Approved consolidated methodology ACM0001

"Flaring or use of landfill gas"

I. SOURCE, DEFINITIONS AND APPLICABILITY

Sources

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

- AM0002: Greenhouse Gas Emission Reductions through Landfill Gas Capture and Flaring where the Baseline is established by a Public Concession Contract (approved based on proposal NM0004-rev: Salvador da Bahia LFG project, whose project design document and baseline study, monitoring and verification plans were developed by ICF Consulting (version 03, June 2003);
- AM0003: Simplified financial analysis for LFG capture projects (approved based on proposal NM0005: Nova Gerar LFG to energy project, whose project design document and baseline study, monitoring and verification plans were developed by EcoSecurities Ltd. (version 14, July 2003) for the Carbon Finance Unit of the World Bank);
- AM0010: Landfill gas capture and electricity generation projects where LFG capture is not mandated by law (approved based on proposal NM0010-rev: Durban-landfill-gas-to-electricity project, whose project design document and baseline study, monitoring and verification plans were developed by Prototype Carbon Fund of the World Bank (April 2003);
- AM0011: Landfill gas recovery with electricity generation and no capture or destruction of methane in the baseline scenario (approved based on proposal NM0021: Cerupt methodology for LFG recovery, whose project design document and baseline study, monitoring and verification plans were developed by Onyx (July 2003).

The methodology also refers to the latest approved version of the following methodological tools:

- Methodological tool "Emissions from solid waste disposal sites";
- "Combined tool to identify the baseline scenario and demonstrate additionality";
- "Tool to determine project emissions from flaring gases containing methane";
- "Tool to calculate baseline, project and/or leakage emissions from electricity consumption";
- "Tool to calculate project or leakage CO_2 emissions from fossil fuel combustion";
- "Tool to determine the remaining lifetime of equipment";
- "Tool to determine the baseline efficiency of thermal or electric energy generation systems";
- "Tool to determine the mass flow of a greenhouse gas in a gaseous stream".

For more information regarding the approved methodologies and the tools as well as their consideration by the CDM Executive Board (the 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", or

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

Definitions

For the purpose of this methodology the following definitions apply:

Continuous brick kiln. A brick kiln where bricks are loaded continuously into the kiln, rather than in batches. Continuous brick kilns are distinguished as moving ware kilns and moving fire annular kilns. Moving ware kilns include tunnel and vertical shaft kilns. Moving fire annualar kilns use Hoffmann, Bull's trench and Zig-zag technologies.

Existing LFG capture system. An existing active LFG capture system is a system that has been in operation in the last calendar year prior to the start of the project activity.

LFG capture system. A system to capture LFG. The system may be passive, active or a combination of both active and passive components. Passive systems capture LFG by means of natural pressure, concentration, and density gradients. Active systems use mechanical equipment to capture LFG by providing pressure gradients. Captured LFG can be vented, flared or used.

Intermittent brick kiln. Bricks are loaded into the kiln and fired in batches. Types include Clamp, Scotch and Scove technologies.

Landfill gas (LFG). The gas generated by decomposition of waste in a SWDS. LFG is mainly composed of methane, carbon dioxide and small fractions of ammonia and hydrogen sulfide.

Reference conditions. Reference conditions are defined as 0^oC (273.15 K, 32oF) and 1 atm (101.325 kN/m2, 101.325 kPa, 14.69 psia, 29.92 in Hg, 760 torr).

Solid waste. Material that is unwanted and insoluble (including gases or liquids in cans or containers). Hazardous waste is not included in the definition of solid waste.

Solid waste disposal site (SWDS). Designated areas intended as the final storage place for solid waste.

Applicability

This methodology is applicable to project activities which:

(a) Install a new LFG capture system in a new or existing SWDS; or

(b) Make an investment into an existing LFG capture system to increase the recovery rate or change the use of the captured LFG, provided that:

    (i) The captured LFG was only vented or flared and not used prior to the implementation of the project activity; and

    (ii) In the case of an existing active LFG capture system for which the amount of LFG can not be collected separately from the project system after the implementation of the project activity and its efficiency is not impacted on by the project system: historical data on the amount of LFG capture and flared is available.

(c) Flare the LFG and/or use the captured LFG in any (combination) of the following ways:

    (i) Generating electricity;

(ii) Generating heat in a boiler, air heater or kiln (brick firing only);[1] and/or

(iii) Supplying the LFG to consumers through a natural gas distribution network.

(d) Do not reduce the amount of organic waste that would be recycled in the absence of the project activity.

The methodology is only applicable if the application of the procedure to identify the baseline scenario confirms that the most plausible baseline scenario is

(a) Partial or total release of the LFG from the SWDS; and

(b) In the case that the LFG is used in the project activity for generating electricity and/or generating heat in a boiler, air heat or kiln;

(i) For electricity generation: that electricity would be generated in the grid or in captive fossil fuel fired power plants; and/or

(ii) For heat generation: that heat would be generated using fossil fuels in on-site equipment.

This methodology is not applicable:

(a) In combination with other approved methodologies. For instance, ACM0001 cannot be used to claim emission reductions for the displacement of fossil fuels in a kiln, where the purpose of the CDM project activity is to implement energy efficiency measures at the kiln;

(b) If the management of the SWDS in the project activity is deliberately changed in order to increase methane generation compared to the situation prior to the implementation of the project activity (e.g. other to meet a technical or regulatory requirement). For example, this may apply to the addition of liquids to a SWDS, pre-treating waste to seed it with bacteria for the purpose of increasing the anaerobic degradation environment of the SWDS or changing the shape of the SWDS to increase the Methane Correction Factor.[2]

If during the project activity the project participant wishes to change the use of the captured LFG, for instance from flaring to energy generation, then the latest version of the "Procedures for notifying and requesting approval of changes from the project activity as described in the registered Project Design Document" must be applied.

The applicability conditions included in the tools referred to above also apply.

II. BASELINE METHODOLOGY

Project Boundary

The project boundary of the project activity shall include the site where the LFG is captured and, as applicable:

[1] For claiming emission reductions for other heat generation equipment (including other products in kilns), project participants may submit a revision to this methodology.

[2] The Methane Correction Factor (MCF) accounts for the fact that unmanaged SWDS produce less methane from a given amount of waste than managed SWDS because a larger fraction of waste decomposes aerobically in the top layers of unmanaged SWDS. MCF is a parameter used in the tool to estimate "Emissions from Solid Waste Disposal Sites".

- Sites where the LFG is flared or used (e.g. flare, power plant, boiler, air heater, kiln or natural gas distribution network);
- Captive power plant(s) or power generation sources connected to the grid, which are supplying electricity to the project activity;
- Captive power plant(s) or power generation sources connected to the grid, which are supplying electricity in the baseline that is displaced by electricity generated by captured LFG in the project activity; and
- Heat generation equipment or sources which are supplying heat in the baseline that is displaced by heat generated by captured LFG in the project activity.

Table 1: Summary of greenhouse gases and sources included in and excluded from the project boundary

	Source	Gas	Included?	Justification / Explanation
Baseline	Emissions from decomposition of waste at the SWDS site	CH_4	Yes	The major source of emissions in the baseline
		N_2O	No	N_2O emissions are small compared to CH_4 emissions from SWDS. This is conservative
		CO_2	No	CO_2 emissions from decomposition of organic waste are not accounted since the CO_2 is also released under the project activity
	Emissions from electricity generation	CO_2	Yes	Major emission source if power generation is included in the project activity
		CH_4	No	Excluded for simplification. This is conservative
		N_2O	No	Excluded for simplification. This is conservative
	Emissions from heat generation	CO_2	Yes	Major emission source if heat generation is included in the project activity
		CH_4	No	Excluded for simplification. This is conservative
		N_2O	No	Excluded for simplification. This is conservative
	Emissions from the use of natural gas	CO_2	No	Excluded for simplification. This is conservative
		CH_4	Yes	Major emission source if supply of LFG through a natural gas distribution network is included in the project activity
		N_2O	No	Excluded for simplification. This is conservative
Project Activity	Emissions from fossil fuel consumption for purposes other than electricity generation or transportation due to the project activity	CO_2	Yes	May be an important emission source
		CH_4	No	Excluded for simplification. This emission source is assumed to be very small
		N_2O	No	Excluded for simplification. This emission source is assumed to be very small
	Emissions from electricity consumption due to the project activity	CO_2	Yes	May be an important emission source
		CH_4	No	Excluded for simplification. This emission source is assumed to be very small
		N_2O	No	Excluded for simplification. This emission source is assumed to be very small

Procedure for estimating the end of the remaining lifetime of existing equipment

This procedure applies if LFG is used in equipment that was in operation prior to the implementation of the project activity.

For each item of equipment which was in operation prior to the implementation of the project activity and in which the captured LFG is used after the implementation of the project activity,[3] project participants shall estimate its remaining lifetime by applying the "Tool to determine the remaining lifetime of equipment". These items of equipment and their remaining lifetime shall be recorded in the CDM-PDD.

At the end of the remaining lifetime of each item of equipment, the procedure for the selection of the most plausible baseline scenario related to electricity and/or heat generation shall be updated in order to determine the most plausible baseline fuel that would be used after installation of the new equipment in the absence of the CDM project activity. At the same time, the parameters related to this item of equipment shall also be re-estimated according to the procedures in this methodology used to make the original estimation (for example the baseline fuel may change and this then has impacts on the emission factor for this baseline fuel).

Procedure for the selection of the most plausible baseline scenario and demonstrate additionality

Identify the baseline scenario and demonstrate additionality using the "Combined tool to identify the baseline scenario and demonstrate additionality" and following the requirements below.

In applying Step 1 of the tool, baseline alternatives for the destruction of LFG, shall take into consideration , *inter alia*, the following alternatives:

- LFG1: The project activity implemented without being registered as a CDM project activity (i.e. capture and flaring or use of LFG);
- LFG2: Atmospheric release of the LFG or partial capture of LFG and destruction to comply with regulations or contractual requirements, or to address safety and odour concerns;
- LFG3: LFG is partially not generated because part of the organic fraction of the solid waste is recycled and not disposed in the SWDS;
- LFG4: LFG is partially not generated because part of the organic fraction of the solid waste is treated aerobically and not disposed in the SWDS;
- LFG5: LFG is partially not generated because part of the organic fraction of the solid waste is incinerated and not disposed in the SWDS.

In addition to the alternative baseline scenarios identified for the destruction of LFG, alternative scenarios for the use of LFG shall also be identified (if this is an aspect of the project activity):

(a) For electricity generation, alternative(s) shall include, *inter alia*:

- E1: Electricity generation from LFG, undertaken without being registered as CDM project activity;
- E2: Electricity generation in existing or new on-site or off-site renewable based captive power plant(s);
- E3: Electricity generation in existing and/or new grid-connected power plants.

[3] Depending on the project activity, relevant items of equipment may include power plants, boilers, air heaters or kilns.

(b) For heat generation, alternative(s) shall include, *inter alia*:

- H1: Heat generation from LFG undertaken without being registered as CDM project activity;
- H2: Heat generation in existing or new on-site or off-site fossil fuel fired cogeneration plant(s);
- H3: Heat generation in existing or new on-site or off-site renewable based cogeneration plant(s);
- H4: Heat generation in existing or new on-site or off-site fossil fuel based boiler(s), air heater(s) or kiln(s);
- H5: Heat generation in existing or new on-site or off-site renewable energy based boiler(s), air heater(s) or kiln(s);
- H6: Any other source, such as district heat; and
- H7: Other heat generation technologies (e.g. heat pumps or solar energy).

(c) For the supply of LFG to a natural gas distribution network, the baseline is assumed to be the supply with natural gas.

Identification of the baseline fuel for electricity generation by captive fossil fuel fired power plants and/or heat generation

Project participants shall demonstrate that the identified baseline fuel used for generation of electricity and/or heat is available in abundance in the host country and there is no supply constraint. In case of partial supply constraints (seasonal supply), the project participants shall consider the period of partial supply among potential alternative fuel(s) the one that results in the lowest baseline emissions.

Detailed justifications shall be provided and documented in the CDM-PDD for the selected baseline fuel. As a conservative approach, the lowest carbon intensive fuel, such as natural gas, may be used throughout all period of the year.

Baseline emissions

Baseline emissions are determined according to equation 1 and comprise the following sources:

(A) Methane emissions from the SWDS in the absence of the project activity;

(B) Electricity generation using fossil fuels or supplied by the grid in the absence of the project activity;

(C) Heat generation using fossil fuels in the absence of the project activity; and

(D) Natural gas used from the natural gas network in the absence of the project activity.

$$BE_{y} = BE_{CH4,y} + BE_{EC,y} + BE_{HG,y} + BE_{NG,y} \quad \textbf{(1)}$$

Where:

BE_y	=	Baseline emissions in year *y* (t CO_2e/yr)
$BE_{CH4,y}$	=	Baseline emissions of methane from the SWDS in year *y* (t CO_2e/yr)
$BE_{EC,y}$	=	Baseline emissions associated with electricity generation in year *y* (t CO_2/yr)
$BE_{HG,y}$	=	Baseline emissions associated with heat generation in year *y* (t CO_2/yr)
$BE_{NG,y}$	=	Baseline emissions associated with natural gas use in year *y* (t CO_2/yr)

Step (A): Baseline emissions of methane from the SWDS ($BE_{CH4,y}$)

Baseline emissions of methane from the SWDS are determined as follows, based on the amount of methane that is captured under the project activity and the amount that would be captured and destroyed in the baseline (such as due to regulations). In addition, the effect of methane oxidation that is present in the baseline and absent in the project is taken into account:[4]

$$BE_{CH4,y} = \left(1 - OX_{top\_layer}\right)\left(F_{CH4,PJ,y} - F_{CH4,BL,y}\right) GWP_{CH4} \quad \textbf{(2)}$$

Where:

$BE_{CH4,y}$	=	Baseline emissions of LFG from the SWDS in year *y* (t CO_2e/yr)
OX_{top_layer}	=	Fraction of methane in the LFG that would be oxidized in the top layer of the SWDS in the baseline (dimensionless)
$F_{CH4,PJ,y}$	=	Amount of methane in the LFG which is flared and/or used in the project activity in year *y* (t CH_4/yr)
$F_{CH4,BL,y}$	=	Amount of methane in the LFG that would be flared in the baseline in year *y* (t CH_4/yr)
GWP_{CH4}	=	Global warming potential of CH_4 (t CO_2e/t CH_4)

Step A.1: Ex post determination of $F_{CH4,PJ,y}$

During the crediting period, $F_{CH4,PJ,y}$ is determined as the sum of the quantities of methane flared and used in power plant(s), boiler(s), air heater(s), kiln(s) and natural gas distribution network, as follows:

$$F_{CH4,PJ,y} = F_{CH4,flared,y} + F_{CH4,EL,y} + F_{CH4,HG,y} + F_{CH4,NG,y} \quad \textbf{(3)}$$

Where:

$F_{CH4,PJ,y}$	=	Amount of methane in the LFG which is flared and/or used in the project activity in year *y* (t CH_4/yr)
$F_{CH4,flared,y}$	=	Amount of methane in the LFG which is destroyed by flaring in year *y* (t CH_4/yr)
$F_{CH4,EL,y}$	=	Amount of methane in the LFG which is used for electricity generation in year *y* (t CH_4/yr)
$F_{CH4,HG,y}$	=	Amount of methane in the LFG which is used for heat generation in year *y* (t CH_4/yr)
$F_{CH4,NG,y}$	=	Amount of methane in the LFG which is sent to the natural gas distribution network in year *y* (t CH_4/yr)

The working hours of the power plant(s), boiler(s), air heater(s) and kiln(s) should be monitored and no emission reduction should be claimed for methane destruction during non-working hours.

$F_{CH4,EL,y}$, $F_{CH4,HG,y}$ and $F_{CH4,NG,y}$ are determined using the "Tool to determine the mass flow of a greenhouse gas in a gaseous stream". The following requirements apply:

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[4] $OX_{top-layer}$ is the fraction of the methane in the LFG that would oxidize in the top layer of the SWDS in the absence of the project activity. Under the project activity, this effect is reduced as a part of the LFG is captured and does not pass through the top layer of the SWDS. This oxidation effect is also accounted for in the methodological tool "Emissions from solid waste disposal sites". In addition to this effect, the installation of a LFG capture system under the project activity may result in the suction of additional air into the SWDS. In some cases, such as with a high suction pressure, the air may decrease the amount of methane that is generated under the project activity. However, in most circumstances where the LFG is captured and used this effect was considered to be very small, as the operators of the SWDS have in most cases an incentive to main a high methane concentration in the LFG. For this reason, this effect is neglected as a conservative assumption.

- The gaseous stream the tool shall be applied to is the LFG delivery pipeline to each item of electricity generation or heat generation equipment *j*, or the natural gas distribution system. $F_{CH4,EL,y}$ and $F_{CH4,HG,y\ y}$ are then calculated as the sum of mass flows to each item of electricity generation or heat generation equipment *j*;
- CH_4 is the greenhouse gases for which the mass flow should be determined;
- The flow of the gaseous stream should be measured on continuous basis;
- The simplification offered for calculating the molecular mass of the gaseous stream is valid (equations 3 or 17 in the tool); and
- The mass flow should be summed to a yearly unit basis (t CH_4/yr).

Amount of methane destroyed by flaring ($F_{CH4,flared,y}$)

$F_{CH4,flared,y}$ is determined as the difference between the amount of methane supplied to the flare(s) and any methane emissions from the flare(s), as follows:

$$F_{CH4,flared,y} = F_{CH4,sent\_flare,y} - \frac{PE_{flare,y}}{GWP_{CH4}} \quad (4)$$

Where:

$F_{CH4,flared,y}$	=	Amount of methane in the LFG which is destroyed by flaring in year *y* (t CH_4/yr)
$F_{CH4,sent\_flare,y}$	=	Amount of methane in the LFG which is sent to the flare in year *y* (t CH_4/yr)
$PE_{flare,y}$	=	Project emissions from flaring of the residual gas stream in year *y* (t CO_2e/yr)
GWP_{CH4}	=	Global warming potential of CH_4 (t CO_2e/t CH_4)

$F_{CH4,sent\_flare,y}$ is determined directly using the "Tool to determine the mass flow of a greenhouse gas in a gaseous stream", applying the requirements described above where the gaseous stream the tool shall be applied to is the LFG delivery pipeline to the flare(s).

$PE_{flare,y}$ shall be determined using the "Tool to determine project emissions from flaring gases containing methane". If LFG is flared through more than one flare, then $PE_{flare,y}$ is the sum of the emissions for each flare determined separately.

Step A.1.1: Ex ante estimation of $F_{CH4,PJ,y}$

An *ex ante* estimate of $F_{CH4,PJ,y}$ is required to estimate baseline emission of methane from the SWDS (according to equation 2) in order to estimate the emission reductions of the proposed project activity in the CDM-PDD. It is determined as follows:

$$F_{CH4,PJ,y} = \eta_{PJ} \cdot BE_{CH4,SWDS,y} / GWP_{CH4} \quad (5)$$

Where:

$F_{CH4,PJ,y}$	=	Amount of methane in the LFG which is flared and/or used in the project activity in year *y* (t CH_4/yr)
$BE_{CH4,SWDS,y}$	=	Amount of methane in the LFG that is generated from the SWDS in the baseline scenario in year *y* (t CO_2e/yr)
η_{PJ}	=	Efficiency of the LFG capture system that will be installed in the project activity
GWP_{CH4}	=	Global warming potential of CH_4 (t CO_2e/t CH_4)

$BE_{CH4,SWDS,y}$ is determined using the methodological tool "Emissions from solid waste disposal sites". The following guidance should be taken into account when applying the tool:

- f_y in the tool shall be assigned a value of 0 because the amount of LFG that would have been captured and destroyed is already accounted for in equation 2 of this methodology;
- In the tool, x begins with the year that the SWDS started receiving wastes (e.g. the first year of SWDS operation); and
- Sampling to determine the fractions of different waste types is not necessary because the waste composition can be obtained from previous studies.

Step A.2: Determination of $F_{CH4,BL,y}$

This step provides a procedure to determine the amount of methane that would have been captured and destroyed (by flaring) in the baseline due to regulatory or contractual requirements, or to address safety and odour concerns (collectively referred to as *requirement* in this step). The four cases in Table 2 are distinguished. The appropriate case should be identified and the corresponding instructions followed.

Table 2: Cases for determining methane captured and destroyed in the baseline

Situation at the start of the project activity:	Requirement to destroy methane	Existing LFG capture system
Case 1	No	No
Case 2	Yes	No
Case 3	No	Yes
Case 4	Yes	Yes

Case 1: No requirement to destroy methane exists and no existing LFG capture system

In this situation:

$$F_{CH4,BL,y} = 0 \quad \textbf{(6)}$$

Case 2: Requirement to destroy methane exists and no existing LFG capture system

In this situation:

$$F_{CH4,BL,y} = F_{CH4,BL,R,y} \quad \textbf{(7)}$$

$F_{CH4,BL,R,y}$ should be determined based on the information contained in the requirement to destroy methane, as follows:

- If the requirement specifies the amount of methane that must be flared then that amount is $F_{CH4,BL,R,y}$;
- If the requirement specifies a percentage of the LFG that is required to be flared, the amount shall be calculated as follows:

$$F_{CH4,BL,R,y} = \rho_{reg,y} \cdot F_{CH4,PJ,y} \quad \textbf{(8)}$$

Where:

$F_{CH4,BL,R,y}$	=	Amount of methane in the LFG which is flared in the baseline due to a requirement in year *y* (t CH_4/yr)
$\rho_{reg,y}$	=	Fraction of LFG that is required to be flared due to a requirement in year *y*
$F_{CH4,PJ,y}$	=	Amount of methane in the LFG which is flared and/or used in the project activity in year *y* (t CH_4/yr)

- If the requirement does not specify the amount or percentage of LFG that should be destroyed but requires the installation of a capture system, without requiring the captured LFG to be flared then:

$$F_{CH4,BL,R,y} = 0 \quad \textbf{(9)}$$

- If the requirement does not specify any amount or percentage of LFG that should be destroyed but requires the installation of a system to capture and flare the LFG, then a typical destruction rate of 20% is assumed:[5]

$$F_{CH4,BL,R,y} = 20\% \cdot F_{CH4,PJ,y} \quad \textbf{(10)}$$

Case 3: No requirement to destroy methane exists and a LFG capture system exists

In this situation:

$$F_{CH4,BL,y} = F_{CH4,BL,sys,y} \quad \textbf{(11)}$$

- If the amount of methane captured with the existing system can be monitored separately from the amount captured under the project, and the efficiency of the existing system is not impacted on by the project system during the crediting period(s), then $F_{CH4,BL,sys,y}$ is determined as follows:

$$F_{CH4,BL,sys,y} = F_{CH4,BL\_flare,y} \quad \textbf{(12)}$$

Where:

$F_{CH4,BL,sys,y}$	=	Amount of methane in the LFG that would be flared in the baseline in year *y* for the case of an existing LFG capture system (t CH_4/yr)
$F_{CH4,BL\_flare,y}$	=	Amount of methane in the LFG which is captured by the existing LFG capture system in year *y* (t CH_4/yr)

$F_{CH4,BL\_flare,y}$ is determined using the "Tool to determine the mass flow of a greenhouse gas in a gaseous stream" and applying the requirements described in Step A.1, where the gaseous stream the tool shall be applied to is the pipeline collecting LFG from the existing LFG capture system.

- If there is no monitored data available, but there is historic data on the amount of methane that was captured in the year prior to the implementation of the project activity, then in this situation:

$$F_{CH4,BL,sys,y} = F_{CH4,hist,y} \quad \textbf{(13)}$$

In determining $F_{CH4,hist,y}$ it is assumed that the fraction of LFG that was recovered in the year prior to the implementation of the project activity will be the same fraction recovered under the project activity:

$$F_{CH4,hist,y} = \frac{F_{CH4,BL,x-1}}{F_{CH4,x-1}} \cdot F_{CH4,PJ,y} \quad \textbf{(14)}$$

[5] This default value of 20% is based on assuming a situation in which: the efficiency of the LFG capture system in the project is 50%; the efficiency of the LFG capture system in the baseline is 20%; and, the amount captured in the baseline is flared using an open flare with a destruction efficiency of 50% (consistent with the default value provided in the "Tool to determine project emissions from flaring gases containing methane"). Project participants may propose and justify an alternative default value as a request for revision to this methodology.

Where:

$F_{CH4,hist,y}$ = Historical amount of methane in the LFG which is captured and destroyed (t CH_4/yr)

$F_{CH4,BL,x-1}$ = Historical amount of methane in the LFG which is captured and destroyed in the year prior to the implementation of the project activity (t CH_4/yr)

$F_{CH4,x-1}$ = Amount of methane in the LFG generated in the SWDS in the year prior to the implementation of the project activity (t CH_4/yr)

$F_{CH4,PJ,y}$ = Amount of methane in the LFG which is flared and/or used in the project activity in year *y* (t CH_4/yr)

$F_{CH4,x-1}$ shall be estimated using the methodological tool "Emissions from solid waste disposal sites". The guidance and requirements described in Step A.1.1 for applying the tool shall be followed. The year *y* in the tool is equivalent to the year prior to the implementation of the project activity.

- If there is no monitored or historic data on the amount of methane that was captured in the year prior to the implementation of the project situation, then:

$$F_{CH4,BL,sys,y} = 20\% \cdot F_{CH4,PJ,y} \quad \textbf{(15)}$$

The 20% default factor is consistent with the default factor given in equation 10.

Case 4: Requirement to destroy methane exists and LFG capture system exists

$F_{CH4,BL,y}$ shall be determined based on information in contract of regulation requirements and data related to the existing LFG capture system, as follows:

$$F_{CH4,BL,y} = \max\left\{F_{CH4,BL,R,y};\quad F_{CH4,BL,sys,y}\right\} \quad \textbf{(16)}$$

Where:

$F_{CH4,BL,R,y}$ = Amount of methane in the LFG which is flared in the baseline due to a requirement in year *y* (t CH_4/yr)

$F_{CH4,BL.sys,y}$ = Amount of methane in the LFG that would be flared in the baseline in year *y* for the case of an existing LFG capture system (t CH_4/yr)

$F_{CH4,BL,R,y}$ and $F_{CH4,BL.sys,y}$ shall be determined according to the respective procedures for Case 2 and Case 3 above.

Step B: Baseline emissions associated with electricity generation ($BE_{EC,y}$)

The baseline emissions associated with electricity generation in year *y* ($BE_{EC,y}$) shall be calculated using the "Tool to calculate baseline, project and/or leakage emissions from electricity consumption". When applying the tool:

- The electricity sources *k* in the tool correspond to the sources of electricity generated identified in the selection of the most plausible baseline scenario; and
- $EC_{BL,k,y}$ in the tool is equivalent to the net amount of electricity generated using LFG in year *y*.

Step C: Baseline emissions associated with heat generation ($BE_{HG,y}$)

The baseline emissions associated with heat generation in year *y* ($BE_{HG,y}$) are determined based on the amount of methane in the LFG which is sent to the heat generation equipment in the project activity (boiler, air heater and/or kiln), as follows:

$$BE_{HG,y} = NCV_{CH4} \cdot \sum_{j=1}^{n} \left(R_{efficiency,j,y} \cdot F_{CH4,HG,dest,j,y} \cdot EF_{CO2,BL,HG,j} \right) \quad \textbf{(17)}$$

Where:

$BE_{HG,y}$	=	Baseline emissions associated with heat generation in year *y* (t CO_2/yr)
NCV_{CH4}	=	Net calorific value of methane at reference conditions (TJ/t CH_4)
$R_{efficiency,j,y}$	=	Ratio of the project and baseline efficiency of heat equipment type *j* in year *y*
$F_{CH4,HG,dest,j,y}$	=	Amount of methane in the LFG which is destroyed for heat generation by equipment type *j* in year *y* (t CH_4/yr)
$EF_{CO2,BL,HG,j}$	=	CO_2 emission factor of the fossil fuel type used for heat generation by equipment type *j* in the baseline (t CO_2/TJ)
j	=	Heat generation equipment (boiler, air heater or kiln)
n	=	Number of different heat generation equipment used in the project activity

Step C.1: Determination of $R_{efficiency,j,y}$

The ratio of the project and baseline efficiency of an air heater, boiler or kiln is determined as follows:

$$R_{efficiency,j,y} = \min\left\{1;\ \frac{\eta_{HG,PJ,j,y}}{\eta_{HG,BL,j}}\right\} \quad \textbf{(18)}$$

Where:

$R_{efficiency,j,y}$	=	Ratio of the project and baseline efficiency of equipment type *j* in year *y*
$\eta_{HG,BL,j}$	=	Efficiency of the heat generation equipment type *j* used in the baseline
$\eta_{HG,PJ,y}$	=	Efficiency of the heat generation equipment type *j* used in the project activity in year *y*
j	=	Heat generation equipment type (boiler, air heater or kiln)

To estimate the baseline energy efficiency of an air heater, boiler or kiln ($\eta_{HG,BL,j}$) project participants shall apply the “Tool to determine the baseline efficiency of thermal or electric energy generation systems”.

Step C.2: Determination of $F_{CH4,HG,dest,j,y}$

The amount of methane that is destroyed in the LFG that is sent to heat generation equipment *j* is determined with equation 19 if *j* is a boiler or air heater, or with equation 20 if *j* is a brick kiln. For the particular case of intermittent brick kilns, project participants may choose to apply either equation 19 or 20.

$$F_{CH4,HG,dest,j,y} = fd_{CH4,HG,j,default} \cdot F_{CH4,HG,j,y} \quad \textbf{(19)}$$

Where:

$F_{CH4,HG,dest,j,y}$	=	Amount of methane in the LFG which is destroyed for heat generation by equipment type *j* in year *y* (t CH_4/yr)
$fd_{CH4,HG,j,default}$	=	Default value for the fraction of methane destroyed when used for heat generation equipment type *j*
$F_{CH4,HG,j,y}$	=	Amount of methane in the LFG which is used for heat generation equipment type *j* in year *y* (t CH_4/yr)

$F_{CH4,HG,j,y}$ is determined according to Step A.1, where *j* is each item of heat generation equipment:

$$F_{CH4,HG,dest,j,y} = \sum_{h=1}^{8,760}\left(fd_{CH4,kiln,h} \cdot F_{CH4,HG,kiln,h}\right)$$

With: $fd_{CH4,kiln,h} = 1$ if $Q_{O2,kiln,h} > 0$, and otherwise $fd_{CH4,kiln,h} = 0$ **(20)**

Where:

$F_{CH4,HG,dest,kiln,y}$	=	Amount of methane in the LFG which is destroyed for heat generation by brick kiln in year *y* (t CH_4/yr)
$fd_{CH4,kiln,h}$	=	Fraction of methane destroyed when used for heat generation in a brick kiln in hour *h*
$F_{CH4,HG,kiln,h}$	=	Amount of methane in the LFG which is used for heat generation by brick kiln in hour *h* (t CH_4/hr)
$Q_{O2,kiln,h}$	=	Average volumetric fraction of oxygen in the exhaust gas flow of the kiln in hour *h* (volume of O_2/volume of the gas stream)
h	=	Hours in year *y*

$F_{CH4,HG,kiln,h}$ is determined using the "Tool to determine the mass flow of a greenhouse gas in a gaseous stream", following the requirements given in Step A.1 for *j* = kiln, except that the mass flow should be summed to an hourly (not yearly) unit basis (t CH_4/hr).

Step D: Baseline emissions associated with natural gas use ($BE_{NG,y}$)

$BE_{NG,y}$ is estimated as follows:

$$BE_{NG,y} = LFG_{NG,y} \cdot NCV_{LFG,NG,y} \cdot EF_{CO2,NG,y}$$

Where:

$BE_{NG,y}$	=	Baseline emissions associated with natural gas use in year *y* (t CO_2/yr)
$LFG_{NG,y}$	=	Amount of upgraded LFG sent to the natural gas network due to the project activity in year *y* (Nm^3/yr)
$NCV_{LFG,NG,y}$	=	Net Calorific Value of upgraded LFG sent to the natural gas network due to the project activity in year *y* (TJ/Nm^3)
$EF_{CO2,NG,y}$	=	Average CO_2 emission factor of natural gas in the natural gas network in year *y* (t CO_2/TJ)

$EF_{CO2,NG,y}$ is determined using the "Tool to calculate project or leakage CO_2 emissions from fossil fuel combustion".

Project emissions

Project emissions are calculated as follows:

$$PE_y = PE_{EC,y} + PE_{FC,y} \quad \textbf{(21)}$$

Where:

PE_y	=	Project emissions in year *y* (t CO_2/yr)
$PE_{EC,y}$	=	Emissions from consumption of electricity due to the project activity in year *y* (t CO_2/yr)
$PE_{FC,y}$	=	Emissions from consumption of fossil fuels due to the project activity, for purpose other than electricity generation, in year *y* (t CO_2/yr)

The project emissions from consumption of electricity by the project activity ($PE_{EC,y}$) shall be calculated using the "Tool to calculate baseline, project and/or leakage emissions from electricity consumption". When applying the tool:

- Electricity sources *j* in the tool corresponds to the sources of electricity consumed due to the project activity. This shall include, where applicable, electricity consumed for the operation of the LFG capture system, for any processing and upgrading of the LFG, for transportation of the LFG to the flare or other applications (boilers, power generators), for the compression of the LFG into the natural gas network, etc.;
- If in the baseline a proportion of LFG is destroyed ($F_{CH4,BL,y} > 0$), then the electricity consumption in the tool ($EC_{PJ,j,y}$) should refer to the net quantity of electricity consumption (i.e. the increase due to the project activity). The determination of the amount of electricity consumed in the baseline shall be transparently documented in the CDM-PDD.

The project emissions from fossil fuel combustion for purposes other than electricity generation ($PE_{FC,y}$) shall be calculated using the "Tool to calculate project or leakage CO_2 emissions from fossil fuel combustion". When applying the tool:

- Processes *j* in the tool correspond to the sources of fossil fuel consumption due to the project activity other than for electricity generation or and any on-site transportation by trucks or cars;
- If in the baseline a proportion of LFG is captured and flared ($F_{CH4,BL,y} > 0$), then the fossil fuels consumption used in calculation ($FC_{i,j,y}$) should refer to the net of that consumed in the baseline. The determination of the amount of fossil fuels consumed in the baseline shall be transparently documented in the CDM-PDD.

Leakage

No leakage effects are accounted for under this methodology.

Emission Reduction

Emission reductions are calculated as follows:

$$ER_y = BE_y - PE_y \tag{22}$$

Where:

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

Project participants should provide an *ex ante* estimate of emissions reductions in the CDM-PDD. This requires projecting the future GHG emissions of the SWDS for the calculation of baseline emissions.

If the energy component is intended to be implemented after the first year of the project activity, then project participants may exclude the energy component from the ex-ante estimation of baseline emissions. This avoids overestimating *ex ante* estimate of emissions if energy generation is not implemented, or a lower capacity is implemented than originally envisaged. This exclusion is not applicable to the determination of the baseline or demonstration of additionality.

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:	OX_{top_layer}
Data unit:	Dimensionless
Description:	Fraction of methane that would be oxidized in the top layer of the SWDS in the baseline
Source of data:	Consistent with how oxidation is accounted for in the methodological tool "Emissions from solid waste disposal sites"
Value to be applied:	0.1
Any comment:	Applicable to Step A.

Data/Parameter:	$F_{CH4,BL,x-1}$
Data unit:	t CH_4/yr
Description:	Historical amount of methane in the LFG which is captured and destroyed in the year prior to the implementation of the project activity
Source of data:	Information recorded by the SWDS operator
Value to be applied:	
Any comment:	Applicable to Case 3 of Step A.2

Date / Parameter:	GWP_{CH4}
Data unit:	t CO_2e/t CH_4
Description:	Global warming potential of CH_4
Source of data:	IPCC
Value to be applied:	21 for the first commitment period. Shall be updated according to any future COP/MOP decisions
Any comment:	

Data / Parameter:	NCV_{CH4}
Data unit:	TJ/t CH_4
Description:	Net calorific value of methane at reference conditions
Source of data:	Technical literature
Value to be applied:	0.0504
Any comment:	

Data / Parameter:	$EF_{CO2,BL,HG,j}$
Data unit:	t CO_2/TJ
Description:	CO_2 emission factor of the fossil fuel type used for heat generation by equipment type *j* in the baseline
Source of data:	Table 1.4 of Chapter 1 of Vol. 2 (Energy) of the 2006 IPCC Guidelines on National GHG Inventories
Value to be applied:	The lower limit of the 95% confidence interval of the default values provided in table 1.4 of reference above shall be used
Any comment:	Applicable to Step C.

Data/Parameter:	η_{PJ}
Data unit:	Dimensionless

Description:	Efficiency of the LFG capture system that will be installed in the project activity
Source of data:	
Value to be applied:	Technical specifications of the LFG capture system to be installed (if available) or a default value of 50%.
Any comment:	Applicable to Step A.1.1

Data/Parameter:	$fd_{CH4,HG,j,default}$
Data unit:	
Description:	Default value for the fraction of methane destroyed when used for heat generation equipment type *j*
Source of data:	The values for boilers and air heaters are based on default values provided in the 2006 IPCC Guidelines (Tier 3 approach for Chapter 2: Stationary Combustion of Volume 2: Energy Use). The value for intermittent brick kilns is based on the assumption that combustion temperatures in the kiln will exceed 600 °C and that the time of exposure is sufficiently long to support 90% combustion
Value to be applied	Select the appropriate factor for the fraction of methane destroyed from the following table:
Any comment:	Applicable to calculating $F_{CH4,HG,dest,j,y}$ using equation 19 in Step C.2. For intermittent brick kilns, project participants may choose to instead determine $F_{CH4,HG,dest,j,y}$ using equation 20

Fraction of CH_4 destroyed	**Equipment type j**
1	Boilers
1	Air heaters
0.9	Intermittent brick kiln

III. MONITORING METHODOLOGY

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:	$F_{CH4,BL,R,y}$
Data unit:	t CH_4 / yr
Description:	Amount of methane in the LFG which is flared due to a requirement in year *y*
Source of data:	Information of the host country's regulatory requirements relating to LFG, contractual requirements, or requirements to address safety and odour concerns
Measurement procedures (if any):	-
Monitoring frequency:	Annually
QA/QC procedures:	-
Any comment:	Applicable to Case 2 of Step A.2

Date / Parameter:	
Data unit:	Dimensionless
Description:	Fraction of LFG that is required to be flared due to a requirement in year *y*

Source of data:	Information of the host country's regulatory requirements relating to LFG, contractual requirements, or requirements to address safety and odour concerns
Measurement procedures (if any):	-
Monitoring frequency:	Annually
QA/QC procedures:	-
Any comment:	Applicable to Case 2 of Step A.2

Data / Parameter:	$NCV_{LFG,NG,y}$
Data unit:	TJ/Nm^3
Description:	Net Calorific Value of upgraded LFG sent to the natural gas network due to the project activity in year *y*
Source of data:	Project participants
Measurement procedures (if any):	Measured directly using an online Heating Value Meter from the gas stream. The measurement must be in volume basis and adjusted to reference conditions
Monitoring frequency:	Continuous
QA/QC procedures:	Flow meters shall be subject to a regular maintenance and testing regime to ensure accuracy. Calibration shall be according to manufacturers specifications
Any comment:	Applicable to Step D

Data / Parameter:	$LFG_{NG,y}$
Data unit:	Nm^3/yr
Description:	Amount of upgraded LFG sent to the natural gas network due to the project activity in year *y*
Source of data:	Project participants
Measurement procedures (if any):	Measured by a flow meter and adjusted to reference conditions. Data to be aggregated monthly and yearly
Monitoring frequency:	Continuous (average value in a time interval not greater than an hour shall be used in the calculations of emission reductions)
QA/QC procedures:	Flow meters shall be subject to a regular maintenance and testing regime to ensure accuracy. Calibration shall be according to manufacturers specifications
Any comment:	Applicable to Step D

Data / Parameter:	$\eta_{HG,PJ,j,y}$
Data unit:	Dimensionless
Description:	Efficiency of the heat generation equipment used in the project activity in year *y*
Source of data:	Use one of the following options to determine the efficiency: • Measured efficiency during monitoring; • Manufacturer's information on the efficiency; or • Use a default value of 60%

Measurement procedures (if any):	If measurements are conducted, use recognized standards for the measurement of the heat generator efficiency, such as the "*British Standard Methods for Assessing the thermal performance of boilers for steam, hot water and high temperature heat transfer fluids*" (BS845). Where possible, use preferably the direct method (dividing the net heat generation by the energy content of the fuels fired during a representative time period), as it is better able to reflect average efficiencies during a representative time period compared to the indirect method (determination of fuel supply or heat generation and estimation of the losses). Document measurement procedures and results and manufacturer's information transparently in the CDM-PDD
Monitoring frequency:	Annually
QA/QC procedures:	
Any comment:	Applicable to Step C.1

Data / Parameter:	$Q_{O2,kiln,h}$
Data unit:	volume of O_2 / volume of the exhaust gas flow
Description:	Average volumetric fraction of oxygen in the exhaust gas flow of the kiln in hour *h*
Measurement procedures (if any):	Monitor oxygen content in the exhaust gas from the kiln, using a continuous analyzer
Monitoring frequency:	Continuously and readings averaged hourly
QA/QC procedures:	Equipment should be maintained and calibrated in accordance with manufacturer's specifications
Any comment:	Applicable to Step C.2

Data / Parameter:	Operation of the energy plant
Data unit:	hr
Description:	Operation of the energy plant
Source of data:	Project participants
Measurement procedures (if any):	
Monitoring frequency:	Hourly
QA/QC procedures:	
Any comment:	Applicable to Step A.1.This is monitored to ensure methane destruction is claimed for methane used in electricity plant when it is operational

Data / Parameter:	Operation of the heat generating plant
Data unit:	hr
Description:	Operation of the heat generating plant
Source of data:	Project participants
Measurement procedures (if any):	Operating hours shall be identified for each item of equipment
Monitoring frequency:	Hourly
QA/QC procedures:	
Any comment:	Applicable to Step A.1.This is monitored to ensure methane destruction is only claimed for methane used in boiler/air heater when it is operational

IV. REFERENCES AND ANY OTHER INFORMATION

Not applicable.

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History of the document

Version	Date	Nature of revision
12.0.0	EB 65, Annex 15 25 November 2011	Revision to: • Clarify that the methodology is applicable to new and existing SWDS; • Broaden the applicability by allowing the use of landfill gas in brick kilns, by allowing the claim of certified emission reductions associated with fossil fuel displaced by landfill gas fed into a natural gas network and allowing that the use but not the amount of LFG changes between the baseline and project; • Revise the applicability conditions, requiring that: o If an existing active landfill gas capture system was in place prior to the implementation of the project activity, then historical or monitored information on the amount of landfill gas captured is required; and o The implementation of the project activity does not reduce the amount of organic waste that would be recycled in the absence of the project activity; • Incorporate the effect of methane oxidation in the top layer of the solid waste disposal site in the baseline scenario; • Refer to relevant tools; • Change the title from "Consolidated baseline and monitoring methodology for landfill gas project activities" to "Flaring or use of landfill gas".
11	EB 47, Annex 6 28 May 2009	• Allow only the option of continuous measurement of methane content of the LFG; • Include definition of continuous monitoring system.
10	EB 45, Annex 9 13 February 2009	• Include guidance for air heater efficiency; • Include a clarification that emission reductions can be claimed for generation of thermal energy provided that the LFG displaces use of fossil fuel either in a boiler or in an air heater.
09.1	EB 43, Annex 2 24 October 2008	Editorial changes to reflect that the source of data for the "Regulatory requirements relating to LFG" has been changed. Publicly available information should be used instead of contacting the DNA for collecting the information.

09	EB 41, Annex 4 02 August 2008	Following clarifications have been added: • The measurement of both LFG flow and methane fraction in LFG have to be conducted on the same basis (wet or dry); • Inclusion of cases where periodical measurements are allowed and guidance on performing periodical measurements for monitoring the fraction of methane in the LFG; • The title of the “Tool to determine methane emissions avoided from dumping waste at a solid waste disposal site” changes to “Tool to determine methane emissions avoided from disposal of waste at a solid waste disposal site”.
08.1	EB 39, Paragraph 22 16 May 2008	“Tool to calculate baseline, project and/or leakage emissions from electricity consumption” replaces the withdrawn “Tool to calculate project emissions from electricity consumption”.
08	EB 36, Annex 10 30 November 2007	Clarify the procedure to calculate the Adjustment Factor, where in the baseline the LFG was captured and destroyed/used; Clarify how to apply the “Tool to determine methane emissions avoided from the dumping waste at a solid waste disposal site” for estimating *ex ante* LFG emissions over the crediting period.
07	EB 35, Annex 11 19 October 2007	• To include AM0002, AM0003, AM0010, and AM0011; • Reference to the following tools was added: “Tool to calculate project emissions from electricity consumption”, “Tool to calculate project or leakage CO2 emissions from fossil fuel combustion”, and “Combined tool to identify the baseline scenario and demonstrate additionality”.
06	EB 32, Annex 6 22 June 2007	• Include procedures for estimating emissions reductions from use of captured LFG for energy generation; • Expand the applicability to project activities where the captured LFG is used to supply consumers through a natural gas distribution network.
05	EB 28, Annex 9 15 December 2006	Replace the procedure for estimating flare efficiency with a reference to the Methodological “Tool to determine project emissions from flaring gases containing methane”.
04	EB 25, Annex 6 21 July 2006	• Allow the use of one measurement point for LFG captured, if the captured LFG is flared only and not used for energy and/or electricity generation; • Provide a default value for methane destruction flare efficiency (50%) should the methane destruction efficiency not be measured.
03	EB 24, Annex 6 12 May 2006	• Reflect that separate monitoring of LFG temperature and pressure is not required if the monitoring equipment used automatically adjusts the volume for these two parameters; • Incorporate the procedures of estimating emissions reductions to take into account situations where project activities may not utilize the captured LFG but require use of fossil fuel or purchased electricity in operating the project activity.
02	EB 21, Annex 9 30 September 2005	Guidance on how to estimate the Adjustment Factor (AF) was provided.
01	EB 15, Annex 1 03 September 2004	Initial adoption.
Decision Class: Regulatory **Document Type**: Standard **Business Function**: Methodology		