Proposed new baseline and monitoring methodology

Draft baseline and monitoring methodology

"Interception, recovery and use of methane from CBM seeps that would otherwise be released to the atmosphere"

Version 1

Wednesday, 09 June 2010

I. SOURCE, DEFINITIONS AND APPLICABILITY

Sources

This baseline and monitoring methodology is based on the following approved baseline and monitoring methodologies:

- ACM0008 "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"
- AM0009 "Recovery and utilization of gas from oil wells that would otherwise be flared or vented"

This methodology also refers to the latest approved versions of the following tools:

- "Tool to calculate project or leakage CO_2 emissions from fossil fuel combustion";
- "Tool to calculate project emissions from electricity consumption";
- "Combined tool to identify the baseline scenario and demonstrate additionality";
- "Tool to determine project emissions from flaring gases containing methane";
- "Tool to determine the emission factor for an electricity system".

Selected approach from paragraph 48 of the CDM modalities and procedures

"Existing actual or historical emissions, as applicable"

Definitions

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

- **Coal Bed Methane (CBM).** Coal bed methane is the methane gas that resides inside underground coal seams, under pressure, and thus adsorbed to the coal.

- **Coal Bed Methane Production (CBM Production).** Coal bed methane production refers to the extraction of methane from underground coal seams, the subsequent treatment and injection of the gas into natural gas grids for utilization by end users. CBM extraction involves the removal of water or gas from the coal seam to decrease the hydrostatic pressure in order to cause methane to desorb from coal allowing for its removal. For the purposes of this methodology, the act of removing water from coal seams to produce methane constitutes a coal bed methane project.

- **"Up-dip".** The up-dip areas of the coal seam refer to the ground level elevations where coal outcroppings and methane gas seeps exist. Coalbed methane flows from down-dip to up-dip within the coal seam until it reaches the outcropping where it is released to the atmosphere as fugitive emissions.

- **"Down-dip".** The down-dip areas of the coal seam refer to the location where coalbed methane extraction typically takes place. Down-dip can be considered to be in the coal seam at 1000 to 4000 feet below the surface where high pressures readily allow for the removal of methane.

- **Produced water.** Water which is pumped and removed from a coal seam in order to liberate methane from the coal.

- **Coal bed methane seep**. Ground level fugitive methane emissions from coal seam outcroppings which originate from coal beds deep underground.

- **Gas interception system**. A system consisting of gas wells, vacuum compressors and gas transmission pipelines designed to intercept and recover gas in coal seams prior to its release at coal outcroppings.

- **Fugitive methane**. Methane which is emitted to the atmosphere from underground coal seams and results partly from down dip coal bed methane production operations.

Applicability conditions

This methodology applies to project activities that capture and destroy methane which would otherwise be released to the atmosphere from coalbed outcroppings. Projects using this methodology will be implemented on coal seams or where exposed coalbed outcroppings exist. The methodology does not apply to methane captured at CBM extraction operations, but may apply to mitigation projects located near existing CBM operations.

The methodology applies to project activities that involve the use of any of the following extraction techniques:

- The use of gas drainage wells and monitoring wells drilled near locations where methane gas seeps are present;

- The use of a gas membranes or surface cover to capture fugitive methane emissions at the ground level.

This methodology applies to methane capture, utilization and destruction project activities at or near known locations of methane gas seeps, where the baseline is the partial or total atmospheric release of the methane and the project activities include the following gas destruction scenarios:

- Captured methane is destroyed through flaring; and/or

- Captured methane is destroyed through utilization on-site to produce electricity, and/or thermal energy; and/or

- Captured methane is destroyed through utilization by end users following injection into natural gas distribution grids.

This methodology **does not apply** to the following project activities:

- Methane captured at active CBM extraction wells;

- Methane captured at active or abandoned coal mines;

- Injection of any fluid/gas “down-dip” of the location of methane interception in order to enhance methane capture;

- Removal of water from coal seams where gas interception systems are constructed in order to enhance gas recovery.

II. BASELINE METHODOLOGY PROCEDURE

Project boundary

For the purpose of determining **project activity emissions**, project participants shall include:

- CO2 emissions from the combustion of methane in a flare, engine, power plant, or heat generation plant;

- CO2 emissions from the combustion of non-methane hydrocarbons (NMHCs), if they represent more than 1% by volume of the extracted coal mine gas:

- CO2 emissions from on-site fuel consumption due to the project activity, including transport of the fuel

- Fugitive emissions from unburned methane and from gas treatment equipment

For the purpose of determining **baseline emissions**, project participants shall include the following emission sources:

- Fugitive CH4 emissions from coal bed methane seeps;

- CO2 emissinos from the destruction of methane in the baseline scenario;

- CO2 emissions from the production of heat and power (motive and electrical) that is replaced by the project activity.

The **spatial extent** of the project boundary encompasses:

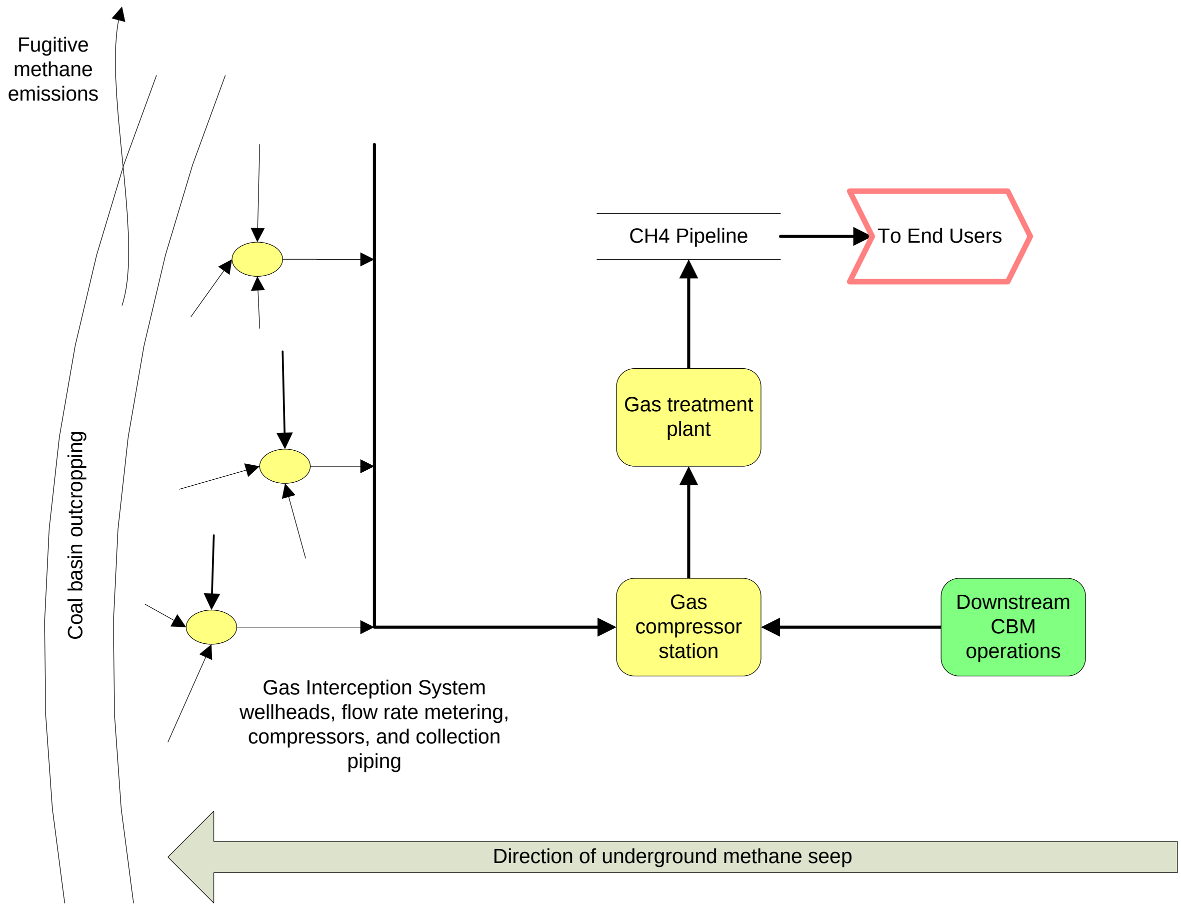
- All equipment installed and used as part of the project activity for the extraction, compression, storage, and treatment of methane at the project site, and transport to an off-site user, including transport through natural gas distribution grids. Project equipment may be common between methane emissions mitigation projects and co-located CBM operations such as gas compression and treatment systems and in which case fugitive emission should be allocated appropriately

- Flaring, flameless oxidation, captive power and/or heat generation facilities installed and used as part of the project activity.

- Power plants connected to the electricity grid, where the project activity exports power to the grid, as per the definition of the project electricity system and connected electricity system given in "Tool to calculate the emission factor for an electricity system."

- Combustion of methane by end users connected to natural gas grids into which gas has been injected.

Figure 1: Project schematic showing a gas interception system consisting of 7 wellheads connected to three compression and metering systems to deliver raw gas to a common pipeline booster compressor station and gas treatment plant shared by an existing CBM operation



The greenhouse gases included in or excluded from the project boundary are shown in Table 1.

Table 1: Emissions sources included in or excluded from the project boundary

Source		Gas	Included?	Justification / Explanation
Baseline	Emissions of methane from surface gas seeps at coal outcroppings	CO_2	No	Excluded for simplification. This is conservative.
		CH_4	Yes	This is the main source of emissions. The amount included in the baseline is the lesser of the pre-project monitored fugitive emission rate or the annually recovered volumes. This is not a total inventory of all methane seepage in the project's spatial boundary.
		N_2O	No	Excluded for simplification. This is conservative.
	Grid electricity generation (electricity provided to the grid)	CO_2	Yes	Only CO2 emissions associated to the same quantity of electricity than electricity generated as a result of the use of methane included as baseline emission will be counted; Use of combined margin method as described in "Tool to calculate the emission factor for an electricity system" should be made.
		CH_4	No	Excluded for simplification. This is conservative.
		N_2O	No	Excluded for simplification. This is conservative.
	Captive power and/or heat and injection into gas grids	CO_2	Yes	Only when the baseline scenario involves such usage.
		CH_4	No	Excluded for simplification. This is conservative.
		N_2O	No	Excluded for simplification. This is conservative.
Project	On-site fuel and electricity consumption due to the project activity required to transport, compress, clean and upgrade the gas	CO_2	Yes	Energy consumption from equipment required for compressing, cleaning, upgrading and transporting gas will be accounted for. Energy use allocations will be made in cases where production facilities are shared between multiple operations.
		CH_4	No	Excluded for simplification. This emission source is assumed to be very small.
		N_2O	No	Excluded for simplification. This emission source is assumed to be very small.
	Emissions from methane destruction	CO_2	Yes	From the combustion of methane in a flare, flameless oxidation, or heat/power generation.
	Emissions from NMHC destruction	CO_2	Yes	From the combustion of NMHC in a flare of flameless oxidizer or heat/power generation, if NMHC accounts for more than 1% by volume of extracted gas.
	Fugitive emissions of un-combusted methane	CH_4	Yes	Small amounts of methane will remain unburned in flares, flameless oxidizers or heat/power generation.

	Fugitive methane emissions from on-site gas processing equipment	CH4	Yes	If gas sales are metered upstream of a processing facility, then fugitive emissions are to be accounted for. If gas sales are metered downstream of a processing facility, then this source is not included.
	Fugitive methane emissions from gas supply pipeline	CH4	No	Excluded for simplification. This emission source is assumed to be very small.
	Accidental methane release	CH4	No	Excluded for simplification. This emission source is assumed to be very small.

Identification of the baseline scenario

Project participants should refer to the latest version of the “Combined tool to identify the baseline scenario and demonstrate additionality”.

Additionality

The additionality of the project activity shall be demonstrated and assessed using the latest version of the “Combined tool to identify the baseline scenario and demonstrate additionality”.

Baseline emissions

Baseline emissions included in this methodology are:

- CH_4 from free flowing gas seeps at locations where exposed coal outcroppings exist
- CO2 emissions from the generation of heat and / or power replaced by the project activity using recovered methane

Baseline emissions are calculated as follows:

$$\mathbf{BE_y = BE_{MD,y} + BE_{MR,y} + BE_{USE,y}} \quad \textbf{(1)}$$

Where:

BE_y = Baseline emissions in year *y* (t CO_2e/yr)

$BE_{MD,y}$ = Baseline emissions from destruction of methane in the baseline scenario in year *y* (t CO_2e/yr)

$BE_{MR,y}$ = Baseline emissions from release of methane into the atmosphere in year *y* that is avoided by the project activity (t CO_2e/yr)

$BE_{USE,y}$ = Baseline emissions from the production of power, heat or supply to the gas grid replaced by the project activity in year *y* (t CO2e/yr)

Methane destruction in the baseline

Depending on the project type, methane destruction may already be occurring in the baseline in flares, flameless oxidation units or for the production or heat and/or power.

$$\mathbf{BE_{MD} = (CEF_{CH4} + r \times CEF_{NMHC}) \times \sum_i CMB_i} \quad \textbf{(2)}$$

With:

$$r = PC_{NMHC}/PC_{CH4} \quad \textbf{(3)}$$

Where:

$BE_{MD,y}$ = Baseline emissions from destruction of methane in the baseline scenario in year *y* (t CO_2e/yr)

CEF_{CH4} = Carbon emission factor for combusted methane (2.75 t CO_2/ t CH_4)

CEF_{NMHC} = Carbon emission factor for combusted non-methane hydrocarbons. This parameter should be obtained through periodical analysis of captured methane (t CO_2/ t NMHC)

CMB_i = Captured methane that is destroyed by use *i* in the baseline (t CH_4)

r = Relative proportion of NMHC compared to methane

PC_{CH4} = Concentration (in mass) of methane in extracted gas (%), measured on wet basis

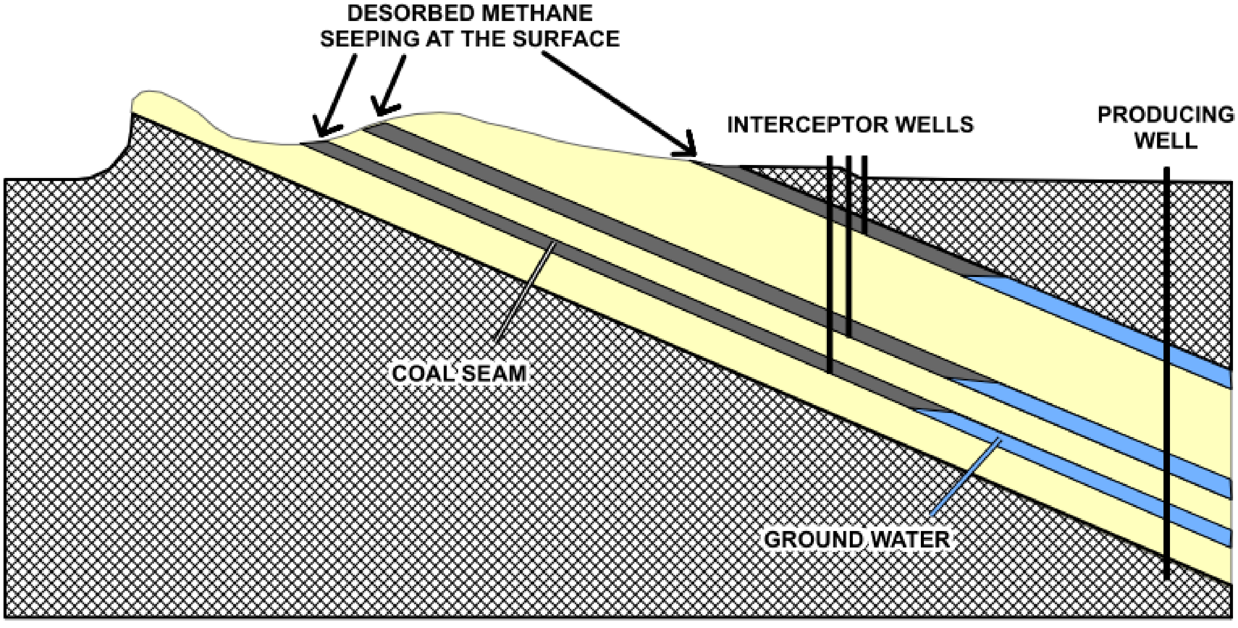
PC_{NMHC} = NMHC concentration (in mass) in extracted gas (%) measured on wet basis

Methane released into the atmosphere

Actual baseline emissions estimates would need to be made by measuring ground level methane flux and integrating this over areas of know CBM gas seeps which are influenced by the project. For a number of reasons, this technique is not accurate or practical enough for GHG emission reduction projects. An alternative approach is to drill wells into the coal seam at prescribed locations where up-dip migrating methane flow rates can be monitored. This technique will not allow for an accurate measurement of the total methane flow rate from the outcropping, however, it is an approach that will allow for a consistent measurement through time.

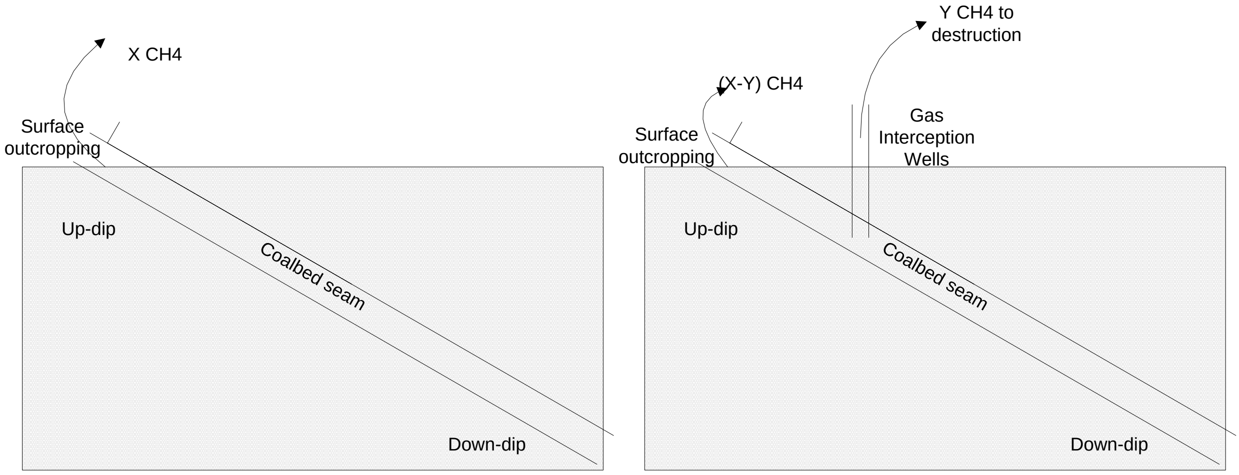
It is this approach that is utilized by the CMB gas interception project. Using the gas interception wells, methane is captured before it reaches the ground level of the coal seam and a flow rate measurement can be made in the absence of vacuum pressure. As the gas interception system will not capture all methane that seeps from the coal outcroppings, this procedure will not produce the baseline emission rate for the entire affected area, but rather for a fraction of this area which the emission reduction project is capable of influencing. For this reason, the project boundary does not include fugitive emissions of methane that remain un-captured by the gas interception system. Baseline emissions of methane are therefore considered to be the methane freely flowing to the interceptor wells and metered at the wellheads prior to project start, in the absence of vacuum pressure.

Figure 2: Cross section showing how gas interception system wells are placed between CBM operations and the coal outcroppings where fugitive emissions occur in order to capture methane before it reaches the surface. Fugitive methane emitted at the surface can originate both from within the seam above the ground water level as well as from the main part of the CBM field below the ground water level



The interceptor wells will only capture a portion of the fugitive methane emitted at the outcroppings (X CH4), as illustrated by Figure 3. The volume of gas captured by the system will be considered the baseline emissions (Y CH4) and fugitive methane eluding capture (X-Y CH4) is excluded from the project boundary, since this would be emitted in both the baseline and project cases. The figure also shows how methane flows from down-dip to up-dip before being emitted at the outcroppings.

Figure 3: Schematic illustrating the change in fugitive emissions at the coal seam outcropping resulting from methane capture by the gas interception systems.



Ex ante projections of the baseline rate of methane release to the atmosphere are developed using metered flow rates from the gas interception wells prior to applying vacuum pressure, i.e. before project implementation. A minimum of 1 month of continuously metered flow rate corrected for temperature and pressure data shall be compiled to determine the baseline emission release rate. This annually-averaged methane release rate will serve as the maximum baseline emission rate.

The fugitive methane emissions originate from large gas reserves down –dip and, in general, their release rate is fairly constant over time. However, to correct for uncertainties and possible slowing of methane release rates in the baseline case over the project time period, a conservative approach is adopted for determining the baseline methane emission rate. The average maximum baseline emission rate is compared with annual total gas production and the lesser value is used in annual baseline emission calculations. This approach is conservative in that it will not reward projects which produce methane if gas production declines significantly over time.

$$BE_{MR} = \min\left(FM_{IS}, \sum_{i} CM_{i}\right) \quad \textbf{(4)}$$

Where:

BE_{MR} = Baseline emissions from release of methane into the atmosphere that is avoided by the project activity (t CO_2e)

FM_{IS} = Fugitive methane redirected by the methane interception system measured *ex ante* and expressed as (t CH_4)

CM_i = Captured methane that is destroyed by use *i* of the project activity (t CH_4)

Emissions from power/heat generation replaced by project

$$BE_{USE} = GEN \times EF_{ELEC} + HEAT \times EF_{HEAT} + GAS \times EF_{GAS} \quad \textbf{(5)}$$

Where:

BE_{USE}	=	Baseline emissions from the production of power and / or heat or from destruction following injection into gas grids replaced by the project activity (t CO_2e/yr)
GEN	=	Electricity generated by project activity (MWh)
EF_{ELEC}	=	Emission factor of electricity (grid, captive or a combination) replaced by project (t CO_2/MWh)
HEAT	=	Heat generated by project activity (GJ)
EF_{HEAT}	=	Emission factor of heat production replaced by project activity (t CO_2/GJ)
GAS	=	Gas delivered to the gas grid (GJ)
EF_{GAS}	=	Emission factor for gas grid fuel replaced by the project activity (t CO_2/GJ)

Grid power emission factor

If the baseline scenario includes grid power supply that would be replaced by the project activity, the Emission Factor for replaced electricity is calculated as per “Tool to calculate the emission factor for an electricity system”.

Captive power emissions factor

If the baseline scenario includes captive power generation (either existing or new) that would be replaced by the project activity, the Emissions Factor for replaced electricity is calculated as follows:

$$EF_{captive} = \frac{EF_{CO2,i}}{Eff_{captive}} \times \frac{44}{12} \times \frac{3.6TJ}{1000MWh} \qquad \textbf{(6)}$$

Where:

$EF_{captive}$	=	Emission factor for captive power generation (t CO_2e/MWh)
$EF_{CO2,i}$	=	CO2 emission factor of fuel used in captive power generation (tC/TJ)
$Eff_{captive}$	=	Efficiency of the captive power generation (%)
44/12	=	Carbon to Carbon Dioxide conversion factor
3.6/1000	=	TJ to MWh conversion factor

Combination of grid power and captive power emissions factor

If the baseline scenario selection determines that both captive and grid power would be used, then the emission factor for the baseline is the weighted average of the emissions factor for grid power and captive power.

$$EF_{ELEC} = s_{grid} \times EF_{grid} + s_{captive} \times EF_{captive} \qquad \textbf{(7)}$$

Where:

EF_{ELEC} = CO_2 baseline emission factor for the electricity replaced due to the project activity (t CO_2/MWh)

EF_{grid} = CO_2 baseline emission factor for the grid electricity replaced due to the project activity (t CO_2/MWh)

$EF_{captive}$ = CO_2 baseline emission factor for the captive electricity replaced due to the project activity (t CO_2/MWh)

s_{grid} = Share of facility electricity demand supplied by grid imports over the last 3 years (%)[1]

$s_{captive}$ = Share of facility electricity demand supplied by captive power over the last 3 years (%)[1]

Heat generation emissions factor

If the baseline scenario includes heat generation (either existing or new) that is replaced by the project activity, the Emissions Factor for replaced heat generation is calculated as follows:

$$EF_{HEAT} = \frac{EF_{CO2,i}}{Eff_{heat}} \times \frac{44}{12} \times \frac{1TJ}{1000GJ} \quad \textbf{(8)}$$

Where:

EF_{HEAT} = Emission factor for heat generation (t CO_2/GJ)

$EF_{CO2,i}$ = CO_2 emission factor of fuel used in heat generation (t C/TJ)

Eff_{heat} = Boiler efficiency of the heat generation (%)

44/12 = Carbon to Carbon Dioxide conversion factor

1/1000 = TJ to GJ conversion factor

To estimate the boiler efficiency, project propoents may choose between the following two options:

Option A:

Use the highest value among the following three values as a conservative approach:

(a) Measured efficiency prior to project implementation

(b) Measured efficiency during monitoring

(c) Manufacturer nameplate data for efficiency of the existing boilers

Option B:

Assume a boiler efficiency of 100% based on the net calorific values as a conservative approach.

Gas grid emission factor

The emission factor occuring in the baseline from the use of gas grid fuel replaced by the project activity is calculated as follows:

[1] If the facility is a new facility, then the share of grid versus import power determined to be the most likely baseline scenario should be used.

$$\mathbf{EF_{GAS} = EF_{CO2,i} \times Eff_{processing} \times \frac{44}{12} \times \frac{1TJ}{1000GJ}} \quad \textbf{(9)}$$

Where:

EF_{GAS}	=	Emission factor for gas grid fuel replaced by the project activity (t CO_2/GJ)
$EF_{CO2,i}$	=	CO_2 emission factor for displaced gas grid fuel (t C/TJ)
$Eff_{processing}$	=	The efficiency of gas processing facilities used to treat captured methane onsite prior to injection into gas grids (%)[2]
44/12	=	Carbon to Carbon Dioxide conversion factor
1/1000	=	TJ to GJ conversion factor

[2] This efficiency refers to the combined efficiency of upgrading and injection into gas grids where resulting losses are fugitive emissions, gas flared and / or used for heat and power onsite. If gas delivered to gas grids is metered after the processing facility, then $Eff_{processing}$ is equal to 1. When gas sales to grid are metered before processing, $Eff_{processing}$ should reflect the fugitive emissions by the processing facility used.

Project emissions

Project emissions included in this methodology are:

- CO_2 emissions due to consumption of fossil fuels and electricity for the recovery, compression, and transportation of the raw gas stream;
- CO_2 emissions from the destruction of methane and non-methane hydrocarbons by flares, by heat and / or power generation equipment ;
- CH_4 emissions from incomplete combustion of cleaned and / or raw gas by flares and heat and / or power generation equipment;
- CH_4 emissions from leaks in the natural gas grid to which cleaned gas is supplied

Project emissions are calculated as follows:

$$PE_y = PE_{ME,y} + PE_{MD,y} + PE_{UM,y} \quad \textbf{(10)}$$

Where:

PE_y = Project emissions in year *y* (t CO_2e/yr)

$PE_{ME,y}$ = Project emissions from energy use to capture and use methane in year *y* (t CO_2e/yr)

$PE_{MD,y}$ = Project emissions from methane destroyed in year *y* (t CO_2e/yr)

$PE_{UM,y}$ = Project emissions from un-combusted methane in year *y* (t CO_2e/yr)

Combustion emissions from additional energy required for methane capture and use

Additional energy may be used for the capture, transport, compression, clean-up, and use or destruction of methane. Emissions from this energy use should be included as project emissions.

$$PE_{ME} = CONS_{ELEC,PJ} \times CEF_{ELEC} + CONS_{HEAT\,PJ} \times CEF_{HEAT} + CONS_{FossFuel,PJ} \times CEF_{FossFuel} \quad \textbf{(11)}$$

Where:

PE_{ME} = Project emissions from energy use to capture and use or destroy methane (t CO_2/yr)

$CONS_{ELEC,PJ}$ = Additional electricity consumption for capture and use or destruction of methane, if any (MWh)[3]

CEF_{ELEC} = Carbon emissions factor of electricity used by the process equipment (t CO_2/MWh)

$CONS_{HEAT,PJ}$ = Additional heat consumption for capture and use or destruction of methane, if any (GJ)

CEF_{HEAT} = Carbon emissions factor of heat used by the process equipment (t CO_2/GJ)

$CONS_{FossFuel,PJ}$ = Additional fossil fuel consumption for capture and use or destruction of methane, if any (GJ)

$CEF_{FossFuel}$ = Carbon emissions factor of fossil fuel used by the process equipment (t CO_2/GJ)

For electricity emissions factor, the same formulae are used as in the calculations of baseline emissions. In other words, if the source of power for the process equipment is the grid, then the formulae from “Tool

[3] For example, electricity may be required to run pumps, motors, compressors, and gas clean-up equipment

to calculate the emission factor for an electricity system" for calculating the combined margin emissions factor are used. If the source of power for the process equipment is captive power generation, then the emissions factor is calculated based on the emission factor for the fuel used and efficiency of the captive power plant.

For the heat generation emission factor, the same formulae are used as in the calculations of baseline emissions. In other words, the boiler efficiency and the emission factor for the fuel used are the basis of the emissions factor.

Combustion emissions from use of captured methane

When the captured methane is burned in a flare, heat or power plant, or oxidized in a flameless oxidation unit, combustion emissions are released. In addition, if NMHC account for more than 1% by volume of the extracted raw gas, combustion emissions from these gases should also be included. Captured methane delivered to heat and / or power generation is equal to the methane destroyed by these end uses since IPCC 2006 assumes complete combustion in these end uses.

$$\mathbf{PE_{MD} = (MD_{FL} + CM_{ELEC} + CM_{HEAT} + MD_{GAS}) \times (CEF_{CH4} + r \times CEF_{NMHC})} \quad \mathbf{(12)}$$

With:

$$r = PC_{NMHC}/PC_{CH4} \quad \mathbf{(13)}$$

Where:[4]

PE_{MD}	=	Project emissions from destruction of captured methane (t CO_2/yr)
MD_{FL}	=	Methane destroyed through flaring (t CH_4)
CM_{ELEC}	=	Captured methane delivered to power plant (t CH_4)
CM_{HEAT}	=	Captured methane delivered to heat plant(t CH_4)
MD_{GAS}	=	Methane destroyed after being supplied to natural gas grid (t CH_4), this is equal to methane supplied to natural gas grids
CEF_{CH4}	=	Carbon emissions factor for combusted methane (2.75 t CO_2/ t CH_4)
CEF_{NMHC}	=	Carbon emissions factor for combusted non methane hydrocarbons (the concentration varies and, therefore, to be obtained through periodical analysis of captured methane) (t CO_2/ t NMHC)
r	=	Relative proportion of NMHC compared to methane
PC_{CH4}	=	Concentration (in mass) of methane in extracted gas (%), measured on wet basis
PC_{NMHC}	=	NMHC concentration (in mass) in extracted gas (%) measured on wet basis

In each end-use, the amount of gas destroyed depends on the efficiency of combustion of each end use.

$$MD_{FL} = CM_{FL} - \left(PE_{flare}/GWP_{CH4}\right) \quad \mathbf{(14)}$$

Where:

MD_{FL}	=	Methane destroyed through flaring (t CH_4)
CM_{FL}	=	Captured methane delivered to flare (t CH_4)
PE_{FL}	=	Project emissions of non-combusted CH_4, expressed in terms of CO_2e, from flaring of the raw gas stream (t CO_2e)
GWP_{CH4}	=	Global warming potential of methane (21 t CO_2e/tCH_4)

[4] Note that throughout this baseline methodology, it is assumed that measured quantities of raw gas are converted to tones of methane using the measured concentration of the extracted raw gas and the density of methane.

The project emissions of non-combusted CH_4 expressed in terms of CO_2e from flaring of the raw gas stream (PE_{flare}) shall be calculated following the procedures described in the "Tool to determine project emissions from flaring gases containing methane". PE_{flare} can be calculated on an annual basis or for the required period of time using this tool.

Un-combusted methane from project activity

Not all of the methane sent to the flare, or used to generate power and heat will be combusted, so a small amount will escape to the atmosphere. These emissions are calculated using the following:

$$PE_{UM} = \left[GWP_{CH4} \times \sum_{i} CM_{i} \times \left(1 - Eff_{i}\right) \right] + PE_{flare} \quad \textbf{(15)}$$

Where:

PE_{UM}	=	Project emissions from un-combusted methane (t CO_2e)
GWP_{CH4}	=	Global warming potential of methane (21 t CO_2e/tCH_4)
i	=	Use of methane (power generation, heat generation, supply to gas grid to various combustion end uses)
CM_i	=	Captured methane delivered to use *i* (t CH_4)
Eff_i	=	Efficiency of methane destruction in use *i* (%)
PE_{flare}	=	Project emissions of non-combusted CH4 expressed in terms of CO2e from flaring of the raw gas stream (t CO_2e)

The project emissions from flaring of the raw gas stream (PE_{flare}) shall be calculated following the procedures described in the "Tool to determine project emissions from flaring gases containing methane". PE_{flare} can be calculated on an annual basis or for the required period of time using this tool.

Leakage

There are no known sources of emissions leakage caused by the project type.

Emission Reductions

Emission reductions are calculated as follows:

$$ER_y = BE_y - PE_y - LE_y \quad \textbf{(16)}$$

Where:

ER_y	=	Emission reductions in year *y* (t CO_2e/yr)
BE_y	=	Baseline emissions in year *y* (t CO_2e/yr)
PE_y	=	Project emissions in year *y* (t CO_2/yr)
LE_y	=	Leakage emissions in year *y* (t CO_2/yr)

Data and parameters not monitored

In addition to the parameters listed in the tables below, the provisions on data and parameters not monitored in the tools referred to in this methodology apply.

Data / parameter:	CMBi
Data unit:	tCH4
Description:	Captured methane destroyed by use i in the baseline, pre-project monitoring data are used for future crediting periods
Source of data:	
Measurement procedures (if any):	
Any comment:	

III. MONITORING METHODOLOGY

All data collected as part of monitoring should be archived electronically and be kept at least for 2 years after the end of the last crediting period. 100% of the data should be monitored if not indicated otherwise in the tables below. All measurements should be conducted with calibrated measurement equipment according to relevant industry standards.

In addition, the monitoring provisions in the tools referred to in this methodology apply.

Data and parameters monitored

Data / parameter:	FM_{IS}
Data unit:	tCH_4
Description:	Measurement of fugitive methane which is collected by the gas interception system prior to project implementation.
Source of data:	Project site
Measurement procedures (if any):	This is determined by measuring free flowing methane at the gas interception system wellheads prior to project implementation and prior to use of vacuum pumps to extract and compress methane. Continuously metered methane flow rates for a period of no less 1 month and adjusted for temperature and pressure should be used to determine an annual average methane emission rate.
Monitoring frequency:	*Ex ante*
QA/QC procedures:	
Any comment:	Metered gas volumes are converted to mass using a density of 0.67 kg/Nm^3

Data / parameter:	GEN
Data unit:	MWh
Description:	Electricity generated by the project activity
Source of data:	Project site
Measurement procedures (if any):	
Monitoring frequency:	Continuous
QA/QC procedures:	
Any comment:	

Data / parameter:	HEAT
Data unit:	GJ
Description:	Heat generated by the project activity
Source of data:	Project site
Measurement procedures (if any):	
Monitoring frequency:	Continuous
QA/QC procedures:	
Any comment:	

Data / parameter:	GAS
Data unit:	GJ
Description:	Gas delivered to natural gas distribution grids and supplied to end users by the project activity.
Source of data:	Project site
Measurement procedures (if any):	
Monitoring frequency:	Continuous
QA/QC procedures:	
Any comment:	Gas flow meters will measure methane injected into pipelines. The energy content of methane is determined by converting this volumetric measurement to energy. Utility sales invoices should be used where available.

Data / parameter:	EF_{ELEC}
Data unit:	t CO_2/MWh
Description:	The emission factor of electricity replaced by the project
Source of data:	Project site
Measurement procedures (if any):	
Monitoring frequency:	Annually or *Ex ante*
QA/QC procedures:	
Any comment:	If grid electricity is replaced by the project, the emission factor should be calculated annually using “Tool to calculate the emission factor for an electricity system”

Data / parameter:	EF_{HEAT}
Data unit:	t CO_2/GJ
Description:	The emission factor of heat replaced by the project
Source of data:	Project site
Measurement procedures (if any):	
Monitoring frequency:	*Ex ante*
QA/QC procedures:	
Any comment:	

Data / parameter:	EF_{GAS}
Data unit:	t CO_2/GJ
Description:	The emission factor of gas grid fuel replaced by the project
Source of data:	Project site
Measurement procedures (if any):	
Monitoring frequency:	*Ex ante*
QA/QC procedures:	
Any comment:	

Data / parameter:	$EF_{CO2,i}$
Data unit:	t C/TJ
Description:	The emission factor of fuel used in captive power generation
Source of data:	Project site
Measurement procedures (if any):	
Monitoring frequency:	*Ex ante*
QA/QC procedures:	
Any comment:	

Data / parameter:	$Eff_{captive}$
Data unit:	%
Description:	The efficiency of captive power generation
Source of data:	Project site
Measurement procedures (if any):	
Monitoring frequency:	Annually
QA/QC procedures:	
Any comment:	Annual average electrical efficiency based on the lower heating value of the fuel

Data / parameter:	Eff_{heat}
Data unit:	%
Description:	Boiler efficiency of the heat generation
Source of data:	Project site
Measurement procedures (if any):	
Monitoring frequency:	Annually
QA/QC procedures:	
Any comment:	Annual average thermal efficiency based on the lower heating value of the fuel

Data / parameter:	$Eff_{processing}$
Data unit:	%
Description:	The efficiency of gas processing including cleanup, compression, and upgrading prior to injection into gas grids. Combined efficiency including losses for use as fuel, flaring, venting and fugitive emissions. Only to be used if gas sales metered before processing facility.
Source of data:	Project site
Measurement procedures (if any):	
Monitoring frequency:	Continuously or Annually
QA/QC procedures:	
Any comment:	

Data / parameter:	$CONS_{ELEC,PJ}$
Data unit:	MWh
Description:	Additional electricity consumption for capture and use or destruction of methane
Source of data:	Project site
Measurement procedures (if any):	Taken from machinery data acquisition systems or utility bills
Monitoring frequency:	Continuously
QA/QC procedures:	
Any comment:	

Data / parameter:	CEF_{ELEC}
Data unit:	t CO_2/MWh
Description:	Carbon emission factor for electricity used by the project activity
Source of data:	Project site
Measurement procedures (if any):	
Monitoring frequency:	*Ex ante*
QA/QC procedures:	
Any comment:	

Data / parameter:	$CONS_{HEAT,PJ}$
Data unit:	GJ
Description:	Additional heat consumption for capture and use or destruction of methane
Source of data:	Project site
Measurement procedures (if any):	Taken from machinery data acquisition systems or utility bills
Monitoring frequency:	Continuously
QA/QC procedures:	
Any comment:	

Data / parameter:	CEF_{HEAT}
Data unit:	t CO_2/GJ
Description:	Carbon emission factor of heat used by the project activity
Source of data:	Project site
Measurement procedures (if any):	
Monitoring frequency:	*Ex ante*
QA/QC procedures:	
Any comment:	

Data / parameter:	$CONS_{FossFuel,PJ}$
Data unit:	GJ
Description:	Additional fossil fuel consumption for capture and use or destruction of methane
Source of data:	Project site
Measurement procedures (if any):	
Monitoring frequency:	Continuously
QA/QC procedures:	
Any comment:	

Data / parameter:	$CEF_{FossFuel}$
Data unit:	t CO_2/GJ
Description:	Carbon emission factor for fossil fuel used by the project activity to capture and use or destroy methane
Source of data:	Project site
Measurement procedures (if any):	
Monitoring frequency:	*Ex ante*
QA/QC procedures:	
Any comment:	

Data / parameter:	CEF_{CH4}
Data unit:	t CO_2/ t CH_4
Description:	Carbon emission factor for combusted methane captured by the project activity
Source of data:	Project site
Measurement procedures (if any):	
Monitoring frequency:	*Ex ante*
QA/QC procedures:	
Any comment:	Set at 2.75 t CO_2/ t CH_4

Data / parameter:	CEF_{NMHC}
Data unit:	t CO_2/ t NMHC
Description:	Carbon emission factor for combusted non methane hydrocarbons captured by the project activity
Source of data:	Project site
Measurement procedures (if any):	
Monitoring frequency:	Continuously
QA/QC procedures:	
Any comment:	To be obtained through annual analysis of the fractional composition of captured gas delivered to end users

Data / parameter:	CM_{FL}
Data unit:	t CH_4
Description:	Captured methane delivered to a flare and combusted
Source of data:	Project site
Measurement procedures (if any):	
Monitoring frequency:	Continuously
QA/QC procedures:	
Any comment:	Metered gas volumes are converted to mass using a density of 0.67 kg/Nm^3

Data / parameter:	CM_{ELEC}
Data unit:	t CH_4
Description:	Captured methane delivered to a power plant
Source of data:	Project site
Measurement procedures (if any):	
Monitoring frequency:	Continuously
QA/QC procedures:	
Any comment:	Metered gas volumes are converted to mass using a density of 0.67 kg/Nm^3

Data / parameter:	CM_{HEAT}
Data unit:	t CH_4
Description:	Captured methane delivered to a heat plant
Source of data:	Project site
Measurement procedures (if any):	
Monitoring frequency:	Continuously
QA/QC procedures:	
Any comment:	Metered gas volumes are converted to mass using a density of 0.67 kg/Nm^3

Data / parameter:	CM_{GAS}
Data unit:	t CH_4
Description:	Captured methane delivered to a natural gas grid
Source of data:	Project site
Measurement procedures (if any):	
Monitoring frequency:	Continuously
QA/QC procedures:	
Any comment:	Metered gas volumes are converted to mass using a density of 0.67 kg/Nm^3

Data / parameter:	Eff_{GAS}
Data unit:	%
Description:	Overall efficiency of methane destruction through gas grid to various combustion end uses, combining fugitive emissions from the gas grid and combustion efficiency at end user
Source of data:	Project site
Measurement procedures (if any):	
Monitoring frequency:	*Ex ante*
QA/QC procedures:	
Any comment:	Set at 99.7% (from IPCC)

Data / parameter:	
Data unit:	
Description:	
Source of data:	
Measurement procedures (if any):	
Monitoring frequency:	
QA/QC procedures:	
Any comment:	

IV. REFERENCES AND ANY OTHER INFORMATION

Section D. Explanations / justifications to the proposed new baseline and monitoring methodology

Baseline emissions

Fugitive emission from gas transmission and distribution calculation based off of Table 4.2.4 in IPCC 2006 and using a density of methane of 0.67 kg/Nm^3. These losses are considered small enough to neglect for both the project and baseline scenarios.

Table 2: Calculation of gas grid efficiency

	Methane Emissions (Gg per 10^6 m3 of marketable gas)			Methane Emissions (Gg per 10^6 m3 of utility sales)	CH4 (% of gas Marketable)	CH4 (% of gas delivered)	Eff
Category	Low	Reported	High	Reported			
Gas transmission, fugitives	6.60E-05		4.80E-04		0.072%		99.928%
Gas transmission, venting	4.40E-05		3.20E-04		0.048%		99.952%
Gas Storage		2.50E-05			0.004%		99.996%
Gas Distribution				1.10E-03	0.164%	0.164%	99.836%
Combined efficiency of transmission & distribution to end users					**99.7%**		

Baseline emissions of methane released into the atmosphere can be determined by measuring methane flux from the soil and rock where gas seeps are present and where gas seeps will be affected by the project activity. Methane flux from the ground can be estimated using a slide hammer or flux meter method. Methane flux rate data determined using these methods is integrated over the area of influence to determine a volumetric flow rate of methane from the seep area. The accuracy of the flux rate estimation is limited by several variables involved in these methods, including, but not limited to, the assumed radius of influence of the measurement point and the ability of the sample locations to accurately represent the heterogeneous nature of the geologic formation. Additionally, these techniques may be very expensive and time consuming depending on the size of emission reduction projects.

A technique called Airborne Differential Absorption Lidar (DIAL) can be used to aerially indentify areas where high methane gas concentrations exist (methane gas seeps). DIAL has been used extensively to detect leaks in natural gas pipelines and is now being applied to locate gas seeps from underground coal beds.[5] While this technique is useful for identifying areas where measurements should be taken, the data developed by DIAL is not sufficient to reconstruct fugitive methane emission rates.

Project emissions

In the section “Combustion emissions from use of captured methane”, the methane carbon oxidation factors used in ACM0008 of 99.5% for heat and power production from IPCC 1996 have been removed since IPCC 2006 assumes 100% carbon oxidation efficiencies for all fuels and uses in stationary combustion. This simplifies the calculation of project emissions.

[5] Refer to “Airborne differential absorption LIDAR application to coalbed methane seep detection for exploration and environmental monitoring”, 2009 by Simmons, R.E., Brake, D., and Flint, B.