Approved consolidated baseline and monitoring methodology 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"

I. SOURCE, DEFINITIONS AND APPLICABILITY

Sources

This consolidated methodology is based on elements from the following methodologies:

- NM0066 "Baseline methodology for grid-connected coalmine methane power generation at an active coal mine with existing methane extraction and partial utilization," submitted by Hegang Coal Industry Group Limited;
- NM0075 "Baseline methodology for coal mine methane (CMM) utilization and destruction at a working coal mine", prepared by IT Power;
- NM0093 "Baseline methodology for methane utilization and destruction project activities at working coal mines where both coal mine methane (drained from within the mine) and coal bed methane (drained from the surface within the coal mining concession area) is used and/or destroyed", prepared by Westlake Associates, Ltd and Asian Development Bank;
- NM0094 "Baseline methodology for coal mine methane recovery and utilization at active coal mines", prepared by Millennium Capital Services, Co.;
- NM0102 "Generalised baseline methodology for coal mine methane (CMM) power generation", prepared by the Prototype Carbon Fund.

This methodology also refers to the latest approved version of the following tool(s):

- "Tool to calculate the emission factor for an electricity system";
- "Tool for the demonstration and assessment of additionality";
- "Tool to determine project emissions from flaring gases containing methane".

For more information regarding the proposals 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

"Existing actual or historical emissions, as applicable".

Definitions

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

Coal bed methane (CBM). A generic term (USA) for the methane originating in coal seams that is drained from surface boreholes before mining takes place.

Coal mine methane (CMM). Methane component of gases captured in a working mine by methane drainage techniques.

Goaf. Collapsed area of strata produced by the removal of coal and artificial supports behind a working coalface. Strata above and below the goaf is de-stressed and fractured by the mining activity. Methane released from this disturbed zone is available for Post mining CMM Extraction through either surface goaf wells or underground boreholes or drainage galleries.

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.

Pre-mining CMM (also known as pre drainage). Methane extraction prior to the mining process from underground boreholes in the mine (for safety reasons).

Post mining CMM (also known as post drainage). Methane extraction after completion of the mining process from vertical surface goaf wells, underground inclined or horizontal boreholes, gas drainage galleries or other goaf gas capture techniques, including drainage of sealed areas, in the mine (for safety reasons).

Mining Activities. Working of an area, or panel, of coal that has been developed and equipped to facilitate coal extraction and is shown on a mining plan.

Flameless oxidation. Technology for flameless destruction of methane with or without utilization of thermal energy and/or with or without a catalyst.

Applicability

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

- Surface drainage wells to capture CBM associated with mining activities;
- Underground boreholes in the mine to capture pre mining CMM;
- Surface goaf wells, underground boreholes, gas drainage galleries or other goaf gas capture techniques, including gas from sealed areas, to capture post mining CMM;
- Ventilation air methane-that would normally be vented.

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

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

Project participants must be able to supply the necessary to data for *ex ante* projections of methane demand as described in sections Baseline Emissions and Leakage to use this methodology.

The methodology applies to both new and existing mining activities.

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

- Operate in open cast mines;
- Capture methane from abandoned/decommissioned coalmines;
- Capture/use of virgin coal bed methane, e.g. methane of high quality extracted from coal seams independently of any mining activities;
- Use CO_2 or any other fluid/gas to enhance CBM drainage before mining takes place.

II. BASELINE METHODOLOGY PROCEDURE

Project boundary

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

- CO_2 emissions from the combustion of methane in a flare, engine, power plant or heat generation plant;
- CO_2 emissions from the oxidation of methane in an flameless oxidation unit;
- CO_2 emissions from the combustion of non methane hydrocarbons (NMHCs), if they represent more than 1% by volume of the extracted coal mine gas;
- CO_2 emissions from on-site fuel consumption due to the project activity, including transport of the fuel;
- Fugitive emissions from unburned methane.

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

- CH_4 emissions as a result of venting gas that would be captured in the project scenario;
- CO_2 emissions from the destruction of methane in the baseline scenario;
- CO_2 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 comprises:

- All equipment installed and used as part of the project activity for the extraction, compression, and storage of CMM and CBM at the project site, and transport to an off-site user;
- Flaring, flameless oxidation, 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 power to the grid, as per the definition of project electricity system and connected electricity system given in "Tool to calculate the emission factor for an electricity system".[1]

Table 1 illustrates which emissions sources are included and which are excluded from the project boundary for determination of both baseline and project emissions.

[1] Please refer to: <http://cdm.unfccc.int/goto/MPappmeth>

Table 1: Overview on emissions sources included in or excluded from the project boundary

	Source	Gas		Justification / Explanation
Baseline Emissions	Emissions of methane as a result of venting	CH_4	Included	• Main emission source. However, certain sources of methane may not be included, as noted in the applicability conditions; • Recovery of methane from coal seams will be taken into account only when the particular seams are mined through or disturbed by the mining activity; • Recovery of methane from abandoned coalmines will not be included; • The amount of methane to be released depends on the amount used (for local consumption, gas sales, etc) in the baseline.
	Emissions from destruction of methane in the baseline	CO_2	Included	• Considers any flaring or use for heat and power in the baseline scenario.
		CH_4	Excluded	• Excluded for simplification. This is conservative.
		N_2O	Excluded	• Excluded for simplification. This is conservative.
	Grid electricity generation (electricity provided to the grid)	CO_2	Included	• Only CO_2 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	Excluded	• Excluded for simplification. This is conservative.
		N_2O	Excluded	• Excluded for simplification. This is conservative.
	Captive power and/or heat, and vehicle fuel use	CO_2	Included	• Only when the baseline scenario involves such usage.
		CH_4	Excluded	• Excluded for simplification. This is conservative.
		N_2O	Excluded	• Excluded for simplification. This is conservative.
Project Emissions	Emissions of methane as a result of continued venting	CH_4	Excluded	• Only the change in CMM/CBM/VAM emissions release will be taken into account, by monitoring the methane used or destroyed by the project activity.
	On-site fuel consumption due to the project activity, including transport of the gas	CO_2	Included	• If additional equipment such as compressors or fans are required on top of what is required for purely drainage, energy consumption from such equipment should be accounted for.

	Source	Gas		Justification / Explanation
		CH_4	Excluded	• Excluded for simplification. This emission source is assumed to be very small.
		N_2O	Excluded	• Excluded for simplification. This emission source is assumed to be very small.
	Emissions from methane destruction	CO_2	Included	• From the combustion of methane in a flare, flameless oxidation, or heat/power generation.
	Emissions from NMHC destruction	CO_2	Included	• From the combustion of NMHC in a flare or flameless oxidizer, or heat/power generation, if NMHC accounts for more than 1% by volume of extracted coal mine gas.
	Fugitive emissions of unburned methane	CH_4	Included	• Small amounts of methane will remain unburned in flares, flameless oxidizers or heat/power generation.
	Fugitive methane emissions from on-site equipment	CH_4	Excluded	• Excluded for simplification. This emission source is assumed to be very small.
	Fugitive methane emissions from gas supply pipeline or in relation to use in vehicles	CH_4	Excluded	• Excluded for simplification. However taken into account among other potential leakage effects (see leakage section).
	Accidental methane release	CH_4	Excluded	• Excluded for simplification. This emission source is assumed to be very small.

Identification of the baseline scenario

Step 1: Identify technically feasible options for capturing and/or using CBM or CMM or VAM

Step 1a: Options for CBM and CMM or VAM extraction

The baseline scenario alternatives should include all possible options that are technically feasible to handle CBM and CMM or VAM to comply with safety regulations. These options could include:

A. Pre mining CMM extraction including CBM to Goaf drainage and/or Indirect CBM to Goaf only;
B. Post mining CMM extraction;
C. Possible combinations of options A, B and C with the relative shares of gas specified.

These options should include the CDM project activity not implemented as a CDM project.

Step 1b: Options for extracted CBM and CMM or VAM treatment

The baseline scenario alternatives should include all possible options that are technically feasible to use CBM and CMM or VAM. These options could include:

(i) Venting;
(ii) Using/destroying ventilation air methane rather than venting it;
(iii) Flaring of CBM/CMM;
(iv) Use for additional grid power generation;
(v) Use for additional captive power generation;
(vi) Use for additional heat generation;
(vii) Feed into gas pipeline (to be used as fuel for vehicles or heat/power generation);
(viii) Possible combinations of options i to vii with the relative shares of gas treated under each option specified.

These options should include the proposed project activity not implemented as a CDM project.

Step 1c: Options for energy production

The baseline scenario alternatives should include all possible options to generate electricity (grid, captive power plant using CBM/CMM/VAM or other fuels) and/or heat (using CBM/CMM/VAM or another fuel) and/or to fuel vehicles.

These options should include the proposed project activity that has however not been implemented as a CDM project activity.

Step 2: Eliminate baseline options that do not comply with legal or regulatory requirements

Any options for CBM/CMM/VAM management and use that do not meet with local legal or regulatory requirements should be eliminated. The project participants shall provide evidence and supporting documents to exclude baseline options that meet the above-mentioned criteria.

Step 3: Formulate baseline scenario alternatives

On the basis of the options that are technically feasible and comply with all legal and regulatory requirements, the project participants should construct coherent and comprehensive baseline scenario alternative(s). One of these alternative(s) shall be the CDM project activity not being registered as a CDM project.

All alternative(s) shall be in compliance with all applicable legal and regulatory requirements, even if these laws and regulations have objectives other than GHG reductions, e.g. to mitigate local air pollution. This does not consider national and local policies that do not have legally-binding status.

If an alternative does not comply with all applicable legislation and regulations, then show that, based on an examination of current practice in the country or region in which the law or regulation applies, those applicable legal or regulatory requirements are systematically not enforced and that non-compliance with those requirements is widespread in the country. If this cannot be shown, then eliminate the alternative from further consideration.

The baseline scenario alternatives should clearly identify what share or volumes of potential CBM, CMM and VAM would be managed according to the different technology options, and what share or volumes of CBM/CMM/VAM would be used for which end-uses, where appropriate (including flaring and flameless oxidation if applicable). The baseline scenario alternatives should also identify whether the power used at the coalmine would be from the grid, from captive power, or a combination of the two.

Step 4: Eliminate baseline scenario alternatives that face prohibitive barriers

Establish a complete list of barriers that would prevent identified baseline scenario alternatives to occur in the absence of the CDM. Such barriers may include, among others:

Investment barriers *inter alia*:

- Debt funding is not available for this type of innovative project activity;
- Neither access to international capital markets due to real or perceived risks associated with domestic or foreign direct investment in the country where the project activity is to be implemented, nor sufficient ODA can be allocated to finance the considered project alternatives.

Technological barriers, *inter alia*:

- Skilled and/or properly trained labour to operate and maintain the technology is not available and no education/training institution in the Host country provides the needed skill, leading to equipment disrepair and malfunctioning;
- Lack of infrastructure for implementation of the technology.

Barriers due to prevailing practice, *inter alia*:

- The project activity is the "first of its kind": No project activity of this type is currently operational in the host country or region.

Provide transparent and documented evidence, and offer conservative interpretations of this documented evidence, as to how it demonstrates the existence and significance of the identified barriers. Anecdotal evidence can be included, but alone is not sufficient proof of barriers. The type of evidence to be provided may include:

(a) Relevant legislation, regulatory information or industry norms;

(b) Relevant (sectoral) studies or surveys (e.g. market surveys, technology studies, etc.) undertaken by universities, research institutions, industry associations, companies, bilateral/multilateral institutions, etc.;

(c) Relevant statistical data from national or international statistics;

(d) Documentation of relevant market data (e.g. market prices, tariffs, rules);

(e) Written documentation from the company or institution developing or implementing the CDM project activity or the CDM project developer, such as minutes from Board meetings, correspondence, feasibility studies, financial or budgetary information, etc.;

(f) Documents prepared by the project developer, contractors or project partners in the context of the proposed project activity or similar previous project implementations;

(g) Written documentation of independent expert judgements from industry, educational institutions (e.g. universities, technical schools, training centres), industry associations and others.

The baseline scenario alternatives that face barriers that would prohibit them from being implemented should be eliminated.

If all project alternatives are prevented by at least one barrier, either the proposed CDM project is itself the baseline, or the set of project alternatives has to be completed to include the potential baseline.

If there are several potential baseline scenario candidates that do not face barriers:

(1) Either choose the most conservative (results in least emissions) alternative as the baseline scenario, or
(2) Go to Step 5, and choose the economically most viable scenario as the baseline scenario.

Step 5: Identify most economically attractive baseline scenario alternative (optional)

Determine which of the remaining baseline scenario alternatives not prevented by any barrier is the most economically or financially attractive, and, therefore, is a possible baseline scenario. For this purpose, Step 2 (investment analysis) of the latest approved version of the "Tool for the demonstration and assessment of additionality" shall be used to identify the most plausible baseline scenarios by eliminating options which are clearly economically unattractive.

In these cases, investment comparison analysis should be applied, except in cases where the alternative does not involve an investment (e.g. consumption of electricity from the grid) where a benchmark analysis should be applied.

Additionality

The additionality of the project activity shall be demonstrated and assessed using the latest version of the "Tool for the demonstration and assessment of additionality" agreed by the Executive Board.[2]

This section elaborates on the use of the tool, and in particular how it relates to the selection of the baseline scenario. Because of the similarity of both approaches used to determine the baseline scenario and the additionality tool, Step 1 of the "Tool for the demonstration and assessment of additionality" can be ignored.

Consistency shall be ensured between baseline scenario determination and additionality demonstration.

The baseline scenario alternative selected in the previous section shall be used when applying Steps 2 (or 3) to 5 of the "Tool for the demonstration and assessment of additionality".

The investment analysis approach, if used, should identify whether the baseline scenario selected above is economically and/or financially more attractive than the CDM project activity if not registered as a CDM project.

Project Emissions

Project emissions are defined by the following equation:

$$PE_y = PE_{ME} + PE_{MD} + PE_{UM} \quad \textbf{(1)}$$

[2] Please refer to: <http://cdm.unfccc.int/methodologies/PAmethodologies/approved.html>.

Where:

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

Combustion emissions from additional energy required for CBM/CMM/VAM capture and use

Additional energy may be used for the capture, transport, compression and use or destruction of CBM/CMM/VAM. Emissions from this energy use should be included as project emissions.

$$PE_{ME} = CONS_{ELEC,PJ} \times CEF_{ELEC} + CONS_{HEAT,PJ} \times CEF_{HEAT} + CONS_{Foss\ Fuel,PJ} \times CEF_{Foss\ Fuel} \quad \textbf{(2)}$$

Where:

PE_{ME}	=	Project emissions from energy use to capture and use or destroy methane (tCO_2e)
$CONS_{ELEC,PJ}$	=	Additional electricity consumption for capture and use or destruction of methane, if any (MWh)[3]
CEF_{ELEC}	=	Carbon emissions factor of electricity used by coal mine (tCO_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 coal mine (tCO_2e/GJ)
$CONS_{FossFuel,PJ}$	=	Additional fossil fuel consumption for capture and use or destruction of methane, if any (GJ)[4]
$CEF_{FossFuel}$	=	Carbon emissions factor of fossil fuel used by coal mine (tCO_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 coalmine is the grid, then the formulae from "Tool 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 coalmine is captive power generation, then the emissions factor is calculated based on the emission factor for the fuel used and the 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 CMM/CBM or more than 0.1% by volume of the extracted VAM, combustion emission from these gases should also be included.

$$PE_{MD} = (MD_{FL} + MD_{OX} + MD_{ELEC} + MD_{HEAT} + MD_{GAS}) \times (CEF_{CH4} + r \times CEF_{NMHC}) \quad \textbf{(3)}$$

with:

[3] For instance, VAM units will consume electricity in fan motors, which are required to push the VAM through the unit without creating any back-pressure on the existing mine ventilation systems.

[4] Pre-heating of VAM units prior to start-up will utilize some form of heat, most likely bottled butane or propane. Emissions from this source will be counted as $CONS_{FossFuel,PJ}$

$r = PC_{NMHC} / PC_{CH4}$ **(4)**

Where:[5]

PE_{MD}	=	Project emissions from CMM/CBM destroyed (tCO_2e)
MD_{FL}	=	Methane destroyed through flaring (tCH_4)
MD_{OX}	=	Methane destroyed through flameless oxidation (tCH_4)
MD_{ELEC}	=	Methane destroyed through power generation (tCH_4)
MD_{HEAT}	=	Methane destroyed through heat generation (tCH_4)
MD_{GAS}	=	Methane destroyed after being supplied to gas grid or for vehicle use (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
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 of each end use.

$MD_{FL} = MM_{FL} - (PE_{flare}/GWP_{CH4})$ **(5)**

Where:

MD_{FL}	=	Methane destroyed through flaring (tCH_4)
MM_{FL}	=	Methane measured sent to flare (tCH_4)
PE_{flare}	=	Project emissions of non-combusted CH_4, expressed in terms of CO_{2e}, from flaring of the residual gas stream (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}) 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.

$MD_{OX} = MM_{OX} - PE_{OX}$ **(6)**

Where:

MD_{OX}	=	Methane destroyed through flameless oxidation (tCH_4)
MM_{OX}	=	Methane measured sent to flameless oxidizer (tCH_4)
PE_{OX}	=	Project emissions of non oxidized CH_4 from flameless oxidation of the VAM stream (tCH_4)

And where:

$MM_{OX} = VAM_{flow.rate,y} * time_y * PC_{CH4.VAM} * D_{CH4,corr\ inflow}$ **(6a)**

[5] Note that throughout this baseline methodology, it is assumed that measured quantities of coal mine gas are converted to tonnes of methane using the measured methane concentration of the coal mine gas and the density of methane.

Where:

$VAM_{flow.rate,y}$	=	Average flow rate of VAM entering the flameless oxidation unit during period 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 flameless oxidation unit (m^3/m^3)
$D_{CH4,corr\ inflow}$	=	Density of methane entering the flameless oxidation unit corrected for pressure and temperature ($P_{VAMinflow}$ and $T_{VAMinflow}$ respectively) (tCH_4/m^3)

and

$$PE_{OX} = VAM_{flow.rate,y} * time_y * PC_{CH4.exhaust} * D_{CH4,corr\ exh} \quad \textbf{(6b)}$$

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%.

$$MD_{ELEC} = MM_{ELEC} \times Eff_{ELEC} \quad \textbf{(7)}$$

Where:

MD_{ELEC}	=	Methane destroyed through power generation (tCH_4)
MM_{ELEC}	=	Methane measured sent to power plant (tCH_4)
Eff_{ELEC}	=	Efficiency of methane destruction/oxidation in power plant (taken as 99.5% from IPCC)

$$MD_{HEAT} = MM_{HEAT} \times Eff_{HEAT} \quad \textbf{(8)}$$

Where:

MD_{HEAT}	=	Methane destroyed through heat generation (tCH_4)
MM_{HEAT}	=	Methane measured sent to heat plant (tCH_4)
Eff_{HEAT}	=	Efficiency of methane destruction/oxidation in heat plant (taken as 99.5% from IPCC)

$$MD_{GAS} = MM_{GAS} \times Eff_{GAS} \quad \textbf{(9)}$$

Where:

MD_{GAS}	=	Methane destroyed after being supplied to gas grid (tCH_4)
MM_{GAS}	=	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)[6]

[6]The Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories gives 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}

Un-combusted methane from project activity

Not all of the methane sent to the flare, to the flameless 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:

$$PE_{UM} = [GWP_{CH4} \times \sum_i MM_i \times (1 - Eff_i)] + PE_{flare} + PE_{OX} \times GWP_{CH4} \quad \textbf{(10)}$$

Where:

PE_{UM}	=	Project emissions from un-combusted methane (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)
MM_i	=	Methane measured sent to use i (tCH_4)
Eff_i	=	Efficiency of methane destruction in use i (%)
PE_{flare}	=	Project emissions of non-combusted CH_4 expressed in terms of CO_{2e} from flaring of the residual gas stream (tCO_2e)
PE_{OX}	=	Project emissions of non oxidized CH_4 from flameless oxidation of the VAM stream (tCH_4)

The project emissions from flaring of the residual 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.

Baseline Emissions

Baseline emissions are given by the following equation:

$$BE_y = BE_{MD,y} + BE_{MR,y} + BE_{Use,y} \quad \textbf{(11)}$$

Where:

BE_y	=	Baseline emissions in year y (tCO_2e)
$BE_{MD,y}$	=	Baseline emissions from destruction of methane in the baseline scenario in year y (tCO_2e)
$BE_{MR,y}$	=	Baseline emissions from release of methane into the atmosphere in year y that is avoided by the project activity (tCO_2e)
$BE_{Use,y}$	=	Baseline emissions from the production of power, heat or supply to gas grid replaced by the project activity in year y (tCO_2e)

Methane destruction in the baseline

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

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.

Depending on the baseline scenario, part of this methane may be destroyed in the baseline scenario through flaring, flameless oxidation, power generation, heat generation, supply to gas grid to various combustion end uses. Baseline emissions should account for the CO_2 emissions resulting from the destruction of that methane.

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

Where:

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

with :

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

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 to estimate conservatively 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 to data for *ex ante* projections of methane demand in order to use this methodology.

Calculation of the mean annual demand (Thy) 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, this section presumes that such power generation (or other uses) projects are designed to primarily (or exclusively) use extracted VAM/CMM that would *not* be used for baseline thermal energy 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.

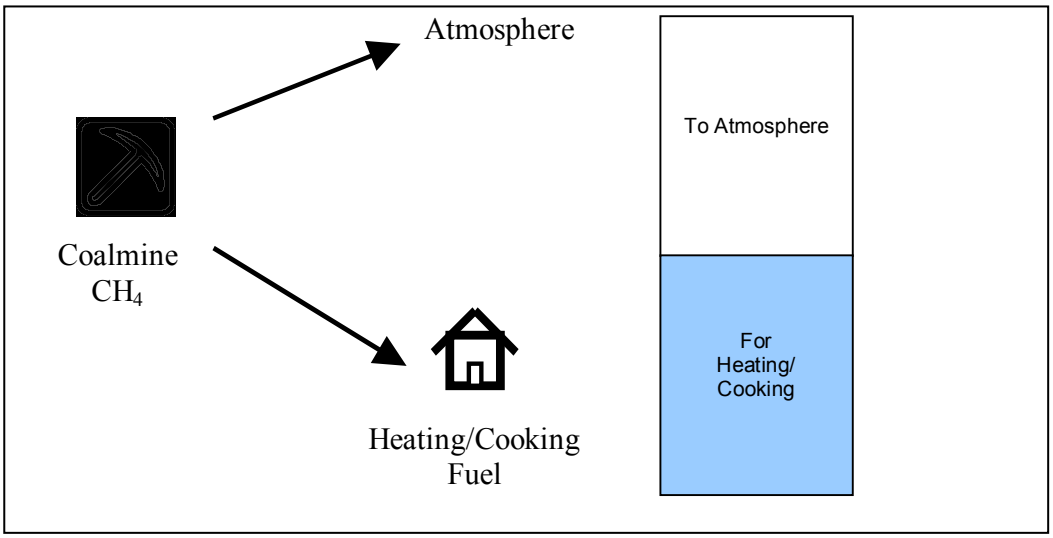

Figure 1: Baseline Disposition of VAM/CMM/CBM

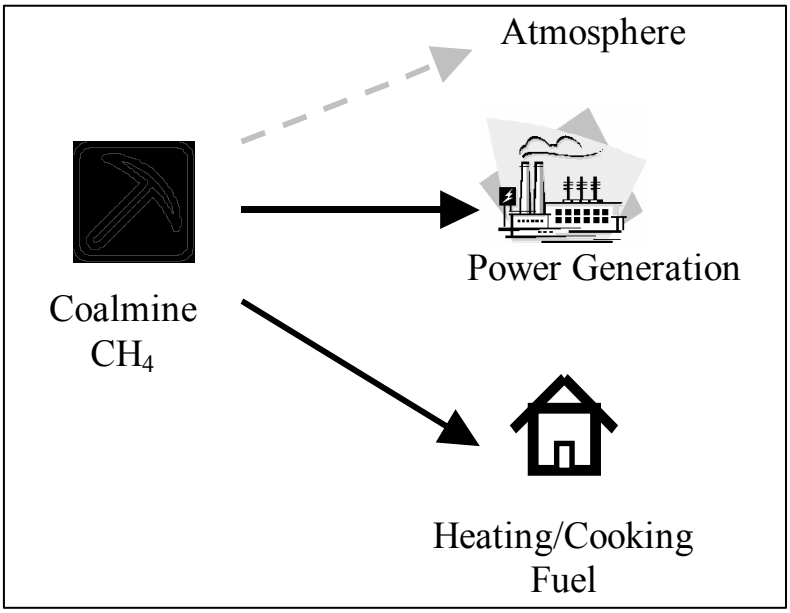

Figure 2: Project Case Disposition of VAM/CMM/CBM

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

Under some circumstances, some portion of the VAM/CMM/CBM used by a project for power generation might otherwise have gone to produce thermal energy under the baseline. This situation is shown in Figure 3, indicating an "overlap" between VAM/CMM/CBM used for power and baseline use of VAM/CMM for heating/cooking. This overlap may occur if VAM/CMM flows fall below expected levels (left column at bottom of Figure 3), or if baseline thermal energy demand exceeds expected levels (right column at bottom of Figure 3). Such overlaps may occur even where total annual VAM/CMM/CBM 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 in the baseline. Emissions from the project are reduced only to the extent that the power generation uses methane that would have been *emitted* in the baseline (i.e., "emitted to atmosphere" in Figure 1).

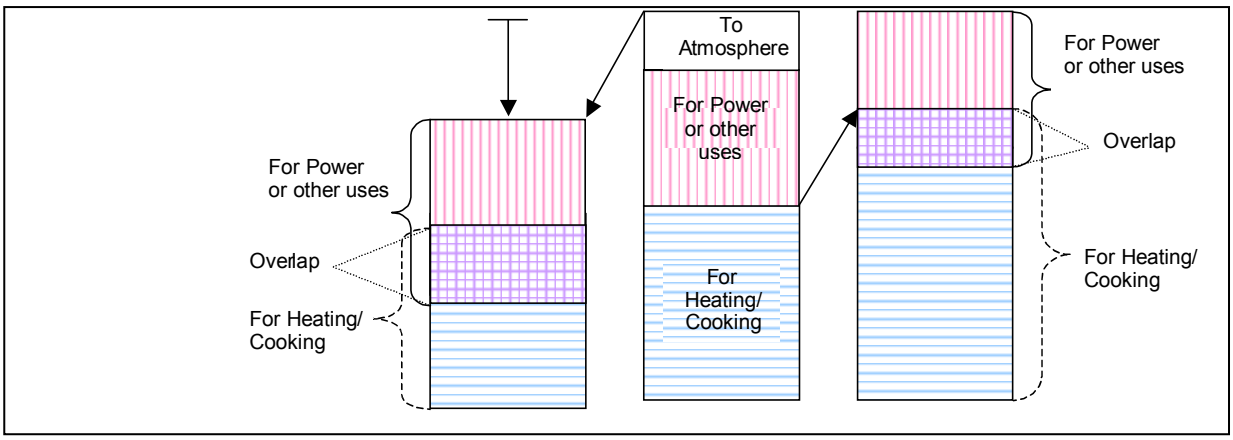

Figure 3: Project Case VAM/CMM/CBM for Power (or other uses) Overlaps with Baseline Thermal VAM/CMM

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

The likely fluctuation around daily estimates of baseline thermal energy demand for CBM/VAM/CMM 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 on each day.

These sources of volatility are combined into a single distribution around daily estimates of thermal energy demand. This distribution is in 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 with the following equation:

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

Where:

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

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

$$TH_{BL,k} = \frac{TH_{BL,y}}{365} \times d_k^{\max} \quad \textbf{(15)}$$

Where:

$TH_{BL,k}$	=	Methane used to serve 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 $\Sigma d_k=365$
$d_k^{\max}$	=	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. $d_k^{\max}$).

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 VAM/CMM/CBM distribution system operators, supported by a detailed description of the drivers of, and constraints on, future VAM/CMM/CBM thermal energy demand.
The project participants will use the methods below to project thermal energy demand. If using approach (b) project proponents must document why (a) cannot be used. If using approach (c) project proponents must document why neither (a) or (b) can be used.

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

- Who the users of VAM/CMM for thermal energy are, by quantity and type (e.g., residential, commercial, industrial);
- What service agreements are in place with these end users;
- Average VAM/CMM/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 VAM/CMM/CBM thermal energy system;
- The cost/benefits of expanding the VAM/CMM/CBM delivery system to additional end users;
- The type and cost of alternative fuels for potential or existing VAM/CMM/CBM thermal energy customers, compared to the cost of delivering VAM/CMM/CBM;
- Any other variables relevant to the particular thermal energy VAM/CMM/CBM distribution system associated with the project.

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

(b) *Statistical projection*. If detailed information on thermal energy demand or the existing VAM/CMM distribution system is not available, project proponents may use a statistical projection based on VAM/CMM/CBM availability and thermal energy VAM/CMM/CBM 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 may be estimated from the maximum amount of VAM/CMM/CBM that could be delivered to end users through existing pipelines. To be conservative, this approach should assume that thermal energy demand for VAM/CMM/CBM in all future years will be equal to the maximum amount of VAM/CMM/CBM that can be delivered. Maximum throughput estimates should be based on a detailed engineering description of the existing pipeline infrastructure. This analysis may also inform the analysis for (a) and (b), above.

Methane released into the atmosphere

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

This methane would have been emitted to the atmosphere in the baseline scenario, unless some capture and use activities form part of the baseline:

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

Where:

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

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

For CBM captured, the avoided emissions should only be credited in the year in which the seam is mined through the CBM well influence zone, as explained in the next section.

Eligible CBM

The approach to quantify the eligible CBM is to identify the zone of influence of CBM wells, and when these are impacted by mining activities.

Step 1: Identify relevant wells

The first step is to identify the drilling plan and the wells that will be intersected by mining or are likely to extract methane from an area that will overlap with future coal extraction.

The location of CBM wells in relation to the mine concession area and mining plan during the initial crediting period is estimated using the latest mine plan information, and a map should be included in the Project Design Document. An indicative mining map showing relevant CBM wells and their zones of influence is shown in Figure 4.

Note: Wells that extract virgin coal bed methane, i.e. from areas that would not be mined and would not influence eventual CMM emissions in mined areas, are out of the boundary of both the baseline and the project. Any activity intending to extract and use such virgin coal bed methane should refer to another methodology.

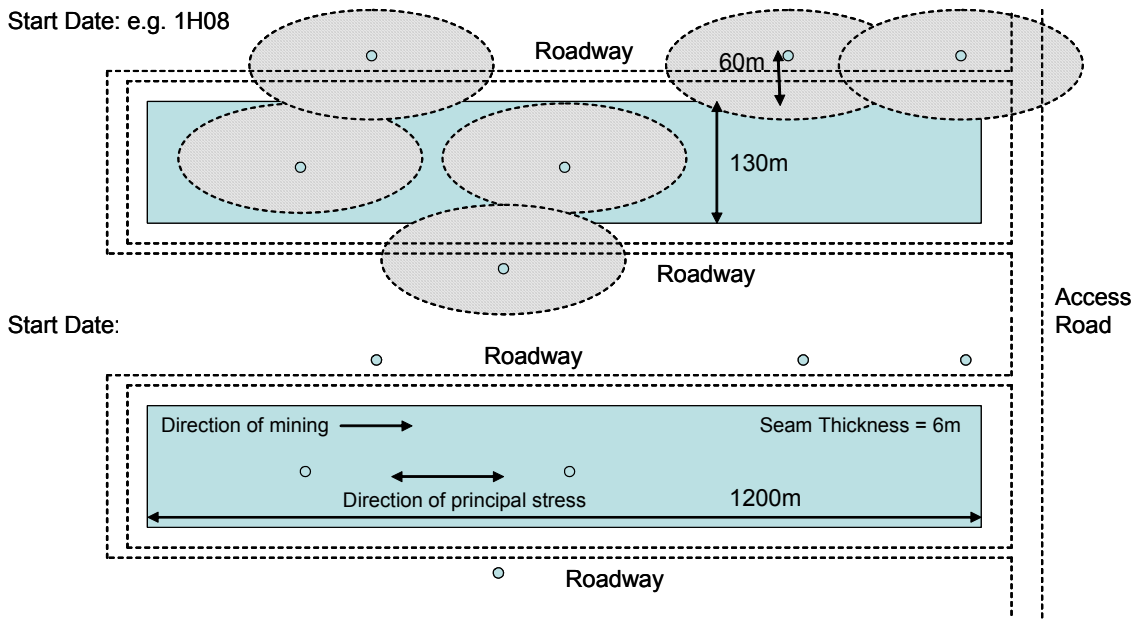

Figure 4: Indicative Figure Showing Mining Plan, relevant CBM wells and their zones of influence

Step 2: Estimation of the Zone of Influence of a CBM Well and eligible methane

This methodology estimates the overlap between a cylindrical gas drainage zone around a production well with the zone of disturbance around a longwall panel, from which gas is emitted into the mine.

A generalised zone or radius of influence, R, for a particular well can be estimated at any time during the pre drainage process based on either (i) the cumulative flow measured at the well V_w or (ii) on the total cumulative gas drained from all the wells measured at the centralised monitoring station V_c. Idealised uniform degassing is assumed within a cylindrical zone centred on the borehole and a constant production flow.

(i) Using cumulative flow at an individual well:

$$R = ((V_w)/(\pi \times T \times \rho_{coal} \times g_{coal}))^{0.5} \quad \textbf{(17)}$$

Where:

R	=	Cumulative radius of zone of influence (m)
V_w	=	Cumulative flow measured at an individual well (m^3)
T	=	Total thickness of coal in section accessed by well (m)
ρ_{coal}	=	Density of locally mined coal (t/m^3)– default value 1.4 t/m^3
g_{coal}	=	Gas content of the coal (m^3 CH_4/tonne coal)

(ii) Using cumulative flow from a number of wells:

$$R = ((n \times V_a)/(\pi \times T \times \rho_{coal} \times g_{coal}))^{0.5} \quad \textbf{(18)}$$

Where:

R	=	Cumulative radius of zone of influence (m)
n	=	Number of days the selected wells are operational
V_a	=	Average flow per day across all wells (m^3/d)
T	=	Total thickness of coal in section accessed by well (m)
ρ_{coal}	=	Density of locally mined coal – default value 1.4 t/m^3
g_{coal}	=	Gas content of the coal (tCH_4/tonne coal)

and

$$V_a = V_c / N = \frac{\sum V_w}{N} \quad \textbf{(19)}$$

Where:

V_a	=	Average flow per day (m^3/d)
V_c	=	Total cumulative gas drained from all the wells measured at the centralised monitoring station (m^3)
V_w	=	Cumulative flow measured at an individual well (m^3)
N	=	Sum of days that all wells have been operational (days)

As an example, taking the density of coal as 1.4 tonne per m^3, the gas in coal to be 12 m^3 per tonne, the thickness of the section to be 40 metres and the flow rate to be 2400m^3/day, then the radius of zone of influence will increase by 20 m per year. Therefore, if the number pre-drainage years are 'n' the corresponding radius of zone of influence will be n x20 m. The Project Design Document should elaborate the project specific values for the zone of influence.

Area of Overlap

Once the zone of influence for a well in a given year overlaps the longwall panel to be mined, then the gas from the well is considered to be eligible CBM. To estimate portion of CBM that would have been released from mining activities, a geometric approach in the horizontal plane and the vertical plane is used where the area of overlap between the defined zones of influence for each well and the longwall panel to be mined ("*Area of Overlap*") is used as well as the de-stressing zone above and below the seam to be mined.

<u>*Horizontal plane*</u>*:* The ratio of the Area of Overlap to the total area of the zones of influence of the wells considered is calculated and used to identify the appropriate share of gas counted as eligible CBM. The equations for this are:

$$ES_h = \frac{\sum_w AO_w}{\sum_w AT_w} \quad \textbf{(20)}$$

Where:

ES_h	=	Eligible share of CBM based on the horizontal plane overlap (%)
AO_w	=	Area of overlap of well w with the longwall mining panel (m^2)
AT_w	=	Total zone of influence of well w (m^2)
w	=	CBM wells with zones of influence that overlap with mining activity

Note that for CBM wells which will be physically intersected by mining, ES_h is unity by definition. In other words, all of the CBM drained from this type of well is eligible, unless there is gas coming from seams beyond the de-stressing zone.

Vertical plane: The de-stressing zone typically extends upwards 140 m and downwards 40 metres. If cased boreholes are used and the seams are fractured within the de-stressing zone, then all the gas entering the CBM well is gas that would have appeared as methane in ventilation air and CMM during and after mining. If other seams outside of the de-stressed zone are fractured, then this gas must be excluded from the eligible CBM. The eligible share is defined as follows:

$$ES_v = \frac{t}{T} \quad \textbf{(21)}$$

Where:

ES_v	=	Eligible share of CBM based on the vertical plane overlap (%)
t	=	Thickness of coal which lies within the longwall emission zone (m)
T	=	Total thickness of coal that is producing gas in the production well (m)

The value for ES_v would be 1 for cased boreholes where fraccing is only done in the seams of relevance. A mine cross section should be included in the PDD together and supporting documentation on the well drilling process should be supplied to the Validator to justify the ratio of *t/T*.

Eligible CBM: Summarising the eligible contribution of CBM in the horizontal and vertical planes gives the final ratio of eligible CBM:

$$ES_t = ES_h \cdot ES_v \quad \textbf{(22)}$$

Where:

ES_t	=	Total eligible share of CBM (%)
ES_h	=	Eligible share of CBM based on the horizontal plane overlap (%)
ES_v	=	Eligible share of CBM based on the vertical plane overlap (%)

CO_2 emissions from use or destruction of CBM

Note that while only the eligible CBM should be accounted to calculate the volume of methane emissions avoided by the project, the totality of the CO_2 resulting from the use or the destruction of all the CBM extracted should be accounted as project emissions.
Note that once a CBM well has been mined through, then the well acts in the same manner as conventional underground post mining CMM drainage (surface goaf well) and therefore all of the methane that is drained through this type of well is eligible, irrespective of whether the well is drilled off-centre to the longwall panel and some of the area of influence is outside the area of the longwall panel.

The Project Design Document should contain the relevant project specific data in order to calculate an *ex ante* estimate of the above. Furthermore this will be updated ex-post using mining plans and accurate measurements of the locations of the actually drilled wells, as the final location of the relevant CBM wells will be determined after proper risk assessments and taking into account local conditions for drilling.

If any CBM wells that were planned to be intersected by mining, or their zones of influence overlap with mining, are not reached by the mining activities, then corresponding methane extracted should not be taken into account in the emission reduction calculation.

Step 3: Temporal adjustments for baseline emissions within a defined crediting period

No emission reductions from CBM utilization and or destruction can be claimed until the mining activity enters the zone of influence of the well. At that time the emission reductions from the share of eligible pre-drainage and subsequent post-drainage methane can be claimed. This is calculated as follows:

$$CBM_{e,y} = \left[ES_t \cdot \sum_{w} \sum_{m=1}^{y-b} V_{w,y-m} \right] + \left[ES_t \cdot \sum_{w} V_{w,y} \right] \quad \textbf{(23)}$$

Where:

$CBM_{e,y}$	=	Eligible CBM captured by the project for year *y* (tCH_4)
ES_t	=	Total eligible share of CBM (%)
$V_{w,y-m}$	=	Volume of methane captured from well *w* in year *y-m* (tCH_4)
$V_{w,y}$	=	Volume of methane captured from well *w* in year *y* (tCH_4)
W	=	Number of wells where mining reached the zone of influence in year *y*
b	=	Initial year of crediting period

Note that the first term covers the sum of all the methane drained from each new well for which mining has actually entered the zone of influence during a given year *y*, from the start of the crediting period to the end of the previous year (i.e. end of year *y*-1). The second term covers the sum of all methane drained from each well for which mining has entered the zone of influence for the year *y*. For example, at a mine in which 5 CBM wells had been drilled, if mining entered the zone of influence of all five wells in year 4, then in years 1 to 3 the eligible CBM would be zero. In year 4 it would be the cumulative volume for the previous 3 years plus the volume extracted in year 4. In year 5 it would only be the volume extracted in year 5.

Pre-mining and post-mining CMM extraction and VAM

Both $CMM_{PJ,y}$, $PMM_{PJ,y}$ and VAM are directly monitored as part of the project activity. In all three cases, the avoided methane equals the amount captured, less any that would have been captured in the baseline. The amount captured in the baseline may be defined as an absolute amount, or as a share of the amount captured in the project activity. In each case, these assumptions must be justified by the project participants.

Emissions from power/heat generation and vehicle fuel replaced by project

For emissions from displacing other energy forms, it is necessary to distinguish between emissions reductions derived from the use of CBM versus CMM, because CBM emissions reductions should only be credited once the mining area has intersected the zone of influence of the CBM well.

$$BE_{Use,y} = ED_{CBMw,y} + ED_{CBMz,y} + ED_{CPMM,y} \quad \textbf{(24)}$$

Where:

$BE_{Use,y}$	=	Total baseline emissions from the production of power or heat replaced by the project activity in year *y* (tCO_2)
$ED_{CBMw,y}$	=	Emissions from displacement of end uses by use of coal bed methane captured from wells where the mining area intersected the zone of influence in year *y* (tCO_2)
$ED_{CBMz,y}$	=	Emissions from displacement of end uses by use of coal bed methane captured from wells where the mining area intersected the zone of influence prior to year *y* (tCO_2)
$ED_{CPMM,y}$	=	Emissions from displacement of end uses by use of coal mine methane, VAM and post-mining methane (tCO_2)

The total methane captured during year *y* can be described as follows:

$$CBMM_{tot,y} = CBM_{w,y} + CBM_{z,y} + CBM_{x,y} + CMM_{PJ,y} + PMM_{PJ,y} + VAM_{PJ,y} \quad \textbf{(25)}$$

Where:

$CBMM_{tot,y}$	=	Total CBM, CMM and VAM captured and utilised by the project activity (tCH_4)
$CBM_{w,.y}$	=	CBM captured from wells where the mining area intersected the zone of influence in year *y* (tCH_4)
$CBM_{z,.y}$	=	CBM captured from wells where the mining area intersected the zone of influence prior to year *y* (tCH_4)
$CBM_{x,.y}$	=	CBM captured from wells where the mining area has not yet intersected the zone of influence in year *y* (tCH_4)
$CMM_{PJ,i,y}$	=	Pre-mining CMM captured by the project activity in year *y* (tCH_4)
$PMM_{PJ,y}$	=	Post-mining CMM captured by the project activity in year *y* (tCH_4)
$VAM_{PJ,y}$	=	VAM captured by the project activity year *y* (tCH_4)

The total potential emissions reductions from displacement of power/heat generation and vehicle fuels are given by the following equation:

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

Where:

$PBE_{Use,y}$	=	Potential total baseline emissions from the production of power or heat replaced by the project activity in year *y* (tCO_2e)
GEN_y	=	Electricity generated by project activity in year *y* (MWh), including through the use of CBM
EF_{ELEC}	=	Emissions factor of electricity (grid, captive or a combination) replaced by project (tCO_2/MWh)
$HEAT_y$	=	Heat generation by project activity in year *y* (GJ), including through the use of CBM
EF_{HEAT}	=	Emissions factor for heat production replaced by project activity (tCO_2/GJ)
$VFUEL_y$	=	Vehicle fuel provided by the project activity in year *y* (GJ), including through the use of CBM
EF_V	=	Emissions factor for vehicle operation replaced by project activity (tCO_2/GJ)

To identify the CBM/CMM that should receive credits in the year during which the gas is captured and used, the following formulae are used, assuming that CMM and CBM are used for various end uses in the same proportions as the overall supply for that year of different gas sources:

$$ED_{CBMz,y} = \frac{CBM_{z,y}}{CBMM_{tot,y}} \times PBE_{Use,y} \quad \textbf{(27)}$$

Where:

$ED_{CBMz,y}$	=	Emissions from displacement of end uses by use of coal bed methane captured from wells where the mining area intersected the zone of influence prior to year *y* (tCO_2e)
$CBM_{z,y}$	=	CBM captured from wells where the mining area intersected the zone of influence prior to year *y* (tCH_4)
$CBMM_{tot,y}$	=	Total CBM, CMM and VAM captured and utilised by the project activity in year *y* (tCH_4)
$PBE_{Use,y}$	=	Potential total baseline emissions from the production of power or heat replaced by the project activity in year *y* (tCO_2e)

$$ED_{CPMM,y} = \frac{CMM_{PJ,y} + PMM_{PJ,y} + VAM_{PJ,y}}{CBMM_{tot,y}} \times PBE_{Use,y} \quad \textbf{(28)}$$

Where:

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

$$ED_{CBMw,y} = \sum_{m=0}^{y-b} \left[\frac{CBM_{w,y-m}}{CBMM_{tot,y-m}} \times PBE_{Use,y-m} \right] \quad \textbf{(29)}$$

Where:

$ED_{CBMw,y}$	=	Emissions from displacement of end uses by use of coal bed methane captured from wells where the mining area intersects the zone of influence in year *y* (tCO_2e)
$CBM_{w,y-m}$	=	CBM captured in the year y-m from wells where the mining area intersected the zone of influence in year *y* (tCH_4)
$CBMM_{tot,y-m}$	=	Total CBM, CMM and VAM captured and utilised by the project activity in year y-m (tCH_4)
$PBE_{Use,y-m}$	=	Potential total baseline emissions from the production of power or heat replaced by the project activity in year y-m (tCO_2e)
b	=	Initial year of crediting period

Note that no emissions reductions are associated with $CBM_{x,y}$, so the actual baseline emissions in each year will vary from the potential baseline emissions.

Grid power emission factor

If the baseline scenario includes grid power supply that would be replaced by the project activity, the Emissions Factor for displaced 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 displaced electricity is calculated as follows:

$$EF_{captive,y} = \frac{EF_{CO2,i}}{Eff_{captive}} \cdot \frac{44}{12} \cdot \frac{3.6TJ}{1000MWH} \quad \textbf{(30)}$$

Where:

$EF_{captive,y}$	=	Emissions factor for captive power generation (tCO_2/MWh)
$EF_{CO2,i}$	=	CO_2 emissions 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 emissions factor for the baseline is the weighted average of the emissions factor for grid power and captive power.

$$EF_{ELEC,y} = s_{grid} \cdot EF_{grid,y} + s_{captive} \cdot EF_{captive,y} \quad \textbf{(31)}$$

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 facility electricity demand supplied by grid imports over the last 3 years (%)[7]
$s_{captive}$	=	Share of facility electricity demand supplied by captive power over the last 3 years (%)[2]

[7] 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.

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 displaced heat generation is calculated as follows:

$$EF_{heat,y} = \frac{EF_{CO2,j}}{Eff_{heat}} \cdot \frac{44}{12} \cdot \frac{1TJ}{1000GJ} \quad \textbf{(32)}$$

Where:

$EF_{heat,y}$	=	Emissions factor for heat generation (tCO_2/GJ)
$EF_{CO2,i}$	=	CO_2 emissions factor of fuel used in heat generation (tC/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 boiler efficiency, project participants may choose between the following two options:

Option A:

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

- Measured efficiency prior to project implementation;
- Measured efficiency during monitoring;
- 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.

Vehicle fuel use emissions factor

If the baseline scenario includes vehicle operation that will be fuelled by gas produced by the project activity, the Emissions Factor for displaced vehicle fuel use is calculated as follows:

$$EF_V = \frac{EF_{CO2,j}}{EFF_V} \cdot \frac{44}{12} \cdot \frac{1TJ}{1000GJ} \quad \textbf{(33)}$$

Where:

EF_V	=	Emissions factor for vehicle operation replaced by project activity (tCO_2/GJ)
$EF_{CO2,i}$	=	CO_2 emissions factor of fuel used for vehicle operation (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 project implementation;
- Measured fuel efficiency during monitoring;
- Manufacturer reported data for efficiency for vehicle.

Leakage

The formula for leakage is given as follows:

$$LE_y = LE_{d,y} + LE_{o,y} \quad \textbf{(34)}$$

Where:

LE_y	=	Leakage emissions in year *y* (tCO_2e)
$LE_{d,y}$	=	Leakage emissions due to displacement of other baseline thermal energy uses of methane in year *y* (tCO_2e)
$LE_{o,y}$	=	Leakage emissions due to other uncertainties in year *y* (tCO_2e)

Displacement of baseline thermal energy uses

Leakage may occur if the project activity prevents CMM/CBM from being used to meet baseline thermal energy demand, whether as a result of physical constraints on delivery, or price changes. Where regulations require that local thermal demand is 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 CMM 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 is not available, of project-case demand for CMM for non-thermal uses compared against estimates of baseline CMM demand for thermal uses. For each day (or month) of the crediting period, this form of leakage must be calculated if:

$$ME_k - (MM_{ELEC,k} + MM_{HEAT,k}) < TH_k \quad \textbf{(35)}$$

with:

$$TH_k = \frac{\overline{TH_{BL}}}{365} \times d_k^{\max} \quad \textbf{(36)}$$

Where:

ME_k	=	Methane extracted on day *k* (tCH_4)
$MM_{ELEC,k}$	=	Methane measured sent to power plant on day *k* (tCH_4)
$MM_{HEAT,k}$	=	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 (tCH_4)
d_k	=	Scalar adjustment factor for day k to reflect seasonal variations such that $\Sigma d_k=365$
$d_k^{\max}$	=	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 CMM/VAM that would have gone to meet thermal energy demand in the baseline scenario is instead used by the project. 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 CMM/VAM diverted from thermal uses existing in the baseline diverted to other uses by the project should be calculated on a daily basis, and then summed up for each year *y*:

$$ED_{th,y} = \Sigma(ED_{th,k}) = \Sigma[\max(0, (TH_k - (ME_k - (MM_{ELEC,k} + MM_{HEAT,k}))) \times NCV_{CH4}] \quad \textbf{(37)}$$

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* (tCH_4)
$MM_{ELEC,k}$	=	Methane measured sent to power plant on day *k* (tCH_4)
$MM_{HEAT,k}$	=	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 VAM/CMM is not available. They must then calculate the amount of alternative fuel required to provide the same heat output as the VAM/CMM.

$$Q_{AF,y} = ED_{th,y} / NCV_{AF} \quad \textbf{(38)}$$

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:

$$LE_{d,y} = Q_{AF,y} \times NCV_{AF} \times EF_{AF} \times OXID \quad \textbf{(39)}$$

Where:

$LE_{d,y}$	=	Leakage emissions in year *y* (tCO_2e)
$Q_{AF,y}$	=	Quantity of alternative fuels displaced by the project activity in year *y* (tonnes or m^3)
NCV_{AF}	=	Net calorific value for alternative fuels (GJ/tonne or m_3)
EF_{AF}	=	Emissions factor for alternative fuel (tCO_2/GJ), sourced from IPCC
OXID	=	Oxidation efficiency of combustion (%), sourced from IPCC

CBM drainage from outside the de-stressed zone

Surface CBM drainage wells can in some cases drain gas from seams that are outside the de-stressed zone for 140m specified in this methodology, or could extract from an area larger than the circular zone of influence used in this methodology. The vertical leakage would only occur if the surface wells were not cased. Similarly, if there is surface CBM extraction in the baseline, then the gas drawn from other seams would be the same in the baseline and project scenario. Therefore, in cases where:

(1) Surface boreholes drilled in the project activity are not cased;
(2) There are no surface boreholes for CBM draining present in the baseline scenario.

Project participants should discount the total emissions reductions achieved. The amount of discount should be based on:

Option 1: A comparison of *ex ante* engineering estimates of CBM production from surface boreholes versus actual project activity CBM production;
Option 2: A standard discount factor of 10%.

Impact of CDM project activity on coal production

The additional CBM/CMM extraction from the CDM project activity could in some cases release certain constraints that currently limit mining operations. In cases of gassy mines where production is constrained by gas drainage capacity (i.e. too high concentration requires temporary interruption of mining operation), CER value can cover both the cost of CMM/CBM destruction and increase of extraction capacity to release the concentration constraint, then allowing increased coal production. This will only be the case, however, when no CBM/CMM extraction is present in the baseline scenario (i.e. the baseline scenario is ventilation of mine gas only).

If the project activity is CBM/CMM extraction and the baseline scenario is ventilation only, project participants should:

Option 1: Calculate the extra coal production likely by the relaxing of the production constraint. The emission reductions claimed by the project should then be discounted so that CBM/CMM capture from the additional coal production is not included;
Option 2: Apply a standard discount factor of 10%. Note that for projects using CBM this leakage is to be calculated in addition to leakage described in section "CBM drainage from outside the de-stressed zone" above.

Impact of CDM project activity on coal prices and market dynamics

Depending on relative market price of coal and the value of CERs for the CDM project activity, the new carbon revenue could theoretically eventually induce a decrease in coal prices and, as a result, lead to an increase of coal demand (i.e. a rebound effect). The share of coal in national energy demand could therefore increase, leading to higher emissions that could offset emission reduction achieved through CMM/CBM destruction.

While this impact is theoretically possible, reliable scientific information is not currently available to assess this risk and check if the phenomenon would be negligible or not. Moreover, it is difficult to assess *ex ante* the contribution of any particular project given the dynamic nature of local and global coal markets.[8]

[8] The Meth Panel recommends that the EB further investigate and monitor this issue after approving this methodology and considers to decide after 2-3 years of projects being implemented using this methodology, whether it should be revised to reflect price and market impacts.

Emission Reductions

The emission reduction ER_y by the project activity during a given year y is the difference between the baseline emissions (BE_y) and project emissions (PE_y), as follows:

$$ER_y = BE_y - PE_y - LE_y \quad \textbf{(40)}$$

Where:

ER_y	=	Emissions reductions of the project activity during the year y (tCO_2e)
BE_y	=	Baseline emissions during the year y (tCO_2e)
PE_y	=	Project emissions during the year y (tCO_2e)
LE_y	=	Leakage emissions in year y (tCO_2e)

Note that, because emissions reductions from CBM are only credited when the seam is mined through, there could be cases where CBM drainage commenced before the start of the crediting period.

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:	$TH_{BL,y}$
Data unit:	tCH_4
Description:	Projected annual baseline CMM/CBM demand for thermal energy uses
Source of data:	
Measurement procedures (if any):	
Monitoring frequency:	*Ex ante*
QA/QC procedures:	
Any comment:	Estimated by procedure defined in the corresponding baseline methodology

Data / Parameter:	d_k^{max}
Data unit:	
Description:	Scalar adjustment factor for day k, based on the seasonal load shape ($\Sigma\ d_k^{max} > 365$)
Source of data:	
Measurement procedures (if any):	
Monitoring frequency:	*Ex ante*
QA/QC procedures:	
Any comment:	

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

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

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

Data / Parameter:	$VAM_{BLi,y}$
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):	
Monitoring frequency:	Estimated *ex ante* at start of project
QA/QC procedures:	
Any comment:	

Data / Parameter:	$CBMe_{i,y}$
Data unit:	tCH_4
Description:	Eligible CBM captured, sent to and destroyed by use *i* in the project for year *y*
Source of data:	
Measurement procedures (if any):	
Monitoring frequency:	Yearly
QA/QC procedures:	
Any comment:	

Data / Parameter:	$CBM_{BL,i,y}$
Data unit:	tCH_4
Description:	CBM that would have been captured , sent to and destroyed by use *i* in the baseline scenario
Source of data:	
Measurement procedures (if any):	
Monitoring frequency:	*Ex ante*
QA/QC procedures:	
Any comment:	

Data / Parameter:	$CMM_{BL, i,y}$
Data unit:	tCH_4
Description:	Pre-mining CMM that would have been captured , sent to and destroyed by use *i* in the baseline scenario in year *y*
Source of data:	
Measurement procedures (if any):	
Monitoring frequency:	*Ex ante*
QA/QC procedures:	
Any comment:	

Data / Parameter:	$VAM_{BL, i,y}$
Data unit:	tCH_4
Description:	VAM that would have been captured , sent to and destroyed by use *i* in the baseline scenario in year *y*
Source of data:	
Measurement procedures (if any):	
Monitoring frequency:	*Ex ante*
QA/QC procedures:	
Any comment:	

Data / Parameter:	$PMM_{BL,\,i,y}$
Data unit:	tCH_4
Description:	Post-mining CMM that would have been captured, sent to and destroyed by use *i* in the baseline scenario in year *y*
Source of data:	
Measurement procedures (if any):	
Monitoring frequency:	*Ex ante*
QA/QC procedures:	
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 CMM/CBM/VAM gas collected, using a continuous flow meter and monitoring of temperature and pressure;
- Percentage of CMM/CBM/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 flameless 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 CMM/CBM/VAM gas are required to determine the density of methane in the CMM/CBM/VAM gas.

Methane in ventilation air destroyed through flameless oxidation

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.

Data and parameters 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:	$CONS_{ELEC,PJ}$
Data unit:	MWh
Description:	Additional electricity consumption for capture and use or destruction of methane, if any
Source of data:	Project site
Measurement procedures (if any):	
Monitoring frequency:	Continuous
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):	
Monitoring frequency:	Continuous
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:	Continuous
QA/QC procedures:	
Any comment:	

Data / Parameter:	CEF_{ELEC}
Data unit:	tCO_2/MWh
Description:	Carbon emissions factor of electricity used by coal mine
Source of data:	
Measurement procedures (if any):	
Monitoring frequency:	*Ex ante*
QA/QC procedures:	
Any comment:	

Data / Parameter:	CEF_{HEAT}
Data unit:	tCO_2/GJ
Description:	Carbon emissions factor of heat used by coal mine
Source of data:	
Measurement procedures (if any):	
Monitoring frequency:	*Ex ante*
QA/QC procedures:	
Any comment:	

Data / Parameter:	$CEF_{FossFuel}$
Data unit:	tCO_2/GJ
Description:	Carbon emissions factor of fossil fuel used by coal mine
Source of data:	
Measurement procedures (if any):	
Monitoring frequency:	*Ex ante*
QA/QC procedures:	
Any comment:	Use of IPCC default or national values would suffice

Data / Parameter:	MM_{FL}
Data unit:	tCH_4
Description:	Methane measured sent to flare
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 flameless 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 flameless 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 flameless oxidation unit
Source of data:	Ppressure 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 flameless 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 flameless oxidation unit
Source of data:	M (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 flameless 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:	MM_{ELEC}
Data unit:	tCH_4
Description:	Methane sent to power plant
Source of data:	m
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:	Eff_{ELEC}
Data unit:	-
Description:	Efficiency of methane destruction/oxidation in power plant
Source of data:	
Measurement procedures (if any):	
Monitoring frequency:	*Ex ante*
QA/QC procedures:	
Any comment:	Set at 99.5%(IPCC)

Data / Parameter:	MM_{HEAT}
Data unit:	tCH_4
Description:	Methane sent to boiler
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:	Eff_{HEAT}
Data unit:	-
Description:	Efficiency of methane destruction/oxidation in heat plant
Source of data:	e
Measurement procedures (if any):	
Monitoring frequency:	*Ex ante*
QA/QC procedures:	
Any comment:	Set at 99.5%(IPCC)

Data / Parameter:	MM_{GAS}
Data unit:	tCH_4
Description:	Methane sent to gas grid for end users
Source of data:	m
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:	Eff_{GAS}
Data unit:	-
Description:	Overall efficiency of methane destruction/oxidation through gas grid
Source of data:	e
Measurement procedures (if any):	
Monitoring frequency:	*Ex ante*
QA/QC procedures:	
Any comment:	Set at 98.5% (IPCC)

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

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 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 flameless 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:	%
Description:	Concentration of methane in exhaust gas from flameless 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:	MM_i
Data unit:	tCH_4
Description:	Methane measured sent to use *i*
Source of data:	
Measurement procedures (if any):	
Monitoring frequency:	Continuous
QA/QC procedures:	
Any comment:	Flow meters will record gas volumes, pressure and temperature

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)
Source of data:	
Measurement procedures (if any):	
Monitoring frequency:	*Ex ante* or *ex post*
QA/QC procedures:	
Any comment:	

Data / Parameter:	PE_{Mvent}
Data unit:	tCH_4
Description:	Emissions of methane vented to atmosphere during the project activity
Source of data:	
Measurement procedures (if any):	
Monitoring frequency:	Continuous
QA/QC procedures:	
Any comment:	This parameter is to include any methane vented to atmosphere through flares, in ventilation air methane as well as direct emissions through vents

Data / Parameter:	$CBMe_{i,,y}$
Data unit:	tCH_4
Description:	Eligible CBM captured, sent to and destroyed by use *i* in the project for year *y*
Source of data:	
Measurement procedures (if any):	
Monitoring frequency:	Yearly
QA/QC procedures:	
Any comment:	

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

Data / Parameter:	$VAM_{PJ, i,y}$
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:	

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

Data / Parameter:	GWP_{CH4}
Data unit:	tCO_2e/ tCH_4
Description:	Global warming potential of methane
Source of data:	
Measurement procedures (if any):	
Monitoring frequency:	*Ex ante*
QA/QC procedures:	
Any comment:	21 tCO_2e/tCH_4

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:	R
Data unit:	m
Description:	Cumulative radius of zone of influence
Source of data:	c
Measurement procedures (if any):	
Monitoring frequency:	Annually
QA/QC procedures:	
Any comment:	

Data / Parameter:	V_w
Data unit:	m^3
Description:	Cumulative flow at well
Source of data:	
Measurement procedures (if any):	
Monitoring frequency:	
QA/QC procedures:	
Any comment:	Monitoring at each well should record gas flow, methane concentration, pressure, and temperature

Data / Parameter:	T
Data unit:	m coal
Description:	Thickness of all coal accessed by wells
Source of data:	
Measurement procedures (if any):	
Monitoring frequency:	Annually
QA/QC procedures:	
Any comment:	Depth of fractures into respective seams and casing used should be recorded at time of drilling

Data / Parameter:	ρ_{coal}
Data unit:	t/m^3
Description:	Density of locally mined coal
Source of data:	
Measurement procedures (if any):	
Monitoring frequency:	At start of each crediting period
QA/QC procedures:	
Any comment:	Default value is 1.4

Data / Parameter:	g_{coal}
Data unit:	m^3CH_4/t coal
Description:	Gas content of coal
Source of data:	
Measurement procedures (if any):	
Monitoring frequency:	At start of each crediting period
QA/QC procedures:	
Any comment:	

Data / Parameter:	n
Data unit:	Days
Description:	Number of days the selected well is operational
Source of data:	
Measurement procedures (if any):	
Monitoring frequency:	
QA/QC procedures:	
Any comment:	

Data / Parameter:	V_a
Data unit:	m^3/day
Description:	Average flow per day
Source of data:	
Measurement procedures (if any):	
Monitoring frequency:	
QA/QC procedures:	
Any comment:	

Data / Parameter:	V_c
Data unit:	m^3/day
Description:	Cumulative flow from all wells
Source of data:	
Measurement procedures (if any):	
Monitoring frequency:	
QA/QC procedures:	
Any comment:	Total flow from all boreholes measured at collection manifold using automatic remote monitoring of gas flow, methane concentration, pressure and temperature

Data / Parameter:	N
Data unit:	Days
Description:	Sum of days all wells operational
Source of data:	
Measurement procedures (if any):	
Monitoring frequency:	
QA/QC procedures:	
Any comment:	

Data / Parameter:	
Data unit:	Coordinates
Description:	Position of wells relative to mining plan
Source of data:	
Measurement procedures (if any):	
Monitoring frequency:	Annually
QA/QC procedures:	
Any comment:	Recorded in PDD *ex ante*. New drawing produced each year

Data / Parameter:	
Data unit:	Coordinates
Description:	Well profile
Source of data:	
Measurement procedures (if any):	
Monitoring frequency:	Annually
QA/QC procedures:	
Any comment:	Shows each well and zone of influence against latest mining plan

Data / Parameter:	
Data unit:	m
Description:	Well depth
Source of data:	
Measurement procedures (if any):	
Monitoring frequency:	At time of drilling
QA/QC procedures:	
Any comment:	Based on actual drilling records

Data / Parameter:	t
Data unit:	m
Description:	Total thickness of coal in longwall emission zone
Source of data:	
Measurement procedures (if any):	
Monitoring frequency:	At start of each crediting period
QA/QC procedures:	
Any comment:	From geology report and drilling records

Data / Parameter:	ES_t
Data unit:	%
Description:	Total eligible share of CBM
Source of data:	
Measurement procedures (if any):	
Monitoring frequency:	Annually
QA/QC procedures:	
Any comment:	

Data / Parameter:	ES_h
Data unit:	%
Description:	Eligible share of CBM based on the horizontal plane overlap
Source of data:	
Measurement procedures (if any):	
Monitoring frequency:	Annually
QA/QC procedures:	
Any comment:	

Data / Parameter:	ES_v
Data unit:	%
Description:	Eligible share of CBM based on the vertical plane overlap
Source of data:	
Measurement procedures (if any):	
Monitoring frequency:	
QA/QC procedures:	
Any comment:	

Data / Parameter:	AO_w
Data unit:	m^2
Description:	Area of overlap with longwall panel
Source of data:	
Measurement procedures (if any):	
Monitoring frequency:	Annually
QA/QC procedures:	
Any comment:	

Data / Parameter:	AT_w
Data unit:	m^2
Description:	Total zone of influence
Source of data:	
Measurement procedures (if any):	
Monitoring frequency:	Annually
QA/QC procedures:	
Any comment:	

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

Data / Parameter:	$ED_{CBMw,y}$
Data unit:	tCO_2
Description:	Avoided emissions related to CBM wells intersected by mine in year *y*
Source of data:	
Measurement procedures (if any):	
Monitoring frequency:	Annually
QA/QC procedures:	
Any comment:	

Data / Parameter:	$ED_{CBMz,y}$
Data unit:	tCO_2
Description:	Avoided emissions related to CBM wells intersected before year *y*
Source of data:	
Measurement procedures (if any):	
Monitoring frequency:	Annually
QA/QC procedures:	
Any comment:	

Data / Parameter:	$ED_{CPMM,y}$
Data unit:	tCO_2
Description:	Avoided emissions related to CMM and PMM
Source of data:	
Measurement procedures (if any):	
Monitoring frequency:	Annually
QA/QC procedures:	
Any comment:	

Data / Parameter:	$CBM_{w,y}$
Data unit:	tCH_4
Description:	CBM captured from well intersected in year *y*
Source of data:	
Measurement procedures (if any):	
Monitoring frequency:	Continuous
QA/QC procedures:	
Any comment:	Monitor each well separately

Data / Parameter:	$CBM_{z,y}$
Data unit:	tCH_4
Description:	CBM captured from well intersected before year *y*
Source of data:	
Measurement procedures (if any):	
Monitoring frequency:	Continuous
QA/QC procedures:	
Any comment:	Monitor each well separately

Data / Parameter:	$CBM_{x,y}$
Data unit:	tCH_4
Description:	CBM captured from well not yet intersected in year *y*
Source of data:	
Measurement procedures (if any):	
Monitoring frequency:	Continuous
QA/QC procedures:	
Any comment:	Monitor each well separately

Data / Parameter:	$PBE_{Use,y}$
Data unit:	tCO_2e
Description:	Potential baseline emissions from displacement fuels
Source of data:	
Measurement procedures (if any):	
Monitoring frequency:	Annually
QA/QC procedures:	
Any comment:	

Data / Parameter:	GEN_y
Data unit:	MWh
Description:	Electricity generation by project
Source of data:	
Measurement procedures (if any):	
Monitoring frequency:	Continuous
QA/QC procedures:	
Any comment:	

Data / Parameter:	$HEAT_y$
Data unit:	GJ
Description:	Heat generation by project
Source of data:	
Measurement procedures (if any):	
Monitoring frequency:	Continuous
QA/QC procedures:	
Any comment:	

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

Data / Parameter:	EF_{ELEC}
Data unit:	tCO_2/MWh
Description:	CO_2 emission factor of the grid
Source of data:	
Measurement procedures (if any):	
Monitoring frequency:	Annually
QA/QC procedures:	
Any comment:	Calculated as per "Tool to calculate the emission factor for an electricity system"

Data / Parameter:	$EF_{OM,y}$
Data unit:	tCO_2/MWh
Description:	CO_2 Operating Margin emission factor of the grid
Source of data:	
Measurement procedures (if any):	
Monitoring frequency:	Annually or *ex ante*
QA/QC procedures:	
Any comment:	Calculated as per "Tool to calculate the emission factor for an electricity system"

Data / Parameter:	$EF_{BM,y}$
Data unit:	tCO_2/MWh
Description:	CO_2 Build Margin emission factor of the grid
Source of data:	
Measurement procedures (if any):	
Monitoring frequency:	Annually or *ex ante*
QA/QC procedures:	
Any comment:	Calculated as per "Tool to calculate the emission factor for an electricity system"

Data / Parameter:	$F_{i,j,y}$
Data unit:	t or m_3/yr
Description:	Amount of each fossil fuel consumed by each power source/plant
Source of data:	
Measurement procedures (if any):	
Monitoring frequency:	Annually or *ex ante*
QA/QC procedures:	
Any comment:	Obtained from the power producers, dispatch centers or latest local statistics

Data / Parameter:	$COEF_{i,k}$
Data unit:	tCO_2/t or m^3
Description:	CO_2 emission coefficient of each fuel type and each power source/plant
Source of data:	
Measurement procedures (if any):	
Monitoring frequency:	Annually
QA/QC procedures:	
Any comment:	Plant or country-specific values to calculate COEF are preferred to IPCC default values, in case of obtaining EF_{OM} *ex post*

Data / Parameter:	$GEN_{j,y}$
Data unit:	MWh/yr
Description:	Electricity generation of each power source/plant
Source of data:	
Measurement procedures (if any):	
Monitoring frequency:	Annually or *ex ante*
QA/QC procedures:	
Any comment:	Obtained from the power producers, dispatch centers or latest local statistics

Data / Parameter:	$EF_{CO2,i}$
Data unit:	tC/TJ
Description:	CO_2 emission factor of fuel used for captive power or heat
Source of data:	
Measurement procedures (if any):	
Monitoring frequency:	Annually or *ex ante*
QA/QC procedures:	
Any comment:	National sources or IPCC defaults

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

Data / Parameter:	Eff_{heat}
Data unit:	%
Description:	Energy efficiency of heat plant
Source of data:	
Measurement procedures (if any):	
Monitoring frequency:	Annually
QA/QC procedures:	
Any comment:	

Data / Parameter:	Eff_V
Data unit:	%
Description:	Efficiency of vehicle engine
Source of data:	
Measurement procedures (if any):	
Monitoring frequency:	Annually
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:	$MM_{ELEC,k}$
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:	$MM_{HEAT,k}$
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:	

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History of the Document

Version	Date	Nature of Revision
06	EB 46, Annex 7 25 March 2009	Revision to make provision for benchmark analysis as a part of investment analysis for the projects where no investment is required.
05	EB 42, Annex 7 26 September 2008	Revision to clarify that the methodology is applicable to project activities where methane is destructed using flameless oxidation without the use of a catalyst.
04	EB 35, Annex 7 02 November 2007	Include project activities that flare ventilation air methane using catalyst oxidation.
03	EB 28, Annex 10 22 December 2006	Adoption of methodological tool: “Tool to determine project emissions from flaring gases containing methane”.
02	EB 25, Annex 10 28 July 2006	Insertion of new procedures to estimate efficiency of closed and open flares.
01	EB 22, Annex 10 28 November 2005	Initial adoption.