Approved baseline and monitoring methodology AM0064

"Methodology for mine methane capture and utilisation or destruction in underground, hard rock, precious and base metal mines"

I. SOURCE, DEFINITIONS AND APPLICABILITY

Sources

This baseline and monitoring methodology is based on the proposed new methodology NM0236 "Beatrix Underground Methane Capture Project" prepared by Promethium Carbon (Pty) Ltd., South Africa.

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;
- Tool for the demonstration and assessment of additionality;
- Combined tool to identify the baseline scenario and demonstrate additionality;
- Tool to determine project emissions from flaring gases containing methane;
- Tool to calculate the emission factor for an electricity system.

For more information regarding the proposed new methodology and the tools as well as their consideration by the Executive Board please refer to http://cdm.unfccc.int/goto/MPappmeth.

Selected approach from paragraph 48 of the CDM modalities and procedures

"Emissions from a technology that represents an economically attractive course of action, taking into account barriers to investment"

Definitions

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

Mine methane (MM). The term used under this methodology to refer to a gas of geological or biological origin, which contains methane and other components such as hydrocarbons. Mine methane may be transported along geological fault zones and may accumulate in porous rock formations. Mine methane is released when a reservoir or a fault zone carrying the gas is breached due to mining activities. Mine methane is not necessarily associated with the mineral being mined.

Ventilation air methane. (VAM). Methane mixed with the ventilation air in the mine that is circulated in sufficient quantity to dilute the methane to low concentrations for safety reasons.

Operating mine. A mine with ongoing mining activities or a mine temporarily put under care and maintenance with a view to resuming mining activities in the future[1].

Applicability

This methodology applies to project activities that involve capture, utilisation or destruction of methane from any operating mine, excluding mines where coal is extracted.

Mine methane can be captured from the following[2]:

- Underground boreholes in the mine, where mine methane can be captured from:
  - Development ends including shafts, access drives, ore passes or other developments;
  - Existing infrastructure such as shafts, access drives, raises and winzes;
  - Working areas including working stopes and worked out stopes; or
  - Any other area opened up for the development of the mine or the extraction of ore;
- Surface wells drilled into sealed off areas where the mine methane is accumulated;
- Gas drainage galleries or other infrastructure using mine methane capture techniques, including capture of gas from sealed areas;
- Ventilation air.

The mine methane can be removed from the mine, in which the project activity is implemented, in two ways:

1. By sealing off an area into which the methane is released and pipe it from that area, and/or
2. By piping the methane from underground boreholes.

For the purposes of this methodology, drainage to surface boreholes is only allowed in the following cases:

- Where a hole is drilled from the surface to an underground mining area where mine methane is allowed to accumulate. For safety reasons, such an area will be isolated (sealed off) from the rest of the workings by walls. Methane will be drained into these areas with the purpose of taking it to the surface via the borehole.
- Where a hole is drilled from the surface to an underground mining area and a pipe into which mine methane has been collected is connected to the opening of the borehole where it intersects the mining area. In this case the borehole is used to convey mine methane to surface rather than to install a pipe column in the shaft.

The methodology is applicable under the following conditions:

- The captured mine methane is utilised to produce electricity, motive power and/or thermal energy[3] and/or destroyed through flaring[4];

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[1] See Annex for more details on an operating mine.
[2] See Annex for internationally accepted mining terminology.
[3] In this case emission reductions may or may not be claimed for displacing or avoiding energy from other sources.

- Prior to the start of the project activity all mine methane was released into the atmosphere or partially used for heat generation[5];
- The methodology applies to both new and existing mining activities;
- Project participants must be able to supply the necessary data for ex-ante projections of methane demand in the case where part of mine methane was used for the heat generation prior to the start of the project activity.

The methodology does not apply to project activities that:

- Operate in coalmines;
- Operate in open cast mines;
- Capture methane from abandoned or decommissioned mines;
- Capture/use methane from surface boreholes that do not intersect mining areas/developments underground;
- Use CO_2 or any other fluid/gas to enhance methane drainage.

In addition, the applicability conditions included in the tools referred to above apply.
Finally, this methodology is only applicable to project activities where the identified baseline scenario is a partial or total atmospheric release of mine methane. In case of a partial atmospheric release, some mine methane is flared and/or used for the heat generation only.

II. BASELINE METHODOLOGY PROCEDURE

Identification of the baseline scenario

Project participants shall apply the latest approved version of the *"Combined tool to identify the baseline scenario and demonstrate additionality".*

Possible baseline alternatives may include, but are not limited to, the following:

- Total atmospheric release of mine methane;
- Partial atmospheric realise of mine methane when part of methane is utilised for heat generation and/or flared;
- Partial atmospheric realise of mine methane when part of methane is utilised for the electricity generation or other useful purpose;
- Utilisation of the captured mine methane as feedstock;
- Flaring of the total amount of the captured mine methane;
- Implementation of the project activity (i.e. capture, utilisation and/or destruction of mine methane) without being registered as a CDM project activity.

[4] The remaining share of the methane, to be diluted for safety reason, may still be vented.
[5] Project activities were electricity was generated using part of mine methane prior to the start of the project activity are not eligible to use this methodology as it does not include a procedure to estimate a demand for electricity produced from mine methane in the baseline scenario.

The baseline scenario alternatives shall be technically feasible and comply with safety regulations. The methodology is only applicable if the identified baseline scenario is a total or partial atmospheric release of mine methane. In case of a partial atmospheric release, some mine methane is flared and/or used for the heat generation only.

Additionality

Project participants shall apply the latest approved version of the *"Combined tool to identify the baseline scenario and demonstrate additionality"*.

Project boundary

The spatial extent of the project boundary comprises of:

- All equipment installed and used as part of the project activity for the extraction, compression, and storage of mine methane at the project site, and its transportation to off-site users;
- Flaring, captive power and heat generation facilities installed and used as part of the project activity;
- Power plants connected to the electricity grid, where the project activity exports or imports power from the grid, as per the definition of an electricity system in the latest approved version of the *"Tool to calculate the emission factor for an electricity system"*.

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	Venting of mine methane	CO_2	No	Excluded.
		CH_4	Yes	Main emission source. However, certain sources of mine methane may not be included, as noted in the applicability conditions.
		N_2O	No	Excluded.
	Emissions from use or destruction of methane in the baseline	CO_2	Yes	Emissions from any flaring or use for heat generation in the baseline scenario.
		CH_4	No	Excluded for simplification. This is conservative.
		N_2O	No	Excluded for simplification. This is conservative.
	Emissions from electricity generation in the grid	CO_2	Yes	Included if the project activity involves power generation
		CH_4	No	Excluded for simplification. This is conservative.
		N_2O	No	Excluded for simplification. This is conservative.
	Emissions from captive power and/or heat generation, and vehicle fuel use	CO_2	Yes	Included if the project activity involves power/heat generation or use of mine methane as vehicle fuel
		CH_4	No	Excluded for simplification. This is conservative.
		N_2O	No	Excluded for simplification. This is conservative.

Project activity	On-site fuel consumption due to the project activity, including transport of the gas	CO_2	Yes	Fuel consumption by all equipment used by the project activity should be accounted for.
		CH_4	No	Excluded for simplification. This emission source is assumed to be negligible.
		N_2O	No	Excluded for simplification. This emission source is assumed to be negligible.
	Emissions from methane combustion	CO_2	Yes	Emissions from the combustion of methane in a flare or heat/power generation.
		CH_4	No	Excluded for simplification.
		N_2O	No	Excluded for simplification.
	Emissions from NMHC destruction	CO_2	Yes	Emissions from the combustion of NMHC in a flare, or heat/power generation, if NMHC accounts for more than 1% by volume of extracted mine methane.
		CH_4	No	Excluded for simplification.
		N_2O	No	Excluded for simplification.
	Fugitive emissions of unburned methane	CO_2	No	Excluded.
		CH_4	Yes	Small amounts of methane will remain unburned in flares or heat/power generation.
		N_2O	No	Excluded.
	Fugitive methane emissions from on-site equipment	CO_2	No	Excluded for simplification. This emission source is assumed to be very small.
		CH_4	No	
		N_2O	No	
	Fugitive methane emissions from gas supply pipeline or in relation to use in vehicles	CO_2	No	Excluded for simplification. However taken into account among other potential leakage effects (see leakage section).
		CH_4	No	
		N_2O	No	
	Accidental methane release	CO_2	No	Excluded for simplification. This emission source is assumed to be very small.
		CH_4	No	
		N_2O	No	

Baseline emissions

Project emissions are calculated as follows:

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

Where:

BE_y = Baseline emissions in year y (tCO_2e/yr)

$BE_{MD,y}$ = Baseline emissions from destruction of methane in the baseline scenario in year y (tCO_2e/yr)

$BE_{MR,y}$	=	Baseline emissions from release of methane into the atmosphere in year *y* that is avoided by the project activity (tCO_2e/yr)
$BE_{Use,y}$	=	Baseline emissions from the production of power, heat or supply to a natural gas grid displaced by the project activity in year *y* (tCO_2e/yr)

Baseline emissions from methane destruction

Depending on the baseline scenario, part of mine methane may be destroyed through flaring and heat generation. Baseline emissions should account for the CO_2 emissions resulting from the destruction of that part of methane:

$$BE_{MD,y} = (CEF_{CH4} + r \times CEF_{NMHC}) \times \sum_i (MM_{BL,i,y} + VAM_{BL,i,y}) \qquad \textbf{(2)}$$

Where:

$BE_{MD,y}$	=	Baseline emissions from destruction of methane in the baseline scenario in year *y* (tCO_2e/yr)
i	=	Use of methane (flaring, heat generation)
$MM_{BL,i,y}$	=	Amount of mine methane that would have been captured, sent to and destroyed by the use *i* in the baseline scenario in the year *y* (expressed in tCH_4)
$VAM_{BL,i,y}$	=	Amount of ventilation air methane that would have been captured, sent to and destroyed by the use *i* in the baseline scenario in the year *y* (expressed in tCH_4)
CEF_{CH4}	=	Carbon emission factor for combusted methane (2.75 tCO2e/tCH4)
CEF_{NMHC}	=	Carbon emission factor for combusted non methane hydrocarbons (To be obtained through periodical analysis of captured mine methane) (tCO2eq/tNMHC)
r	=	Relative proportion of NMHC compared to methane in the captured gas

With

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

Where:

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

Note that for conservative estimation of methane destruction in the baseline over time, it is important to understand the characteristics of any ex ante thermal demand for methane in the baseline scenario. As stated in the applicability conditions of this methodology, project participants must be able to supply the necessary data for ex-ante projections of methane demand in order to use this methodology.

Calculation of the average annual demand for each year of the crediting period

For thermal demand, which includes on-site heat generation and supply to the gas grid for various combustion end uses, demand can vary within the year. More importantly, in this section it is presumed that power generation (or other uses) projects are designed to primarily (or exclusively) use extracted mine methane/ventilation air methane that would not be used for the baseline thermal energy generation and would otherwise be emitted to the atmosphere. Figures 1 and 2 indicate the disposition of methane under the baseline and project scenarios for this type of project.

Figure 1: Baseline Disposition of MM/VAM

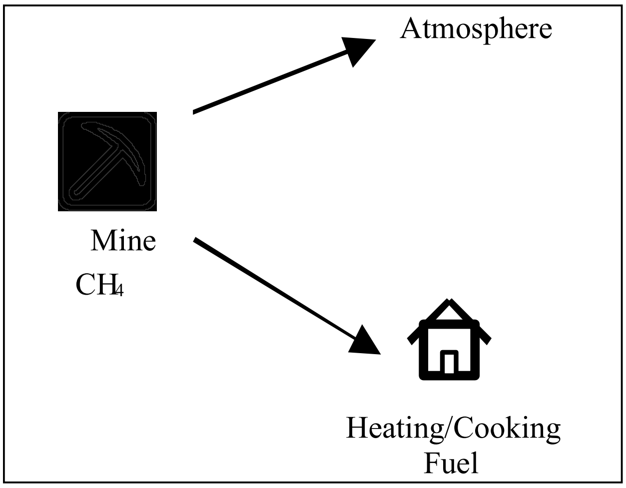
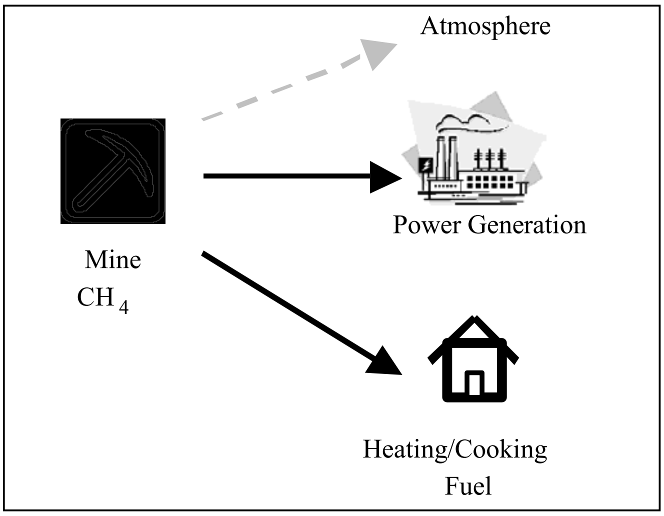


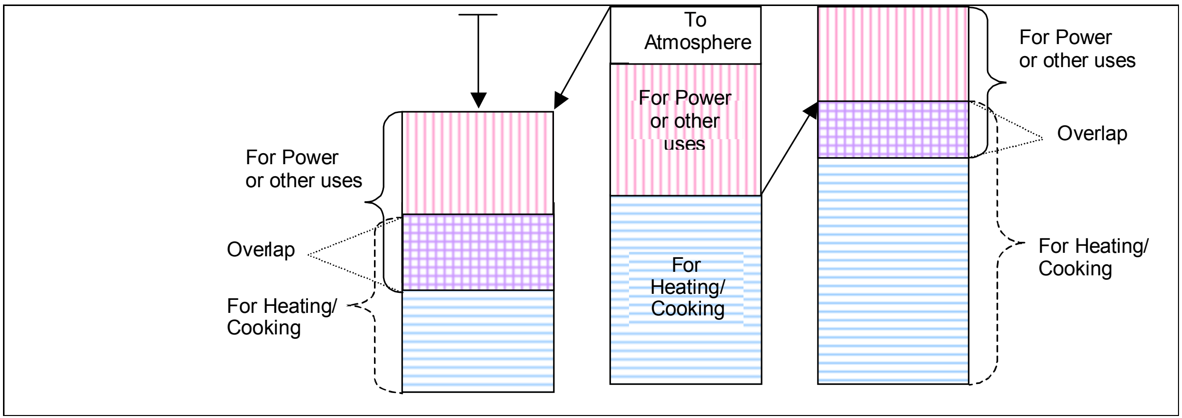
Figure 2: Project Case Disposition of MM/VAM



For eligible project activities, some or all of the MM/VAM used to generate electricity would be emitted to the atmosphere under the baseline (Figure 1). Appropriate MM/VAM flow and concentration meters should directly measure the amount of methane delivered to the project electric generator.

Under some circumstances, some portion of the MM/VAM used by a project for power generation might otherwise have gone to produce thermal energy in the absence of the project activity. This situation is shown in Figure 3, indicating an "overlap" between MM/VAM used for power generation and baseline use of MM/VAM for heating/cooking. This overlap may occur if MM/VAM flows fall below expected levels (left column at bottom of Figure 3), or if the baseline thermal energy demand exceeds expected levels (right column at bottom of Figure 3). Such overlaps may occur even where total annual MM/VAM volumes are more than enough to cover annual thermal energy and power requirements (as in Figure 3). This methodology provides for conservatively estimating what amount of methane – if any – used for power production would have been used for thermal energy generation in the baseline. Emissions from the project activity are reduced only to the extent that the power generation uses methane that would have been emitted in the baseline (i.e., "emitted to the atmosphere" in Figure 1).

Figure 3: Project Case MM/VAM for Power (or other uses) Overlaps with Baseline Thermal MM/VAM



Note that even when a project activity's average annual MM/VAM use for electricity generation or other uses is significantly below baseline MM/VAM use, there may be times – due to daily fluctuations in thermal energy demand or in MM/VAM extraction rates – that the project activity will use MM/VAM that would have been used for thermal energy generation under the baseline conditions. This methodology prescribes a conservative approach to account for how daily/monthly fluctuations in MM/VAM extraction and thermal energy demand will affect actual emissions relating to the baseline.

The likely fluctuation around daily estimates of baseline thermal energy demand for MM/VAM results from both:

- The expected year-to-year volatility in thermal energy demand relative to baseline projections of average demand.
- The expected day-to-day volatility in thermal energy demand, relative to average quantity required for each day.

These sources of volatility are combined into a single distribution around daily estimates of thermal energy demand. This distribution is captured in the equation below, in which the mean daily baseline thermal demand is multiplied by the daily scalar adjustment factor, d_k^{max}.
Baseline thermal demand is estimated using the following equation:

$$(VAM_{BL,th,y} + MM_{BL,th,y}) = \sum_{k=1}^{365} TH_{BL,k} \quad (4)$$

Where:

$VAM_{BL,th,,y}$	=	VAM that would have been captured and destroyed to meet the thermal demand in the baseline scenario in year *y* (tCH_4)
$MM_{BL,th,,y}$	=	MM that would have been captured and destroyed by thermal demand in the baseline

		scenario (tCH_4)
th	=	Index for thermal use *i* of MM and VAM 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 the estimated thermal energy demand in the baseline for day *k* of year *y* (tCH_4)

The quantity $TH_{BL,k}$ should be determined for each day *k* of the annual reporting period. For each day *k*, in a project year *y* the formula is:

$$TH_{BL,k} = \frac{TH_{BL,y}}{365} \times d_k^{\max} \quad \textbf{(5)}$$

Where:

$TH_{BL,k}$	=	Methane used to serve the estimated thermal energy demand in the baseline for day *k* in year *y* (tCH_4)
$TH_{BL,y}$	=	Projected annual baseline thermal demand for year *y* (tCH_4)
d_k	=	Scalar adjustment factor for day *k* to reflect seasonal variations, such that $\Sigma d_k=365$
$d^{max}{}_k$	=	Maximum scalar adjustment factor for day *k* over the 5 years prior to the start of the project activity (i.e. $\Sigma d^{max}{}_k>365$)

The scalar adjustment factor for the day *k* of a year prior to the commencement of the project activity is the ratio between the demand for that day *k* and the mean daily demand for that year. For the past 5 years before the starting date of the proposed project activity, d_k is calculated using real measured data. For each year *y* of the crediting period, d_k takes the highest value observed during the 5 years before the starting date of the proposed project activity (i.e. $d^{max}{}_k$).

If daily data are not available for estimating the scalar factor d_k, then monthly data may be used.
The source of data for mean annual baseline thermal energy demand should be provided on an ex ante projection basis by local MM/VAM distribution system operators, supported by a detailed description of the drivers of, and constraints on, future MM/VAM thermal energy demand.
The project participants should use the methods below to project a thermal energy demand. If the approach (b) is used, project proponents must substantiate why the approach (a) cannot be used. If the approach (c) is used, project proponents must substantiate why neither of the approaches (a) or (b) can be used.

(a) *Engineering/economic study of a thermal energy demand*. Ideally, projections should be based on a detailed description of the existing MM/VAM distribution system for thermal energy generation, how and why it was constructed, and what the primary drivers are behind the thermal energy demand on the system. Based on this description, project proponents should describe how the thermal energy demand is expected to change in the future in the absence of the project activity. Key points to address include:

- Who are the users of MM/VAM for thermal energy generation are, by quantity and type (e.g., residential, commercial, industrial);
- What service agreements are in place with these end users;
- Average MM/VAM thermal energy consumption rates for each type of end user;
- The number of end users serviced by the distribution system relative to the total pool of possible end users, given infrastructure constraints;

- How quickly the total pool of possible end users is expected to grow, if at all;
- Whether official plans exist to expand the MM/VAM thermal energy system;
- The cost/benefits of expanding the MM/VAM delivery system to additional end users;
- The type and cost of alternative fuels for potential or existing MM/VAM thermal energy customers, compared to the cost of delivering MM/VAM;
- Any other variables relevant to the particular thermal energy MM/VAM distribution system associated with the project.

Project proponents should explain why assumptions used in this analysis are conservative.

(b) *Statistical projection*. If detailed information on the thermal energy demand or the existing MM/VAM distribution system is not available, project proponents may use a statistical projection based on MM/VAM availability and thermal energy MM/VAM usage rates over at least the past five years. If the latter approach is used, proponents must explain why such a statistical projection is reasonable, and should supplement any projection with as much engineering/economic information as possible.

(c) *Maximum throughput on the distribution system.* Failing sufficient data for an engineering/ economic assessment or a statistical projection (e.g. if less than five years of data are available), prospective thermal energy demand in the absence of the project activity may be estimated from the maximum amount of MM/VAM that could be delivered to end users through existing pipelines. To be conservative, this approach should assume that thermal energy demand for MM/VAM in all future years will be equal to the maximum amount of MM/VAM that can be delivered. Maximum throughput estimates should be based on a detailed engineering description of the existing pipeline infrastructure. This may also feed to the analysis for (a) and (b) above.

<u>*Baseline emissions from the release of methane into the atmosphere*</u>

Baseline emissions from venting of mine methane are calculated as follows:

$$BE_{MR,y} = GWP_{CH4} \times \sum_{i} [(MM_{PR,i,y} - MM_{BL,i,y}) + (VAM_{PR,i,y} - VAM_{BL,i,y})] \quad \textbf{(6)}$$

Where:

$MM_{PR,i,y}$	=	MM captured, sent to and destroyed by use *i* in the project activity in year *y* (tCH_4)
$MM_{BL,i,y}$	=	MM that would have been captured, sent to and destroyed by use *i* in the baseline scenario in year *y* (tCH_4)
$VAM_{PR,i,y}$	=	VAM captured, sent to and destroyed by use *i* in the project activity in year *y* (tCH_4)
$VAM_{BL,i,y}$	=	VAM that would have been captured, sent to and destroyed by use *i* in the baseline scenario in year *y* (tCH_4)

<u>*Baseline emissions from power/heat generation and vehicle fuel replaced by project activity*</u>

$$BE_{Use,y} = GEN_y * EF_{ELEC,y} + HEAT_y * EF_{HEAT,y} + VFUEL_y * EF_{V,y} + ABS_y * \frac{COP_{ABS}}{COP_{ELEC}} * EF_{ELEC,y} \quad \textbf{(7)}$$

Where:

$BE_{Use,y}$	=	Baseline emissions from the production of power or heat or vehicle fuel use replaced by the project activity in year y (tCO_2e/yr)
$GEN_{,y}$	=	Electricity generated by the project activity in year *y* (MWh)
$EF_{ELEC,y}$	=	Emission factor for electricity generation (grid, captive or a combination) replaced by project activity (tCO_2/MWh)
$HEAT_y$	=	Heat generation by project activity in year *y* (GJ)
$EF_{HEAT,y}$	=	Emission factor for heat generation replaced by the project activity (tCO_2/GJ)
$VFUEL_y$	=	Vehicle fuel provided by the project activity in year *y* (GJ),
$EF_{V,y}$	=	Emission factor for vehicle operation replaced by project activity (tCO_2/GJ)
ABS_y	=	Chilling produced in project activity by absorption chillers in year *y* (MWh)
COP_{ABS}	=	Coefficient of performance of the absorption chillers (MW thermal input / MW thermal output)
COP_{ELEC}	=	Coefficient of performance of the electrical chillers used in the baseline Chillers (MW electrical input / MW thermal output)

Grid emission factor

If the baseline scenario includes power supply from the grid that would be replaced by the project activity, the emission factor for displaced electricity $EF_{ELEC,y} = EF_{grid,y}$ is calculated as per the latest approved version of the *"Tool for calculation of emission factor for electricity systems"*.

Captive power generation emission factor

If the baseline scenario includes captive power generation (either existing or new) that would be replaced by the project activity, the emission factor for displaced electricity $EF_{ELEC,y} = EF_{captive}$ is calculated as follows:

$$EF_{captive,y} = \frac{EF_{CO2,i,y}}{Eff_{captive}} \times \frac{44}{12} \times \frac{3.6}{1000} \quad \textbf{(8)}$$

Where:

$EF_{captive,y}$	=	Emission factor for captive power generation (tCO_2/MWh)
$EF_{CO2,i,y}$	=	CO_2 emissions factor of fuel *i*[6] used in captive power generation during the year *y* (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

[6] In the case where several fossil fuels are used for power generation, the fuel with the lowest emission factor should be used for the calculations of the baseline emissions

Combination of grid power and captive power emissions factor

If the baseline scenario selection determines that both captive and grid power would have been used in the baseline, then the emissions factor is the weighted average of the emission factor for the grid and for the captive power generation:

$$EF_{ELEC,y} = s_{grid} \cdot EF_{grid,y} + s_{captive} \cdot EF_{captive,y} \quad \textbf{(9)}$$

Where:

$EF_{ELEC.,y}$	=	CO_2 baseline emission factor for the electricity displaced due to the project activity during the year *y* (tCO_2/MWh).
$EF_{grid,y}$	=	CO_2 baseline emission factor for the grid electricity displaced due to the project activity during the year *y* (tCO_2/MWh).
$EF_{captive,y}$	=	CO_2 baseline emission factor for the captive electricity displaced due to the project activity during the year *y* (tCO_2/MWh).
s_{grid}	=	Share of the electricity demand supplied by the grid imports over the last 3 years (%)
$s_{captive}$	=	Share of facility electricity demand supplied by captive power over the last 3 years (%)

Heat generation emission factor

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

$$EF_{heat,y} = \frac{EF_{CO2,i,y}}{Eff_{heat}} \times \frac{44}{12} \times \frac{1}{1000} \quad \textbf{(10)}$$

Where:

$EF_{heat,y}$	=	Emission factor for heat generation (tCO_2/GJ)
$EF_{CO2,i,y}$	=	CO_2 emissions factor of fuel[7] used in heat generation during year *y* (tC/TJ)
Eff_{heat}	=	Efficiency of a boiler used for the heat generation (%)
44/12	=	Carbon to carbon dioxide conversion factor
1/1000	=	TJ to GJ conversion factor

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

<u>Option A</u>

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

- Measured efficiency prior to the project activity start;

[7] In the case where several fossil fuels are used for heat generation, the fuel with the lowest emission factor should be used for the calculations of the baseline emissions

- Measured efficiency during monitoring;
- Manufacturer nameplate data for efficiency of the existing boilers.

Option B
Assume a boiler efficiency of 100% as a conservative approach.

Vehicle fuel use emissions factor

If the project activity includes supply of methane for the use as vehicle fuel, the emissions factor for displaced vehicle fuel use in the baseline is calculated as follows:

$$EF_{V,y} = \frac{EF_{CO2,i,y}}{Eff_V} \times \frac{44}{12} \times \frac{1}{1000} \quad \textbf{(11)}$$

Where:

$EF_{V,y}$	=	Emissions factor for vehicle operation replaced by project activity (tCO2/GJ)
$EF_{CO2,i,y}$	=	CO_2 emissions factor of fuel used for vehicle operation during year y (tC/TJ)
Eff_V	=	Vehicle engine efficiency (%)
44/12	=	Carbon to Carbon Dioxide conversion factor
1/1000	=	TJ to GJ conversion factor

To estimate vehicle engine efficiency, project participants should select the highest value among the following three values as a conservative approach:

- Measured fuel efficiency prior to the start of the project activity;
- Measured fuel efficiency during monitoring;
- Manufacturer's specifications for efficiency of vehicle.

Project emissions

Project emissions are defined by the following equation:

$$PE_y = PE_{ME,y} + PE_{MD,y} + PE_{UM,y} \quad \textbf{(12)}$$

Where:

PE_y	=	Project emissions in year y (tCO_2e/yr)
$PE_{ME,y}$	=	Project emissions from energy use to capture and use methane in year y (tCO_2e/yr)
$PE_{MD,y}$	=	Project emissions from methane destroyed in year y (tCO_2e/yr)
PE_{UM}	=	Project emissions from un-combusted methane in year y (tCO_2e/yr)

Project emissions from the use of additional energy required for MM/VAM capture and utilisation

Additional energy may be required for the capture, transportation, compression and utilisation or destruction of MM/VAM. Project emissions from the use of this energy are calculated as follows:

$$PE_{ME,y} = PE_{ELEC,y} + PE_{FF,y} \quad \textbf{(13)}$$

Where:

$PE_{ELEC,y}$	=	Project emissions from the use of electricity for capture, transportation, compression and utilisation or destruction of MM/VAM in year *y* (tCO_2e/yr). Calculated in accordance with the latest approved version of the *"Tool to calculate project emissions from electricity consumption"*.
$PE_{FF,y}$	=	Project emissions from the combustion of fossil fuels for capture, transportation, compression and utilisation or destruction of MM/VAM in year *y* (tCO_2e/yr). Calculated in accordance with the latest approved version of the *"Tool to calculate project or leakage CO_2 emissions from fossil fuel combustion"*

Project emissions from the combustion of MM/VAM

When the captured mine methane is burned in a flare, heat or power plant, or oxidized in a catalytic oxidation unit, emissions from combustion are released. In addition, if NMHC account for more than 1% by volume of the extracted MM or more than 0.1% by volume of the extracted VAM, combustion emissions from these gases should also be included.

$$PE_{MD,y} = (MD_{FL,y} + MD_{OX,y} + MD_{ELEC,y} + MD_{HEAT,y} + MD_{GAS,y}) * (CEF_{CH4} + r * CEF_{NMHC}) \quad \textbf{(14)}$$

Where:

$PE_{MD,y}$	=	Project emissions from MM/VAM destroyed in year *y* (tCO_2e/yr)
$MD_{FL,y}$	=	Amount of methane destroyed through flaring in year *y* (tCH_4)
$MD_{OX,y}$	=	Amount of methane destroyed through catalytic oxidation in year *y* (tCH_4)
$MD_{ELEC,y}$	=	Amount of methane destroyed through power generation in year *y* (tCH_4)
$MD_{HEAT,y}$	=	Amount of methane destroyed through heat generation in year *y* (tCH_4)
$MD_{GAS,y}$	=	Amount of methane destroyed after being supplied to gas grid or for vehicle use in year *y* (tCH_4)
CEF_{CH4}	=	Carbon emission factor for combusted methane (2.75 tCO_2/tCH_4)
CEF_{NMHC}	=	Carbon emission factor for combusted non methane hydrocarbons (the concentration varies and, therefore, to be obtained through periodical analysis of captured methane) (tCO_2/tNMHC)
r	=	Relative proportion of NMHC compared to methane, $r = PC_{NMHC} / PC_{CH4}$
PC_{CH4}	=	Concentration (in mass) of methane in extracted gas (%), measured on wet basis
PC_{NMHC}	=	NMHC concentration (in mass) in extracted gas (%)

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

$$MD_{FL,y} = MMES_{FL,y} - (PE_{flare,y} / GWP_{CH4}) \quad \textbf{(15)}$$

Where:

$MD_{FL,y}$	=	Amount of methane destroyed through flaring in year *y* (tCH_4)
$MMES_{FL,y}$	=	Amount of methane measured sent to flare in year *y* (tCH_4)
$PE_{flare,y}$	=	Project emissions of non-combusted CH_4, expressed in terms of tCO_2e, from flaring of the residual gas stream in year *y* (tCO_2e)
GWP_{CH4}	=	Global warming potential of methane (21 tCO_2e/tCH_4)

The project emissions of non-combusted CH_4 expressed in terms of CO_2e from flaring of the residual gas stream ($PE_{flare,y}$) shall be calculated following the procedures described in the *"Tool to determine project emissions from flaring gases containing methane"*.

$$MD_{OX,y} = MMES_{OX,y} - PE_{OX,y} \quad \textbf{(16)}$$

Where:

$MD_{OX,y}$	=	Amount of methane destroyed through catalytic oxidation in year *y* (tCH_4)
$MMES_{OX,y}$	=	Amount of methane measured sent to catalytic oxidizer in year *y* (tCH_4)
$PE_{OX,y}$	=	Project emissions of non oxidized CH_4 from catalytic oxidation of the VAM stream in year *y* (tCH_4)

$$MMES_{OX,y} = VAM_{flowrate,y} * time_y * PC_{CH4,VAM} * D_{CH4,corr\,inflow} \quad \textbf{(17)}$$

Where:

$VAM_{flow.rate,y}$	=	Average flow rate of VAM entering the oxidation unit during year *y* (m^3/s)
$time_y$	=	Time during which VAM unit is operational during period *y* (s)
$PC_{CH4,VAM}$	=	Concentration of methane in the VAM entering the oxidation unit (m^3/m^3)
$D_{CH4,corr\ inflow}$	=	Density of methane entering the catalytic oxidation unit corrected for pressure and temperature ($P_{VAMinflow}$ and $T_{VAMinflow}$ respectively) (tCH_4/m^3)

$$PE_{OX,y} = VAM_{flowrate,y} * time_y * PC_{CH4.exhaust} * D_{CH4,correxh} \quad \textbf{(18)}$$

Where:

$PC_{CH4exhaust}$	=	Concentration of methane in the VAM exhaust (m^3/m^3)
$D_{CH4,corr\ exh}$	=	Density of methane corrected for pressure and temperature in the exhaust gases ($P_{VAMexhaust}$ and $T_{VAMexhaust}$ respectively) (tCH_4/m^3)

For ex ante projections, the efficiency of destruction of methane in the VAM may be assumed to be 90%.

$$MD_{ELECy} = MMES_{ELEC,y} * Eff_{ELEC} \quad \textbf{(19)}$$

Where:

$MMES_{ELEC,y}$	=	Amount of methane measured sent to power plant in year *y* (tCH_4)
Eff_{ELEC}	=	Efficiency of methane destruction/oxidation in power plant (taken as 99.5% from IPCC)

$$MD_{HEAT,y} = MMES_{HEAT,y} * Eff_{HEAT} \quad \textbf{(20)}$$

Where:

$MMES_{HEAT,y}$	=	Amount of methane measured sent to heat plant in year *y* (tCH_4)
Eff_{HEAT}	=	Efficiency of methane destruction/oxidation in heat plant (taken as 99.5% from IPCC)

$$MD_{GAS,y} = MMES_{GAS,y} * Eff_{GAS} \quad \textbf{(21)}$$

Where:

$MMES_{GAS,y}$	=	Amount of methane measured supplied to gas grid for vehicle use or heat/power generation off-site (tCH_4)
Eff_{GAS}	=	Overall efficiency of methane destruction/oxidation through gas grid to various combustion end uses, combining fugitive emissions from the gas grid and combustion efficiency at end user (taken as 98.5% from IPCC)[8]

Project emissions from un-combusted methane

Not all of the methane sent to the flare, to the catalytic oxidizer 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:

$$PE_{UM,y} = [GWP_{CH4} \times \sum_{i} MMES_{i,y} \times (1 - Eff_i)] + PE_{flare,y} + PE_{OX,y} \times GWP_{CH4} \quad \textbf{(22)}$$

Where:

$PE_{UM,y}$	=	Project emissions from un-combusted methane in year y (tCO_2e)
GWP_{CH4}	=	Global warming potential of methane (21 tCO_2e/tCH_4)
i	=	Use of methane (power generation, heat generation, supply to gas grid to various combustion end uses)
$MMES_{i,y}$	=	Methane measured sent to use i in year y (tCH_4)
Eff_i	=	Efficiency of methane destruction in use i (%)
$PE_{flare,y}$	=	Project emissions of non-combusted CH_4 expressed in terms of CO_2e from flaring of the residual gas stream (tCO_2e)
$PE_{OX,y}$	=	Project emissions of non oxidized CH_4 from catalytic oxidation of the VAM stream in year y (tCH_4)

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

[8]The Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories give a standard value for the fraction of carbon oxidised for gas combustion of 99.5% (Reference Manual, Table 1.6, page 1.29). It also gives a value for emissions from processing, transmission and distribution of gas which would be a very conservative estimate for losses in the grid and for leakage at the end user (Reference Manual, Table 1.58, page 1.121). These emissions are given as 118,000kgCH4/PJ on the basis of gas consumption, which is 0.6%. Leakage in the residential and commercial sectors is given as 0 to 87,000kgCH4/PJ, which is 0.4%, or in industrial plants and power station the losses are 0 to 175,000kg/CH4/PJ, which is 0.8%. These leakage estimates are additive. Eff_{GAS} can now be calculated as the product of these three efficiency factors, giving a total efficiency of (99.5% * 99.4% * 99.6%) 98.5% for residential and commercial sector users, and (99.5% * 99.4% * 99.2%) 98.1% for industrial plants and power stations.

Leakage

Leakage may occur if the project activity prevents MM/VAM from being used to meet the baseline thermal energy demand, whether as a result of physical constraints on delivery, or price changes. Where regulations require that local thermal demand be met before all other uses, which is common in many jurisdictions, then this leakage can be ignored.

If displacement does occur, the project activity may cause increased emissions outside the project boundary associated with meeting thermal energy demand with other fuels. Because of likely day-to-day fluctuations in MM/VAM extraction rates, to ensure a conservative result, CERs should not be calculated solely from annual data. Any CERs generated from methane destruction should be calculated using daily logs, or monthly logs if daily data are not available, of project-case demand for MM/VAM for non-thermal uses compared against estimates of the baseline MM/VAM demand for thermal uses. For each day (or month) of the crediting period, this form of leakage must be calculated if:

$$ME_k - (MMES_{ELEC,k} + MMES_{HEAT,k}) < TH_k \quad \textbf{(23)}$$

$$TH_k = \frac{\overline{TH_{BL}}}{365} \times d_k^{\max} \quad \textbf{(24)}$$

Where:

ME_k	=	Methane extracted on day *k* (tCH4)
$MMES_{ELEC,k}$	=	Methane measured sent to power plant on day k (tCH_4)
$MMES_{HEAT,k}$	=	Methane measured sent to new heat generation uses on day *k* in the project scenario that would not have been sent in the baseline scenario on day *k* (tCH_4)
TH_k	=	Methane used to serve thermal energy demand in the baseline for day *k* (tCH_4)
TH_{BL}	=	Average annual thermal demand over the past 5 years (tCH4)
d_k	=	Scalar adjustment factor for day k to reflect seasonal variations such that $\Sigma d_k=365$
$d^{max}{}_k$	=	Maximum scalar adjustment factor for day k over the past 5 years (i.e. $\Sigma d^{max}{}_k>365$)

Under this condition, some portion of MM/VAM that would have gone to meet the thermal energy demand in the baseline scenario is instead used by the project activity. A corresponding amount of thermal energy demand in the project scenario will have to be met by an alternative fuel, leading to possible increased emissions. To calculate such emissions, the following approach should be used. The amount of thermal energy from MM/VAM diverted from thermal uses existing in the baseline to other uses in the project activity should be calculated on a daily basis and then summed up:

$$ED_{th,y} = \sum_k ED_{th,k} = \sum_k [\max(0,(TH_k - (ME_k - (MMES_{ELEC,k} + MMES_{HEAT,k}))) * NCV_{CH4}] \quad \textbf{(25)}$$

Where:

$ED_{th,y}$	=	Quantity of thermal energy displaced by the project activity in year *y* (GJ)
$ED_{th,k}$	=	Quantity of thermal energy displaced by the project activity on day *k* (GJ)
ME_k	=	Total methane extracted on day *k* (tCH4)
$MMES_{ELEC,k}$	=	Methane measured sent to power plant on day *k* (tCH_4)

$MMES_{HEAT,k}$ = Methane measured sent to new heat generation uses on day *k* in the project scenario that would not have been sent in the baseline scenario on day k (tCH_4)
NCV_{CH4} = Net calorific value for methane (GJ/tCH_4)

Project participants must describe and justify what alternative fuel(s) is (are) used to provide thermal energy in the area when MM/VAM is not available. They must then calculate the amount of alternative fuel required to provide the same heat output as the MM/VAM.

$$Q_{AF,y} = ED_{th,y} / NCV_{AF} \tag{26}$$

Where:
$Q_{AF,y}$ = Quantity of alternative fuels displaced by the project activity in year *y* (tonnes or m^3)
$ED_{th,y}$ = Quantity of thermal energy displaced by the project activity in year *y* (GJ)
NCV_{AF} = Net calorific value for alternative fuels (GJ/tonne or m_3)

Emissions from the use of alternative fuels are calculated as follows:

$$LE_y = Q_{AF} * NCV_{AF} * EF_{AF} * OXID \tag{27}$$

Where:
LE_y = Leakage emissions in year y (tCO_2e/yr)
$Q_{AF,y}$ = Quantity of alternative fuels displaced by the project activity in year *y* (tonnes or m^3)
EF_{AF} = Emissions factor for alternative fuel (tCO_2/GJ), sourced from IPCC
OXID = Oxidation efficiency of combustion (%), sourced from IPCC

Emission reductions

Emission reductions are calculated as follows:

$$ER_y = BE_y - PE_y - LE_y \tag{28}$$

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)

Changes required for methodology implementation in 2nd and 3rd crediting periods

At the renewal of the crediting period, project participants shall assess the continued validity of the baseline scenario or update it as appropriate. This shall include an assessment of the status of mines under care and maintenance to determine if these mines will be closed during the crediting period or resume their operation.

Furthermore, all relevant data contained under "Data and parameters not monitored" should be updated. Regarding the grid emission factor, the provisions in the latest approved version of "Tool to calculate the emission factor for an electricity system" on the update of the emission factor apply.

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:	COP_{ABS}
Data unit:	MW thermal input / MW thermal output
Description:	Coefficient of performance of absorption chillers used in the project activity
Source of data:	Manufacturer
Measurement procedures (if any):	N/A
Any comment:	The manufacturer's specifications on the performance of the absorption chillers should be used.

Data / parameter:	COP_{ELEC}
Data unit:	MW thermal input / MW thermal output
Description:	Coefficient of performance of the electrical chillers used in the baseline
Source of data:	Manufacturer
Measurement procedures (if any):	N/A
Any comment:	The manufacturer's specifications on the performance of the absorption chillers should be used.

Data / parameter:	Eff_{ELEC}
Data unit:	
Description:	Efficiency of methane destruction/oxidation in a power plant
Source of data:	IPCC
Measurement procedures (if any):	N/A
Any comment:	The value is taken as 99.5% from IPCC

Data / parameter:	Eff_{HEAT}
Data unit:	
Description:	Efficiency of methane destruction/oxidation in heat plant
Source of data:	IPCC
Measurement procedures (if any):	N/A
Any comment:	The value is taken as 99.5% from IPCC

Data / parameter:	$Eff_{captive}$
Data unit:	%
Description:	Energy efficiency of captive power plant
Source of data:	
Measurement procedures (if any):	
Monitoring frequency:	N/A
QA/QC procedures:	
Any comment:	Depending on option chosen in baseline, measured before or after project implementation

Data / parameter:	Eff_V
Data unit:	%
Description:	Efficiency of vehicle engine
Source of data:	
Measurement procedures (if any):	To estimate vehicle engine efficiency, project participants should select the highest value among the following three values as a conservative approach: • Measured fuel efficiency prior to the start of the project activity; • Measured fuel efficiency during monitoring; • Manufacturer's specifications for efficiency of vehicle.
Monitoring frequency:	
QA/QC procedures:	
Any comment:	

Data / parameter:	Eff_{GAS}
Data unit:	
Description:	Overall efficiency of methane destruction/oxidation through gas grid to various combustion end uses, combining fugitive emissions from the gas grid and combustion efficiency at end user
Source of data:	IPCC
Measurement procedures (if any):	N/A
Any comment:	Taken as 98.5% from IPCC

Data / parameter:	d_k^{max}
Data unit:	
Description:	Maximum scalar adjustment factor for day *k* over the 5 years prior to the start of the project activity (i.e. Σd^{max}_k>365)
Source of data:	
Measurement procedures (if any):	
Any comment:	

Data / parameter:	$VAM_{BLi,y}$
Data unit:	tCH_4
Description:	VAM 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):	Estimated ex-ante at the start of the project activity
Any comment:	*i* = use of methane (flaring, heat generation)

Data / parameter:	$MM_{BLi,y}$
Data unit:	tCH_4
Description:	MM 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):	Estimated ex-ante at the start of the project activity
Any comment:	*i* = use of methane (flaring, heat generation)

Data / parameter:	CEF_{CH4}
Data unit:	tCO_2e/tCH_4
Description:	Carbon emission factor for combusted methane
Source of data:	
Measurement procedures (if any):	
Monitoring frequency:	Ex ante
QA/QC procedures:	
Any comment:	44/16 = 2.75 tCO_2e/tCH_4

Data / parameter:	$TH_{BL,y}$
Data unit:	tCH_4
Description:	Projected annual baseline MM /VAM demand for thermal energy uses
Source of data:	
Measurement procedures (if any):	Estimated using the procedure defined in the corresponding baseline methodology
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.

Methane collected and flared

The amount of methane actually flared will be determined by monitoring the:

- Amount of MM/VAM gas collected, using a continuous flow meter and monitoring of temperature and pressure;
- Percentage of MM/VAM gas that is methane (%v/v), measured using a continuous analyser or alternatively, with periodical measurements, at a 95% confidence level, using calibrated portable gas meters and taking a statistically valid number of samples;
- The parameters used for determining the project emissions from flaring of the residual gas stream (PE_{flare}) or catalytic oxidation of the VAM stream (PE_{OX}) should be monitored as per the *"Tool to determine project emissions from flaring gases containing Methane";*
- Temperature (T) and pressure (P) of the MM/VAM gas are required to determine the density of methane in the MM/VAM gas.

Methane in ventilation air destroyed by catalytic oxidation

A catalytic oxidation unit differs both from a thermal oxidation unit and a flare in that methane destruction takes place at a substantially lower temperature and also from a flare in that it is a closed system with no additional gas flow inputs (or emissions) between the input and exhaust methane measurement points. The amount of methane entering the reaction chamber will be determined by monitoring the total inlet flow using a continuous flow meter and monitoring temperature and pressure to determine gas density. The amount of VAM that is methane (%v/v) will be measured using a continuous analyser and for mine safety and regulatory reasons this is unlikely to exceed 1%.

Project emissions from a VAM unit will be measured by continuous measurement of methane concentration, pressure and temperature of the exhaust gas stream.

Monitoring of mine development plans

Mine development plans have to be monitored each year of the crediting period to ensure that (i) boreholes that do not intersect the mining activity are not included in a project activity, and (ii) mines under care and maintenance are not scheduled for closure. Mines under care and maintenance cease to be eligible as part of the project activity once measures to initiate the closure of the mine are taken.

Data and parameters monitored

Data / parameter:	GEN_y
Data unit:	MWh
Description:	Electricity generated by project activity in year *y*
Source of data:	Measurement
Measurement procedures (if any):	This variable must be measured continuously with an online meter
Monitoring frequency:	Continuous
QA/QC procedures:	The instrument must be calibrated to manufacturers specifications
Any comment:	

Data / parameter:	$EF_{ELEC,y}$ ($EF_{grid,y}$, $EF_{captive,y}$)
Data unit:	tCO_2/MWh
Description:	Emission factor of electricity displaced by the project activity in year *y*
Source of data:	
Measurement procedures (if any):	Calculated in accordance with the latest approved version of the "Tool to calculate the emission factor for an electricity system"
Monitoring frequency:	Annually
QA/QC procedures:	
Any comment:	

Data / Parameter:	$HEAT_y$
Data unit:	GJ
Description:	Heat generation by project activity in year *y*
Source of data:	Continuous measurement
Measurement procedures (if any):	This variable must be measured continuously with an online meter
Monitoring frequency:	Continuous
QA/QC procedures:	Calibrate to the manufacturers specification
Any comment:	

Data / Parameter:	$EF_{CO2,i,y}$
Data unit:	tC/TJ
Description:	CO_2 emission factor of fuel or energy source *i* used in heat generation in year *y*
Source of data:	IPCC or country default values
Measurement procedures (if any):	
Monitoring frequency:	Annually
QA/QC procedures:	
Any comment:	This value should be established annually as the fuel or energy source used in heat generation may change.
Data / Parameter:	Eff_{heat}
Data unit:	%
Description:	Boiler efficiency of the heat generation
Source of data:	IPCC or country default values
Measurement procedures (if any):	Depending on which option is chosen, the source will be either of the following: • Measured efficiency prior to project implementation; • Measured efficiency during monitoring; • Manufacturer nameplate data for efficiency of the existing boilers
Monitoring frequency:	If the data is obtained by measuring efficiency during monitoring, it must be continuously monitored.
QA/QC procedures:	All meters used in the monitoring must be calibrated to the manufacturer's specifications.
Any comment:	

Data / Parameter:	$MMES_{FL,y}$
Data unit:	tCH_4
Description:	Methane measured sent to flare in year *y*
Source of data:	
Measurement procedures (if any):	
Monitoring frequency:	Continuous
QA/QC procedures:	
Any comment:	Flow meters will record gas volumes, pressure and temperature. Density of methane under normal conditions of temperature and pressure is 0.67kg/m3 (Revised 1996 IPCC Reference Manual p 1.24 and 1.16)

Data / Parameter:	$VAM_{flow.rate,y}$
Data unit:	m^3/s
Description:	Average flow rate of VAM entering the oxidation unit during period *y*
Source of data:	
Measurement procedures (if any):	
Monitoring frequency:	Continuous
QA/QC procedures:	
Any comment:	Readings taken every two minutes to calculate average hourly flow, or more frequently.

Data / Parameter:	$time_y$
Data unit:	s
Description:	Time during which VAM unit is operational during period *y*
Source of data:	
Measurement procedures (if any):	
Monitoring frequency:	Continuous
QA/QC procedures:	
Any comment:	Readings taken every two minutes to calculate average hourly flow, or more frequently.

Data / Parameter:	$D_{CH4,corr\ inflow}$
Data unit:	tCH_4/m^3
Description:	Density of methane entering the catalytic oxidation unit corrected for pressure and temperature ($P_{VAMinflow}$ and $T_{VAMinflow}$ respectively)
Source of data:	
Measurement procedures (if any):	
Monitoring frequency:	Continuous
QA/QC procedures:	
Any comment:	

Data / Parameter:	$D_{CH4,corr\ exh}$
Data unit:	tCH_4/m^3
Description:	Density of methane corrected for pressure and temperature in the exhaust gases ($P_{VAMexhaust}$ and $T_{VAMexhaust}$ respectively)
Source of data:	
Measurement procedures (if any):	
Monitoring frequency:	Continuous
QA/QC procedures:	
Any comment:	

Data / Parameter:	$P_{VAMinflow}$
Data unit:	bar
Description:	Pressure of VAM entering the oxidation unit
Source of data:	Pressure transducer
Measurement procedures (if any):	
Monitoring frequency:	Continuous
QA/QC procedures:	
Any comment:	Readings taken every hour or more frequently to calculate hourly pressure
Data / Parameter:	$T_{VAMinflow}$
Data unit:	Kelvin
Description:	Temperature of VAM entering the oxidation unit
Source of data:	Thermocouple
Measurement procedures (if any):	
Monitoring frequency:	Continuous
QA/QC procedures:	
Any comment:	Readings taken every hour or more frequently to calculate hourly temperature

Data / Parameter:	$P_{VAMexhaust}$
Data unit:	bar
Description:	Pressure of exhaust gases exiting the oxidation unit
Source of data:	Pressure transducer
Measurement procedures (if any):	
Monitoring frequency:	Continuous
QA/QC procedures:	
Any comment:	Readings taken every hour or more frequently to calculate hourly pressure

Data / Parameter:	$T_{VAMexhaust}$
Data unit:	Kelvin
Description:	Temperature of exhaust gases exiting the oxidation unit
Source of data:	Thermocouple
Measurement procedures (if any):	
Monitoring frequency:	Continuous
QA/QC procedures:	
Any comment:	Readings taken every hour or more frequently to calculate hourly temperature

Data / Parameter:	$MMES_{ELEC,y}$
Data unit:	tCH_4
Description:	Methane sent to power plant in year *y*
Source of data:	
Measurement procedures (if any):	
Monitoring frequency:	Continuous
QA/QC procedures:	
Any comment:	

Data / Parameter:	$MM_{HEAT,y}$
Data unit:	tCH_4
Description:	Methane sent to boiler in year *y*
Source of data:	
Measurement procedures (if any):	
Monitoring frequency:	Continuous
QA/QC procedures:	
Any comment:	Flow meters will record gas volumes, pressure and temperature. Density of methane under normal conditions of temperature and pressure is 0.67kg/m3 (Revised 1996 IPCC Reference Manual p 1.24 and 1.16)

Data / Parameter:	$MMES_{GAS,y}$
Data unit:	tCH_4
Description:	Methane sent to gas grid for end users in year *y*
Source of data:	
Measurement procedures (if any):	
Monitoring frequency:	Continuous
QA/QC procedures:	
Any comment:	Flow meters will record gas volumes, pressure and temperature. Density of methane under normal conditions of temperature and pressure is 0.67kg/m3 (Revised 1996 IPCC Reference Manual p 1.24 and 1.16)

Data / Parameter:	CEF_{NMHC}
Data unit:	$tCO_2eq/tNMHC$
Description:	Carbon emission factor for combusted non methane hydrocarbons
Source of data:	
Measurement procedures (if any):	To be obtained through periodical analysis of the fractional composition of the captured mine methane
Monitoring frequency:	Monthly
QA/QC procedures:	
Any comment:	

Data / Parameter:	PC_{CH4}
Data unit:	%
Description:	Concentration (in mass) of methane in extracted gas (%), measured on wet basis
Source of data:	Concentration meters, optical and calorific
Measurement procedures (if any):	
Monitoring frequency:	Hourly/Daily
QA/QC procedures:	
Any comment:	To be measured on a wet basis.

Data / Parameter:	PC_{NMHC}
Data unit:	%
Description:	NMHC concentration (in mass) in extracted gas
Source of data:	Concentration meters, optical and calorific
Measurement procedures (if any):	
Monitoring frequency:	Annually
QA/QC procedures:	
Any comment:	

Data / Parameter:	$PC_{CH4,VAM}$
Data unit:	m^3/m^3 (%)
Description:	Concentration of methane in the VAM entering the oxidation unit
Source of data:	On line, low reading methanometer
Measurement procedures (if any):	
Monitoring frequency:	Continuous
QA/QC procedures:	
Any comment:	Readings taken at least every two minutes and used to calculate average methane concentration per hour or more frequently.

Data / Parameter:	$PC_{CH4,exhaust}$
Data unit:	m^3/m^3 (%)
Description:	Concentration of methane in exhaust gas from catalytic oxidation unit
Source of data:	M (online low reading methanometer)
Measurement procedures (if any):	
Monitoring frequency:	Continuous
QA/QC procedures:	
Any comment:	Readings taken at least every two minutes and used to calculate average methane concentration per hour or more frequently.

Data / Parameter:	$MMES_{i,y}$
Data unit:	tCH_4
Description:	Methane measured sent to use *i* in year *y*
Source of data:	
Measurement procedures (if any):	Flow meters will record gas volumes, pressure and temperature.
Monitoring frequency:	Continuous
QA/QC procedures:	
Any comment:	*i* = Use of methane (power generation, heat generation, supply to gas grid to various combustion end uses)

Data / parameter:	Eff_i
Data unit:	-
Description:	Efficiency of methane destruction / oxidation through use *i* (power generation, heat generation, supply to gas grid to various combustion end uses) in year *y*
Source of data:	
Measurement procedures (if any):	
Monitoring frequency:	Ex ante or ex post
QA/QC procedures:	
Any comment:	

Data / parameter:	$MM_{PR, i,y}$
Data unit:	tCH_4
Description:	MM 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:	*i* = use of methane (flaring, heat generation, electricity generation, use as vehicle fuel)

Data / parameter:	$VAM_{PR, i,y}$
Data unit:	tCH_4
Description:	VAM 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:	*i* = use of methane (flaring, heat generation, electricity generation, use as vehicle fuel)

Data / parameter:	$VFUEL_y$
Data unit:	GJ
Description:	Vehicle power supplied by the project activity
Source of data:	
Measurement procedures (if any):	
Monitoring frequency:	Continuous
QA/QC procedures:	
Any comment:	

Data / parameter:	ME_k
Data unit:	tCH_4
Description:	Methane extracted on day *k*
Source of data:	
Measurement procedures (if any):	
Monitoring frequency:	Daily/continuous
QA/QC procedures:	
Any comment:	

Data / parameter:	$MMES_{ELEC,k}$
Data unit:	tCH_4
Description:	Methane measured for power generation on day *k*
Source of data:	
Measurement procedures (if any):	
Monitoring frequency:	Daily/continuous
QA/QC procedures:	
Any comment:	

Data / parameter:	$MMES_{HEAT,k}$
Data unit:	tCH_4
Description:	Methane measured for new heat generation on day *k*
Source of data:	
Measurement procedures (if any):	
Monitoring frequency:	Daily/continuous
QA/QC procedures:	
Any comment:	

Data / parameter:	$MM_{FL,k}$
Data unit:	tCH_4
Description:	Methane measured sent flare on day *k*
Source of data:	
Measurement procedures (if any):	
Monitoring frequency:	Daily/continuous
QA/QC procedures:	
Any comment:	

Data / Parameter:	ABS_y
Data unit:	MWh
Description:	Chilling produced in project case by absorption chillers in year y (MWh).
Source of data:	Continuous measurement
Measurement procedures (if any):	This variable must be measured continuously with an online meter, preferably as part of the chiller equipment.
Monitoring frequency:	Continuous
QA/QC procedures:	Calibrate to the manufacturers specification
Any comment:	None

IV. REFERENCES AND ANY OTHER INFORMATION

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Annex

Mining terminology

An operating mine is a mine that conforms to at least one of the following:

a) Active development is taking place. Such development could include the sinking of shafts or the development of underground infrastructure. The underground infrastructure includes all work done underground to provide access to the ore-body, supply of utilities (power, air, water and ventilation) to the working areas and to provide a means for the removal or waste rock and ore from underground. Such development can happen in the pre-production phase, during production or as the re-development of a mine to access previously unexploited areas of the ore body;

b) Ore is produced from the mine;

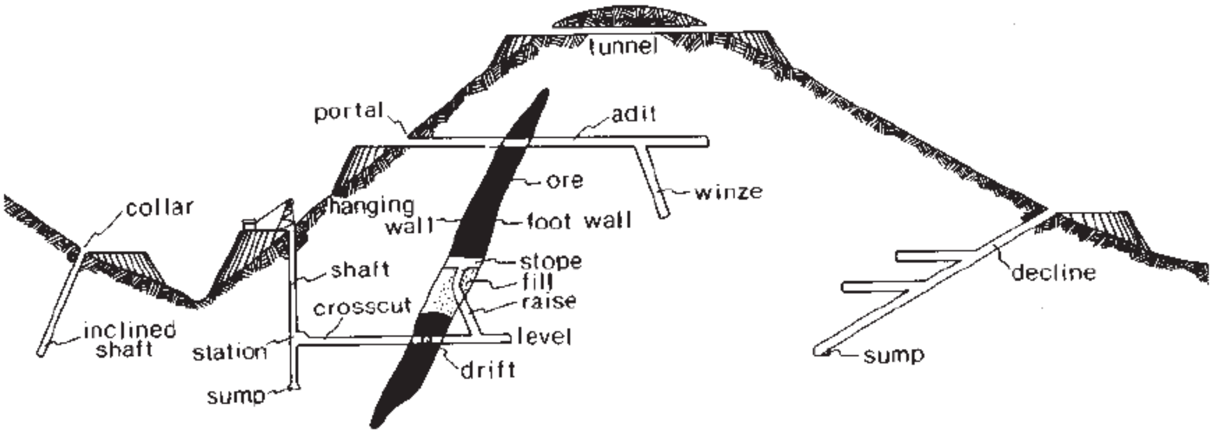
c) The mine is on care and maintenance. This could happen at any stage in the life of the mine. Mines are normally placed on care and maintenance when production of ore from the mine is temporarily suspended, but the intent is there to re-start production at a later stage. This could happen for a variety of reasons, including a drop in the market prices of commodities that may impact on the ability of the mine to be operated profitably. During the time that a mine is placed on care and maintenance the operator of the mine must maintain a presence and actively ensure that the equipment and infrastructure is maintained in a good working order with respect to both operation and safety.

A mine that conforms to one of the following does not qualify as a operating mine:

a) A mine in which the ore body has been depleted. This means that all the ore that could potentially be extracted in an economic fashion has been removed from the mine. It does not refer to a mine where production has been suspended due to economic conditions that may be reversed when market prices of commodities recover – such mines should be placed on care and maintenance (see above);

b) A mine than has been abandoned by the operator. This means that the moment the operator does not maintain a presence at the mine with respect to either development, production or care and maintenance, it is not an operating mine any more;

c) A mine that has implemented the final closure plan as specified in the environmental management plan of that mine, as approved by the relevant regulatory authority of the government of the country in which the mine is situated. Such closure plans are designed to return a mine to a condition where it is safe for humans and the environmental impact of the mining operation is mitigated. It normally involves the sealing of shafts, filling in of voids and capping of tailings dams.



Development in an underground mine refers the creation of tunnels and other access routes that will allow the miner to access the ore. Development ends include areas such as:

- **Shafts**. Shafts can be vertical or inclined. They are designed to take the miner from surface down to the level on which the ore occurs. Shafts can have a general purpose, or be dedicated to specific functions such the hoisting of rock, the hoisting of personnel or they can be dedicated to ventilation ("vent shafts"). Shafts can be vertical or at an angle ("inclined shafts" and "declines")
- **Access drives**. Access drives are horizontal tunnels designed to take the miner from the shaft to the ore body. There are many types of access drives. In the figure above, the following are indicated: tunnel, adit, drift, crosscut, raise and winze.

Working areas: Working areas in mines are called stopes.

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History of the document

Version	Date	Nature of revision
01	EB 36, Annex 5 30 November 2007	Initial adoption