Revisions to ACM0008 to Include Methane Capture and Destruction from Abandoned Coal Mines

A methodology revision submitted to the VCS Association

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Background Information

This document identifies specific revisions to the UNFCCC approved consolidated methodology ACM0008 Version 6 issued 25 March 2009 titled “Consolidated methodology for coal bed methane, coal mine methane and ventilation air methane capture and use for power (electrical or motive) and heat and/or destruction through flaring or flameless oxidation”. The revisions provide text modifications to the methodology language to allow for inclusion of coal mine methane capture and destruction from abandoned coal mines in addition to a proposed calculation procedure for the determination of baseline emissions from venting and sealed abandoned coal mines. The revision document shows the proposed modifications in red text where they are applicable in ACM0008. This document doesn’t provide a complete re-working of ACM0008; only the sections of ACM0008 relevant to the required modifications are shown.

I. SOURCE, DEFINITIONS AND APPLICABILITY

Definitions (page 2)

Recommended Revision: Add Definition

Abandoned Mine Methane (AMM). Methane which has been extracted from open or sealed vents, shafts, portals or gob wells at locations where active mining operations and/or ventilation have ceased.

Applicability (page 2)

Recommended Revision: Add AMM to applicability statements, but exclude flooded abandoned mines

This methodology applies to CMM, AMM and VAM capture, utilisation and destruction project activities at ~~a~~ working and abandoned/decommissioned coal mines, where the baseline is the partial or total atmospheric release of the methane and the project activities include the following method to treat the gas captured:

- The methane is captured and destroyed through flaring; and/or
- The methane is captured and destroyed through flameless oxidation and/or
- The methane is captured and destroyed through utilisation to produce electricity, motive power
- and/or thermal energy; emission reductions may or may not be claimed for displacing or
- avoiding energy from other sources;
- The remaining share of the methane, to be diluted for safety reason, may still be vented;
- All the CBM, AMM or CMM captured by the project should either be used or destroyed, and cannot be vented, with the exception of methane in dilute concentrations vented with other exhaust gases from the processing of methane for supply to gas grid.

Project participants must be able to supply the necessary to data for *ex ante* projections of methane demand as described in sections Baseline Emissions and Leakage to use this methodology, and data for *ex ante* projection of emissions of methane from abandoned mines, if applicable.

The methodology applies to both new, ~~and~~ existing mining, and post-mining activities.

The methodology **does <u>not</u> apply** to project activities with any of the following features:

- Operate in open cast mines;
- ~~Capture methane from abandoned/decommissioned coalmines;~~
- Capture methane from a flooded abandoned/decommissioned coalmine;

- Capture/use of virgin coal bed methane, e.g. methane of high quality extracted from coal seams independently of any mining activities;
- Use CO2 or any other fluid/gas to enhance CBM drainage before mining takes place.

II. BASELINE METHODOLOGY PROCEDURE

Project Boundary (page 4)

Recommended Revision: Amend table 1 so that AMM is not excluded

	Source	Gas		Justification/ Explanation
Baseline Emissions	Emissions of methane as a result of venting	CH_4	Included	• Main emission source. However, certain sources of methane may not be included, as noted in the applicability conditions; • Recovery of methane from coal seams will be taken into account only when the particular seams are mined through or disturbed by the mining activity; • ~~Recovery of methane from abandoned coalmines will not be included;~~ • The amount of methane to be released depends on the amount used (for local consumption, gas sales, etc) in the baseline.

Identification of the Baseline Scenario (page 5, 6, 7, 13, 14, 15, 16, 17)

Recommended Revision: There are numerous references to CMM/CBM/VAM and CMM or CBM or VAM, for example, in the descriptive text on these pages. It is recommended that this text be altered to include AMM, e.g. CMM/CBM/VAM/AMM.

Baseline Emissions (page 12)

Recommended Revision: Remove AMM exclusion from baseline

Methane destruction in the baseline

Depending on the nature of the activities in the baseline scenario, CBM/CMM can be removed at four different stages – (1) as coal bed methane from a CBM to goaf wells prior to mining, or from underground pre-mining CMM drainage; (2) during the mining process using surface or underground post mining CMM drainage techniques, (3) during the mining process using ventilation air or (4) after the mining process by drainage from sealed goafs. ~~but before the mine is closed~~.

Baseline Emissions (page 13)

Recommended Revision: Add AMM to Baseline methane destruction calculation

$$BE_{MDy} = (CEF_{CH4} + r \times CEF_{NMHC}) \times \sum_i (CBM_{BL,i,y} + VAM_{BL,i,y} + CMM_{BL,i,y} + PMM_{BL,i,y} + AMM_{BL,i,y}) \quad \textbf{(12)}$$

Where:

BE_{MDy}	= Baseline emissions from destruction of methane in the baseline scenario in year *y* (tCO_2e)
i	= Use of methane (flaring, power generation, heat generation, supply to gas grid to various combustion end uses)
$CBM_{BL,i,y}$	= CBM that would have been captured, sent to and destroyed by use *i* in the baseline scenario in the year *y* (expressed in tCH_4)
$VAM_{BL,i,y}$	= VAM that would have been captured, sent to and destroyed by use *i* in the baseline scenario in the year *y* (expressed in tCH_4)
$CMM_{BL,i,y}$	= Pre-mining CMM that would have been captured, sent to and destroyed by use *i* in the baseline scenario in year *y* (expressed in tCH_4)
$PMM_{BL,i,y}$	= Post-mining CMM that would have been captured, sent to and destroyed by use *i* in the baseline scenario in year *y* (tCH_4)
$AMM_{BL,i,y}$	= Post-mining AMM that would have been captured, sent to and destroyed by use *i* in the baseline scenario in year *y* (tCH_4)
CEF_{CH4}	= Carbon emission factor for combusted methane (2.75 tCO_2e/tCH_4)
CEF_{NMHC}	= Carbon emission factor for combusted non methane hydrocarbons. This parameter should be obtained through periodical analysis of captured methane ($tCO_2eq/tNMHC$)
r	= Relative proportion of NMHC compared to methane

Calculation of the mean annual demand (Thy) for each year of the crediting period (p. 13)

Recommended Revision: Include AMM in calculation of mean thermal demand in baseline

$$(VAM_{BL,th,y} + CMB_{BL,th,y} + CMM_{BL,th,y+}PMM_{BL,th,y} + AMM_{BL,th,y}) = \sum_{k=1}^{365} TH_{BL,k} \quad \textbf{(14)}$$

Where:

$VAM_{BL,th,y}$	= VAM that would have been captured and destroyed by thermal demand in the baseline scenario (tCH_4)
$CBM_{BL,th,y}$	= CBM that would have been captured and destroyed by thermal demand in the baseline scenario (tCH_4)
$CMM_{BL,th,y}$	= Pre-mining CMM that would have been captured and destroyed by thermal demand in the baseline scenario (tCH_4)
$PMM_{BL,th,y}$	= Post-mining CMM that would have been captured and destroyed by thermal demand in the baseline scenario (tCH_4)
$AMM_{BL,th,y}$	= AMM that would have been captured and destroyed by thermal demand in the baseline scenario (tCH_4)
th	= Index for thermal use of CBM, VAM, CMM and PMM in the baseline, which includes on-site heat generation and supply to the gas grid for various combustion end uses
$TH_{BL,k}$	= Methane used to serve estimated thermal energy demand in the baseline for day k of year y (tCH_4)

Methane released into the atmosphere (page 17)

Recommended Revision: Remove restriction of applicability of AMM; Include AMM in baseline methane release calculation

Depending on the nature of the project activity, CBM/VAM/CMM/AMM can be removed at four different stages – (1) as coal bed methane from a CBM wells prior to mining, or from underground pre-mining CMM drainage; (2) during the mining process using surface or underground post mining CMM drainage techniques; (3) during the mining process using ventilation air or (4) after the mining process by drainage from sealed goafs. ~~but before the mine is closed.~~ This methane would have been emitted to the atmosphere in the baseline scenario, unless some capture and use activities form part of the baseline:

$$BE_{MRy} = GWP_{CH4} \times \left[\sum_i (CBMe_{i,y} - CBM_{BLi,y}) + \sum_i (CMM_{PJi,y} - CMM_{BLi,y}) + \sum_i (PMM_{PJi,y} - PMM_{BLi,y}) + \sum_i (VAM_{PJi,y} - VAM_{BLi,y}) + \sum_i (AMM_{i,y} - AMM_{BLi,y})\right] \quad \textbf{(16)}$$

Where:

BE_{MRy}	= Baseline emissions from release of methane into the atmosphere in year *y* that is avoided by the project activity (tCO_2e)
i	= Use of methane (flaring, power generation, heat generation, supply to gas grid to various combustion end uses)
$CBMe_{i,y}$	= Eligible CBM captured, sent to and destroyed by use i in the project for year *y* (expressed in tCH_4)
$CBM_{BLi,y}$	= CBM that would have been captured, sent to and destroyed by use *i* in the baseline scenario in the year *y* (expressed in tCH_4)
$CMM_{PJi,y}$	= Pre-mining CMM captured, sent to and destroyed by use *i* in the project activity in year *y* (expressed in tCH_4)
$CMM_{BLi,y}$	= Pre-mining CMM that would have been captured, sent to and destroyed by use *i* in the baseline scenario in year *y* (expressed in tCH_4)
$PMM_{PJi,y}$	= Post-mining CMM captured, sent to and destroyed by use *i* in the project activity in year *y* (tCH_4)
$PMM_{BLi,y}$	= Post-mining CMM that would have been captured, sent to and destroyed by use *i* in the baseline scenario in year *y* (tCH_4)
$VAM_{PJi,y}$	= VAM sent to and destroyed by use *i* in the project activity in year *y* (tCH_4). In the case of flameless oxidation, $VAM_{PJ,i,y}$ is equivalent to MD_{OX} defined previously
$VAM_{BLi,y}$	= VAM that would have been captured, sent to and destroyed by use *i* in the baseline scenario in year *y* (tCH_4)
$AMM_{i,y}$	= AMM sent to and destroyed by use *i* that would have been released to the atmosphere in the absence of the project in year *y* (expressed in tCH4).
$AMM_{BLi,y}$	= AMM that would have been captured, sent to and destroyed by use *i* in the baseline scenario in year *y* (expressed in tCH_4)
GWP_{CH4}	= Global warming potential of methane (21 tCO_2e/tCH_4)

Baseline Emissions (page 22)

Recommended Revision: Insert AMMy calculation procedure following "***Pre-mining and post-mining CMM extraction and VAM";*** adjust equation numbers accordingly for the remainder of the document.

Emissions of methane from venting and sealed abandoned mines

The approach to determine the quantity of methane which would be released to the atmosphere by an abandoned mine in year *y* is detailed below.

Step 1: Identify relevant mine parameters

The first step is to collect relevant mine physical parameters which may be necessary to estimate the baseline methane emissions. General parameters to be identified include the following:

1. Date of mine closure or decommissioning
2. Methane emissions at time of mine closure in cubic meters of CH_4 per day (m^3/d) at normal conditions of temperature and pressure
3. Determine the current mine status (venting/sealed/flooded)
4. If the mine is sealed, estimate the percent of sealing
5. Coal adsorption characteristics (adsorption isotherm)
6. Gas content
7. Permeability of the remaining coal to gas
8. Mine size
9. Amount of coal in contact with the void

Step 2: Determine the hyperbolic decline curve equation coefficients

The emissions rate of an abandoned mine through time can be described by an exponential decay function and this function is directly related to the unique physical parameters of the coal mine.

Option A:

Derive hyperbolic decline curve coefficients using measured emission rate data.

If emission rate measurements are available before and for several years following mine closure, these emission rates can be plotted to derive the coefficients describing the curve on which these values lie. The extrapolation of this curve carried out through the crediting period will represent the baseline emissions of abandoned mine methane.

Option B:

Obtain hyperbolic decline curve coefficients used to develop the country of origin's national greenhouse gas inventory.

If published mine or coal type or coal basin specific data used to develop estimates for fugitive emissions of methane from coal mining are available, this is potentially the best way of determining the representative decline curve coefficients. For example, US EPA has such data by coal basin for various levels of gassiness as well as by coal rank for different levels of coal permeability and mined out volume.

Option C:

Derive hyperbolic decline curve coefficients using known physical mine parameters. This option may require computer simulation and is recommended as a last resort.

Step 3: Calculate ex ante projection of emissions of methane from abandoned mines using known coefficients

If the mine is sealed, estimate the ratio of the sealed mine flow rate to that of a fully venting mine using the following equation:

$$S = \frac{V_{AMM,is}}{V_{AMM,i}} \tag{24}$$

Where:

S	= The ratio of fully venting flow for a sealed mine
$V_{AMM,is}$	= Initial emissions of methane from abandoned mine at time t_o (after sealing)
$V_{AMM,i}$	= Emission rate at abandonment prior to sealing

The *ex ante* projection of emissions of methane from venting and sealed abandoned mines can be calculated using the following equation:

$$AMM_{DC,y} = V_{AMM,i} \cdot D_{CH4,corr} \cdot 365 \cdot S \cdot (1 + b \cdot D_i \cdot t)^{\left(\frac{-1}{b}\right)} \tag{25}$$

Where:

AMM_{DCy}	= Emissions of methane from the decline curve of the abandoned mine in year *y* measured (expressed in tCH_4)
V_{AMMi}	= Emissions of methane prior to mine closure at time (t_o) in normal cubic meters per day (m^3/d)
D_{CH4}	= Density of methane at normal conditions of temperature and pressure (0.67 kg CH_4/m^3)
b	= The dimensionless hyperbolic exponent
D_i	= The initial decline rate, (1/yr)
t	= The time elapsed from the date of mine closure to the current crediting year *y* in years
S	= sealed mine fully venting flow ratio ($S < 1$ for sealed mines; $S = 1$ for venting mines)

Step 4: Determine the appropriate value for AMM_y.

On an annual basis, the *ex ante* projected mass of methane emissions calculated using the decline curve are compared to the mass of methane captured by the project activity. The lesser of these two annual masses will be used to calculate the baseline emissions of AMM, as shown in the following equation:

$$AMM_y = \min\left(\sum_i AMM_{PJ,i,y}, AMM_{DC,y}\right) \tag{26}$$

Where:

$AMM_{PJ,i,y}$	= AMM captured by use *i* of the project activity in year *y* (tCH4)

Using the minimum of these values is conservative, and ensures that AMM_y never is greater than either the emissions projected using a decline curve or the amount of methane captured by the project activity.

Emissions from power/heat generation and vehicle fuel replaced by project (page 23)

Recommended Revision: Add abandoned mine methane to definition of ED_{CPMMy}

ED_{CPMMy} = Emissions from displacement of end uses by use of coal mine methane, VAM, ~~and~~ post-mining methane, and AMM (tCO_2)

Recommended Revision: Add $AMM_{PJ,y}$ to calculation of total methane captured.

$$CBMM_{tot,y} = CBM_{w,y} + CBM_{z,y} + CBM_{x,y} + CMM_{PJ,y} + PMM_{PJ,y} + VAM_{PJ,y} + AMM_{PJ,y} \quad \textbf{(28)}$$

Where:

$CBMM_{tot,y}$ = Total CBM, CMM and VAM captured and utilised by the project activity (tCH_4)

$CBM_{w,.y}$ = CBM captured from wells where the mining area intersected the zone of influence in year *y* (tCH_4)

$CBM_{z,.y}$ = CBM captured from wells where the mining area intersected the zone of influence prior to year *y* (tCH_4)

$CBM_{x,.y}$ = CBM captured from wells where the mining area has not yet intersected the zone of influence in year *y* (tCH_4)

$CMM_{PJ,i,y}$ = Pre-mining CMM captured by the project activity in year *y* (tCH_4)

$PMM_{PJ,y}$ = Post-mining CMM captured by the project activity in year *y* (tCH_4)

$VAM_{PJ,y}$ = VAM captured by the project activity year *y* (tCH_4)

$AMM_{PJ,y}$ = AMM captured by the project activity in year *y* (tCH_4)

Recommended Revision: Add emissions calculation for gas delivered to gas grid since MWh or GJ of electricity or heat displaced by pipeline gas cannot easily be determined. This is consistent with how ACM0008 calculates project emissions from pipelined gas.

$$PBE_{Use,y} = GEN_{,y} \times EF_{ELEC} + HEAT_y \times EF_{HEAT} + VFUEL_y \times EF_v + GAS_y \times EF_{GAS} \quad \textbf{(26)}$$

Where:

$PBE_{Use,y}$ = Potential total baseline emissions from the production of power or heat replaced by the project activity in year *y* (tCO_2e)

GEN_y = Electricity generated by project activity in year *y* (MWh), including through the use of CBM

EF_{ELEC} = Emissions factor of electricity (grid, captive or a combination) replaced by project (tCO_2/MWh)

$HEAT_y$ = Heat generation by project activity in year *y* (GJ), including through the use of CBM

EF_{HEAT} = Emissions factor for heat production replaced by project activity (tCO_2/GJ)

$VFUEL_y$ = Vehicle fuel provided by the project activity in year *y* (GJ), including through the use of CBM

EF_V = Emissions factor for vehicle operation replaced by project activity (tCO_2/GJ)

GAS_y = Gas delivered to the gas grid in year *y* (GJ), including through the use of CMB

EF_{GAS} = Emissions factor for gas delivered to gas grid and combusted (tCO_2e/GJ)

Recommended Revision: Add $AMM_{PJ,y}$ to calculation of displaced emissions by end uses of coal mine methane; add AMM to definition.

$$ED_{CPMM,y} = \frac{CMM_{PJ,y}+PMM_{PJ,y}+VAM_{PJ,y}+AMM_{PJ,y}}{CBMM_{tot,y}} \times PBE_{Use,y} \quad (31)$$

Where:

$ED_{CPMM,y}$	= Emissions from displacement of end uses by use of coal mine methane, ~~and~~ post-mining methane, and abandoned mine methane (tCO_2e)
$CMM_{PJ,y}$	= Pre-mining CMM captured by the project activity in year *y* (tCH_4)
$PMM_{PJ,y}$	= Post-mining CMM captured by the project activity in year *y* (tCH_4)
$VAM_{PJ,y}$	= VAM captured by the project activity in year *y* (tCH_4)
$AMM_{PJ,y}$	= AMM captured by the project activity in year *y* (tCH_4)
$CBMM_{tot,y}$	= Total CBM CMM AMM and VAM captured and utilised by the project activity in year *y* (tCH_4)
$PBE_{Use,y}$	= Potential total baseline emissions from the production of power or heat replaced by the project activity in year *y* (tCO_2e)

Emissions from power/heat generation and vehicle fuel replaced by project (page 26)

Recommended Revision: Add calculation of emissions factor for gas delivered to the gas grid

Gas grid fuel displacement emissions factor

The emissions occurring in the baseline from the use of gas grid fuel which the project activity displaces are calculated as follows:

$$EF_{gas,y} = EF_{CO2,i} \cdot Eff_{gas-grid} \cdot \frac{44}{12} \cdot \frac{1TJ}{1000GJ} \quad (33)$$

Where:

$EF_{gas,y}$	= Emissions factor for heat generation (tCO_2e/GJ)
$EF_{CO2,i}$	= CO2 emissions factor for displaced gas grid fuel
$Eff_{gas-grid}$	= the efficiency of transporting, delivering grid gas fuel to end users, IPCC default value of (taken as 99% from IPCC)
44/12	= Carbon to Carbon Dioxide conversion factor
1/1000	= TJ to GJ conversion factor

Data and parameters not monitored (page 30)

Recommended Revision: Add new data and parameters introduced in this methodology revision

Data / Parameter	$V_{AMM,is}$
Data unit:	m^3/d
Description	Initial emissions of methane from abandoned mine at time t_o (after sealing)
Source of data:	Public mining records
Measurement procedures (if any):	
Monitoring frequency:	Estimated *ex ante* at start of project
QA/QC procedures	
Any comment	

Data / Parameter	$V_{AMM,i}$
Data unit:	m^3/d
Description	Emission rate at abandonment prior to sealing
Source of data:	Public mining records
Measurement procedures (if any):	
Monitoring frequency:	Estimated *ex ante* at start of project
QA/QC procedures	
Any comment	

Data / Parameter	$AMM_{BL,i,y}$
Data unit:	tCH_4
Description	AMM that would have been captured, used and destroyed by use *i* in the baseline scenario in year *y*
Source of data:	
Measurement procedures (if any):	
Monitoring frequency:	Estimated *ex ante* at start of project
QA/QC procedures	
Any comment	

Data / Parameter	b
Data unit:	Dimensionless
Description	Dimensionless hyperbolic exponent describing decline rate of AMM emissions
Source of data:	Derived from available mine data parameters or obtained from published sources
Measurement procedures (if any):	
Monitoring frequency:	Estimated *ex ante* at start of project
QA/QC procedures	
Any comment	

Data / Parameter	Di
Data unit:	1/yr
Description	The initial decline rate of decline curve describing AMM emissions in the baseline
Source of data:	Derived from available mine data parameters or obtained from published sources
Measurement procedures (if any):	
Monitoring frequency:	Estimated *ex ante* at start of project
QA/QC procedures	
Any comment	

Data / Parameter	t
Data unit:	yr
Description	The time elapsed from the date of mine closure to the current crediting year *y* in years
Source of data:	Public mining records
Measurement procedures (if any):	
Monitoring frequency:	Calculated at the end of each crediting period
QA/QC procedures	
Any comment	

Data and parameters monitored (page 34)

Recommended Revision: Add and revise data and parameters introduced by this methodology revision

Data / Parameter	$AMM_{PJ,i,y}$
Data unit:	tCH_4
Description	Abandoned mine methane captured, sent to and destroyed by use *i* in the project activity in year *y*
Source of data:	
Measurement procedures (if any):	
Monitoring frequency:	Continuous
QA/QC procedures	
Any comment	

Data / Parameter	GAS_y
Data unit:	GJ
Description	Gas delivered to gas grid in year y
Source of data:	
Measurement procedures (if any):	
Monitoring frequency:	Continuous
QA/QC procedures	
Any comment	

Data / Parameter	$Eff_{gas-grid}$
Data unit:	e
Description	Efficiency of transporting natural gas through the gas grid to end users
Source of data:	
Measurement procedures (if any):	
Monitoring frequency:	*Ex ante*
QA/QC procedures	
Any comment	Set at 99.0%

Data / Parameter	$EF_{CO2,i}$
Data unit:	tC/TJ
Description	CO2 emission factor of fuel used for captive power or heat, or delivered to gas grid
Source of data:	
Measurement procedures (if any):	
Monitoring frequency:	Annually or *ex ante*
QA/QC procedures	
Any comment	National sources or IPCC defaults