande Prairie and Lloydminster. Of these 3,000 facilities, only 9 were identified as having emissions greater than 375 m^3 per day. To validate these detections in the field, the AER sent methane inspectors to 108 of sites the sites that were flown over. Of these 108 sites, 25 appeared to have emissions that were undetected or not present at the time of the fly-over. This may speak to both the variability in emission releases and the importance of understanding the detection capabilities of screening technologies.

Emissions data from the 2020 pilot were used to evaluate limit exceedances, but they are only snapshot detections in time and are not solely able to confirm a noncompliance.

The following important lessons were learned from these pilots:

- Remote sensing technologies that can detect emission rates near compliance limits are valuable tools for assessing risk as part of Alberta's compliance program.
- The role methane inspectors play in validating aerial surveillance data is critical in getting a more comprehensive picture of the emissions being observed during these screenings.
- It is important that detection technologies undergo robust performance testing so that the capabilities of the technology are well understood and can be clearly communicated.

The AER plans to continue remote sensing campaigns annually to collect compliance data and to help direct where ground-based methane inspections will occur.

Part E - Compliance Verification and Enforcement

In pursuit of compliance assurance for offenses in Section 9 of the MERR, as per Section 8 of Directive 060, the AER made requests for various reports or records, conducted various inspections and verifications in 2020 as part of a compliance assurance program. The results are summarized here.

Compliance Assurance and 2020 Activity

Compliance assurance at the AER is guided by the Integrated Compliance Assurance Framework (ICAF), which outlines the AER's vision and overall approach to assuring compliance. The AER's work to help assure compliance contributes to meeting Albertans' expectations that energy development occurs in a manner that considers, balances and respects social, environmental, and economic expectations.

The ICAF is based on the premise of shared stewardship, continuous improvement, and innovative approaches and tools. It embodies the three main components of all effective compliance assurance programs, namely education, prevention and enforcement.

- Education – Promoting Compliance: Compliance promotion is any activity that increases awareness, educates, motivates or changes behaviour, and that encourages voluntary compliance with a regulatory requirement. Promotion may be a stand-alone activity, or it may occur in conjunction with compliance verification activities and be an indirect consequence of enforcement. Compliance promotion includes measures such as: publications; guidelines and best-management practices; educational programs; and performance report cards.

- Prevention – Verifying Compliance: Compliance verification refers to the monitoring, inspection and audit activities that the AER uses to determine regulatory compliance. .Compliance information may be obtained from AER verification activities, regulated parties, or reports from the public. Many factors dictate the frequency and nature of verification activities, including: review of reported data; complaints; releases and spills; emergencies; operational history; potential for adverse effects and damage (e.g., proximity to people, environmental impacts, loss, or damage to public land); unique circumstances (e.g., special operating authorizations, integrated resource management considerations, new technology); and Government of Alberta policy and AER strategic goals and objectives.

- Enforcement – Compelling Compliance: Enforcement includes administrative responses (e.g., warnings, administrative sanctions, orders, directions, administrative penalties) and prosecutorial responses (e.g., charges and potential fines or other penalties). Enforcement is necessary to compel compliance when voluntary compliance is not achieved and to deter future noncompliance. The AER`s Manual 013: Compliance and Enforcement Program guides the selection of appropriate responses to noncompliance.

A summary of compliance verification activities and enforcement or sanctions measures relating to the MERR applied to facilities and wells is given by licenses. This is appropriate since, in most cases, escalating enforcement action will fall to the licensee. In some cases, reported data and records that have been reviewed may apply to multiple facility IDs that are representative of equipment at one site, which may have one, multiple or zero licenses.

Report Cards

In February of 2021, the AER issued report cards to all operators active in 2019 and had a reporting obligation. A total of 450 report cards were issued. 120 report cards noted missing reports, insufficient reporting or suspected inaccurate reporting. The report cards are part of the education component of the compliance assurance program. The AER issued the report cards such that the timing would support improvements to reporting for the 2020 reporting period.

Audits

The AER conducts several different types of methane related audits that are related to a variety of sources of data including reported data, risk indicators, perceived risks and results from other regulatory activities at the AER. Audits are desktop

exercises that mainly review information submitted by industry through various reporting programs or direct exchanges that result from interaction with duty holders.

2019 OneStop Submissions Enforcement

Forty-three (43) Notice of Noncompliance were issued to operators who did not submit 2019 OneStop annual methane emissions report within the timeline (June 1, 2020). Twelve (12) failure to comply letters were issued to those operators who did not address the Notice of Noncompliance. Further enforcement actions are being planned by the AER. These audit activities are applied to operators, not to specific facilities or wells.

Compliance and enforcement efforts have resulted in 6,605 reporting facility IDs submitted between June 2020 and January 2021. Further to the compliance and enforcement actions, the AER has put effort into education on the 2019 annual methane emissions reports. There were more than 200 targeted email reminders sent in July 2020 before issuing Notice of Noncompliance.

Overall Vent Gas Limit Audits

Overall vent gas (OVG) limit audits are conducted to ensure facility IDs and well licences are compliant with the OVG limit of 15 $10^3 m^3$ per month. Noncompliance responses would include the action taken to achieve compliance such as correcting a reporting error, combusting the gas, conserving the gas, or shutting-in gas production. Each facility ID represents an audit, and audits are tracked based on the date the audit started. Petrinex data is monthly so there is a time delay between reported data and non-compliances. The highest vented gas volumes are prioritized each month and a variety of companies and facility types are chosen to get an accurate representation of OVG compliance provincially. Audits would usually result in a noncompliance because the facility ID or well licence was deliberately chosen to identify OVG exceedances. From January 1, 2020 to December 31, 2020, there were fifty-two (52) OVG audits conducted resulting in forty-seven (47) non-compliances.

Fuel Flare Vent Audits

Fuel flare vent (FFV) audits are conducted to ensure accurate reporting of fuel, flare and vent gas volumes to comply with definitions in Directive 060. Audits usually do not result in a noncompliance as long as the necessary changes are made to comply with Directive 060 or documentation is provided to justify the reported volumes. Each facility ID represents an audit, and audits are tracked based on the date the audit started. Petrinex data is monthly so there is a time delay between reported data and non-compliances. Facility IDs are chosen based on perceived under-reporting of vent volumes or over-reporting of fuel volumes to identify facilities that may be inconsistent with the updated definitions in Directive 060. Non-zero reporting of FFV volumes were chosen to ensure no overlap with inspections. A wide variety of facility types, locations, and companies were chosen to get an accurate representation of FFV reporting provincially. From January 1, 2020 to December 31, 2020, there were sixteen (16) FFV audits conducted resulting in 0 non-compliances.

Data Quality (OneStop) Audits

Data quality (OneStop) audits are conducted to ensure accurate reporting of annual methane data to OneStop. The scope of these audits also includes requesting the pneumatic inventory to ensure that vent volumes from pneumatic devices are accurate. Audits usually do not result in a noncompliance as long as the necessary changes are made to comply with Directive 060 or documentation is provided to justify the reported data. Each facility ID represents an audit, and audits are tracked based on the date the audit started. OneStop data is annual so there is a time delay between reported data and audits (e.g., 2020 audits would pertain to 2019 data). Facility IDs are chosen based on perceived errors in reporting to OneStop such as discrepancies between OneStop and Petrinex or discrepancies within the data submitted. From January 1, 2020 to December 31, 2020, there were 138 Data Quality (OneStop) audits conducted resulting in 0 non-compliances.

Fugitive Emission Management Plans and Fugitive Emissions Survey Audits

Fugitive Emission Management Plans (FEMPs) are documents that duty holders must create and maintain as per requirements in Directive 060. They apply to all the operations a duty holder has that are subject to Directive 060. The AER uses management plans such as the FEMP as a leading indicator of risk for non-compliance related to the fugitive emission survey requirements. The audit process can serve as an educational component of compliance assurance as well, since the AER may provide feedback as to what deficiencies or gaps may exist in the program prior to it being a non-compliance in the field.

Twenty-eight (28) FEMP audits were conducted for the 2020 year. The FEMP audit targets a mix of sizes of duty holders. There was one (1) Notice of Noncompliance issued because the duty holder did not respond within the timeline. All duty holders had a FEMP document in place, with a varied of level of detail and quality.

There were five (5) fugitive emissions survey audits completed as of February 2021 for the 2020 year. Duty holders were required to provide 2020 fugitive emissions survey records in the fugitive emissions survey audits. All five duty holders had fugitive emissions surveys conducted in 2020 and have submitted the records to the AER. These audit activities are applied to duty holders, not to specific facilities or wells.

Methane Reduction Retrofit Compliance Plans and Pneumatic Inventory Audits

Methane reduction retrofit compliance plans (MRRCPs) are documents that duty holders must create and maintain as per requirements in Directive 060. They outline what resources, budget and equipment need to be retrofit and under what timelines to be compliant with the new equipment requirements of Directive 060. The AER uses management plans such as the MRRCP as a leading indicator of risk for non-compliance related to the equipment vent limit requirements. MRRCP and pneumatic inventory audits were prioritized by operators who reported all zeros for pneumatic devices vent volume in 2019 OneStop annual methane emissions report and have many reporting facility IDs.

There were seventeen (17) MRRCP and pneumatic inventory audits completed as of February 2021. One (1) Notice of Noncompliance was issued because the duty holder did not have a pneumatic inventory by November 2020. There were five (5) operators who did not to report pneumatic volumes. Six (6) operators have submitted revised data because of the pneumatic inventory audit. These audit activities are applied to duty holders, not to specific facilities or wells.

Compressor Seal Testing Audits

There were six (6) compressor seal testing audits started as of February 2021 for the 2020 year. The operators were required to provide compressor seal testing records for 2020. The review of the audit responses is ongoing.

Inspections

Inspections that are driven by an interest or perceived risk to methane requirements are coded under the AER priority code 18.

As per the compliance assurance principles discussed earlier, education was the focus for the 2020 inspection season. Inspectors were educated internally at the AER from January to July. Significant delays to inspection training occurred due to COVID-19 restrictions since the training required multiple people on-site or in indoor environments as originally planned. As a result, independent inspections conducted by the inspection team were not started until August 11, 2020 across the province. Prior to this numerous training inspections would have occurred where trainers and trainee inspectors were on duty holder sites, mainly for the purpose of inspector training on equipment, methane processes and regulatory record keeping.

Priority was given to educational inspections. An attempt was made to give each licensee in each field center an educational inspection as their first methane inspection. As described in the section above, this often meant meeting with an operator on-site, going through the relevant requirements and which ones would apply to the current site. All non-satisfactory findings at these inspections were enforced as any other inspection, however all educational inspections are recorded in the field inspection system software as satisfactory by default.

For each methane inspection, the methane inspectors have available a FLIR GFX320 OGI camera and Cal-Scan positive displacement vent gas meters with data loggers. In addition, for large vent gas flows there are three Cal-Scan turbine vent gas meters with data loggers, as well as a truck mounted boreal laser, a SkyEye V2 drone with FLIR camera, an Alleycat laminar mass flow meter and four mobile liquid separation tanks for use in case vent gas appears to have entrained liquids that might damage metering equipment. Additional equipment listed is used on an as needed basis depending on the location of the inspection and the anticipated flow rates or equipment on site.

Inspection Results

A total of 266 methane inspections were conducted in Alberta in 2020. Of these, thirty-two (32) inspections were considered to have unsatisfactory outcomes, meaning the inspection resulted in required follow-up work for the duty holders.

All non-compliances in 2020 were dealt with through inspector correspondence with the duty holder through the AER Digital Data Submission system. All issues leading to an unsatisfactory inspection were resolved. There was no enforcement that escalated beyond inspector correspondence.

Two facilities were suspended because of methane inspections. The operator's intention is to review options for compliance and bring the operations back to active status upon finding a cost-effective solution to reduce venting and operate the sites while being compliant.

There were no orders, penalties or convictions related to enforcement of the MERR, Directive 060 Section 8 or Directive 017 requirements pertaining to methane emission reduction requirements in 2020. Table 10 summarizes the number of inspections by well or facility type.

TABLE 10: INSPECTION SUMMARY DATA

Facility or Well Type	Satisfactory	Unsatisfactory	Total
Compressor Station	36	3	39
Crude Bitumen Group Battery	15	1	16
Crude Bitumen Paper Battery	7	1	8
Crude Bitumen Single Battery	2	-	2
Crude Oil Group Battery	45	10	55
Crude Oil Single Battery	30	8	38
Gas Plant Straddle	1	-	1
Gas Plant Sweet	21	-	21
Gas Plant Acid Gas Flaring/Injection	4	-	4
Gas Proration Effluent Battery	27	3	30
Gas Single Battery	7	1	8
Gas Well	11	3	14
Oil Well	21	2	23
Other Injection/Disposal	1	-	1
Other Pipeline	1	-	1
Shale Gas Well	2	-	2
Suspended Well	1	-	1
Waste Plant	2	-	2
Total	**234**	**32**	**266**

Part F - Summary of Annual Reports

Section 4 and Section 6 of the Methane Emission Reduction Regulation (MERR) stipulate that determination of methane emissions must occur and that reporting of methane emissions must be made to the Director. For the 2020 calendar year, annual methane emission reports were accepted through the AER OneStop Single Window reporting system on behalf of the Director and in accordance with Section 8.2 of Directive 060. This data reported by duty holders to the AER is summarized in

Part D - Implementation and Effectiveness of the MERR. As of August 1 2021, 443 Duty Holders submitted OneStop reports (89% compliance rate).

Annex 1 – Summary of Emission Methodologies

TABLE: SUMMARY OF EMISSION METHODOLOGIES

Emission Source	Methodology	Data Source	Methane Content (vol %)	Methane Content Applicability
Pneumatics	Facility Counts	ST98	92	All
	Component Counts	National Inventory Report (2021), Clearstone (2018)[7]		
	Emission Factors	Clearstone 2018, Prasino 2013, and Van Vilet 2018		
Venting:	Reported Vent Volume	Petrinex	78	Natural Gas
Routine &			74	Crude Oil
Non-Routine (2014 – 2018)			95	Primary Crude Bitumen[8]
			97	Primary Crude Bitumen[9]
Venting:	Reported Vent Volume	OneStop	78	Natural Gas
Routine (2019 – 2020)			74	Crude Oil
			95	Primary Crude Bitumen[8]
			97	Primary Crude Bitumen[9]
Venting:	Reported Vent Volume	ST60B	92	All
Non-Routine Well Testing				
Venting:	Equipment Counts	OneStop	89	2014 to 2019
Non-Routine	Emission Factors	Cheremisinoff (2016), Levelton Consultants (2014)	87	2020 onwards
Compressor Blowdowns				
Fugitive Emissions	Facility Counts	Clearstone (2017)	92	Natural Gas (fuel gas)
	Component Counts	Clearstone (2017)	74	Crude Oil
Compressor Seals	Reported Vent Volume	OneStop	89	2014 to 2019
	Facility Counts	OneStop	87	2020 onwards
	Equipment Counts	OneStop		
Glycol Dehydrators	Reported Emissions	OneStop	OneStop	All
	Equipment Counts	Directive 39 Data and ST98		

[7] OneStop data was not used because it resulted in values much lower than the National Inventory Report (2021)
[8] Subtypes H-MPB, H-SWB
[9] Subtypes H-Admin, H-MGB

Incomplete Combustion	Emission Factors Reported Fuel and Flare Volume	National Inventory Report (2021) Petrinex	National Inventory Report	All
Surface Casing Vent Flows	Reported Vent Volume	ID 2003-01 Data	85	All
Spills and Ruptures	Reported Vent Volume	AER Incident Release Report	85	All