Approved consolidated baseline methodology ACM0001

"Consolidated baseline and monitoring methodology for landfill gas project activities"

I. SOURCE AND APPLICABILITY

Sources

This methodology is based on elements from the following approved proposals for baseline 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 landfill gas 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 landfill gas capture projects (approved based on proposal NM0005: Nova Gerar landfill gas 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 landfill gas 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 landfill gas recovery, whose project design document and baseline study, monitoring and verification plans were developed by Onyx (July 2003).

For more information regarding the proposals and its considerations by the Executive Board please refer to the cases on <http://cdm.unfccc.int/goto/MPappmeth>.

The methodology also refers to the latest version of the following tools[1]:

- "Tool for the demonstration and assessment of 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";
- "Combined tool to identify the baseline scenario and demonstrate additionality";
- "Tool to determine methane emissions avoided from dumping waste at a solid waste disposal site";
- "Tool to calculate the emission factor for an electricity system".

Selected approach from paragraph 48 of the CDM modalities and procedures

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

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

Applicability

This methodology is applicable to landfill gas capture project activities, where the baseline scenario is the partial or total atmospheric release of the gas and the project activities include situations such as:

a) The captured gas is flared; and/or
b) The captured gas is used to produce energy (e.g. electricity/thermal energy);
c) The captured gas is used to supply consumers through natural gas distribution network. If emissions reductions are claimed for displacing natural gas, project activities may use approved methodology AM0053.

In addition, the applicability conditions included in the tools referred to above apply.

II. BASELINE METHODOLOGY

Project Boundary

The project boundary is the site of the project activity where the gas is captured and destroyed/used.

If the electricity for project activity is sourced from grid or electricity generated by the LFG captured would have been generated by power generation sources connected to the grid, the project boundary shall include all the power generation sources connected to the grid to which the project activity is connected.

If the electricity for project activity is from a captive generation source or electricity generated by the captured LFG would have been generated by a captive power plant, the captive power plant shall be included in the project boundary.

Table 1: Summary of gases and sources included in the project boundary, and justification / explanation where gases and sources are not included.

	Source	Gas	Included?	Justification / Explanation
Baseline	Emissions from decomposition of waste at the landfill 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 landfills. Exclusion of this gas is conservative.
		CO_2	No	CO_2 emissions from the decomposition of organic waste are not accounted.
	Emissions from electricity consumption	CO_2	Yes	Electricity may be consumed from the grid or generated onsite/offsite in the baseline scenario
		CH_4	No	Excluded for simplification. This is conservative.
		N_2O	No	Excluded for simplification. This is conservative.
	Emissions from thermal energy generation	CO_2	Yes	If thermal energy 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.
Project Activity	On-site fossil fuel consumption due to the project activity other than for electricity generation	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 on-site electricity use	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 the selection of the most plausible baseline scenario

Step 1: Identification of alternative scenarios.

Project participants should use step 1 of the latest version of the "Tool for the demonstration and assessment of additionality", to identify all realistic and credible baseline alternatives. In doing so, relevant policies and regulations related to the management of landfill sites should be taken into account. Such policies or regulations may include mandatory landfill gas capture or destruction requirements because of safety issues or local environmental regulations.[2] Other policies could include local policies promoting productive use of landfill gas such as those for the production of renewable energy, or those that promote the processing of organic waste. In addition, the assessment of alternative scenarios should take into account local economic and technological circumstances.

[2] The project developer must bear in mind the relevant clarifications on the treatment of national and/or sectoral policies and regulations in determining a baseline scenario as per Annex 3 to the Executive Board 22nd meeting and any other forthcoming guidance from the Board on this subject.

National and/or sectoral policies and circumstances must be taken into account in the following ways:

- In Sub-step 1b of the "Tool for the demonstration and assessment of additionality", the project developer must show that the project activity is not the only alternative that is in compliance with all regulations (e.g. because it is required by law);
- Via the adjustment factor AF in the baseline emissions project participants must take into account that some of the methane generated in the baseline may be captured and destroyed to comply with regulations or contractual requirements;
- The project participants must monitor all relevant policies and circumstances at the beginning of each crediting period and adjust the baseline accordingly.

Alternatives for the disposal/treatment of the waste in the absence of the project activity, i.e. the scenario relevant for estimating baseline methane emissions, to be analysed should include, inter alia:

LFG1. The project activity (i.e. capture of landfill gas and its flaring and/or its use) undertaken without being registered as a CDM project activity.

LFG2. Atmospheric release of the landfill gas or partial capture of landfill gas and destruction to comply with regulations or contractual requirements, or to address safety and odour concerns.

If LFG is used for generation of electric or heat energy for export to a grid and/or to a nearby industry or used on-site, realistic and credible alternatives should also be separately determined for:

- Power generation in the absence of the project activity;
- Heat generation in the absence of the project activity.

For power generation, the realistic and credible alternative(s) may include, inter alia:

P1. Power generated from landfill gas undertaken without being registered as CDM project activity.
P2. Existing or construction of a new on-site or off-site fossil fuel fired cogeneration plant.
P3. Existing or construction of a new on-site or off-site renewable based cogeneration plant.
P4. Existing or construction of a new on-site or off-site fossil fuel fired captive power plant.
P5. Existing or construction of a new on-site or off-site renewable based captive power plant.
P6. Existing and/or new grid-connected power plants.

For heat generation, the realistic and credible alternative(s) may include, inter alia:

H1. Heat generated from landfill gas undertaken without being registered as CDM project activity.
H2. Existing or Construction of a new on-site or off-site fossil fuel fired cogeneration plant.
H3. Existing or Construction of a new on-site or off-site renewable based cogeneration plant.
H4. Existing or new construction of on-site or off-site fossil fuel based boilers.
H5. Existing or new construction of on-site or off-site renewable energy based boilers.
H6. Any other source such as district heat, and
H7. Other heat generation technologies (e.g. heat pumps or solar energy).

Step 2: Identify the fuel for the baseline choice of energy source taking into account the national and/or sectoral policies as applicable.

Demonstrate that the identified baseline fuel 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 may consider an alternative fuel that result in lowest baseline emissions during the period of partial supply.

Detailed justification shall be provided for the selected baseline fuel. As a conservative approach, the lowest carbon intensive fuel such as natural gas through out the period may be used.

Note: Steps 3 and 4 shall be applied for each component of the baseline, i.e. baseline for waste treatment, electricity generation and heat generation.

Step 3: Step 2 and/or step 3 of the latest approved version of the "Tool for demonstration and assessment of additionality" shall be used to assess which of these alternatives should be excluded from further consideration (e.g. alternatives facing prohibitive barriers or those clearly economically unattractive).

Step 4: Where more than one credible and plausible alternative remains, project participants shall, as a conservative assumption, use the alternative baseline scenario that results in the lowest baseline emissions as the most likely baseline scenario. The least emission alternative will be identified for each component of the baseline scenario. In assessing these scenarios, any regulatory or contractual requirements should be taken into consideration.

Note: The methodology is only applicable if:

(a) The most plausible baseline scenario for the landfill gas is identified as either the atmospheric release of landfill gas or landfill gas is partially captured and subsequently flared (LFG2).

(b) The most plausible baseline scenario for the energy component of the baseline scenario is one of the following scenarios described in Table 2 below.

Table 2: Combinations of baseline options and scenarios applicable to this methodology

Scenario	Baseline			Description of situation
	Landfill gas	Electricity	Heat	
1	LFG2	P4 or P6	H4	The atmospheric release of landfill gas or landfill gas is partially captured and subsequently flared. The electricity is obtained from an existing/new fossil based captive power plant or from the grid and heat from an existing/new fossil fuel based boiler.

As an alternative to the procedure given above the "Combined tool to identify the baseline scenario and demonstrate additionality" could be used. Same additional guidance as provided above should be used.

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 CDM Executive Board, which is available on the UNFCCC CDM web site[3].

If the "Combined tool to identify the baseline scenario and demonstrate additionality" is used for the selection of the most plausible baseline scenario this same tool should be used for the demonstration of additionality.

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

Baseline emissions

$$BE_y = \left(MD_{project,y} - MD_{BL,y}\right) * GWP_{CH4} + EL_{LFG,y} \cdot CEF_{elec,BL,y} + ET_{LFG,y} * CEF_{ther,BL,y} \quad \textbf{(1)}$$

Where:

BE_y	=	Baseline emissions in year y (tCO_2e)
$MD_{project,y}$	=	The amount of methane that would have been destroyed/combusted during the year, in tonnes of methane (tCH_4) in project scenario
$MD_{BL,y}$	=	The amount of methane that would have been destroyed/combusted during the year in the absence of the project due to regulatory and/or contractual requirement, in tonnes of methane (tCH_4)
GWP_{CH4}	=	Global Warming Potential value for methane for the first commitment period is 21 tCO_2e/tCH_4
$EL_{LFG,y}$	=	Net quantity of electricity produced using LFG, which in the absence of the project activity would have been produced by power plants connected to the grid or by an on-site/off-site fossil fuel based captive power generation, during year y, in megawatt hours (MWh).
$CEF_{elecy,BL,y}$	=	CO_2 emissions intensity of the baseline source of electricity displaced, in tCO_2e/MWh. This is estimated as per equation (9) below.
$ET_{LFG,y}$	=	The quantity of thermal energy produced utilizing the landfill gas, which in the absence of the project activity would have been produced from onsite/offsite fossil fuel fired boiler, during the year y in TJ.
$CEF_{ther,BL,y}$	=	CO_2 emissions intensity of the fuel used by boiler to generate thermal energy which is displaced by LFG based thermal energy generation, in tCO_2e/TJ. This is estimated as per equation (10) below.

In the case where the $MD_{BL,y}$ is given/defined in the regulation and/or contract as a quantity that quantity will be used. In situations where in the baseline LFG captured and destroyed, for reasons other than regulation and/or contract, historic data on actual amount captured shall be used as $MD_{BL,y}$.

In cases where regulatory or contractual requirements do not specify $MD_{BL,y}$ or no historic data exists for LFG captured and destroyed an "Adjustment Factor" (AF) shall be used and justified, taking into account the project context.

$$MD_{BL,y} = MD_{project,y} * AF \quad \textbf{(2)}$$

Guidance on estimating AF:

- In cases where a **specific system for collection and destruction of methane** is mandated by regulatory or contractual requirements or is undertaken for other reasons, the ratio of the destruction efficiency of the baseline system to the destruction efficiency of the system used in the project activity shall be used. The following procedure should be followed:

Step 1: Estimation of the destruction efficiency of the system

a. In situations where the baseline specific system for collection and destruction of methane installed and operating prior to implementation of the project activity and measurements of the amount of methane that is destroyed are available then the following equation will be used:

$$\varepsilon_{BL} = MD_{Hist} / MG_{Hist} \quad (3)$$

Where:

ε_{BL}	=	Destruction efficiency of the baseline system (fraction)
MD_{Hist}	=	Amount of methane destroyed historically measured for the previous year before the start of project activity (tCH_4).
MG_{Hist}	=	Amount of methane generated historically for the previous year before the start of project activity, estimated using the actual amount of waste disposed in the landfill as per the latest version of the "Tool to determine methane emissions avoided from dumping waste at a solid waste disposal site"(tCH_4).

While estimating ex-ante methane emissions, that are generated in the landfill with latest version of the approved "Tool to determine methane emissions avoided from dumping waste at a solid waste disposal site" the following guidance should be taken into account:

- In the tool, x will refer to the year since the landfill started receiving wastes [x runs from the first year of landfill operation (x=1) to the year for which emissions are calculated (x=y)].
- Sampling to determine the different waste types is not necessary. The waste composition can be obtained from previous studies.

b. In cases, where the baseline system for collection and destruction of methane is **not** installed prior to project implementation and/or measurements of the amount of methane that is destroyed are **not** available then the destruction efficiency of the system mandated by regulatory or contractual requirements (ε_{BL}) should be assumed to be equal to the theoretical efficiency of the specific system for collection and destruction of methane that is defined in the regulation or contract. In other cases, a procedure for estimating the amount of landfill gas that would be captured in absence of the project activity shall be provided in the CDM-PDD validated by the DOE. This procedure shall be used to estimate the MD_{Hist} in equation 3 above to estimate the baseline destruction efficiency.

c. In cases where a specific percentage of the "generated" amount of methane to be collected and destroyed is specified in the contract or mandated by regulations, the efficiency of the baseline system (ε_{BL}) is equal to the defined specific percentage.

Step 2: Estimation of the destruction efficiency of the system used in the project activity

Option 1:

The destruction efficiency of the system used in the project activity is estimated once and remains fixed for the whole crediting period and will be estimated as follows:

$$\varepsilon_{PR} = MD_{project,1} / MG_{PR,1} \quad \textbf{(4)}$$

Where:

ε_{PR}	=	Destruction efficiency of the system used in the project activity that will remain fixed for the whole crediting period (fraction)
$MD_{project,1}$	=	Amount of methane destroyed by the project activity during the first year of the project activity (tCH_4)
$MG_{PR,1}$	=	Amount of methane generated during the first year of the project activity estimated using the actual amount of waste disposed in the landfill as per the latest version of the "Tool to determine methane emissions avoided from dumping waste at a solid waste disposal site", see guidance in Step 1 (tCH_4)

Option 2:

The destruction efficiency of the system used in the project activity is estimated every year as follows:

$$\varepsilon_{PR,y} = MD_{project,y} / MG_{PR,y} \quad \textbf{(5)}$$

Where:

$\varepsilon_{PR,y}$	=	Destruction efficiency of the system used in the project activity for year y (fraction)
$MD_{project,y}$	=	Amount of methane destroyed by the project activity during the year y of the project activity (tCH_4).
$MG_{PR,y}$	=	Amount of methane generated during year y of the project activity estimated using the actual amount of waste disposed in the landfill as per the latest version of the "Tool to determine methane emissions avoided from dumping waste at a solid waste disposal site", see further guidance in Step 1 (tCH_4).

Step 3: Estimation of the adjustment factor (AF)

If option 1 is used in step 2 then:

$$AF = \varepsilon_{BL} / \varepsilon_{PR} \quad \textbf{(6)}$$

If option 2 is used in step 2 then:

$$AF_y = \varepsilon_{BL} / \varepsilon_{PR,y} \quad \textbf{(7)}$$

Where:

AF_y Adjustment factor for year y, this factor will be used in equation 2 in place of AF

Project proponents should provide an ex ante estimate of emissions reductions, by projecting the future GHG emissions of the landfill as specified below.

$MD_{project,y}$ will be determined *ex post* by metering the actual quantity of methane captured and destroyed once the project activity is operational.

The methane destroyed by the project activity ($MD_{project,y}$) during a year is determined by monitoring the quantity of methane actually flared and gas used to generate electricity and/or produce thermal energy and/or supply to end users via natural gas distribution pipeline, if applicable, and the total quantity of methane captured.

The sum of the quantities fed to the flare(s), to the power plant(s), to the boiler(s) and to the natural gas distribution network (estimated using equation (3)) must be compared annually with the total quantity of methane generated. The lowest value of the two must be adopted as $MD_{project,y}$.
The following procedure applies when the total quantity of methane generated is the highest. The working hours of the energy plant(s) and the boiler(s) should be monitored and no emission reduction could be claimed for methane destruction in the energy plant or the boiler during non-operational hours.

$$MD_{project,y} = MD_{flared,y} + MD_{electricity,y} + MD_{thermal,y} + MD_{PL,y} \qquad \textbf{(8)}$$

Where:

$MD_{flared,y}$	=	Quantity of methane destroyed by flaring (tCH_4)
$MD_{electricity,y}$	=	Quantity of methane destroyed by generation of electricity (tCH_4)
$MD_{thermal,y}$	=	Quantity of methane destroyed for the generation of thermal energy (tCH_4)
$MD_{PL,y}$	=	Quantity of methane sent to the pipeline for feeding to the natural gas distribution network (tCH_4)

Right Hand Side of the equation (3) is sum over all the points of captured methane use in case the methane is flared in more than one flare, and/or used in more than one electricity generation source, and/or more than one thermal energy generator. The supply to each point of methane destruction, through flaring or use for energy generation, shall be measured separately.

$$MD_{flared,y} = \{LFG_{flare,y} * w_{CH4,y} * D_{CH4}) - (PE_{flare,y} / \mathrm{GWP_{CH4}}) \qquad \textbf{(9)}$$

Where:

$LFG_{flare,y}$	=	Quantity of landfill gas fed to the flare(s) during the year measured in cubic meters (m^3)
$w_{CH4,y}$	=	Average methane fraction of the landfill gas as measured[4] during the year and expressed as a fraction (in $m^3\ CH_4$ / m^3 LFG)
D_{CH4}	=	Methane density expressed in tonnes of methane per cubic meter of methane (tCH_4/m^3CH_4)[5]
$PE_{flare,y}$	=	Project emissions from flaring of the residual gas stream in year y (tCO_{2e}) determined following the procedure described in the "Tool to determine project emissions from flaring gases containing Methane". If methane is flared through more than one flare, the $PE_{flare,y}$ shall be determined for each flare using the tool.

$$MD_{electricity,y} = LFG_{electricity,y} * w_{CH4,y} * D_{CH4} \qquad \textbf{(10)}$$

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[4] Methane fraction of the landfill gas to be measured on wet basis.

[5] At standard temperature and pressure (0 degree Celsius and 1,013 bar) the density of methane is 0.0007168 tCH_4/m^3CH_4.

Where:
$MD_{electricity,y}$ = Quantity of methane destroyed by generation of electricity
$LFG_{electricity,y}$ = Quantity of landfill gas fed into electricity generator.

$$MD_{thermal,y} = LFG_{thermal,y} * w_{CH4,y} * D_{CH4} \quad \textbf{(11)}$$

Where $MD_{thermal,y}$ is the quantity of methane destroyed for the generation of thermal energy and $LFG_{thermal,y}$ is the quantity of landfill gas fed into the boiler.

$$MD_{PL,y} = LFG_{PL,y} * w_{CH4,y} * D_{CH4} \quad \textbf{(12)}$$

Where $LFG_{PL,y}$ is the quantity of landfill gas sent to pipeline for feeding to the natural gas distribution network

Ex-ante estimation of the the amount of methane that would have been destroyed/combusted during the year, in tonnes of methane ($MD_{project,y}$)

The ex-ante estimation of the the amount of methane that would have been destroyed/combusted during the year, in tonnes of methane ($MD_{project,y}$) will be done with the latest version of the approved "Tool to determine methane emissions avoided from dumping waste at a solid waste disposal site", considering the following additional equation:

$$MD_{project,y} = BE_{CH4,SWDS,y}/GWP_{CH4} \quad \textbf{(13)}$$

Where:

$BE_{CH4,SWDS,y}$ = Methane generation from the landfill in the absence of the project activity at year y (tCO_2e), calculated as per the "Tool to determine methane emissions avoided from dumping waste at a solid waste disposal site". The tool estimates methane generation adjusted for, using adjustment factor (f) any landfill gas in the baseline that would have been captured and destroyed to comply with relevant regulations or contractual requirements, or to address safety and odor concerns. As this is already accounted for in equation 2, "f" in the tool shall be assigned a value 0.

Furthermore the following guidance should be taken into account:

- In the tool x will refer to the year since the landfill started receiving wastes [x runs from the first year of landfill operation (x=1) to the year for which emissions are calculated (x=y)];
- Sampling to determine the different waste types is not necessary, the waste composition can be obtained from previous studies.

The efficiency of the degassing system which will be installed in the project activity should be taken into account while estimating the ex-ante estimation.

Determination of $CEF_{elec,BL,y}$

In case the baseline is electricity generated by an on-site/off-site fossil fuel fired captive power plant in the baseline, project proponents may use a default value of 0.8 tCO2/MWh or estimate the emission factor as follows:

$$CEF_{elec,BL,y} = \frac{EF_{fuel,BL}}{\varepsilon_{gen,BL} . NCV_{fuel,BL}.} * 3.6 \cdot \qquad \textbf{(14)}$$

Where:

$EF_{fuel,BL}$	=	Emission factor of baseline fossil fuel used, as identified in the baseline scenario identification procedure, expressed in tCO_2/mass of volume unit
$NCV_{fuel,BL}$	=	Net calorific value of fuel, as identified through the baseline identification procedure, in GJ per unit of volume or mass
$\varepsilon_{gen,BL}$	=	Efficiency of baseline power generation plant
3.6	=	Equivalent of GJ energy in a MWh of electricity

To estimate electricity generation efficiency, project participants may use the highest value among the following three values as a conservative approach:

1. Measured efficiency prior to project implementation;
2. Measured efficiency during monitoring;
3. Data from manufacturer for efficiency at full load;
4. Default efficiency of 60%.

In case the baseline is electricity generated by plants connected to the grid the emission factor should be calculated according to "Tool to calculate the emission factor for an electricity system".

Determination of $CEF_{ther,BL,y}$

$$CEF_{therm,BL,y} = \frac{EF_{fuel,BL}}{\varepsilon_{boiler} \cdot NCV_{fuel,BL}} \quad . \qquad \textbf{(15)}$$

Where:

ε_{boiler}	=	The energy efficiency of the boiler used in the absence of the project activity to generate the thermal energy
$NCV_{fuel,BL}$	=	Net calorific value of fuel, as identified through the baseline identification procedure, used in the boiler to generate the thermal energy in the absence of the project activity in TJ per unit of volume or mass
$EF_{fuel,BL}$	=	Emission factor of the fuel, as identified through the baseline identification procedure, used in the boiler to generate the thermal energy in the absence of the project activity in tCO2 / unit of volume or mass of the fuel.

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:

1. Measured efficiency prior to project implementation;
2. Measured efficiency during monitoring;
3. Manufacturer's information on the boiler efficiency.

Option B

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

In determining the CO_2 emission factors (EF_{fuel}) of fuels, reliable local or national data should be used if available. Where such data is not available, IPCC default emission factors should be chosen in a conservative manner.

$$PE_y = PE_{EC,y} + PE_{FC,j,y} \quad \textbf{(16)}$$

Where:

$PE_{EC,y}$	=	Emissions from consumption of electricity in the project case. The project emissions from electricity consumption ($PE_{EC,y}$) will be calculated following the latest version of "Tool to calculate baseline, project and/or leakage emissions from electricity consumption". If in the baseline a part of LFG was captured then the electricity quantity used in calculation is electricity used in project activity net of that consumed in the baseline.
$PE_{FC,j,y}$	=	Emissions from consumption of heat in the project case. The project emissions from fossil fuel combustion ($PE_{FC,j,y}$) will be calculated following the latest version of "Tool to calculate project or leakage CO_2 emissions from fossil fuel combustion". For this purpose, the processes j in the tool corresponds to all fossil fuel combustion in the landfill, as well as any other on-site fuel combustion for the purposes of the project activity. If in the baseline part of a LFG was captured then the heat quantity used in calculation is fossil fuel used in project activity net of that consumed in the baseline.

Leakage

No leakage effects need to be accounted under this methodology.

Emission Reduction

Emission reductions are calculated as follows:

$$ER_y = BE_y - PE_y \quad \textbf{(17)}$$

Where:

ER_y	=	Emission reductions in year y (tCO_2e/yr)
BE_y	=	Baseline emissions in year y (tCO_2e/yr)
PE_y	=	Project emissions in year y (tCO_2/yr)

Data and parameters not monitored

Data/Parameter:	Regulatory requirements relating to landfill gas projects
Data unit:	--
Description:	Regulatory requirements relating to landfill gas projects
Source of data:	The DNA shall be contacted to provide information regarding host country regulation.
Measurement procedures (if any):	
Any comment:	The information though recorded annually, is used for changes to the adjustment factor (AF) or directly $MD_{BL,y}$ at renewal of the credit period. Relevant regulations for LFG project activities shall be updated at renewal of each credit period. Changes to regulation should be converted to the amount of methane that would have been destroyed/combusted during the year in the absence of the project activity ($MD_{BL,y}$). Project participants should explain how regulations are translated into that amount of gas.

Parameter:	GWP_{CH4}
Data unit:	$tCO_2e/tCH4$
Description:	Global warming potential of CH_4
Source of data:	IPCC
Measurement procedures (if any):	21 for the first commitment period. Shall be updated according to any future COP/MOP decisions.
Any comment:	

Parameter:	D_{CH4}
Data unit:	tCH_4/m^3CH_4
Description:	Methane Density
Source of data:	
Measurement procedures (if any):	At standard temperature and pressure (0 degree Celsius and 1,013 bar) the density of methane is 0.0007168 tCH_4/m^3CH_4
Any comment:	

Parameter:	$BE_{CH4,SWDS,y}$
Data unit:	tCO_2e
Description:	Methane generation from the landfill in the absence of the project activity at year *y*
Source of data:	Calculated as per the “Tool to determine methane emissions avoided from dumping waste at a solid waste disposal site”.
Measurement procedures (if any):	As per the “Tool to determine methane emissions avoided from dumping waste at a solid waste disposal site”
Any comment:	Used for ex-ante estimation of the amount of methane that would have been destroyed/combusted during the year

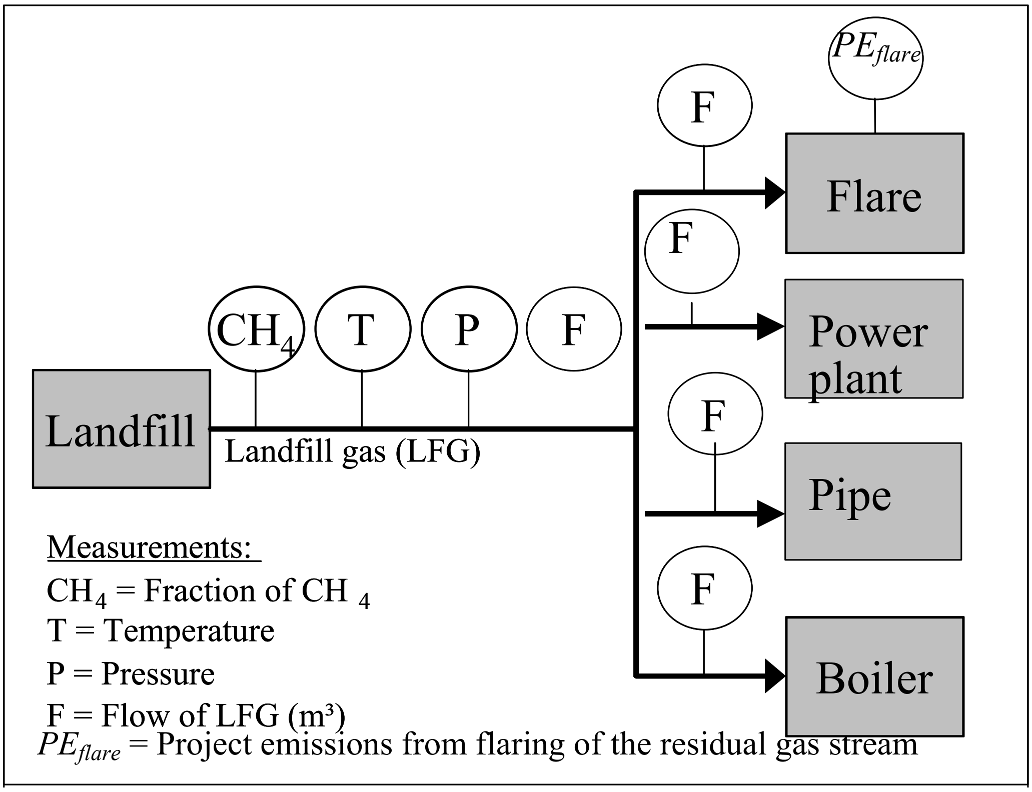
Parameter:	MD_{Hist}
Data unit:	tCH_4
Description:	Amount of methane destroyed historically for the previous year before the start of project activity.
Source of data:	Project proponent.
Measurement procedures (if any):	
Any comment:	This parameter could be used for the estimation of AF.

Parameter:	MG_{Hist}
Data unit:	tCH_4
Description:	Amount of methane generated historically for the previous year before the start of project activity.
Source of data:	Project proponents.
Measurement procedures (if any):	Estimated using the actual amount of waste disposed in the landfill as per the latest version of the "Tool to determine methane emissions avoided from dumping waste at a solid waste disposal site"
Any comment:	This parameter could be used for the estimation of AF.

III. MONITORING METHODOLOGY

The monitoring methodology is based on direct measurement of the amount of landfill gas captured and destroyed at the flare platform(s), the natural gas pipelines and the electricity generating/thermal energy unit(s) to determine the quantities as shown in Figure 1. The monitoring plan provides for continuous measurement of the quantity and quality of LFG flared. The main variables that need to be determined are the quantity of methane actually captured $MD_{project,y}$, quantity of methane flared ($MD_{flared,y}$), the quantity of methane used to generate electricity ($MD_{electricity,y}$)/thermal energy ($MD_{thermal,y}$), the quantity of methane sent to the pipeline to the natural gas distribution network ($MD_{PL,y}$) and the quantity of methane generated ($MD_{total,y}$). The methodology also measures the energy generated by use of LFG ($EL_{LFG,y}$, $ET_{LFG,y}$) and energy consumed by the project activity that is produced using fossil fuels.

Figure 1: Monitoring Plan



To determine these variables, the following parameters have to be monitored:

- The amount of landfill gas generated (in m³, using a continuous flow meter), where the total quantity ($LFG_{total,y}$) as well as the quantities fed to the flare(s) ($LFG_{flare,y}$), to the power plant(s) ($LFG_{electricity,y}$), sent to pipeline for feeding to the natural gas distribution network ($LFG_{PL,y}$), and to the boiler(s) ($LFG_{thermal,y}$) are measured continuously. In the case where LFG is just flared, one flow meter for each flare can be used provided that these meters used are calibrated periodically by an officially accredited entity;
- The fraction of methane in the landfill gas ($w_{CH4,y}$) should be measured with a continuous analyzer or, alternatively, with periodical measurements, at a 95% confidence level , using calibrated portable gas meters and taking a statistically valid number of samples and accordingly the amount of land fill gas from $LFG_{total,y}$, $LFG_{flare,y}$, $LFG_{electricity,y}$, $LF_{PL,y}$ and $LFG_{thermal,y}$ shall be monitored in the same frequency. The continuous methane analyser should be the preferred option because the methane content of landfill gas captured can vary by more than 20% during a single day due to gas capture network conditions (dilution with air at wellheads, leakage on pipes, etc.). Methane fraction of the landfill gas to be measured on wet basis;
- The parameters used for determining the project emissions from flaring of the residual gas stream in year y ($PE_{flare,y}$) should be monitored as per the "Tool to determine project emissions from flaring gases containing methane";

- Temperature (T) and pressure (p) of the landfill gas are required to determine the density of methane in the landfill gas;
- The quantities of fossil fuels required to operate the landfill gas project, including the pumping equipment for the collection system and energy required to transport heat, should be monitored. In projects where LFG gas is captured in the baseline to either meet the regulation or for safety reason, fossil fuel used in the baseline too should be recorded;
- The quantity of electricity imported, in the baseline and the project situation, to meet the requirements of the project activity, if any;
- The quantity of electricity exported out of the project boundary, generated from landfill gas, if any;
- Relevant regulations for LFG project activities shall be monitored and updated at renewal of each credit period. Changes to regulation should be converted to the amount of methane that would have been destroyed/combusted during the year in the absence of the project activity ($MD_{BL,y}$). Project participants should explain how regulations are translated into that amount of gas;
- The operating hours of the energy plant(s) and the boiler(s).

The measurement equipment for gas quality (humidity, particulate, etc.) is sensitive, so a strong QA/QC procedure for the calibration of this equipment is needed.

Data and parameters monitored

Data / parameter:	$LFG_{total,y}$
Data unit:	m^3
Description:	Total amount of landfill gas captured at Normal Temperature and Pressure
Source of data:	Project participants
Measurement procedures (if any):	Measured by a flow meter. Data to be aggregated monthly and yearly.
Monitoring frequency:	Continuous
QA/QC procedures:	Flow meters should be subject to a regular maintenance and testing regime to ensure accuracy.
Any comment:	

Data / parameter:	$LFG_{flare,y}$
Data unit:	m^3
Description:	Amount of landfill gas flared at Normal Temperature and Pressure
Source of data:	Project participants
Measurement procedures (if any):	Measured by a flow meter. Data to be aggregated monthly and yearly for each flare.
Monitoring frequency:	Continuous
QA/QC procedures:	Flow meters should be subject to a regular maintenance and testing regime to ensure accuracy.
Any comment:	

Data / parameter:	$LFG_{electricity,y}$
Data unit:	m^3
Description:	Amount of landfill gas combusted in power plant at Normal Temperature and Pressure
Source of data:	Project participants
Measurement procedures (if any):	Measured by a flow meter. Data to be aggregated monthly and yearly for each power plant.
Monitoring frequency:	Continuous
QA/QC procedures:	Flow meters should be subject to a regular maintenance and testing regime to ensure accuracy.
Any comment:	

Data / parameter:	$LFG_{thermal,y}$
Data unit:	m^3
Description:	Amount of methane combusted in boiler at Normal Temperature and Pressure
Source of data:	Project participants
Measurement procedures (if any):	Measured by a flow meter. Data to be aggregated monthly and yearly for each boiler.
Monitoring frequency:	Continuous
QA/QC procedures:	Flow meters should be subject to a regular maintenance and testing regime to ensure accuracy.
Any comment:	

Data / parameter:	$LFG_{PL,y}$
Data unit:	m^3
Description:	Amount of landfill gas sent to Pipe Line at Normal Temperature and Pressure
Source of data:	Project participants
Measurement procedures (if any):	Measured by a flow meter. Data to be aggregated monthly and yearly for each flare.
Monitoring frequency:	Continuous
QA/QC procedures:	Flow meters should be subject to a regular maintenance and testing regime to ensure accuracy.
Any comment:	

Data / parameter:	$PE_{flare,y}$
Data unit:	tCO_{2e}
Description:	Project emissions from flaring of the residual gas stream in year *y*
Source of data:	Calculated as per the "Tool to determine project emissions from flaring gases containing Methane".
Measurement procedures (if any):	As per the "Tool to determine project emissions from flaring gases containing Methane"
Monitoring frequency:	As per the "Tool to determine project emissions from flaring gases containing Methane"
QA/QC procedures:	As per the "Tool to determine project emissions from flaring gases containing Methane"
Any comment:	-

Data / Parameter:	w_{CH4}
Data unit:	m^3 CH_4 / m^3 LFG
Description:	Methane fraction in the landfill gas
Source of data:	To be measured continuously by project participants using certified equipment
Measurement procedures (if any):	Preferably measured by continuous gas quality analyser. Methane fraction of the landfill gas to be measured on wet basis.
Monitoring frequency:	Continuous
QA/QC procedures:	The gas analyser should be subject to a regular maintenance and testing regime to ensure accuracy.
Any comment:	

Data / parameter:	T
Data unit:	°C
Description:	Temperature of the landfill gas
Source of data:	Project participants
Measurement procedures (if any):	Measured to determine the density of methane D_{CH4}. No separate monitoring of temperature is necessary when using flow meters that automatically measure temperature and pressure, expressing LFG volumes in normalized cubic meters.
Monitoring frequency:	Continuous
QA/QC procedures:	Measuring instruments should be subject to a regular maintenance and testing regime in accordance to appropriate national/international standards.
Any comment:	

Data / parameter:	P
Data unit:	Pa
Description:	Pressure of the landfill gas
Source of data:	Project participants
Measurement procedures (if any):	Measured to determine the density of methane D_{CH4}. No separate monitoring of temperature is necessary when using flow meters that automatically measure temperature and pressure, expressing LFG volumes in normalized cubic meters.
Monitoring frequency:	Continuous
QA/QC procedures:	Measuring instruments should be subject to a regular maintenance and testing regime in accordance to appropriate national/international standards.
Any comment:	

Data / parameter:	EL_{LFG}
Data unit:	MWh
Description:	Net amount of electricity generated using LFG.
Source of data:	Project participants
Measurement procedures (if any):	Electricity meter
Monitoring frequency:	Continuous
QA/QC procedures:	Electricity meter will be subject to regular (in accordance with stipulation of the meter supplier) maintenance and testing to ensure accuracy.
Any comment:	Required to estimate the emission reductions from electricity generation from LFG, if credits are claimed.

Data / Parameter:	ET_{LFG}
Data unit:	TJ
Description:	Total amount of thermal energy generated using LFG
Source of data:	Project participants
Measurement procedures (if any):	-In case of steam meter: The enthalpy of steam and feed water will be determined at measured temperature and pressure and the enthalpy difference will be multiplied with quantity measured by steam meter. -In case of hot air: the temperature, pressure and mass flow rate will be measured.
Monitoring frequency:	Continuous
QA/QC procedures:	In case of monitoring of steam, it will be calibrated for pressure and temperature of steam at regular intervals. The meter shall be subject to regular maintenance and testing to ensure accuracy.
Any comment:	Required to estimate the emission reductions from thermal energy generation from LFG, if credits are claimed.

Data / parameter:	$CEF_{elecy,BL,y}$
Data unit:	tCO_2/MWh
Description:	Carbon emission factor of electricity.
Source of data:	
Measurement procedures (if any):	A default of 0.8 can be used if electricity in the baseline would have been produced using captive power plant. Else, equation 8 provides the estimation equation. In case the baseline source would have been grid, emission factor shall be estimated as described in "Tool to calculate the emission factor for an electricity system".
Monitoring frequency:	Annually
QA/QC procedures:	
Any comment:	

Data / parameter:	$EF_{fuel,BL}$
Data unit:	tCO_2/mass or volume
Description:	CO_2 emission factor of fossil fuel.
Source of data:	The source of data should be the following, in order of preference: project specific data, country specific data or IPCC default values. As per guidance from the Board, IPCC default values should be used only when country or project specific data are not available or difficult to obtain.
Measurement procedures (if any):	
Monitoring frequency:	Annually
QA/QC procedures:	
Any comment:	Fossil fuel that would have been used in the baseline captive power plant or thermal energy generation.

Data / parameter:	$NCV_{fuel,BL}$
Data unit:	GJ/mass or volume units of fuel
Description:	Net calorific value of fossil fuel
Source of data:	The source of data should be the following, in order of preference: project specific data, country specific data or IPCC default values. As per guidance from the Board, IPCC default values should be used only when country or project specific data are not available or difficult to obtain.
Measurement procedures (if any):	
Monitoring frequency:	Annually
QA/QC procedures:	
Any comment:	For fossil fuel that would have been used in the baseline for thermal energy generation and/or electricity generation.

Data / parameter:	$\varepsilon_{gen,BL}$
Data unit:	--
Description:	Efficiency of the baseline captive power plant.
Source of data:	
Measurement procedures (if any):	To estimate electricity generation efficiency, project participants may use the highest value among the following three values as a conservative approach: 1. Measured efficiency prior to project implementation; 2. Measured efficiency during monitoring; 3. Data from manufacturer for efficiency at full load; 4. Default efficiency of 60%.
Monitoring frequency:	Annually
QA/QC procedures:	
Any comment:	

Data / parameter:	ε_{boiler}
Data unit:	--
Description:	Efficiency of the baseline boiler for producing thermal energy.
Source of data:	
Measurement procedures (if any):	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: 1. Measured efficiency prior to project implementation; 2. Measured efficiency during monitoring; 3. Manufacturer's information on the boiler efficiency. Option B Assume a boiler efficiency of 100% based on the net calorific values as a conservative approach.
Monitoring frequency:	Annually
QA/QC procedures:	
Any comment:	

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

Data / parameter:	Operation of the boiler
Data unit:	Hours
Description:	Operation of the boiler
Source of data:	Project participants
Measurement procedures (if any):	
Monitoring frequency:	Annually
QA/QC procedures:	
Any comment:	This is monitored to ensure methane destruction is claimed for methane used in boiler when it is operational.

Data / parameter:	$PE_{EC,y}$
Data unit:	tCO_2
Description:	Project emissions from electricity consumption by the project activity during the year y
Source of data:	Calculated as per the "Tool to calculate baseline, project and/or leakage emissions from electricity consumption".
Measurement procedures (if any):	As per the "Tool to calculate baseline, project and/or leakage emissions from electricity consumption".
Monitoring frequency:	As per the "Tool to calculate baseline, project and/or leakage emissions from electricity consumption".
QA/QC procedures:	As per the "Tool to calculate baseline, project and/or leakage emissions from electricity consumption".
Any comment:	-

Data / parameter:	$PE_{FC,j,y}$
Data unit:	tCO_{2e}
Description:	Project emissions from fossil fuel combustion in process *j* during the year *y* .
Source of data:	Calculated as per the "Tool to calculate project or leakage CO_2 emissions from fossil fuel combustion".
Measurement procedures (if any):	As per the "Tool to calculate project or leakage CO_2 emissions from fossil fuel combustion"
Monitoring frequency:	As per the "Tool to calculate project or leakage CO_2 emissions from fossil fuel combustion"
QA/QC procedures:	As per the "Tool to calculate project or leakage CO_2 emissions from fossil fuel combustion"
Any comment:	-

Data / parameter:	$MG_{PR,y}$
Data unit:	tCH_4
Description:	Amount of methane generated during year y of the project activity
Source of data:	Project Proponents.
Measurement procedures (if any):	Estimated using the actual amount of waste disposed in the landfill as per the latest version of the "Tool to determine methane emissions avoided from dumping waste at a solid waste disposal site".
Monitoring frequency:	Annually
QA/QC procedures:	As per the latest version of the "Tool to determine methane emissions avoided from dumping waste at a solid waste disposal site".
Any comment:	-

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History of the document

Version	Date	Nature of revision
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 landfill gas was captured and destroyed/used; • Clarifiy how to apply the "Tool to determine methane emissions avoided from the dumping waste at a solid waste disposal site" for estimating ex-ante landfill gas 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 landfill gas for energy generation; • Expand the applicability to project activities where the captured landfill gas 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 3 September 2004	Initial adoption.