American Carbon Registry
AT WINROCK INTERNATIONAL

METHODOLOGY FOR THE QUANTIFICATION, MONITORING, REPORTING AND VERIFICATION OF GREENHOUSE GAS EMISSIONS REDUCTIONS AND REMOVALS FROM

CAPTURING AND DESTROYING METHANE FROM U.S. COAL AND TRONA MINES

VERSION 1.1

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American Carbon Registry®

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ABOUT AMERICAN CARBON REGISTRY® (ACR)

A leading carbon offset program founded in 1996 as the first private voluntary GHG registry in the world, ACR operates in the voluntary and regulated carbon markets. ACR has unparalleled experience in the development of environmentally rigorous, science-based offset methodologies as well as operational experience in the oversight of offset project verification, registration, offset issuance and retirement reporting through its online registry system.

ACRONYMS

For purposes of this methodology, the following acronyms apply:

AAPG	American Association of Petroleum Geologists
acf	Actual cubic feet
acfm	Actual cubic feet per minute
ACR	American Carbon Registry
AMM	Abandoned Mine Methane
ASTM	American Society of Testing and Materials
atm	Atmosphere in reference to a unit of pressure
Btu	British thermal unit
CBM	Coalbed Methane
CH_4	Methane
CO_2	Carbon dioxide
CO_2e	Carbon dioxide equivalent
d	Day
F	Fahrenheit
GHG	Greenhouse gas
GWP	Global Warming Potential
h	Hour
kg	Kilogram
lb	Pound
m	Minute

MG	Mine Gas
MM	Mine Methane
MMBtu	Million British thermal units
MMC	Mine Methane Capture
Mscf	Thousand standard cubic feet
Mscf/d	Thousand standard cubic feet per day
MSHA	Mine Safety and Health Administration
MT	Metric Ton
MWh	Megawatt hour
N_2O	Nitrous Oxide
R	Rankine
scf	Standard cubic foot
scf/d	Standard cubic feet per day
scfm	Standard cubic feet per minute
SMM	Surface Mine Methane
SSR	GHG sources, sinks, and reservoirs
STP	Standard temperature and pressure
QA/QC	Quality Assurance and Quality Control
VA	Ventilation Air
VAM	Ventilation Air Methane

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1 PURPOSE

The purpose of the methodology is to quantify greenhouse gas emission reductions associated with the capture and destruction of methane that would otherwise be vented into the atmosphere as a result of mining operations at active underground and surface coal and trona mines and abandoned underground coal mines.

Mine methane refers to methane released from coal or trona and surrounding rock during mining activities, which poses a safety hazard to mine workers and must be managed through engineering controls. In addition, methane continues to desorb from coal and be emitted to the atmosphere long after mines are abandoned. The U.S. Environmental Protection Agency estimates that coal mine methane emissions contribute 9% of global anthropogenic methane emissions.

Mine methane is emitted to the atmosphere from five sources:

1. Ventilation air systems at underground mines
2. Degasification systems at underground mines
3. Earthmoving activities that expose coal at surface mines
4. Abandoned underground mines
5. Fugitive emissions from post-mining transportation, storage, and handling of coal

The methodology addresses mine methane emission reductions from sources 1-4 above, which use a number of technologies readily available to use or destroy methane from active and abandoned mines. The methodology describes separate eligibility requirements and quantification methods for each of the four methane sources – ventilation air methane from underground mines, and drainage gas from underground mines, surface mines, and abandoned mines. Also, the methodology is designed to allow projects to combine methane sources 1 and 2.

2 ELIGIBLE ACTIVITIES – QUANTIFICATION METHODOLOGY

This methodology includes four mine methane capture activities designed to reduce GHG emissions that result from the mining process at active underground mines, active surface mines, and abandoned underground mines. The following types of mine methane capture activities are eligible:

2.1 ACTIVE UNDERGROUND MINE VENTILATION AIR METHANE ACTIVITIES

This methodology applies to MMC projects that install a VAM collection system and a qualifying device to destroy the methane in VA that would otherwise be vented into the atmosphere through the return air shaft(s) as a result of underground coal or trona mining operations.

I. Methane sources eligible for VAM activities include:
   A. Ventilation systems; and
   B. Methane drainage systems from which mine gas is extracted and used to supplement VA. Only the mine methane sent with ventilation air to a destruction device is eligible.

II. In order to be considered a qualifying device for the purpose of this methodology, the device must not have been operational at the mine prior to the project start date unless it was used in a past project located at the mine and was a qualifying device in that project.

III. At active underground mines, a Project Proponent may operate both VAM and methane drainage activities as a single offset project. The mine methane capture and destruction activity that began first shall be used to determine the project start date, per the requirements of Section 3.5. Alternatively, the Project Proponent may elect to operate separate offset projects for each activity with unique start dates.

IV. If a newly constructed ventilation shaft is connected to an existing or new qualifying destruction device after the project start date, the Project Proponent may either classify it as an offset project expansion or list the addition as a new MMC project.

V. If an existing ventilation shaft that was not connected to a destruction device at time of the project start date is connected to an existing or new qualifying destruction device after the project start date, the Project Proponent may either classify it as an offset project expansion or as a new MMC project.

VI. If a new qualifying destruction device is added to a ventilation shaft currently connected to an existing qualifying destruction device this addition of the new qualifying destruction device is considered an offset project expansion.

2.2 ACTIVE UNDERGROUND MINE METHANE DRAINAGE ACTIVITIES

This methodology applies to MMC projects that install equipment to capture and destroy methane extracted through a methane drainage system that would otherwise be vented into the atmosphere as a result of underground coal or trona mining operations.

I. Methane drainage systems must consist of one, or a combination of, the following methane sources that drain methane from the mineral seam, surrounding strata, or underground workings of the mine before, during, and/or after mining:
   A. Pre-mining surface wells; and
   B. In-mine boreholes and post-mining wells.
II. In order to be considered a qualifying device for the purpose of this methodology, a methane destruction device for an active underground mine methane drainage activity must not have been operational at the mine prior to the project start date unless it was used in a past project located at the mine and was a qualifying device in that project.
III. At active underground mines, a Project Proponent may operate both VAM and methane drainage activities as a single project. The mine methane capture and destruction activity that began first shall be used to determine the project start date, per the requirements of Section 3.5. Alternatively, the Project Proponent may elect to operate separate projects for each activity with unique start dates.
IV. If a newly drilled well/borehole is connected to an existing or new qualifying destruction device after the project start date, the Project Proponent may either classify it as an offset project expansion or a new MMC project.
V. If an existing well/borehole that was not connected to a destruction device at the project start date is connected to an existing or new qualifying destruction device after the project start date, the Project Proponent may either classify it as an offset project expansion or a new MMC project.
VI. If a new qualifying destruction device is connected to a well/borehole currently connected to an existing qualifying destruction device, this addition of the new qualifying destruction device is considered an offset project expansion.
VII. Mine methane from any well or borehole connected to a pre-project destruction device at any point during the 24 months prior to the project start date is not eligible for crediting.
VIII. To be eligible for crediting under this methodology, MMC projects at active underground mines must not:

A. Account for virgin CBM extracted from coal seams outside the extents of the mine according to the mine plan or from outside the methane source boundaries as described in Section 3.4; or
B. Use CO_2, steam, or any other fluid/gas to enhance mine methane drainage.

2.3 ACTIVE SURFACE MINE METHANE DRAINAGE ACTIVITIES

This methodology applies to MMC projects that install equipment to capture and destroy methane extracted through a methane drainage system that would otherwise be vented into the atmosphere as a result of surface coal or trona mining operations.

I. Methane drainage systems must consist of one, or a combination, of the following methane sources that drain methane from the coal seam or surrounding strata before and/or during mining:
   A. Pre-mining surface wells;
   B. Existing CBM wells that would otherwise be shut-in and abandoned as a result of encroaching mining;
   C. Abandoned wells that are reactivated; and
   D. Converted dewatering wells.
II. In order to be considered a qualifying device for the purpose of this methodology, a methane destruction device for an active surface mine methane drainage activity must not have been operational at the mine prior to the project start date unless it was used in a past project located at the mine and was a qualifying device in that project.
III. If a newly drilled well/borehole is connected to an existing or new qualifying destruction device after the project start date, the Project Proponent may either classify it as an offset project expansion or a new MMC project.
IV. If an existing well/borehole that was not connected to a destruction device at time of the project start date is connected to an existing or new qualifying destruction device after the project start date, the Project Proponent may either classify it as an offset project expansion or a new MMC project.
V. If a new qualifying destruction device is connected to a well/borehole currently connected to an existing qualifying destruction device, this addition of the new qualifying destruction device is considered an offset project expansion.
VI. To be eligible for crediting under this methodology, MMC projects at active surface mines must not:
   A. Account for CBM produced from wells outside the extents of the mine according to the mine plan or from outside the methane source boundaries as described in Section 3.4;

B. Use CO_2, steam, or any other fluid/gas to enhance mine methane drainage; or

2.4 ABANDONED UNDERGROUND MINE METHANE RECOVERY ACTIVITIES

This methodology applies to MMC projects that install equipment to capture and destroy methane extracted through a methane drainage system that would otherwise be vented into the atmosphere as a result of previous underground coal mining operations.

I. Methane drainage systems must consist of only one methane source:
   A. In-mine boreholes and post-mining wells drilled into the mine during or after mining operations[1];
II. In order to be considered a qualifying device for the purpose of this methodology, a methane destruction device for an abandoned underground mine methane recovery activity must not have been operational at the mine prior to the project start date unless the mine was previously engaged in active underground methane drainage activities and the methane destruction device was considered a qualifying destruction device for those activities or unless it was used in a past project located at the mine and was a qualifying device in that project.
III. Abandoned underground mine methane recovery activities at multiple mines with multiple mine operators may be included in a single project if they meet the following criteria:
   A. A single Project Proponent is identified and emission reductions achieved by the project will be credited to that Project Proponent.
   B. The Project Proponent meets all monitoring and verification requirements in chapters 6, and 7.
   C. Offset project activities at all abandoned mines are in compliance with laws and regulations.
IV. In the event that there are vertically separated mines overlying and underlying other mines, wells completed in one mine can be used to capture methane in overlying or underlying mines provided the wells are within the maximum vertical extent of each mine per Section 3.4(III)(D)(i).
V. If a newly drilled well/borehole is connected to an existing or new qualifying destruction device after the project start date, the Project Proponent may either classify it as an offset project expansion or a new MMC project.

[1] Please note that in this methodology, in-mine boreholes and post-mining wells, are considered to be the same “methane source”. Projects may include one or more in-mine boreholes and post-mining wells within a project.

VI. If an existing well/borehole that was not connected to a destruction device at the project start date is connected to an existing or new qualifying destruction device after the project start date, the Project Proponent may either classify it as an offset project expansion or a new MMC project.

VII. If a new qualifying destruction device is connected to a well/borehole currently connected to an existing qualifying destruction device, this addition of the new qualifying destruction device is considered an offset project expansion.

VIII. AMM from any well or borehole connected to a pre-project destruction device at any point during the 24 months prior to the project start date is not eligible for crediting.

IX. To be eligible for crediting under this methodology, MMC projects at abandoned underground mines must not:

   A. Account for CBM production from wells outside the extents of the mine according to the final mine map(s) or from outside the methane source boundaries described in Section 3.4;

   B. Use CO_2, steam, or any other fluid/gas to enhance mine methane drainage; or

   C. Voluntarily pump water from the mine for the sole purpose of extracting methane.

3 ELIGIBILITY

MMC offset projects must adhere to the eligibility requirements below as well as general ACR program requirements included in the ACR Standard.

3.1 GENERAL ELIGIBILITY REQUIREMENTS

I. Offset projects that use this methodology must:
   A. Involve the installation and operation of a device, or set of devices, associated with the capture and destruction of mine methane;
   B. Capture mine methane that would otherwise be emitted to the atmosphere; and
   C. Destroy the captured mine methane through an eligible end-use management option per Section 3.4.

II. Project Proponents that use this methodology must:
   A. Monitor SSRs within the offset project boundary as delineated in chapter 4 per the requirements of chapter 6;
   B. Quantify GHG emission reductions per chapter 5;
   C. Prepare and submit a GHG project plan in accordance with ACR Standard requirements; and
   D. Obtain validation and verification services from an ACR-approved validation and verification body.

3.2 LOCATION

I. Projects located in North America are eligible under this methodology.

II. Projects must take place at either:
   A. An active underground or surface mine permitted for coal or trona mining by an appropriate state, provincial, or federal agency and classified by MSHA or other applicable state, provincial, or federal agency as active, intermittent, non-producing or temporarily idle;
   B. An abandoned underground coal mine classified by MSHA or other applicable state, provincial, or federal agency as abandoned.

III. Mines located on federal lands are eligible for implementation of MMC projects.

3.3 ADDITIONALITY ASSESSMENT

Offset projects must meet the additionality requirements included below. Eligible offsets must be generated by projects that yield additional GHG reductions that exceed any GHG reductions otherwise required by law or regulation or any GHG reduction that would otherwise occur in a conservative business-as-usual scenario. Assessment of the additionality of a project will be made based on passing EITHER a performance standard evaluation and a regulatory surplus test OR ACR's three-prong additionality test (which, as a first step, includes a regulatory surplus test). Projects shall demonstrate conformance with the full requirements found in EITHER Sections 3.3.1 and 3.3.2 OR Section 3.3.3 only once at the beginning of a crediting period. However, projects shall demonstrate regulatory surplus during verification activities for each reporting period.

3.3.1 Regulatory Surplus Test

I. Emission reductions achieved by an MMC project must exceed those required by any law, regulation, or legally binding mandate.
II. The following legal requirement test applies to all MMC projects:
   A. If no law, regulation, or legally binding mandate exists requiring the destruction of methane at the mine at which the project is located, all emission reductions resulting from the capture and destruction of mine methane are considered to not be legally required, and therefore eligible for crediting under this methodology.
   B. If any law, regulation, or legally binding mandate exists requiring the destruction of methane at the mine at which the project is located, only emission reductions resulting from the capture and destruction of mine methane which exceeds the mandated requirement to comply with those laws, regulations, and/or legally binding mandates are eligible for crediting under this methodology.

3.3.2 Performance Standard Evaluation

I. Emission reductions achieved by an MMC project must exceed those likely to occur in a conservative business-as-usual scenario.
II. The performance standard evaluation is satisfied if the following requirements are met, on the basis of activity type:
   A. Active Underground Mine VAM Activities
      i. Destruction of VAM automatically satisfies the performance standard evaluation because destruction of VAM is not common practice nor considered business-as-usual, and is therefore eligible for crediting under this methodology.

B. Active Underground Mine Methane Drainage Activities
   i. Destruction of extracted mine methane from any end-use management option other than pipeline injection automatically satisfies the performance standard evaluation because it is not common practice nor considered business-as-usual and is therefore eligible for crediting under this methodology.
   ii. Pipeline injection of mine methane extracted from methane drainage systems at active underground mines may potentially be considered common practice or business-as-usual; a three-prong additionality test as described in Section 3.3.3 must be conducted to determine eligibility under this methodology for pipeline injection as an eligible end-use management option for this activity.

C. Active Surface Mine Methane Drainage Activities
   i. Destruction of extracted mine methane automatically satisfies the performance standard evaluation because it is not common practice nor considered business-as-usual, and is therefore eligible for crediting under this methodology.

D. Abandoned Underground Mine Methane Recovery Activities
   i. Destruction of extracted mine methane from any end-use management option automatically satisfies the performance standard evaluation because it is not common practice nor considered business-as-usual and is therefore eligible for crediting under this methodology.
   ii. Pipeline injection of mine methane recovered at abandoned underground mines that also injected mine methane into a natural gas pipeline for off-site consumption while active may potentially be considered common practice business-as-usual; therefore, a three-prong additionality test as described in Section 3.3.3 must be conducted to determine eligibility under this methodology for pipeline injection as an eligible end-use management option for AMM.

3.3.3 ACR's Three-Prong Additionality Test

For project activities that do not automatically qualify under the performance standard evaluation outlined in Section 3.3.2, ACR's three-prong additionality test shall be applied. The first step in the three-prong additionality test, as stated above, is the application of a regulatory surplus test which is followed by a common practice assessment and description of implementation barriers. MMC projects may only demonstrate a financial implementation barrier(s) and may not apply technological or institutional barriers. For a complete description of the ACR three-prong additionality test, please refer to the ACR Standard.

3.4 METHANE SOURCE BOUNDARIES

I. Methane that would otherwise be emitted into the atmosphere during the normal course of mining activities or as a result of past mining activities is eligible under this methodology.
II. Methane from a mine's ventilation and gas drainage systems must be collected from within the mine extents according to an up-to-date or final mine plan.
III. Additional physical boundaries on the basis of activity type are as follows:
   A. Active underground mine ventilation air methane activities may account for:
      i. Methane contained in VA collected from a mine ventilation system; and
      ii. Mine methane contained in mine gas extracted from a methane drainage system used to supplement VA.
   B. To ensure that virgin coalbed methane is excluded from the mine methane accounted for in this methodology, physical boundaries must be placed on methane drainage systems. Active underground mine methane drainage activities may account for:
      i. Mine methane contained in mine gas extracted from strata up to 150 meters above and 50 meters below a mined seam through pre-mining surface wells and in-mine boreholes; and
      ii. Mine methane contained in mine gas extracted through post-mining wells.
   C. Active surface mine methane drainage activities may account for surface mine methane contained in mine gas extracted from all strata above and up to 50 meters below a mined seam through pre-mining surface wells, existing coalbed methane wells that would otherwise be shut-in and abandoned as a result of encroaching mining, abandoned wells that are reactivated, and converted dewatering wells.
   D. Abandoned underground mine methane recovery activities may account for:
      i. Abandoned mine methane contained in mine gas extracted from strata up to 150 meters above and 50 meters below a mined seam through existing or newly drilled in-mine boreholes or post-mining wells.

3.5 START DATE

I. An offset project must meet the start date requirements set forth in the ACR Standard.
II. For this methodology, the project start date is defined as the date on which the project's mine methane capture and destruction equipment becomes operational following a start-up period.

3.6 PROJECT CREDITING PERIOD

I. The crediting period for this methodology is ten years.
II. The crediting period begins on the project start date[2].

3.7 REGULATORY COMPLIANCE

I. An offset project must meet the regulatory compliance requirements set forth in the ACR Standard[3].

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[2] As an exception, projects located at active underground mines that become abandoned (and therefore will reclassify an existing, operational project as an "abandoned underground mine methane project") shall designate a start date for abandoned underground mine methane project activities no later than 9 months following the date of mine abandonment. The date of mine abandonment shall be determined through MSHA or other state, provincial, or federal regulatory body documentation establishing the date on which the mine became abandoned.

[3] Note that ventilation air methane projects are not typically considered to be part of a mine ventilation plan and, therefore, are not typically subject to MSHA jurisdiction.

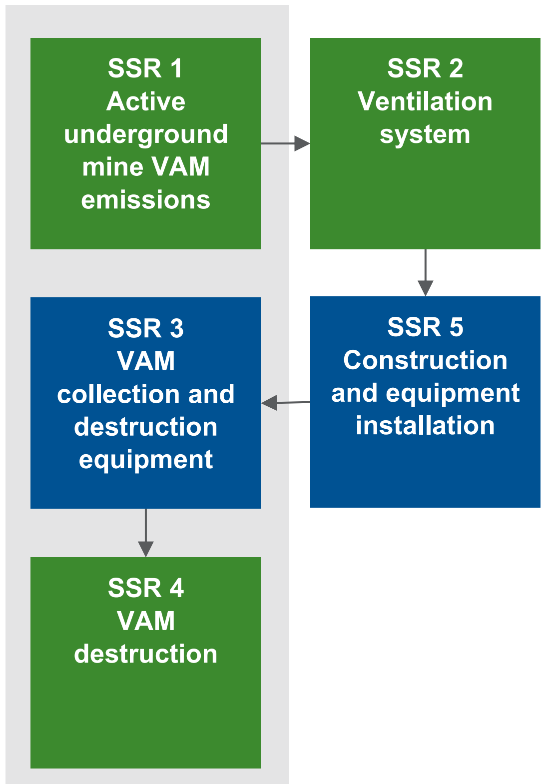
4 OFFSET PROJECT BOUNDARY – QUANTIFICATION METHODOLOGY

The offset project boundary delineates the SSRs that must be included or excluded when quantifying the net change in emissions associated with the installation and operation of a device, or set of devices, associated with the capture and destruction of mine methane. The following offset project boundaries apply to all MMC projects on the basis of activity type:

4.1 ACTIVE UNDERGROUND MINE VAM ACTIVITIES

I. Figure 1 illustrates the offset project boundary for active underground mine VAM activities, indicating which SSRs are included or excluded from the offset project boundary.
   A. All SSRs inside the grey box are included and must be accounted for under this methodology.
   B. SSRs in green boxes are relevant to the baseline and project emissions.
   C. SSRs in blue boxes are relevant only to project emissions.

Figure 1: Offset Project Boundary for Active Underground Mine VAM Activities



II. Table 1 lists the SSRs for active underground mine VAM activities, indicating which gases are included or excluded from the offset project boundary.

Table 1: Greenhouse Gas Sinks, Sources, and Reservoirs for Active Underground Mine VAM Activities

SSR	DESCRIPTION	GHG	BASELINE (B) OR PROJECT (P)	INCLUDED OR EXCLUDED
1 Active underground mine VAM emissions	Emissions from the venting of VAM through mine ventilation system	CH_4	B, P	Included
		CO_2	n/a	Excluded

SSR	DESCRIPTION	GHG	BASELINE (B) OR PROJECT (P)	INCLUDED OR EXCLUDED
2 Ventilation system	Emissions resulting from energy consumed to operate mine ventilation system	CH_4	n/a	Excluded
		N_2O	n/a	Excluded
3 VAM collection and destruction equipment	Emissions resulting from energy consumed to operate additional equipment used to capture or destroy VAM	CO_2	P	Included
		CH_4	n/a	Excluded
		N_2O	n/a	Excluded
4 VAM destruction	Emissions resulting from VAM destruction	CO_2	B, P	Included
		N_2O	n/a	Excluded
	Emissions of uncombusted methane	CH_4	B, P	Included
5 Construction and equipment installation	Emissions from construction and/or installation of new equipment	CO_2	n/a	Excluded
		CH_4	n/a	Excluded
		N_2O	n/a	Excluded
	Fugitive emissions from construction	CH_4	n/a	Excluded

4.2 ACTIVE UNDERGROUND MINE METHANE DRAINAGE ACTIVITIES

I. Figure 2 illustrates the offset project boundary for active underground mine methane drainage activities, indicating which SSRs are included or excluded from the offset project boundary.
   A. All SSRs inside the grey box are included and must be accounted for under this methodology.
   B. SSRs in green boxes are relevant to the baseline and project emissions.
   C. SSRs in blue boxes are relevant only to project emissions.

Figure 2: Offset Project Boundary for Active Underground Mine Methane Drainage Activities

II. Table 2 lists the identified SSRs for active underground mine methane drainage activities, indicating which gases are included or excluded from the offset project boundary.

Table 2: Identified Greenhouse Gas Sinks, Sources, and Reservoirs for Active Underground Mine Methane Drainage Activities

SSR	DESCRIPTION	GHG	BASELINE (B) OR PROJECT (P)	INCLUDED OR EXCLUDED
1 Active underground mine VAM emissions	Emissions from the venting of mine methane extracted through methane drainage system	CH_4	B, P	Included
2 Mine gas collection and destruction equipment	Emissions resulting from energy consumed to operate additional equipment used to capture, treat, or destroy drained mine gas	CO_2	P	Included
		CH_4	n/a	Excluded
		N_2O	n/a	Excluded
	Fugitive emissions from operation of additional equipment used to capture, treat, or destroy drained mine gas	CH_4	n/a	Excluded
3 Transportation of mine gas	Emissions resulting from additional energy consumed to transport mine gas to treatment or destruction equipment	CO_2	P	Included
		CH_4	n/a	Excluded
		N_2O	n/a	Excluded
	Fugitive emissions from the on-site transportation of mine gas	CH_4	n/a	Excluded
4 Liquefaction, compression and storage of CNG/LNG	Emissions resulting from energy consumed to operate additional equipment used to liquefy, compress,	CO_2	P	Included
		CH_4	n/a	Excluded
		N_2O	n/a	Excluded

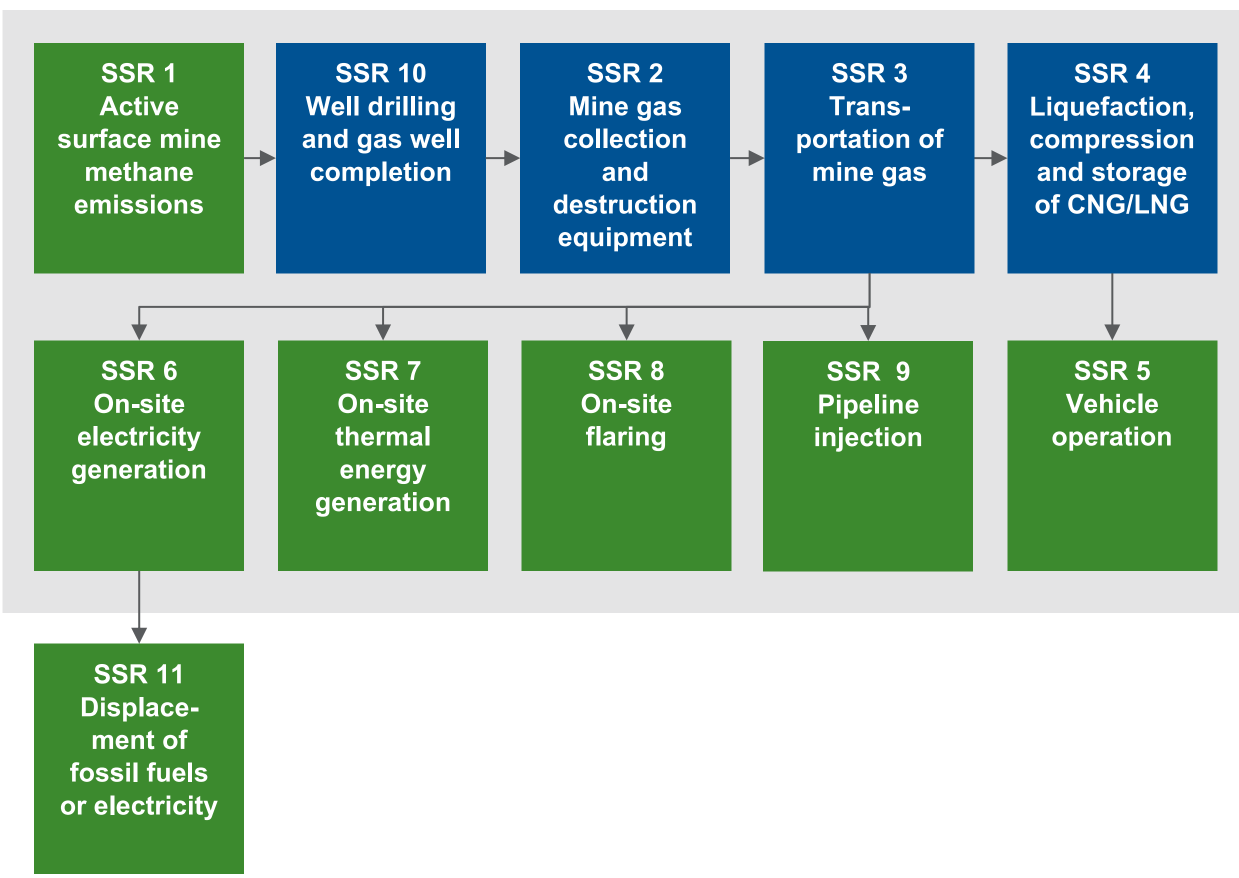
SSR	DESCRIPTION	GHG	BASELINE (B) OR PROJECT (P)	INCLUDED OR EXCLUDED
	or store methane for vehicle use.			
	Fugitive emissions from operation of additional equipment used to liquefy, compress, or store methane for vehicle use	CH_4	n/a	Excluded
5 Vehicle operation	Emissions resulting from mine methane combustion during vehicle operation	CO_2	B, P	Included
		N_2O	n/a	Excluded
	Emissions resulting from incomplete mine methane combustion during vehicle operation	CH_4	B, P	Included
6 On-site electricity generation	Emissions resulting from mine methane combustion during on-site electricity generation	CO_2	B, P	Included
		N_2O	n/a	Excluded
	Emissions resulting from incomplete mine methane combustion during on-site electricity generation	CH_4	B, P	Included
7 On-site thermal energy generation	Emissions resulting from mine methane combustion during on-site thermal energy generation	CO_2	B, P	Included
		N_2O	n/a	Excluded
	Emissions resulting from incomplete mine methane combustion during on-site thermal energy generation	CH_4	B, P	Included
8 On-site flaring		CO_2	B, P	Included

SSR	DESCRIPTION	GHG	BASELINE (B) OR PROJECT (P)	INCLUDED OR EXCLUDED
	Emissions resulting from mine methane combustion during on-site flaring	N_2O	n/a	Excluded
	Emissions resulting from incomplete mine methane combustion during flaring	CH_4	B, P	Included
9 Pipeline injection	Emissions resulting from mine methane combustion resulting from pipeline injection	CO_2	B, P	Included
		N_2O	n/a	Excluded
	Emissions resulting from the incomplete mine methane combustion resulting from pipeline injection	CH_4	B, P	Included
10 Well drilling and gas well completion	Emissions from well drilling and gas well completion	CO_2	n/a	Excluded
		CH_4	n/a	Excluded
		N_2O	n/a	Excluded
	Fugitive emissions from well drilling and gas well completion	CH_4	n/a	Excluded
11 Displacement of fossil fuels or electricity	Emission reductions resulting from the displacement of fossil fuels or electricity	CO_2	n/a	Excluded
		CH_4	n/a	Excluded
		N_2O	n/a	Excluded

4.3 ACTIVE SURFACE MINE METHANE DRAINAGE ACTIVITIES

I. Figure 3 illustrates the offset project boundary for active surface mine methane drainage activities, indicating which SSRs are included or excluded from the offset project boundary.
   A. All SSRs inside the grey box are included and must be accounted for under this methodology.
   B. SSRs in green boxes are relevant to the baseline and project emissions.
   C. SSRs in blue boxes are relevant only to project emissions.

Figure 3: Offset Project Boundary for Active Surface Mine Methane Drainage Activities



II. Table 3 lists the SSRs for active surface mine methane drainage activities, indicating which gases are included or excluded from the offset project boundary.

Table 3: Greenhouse Gas Sinks, Sources, and Reservoirs for Active Surface Mine Methane Drainage Activities

SSR	DESCRIPTION	GHG	BASELINE (B) OR PROJECT (P)	INCLUDED OR EXCLUDED
1 Active surface mine methane emissions	Emissions from the venting of mine methane during the mining process	CH_4	B, P	Included
2 Mine gas collection and destruction equipment	Emissions resulting from energy consumed to operate additional equipment used to capture, treat, or destroy drained mine gas	CO_2	P	Included
		CH_4	n/a	Excluded
		N_2O	n/a	Excluded
	Fugitive emissions from operation of additional equipment used to capture, treat, or destroy drained mine gas	CH_4	n/a	Excluded
3 Transportation of mine gas	Emissions resulting from additional energy consumed to transport mine gas to treatment or destruction equipment	CO_2	P	Included
		CH_4	n/a	Excluded
		N_2O	n/a	Excluded
	Fugitive emissions from the on-site transportation of mine gas	CH_4	n/a	Excluded
4 Liquefaction, compression and storage of CNG/LNG	Emissions resulting from energy consumed to operate additional equipment used to liquefy, compress,	CO_2	P	Included
		CH_4	n/a	Excluded
		N_2O	n/a	Excluded

SSR	DESCRIPTION	GHG	BASELINE (B) OR PROJECT (P)	INCLUDED OR EXCLUDED
	or store methane for vehicle use.			
	Fugitive emissions from operation of additional equipment used to liquefy, compress, or store methane for vehicle use	CH_4	n/a	Excluded
5 Vehicle operation	Emissions resulting from mine methane combustion during vehicle operation	CO_2	B, P	Included
		N_2O	n/a	Excluded
	Emissions resulting from incomplete mine methane combustion during vehicle operation	CH_4	B, P	Included
6 On-site electricity generation	Emissions resulting from mine methane combustion during on-site electricity generation	CO_2	B, P	Included
		N_2O	n/a	Excluded
	Emissions resulting from incomplete mine methane combustion during on-site electricity generation	CH_4	B, P	Included
7 On-site thermal energy generation	Emissions resulting from mine methane combustion during on-site thermal energy generation	CO_2	B, P	Included
		N_2O	n/a	Excluded
	Emissions resulting from incomplete mine methane combustion during on-site thermal energy generation	CH_4	B, P	Included
8 On-site flaring		CO_2	B, P	Included

SSR	DESCRIPTION	GHG	BASELINE (B) OR PROJECT (P)	INCLUDED OR EXCLUDED
	Emissions resulting from mine methane combustion during on-site flaring	N_2O	n/a	Excluded
	Emissions resulting from incomplete mine methane combustion during flaring	CH_4	B, P	Included
9 Pipeline injection	Emissions resulting from mine methane combustion resulting from pipeline injection	CO_2	B, P	Included
		N_2O	n/a	Excluded
	Emissions resulting from the incomplete mine methane combustion resulting from pipeline injection	CH_4	B, P	Included
10 Well drilling and gas well completion	Emissions from additional well drilling and well gas completion	CO_2	P	Included
		CH_4	n/a	Excluded
		N_2O	n/a	Excluded
	Fugitive emissions from additional well drilling and gas well completion	CH_4	n/a	Excluded
11 Displacement of fossil fuels or electricity	Emission reductions resulting from the displacement of fossil fuels or electricity	CO_2	n/a	Excluded
		CH_4	n/a	Excluded
		N_2O	n/a	Excluded

4.4 ABANDONED UNDERGROUND MINE METHANE RECOVERY ACTIVITIES

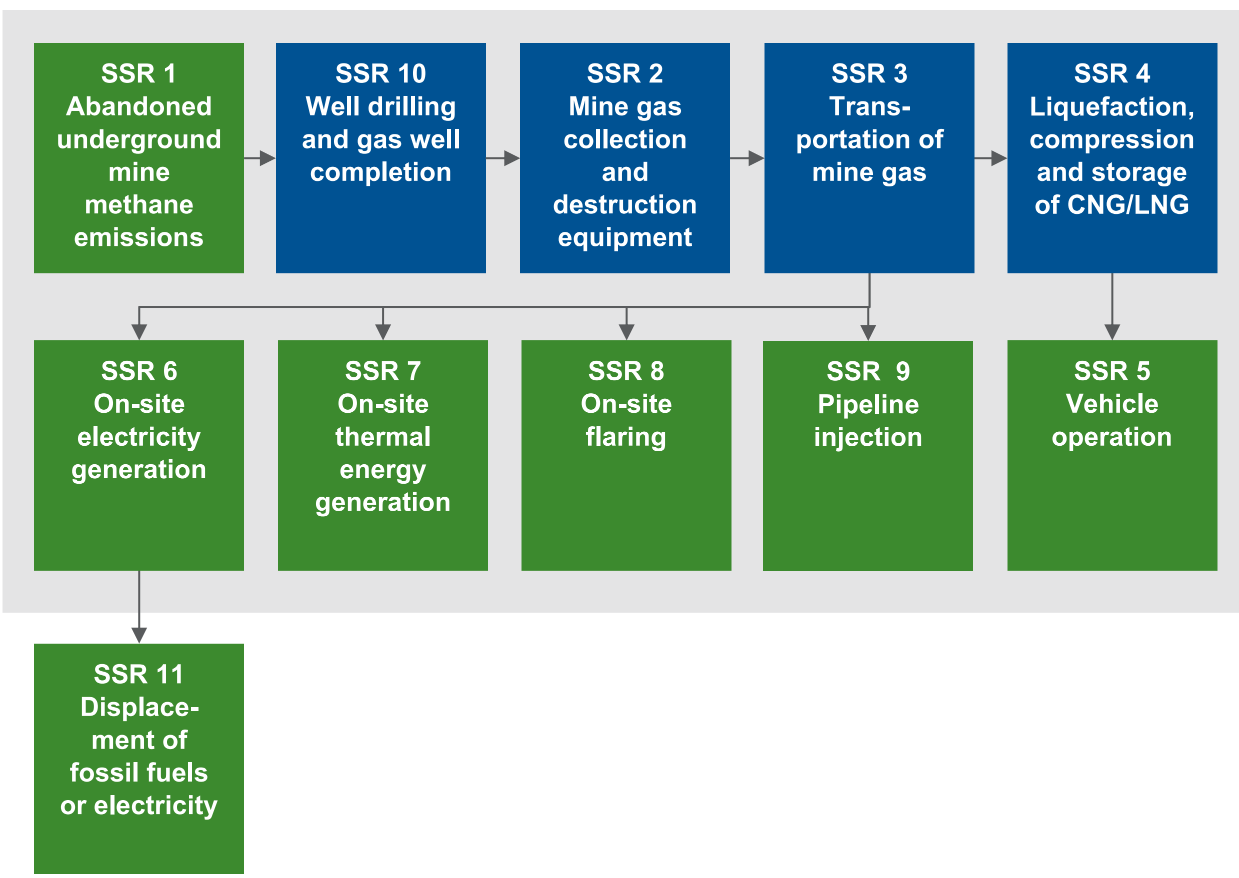
I. Figure 4 illustrates the offset project boundary for abandoned underground mine methane recovery activities, indicating which SSRs are included or excluded from the offset project boundary.

A. All SSRs inside the grey box are included and must be accounted for under this methodology.

B. SSRs in green boxes are relevant to the baseline and project emissions.

C. SSRs in blue boxes are relevant only to project emissions.

Figure 4: Offset Project Boundary for Abandoned Underground Mine Methane Recovery Activities



II. Table 4 lists the SSRs for abandoned underground mine methane recovery activities, indicating which gases are included or excluded from the offset project boundary.

Table 4: Greenhouse Gas Sinks, Sources, and Reservoirs for Abandoned Underground Mine Methane Recovery Activities

SSR	DESCRIPTION	GHG	BASELINE (B) OR PROJECT (P)	INCLUDED OR EXCLUDED
1 Abandoned underground mine methane emissions	Emissions of mine methane liberated after the conclusion of mining operations	CH_4	B, P	Included
2 Mine gas collection and destruction equipment	Emissions resulting from energy consumed to operate additional equipment used to capture, treat, or destroy drained mine gas	CO_2	P	Included
		CH_4	n/a	Excluded
		N_2O	n/a	Excluded
	Fugitive emissions from operation of additional equipment used to capture, treat, or destroy drained mine gas	CH_4	n/a	Excluded
3 Transportation of mine gas	Emissions resulting from additional energy consumed to transport mine gas to treatment or destruction equipment	CO_2	P	Included
		CH_4	n/a	Excluded
		N_2O	n/a	Excluded
	Fugitive emissions from the on-site transportation of mine gas	CH_4	n/a	Excluded
		CO_2	P	Included

SSR	DESCRIPTION	GHG	BASELINE (B) OR PROJECT (P)	INCLUDED OR EXCLUDED
4 Liquefaction, compression and storage of CNG/LNG	Emissions resulting from energy consumed to operate equipment used to liquefy, compress, or store methane for vehicle use.	CH_4	n/a	Excluded
		N_2O	n/a	Excluded
	Fugitive emissions from operation of equipment used to liquefy, compress, or store methane for vehicle use	CH_4	n/a	Excluded
5 Vehicle operation	Emissions resulting from mine methane combustion during vehicle operation	CO_2	B, P	Included
		N_2O	n/a	Excluded
	Emissions resulting from incomplete mine methane combustion during vehicle operation	CH_4	B, P	Included
6 On-site electricity generation	Emissions resulting from mine methane combustion during on-site electricity generation	CO_2	B, P	Included
		N_2O	n/a	Excluded
	Emissions resulting from incomplete mine methane combustion during on-site electricity generation	CH_4	B, P	Included
7 On-site thermal energy generation	Emissions resulting from mine methane combustion during on-site thermal energy generation	CO_2	B, P	Included
		N_2O	n/a	Excluded
	Emissions resulting from incomplete mine methane	CH_4	B, P	Included

SSR	DESCRIPTION	GHG	BASELINE (B) OR PROJECT (P)	INCLUDED OR EXCLUDED
	combustion during on-site electricity generation			
8 On-site flaring	Emissions resulting from mine methane combustion during on-site flaring	CO_2	B, P	Included
		N_2O	n/a	Excluded
	Emissions resulting from incomplete mine methane combustion during flaring	CH_4	B, P	Included
9 Pipeline injection	Emissions resulting from mine methane combustion resulting from pipeline injection	CO_2	B, P	Included
		N_2O	n/a	Excluded
	Emissions resulting from the incomplete mine methane combustion resulting from pipeline injection	CH_4	B, P	Included
10 Well drilling and gas well completion	Emissions from additional well drilling and well gas completion	CO_2	B, P	Included
		CH_4	n/a	Excluded
		N_2O	n/a	Excluded
	Fugitive emissions from additional well drilling and gas well completion	CH_4	n/a	Excluded
11 Displacement of fossil fuels or electricity	Emission reductions resulting from the displacement of fossil fuels or electricity	CO_2	n/a	Excluded
		CH_4	n/a	Excluded
		N_2O	n/a	Excluded

5 QUANTIFYING GHG EMISSION REDUCTIONS – QUANTIFICATION METHODOLOGY

I. GHG emission reductions from an MMC project are quantified by comparing project emissions to baseline emissions at the mine.
II. Project Proponents must use the activity type-specific calculation methods provided in this methodology to determine baseline and project GHG emissions.
III. Measurements used to quantify GHG emission reductions must be quantified using flow rates and methane densities adjusted to standard conditions of 60°F and 14.7 pounds per square inch (1 atm).
IV. Depending on the methane analyzer technology used, methane concentration readings may or may not need to be adjusted for temperature and pressure. If readings require adjustment, then such adjustments must be performed.
V. Global warming potential values must be determined in accordance with the requirements set forth in the ACR Standard.

5.1 ACTIVE UNDERGROUND MINE VENTILATION AIR METHANE ACTIVITIES

I. GHG emission reductions for a reporting period (ER) must be quantified by subtracting the project emissions for that reporting period (PE) from the baseline emissions for that reporting period (BE) using Equation 1.

Equation 1: GHG Emission Reductions

$$ER = BE - PE$$

WHERE

ER	Emission reductions achieved by the project during the reporting period (MT CO_2e)
BE	Baseline emissions during the reporting period (MT CO_2e)

PE	Project emissions during the reporting period (MT CO_2e)

5.1.1 Quantifying Baseline Emissions

I. For active underground mine ventilation air methane projects, baseline emissions equal methane released into the atmosphere during the reporting period.

Equation 2: Baseline Emissions

$$BE = BE_{MR}$$

AND

$$BE_{MR} = \sum_{i} \sum_{t} BE_{MR_{i,t}}$$

WHERE

BE	Baseline emissions during the reporting period (MT CO_2e)
i	Use of methane (oxidation or alternative end-use) by qualifying destruction device i
t	Time interval (not exceeding 15 minutes)
BE_{MR}	Baseline emissions from methane captured and sent to qualifying devices for destruction that would have been released to the atmosphere in the absence of the project (MT CO_2e)
$BE_{MR_{i,t}}$	Baseline emissions from methane captured and sent to qualifying device i for destruction during time interval t that would have been released to the atmosphere in the absence of the project (MT CO_2e).

II. Baseline emissions from the release of methane ($BE_{MRi,t}$) must be quantified using Equation 3.

III. $BE_{MRi,t}$ must account for the total amount of methane captured and sent to all qualifying devices during the reporting period.

IV. VAM project activities may supplement VA with mine gas (MG) extracted from a methane drainage system to either increase or help balance the methane concentration of VA flowing into the destruction device. If MG is used to supplement VA, the MG destroyed by the project during the reporting period must be accounted for using Equation 3 as $MG_{flow,t}$.

V. Methane that is still vented in the project scenario is not accounted for in the project emissions or baseline emissions since it is vented in both scenarios.

Equation 3: Baseline Emissions from Release of Methane

$$BE_{MR_{i,t}} = \sum_{t} \left[\left(VA_{flow_t} \times T \times C_{CH4_t} \right) + \left(MG_{flow_t} \times T \times C_{CH4,MG_t} \right) \right] \times 0.0423 \times 0.000454 \times GWP_{CH4}$$

WHERE

$BE_{MR_{i,t}}$	Baseline emissions from methane captured and sent to qualifying device i for destruction during time interval t that would have been released to the atmosphere in the absence of the project (MT CO_2e)
VA_{flow_t}	Volume flow rate of ventilation air sent to qualifying device i for destruction during time interval t (scfm)
C_{CH4_t}	Measured methane concentration of captured ventilation air sent to qualifying device i for destruction during time interval t (scfm CH_4/scfm)
MG_{flow_t}	Volume flow rate of mine gas extracted from a methane drainage system and sent with ventilation air to qualifying device i for destruction during time interval t (scfm)
C_{CH4,MG_t}	Measured methane concentration of captured mine gas that would have been sent with ventilation air to qualifying device i for destruction during time interval t (scfm CH_4/scfm)
i	Use of methane (oxidation or alternative end-use) by qualifying destruction device i
t	Time interval (not exceeding 15 minutes)
T	Duration of time interval (minutes)
0.0423	Standard density of methane (lb CH_4/scf CH_4)

0.000454	MT CH_4/lb CH_4
GWP_{CH4}	Global warming potential of methane (MT CO_2e/MT CH_4)

Methane concentrations and flow rate recordings must not exceed fifteen-minute intervals.

If a mass flow meter is used to monitor gas flow instead of a volumetric flow meter, the volume and density terms must be replaced by the monitored mass value and the methane concentration must be in mass percent.

5.1.2 Quantifying Project Emissions

I. Project emissions must be quantified during the entire reporting period.
II. Project emissions for a reporting period (PE) must be quantified by summing the emissions for all SSRs identified as included in the project in Table 1 and using Equation 4.
III. VAM that is still vented in the project scenario is not accounted for in the project emissions or baseline emissions since it is vented in both scenarios.

Equation 4: Project Emissions

$$PE = PE_{EC} + PE_{MD} + PE_{UM}$$

WHERE

PE	Project emissions during the reporting period (MT CO_2e)
PE_{EC}	Project emissions from energy consumed to capture and destroy methane during the reporting period (MT CO_2e)
PE_{MD}	Project emissions from destruction of methane during the reporting period (MT CO_2e)
PE_{UM}	Project emissions from uncombusted methane during the reporting period (MT CO_2e)

IV. If the project uses fossil fuel or grid electricity to power additional equipment required for project activities (e.g., capturing and destroying ventilation air, transporting ventilation air, etc.), the resulting CO_2 emissions from the energy consumed to capture and destroy methane (PE_{EC}) must be quantified using Equation 5.

Equation 5: Project Emissions from Energy Consumed to Capture and Destroy Methane

$$PE_{EC} = (CONS_{ELEC} \times CEF_{ELEC}) + \frac{(CONS_{HEAT} \times CEF_{HEAT} + CONS_{FF} \times CEF_{FF})}{1,000}$$

WHERE

PE_{EC}	Project emissions from energy consumed to capture and destroy methane during the reporting period (MT CO_2e)
$CONS_{ELEC}$	Additional electricity consumption for the capture and destruction of methane during the reporting period (MWh)
CEF_{ELEC}	CO_2 emission factor of electricity used from Table 10 in Appendix A (MT CO_2e/MWh)
$CONS_{HEAT}$	Additional heat consumption for the capture and destruction of methane during the reporting period (volume)
CEF_{HEAT}	CO_2 emission factor of heat used from Equation 39 in Appendix A (kg CO_2/volume)
$CONS_{FF}$	Additional fossil fuel consumption for the capture and destruction of methane during the reporting period (volume)
CEF_{FF}	CO_2 emission factor of fossil fuel used from Table 9 in Appendix A (kg CO_2/volume)
$\frac{1}{1,000}$	Conversion of kg to metric tons

V. Project emissions from the destruction of methane (PE_{MD}) must be quantified using Equation 6.

Equation 6: Project Emissions from Destruction of Methane

$$\mathbf{PE_{MD}} = \sum_{i}\sum_{t} \mathbf{PE_{MD_{i,t}}}$$

AND

$$\mathbf{PE_{MD_{i,t}}} = \mathbf{MD_{i,t}} \times \mathbf{CEF_{CH4}}$$

WHERE

PE_{MD}	Project emissions from destruction of methane by all qualifying devices during the reporting period (MT CO_2e)
$PE_{MD_{i,t}}$	Project emissions from destruction of methane by qualifying device i during time interval t (MT CO_2e)
$MD_{i,t}$	Methane destroyed by qualifying device i during time interval t; calculated separately for each destruction device (MT CH_4)
CEF_{CH4}	CO_2 emission factor for combusted methane (2.744 MT CO_2e/MT CH_4)
i	Use of methane (oxidation or alternative end-use) by qualifying destruction device i
t	Time interval (not exceeding 15 minutes)

VI. The amount of methane destroyed ($MD_{i,t}$) must be quantified using Equation 7.

VII. If MG is used to supplement VA, the MG destroyed by the project during the reporting period must be accounted for using Equation 7 as $MG_{flow,t}$.

VIII. If cooling air was added to the destruction device after the point of metering for VA, this must be accounted for with term $CA_{flow,t}$ in Equations 7 and 8. If no cooling air is added, then $CA_{flow,t}$ = 0.

IX. If the flow rate of cooling air was metered, then the metered data flow rate must be used. If the flow rate was not metered, the maximum capacity of the cooling air intake system must be used for the flow rate.

Equation 7: Methane Destroyed

$$MD_{i,t} = \left(MM_{i,t} - PE_{NO_{i,t}}\right)$$

WHERE

$MD_{i,t}$	Methane destroyed by qualifying device i during time interval t; calculated separately for each destruction device (MT CH_4)
$MM_{i,t}$	Measured methane sent to qualifying device i for destruction during time interval t (MT CH_4)
$PE_{NO_{i,t}}$	Project emissions of non-oxidized methane emitted as a result of incomplete oxidation of the ventilation air stream sent to qualifying device i for destruction during time interval t (MT CH_4)
i	Use of methane (oxidation or alternative end-use) by qualifying destruction device i
t	Time interval (not exceeding 15 minutes)

WITH

$$MM_{i,t} = \sum_{t}\left(VA_{flow_t} \times T \times C_{CH4_t}\right) + \left(MG_{flow_t} \times T \times C_{CH4,MG_t}\right) \times 0.0423 \times 0.000454$$

WHERE

VA_{flow_t}	Volume flow rate of ventilation air sent to qualifying device i for destruction during time interval t (scfm)
C_{CH4_t}	Measured methane concentration of captured ventilation air sent to qualifying device i for destruction during time interval t (scfm CH_4/scfm)
MG_{flow_t}	Volume flow rate of mine gas extracted from a methane drainage system and sent with ventilation air to qualifying device i for destruction during time interval t (scfm)
C_{CH4,MG_t}	Measured methane concentration of captured mine gas sent with ventilation air to qualifying device i for destruction during time interval t (scfm CH_4/scfm)

0.0423	Standard density of methane (lb CH_4/scf CH_4)
0.000454	MT CH_4/lb CH_4
i	Use of methane (oxidation or alternative end-use) by qualifying destruction device i
t	Time interval (not exceeding 15 minutes)
T	Duration of time interval (minutes)

WITH

$$PE_{NO_{i,t}} = \sum_{t} \left[\left(VA_{flow_t} \times T \right) + \left(CA_{flow_t} \times T \right) \right] \times C_{CH4_{exhaust_t}} \times 0.0423 \times 0.000454$$

WHERE

VA_{flow_t}	Volume flow rate of ventilation air sent to qualifying device i for destruction during time interval t (scfm)
CA_{flow_t}	Volume flow rate of cooling air sent to qualifying device i for destruction after the metering point of the ventilation air stream during time interval t (scfm)
$C_{CH4_{exhaust_t}}$	Measured methane concentration of exhaust gas emitted from qualifying device i during time interval t (scfm CH_4/scfm)
i	Use of methane (oxidation or alternative end-use) by qualifying destruction device i
t	Time interval (not exceeding 15 minutes)
T	Duration of time interval (minutes)

Methane concentrations and flow rates must not exceed fifteen-minute intervals.

If a mass flow meter is used to monitor gas flow instead of a volumetric flow meter, the volume and density terms must be replaced by the monitored mass value and the methane concentration must be in mass percent.

X. Project emissions from uncombusted methane (PE_{UM}) must be quantified using Equation 8.

Equation 8: Project Emissions from Uncombusted Methane

$$\mathbf{PE_{UM}} = \sum_{i}\sum_{t}\left(\mathbf{PE_{NO_{i,t}}} \times \mathbf{GWP_{CH_4}}\right)$$

WHERE

PE_{UM}	Project emissions from uncombusted methane during the reporting period (MT CO_2e)
$PE_{NO_{i,t}}$	Project emissions of non-oxidized methane emitted as a result of incomplete oxidation of the ventilation air stream sent to qualifying device i for destruction during time interval t; calculated separately for each destruction device per Equation 7 (MT CH_4)
GWP_{CH_4}	Global warming potential of methane (MT CO_2e/MT CH_4)
i	Use of methane (oxidation or alternative end-use) by qualifying destruction device i
t	Time interval (not exceeding 15 minutes)

Methane concentrations and flow rates must not exceed fifteen-minute intervals.

If a mass flow meter is used to monitor gas flow instead of a volumetric flow meter, the volume and density terms must be replaced by the monitored mass value and the methane concentration must be in mass percent.

XI. If gas flow metering equipment provides an actual or non-standardized flow rate instead of a flow rate adjusted to standard conditions, apply Equation 41 in Appendix C to standardize the flow rate of VA entering the destruction device.

5.2 ACTIVE UNDERGROUND MINE METHANE DRAINAGE ACTIVITIES

I. GHG emission reductions for a reporting period (ER) must be quantified by subtracting the project emissions for that reporting period (PE) from the baseline emissions for that reporting period (BE) using Equation 9.

Equation 9: GHG Emission Reductions

$$ER = BE - PE$$

WHERE

ER	Emission reductions achieved by the project during the reporting period (MT CO_2e)
BE	Baseline emissions during the reporting period (MT CO_2e)
PE	Project emissions during the reporting period (MT CO_2e)

5.2.1 Quantifying Baseline Emissions

I. For active underground mine methane drainage projects, baseline emissions equal the methane released into the atmosphere during the reporting period.

II. BE_{MR} must account for the total amount of methane captured and sent to all qualifying devices during the reporting period.

Equation 10: Baseline Emissions

$$\mathbf{BE = BE_{MR}}$$

AND

$$\mathbf{BE_{MR} = \sum_{i}\sum_{t} BE_{MR_{i,t}}}$$

WHERE

BE	Baseline emissions during the reporting period (MT CO_2e)
BE_{MR}	Baseline emissions from methane captured and sent to qualifying destruction devices that would have been released to the atmosphere in the absence of the project (MT CO_2e)
$BE_{MR_{i,t}}$	Baseline emissions from methane captured and sent to qualifying destruction device i during time interval t that would have been released to the atmosphere in the absence of the project (MT CO_2e).
i	Use of methane (oxidation or alternative end-use) by qualifying destruction device i
t	Time interval (not exceeding 15 minutes)

III. Baseline emissions from methane that would have been released to the atmosphere but that is captured and sent to qualifying destruction devices ($BE_{MR,i,t}$) must be quantified using Equation 11.

IV. Emissions from the release of methane through a pre-mining surface well is only accounted for in the baseline during the reporting period in which the emissions would have occurred (i.e., when the well is mined through). For the purposes of this methodology, a well at an active underground mine is considered mined through when any of the following occur:

A. The working face intersects the borehole, as long as the endpoint of the borehole is not more than 50 meters below the mined coal seam;

B. The working face passes directly underneath the bottom of the borehole, as long as the endpoint of the borehole is not more than 150 meters above the mined coal seam;

C. The working face passes both underneath (not more than 150 meters below the end-point of the borehole) and to the side of the borehole if room and pillar mining technique is employed and the endpoint of the borehole lies above a block of coal that will be left unmined as a pillar; or

D. The well produces elevated amounts of atmospheric gases (the percent concentration of nitrogen in MG increases by five compared to baseline levels). A full gas analysis using a gas chromatograph must be completed by an ISO 17025 accredited lab or a lab that has been certified by an accreditation body conformant with ISO 17025 to perform test methods appropriate for atmospheric gas content analysis. To ensure that elevated nitrogen levels are the result of a well being mined through and not the result of a leak in the well, the gas analysis must show that oxygen levels did not increase by the same proportion as the nitrogen levels.

V. If using Section 5.2.1(IV)(A), (B), or (C) to demonstrate that a well is mined through, an up-to-date mine plan must be used to identify which wells were mined through, based on the above criteria, and therefore eligible for baseline quantification in any given reporting period.

VI. If the mine plan calls for mining past rather than through a borehole, MG from that borehole extracted from within the methane source boundaries as described in Section 3.4(III)(B) is eligible for quantification in the baseline when the linear distance between the endpoint of the borehole and the working face that will pass nearest the endpoint of the borehole has reached an absolute minimum.

VII. If an MMC project at an active underground mine consists of both VAM and methane drainage activities, MG extracted from a methane drainage system ($MG_{flow,t}$) may be used to supplement VA to either increase or help balance the concentration of methane flowing into the destruction device. If MG is used to supplement VA, the MG destroyed by the project during the reporting period must be accounted for using Equation 11 as $MG_{flow,t.}$

VIII. MM that is still vented in the project scenario is not accounted for in the project emissions or baseline emissions, since it is vented in both scenarios.

Equation 11: Baseline Emissions from Release of Methane

$$\mathbf{BE_{MR_{i,t}}} = \sum_{t}\left[\mathbf{PSW_{flow_t}} + \left(\mathbf{IBPW_{flow_t}} \times \mathbf{T} \times \mathbf{C_{CH4_t}}\right) - \left(\mathbf{MG_{flow_t}} \times \mathbf{T} \times \mathbf{C_{CH4_{MG,t}}}\right)\right] \times \mathbf{0.0423} \times \mathbf{0.000454} \times \mathbf{GWP_{CH4}}$$

WHERE

$BE_{MRi,t}$	Baseline emissions from methane captured and sent to qualifying device **i** for destruction during time interval **t** that would have been released to the atmosphere in the absence of the project (MT CO_2e)

PSW_{flow_t}	Volume flow rate of MG from pre-mining surface wells sent to qualifying device i for destruction during time interval t. For qualifying devices, only the eligible amount per Equation 12 in accordance with Sections 5.2.1(IV), (V), and (VI) must be quantified (scfm)
$IBPW_{flow_t}$	Volume flow rate of MG from in-mine boreholes and post-mining wells sent to qualifying device i for destruction during time interval t (scfm)
C_{CH4_t}	Measured methane concentration of mine gas sent to qualifying device i for destruction during time interval t; calculated separately for each methane source (scfm CH_4/scfm)
MG_{Flow_t}	Volume flow rate of mine gas extracted from a methane drainage system and sent with ventilation air to qualifying device i for destruction during time interval t (scfm)
$C_{CH4_{MG,t}}$	Measured methane concentration of captured mine gas sent with ventilation air to qualifying devices for destruction during time interval t (scfm CH_4/scfm)
i	Use of methane (flaring, power generation, heat generation, production of transportation fuel, injection into natural gas pipeline, etc.) by qualifying destruction device i
t	Time interval (not exceeding 15 minutes)
T	Duration of time interval (minutes)
0.0423	Standard density of methane (lb CH_4/scf CH_4)
0.000454	MT CH_4/lb CH_4
GWP_{CH4}	Global warming potential of methane (MT CO_2e/MT CH_4)

Methane concentrations and flow rates must not exceed fifteen-minute intervals.

If a mass flow meter is used to monitor gas flow instead of a volumetric flow meter, the volume and density terms must be replaced by the monitored mass value and the methane concentration must be in mass percent.

IX. The eligible amount of MG from pre-mining surface wells destroyed by qualifying devices (PSW_{flow_t}) must be determined by using Equation 12.

Equation 12: Eligible MG from Pre-mining Surface Boreholes

$$PSW_{flow_t} = \sum_t (PSW_{pre_t} \times T \times C_{CH4_t}) + (PSW_{post_t} \times T \times C_{CH4_t})$$

WHERE

PSW_{flow_t}	Volume flow rate of MG from pre-mining surface wells sent to qualifying device i for destruction during time interval t that is eligible for quantification in the reporting period for use in Equation 11 (scfm)
PSW_{pre_t}	Volume flow rate of MG sent to qualifying device i for destruction during time interval t, from the beginning of the crediting period through the end of the reporting period, captured from pre-mining surface wells that were mined through during the reporting period (scfm)
PSW_{post_t}	Volume flow rate of MG sent to qualifying device i for destruction during time interval t in the reporting period captured from pre-mining surface wells that were mined through during earlier reporting periods (scfm)
t	Time interval (not exceeding 15 minutes)
T	Duration of time interval (minutes)
C_{CH4_t}	Measured methane concentration of mine gas sent to qualifying device i for destruction during time interval t; calculated separately for each methane source (scfm CH_4/scfm)

5.2.2 Quantifying Project Emissions

I. Project emissions must be quantified during the entire reporting period.
II. Project emissions for a reporting period (PE) must be quantified by summing the emissions for all SSRs identified as included in the project in Table 2 and using Equation 13.
III. Mine methane that is still vented in the project scenario is not accounted for in the project emissions or baseline emissions since it is vented in both scenarios.

Equation 13: Project Emissions

$$PE = PE_{EC} + PE_{MD} + PE_{UM}$$

WHERE

PE	Project emissions during the reporting period (MT CO_2e)
PE_{EC}	Project emissions from energy consumed to capture and destroy methane during the reporting period (MT CO_2e)
PE_{MD}	Project emissions from destruction of methane during the reporting period (MT CO_2e)
PE_{UM}	Project emissions from uncombusted methane during the reporting period (MT CO_2e)

IV. If the project uses fossil fuel or grid electricity to power additional equipment required for project activities (e.g., capturing and destroying mine gas, transporting mine gas, etc.), the resulting CO_2 emissions from the energy consumed to capture and destroy methane (PE_{EC}) must be quantified using Equation 14.

V. If the total electricity generated by project activities is greater than the additional electricity consumed for the capture and destruction of methane, then $CONS_{ELEC}$ = 0 in Equation 14.

Equation 14: Project Emissions from Energy Consumed to Capture and Destroy Methane

$$PE_{EC} = (CONS_{ELEC} \times CEF_{ELEC}) + \frac{(CONS_{HEAT} \times CEF_{HEAT} + CONS_{FF} \times CEF_{FF})}{1,000}$$

WHERE

PE_{EC}	Project emissions from energy consumed to capture and destroy methane during the reporting period (MT CO_2e)
$CONS_{ELEC}$	Additional electricity consumption for the capture and destruction of methane during the reporting period (MWh)
CEF_{ELEC}	CO_2 emission factor of electricity used from Table 10 in Appendix A (MT CO_2e/MWh)
$CONS_{HEAT}$	Additional heat consumption for the capture and destruction of methane during the reporting period (volume)

CEF_{HEAT}	CO_2 emission factor of heat used from Equation 39 (kg CO_2/volume)
$CONS_{FF}$	Additional fossil fuel consumption for the capture and destruction of methane during the reporting period (volume)
CEF_{FF}	CO_2 emission factor of fossil fuel used from Table 9 in Appendix A (kg CO_2/volume)
$\frac{1}{1,000}$	Conversion of kg to metric tons

VI. Project emissions from the destruction of methane (PE_{MD}) must be quantified using Equation 15.

VII. Project emissions for pre-mining surface wells that are mined through during the reporting period must include the CO_2 emissions resulting from the destruction of all MG from the mined-through wells that took place during and prior to the reporting period.

Equation 15: Project Emissions from Destruction of Captured Methane

$$PE_{MD} = \sum_{i} \sum_{t} PE_{MD_{i,t}}$$

AND

$$PE_{MD_{i,t}} = MD_{i,t} \times CEF_{CH4}$$

WHERE

PE_{MD}	Project emissions from destruction of methane by all qualifying devices during the reporting period (MT CO_2e)
$PE_{MD_{i,t}}$	Project emissions from destruction of methane by qualifying destruction device i during time interval t (MT CO_2e)
$MD_{i,t}$	Methane destroyed by qualifying device i during time interval t; calculated separately for each destruction device (MT CH_4)
CEF_{CH4}	CO_2 emission factor for combusted methane (2.744 MT CO_2e/MT CH_4)

i	Use of methane (oxidation or alternative end-use) by all qualifying destruction devices
t	Time interval (not exceeding 15 minutes)

VIII. The amount of methane destroyed ($MD_{i,t}$) must be quantified using Equation 16.

Equation 16: Methane Destroyed

$$MD_{i,t} = (MM_{i,t} \times DE_i)$$

WHERE

$MD_{i,t}$	Methane destroyed through use i by qualifying devices during time interval t; calculated separately for each destruction device ($MT\ CH_4$)
$MM_{i,t}$	Measured methane sent to qualifying devices for destruction through use i during time interval t ($MT\ CH_4$)
DE_i	Efficiency of methane destruction device i, either site-specific or from Table 12 in Appendix B (decimal)
i	Use of methane (flaring, power generation, heat generation, production of transportation fuel, injection into natural gas pipeline, etc.) by qualifying destruction device i
t	Time interval (not exceeding 15 minutes)

WITH

$$MM_{i,t} = \sum_t \left[PSW_{flow_t} + \left(IBPW_{flow_t} \times T \times C_{CH4,t}\right) - \left(MG_{flow_t} \times T \times C_{CH4_{MG,t}}\right)\right] \times 0.0423 \times 0.000454$$

WHERE

$MM_{i,t}$	Measured methane sent to qualifying devices for destruction through use i during time interval t ($MT\ CH_4$)

PSW_{flow_t}	Volume flow rate of MG from pre-mining surface wells sent to qualifying device i for destruction during time interval t that is eligible for quantification in the reporting period quantified per Equation 12 (scfm)
$IBPW_{flow_t}$	Volume flow rate of MG from in-mine boreholes and post-mining wells sent to qualifying device i for destruction during time interval t (scfm)
$C_{CH4,t}$	Measured methane concentration of mine gas sent to qualifying devices for destruction during time interval t; calculated separately for each methane source (scfm CH_4/scfm)
MG_{flow_t}	Volume flow rate of mine gas extracted from a methane drainage system and sent with ventilation air to qualifying device i for destruction during time interval t (scfm)
$C_{CH4_{MG,t}}$	Measured methane concentration of captured mine gas sent with ventilation air to qualifying devices for destruction during time interval t (scfm CH_4/scfm)
i	Use of methane (flaring, power generation, heat generation, production of transportation fuel, injection into natural gas pipeline, etc.) by qualifying destruction device i
t	Time interval (not exceeding 15 minutes)
T	Duration of time interval (minutes)
0.0423	Standard density of methane (lb CH_4/scf CH_4)
0.000454	MT CH_4/lb CH_4

Methane concentrations and flow rates must not exceed fifteen-minute intervals.

If a mass flow meter is used to monitor gas flow instead of a volumetric flow meter, the volume and density terms must be replaced by the monitored mass value and the methane concentration must be in mass percent.

IX. Project emissions from uncombusted methane (PE_{UM}) must be quantified using Equation 17.

X. Project emissions for pre-mining surface wells that are mined through during the reporting period must include the uncombusted methane portion of MG from the mined-through ells that was emitted during and prior to the reporting period.

Equation 17: Project Emissions from Uncombusted Methane

$$PE_{UM} = \sum_{i}\sum_{t}\left[MM_{i,t} \times (1 - DE_i)\right] \times GWP_{CH_4}$$

WHERE

PE_{UM}	Project emissions from uncombusted methane during the reporting period (MT CO_2e)
$MM_{i,t}$	Measured methane sent to qualifying device i during time period t; calculated separately for each destruction device per Equation 16 (MT CH_4)
DE_i	Efficiency of methane destruction device i, either site-specific or from Table 12 in Appendix B (decimal)
GWP_{CH_4}	Global warming potential of methane (MT CO_2e/MT CH_4)
i	Use of methane (flaring, power generation, heat generation, production of transportation fuel, injection into natural gas pipeline etc.) by qualifying destruction device i
t	Time interval (not exceeding 15 minutes)

Methane concentrations and flow rates must not exceed fifteen-minute intervals.

If a mass flow meter is used to monitor gas flow instead of a volumetric flow meter, the volume and density terms must be replaced by the monitored mass value and the methane concentration must be in mass percent.

XI. If gas flow metering equipment provides an actual or non-standardized flow rate or volume instead of a flow rate or volume adjusted to standard conditions, use Equation 42 in Appendix C to standardize the amount of MG sent to each qualifying and non-qualifying device during the reporting period.

5.3 ACTIVE SURFACE MINE METHANE DRAINAGE ACTIVITIES

I. GHG emission reductions for a reporting period (ER) must be quantified by subtracting the project emissions for that reporting period (PE) from the baseline emissions for that reporting period (BE) using Equation 18.

Equation 18: GHG Emission Reductions

$$\mathbf{ER = BE - PE}$$

WHERE

ER	Emission reductions achieved by the project during the reporting period (MT CO_2e)
BE	Baseline emissions during the reporting period (MT CO_2e)
PE	Project emissions during the reporting period (MT CO_2e)

5.3.1 Quantifying Baseline Emissions

I. Baseline emissions for a reporting period (BE) must be estimated by summing the baseline emissions for all SSRs identified as included in the baseline in Table 3 and using Equation 19.

II. For active surface mine methane drainage projects, baseline emissions equal methane released into the atmosphere during the reporting period.

III. BE_{MR} must account for the total amount of methane captured and sent to all qualifying devices during the reporting period.

Equation 19: Baseline Emissions

$$\mathbf{BE = BE_{MR}}$$

AND

$$\mathbf{BE_{MR} = \sum_{i} \sum_{t} BE_{MR_{i,t}}}$$

WHERE

BE	Baseline emissions during the reporting period (MT CO_2e)
BE_{MR}	Total Baseline emissions from methane captured and sent to all qualifying destruction devices that would have been released to the atmosphere in the absence of the project during the Reporting Period (MT CO_2e)
$BE_{MR_{i,t}}$	Baseline emissions from methane captured and sent to qualifying device i for destruction during time interval t that would have been released to the atmosphere in the absence of the project (MT CO_2e)
i	Use of methane (oxidation or alternative end-use) by qualifying destruction device i
t	Time interval (not exceeding 15 minutes)

IV. Baseline emissions from methane that would have been released to the atmosphere but that is captured and sent to qualifying destruction devices ($BE_{MR,i,t}$) must be quantified using Equation 20.

V. Emissions from the release of methane are only accounted for in the baseline during the reporting period in which the emissions would have occurred (i.e., when the well is in communication with the mine face or mined through). For the purposes of this methodology, a well at an active surface mine is considered mined through when either of the following occurs:

   A. The well is physically bisected by surface mining activities, such as excavation of overburden, drilling and blasting, and removal of the coal; or

   B. The well is considered in communication with the mine face when it produces elevated amounts of atmospheric gases (the percent concentration of nitrogen in MG increases by five compared to baseline levels). A full gas analysis using a gas chromatograph must be completed by an ISO 17025 accredited lab or a lab that has been certified by an accreditation body conformant with ISO 17025 to perform test methods appropriate for atmospheric gas content analysis. To ensure that elevated nitrogen levels are the result of a well being mined through and not the result of a leak in the well, the gas analysis must show that oxygen levels did not increase by the same proportion as the nitrogen levels.

VI. If using Section 5.3.1(V)(A) to demonstrate that a well is mined through, an up-to-date mine plan must be used to identify which wells were mined through and therefore eligible for baseline quantification in any given reporting period.

VII. SMM that is still vented in the project scenario is not accounted for in the project emissions or baseline emissions, since it is vented in both scenarios.

Equation 20: Baseline Emissions from Release of Methane

$$\mathbf{BE_{MR_{i,t}}} = \sum_{\mathbf{t}} [\mathbf{PSW_{flow_t}} + \mathbf{ECW_{flow_t}} + \mathbf{ARW_{flow_t}} + \mathbf{CDW_{flow_t}}] \times \mathbf{0.0423} \times \mathbf{0.000454} \times \mathbf{GWP_{CH4}}$$

WHERE

$BE_{MR_{i,t}}$	Baseline emissions from methane captured and sent to qualifying devices for destruction that would have been released to the atmosphere in the absence of the project (MT CO_2e)
PSW_{flow_t}	Volume flow rate of MG from pre-mining surface wells sent to qualifying device i for destruction during time interval t. For qualifying devices, only the eligible amount per Equation 21 in accordance with Sections 5.3.1(V) and (VI) must be quantified (scfm)
ECW_{flow_t}	Volume flow rate of MG from existing coalbed methane wells that would otherwise be shut-in and abandoned as a result of encroaching mining sent to qualifying device i for destruction during time interval t. For qualifying devices, only the eligible amount per Equation 22 in accordance with Sections 5.3.1(V) and (VI) must be quantified (scfm)
ARW_{flow_t}	Volume flow rate of MG from abandoned wells that are reactivated sent to qualifying device i for destruction during time interval t. For qualifying devices, only the eligible amount per Equation 23 in accordance with Sections 5.3.1(V) and (VI) must be quantified (scfm)
CDW_{flow_t}	Volume flow rate of MG from converted dewatering wells sent to qualifying device i for destruction during time interval t. For qualifying devices, only the eligible amount per Equation 24 in accordance with Sections 5.3.1(V) and (VI) must be quantified (scfm)
i	Use of methane (flaring, power generation, heat generation, production of transportation fuel, injection into natural gas pipeline, etc.) by qualifying destruction device i
t	Time interval (not exceeding 15 minutes)

0.0423	Standard density of methane (lb CH_4/scf CH_4)
0.000454	MT CH_4/lb CH_4
GWP_{CH4}	Global warming potential of methane (MT CO_2e/MT CH_4)

Methane concentrations and flow rates must not exceed fifteen-minute intervals.

If a mass flow meter is used to monitor gas flow instead of a volumetric flow meter, the volume and density terms must be replaced by the monitored mass value and the methane concentration must be in mass percent.

VIII. The eligible amount of MG destroyed by qualifying devices must be determined by using Equations 21, 22, 23, and 24.

Equation 21: Eligible MG from Pre-mining Surface Wells

$$PSW_{flow_t} = \sum_t (PSW_{pre_t} \times T \times c_{CH4_t}) + (PSW_{post_t} \times T \times c_{CH4_t})$$

WHERE

PSW_{flow_t}	Volume flow rate of MG from pre-mining surface wells sent to qualifying device i for destruction during time interval t that is eligible for quantification in the reporting period for use in Equation 20 (scfm)
PSW_{pre_t}	Volume flow rate of MG sent to qualifying device i for destruction during time interval t, from the beginning of the crediting period through the end of the reporting period, captured from pre-mining surface wells that were mined through during the reporting period (scfm)
PSW_{post_t}	Volume flow rate of MG sent to qualifying device i for destruction during time interval t captured from pre-mining surface wells that were mined through during earlier reporting periods (scfm)
t	Time interval (not exceeding 15 minutes)
T	Duration of time interval (minutes)

C_{CH4_t}	Measured methane concentration of mine gas sent to qualifying device i for destruction during time interval t; calculated separately for each methane source (scfm CH_4/scfm)

Equation 22: Eligible MG from Existing Coalbed Methane Wells that Would Otherwise Be Shut-in and Abandoned as a Result of Encroaching Mining

$$\mathbf{ECW_{flow_t}} = \sum_{t} \left(\mathbf{ECW_{pre_t}} \times \mathbf{T} \times \mathbf{C_{CH4_t}}\right) + \left(\mathbf{ECW_{post_t}} \times \mathbf{T} \times \mathbf{C_{CH4_t}}\right)$$

WHERE

ECW_{flow_t}	Volume flow rate of MG from existing coalbed methane wells that would otherwise be shut-in and abandoned as a result of encroaching mining sent for destruction to qualifying destruction device i during time interval t for use in Equation 20 (scfm)
ECW_{pre_t}	Volume flow rate of MG sent to qualifying destruction device i during time interval t, from the beginning of the crediting period through the end of the reporting period, captured from existing coalbed methane wells that would otherwise be shut-in and abandoned as a result of encroaching mining that were mined through during the reporting period (scfm)
ECW_{post_t}	Volume flow rate of MG sent to qualifying destruction device i during time interval t in the reporting period captured from existing coalbed methane wells that would otherwise be shut-in and abandoned as a result of encroaching mining that were mined through during earlier reporting periods (scfm)
t	Time interval (not exceeding 15 minutes)
T	Duration of time interval (minutes)
C_{CH4_t}	Measured methane concentration of mine gas sent to qualifying device i for destruction during time interval t; calculated separately for each methane source (scfm CH_4/scfm)

Equation 23: Eligible MG from Abandoned Wells that are Reactivated

$$AWR_{flow_t} = \sum_t (AWR_{pre_t} \times T \times C_{CH4_t}) + (AWR_{post_t} \times T \times C_{CH4_t})$$

WHERE

AWR_{flow_t}	Volume flow rate of MG from abandoned wells that are reactivated that is sent for destruction to qualifying destruction device i during time interval t that is eligible for quantification in the reporting period for use in Equation 20 (scfm)
AWR_{pre_t}	Volume flow rate of MG sent to qualifying destruction device i during time interval t, from the beginning of the crediting period through the end of the reporting period, captured from abandoned wells that are reactivated that were mined through during the current reporting period (scfm)
AWR_{post_t}	Volume flow rate of MG sent to qualifying destruction device i during time interval t in the reporting period captured from abandoned wells that are reactivated that were mined through during earlier reporting periods (scfm)
t	Time interval (not exceeding 15 minutes)
T	Duration of time interval (minutes)
C_{CH4_t}	Measured methane concentration of mine gas sent to qualifying device i for destruction during time interval t; calculated separately for each methane source (scfm CH_4/scfm)

Equation 24: Eligible MG from Converted Dewatering Wells that are Reactivated

$$CDW_{flow_t} = \sum_t (CDW_{pre_t} \times T \times C_{CH4_t}) + (CDW_{post_t} \times T \times C_{CH4_t})$$

WHERE

CDW_{flow_t}	Volume flow rate of MG from converted dewatering wells sent for destruction to qualifying destruction device i during time period t for use in Equation 20 (scfm)

CDW_{pre_t}	Volume flow rate of MG sent to for destruction to qualifying destruction device i, from the beginning of the crediting period through the end of time period t, captured from converted dewatering wells that were mined through during the reporting period (scfm)
CDW_{post_t}	Volume flow rate of MG sent to for destruction to qualifying destruction device i during time period t captured from converted dewatering wells that were mined through during earlier reporting periods (scfm)
t	Time interval (not exceeding 15 minutes)
T	Duration of time interval (minutes)
C_{CH4_t}	Measured methane concentration of mine gas sent to qualifying device i for destruction during time interval t; calculated separately for each methane source (scfm CH_4/scfm)

5.3.2 Quantifying Project Emissions

I. Project emissions must be quantified during the entire reporting period.
II. Project emissions for a reporting period (PE) must be quantified by summing the emissions for all SSRs identified as included in the project in Table 3 and using Equation 25.
III. SMM that is still vented in the project scenario is not accounted for in the project emissions or baseline emissions, since it is vented in both scenarios.

Equation 25: Project Emissions

$$PE = PE_{EC} + PE_{MD} + PE_{UM}$$

WHERE

PE	Project emissions during the reporting period (MT CO_2e)
PE_{EC}	Project emissions from energy consumed to capture and destroy methane during the reporting period (MT CO_2e)
PE_{MD}	Project emissions from destruction of methane during the reporting period (MT CO_2e)

PE_{UM}	Project emissions from uncombusted methane during the reporting period (MT CO_2e)

IV. If the project uses fossil fuel or grid electricity to power additional equipment required for project activities (e.g., drilling and completing additional wells or boreholes, capturing and destroying mine gas, transporting mine gas, etc.), the resulting CO_2 emissions from the energy consumed to capture and destroy methane (PE_{EC}) must be quantified using Equation 26.

V. If the total electricity generated by project activities is greater than the additional electricity consumed for the capture and destruction of methane, then $CONS_{ELEC}$ = 0 in Equation 26.

Equation 26: Project Emissions from Energy Consumed to Capture and Destroy Methane

$$PE_{EC} = (CONS_{ELEC} \times CEF_{ELEC}) + \frac{(CONS_{HEAT} \times CEF_{HEAT} + CONS_{FF} \times CEF_{FF})}{1,000}$$

WHERE

PE_{EC}	Project emissions from energy consumed to capture and destroy methane during the reporting period (MT CO_2e)
$CONS_{ELEC}$	Additional electricity consumption for the capture and destruction of methane during the reporting period (MWh)
CEF_{ELEC}	CO_2 emission factor of electricity used from Table 10 in Appendix A (MT CO_2e/MWh)
$CONS_{HEAT}$	Additional heat consumption for the capture and destruction of methane during the reporting period (volume)
CEF_{HEAT}	CO_2 emission factor of heat used from Equation 39 (kg CO_2/volume)
$CONS_{FF}$	Additional fossil fuel consumption for the capture and destruction of methane during the reporting period (volume)
CEF_{FF}	CO_2 emission factor of fossil fuel used from Table 9 in Appendix A (kg CO_2/volume)

$\frac{1}{1{,}000}$	Conversion of kg to metric tons

VI. Project emissions from the destruction of methane (PE_{MD}) must be quantified using Equation 27.

VII. Project emissions for pre-mining surface wells that are mined through during the reporting period must include the CO_2 emissions resulting from the destruction of all MG from the mined-through wells that took place during and prior to the reporting period.

Equation 27: Project Emissions from Destruction of SMM

$$PE_{MD} = \sum_{i}\sum_{t} PE_{MD_{i,t}}$$

AND

$$PE_{MD_{i,t}} = MD_{i,t} \times CEF_{CH4}$$

WHERE

PE_{MD}	Project emissions from destruction of methane by all qualifying devices during the reporting period (MT CO_2e)
$PE_{MD_{i,t}}$	Project emissions from destruction of methane by qualifying destruction device i during time interval t (MT CO_2e)
i	Use of methane (flaring, power generation, heat generation, production of transportation fuel, injection into natural gas pipeline, etc.) by all qualifying destruction devices
t	Time interval (not exceeding 15 minutes)
$MD_{i,t}$	Methane destroyed by qualifying device i during time interval t; calculated separately for each destruction device (MT CH_4)
CEF_{CH4}	CO_2 emission factor for combusted methane (2.744 MT CO_2e/MT CH_4)

VIII. The amount of mine methane destroyed ($MD_{i,t}$) must be quantified using Equation 28.

Equation 28: Methane Destroyed

$$MD_{i,t} = (MM_{i,t} \times DE_i)$$

WHERE

$MD_{i,t}$	Methane destroyed through use i by qualifying devices during time interval t; calculated separately for each destruction device (MT CH_4)
$MM_{i,t}$	Measured methane sent to qualifying devices for destruction through use i during time interval t (MT CH_4)
i	Use of methane (flaring, power generation, heat generation, production of transportation fuel, injection into natural gas pipeline, etc.) by qualifying destruction device i
t	Time interval (not exceeding 15 minutes)
DE_i	Efficiency of methane destruction device i, either site-specific or from Table 12 in Appendix B (decimal)

WITH

$$MM_{i,t} = \sum_{t} [PSW_{flow_t} + ECW_{flow_t} + AWR_{flow_t} + CDW_{flow_t}] \times 0.0423 \times 0.000454$$

WHERE

$MM_{i,t}$	Measured methane sent to qualifying devices for destruction through use i during time interval t (MT CH_4); calculated separately for each destruction device (MT CH_4)
PSW_{flow_t}	Volume flow rate of MG from pre-mining surface wells sent to qualifying device i for destruction during time interval t that is eligible for quantification in the reporting period quantified per Equation 21 (scfm)
ECW_{flow_t}	Volume flow rate of MG from existing coalbed methane wells that would otherwise be shut-in and abandoned as a result of encroaching mining sent for destruction to qualifying destruction device i during time interval t quantified per Equation 22 (scfm)

AWR_{flow_t}	Volume flow rate of MG from abandoned wells that are reactivated that is sent for destruction to qualifying destruction device i during time interval t that is eligible for quantification in the reporting period quantified per Equation 23 (scfm)
CDW_{flow_t}	Volume flow rate of MG from converted dewatering wells sent for destruction to qualifying destruction device i during time period t quantified per Equation 24 (scfm)
i	Use of methane (flaring, power generation, heat generation, production of transportation fuel, injection into natural gas pipeline, etc.) by qualifying destruction device i
t	Time interval (not exceeding 15 minutes)
0.0423	Standard density of methane (lb CH_4/scf CH_4)
0.000454	MT CH_4/lb CH_4

Methane concentrations and flow rates must not exceed fifteen-minute intervals.

If a mass flow meter is used to monitor gas flow instead of a volumetric flow meter, the volume and density terms must be replaced by the monitored mass value and the methane concentration must be in mass percent.

IX. Project emissions from uncombusted methane (PE_{UM}) must be quantified using Equation 29.

X. Project emissions for pre-mining surface wells that are mined through during the reporting period must include the uncombusted methane portion of MG from the mined-through wells that was emitted during and prior to the reporting period.

Equation 29: Project Emissions from Uncombusted Methane

$$PE_{UM} = \sum_{i}\sum_{t}\left[MM_{i,t} \times (1 - DE_i)\right] \times GWP_{CH_4}$$

WHERE

PE_{UM}	Project emissions from uncombusted methane during the reporting period (MT CO_2e)

$MM_{i,t}$	Measured methane sent to qualifying device i during time period t; calculated separately for each destruction device per Equation 28 (MT CH_4)
i	Use of methane (flaring, power generation, heat generation, production of transportation fuel, injection into natural gas pipeline, etc.) by qualifying destruction device i
DE_i	Efficiency of methane destruction device i, either site-specific or from Table 12 in Appendix B (decimal)
GWP_{CH_4}	Global warming potential of methane (MT CO_2e/MT CH_4)

Methane concentrations and flow rates must not exceed fifteen-minute intervals.

If a mass flow meter is used to monitor gas flow instead of a volumetric flow meter, the volume and density terms must be replaced by the monitored mass value and the methane concentration must be in mass percent.

XI. If gas flow metering equipment provides an actual or non-standardized flow rate or volume instead of a flow rate or volume adjusted to standard conditions, use Equation 42 to standardize the amount of MG sent to each qualifying device during the reporting period.

5.4 ABANDONED UNDERGROUND MINE METHANE RECOVERY ACTIVITIES

I. GHG emission reductions for a reporting period (ER) must be quantified by subtracting the project emissions for that reporting period (PE) from the baseline emissions for that reporting period (BE) using Equation 30.

Equation 30: GHG Emission Reductions

$$ER = BE - PE$$

WHERE

ER	Emission reductions achieved by the project during the reporting period (MT CO_2e)

BE	Baseline emissions during the reporting period (MT CO_2e)
PE	Project emissions during the reporting period (MT CO_2e)

5.4.1 Quantifying Baseline Emissions

II. Baseline emissions for a reporting period (BE) must be estimated by summing the baseline emissions for all SSRs identified as included in the baseline in Table 4 and using Equation 31.

III. BE_{MR} must account for the total amount of methane captured and sent to all qualifying devices during the reporting period.

IV. For abandoned underground mine methane drainage projects, baseline emissions equal methane released into the atmosphere during the reporting period.

Equation 31: Baseline Emissions

$$BE = BE_{MR}$$

AND

$$BE_{MR} = \sum_{i}\sum_{t} BE_{MR_{i,t}}$$

WHERE

BE	Baseline emissions during the reporting period (MT CO_2e)
BE_{MR}	Baseline emissions from methane captured and sent to qualifying destruction devices that would have been released to the atmosphere in the absence of the project (MT CO_2e)
$BE_{MR_{i,t}}$	Baseline emissions from methane captured and sent to qualifying destruction device i during time interval t that would have been released to the atmosphere in the absence of the project (MT CO_2e).
i	Use of methane (flaring, power generation, heat generation, production of transportation fuel, injection into natural gas pipeline, or alternative end-use) by qualifying destruction device i
t	Time interval (not exceeding 15 minutes)

V. Baseline emissions from methane that would have been released to the atmosphere but that is captured and sent to qualifying destruction devices ($BE_{MR,i,t}$) must be quantified using Equation 32.

VI. AMM that is still vented in the project scenario is not accounted for in the project emissions or baseline emissions, since it is vented in both scenarios.

Equation 32: Baseline Emissions from Release of Methane

$$BE_{MR_{i,t}} = \sum_{t} MM_{i,t} \times GWP_{CH4}$$

WHERE

$BE_{MR_{i,t}}$	Baseline emissions from methane captured and sent to qualifying destruction device i during time interval t that would have been released to the atmosphere in the absence of the project (MT CO_2e)
$MM_{i,t}$	Measured methane sent for destruction to qualifying device i during time period t (MT CH_4)
i	Use of methane (flaring, power generation, heat generation, production of transportation fuel, injection into natural gas pipeline, etc.) by qualifying destruction devices
t	Time interval (not exceeding 15 minutes)
GWP_{CH4}	Global warming potential of methane (MT CO_2e/MT CH_4)

VII. Measured methane sent to a qualifying destruction device ($MM_{i,t}$) is quantified using equation 33.

Equation 33: Baseline Emissions from Release of Methane

$$MM_{i,t} = \sum_{t} \left(IBPW_{flow_t} \times T \times C_{CH4_t}\right) \times 0.0423 \times 0.000454$$

WHERE

$MM_{i,t}$	Measured methane sent for destruction to qualifying device i during time interval t (MT CH_4)
$IBPW_{flow_t}$	Volume flow rate of MG from in-mine boreholes and post-mining wells sent to qualifying device i during time interval t (scfm)
i	Use of methane (flaring, power generation, heat generation, production of transportation fuel, injection into natural gas pipeline, etc.) by all qualifying destruction devices
t	Time interval (not exceeding 15 minutes)
T	Duration of time interval (minutes)
C_{CH4_t}	Measured methane concentration of mine gas sent to qualifying destruction device i during time interval t (scfm CH_4/scfm)
0.0423	Standard density of methane (lb CH_4/scf CH_4)
0.000454	MT CH_4/lb CH_4

5.4.2 Quantifying Project Emissions

I. Project emissions must be quantified over the entire reporting period.
II. Project emissions for a reporting period (PE) must be quantified by summing the emissions for all SSRs identified as included in the project in Table 4 and using Equation 34.
III. AMM that is still vented in the project scenario is not accounted for in the project emissions or baseline emissions, since it is vented in both scenarios.

Equation 34: Project Emissions

$$\mathbf{PE = PE_{EC} + PE_{MD} + PE_{UM}}$$

WHERE

PE	Project emissions during the reporting period (MT CO_2e)
PE_{EC}	Project emissions from energy consumed to capture and destroy methane during the reporting period (MT CO_2e)

PE_{MD}	Project emissions from destruction of methane during the reporting period (MT CO_2e)
PE_{UM}	Project emissions from uncombusted methane during the reporting period (MT CO_2e)

IV. If the project uses fossil fuel or grid electricity to power additional equipment required for project activities (e.g., drilling and completing additional wells or boreholes, capturing and destroying mine gas, transporting mine gas, etc.), the resulting CO_2 emissions from the energy consumed to capture and destroy methane (PE_{EC}) must be quantified using Equation 35.

V. If the total electricity generated by project activities is greater than the additional electricity consumed for the capture and destruction of methane, then $CONS_{ELEC}$ = 0 in Equation 35.

Equation 35: Project Emissions from Energy Consumed to Capture and Destroy Methane

$$PE_{EC} = (CONS_{ELEC} \times CEF_{ELEC}) + \frac{(CONS_{HEAT} \times CEF_{HEAT} + CONS_{FF} \times CEF_{FF})}{1,000}$$

WHERE

PE_{EC}	Project emissions from energy consumed to capture and destroy methane during the reporting period (MT CO_2e)
$CONS_{ELEC}$	Additional electricity consumption for the capture and destruction of methane during the reporting period (MWh)
CEF_{ELEC}	CO_2 emission factor of electricity used from Table 10 in Appendix A (MT CO_2e/MWh)
$CONS_{HEAT}$	Additional heat consumption for the capture and destruction of methane during the reporting period (volume)
CEF_{HEAT}	CO_2 emission factor of heat used from Equation 39 (kg CO_2/volume)
$CONS_{FF}$	Additional fossil fuel consumption for the capture and destruction of methane during the reporting period (volume). Default emission factors from drilling in Appendix A

CEF_{FF}	CO_2 emission factor of fossil fuel used from Table 9 in Appendix A (kg CO_2/volume)
$\frac{1}{1,000}$	Conversion of kg to metric tons

VI. Project emissions from the destruction of methane (PE_{MD}) must be quantified using Equation 36.

Equation 36: Project Emissions from Destruction of Captured Methane

$$PE_{MD} = \sum_{i}\sum_{t} PE_{MD_{i,t}}$$

AND

$$PE_{MD_{i,t}} = MD_{i,t} \times CEF_{CH4}$$

WHERE

PE_{MD}	Project emissions from destruction of methane by all qualifying devices during the reporting period (MT CO_2e)
$PE_{MD_{i,t}}$	Project emissions from destruction of methane by qualifying destruction device i during time interval t (MT CO_2e)
$MD_{i,t}$	Methane destroyed by qualifying device i during time interval t; calculated separately for each destruction device (MT CH_4)
i	Use of methane (flaring, power generation, heat generation, production of transportation fuel, injection into natural gas pipeline, etc.) by all qualifying destruction devices
t	Time interval (not exceeding 15 minutes)
CEF_{CH4}	CO_2 emission factor for combusted methane (2.744 MT CO_2e/MT CH_4)

VII. The amount of methane destroyed ($MD_{i,t}$) must be quantified using Equation 37.

Equation 37: Methane Destroyed

$$MD_{i,t} = (MM_{i,t} \times DE_i)$$

WHERE

$MD_{i,t}$	Methane destroyed through use i by qualifying devices during time interval t; calculated separately for each destruction device (MT CH_4)
$MM_{i,t}$	Measured methane sent to qualifying devices for destruction through use i during time interval t (MT CH_4)
i	Use of methane (flaring, power generation, heat generation, production of transportation fuel, injection into natural gas pipeline, etc.) by all qualifying destruction device i
t	Time interval (not exceeding 15 minutes)
DE_i	Efficiency of methane destruction device i, either site-specific or from Table 12 in Appendix B (decimal)

WITH

$$MM_{i,t} = \sum_{t} (IBPW_{flow_t} \times T \times C_{CH4,t}) \times 0.0423 \times 0.000454$$

WHERE

$MM_{i,t}$	Measured methane sent to qualifying devices for destruction through use i during time interval t (MT CH_4)
$IBPW_{flow_t}$	Volume of MG from in-mine boreholes and post-mining wells sent to qualifying device i for destruction during time period t (scfm)
i	Use of methane (flaring, power generation, heat generation, production of transportation fuel, injection into natural gas pipeline, etc.) by all qualifying destruction device i
t	Time interval (not exceeding 15 minutes)

$C_{CH4,t}$	Measured methane concentration of mine gas sent to qualifying destruction device i during time period t (scfm CH_4/scfm)
0.0423	Standard density of methane (lb CH_4/scf CH_4)
0.000454	MT CH_4/lb CH_4

Methane concentrations and flow rates must not exceed fifteen-minute intervals.

If a mass flow meter is used to monitor gas flow instead of a volumetric flow meter, the volume and density terms must be replaced by the monitored mass value and the methane concentration must be in mass percent.

VIII. Project emissions from uncombusted methane (PE_{UM}) must be quantified using Equation 38.

Equation 38: Uncombusted Methane Emissions

$$PE_{UM} = \sum_{i}\sum_{t}\left[MM_{i,t} \times (1 - DE_i)\right] \times GWP_{CH_4}$$

WHERE

PE_{UM}	Project emissions from uncombusted methane during the reporting period (MT CO_2e)
$MM_{i,t}$	Measured methane sent for destruction to qualifying device i during time period t; calculated separately for each destruction device per Equation 37 (MT CH_4)
i	Use of methane (flaring, power generation, heat generation, production of transportation fuel, injection into natural gas pipeline etc.) by all qualifying destruction device i
DE_i	Efficiency of methane destruction device i, either site-specific or from Table 12 in Appendix B (decimal)
GWP_{CH_4}	Global warming potential of methane (MT CO_2e/MT CH_4)

Methane concentrations and flow rate recordings must not exceed fifteen-minute intervals.

If a mass flow meter is used to monitor gas flow instead of a volumetric flow meter, the volume and density terms must be replaced by the monitored mass value and the methane concentration must be in mass percent.

IX. If gas flow metering equipment provides an actual or non-standardized flow rate or volume instead of a flow rate or volume adjusted to standard conditions, use Equation 42 to standardize the amount of MG sent to each qualifying device during the reporting period.

6 MONITORING – QUANTIFICATION METHODOLOGY

6.1 GENERAL MONITORING REQUIREMENTS

I. The Project Proponent is responsible for monitoring the performance of the offset project and operating each component of the collection and destruction system(s) in a manner consistent with the manufacturer's specifications.

II. Operational activity of the methane drainage and ventilation systems and the destruction devices must be the same as time interval t to ensure actual methane destruction. GHG reductions will not be accounted for during periods in which the destruction device is not operational.

   A. For flares, operation is defined as thermocouple readings above 500°F.

   B. For all other destruction devices, the Project Proponent must demonstrate the destruction device was operational. This demonstration is subject to the review and verification of the verification body.

III. If gas flow metering equipment does not internally adjust for temperature and pressure, flow data must be adjusted according to the appropriate quantification methodologies in chapter 5.

IV. If a project uses elevated amounts of atmospheric gases in extracted MG as evidence of a pre-mining well being mined through, nitrogen and oxygen concentrations must be determined for each well at the time of the project start date and when the Project Proponent reports a pre-mining well as eligible. Gas samples must be collected by a third-party technician and amounts of nitrogen and oxygen concentrations determined by a full gas analysis using a chromatograph at an ISO 17025 accredited lab or a lab that has been certified by an accreditation body conformant with ISO 17025 to perform test methods appropriate for atmospheric gas content analysis.

V. Data substitution is allowed for limited circumstances where a project encounters flow rate or methane concentration data gaps. Project Proponents may apply the data substitution methodology provided in Appendix D. No data substitution is permissible for data gaps resulting from inoperable equipment that monitors the proper functioning of destruction devices and no emission reductions will be credited under such circumstances.

6.2 INSTRUMENT QA/QC

Instruments and equipment used to monitor the destruction of mine methane or the temperature and pressure used to adjust data measurements to STP must be inspected, maintained, checked and calibrated according to the following:

I. All instruments must be:
   A. Inspected and maintained on a quarterly basis, with the activities performed and "as found/as left condition" of the equipment documented;
   B. Checked per manufacturer specifications by a trained professional for calibration accuracy (the project proponent may conduct this check) with the percent drift documented, with the check occurring no more than two months before the end date of the reporting period; and
   C. Calibrated by the manufacturer or a certified calibration service per manufacturer's specifications. Instruments are exempted from calibration requirements if the manufacturer's specifications state that no calibration is required.
II. A check must be performed before any corrective action (e.g., instrument calibration or repositioning) is applied.
III. If a portable instrument is used (such as a handheld methane analyzer), the portable instrument must be calibrated according to manufacturer's specifications prior to each use.
IV. For active underground VAM activities, the methane concentration of the reference gas used to check methane analyzers must be below or equal to 2% methane.
V. Flow meter and methane analyzer calibrations must be documented to show that the calibration was carried out to the range of conditions corresponding to the range of conditions as measured at the mine.
VI. If a check on a piece of equipment reveals accuracy beyond a +/- 5% threshold, all data from that piece of equipment must be scaled according to the following procedure. These adjustments must be made for the entire period from the last successful check until such time as corrective action is taken and a subsequent check demonstrates the equipment to again be within the +/-5% accuracy threshold.
   A. For each check that indicates the piece of equipment was beyond the +/- 5% accuracy threshold, the project developer shall calculate total emission reductions using:
      i. The monitored values without correction; and
      ii. The monitored values adjusted based on the calibration drift recorded at the time of the check.
   B. The lower of the two emission reduction estimates shall be reported as the scaled emission reduction estimate.

6.3 DOCUMENT RETENTION

I. The Project Proponent is required to keep all documentation and information outlined in this methodology. Record retention requirements are set forth in the ACR Standard.

II. Information that must be retained by the Project Proponent must include:

A. All data inputs for the calculation of the project baseline emissions and project emission reductions;

B. Emission reduction calculations;

C. NOVs, and any administrative or legal consent orders related to project activities dating back at least three years prior to the project start date and for each year of project operation;

D. Gas flow meter information (model number, serial number, manufacturer's calibration procedures);

E. Methane analyzer information (model number, serial number, manufacturer's calibration procedures);

F. Cleaning and inspection records for all gas meters;

G. Field check results for all gas meters and methane analyzers;

H. Calibration results for all gas meters and methane analyzers;

I. Corrective measures taken if meter does not meet performance specifications;

J. Gas flow data (for each flow meter);

K. Methane concentration monitoring data;

L. Gas temperature and pressure readings (only if flow meter does not adjust for temperature and pressure automatically);

M. Destruction device information (model numbers, serial numbers, installation date, operation dates);

N. Destruction device monitoring data (for each destruction device);

O. All maintenance records relevant to the methane collection and/or destruction device(s) and monitoring equipment;

P. For any portable instrument used in the project, the following records must be maintained:

i. Measurement instrument information (model number and serial number);

ii. Date, time, and results of instrument calibration; and

iii. Corrective measures taken if instrument does not meet performance specifications.

Q. If using a calibrated portable gas analyzer for CH_4 content measurement the following records must be retained:

i. Date, time, and location of methane measurement;

ii. Methane content of gas (% by volume or mass) for each measurement;

iii. Methane measurement instrument information (model number and serial number);

iv. Date, time, and results of instrument calibration; and

v. Corrective measures taken if instrument does not meet performance specifications.

6.4 ACTIVE UNDERGROUND MINE VENTILATION AIR METHANE ACTIVITIES

I. The flow rate of ventilation air entering the destruction device must be measured continuously, recordings must not exceed fifteen-minute intervals, and adjusted for temperature and pressure, if applicable.

II. The methane concentration of the ventilation air entering the destruction device and of the exhaust gas leaving the destruction device must be measured continuously, and recordings must not exceed fifteen-minute intervals to calculate methane concentrations.

III. If required in order to standardize the flow rate, volume, or mass of ventilation air, the temperature and pressure in the vicinity of the flow meter must be measured continuously and recorded at the same interval as time interval t.

IV. Project Proponents must monitor the parameters prescribed in Table 5. Data measurements may be recorded in an alternative unit, but must be appropriately converted to specified unit for use in equations provided in chapter 5.

Table 5: Active Underground Mine VAM Activity Monitoring Parameters

EQUATION #	PARAMETER	DESCRIPTION	DATA UNIT	MEASUREMENT FREQUENCY	CALCULATED (C) MEASURED (M) REFERENCE (R) OPERATING RECORDS (O)	COMMENT
3 7	$C_{CH4,t}$	Measured methane concentration of ventilation air sent to a qualifying destruction device i for time interval t	scfm CH_4/scfm	Continuously	M, C	Selected time interval cannot exceed fifteen minutes

EQUATION #	PARAMETER	DESCRIPTION	DATA UNIT	MEASUREMENT FREQUENCY	CALCULATED (C) MEASURED (M) REFERENCE (R) OPERATING RECORDS (O)	COMMENT
3 7 8	$VA_{flow,t}$	Flow rate of ventilation air sent to a qualifying device for destruction through use i during the time interval t	scfm	Continuously	M, C	Selected time interval cannot exceed fifteen minutes; adjusted to standard conditions, if applicable, using Equation 41
7 8	$CA_{flow,t}$	Flow rate of cooling air sent to a destruction device after the metering point of the ventilation air stream during the reporting period	scfm	Continuously	M, C	Selected time interval cannot exceed fifteen minutes; adjusted to standard conditions, if applicable using Equation 41. If the flow of cooling air is not metered, the maximum capacity of the air intake system must be used for the flow
3 7	$MG_{flow,t}$	Volume of mine gas extracted from a methane drainage system and sent with ventilation air to qualifying	scfm	Every reporting period	M, C	Selected time interval cannot exceed fifteen minutes; Adjusted to standard con-

EQUATION #	PARAMETER	DESCRIPTION	DATA UNIT	MEASUREMENT FREQUENCY	CALCULATED (C) MEASURED (M) REFERENCE (R) OPERATING RECORDS (O)	COMMENT
		device i for destruction during time interval t				ditions, if applicable, using Equation 42
3 7	$C_{CH4,MG,,t}$	Measured methane concentration of mine gas sent with ventilation air to destruction device i during time interval t	scfm CH_4/scfm	Continuously	M, C	Selected time interval cannot exceed fifteen minutes
5	$CONS_{ELEC}$	Additional electricity consumption for the capture and destruction of methane during the reporting period	MWh	Every reporting period	O	From electricity use records
5	$CONS_{HEAT}$	Additional heat consumption for the capture and destruction of methane during the reporting period	Volume	Every reporting period	O	From heat use records
5	$CONS_{FF}$	Additional fossil fuel consumption for the capture and destruction of methane during the reporting period	Volume	Every reporting period	O	From fuel use records
41	$VA_{actual,t}$	Measured flow rate or total volume of ventilation air sent to a	acfm or acf	Continuously	M, C	Readings not exceeding fifteen minutes to calculate

EQUATION #	PARAMETER	DESCRIPTION	DATA UNIT	MEASUREMENT FREQUENCY	CALCULATED (C) MEASURED (M) REFERENCE (R) OPERATING RECORDS (O)	COMMENT
		qualifying destruction device i during tome interval **t**				temperature for time interval **t**
41	$T_{VAinflow,t}$	Measured absolute temperature of ventilation air sent to a destruction device for the time interval **t**, °R=°F + 459.67	°R	Continuously	M, C	Readings taken the same as time interval **t** to calculate temperature for
41	$P_{VAinflow,t}$	Measured absolute pressure of ventilation air sent to a destruction device for the time interval **t**	atm	Continuously	M, C	Readings taken the same as time interval **t** to calculate pressure

6.5 ACTIVE UNDERGROUND MINE METHANE DRAINAGE ACTIVITIES

I. Mine gas from each methane source (i.e., pre-mining surface wells, and in-mine boreholes and post-mining wells) must be monitored separately prior to interconnection with other MG sources. The volumetric or mass gas flow, methane concentration, temperature, and pressure must be monitored and recorded separately for each methane source.

II. The flow rate of MG sent to a destruction device must be measured continuously, recordings must not exceed 15-minute intervals, and adjusted for temperature and pressure, if applicable, to calculate daily volume of MG sent to a destruction device. The flow of mine gas to a destruction device must be monitored separately for each destruction device, unless:

A. A project consists of destruction devices that are of identical efficiency and verified to be operational throughout the reporting period; then a single flow meter may be used to monitor gas flow to all destruction devices; or
B. A project consists of destruction devices that are not of identical efficiency, in which case the methane destruction efficiency of the least efficient destruction device must be used as the methane destruction efficiency for all destruction devices monitored by that meter.

III. If a project using a single meter to monitor gas flow to multiple destruction devices has any periods of time when not all destruction devices downstream of a single flow meter are operational, methane destruction from the set of downstream devices during these periods of time will only be eligible provided that the offset verifier can confirm all of the following requirements and conditions are met:
A. The methane destruction efficiency of the least efficient downstream destruction device in operation must be used as the methane destruction efficiency for all destruction devices downstream of the single meter;
B. All devices are either equipped with valves on the input gas line that close automatically if the device becomes non-operational (requiring no manual intervention), or designed in such a manner that it is physically impossible for gas to pass through while the device is non-operational; and
C. For any period of time during which one or more downstream destruction devices are not operational, it must be documented that the remaining operational devices have the capacity to destroy the maximum gas flow recorded during the period.

IV. The methane concentration of the mine gas extracted from each methane source must be measured continuously, and recordings must not exceed 15-minute intervals to calculate methane concentration.

V. If required in order to adjust the flow rate, volume, or mass of mine gas, the temperature and pressure of the mine gas from each methane source must be measured continuously and recorded at the same interval as time interval t to calculate temperature and pressure.

VI. Project Proponents must monitor the parameters prescribed in Table 6. Data measurements may be recorded in an alternative unit, but must be appropriately converted to specified unit for use in equations provided in chapter 5.

Table 6: Active Underground Mine Methane Drainage Activity Monitoring Parameters

EQUATION #	PARAMETER	DESCRIPTION	DATA UNIT	MEASUREMENT FREQUENCY	CALCULATED (C) MEASURED (M) REFERENCE (R) OPERATING RECORDS (O)	COMMENT
11 12 16 17	$C_{CH4,t}$	Measured methane concentration of mine gas sent to qualifying destruction devices i during time interval t	scfm CH_4/scfm	Continuously	M, C	Selected time interval cannot exceed fifteen minutes
11 16 17	$IBPW_{flow,t}$	Volume flow rate of MG from in-mine boreholes and post-mining wells sent to qualifying devices i during time interval t	scfm	Every reporting period	M, C	Selected time interval cannot exceed fifteen minutes; adjusted to standard conditions, if applicable, using Equation 42
11 16 17	$MG_{flow,t}$	Volume flow rate of mine gas extracted from a methane drainage system and sent with ventilation air to qualifying device i for destruction during time interval t	scfm	Every reporting period	M, C	Selected time interval cannot exceed fifteen minutes; adjusted to standard conditions, if applicable, using Equation 42
12	$PSW_{pre,t}$	Volume flow rate of MG sent	scfm	Every reporting period	M, C	Selected time interval cannot exceed

EQUATION #	PARAMETER	DESCRIPTION	DATA UNIT	MEASUREMENT FREQUENCY	CALCULATED (C) MEASURED (M) REFERENCE (R) OPERATING RECORDS (O)	COMMENT
		to qualifying destruction devices i during time interval t, from the beginning of the crediting period through the end of the reporting period, captured from pre-mining surface wells that were mined through during the reporting period				fifteen minutes; adjusted to standard conditions, if applicable, using Equation 42
12	$PSW_{post,t}$	Volume flow rate of MG sent to qualifying destruction device i during time period t in the reporting period; captured from pre-mining surface wells that were mined through during earlier reporting periods	scfm	Every reporting period	M, C	Selected time interval cannot exceed fifteen minutes; adjusted to standard conditions, if applicable, using Equation 42
14	$CONS_{ELEC}$	Additional electricity consumption for the capture and destruction of methane during the reporting period	MWh	Every reporting period	O	From electricity use records

EQUATION #	PARAMETER	DESCRIPTION	DATA UNIT	MEASUREMENT FREQUENCY	CALCULATED (C) MEASURED (M) REFERENCE (R) OPERATING RECORDS (O)	COMMENT
14	$CONS_{HEAT}$	Additional heat consumption for the capture and destruction of methane during the reporting period	Volume	Every reporting period	O	From heat use records
14	$CONS_{FF}$	Additional fossil fuel consumption for the capture and destruction of methane during the reporting period	Volume	Every reporting period	O	From fuel use records
16 17	$PSW_{flow,t}$	Volume flow rate of MG from pre-mining surface wells sent to qualifying device i during time interval t	scfm	Continuously	M, C	Selected time interval cannot exceed fifteen minutes; adjusted to standard conditions, if applicable, using Equation 42
16 17	DE_i	Efficiency of methane destruction device i	%	Each reporting period	R or M	Default methane destruction efficiencies provided in Appendix B or site-specific methane destruction efficiencies approved by validation and

EQUATION #	PARAMETER	DESCRIPTION	DATA UNIT	MEASUREMENT FREQUENCY	CALCULATED (C) MEASURED (M) REFERENCE (R) OPERATING RECORDS (O)	COMMENT
						verification body
42	$MG_{actual,t}$	Measured flow rate or total volume of MG sent to a qualifying destruction device **i** during time interval **t**	acfm or acf	Continuously	M	Readings not exceeding fifteen minutes to calculate temperature for time interval **t**
42	$T_{MG,t}$	Measured absolute temperature of MG for the time interval **t**, °R=°F + 459.67	°R	Continuously	M, C	Readings taken the same as time interval t to calculate temperature
42	$P_{MG,t}$	Measured absolute pressure of MG for the time interval **t**	atm	Continuously	M, C	Readings taken the same as time interval t to calculate pressure

6.6 ACTIVE SURFACE MINE METHANE DRAINAGE ACTIVITIES

I. Mine gas from each methane source (i.e., pre-mining surface wells, , existing CBM wells that would otherwise be shut-in and abandoned as a result of encroaching mining, abandoned wells that reactivated, and converted dewatering wells) must be monitored separately prior to interconnection with other MG sources. The volumetric or mass gas flow, methane concentration, temperature, and pressure must be monitored and recorded separately for each methane source.

II. The flow rate of MG sent to a destruction device must be measured continuously, recordings must not exceed 15-minute intervals, and adjusted for temperature and pressure, if applicable, to calculate daily volume of MG sent to a destruction device. The flow of gas to a destruction device must be monitored separately for each destruction device, unless:

A. A project consists of destruction devices that are of identical efficiency and verified to be operational throughout the reporting period; then a single flow meter may be used to monitor gas flow to all destruction devices; or
B. A project consists of destruction devices that are not of identical efficiency, in which case the methane destruction efficiency of the least efficient methane destruction device must be used as the methane destruction efficiency for all destruction devices monitored by that meter.

III. If a project using a single meter to monitor gas flow to multiple destruction devices has any periods of time when not all destruction devices downstream of a single flow meter are operational, methane destruction from the set of downstream devices during these periods of time will only be eligible provided that the offset verifier can confirm all of the following requirements and conditions are met:
   A. The methane destruction efficiency of the least efficient downstream destruction device in operation must be used as the methane destruction efficiency for all destruction devices downstream of the single meter;
   B. All devices are either equipped with valves on the input gas line that close automatically if the device becomes non-operational (requiring no manual intervention), or designed in such a manner that it is physically impossible for gas to pass through while the device is non-operational; and
   C. For any period of time during which one or more downstream destruction devices are not operational, it must be documented that the remaining operational devices have the capacity to destroy the maximum gas flow recorded during the period.

IV. The methane concentration of the SMM extracted from each methane source must be measured continuously, and recordings must not exceed 15-minute intervals to calculate methane concentration.

V. If required in order to adjust the flow rate, volume, or mass of mine gas, the temperature and pressure of the SMM must be measured continuously and recorded at the same interval as time interval t to calculate temperature and pressure.

VI. Project Proponents must monitor the parameters prescribed in Table 7. Data measurements may be recorded in an alternative unit, but must be appropriately converted to specified unit for use in equations provided in chapter 5.

Table 7: Active Surface Mine Methane Drainage Activity Monitoring Parameters

EQUATION #	PARAMETER	DESCRIPTION	DATA UNIT	MEASUREMENT FREQUENCY	CALCULATED (C) MEASURED (M) REFERENCE (R) OPERATING RECORDS (O)	COMMENT
20 28 29	$C_{CH4,t}$	Measured methane concentration of mine gas sent to a qualifying destruction device i during time interval t	scfm CH_4/scfm	Continuously	M, C	Selected time interval cannot exceed fifteen minutes; calculated separately for each methane source
21	$PSW_{pre,t}$	Volume flow rate of MG sent to qualifying destruction device i during time interval t, from the beginning of the crediting period through the end of the reporting period, captured from pre-mining surface wells that were mined through during the reporting period	scfm	Every reporting period	M, C	Selected time interval cannot exceed fifteen minutes; adjusted to standard conditions, if applicable, using Equation 42
21	$PSW_{post,t}$	Volume flow rate of MG sent to qualifying destruction device i during time interval t; in the reporting period captured from pre-mining surface wells that	scfm	Every reporting period	M, C	Selected time interval cannot exceed fifteen minutes; adjusted to standard con-

EQUATION #	PARAMETER	DESCRIPTION	DATA UNIT	MEASUREMENT FREQUENCY	CALCULATED (C) MEASURED (M) REFERENCE (R) OPERATING RECORDS (O)	COMMENT
		were mined through during earlier reporting periods				ditions, if applicable, using Equation 42
22	$ECW_{pre,t}$	Volume flow rate of MG sent to qualifying destruction device **i** during time interval **t**, from the beginning of the crediting period through the end of the reporting period, captured from existing coalbed methane wells that would otherwise be shut-in and abandoned as a result of encroaching mining that were mined through during the reporting period	scfm	Every reporting period	M, C	Selected time interval cannot exceed fifteen minutes; adjusted to standard conditions, if applicable, using Equation 42
22	$ECW_{post,t}$	Volume flow rate of MG sent to qualifying destruction device **i** during time interval **t**, in the reporting period captured from existing coalbed methane wells	scfm	Every reporting period	M, C	Selected time interval cannot exceed fifteen minutes; adjusted to standard conditions, if applicable, using Equation 42

EQUATION #	PARAMETER	DESCRIPTION	DATA UNIT	MEASUREMENT FREQUENCY	CALCULATED (C) MEASURED (M) REFERENCE (R) OPERATING RECORDS (O)	COMMENT
		that would otherwise be shut-in and abandoned as a result of encroaching mining that were mined through during earlier reporting periods				
23	$AWR_{pre,t}$	Volume flow rate of MG sent to qualifying destruction device $\mathbf{i}$ during time interval $\mathbf{t}$, from the beginning of the crediting period through the end of the reporting period, captured from abandoned wells that are reactivated that were mined through during the reporting period	scfm	Every reporting period	M, C	Selected time interval cannot exceed fifteen minutes; adjusted to standard conditions, if applicable, using Equation 42
23	$AWR_{post,t}$	Volume flow rate of MG sent to qualifying destruction device $\mathbf{i}$ during time interval $\mathbf{t}$, in the reporting period captured from abandoned	scfm	Every reporting period	M, C	Selected time interval cannot exceed fifteen minutes; adjusted to standard con-

EQUATION #	PARAMETER	DESCRIPTION	DATA UNIT	MEASUREMENT FREQUENCY	CALCULATED (C) MEASURED (M) REFERENCE (R) OPERATING RECORDS (O)	COMMENT
		wells that are reactivated that were mined through during earlier reporting periods				ditions, if applicable, using Equation 42
24	$CDW_{pre,t}$	Volume flow rate of MG sent to qualifying destruction device i during time interval t, from the beginning of the crediting period through the end of the reporting period, captured from converted dewatering wells that were mined through during the reporting period	scfm	Every reporting period	M, C	Selected time interval cannot exceed fifteen minutes; adjusted to standard conditions, if applicable, using Equation 42
24	$CDW_{post,t}$	Volume flow rate of MG sent to qualifying destruction device i during time interval t in the reporting period captured from converted dewatering wells that were mined through during earlier reporting periods	scfm	Every reporting period	M, C	Selected time interval cannot exceed fifteen minutes; adjusted to standard conditions, if applicable, using Equation 42

EQUATION #	PARAMETER	DESCRIPTION	DATA UNIT	MEASUREMENT FREQUENCY	CALCULATED (C) MEASURED (M) REFERENCE (R) OPERATING RECORDS (O)	COMMENT
26	$CONS_{ELEC}$	Additional electricity consumption for the capture and destruction of methane during the reporting period	MWh	Every reporting period	O	From electricity use records
26	$CONS_{HEAT}$	Additional heat consumption for the capture and destruction of methane during the reporting period	Volume	Every reporting period	O	From heat use records
26	$CONS_{FF}$	Additional fossil fuel consumption for the capture and destruction of methane during the reporting period	Volume	Every reporting period	O	From fuel use records
28 **29**	$PSW_{flow,t}$	Volume flow rate of MG from pre-mining surface wells sent to qualifying destruction device i during time interval t	scfm	Every reporting period	M, C	Selected time interval cannot exceed fifteen minutes; adjusted to standard conditions, if applicable, using Equation 42
28 **29**	$ECW_{flow,t}$	Volume flow rate of MG from existing coalbed methane wells	scfm	Every reporting period	M, C	Selected time interval cannot exceed fifteen

EQUATION #	PARAMETER	DESCRIPTION	DATA UNIT	MEASUREMENT FREQUENCY	CALCULATED (C) MEASURED (M) REFERENCE (R) OPERATING RECORDS (O)	COMMENT
		that would otherwise be shut-in and abandoned as a result of encroaching mining sent to qualifying device **i** during time interval **t**				minutes; adjusted to standard conditions, if applicable, using Equation 42
28 29	$AWR_{flow,t}$	Volume flow rate of MG from abandoned wells that are reactivated sent to qualifying device **i** during time period **t**	scfm	Every reporting period	M, C	Selected time interval cannot exceed fifteen minutes; adjusted to standard conditions, if applicable, using Equation 42
28 29	$CDW_{flow,t}$	Volume of MG from converted dewatering wells sent to qualifying device **i** for destruction during time period **t**	scfm	Every reporting period	M, C	Selected time interval cannot exceed fifteen minutes; adjusted to standard conditions, if applicable, using Equation 42
28 29	DE_i	Efficiency of methane destruction device **i**	%	Each reporting period	R or M	Default methane destruction efficiencies provided in Appendix B or site-specific

EQUATION #	PARAMETER	DESCRIPTION	DATA UNIT	MEASUREMENT FREQUENCY	CALCULATED (C) MEASURED (M) REFERENCE (R) OPERATING RECORDS (O)	COMMENT
						methane destruction efficiencies approved by the validation and verification body
42	$MG_{actual,t}$	Measured flow rate or total volume of MG sent to a destruction device **i** during time interval **t**	acfm or acf	Continuously	M	Readings not exceeding fifteen minutes to calculate temperature for time interval **t**
42	$T_{MG,t}$	Measured absolute temperature of MG for the time interval **t**, °R=°F +459.67	°R	Continuously	M, C	Readings taken the same as time interval **t** to calculate temperature
42	$P_{MG,t}$	Measured absolute pressure of MG for the time interval **t**	atm	Continuously	M, C	Readings taken the same as time interval **t** to calculate pressure

6.7 ABANDONED UNDERGROUND MINE METHANE RECOVERY ACTIVITIES

I. Mine gas from the methane source (i.e., in-mine boreholes and post-mining wells drilled into the mine during or after active mining operations) can be monitored in at a single location, but abandoned mine MG must be monitored separately prior to interconnection with any active mine MG sources. The volumetric or mass gas flow, methane concentration, temperature, and pressure must be monitored and recorded separately for each methane source.

II. The flow rate of MG sent to a destruction device must be measured continuously, recordings must not exceed 15-minute intervals, and adjusted for temperature and pressure, if applicable, to calculate daily volume of MG sent to a destruction device. The flow of gas to a destruction device must be monitored separately for each destruction device, unless:
   A. A project consists of destruction devices that are of identical efficiency and verified to be operational throughout the reporting period; then a single flow meter may be used to monitor gas flow to all destruction devices; or
   B. A project consists of destruction devices that are not of identical efficiency, in which case the methane destruction efficiency of the least efficient destruction device must be used as the methane destruction efficiency for all destruction devices monitored by that meter.

III. If a project using a single meter to monitor gas flow to multiple destruction devices has any periods of time when not all destruction devices downstream of a single flow meter are operational, methane destruction from the set of downstream devices during these periods of time will only be eligible provided that the offset verifier can confirm all of the following requirements and conditions are met:
   A. The methane destruction efficiency of the least efficient downstream destruction device in operation must be used as the methane destruction efficiency for all destruction devices downstream of the single meter;
   B. All devices are either equipped with valves on the input gas line that close automatically if the device becomes non-operational (requiring no manual intervention), or designed in such a manner that it is physically impossible for gas to pass through while the device is non-operational; and
   C. For any period of time during which one or more downstream destruction devices are not operational, it must be documented that the remaining operational devices have the capacity to destroy the maximum gas flow recorded during the period.

IV. The methane concentration of the MG must be measured continuously, and recordings must not exceed 15-minute intervals to calculate methane concentration.

V. If required in order to adjust the flow rate, volume, or mass of AMM, the temperature and pressure of the AMM must be measured continuously and recorded at the same time interval as time interval t to calculate temperature and pressure.

VI. Project Proponents must monitor the parameters prescribed in Table 8. Data measurements may be recorded in an alternative unit, but must be appropriately converted to specified unit for use in equations provided in chapter 5.

Table 8: Abandoned Underground Mine Methane Recovery Activity Monitoring Parameters

EQUATION #	PARAMETER	DESCRIPTION	DATA UNIT	MEASUREMENT FREQUENCY	CALCULATED (C) MEASURED (M) REFERENCE (R) OPERATING RECORDS (O)	COMMENT
33 37 38	$IBPW_{flow,t}$	Volume flow rate of MG from in-mine boreholes and post-mining wells sent to qualifying device i during time interval t	scfm	Every reporting period	M, C	Readings not exceeding fifteen minutes; adjusted to standard conditions, if applicable, using Equation 42
33 37 38	$C_{CH4,}$	Measured methane concentration of mine gas sent to a destruction device i during time interval t	scfm CH_4/scfm	Continuously	M, C	Readings not exceeding fifteen minutes;
35	$CONS_{ELEC}$	Additional electricity consumption for the capture and destruction of methane during the reporting period	MWh	Every reporting period	O	From electricity use records
35	$CONS_{HEAT}$	Additional heat consumption for the capture and destruction of methane during the reporting period	Volume	Every reporting period	O	From heat use records

EQUATION #	PARAMETER	DESCRIPTION	DATA UNIT	MEASUREMENT FREQUENCY	CALCULATED (C) MEASURED (M) REFERENCE (R) OPERATING RECORDS (O)	COMMENT
35	$CONS_{FF}$	Additional fossil fuel consumption for the capture and destruction of methane during the reporting period	Volume	Every reporting period	O	From fuel use records
37 38	DE_i	Efficiency of methane destruction device i	%	Each reporting period	R or M	Default methane destruction efficiencies provided in Appendix B or site-specific methane destruction efficiencies approved by the validation and verification body
42	$MG_{actual,t}$	Measured flow rate or total volume of MG sent to a destruction device i during time interval t	acfm or acf	Continuously	M	Readings not exceeding fifteen minutes to calculate temperature for time interval t
42	$T_{MG,t}$	Measured absolute temperature of MG for the time interval t, °R=°F + 459.67	°R	Continuously	M, C	Readings taken the same as time interval t to calculate temperature

EQUATION #	PARAMETER	DESCRIPTION	DATA UNIT	MEASUREMENT FREQUENCY	CALCULATED (C) MEASURED (M) REFERENCE (R) OPERATING RECORDS (O)	COMMENT
42	$P_{MG,t}$	Measured absolute pressure of MG for the time interval t	atm	Continuously	M, C	Readings taken the same as time interval t to calculate pressure

7 VERIFICATION REQUIREMENTS

I. See the ACR Standard for guidance on project validation and verification requirements.

II. Project Proponents are responsible for producing mine and project records requested by the validation and verification body, which could include, but is not limited to, the following:

   A. Mine plans;

   B. Mine ventilation plans;

   C. Mine maps;

   D. Mine operating permits, leases (if applicable), and air, water, and land use permits;

   E. Inspection, cleaning, and calibration records for metering equipment; and

   F. Source testing records for destruction devices that use site-specific methane destruction efficiencies.

DEFINITIONS

For the purposes of this methodology, the following definitions apply:

Abandoned Mine Methane (AMM)	Methane released from an abandoned mine.
Abandoned Underground Mine	A mine where all mining activity including mine development and mineral production has ceased, mine personnel are not present in the mine workings, and mine ventilation fans are no longer operative. A mine must provide evidence to demonstrate it to be abandoned by the Mine Safety and Health Administration (MSHA) or other applicable state, provincial, or federal agencies to be eligible for an abandoned mine methane recovery activity.
Abandoned Wells that are Reactivated	Wells drilled for producing natural gas, dewatering, or providing a conduit to the mine workings that are retrofitted to recover methane gas from the mine workings.
Active Surface Mine	A permitted mine in which the mineral lies near the surface and can be extracted by removing the covering layers of rock and soil. A mine must be classified by the Mine Safety and Health Administration (MSHA) or other applicable state, provincial, or federal agencies as active, intermittent, non-producing or temporarily idle in order to be eligible for an active surface mine methane drainage activity.
Active Underground Mine	A permitted mine most of which is located below the earth's surface. A mine must be classified by the Mine Safety and Health Administration (MSHA) or other applicable state, provincial, or federal agencies as active, intermittent, non-producing, or temporarily idle in order to be eligible for an active underground mine methane drainage or ventilation air methane activity.
Borehole	A hole made with a drill, augur, or other tool into a coal seam, mine void, or surrounding strata from which mine gas can be extracted. This includes boreholes designated as methane extraction boreholes as well as other utility boreholes from which methane can be extracted.
Coal	Solid fuels classified as anthracite, bituminous, sub-bituminous, or lignite

Coal Bed Methane (CBM or Virgin Coal Bed Methane)	Methane-rich natural gas drained from coal seams and surrounding strata not disturbed by mining.
Coalbed Methane (CBM) Wells	Wells drilled to recover and produce coalbed methane. CBM wells can be considered pre-mining CMM wells, however the extraction, capture, and destruction of virgin coalbed methane unrelated to mining activities is not eligible under this methodology.
Converted Dewatering Wells	Wells originally drilled and used with pumping equipment to remove groundwater from areas near mining activities that are retrofitted to recover methane gas.
Emission Factor	See ACR Standard for definition
Enclosed Flare	A flare that is situated in an enclosure for the purposes of safety, efficiency and accurate measurement of gas combustion. For purposes of this methodology, an enclosed flare is considered a flare.
End-use Option	A method of methane destruction deemed either eligible or ineligible for the purpose crediting under this methodology.
Flare	A combustion device that with a flame used to burn gas when mixed with combustion air; may be classified as “open” or “enclosed”.
Flow Meter	Device used to measure the amount of gas flowing through a pipe as measured at a specific point(s).
Gas Treatment	Applying techniques to extracted mine gas such as dehydration, gas separation, and the removal of non-methane components to prepare the mine gas for an end-use management option, including pipeline injection.
Gob	The part of the mine from which the mineral and artificial supports have been removed and the roof allowed to fall in. Gob is also known as “Goaf.” Generally regarded as the area behind the supports of a longwall mining machine.
In-mine Boreholes	A borehole or well drilled into an unmined seam from within the mine to drain methane from the seam ahead of the advancement of mining.

Longwall	A method of underground mining where a mechanical shearer is pulled back and forth across a coal face and loosened coal falls onto a conveyor for removal from the mine.
Methane Drainage System (Drainage System)	A system that drains methane from coal or trona seams and/or surrounding rock strata and transports it to a common collection point. This includes drainage systems within the mine workings or on the surface. Methane drainage systems may comprise multiple methane sources.
Methane Source	A methane source type from the following categories in the aggregate: • Ventilation shafts • Pre-mining surface wells • In-mine boreholes and post-mining wells • Existing coalbed methane wells that would otherwise be shut-in and abandoned • Abandoned wells that are reactivated • Converted dewatering wells
Mine Gas (MG)	The untreated gas extracted from within a mine through a methane drainage system that often contains various levels of other components (e.g., nitrogen, oxygen, carbon dioxide, hydrogen sulfide, and nonmethane hydrocarbons) in addition to methane.
Mine Methane (MM)	Methane contained in mineral deposits and surrounding strata that is released as a result of mining operations; the methane portion of mine gas.
Mine Operator	Any owner, lessee, or other person who operates, controls, or supervises a coal or other mine or any independent contractor performing services or construction at such mine. For purposes of this methodology, the Mine Operator is the operating entity listed on the state, provincial, or federal mining permit.
Mine Safety and Health Administration (MSHA)	The U.S. federal agency that regulates mine health and safety.
Mining Activities	Activities related to mineral extraction from active surface or underground coal or trona mine.

Natural Gas Pipeline (Pipeline)	A high-pressure pipeline transporting saleable quality natural gas offsite to gathering or distribution systems, or directly to customers.
Offset Project Expansion	The addition of a new methane source or new destruction device to an existing MMC project. A methane source is deemed new if it is either drilled after the project start date or connected to a destruction device after the project start date. A destruction device is deemed new if it becomes operational after the project start date. Under certain circumstances, described in chapter 2, the addition of new methane sources or new destruction devices may qualify as a new MMC project or an offset project expansion. In those cases, a Project Proponent may choose how to define the addition. Offset project expansion, unlike the establishment of a new MMC project, will not result in a new project start date or crediting period. Offset project expansion, unlike the establishment of a new MMC project, allows the Project Proponent to submit a single monitoring report and undergo a single verification for the reporting period.
Open Flare	A flare in which the main flame is atop a stack and visible. For purposes of this methodology, an open flare is considered a flare.
Pre-Project Destruction Device (Pre-Project Device)	A destruction device that is operational at the mine prior to the project start date, except as specified in Section 2.4(II). A destruction device that is operational at the mine prior to the project start date is considered a non-qualifying destruction device even if retrofitted thereafter.
Post-mining Well	A well or borehole used to extract or vent methane from the underground mine workings or gob area. Post-mining wells may be drilled from the surface or within the mine during or after mining activities. This includes gob wells.
Pre-mining Surface Wells	A well or borehole drilled into an unmined seam from the surface to drain methane from the seam and surrounding strata, often months or years in advance of mining. This is also known as surface pre-mining boreholes, surface-to-seam boreholes, and surface-drilled directional boreholes.
Qualifying Destruction Device (Qualifying Device)	A destruction device that was not operational at the mine prior to the project start date, except as specified in Section 2.4(II). Methane destroyed by a qualifying device must be monitored for quantification of both the baseline and project scenarios.

Room and Pillar	A method of underground mining in which approximately half of the coal is left in place as “pillars” to support the roof of the active mining area while "rooms" of coal are extracted. Also known as pillar and stall or board and pillar method.
Shut-in	To close, temporarily, a well capable of production.
Standard Conditions (Standard Temperature and Pressure or STP)	For the purposes of this methodology, 60 degrees Fahrenheit and 14.7 pounds per square inch absolute (1 atm).
Standard Cubic Foot (scf)	For the purposes of this methodology, a measure of quantity of gas, equal to a cubic foot of volume at 60 degrees Fahrenheit and 14.7 pounds per square inch (1 atm) of pressure.
Start-up period	The period between qualifying destruction device installation and the project start date. After the installation of the qualifying destruction device, the Project Proponent may run, tune, and test the system to ensure its operational quality. A start-up period must not exceed 9 months.
Strata	Plural of stratum, the layers of sedimentary rock surrounding a coal seam.
Surface Mine Methane (SMM)	Methane contained in mineral deposits and surrounding strata that is released as a result of surface mining operations.
Thermal Energy	The thermal output produced by a combustion source used directly as part of a manufacturing process, industrial/commercial process, or heating/cooling application, but not used to produce electricity.
Trona	A water-bearing sodium carbonate compound mineral that is mined and processed into soda ash or bicarbonate of soda.
Ventilation Air (VA)	The gas emitted from the ventilation system of a mine.
Ventilation Air Methane (VAM)	Methane contained in ventilation air.
Ventilation Air Methane Collection System	A system that captures all or a portion of the ventilation air methane from the ventilation system.

(VAM Collection System)	
Ventilation Shaft	A large diameter borehole used to supply fresh air underground or to remove contaminated air (methane and other gases) from an underground mine.
Ventilation System	A system of fans and barriers that provides a flow of air to underground workings of a mine for the purpose of sufficiently diluting and removing methane and other noxious gases in order to provide a safe working environment.
Well	A well drilled for exploration or extraction of natural gas from a coal seam, surrounding strata, or mine.

APPENDIX A: EMISSION FACTORS – QUANTIFICATION METHODOLOGY

Table 9: CO_2 Emission Factors for Fossil Fuel Use

FUEL TYPE	DEFAULT HIGH HEAT VALUE	DEFAULT CO_2 EMISSION FACTOR	DEFAULT CO_2 EMISSION FACTOR
COAL AND COKE	**MMBTU / SHORT TON**	**KG CO_2 / MMBTU**	**KG CO_2 / SHORT TON**
Anthracite	25.09	103.54	2597.819
Bituminous	24.93	93.40	2328.462
Subbituminous	17.25	97.02	1673.595
Lignite	14.21	96.36	1369.276
Coke	24.80	102.04	2530.592
Mixed (Commercial sector)	21.39	95.26	2037.611
Mixed (Industrial coking)	26.28	93.65	2461.122
Mixed (Electric Power sector)	19.73	94.38	1862.117
NATURAL GAS	**MMBTU / SCF**	**KG CO_2 / MMBTU**	**KG CO_2 / SCF**
(Weighted U.S. Average)	1.028×10^{-3}	53.02	0.055

FUEL TYPE	DEFAULT HIGH HEAT VALUE	DEFAULT CO_2 EMISSION FACTOR	DEFAULT CO_2 EMISSION FACTOR
PETROLEUM PRODUCTS	**MMBTU / GALLON**	**KG CO_2 / MMBTU**	**KG CO_2 / GALLON**
Distillate Fuel Oil No. 1	0.139	73.25	10.182
Distillate Fuel Oil No. 2	0.138	73.96	10.206
Distillate Fuel Oil No. 4	0.146	75.04	10.956
Distillate Fuel Oil No. 5	0.140	72.93	10.210
Residual Fuel Oil No. 6	0.150	75.10	11.265
Used Oil	0.135	74.00	9.990
Kerosene	0.135	75.20	10.152
Liquefied petroleum gases (LPG)	0.092	62.98	5.794
Propane	0.091	61.46	5.593
Propylene	0.091	65.95	6.001
Ethane	0.069	62.64	4.322
Ethanol	0.084	68.44	5.749
Ethylene	0.100	67.43	6.743
Isobutane	0.097	64.91	6.296
Isobutylene	0.103	67.74	6.977

FUEL TYPE	DEFAULT HIGH HEAT VALUE	DEFAULT CO_2 EMISSION FACTOR	DEFAULT CO_2 EMISSION FACTOR
PETROLEUM PRODUCTS	**MMBTU / GALLON**	**KG CO_2 / MMBTU**	**KG CO_2 / GALLON**
Butane	0.101	65.15	6.580
Butylene	0.103	67.73	6.976
Naphtha (<401 deg F)	0.125	68.02	8.503
Natural Gasoline	0.110	66.83	7.351
Other Oil (>401 deg F)	0.139	76.22	10.595
Pentanes Plus	0.110	70.02	7.702
Petrochemical Feedstocks	0.129	70.97	9.155
Petroleum Coke	0.143	102.41	14.645
Special Naphtha	0.125	72.34	9.043
Unfinished Oils	0.139	74.49	10.354
Heavy Gas Oils	0.148	74.92	11.088
Lubricants	0.144	74.27	10.695
Motor Gasoline	0.125	70.22	8.778
Aviation Gasoline	0.120	69.25	8.310
Kerosene-Type Jet Fuel	0.135	72.22	9.750
Asphalt and Road Oil	0.158	75.36	11.907
Crude Oil	0.138	74.49	10.280

FUEL TYPE	DEFAULT HIGH HEAT VALUE	DEFAULT CO_2 EMISSION FACTOR	DEFAULT CO_2 EMISSION FACTOR
OTHER FUELS (SOLID)	**MMBTU / SHORT TON**	**KG CO_2 / MMBTU**	**KG CO_2 / SHORT TON**
Municipal SolidWaste	9.95	90.7	902.465
Tires	26.87	85.97	2310.014
Plastics	38.00	75.00	2850.000
Petroleum Coke	30.00	102.41	3072.300
OTHER FUELS (GASEOUS)	**MMBTU / SCF**	**KG CO_2 / MMBTU**	**KG CO_2 / SCF**
Blast Furnace Gas	0.092×10^{-3}	274.32	0.025
Coke Oven Gas	0.599×10^{-3}	46.85	0.028
Propane Gas	2.516×10^{-3}	61.46	0.155
Fuel Gas	1.388×10^{-3}	59.00	0.082
BIOMASS FUELS (SOLID)	**MMBTU / SHORT TON**	**KG CO_2 / MMBTU KG**	**CO_2 / SHORT TON**
Wood and Wood Residuals	15.38	93.80	1442.644
Agricultural Byproducts	8.25	118.17	974.903
Peat	8.00	111.84	894.720
Solid Byproducts	25.83	105.51	2725.323
BIOMASS FUELS (GASEOUS)	**MMBTU / SCF**	**KG CO_2 / MMBTU**	**KG CO_2 / SCF**
Biogas (Captured methane)	0.841×10^{-3}	52.07	0.044

FUEL TYPE	DEFAULT HIGH HEAT VALUE	DEFAULT CO_2 EMISSION FACTOR	DEFAULT CO_2 EMISSION FACTOR
BIOMASS FUELS (GASEOUS)	**MMBTU / SCF**	**KG CO_2 / MMBTU**	**KG CO_2 / SCF**
Biogas (Captured methane)	0.841×10^{-3}	52.07	0.044
BIOMASS FUELS (LIQUID)	**MMBTU / GALLON**	**KG CO_2 / MMBTU**	**KG CO_2 / GALLON**
Ethanol	0.084	68.44	5.749
Biodiesel	0.128	73.84	9.452
Rendered Animal Fat	0.125	71.06	8.883
Vegetable Oil	0.120	81.55	9.786

Source: United States Environmental Protection Agency Mandatory Reporting of Greenhouse Gases (Title 40, Code of Federal Regulations, Part 98, Subpart C, Table C-1) (2013) http://www.arb.ca.gov/cc/reporting/ghg-rep/regulation/subpart_c_rule_part98.pdf.

Table 10: Emissions & Generation Resource Integrated Database (eGRID2016)

		ANNUAL OUTPUT EMISSION RATES	
EGRID SUBREGION ACRONYM	**EGRID SUBREGION NAME**	**(LB CO_2/MWh)**	**(METRIC TON CO_2/MWh)**
AKGD	ASCC Alaska Grid	1,072.3	0.486
AKMS	ASCC Miscellaneous	503.1	0.228
AZNM	WECC Southwest	1,043.6	0.473
CAMX	WECC California	527.9	0.239
ERCT	ERCOT All	1,009.2	0.458

FRCC	FRCC All	1,011.7	0.459
HIMS	HICC Miscellaneous	1,152.0	0.523
HIOA	HICC Oahu	1,662.9	0.754
MORE	MRO East	1,668.2	0.757
MROW	MRO West	1,238.8	0.562
NEWE	NPCC New England	558.2	0.253
NWPP	WECC Northwest	651.2	0.295
NYCW	NPCC NYC/Westchester	635.8	0.288
NYLI	NPCC Long Island	1,178.3	0.534
NYUP	NPCC Upstate NY	294.7	0.134
RFCE	RFC East	758.2	0.344
RFCM	RFC Michigan	1,272.0	0.577
RFCW	RFC West	1,243.4	0.564
RMPA	WECC Rockies	1,367.8	0.620
SPNO	SPP North	1,412.4	0.641
SPSO	SPP South	1,248.3	0.566
SRMV	SERC Mississippi Valley	838.9	0.381
SRMW	SERC Midwest	1,612.6	0.731
SRSO	SERC South	1,089.4	0.494
SRTV	SERC Tennessee Valley	1,185.4	0.538
SRVC	SERC Virginia/Carolina	805.3	0.365

U.S.	**998.4**	**0.453**

Source: U.S. EPA eGRID2016, Version 1.0 Year 2016 GHG Annual Output Emission Rates (Created February 2018) https://www.epa.gov/sites/production/files/2018-02/documents/egrid2016_summarytables.pdf.

Table 11: Default Emission Factors for Fuel Combustion During Gas Well Drilling

Diesel usage rate — as a function of drilling footage	1.55 gallons/ft

Source: California Air Resources Board, Emissions Inventory Technical Support Studies, Attachment L: Fuel Combustion for Oil and Gas Production (January 2003)

Equation 39: Calculating Heat Generation Emission Factor

$$\mathbf{CEF_{HEAT}} = \frac{\mathbf{CEF_{CO_{2i}}}}{\mathbf{Eff_{HEAT}}} \times \frac{\mathbf{44}}{\mathbf{12}}$$

WHERE

CEF_{HEAT}	CO_2 emission factor for heat generation
$CEF_{CO_{2i}}$	CO_2 emission factor of fuel used in heat generation (see Table 10)
Eff_{HEAT}	Boiler efficiency of the heat generation (either measured efficiency, manufacturer nameplate data for efficiency, or 100%)
$\frac{44}{12}$	Carbon to carbon dioxide conversion factor

Equation 40: Converting from lbs CO_2/MWh to metric tons CO_2/MW

$$\mathbf{Metric\ Tons_{CO_2}} = \frac{\mathbf{lbs_{CO_2}}}{\mathbf{2204.62}}$$

APPENDIX B: DEVICE DESTRUCTION EFFICIENCIES – QUANTIFICATION METHODOLOGY

Table 12: Default Methane Destruction Efficiencies by Destruction Device

Open Flare	0.960
Enclosed Flare	0.995
Lean-burn Internal Combustion Engine	0.936
Rich-burn Internal Combustion Engine	0.995
Boiler	0.980
Microturbine or large gas turbine	0.995
Upgrade and use of gas as CNG/LNG fuel	0.950
Upgrade and injection into natural gas transmission and distribution pipeline	0.981

APPENDIX C: STANDARDIZED FLOW RATE ENTERING DESTRUCTION DEVICES

Equation 41: VA Flow Rate or Volume Adjusted for Temperature and Pressure

$$VA_{adjusted_t} = VA_{actual_t} \times \frac{519.67}{T_{VA_{inflow_t}}} \times \frac{P_{VA_{inflow_t}}}{1}$$

WHERE

$VA_{adjusted_t}$	Flow rate or total volume of ventilation air sent to a destruction device during time interval t, adjusted to standard conditions (scfm or scf)
VA_{actual_t}	Measured flow rate or total volume of ventilation air sent to a destruction device during time interval t (acfm or acf)
$T_{VA_{inflow_t}}$	Measured absolute temperature of ventilation air sent to a destruction device for the time interval t, °R = °F + 459.67 (°R)
$P_{VA_{inflow_t}}$	Measured absolute pressure of ventilation air sent to a destruction device for the time interval t (atm)

Equation 42: MG Flow Rate or Volume Adjusted for Temperature and Pressure

$$MG_{adjusted_t} = MG_{actual_t} \times \frac{519.67}{T_{MG_t}} \times \frac{P_{MG_t}}{1}$$

WHERE

$MG_{adjusted_t}$	Flow rate or total volume of MG sent to a destruction device during time interval t, adjusted to standard conditions (scfm or scf)
MG_{actual_t}	Measured flow rate or total volume of MG sent to a destruction device during time interval t (acfm or acf)

T_{MG_t}	Measured absolute temperature of MG for the time interval y, °R=°F + 459.67 (°R)
P_{MG_t}	Measured absolute pressure of ventilation air sent to a destruction device for the time interval y (atm)

APPENDIX D: DATA SUBSTITUTION METHODOLOGY – QUANTIFICATION METHODOLOGY

I. ACR expects that MMC projects will have continuous, uninterrupted data for the entire reporting period. However, ACR recognizes that unexpected events or occurrences may result in brief data gaps.

II. This Appendix provides a quantification methodology to be applied to the calculation of GHG emission reductions for MMC projects when data integrity has been compromised due to missing data points.

III. This methodology is applicable to monitored parameters used to quantify emission reductions such as gas flow metering and methane concentration parameters. Data substitution is not allowed for equipment that monitors the proper functioning of destruction devices such as thermocouples.

IV. This methodology may be used for missing temperature and pressure data used to adjust flow rates to standard conditions.

V. The following data substitution methodology may be used only for flow and methane concentration data gaps that are discrete, limited, non-chronic, and due to unforeseen circumstances.

VI. Substitution may only occur when two other monitored parameters corroborate proper functioning of the destruction device and system operation within normal ranges. These two parameters must be demonstrated as follows:

   A. Proper functioning can be evidenced by thermocouple readings for flares or engines, energy output for engines, etc.

   B. For methane concentration substitution, flow rates during the data gap must be consistent with normal operation.

   C. For flow substitution, methane concentration rates during the data gap must be consistent with normal operations.

VII. If corroborating parameters fail to demonstrate any of these requirements, no substitution may be employed. If the requirements above can be met, the following substitution methodology may be applied:

Table 13: Data Substitution Duration and Methodology

Less than six hours	Use the average of the four hours of normal operation immediately before and following the outage or a more conservative value.
Six to 24 hours	Use the 90% upper or lower confidence limit (whichever is more conservative) of the 24 hours of normal operation prior to and after the outage or a more conservative value.
One to seven days	Use the 95% upper or lower confidence limit (whichever is more conservative) of the 72 hours of normal operation prior to and after the outage or a more conservative value.
Greater than one week	No data may be substituted, and no credits may be generated

APPENDIX E: PERFORMANCE STANDARD FOR CANADA AND MÉXICO

The predominant mine methane methodology in use in the United States is the compliance offset methodology from the California Air Resources Board. In that methodology, only projects located in the United States are eligible. In this methodology, projects located in Canada and México are also eligible as presented in this Appendix.

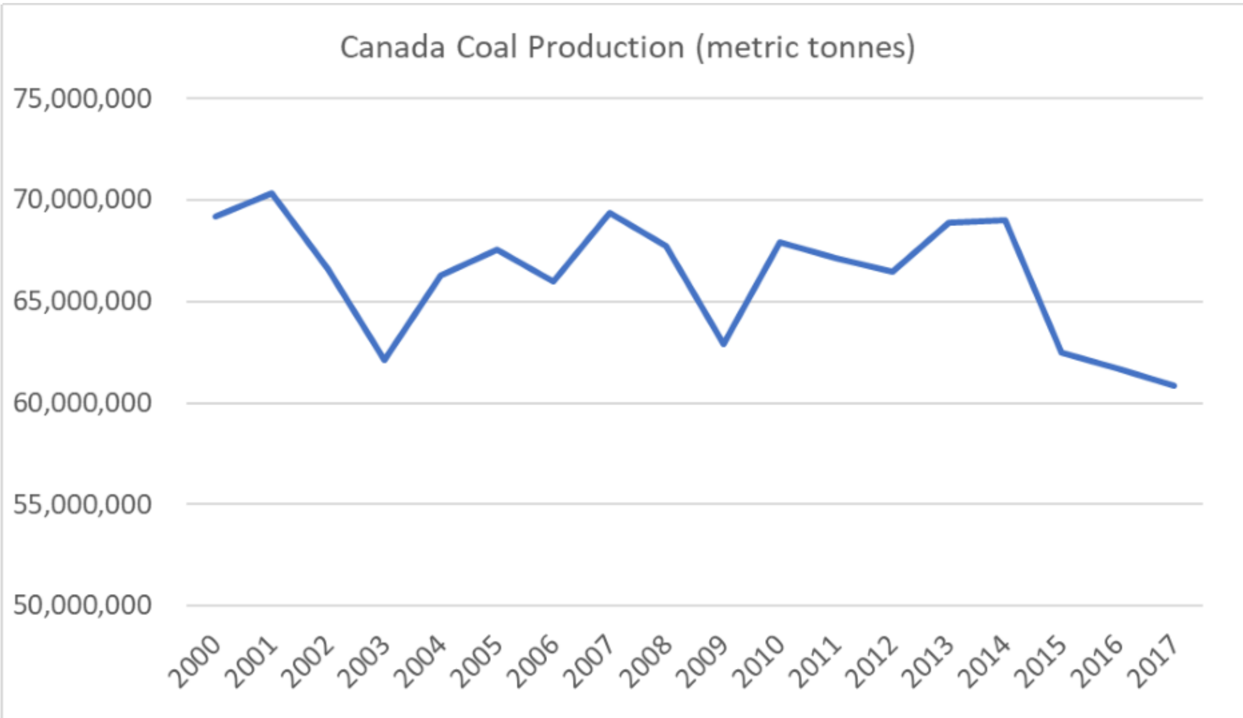
E.1 COAL INDUSTRY IN CANADA

Canada's coal resources extend across the country, but coal is actively mined only in Alberta, British Columbia, Saskatchewan, and Nova Scotia. Alberta and British Columbia produce 85% of Canada's coal. The country's coal production peaked in 1997 at 78 million tonnes, and since then, coal production has remained flat or has generally declined; it fell to an estimated 30-year low in 2016 at 60.4 million tonnes.

In recent years, just over half of Canada's coal production was metallurgical coal used for steel manufacturing and the rest was thermal coal used for electricity. The Government of Canada plans to eliminate the use of traditional coal-fired electricity in Canada by 2030; coal is still being mined but an increasing amount is exported. Canada exported 31 million tonnes of coal in 2017, primarily to Asian markets.

Most coal (97%) mined in Canada is from surface mines. In the last ten years there have only been two operating underground mines in Canada—the Grande Cache mine in Alberta and the Quinsam mine on Vancouver Island in British Columbia. A third underground mine, the Donkin mine in Cape Breton, Nova Scotia operated intermittently in 2017, 2018, and into 2019 because of safety concerns. Approximately 20 surface coal mines operated during the same time period. There are plans for additional underground operations—such as the Murray River Project in British Columbia—which may increase the contribution from underground mines in the future.

Figure 5. Coal Production in Canada



Source: Energy Statistics Canada

E.2 CMM EMISSIONS IN CANADA

Canada is home to 24 permitted coal mines, 19 of which operated in 2017. CMM emissions are limited to these locations as well as several abandoned underground mines. Environment and Climate Change Canada (ECCC) publishes annual fugitive methane emissions from coal mining in its National Inventory Reports (NIRs) and releases annual emissions data for individual coal mines in Canada gathered through its GHG Reporting Program. Emissions from active underground coal mines were estimated to be 90,000 tCO_2e in 2013, 108,000 tCO_2e in 2014, and 84,000 tCO_2e in 2015. Emissions from abandoned coal mines were estimated to be 100,000 tCO_2e in 2013, 54,000 tCO_2e in 2014, and 53,000 tCO_2e in 2015. During the same time period, emissions from surface mine activities were estimated to be about 900,000 tCO_2e annually.

The most recent NIR data is for 2016 when emissions were estimated to be 69,000 tCO_2e from abandoned coal mines and 0 tCO_2e from active underground coal mines because there were no producing underground mines. Surface mine emissions remained constant at 900,000 tCO_2e.

Two provinces, Alberta and British Columbia, also publish emissions data for individual mines gathered through their provincial-level GHG reporting programs. The data is somewhat inconsistent between British Columbia's provincial level data and ECCC's data, which is also inconsistent with NIR data, but this is likely the result of differences in methods for estimating emissions. ECCC and Alberta use IPCC Tier 2 equations to calculate emissions which include the application of an average emission rate; emissions estimates in British Columbia use measurements from the underground mines to calculate emissions.

E.3 PROJECT OPPORTUNITIES IN CANADA

Opportunities for CMM recovery in Canada are limited. The total annual CMM emissions reported in Canada's NIRs over the past five years are about 1 million tCO_2e. There have not been any CMM utilization projects developed in the past, and there are currently no CMM utilization projects operating in Canada. As of 2018, underground coal mine methane project opportunity was limited to one gassy mine operating intermittently in Nova Scotia, while the largest source of CMM emissions is from surface mines operating in western Canada coalfields with coalbed methane potential.

Environment Canada estimates there to be over 1,400 abandoned underground coal mines in Canada; however, the number of those mines with high CMM emissions is unknown and could be less than 10%. The gassiest underground coal mines with the greatest methane potential are located in Nova Scotia, but Nova Scotia Environment confirmed that all mines were flooded as of 2013. The best remaining abandoned mine opportunities are located at non-flooded mines in Alberta and British Columbia.

Currently, no law, regulation, or legal mandate exists in Canada requiring the destruction of methane at coal mines. All emission reductions resulting from the recovery and destruction of mine methane are considered eligible for crediting under this performance standard.

Figure 6: Atlas of Coal Mines in Canada

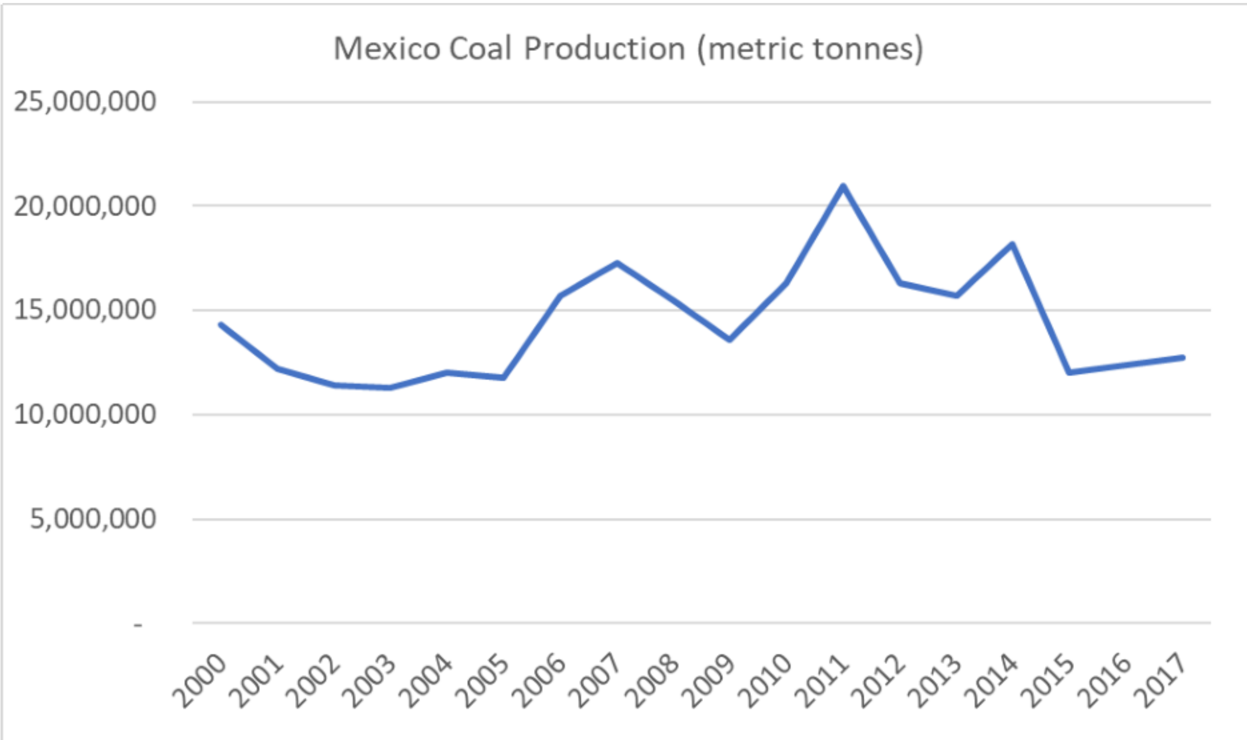
Source: Natural Resources Canada http://atlas.gc.ca/mins/en/index.html

E.4 COAL INDUSTRY IN MÉXICO

Approximately 95% of México's coal resources are located in northeast México in the State of Coahuila. According to the Mexican Geologic Service (Servicio Geológico Mexicano) there were at least 9 active mines operating in the state of Coahulia which represents 100% of coal production in México. Around 60% of the coal is used to generate electrical energy while the remainder is used to produce iron and steel (Geologia Económica de México).

Coal production peaked in México at about 21 million tons in 2011 when as many as 32 coal mines were operating. From 2015 to 2017, coal production was down to approximately 12-13 million tons/yr. with fewer mines operating. Five of the large active mines are gassy underground coal mines operated by Minera del Norte S.A. de C.V. (MIMOSA Unit). These mines produce most of México's coal. MIMOSA plans to develop a new area, the Conchas Mine Complex, with three underground mines (Minas IX, X, XI) in the southern Sabinas Basin.

Figure 7: Coal Production in México



Source: Mexican Mining Statistic Yearbook (Sistema Geológico Mexicano)

E.5 COAL MINE METHANE EMISSIONS IN MÉXICO

México's coal mine methane (CMM) emissions are estimated using IPCC Tier I default emission factors and are not reported based on methane measurements. Project feasibility studies have shown México coal mines to have higher methane emission rates than the IPCC defaults. Also, uncertainty exists with the coal production activity data used to estimate emissions. As a result, the applied Tier I method uncertainty for CMM emissions is a factor of 2. México's National Inventory Report for 2015 estimated CMM emissions to be greater than 7 million tCO_2e (with 98% from underground mines); however, the U.S. EPA estimated CMM emissions in México to be about 3 million tCO_2e in 2015, which was based on lower coal production numbers.

Between September 2011 and April 2014, MIMOSA developed a CMM destruction project by installing three enclosed flares – one at each of three mines: Mine V (Esmeralda), Mine VI, and Mine VII. The project destroys a portion of the methane recovered from the underground mines' gas drainage systems. The project was successfully registered as a CDM project in October

2013 with a fixed crediting period until October 2023. However, only the first monitoring period from October 2013 to October 2014 was verified with 85,865 tCO_2e (about 20% of the ex-ante estimate). The operational status of the project over the past four years is unknown as of 2018.

E.6 PROJECT OPPORTUNITIES IN MÉXICO

All CMM project opportunities (surface mines, underground mines, and abandoned underground mines) in México are located in the State of Coahuila. The largest opportunities reside with MIMOSA's underground mines (between 3-6 mines), which represent a large portion of total CMM emissions in México. Most emissions are from ventilation air methane (VAM) at vent shafts, but a significant amount of useable methane is recovered from gas drainage systems. MIMOSA also controls four abandoned underground mines with methane recovery opportunity.

Currently, no law, regulation, or legal mandate exists in México requiring the destruction of methane at coal mines. All emission reductions resulting from the recovery and destruction of mine methane are considered eligible for crediting under this performance standard.

Figure 8: Coal Basins in the State of Coahuila

Source: Panorama Minero del Estado de Coahulia del Servicio Geológico Mexicano

APPENDIX F: REFERENCES

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