Draft revision to the approved consolidated baseline methodology ACM0001 version 05

"Consolidated baseline methodology for landfill gas project activities"

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/methodologies/PAmethodologies/approved.html >

The methodology also refers to the latest version of the *"Tool for the demonstration and assessment of additionality"*[1] and the latest version of the *"Tool to determine project emissions from flaring gases containing Methane"*.

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."

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).~~, but no emission reductions are claimed for displacing or avoiding energy from other sources~~[2]~~; or~~

[1] Please refer to < http://cdm.unfccc.int/methodologies/PAmethodologies/approved.html >
[2] Although in this case no emission reductions are claimed for displacing or avoiding energy from other sources, all possible financial revenues and/or emission leakages shall be taken into account in all the analyses performed.

c) The captured gas is used to produce energy (e.g. electricity/thermal energy, and emission reductions are claimed for displacing or avoiding energy generation from other sources. In this case a baseline methodology for electricity and/or thermal energy displaced shall be provided or an approved one used, including the ACM0002 "Consolidated Methodology for Grid-Connected Power Generation from Renewable". If capacity of electricity generated is less than 15MW, and/or thermal energy displaced is less than 54 TJ (15GWh), small-scale methodologies can be used.

This baseline methodology shall be used in conjunction with the approved monitoring methodology ACM0001 ("Consolidated monitoring methodology for landfill gas project activities").

II. BASELINE METHODOLOGY

Project Boundary

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

Possible CO_2 emissions resulting from combustion of other fuels than the methane recovered should be accounted as project emissions. Such emissions may include fuel combustion due to pumping and collection of landfill gas or fuel combustion for transport of generated heat to the consumer locations. In addition, electricity required for the operation of the project activity, including transport of heat, should be accounted and monitored. Where the project activity involves electricity generation, only the net quantity of electricity fed into the grid should be used in equation (1) above to account for emission reductions due to displacement of electricity in other power plants. Where the project activity does not involve electricity generation, project participants should account for CO_2 emissions by multiplying the quantity of electricity required with the CO_2 emissions intensity of the electricity displaced ($CEF_{electricity,y}$).

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.

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.[3] Other policies could include

[3] 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.

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.

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 energy is exported 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 1 below.

Table 1: 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.

Emission Reduction

The greenhouse gas emission reduction achieved by the project activity during a given year "y" (ER_y) are estimated as follows:

$$ER_y = (MD_{project,y} - MD_{reg,y}) * GWP_{CH4} + EL_{LFG,y} \cdot CEF_{elec,BL,y} - EL_{PR}.CEF_{elec,PR,y} + ET_{LFG,y} * CEF_{ther,BL,y} - ET_{PR,y} * EF_{fuel,PR,y} \quad (1)$$

where:

ER_y	is emissions reduction, in tonnes of CO_2 equivalents (tCO_2e).
$MD_{project,y}$	the amount of methane that would have been destroyed/combusted during the year, in tonnes of methane (tCH_4)
$MD_{reg,y}$ [4]	the amount of methane that would have been destroyed/combusted during the year in the absence of the project, 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, ~~exported~~ 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 can be estimated using either ACM0002 or AMSI.D, if the capacity is within the small scale threshold values, when grid electricity is used or displaced, or AMS-I.A if captive electricity is used or displaced.~~ This is estimated as per equation (6) 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~~incremental quantity of fossil fuel, defined as difference of fossil fuel used in the baseline and fossil use during project, for energy requirement on site under project activity during the year y, in TJ~~.
$CEF_{ther,BL,y}$	CO_2 emissions intensity of the fuel used by boiler to generate thermal~~/mechanical~~ energy which is displaced by LFG based thermal energy generation, in tCO_2e/TJ. This is estimated as per equation (7) below.
$EL_{PR,y}$	is the amount of electricity generated in an on-site fossil fuel fired power plant or

[4] Reg = regulatory and contractual requirements

	imported from the grid as a result of the project activity, measured using an electricity meter (MWh)[5]
$CEF_{elec,y,PR,y}$	is the carbon emissions factor for electricity generation in the project activity (tCO2/MWh). This is estimated as per equation (8) below
$ET_{PR,y}$	is the fossil fuel consumption on site during project activity in year y (tonne)[6]
$EF_{fuel,,PR,y}$	CO_2 emissions factor of the fossil fuel used by boiler to generate thermal energy in the project activity during year y.

~~$EL_{EX,LFG}$~~	~~net quantity of electricity exported during year y, produced using landfill gas, in megawatt hours (MWh).~~
~~EL_{IMP}~~	~~Net incremental electricity imported, defined as difference of project imports less any imports of electricity in the baseline, to meet the project requirements, in MWh~~

In the case where the $MD_{reg,y}$ is given/defined as a quantity that quantity will be used.

In cases where regulatory or contractual requirements do not specify $MD_{reg,y}$ an "Adjustment Factor" (AF) shall be used and justified, taking into account the project context.

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

The following examples provide guidance on how to estimate AF:

- In cases where a specific system for collection and destruction of methane is mandated by regulatory or contractual requirements, the ratio of the destruction efficiency of that system to the destruction efficiency of the system used in the project activity shall be used.
- 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, this percentage divided by an assumed efficiency for the collection and destruction system used in the project activity shall be used.

Project proponents should provide an ex ante estimate of emissions reductions, by projecting the future GHG emissions of the landfill. In doing so, verifiable methods should be used. Ex ante emission estimates may have an influence on $MD_{reg,y}$. $MD_{project,y}$ 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, if applicable, and the total quantity of methane captured.

[5] 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.
[6] If in the baseline part of a LFG was captured then the heat quantity used is calculation is fossil fuel used in project activity net of that consumed in the baseline.

The sum of the quantities fed to the flare(s), to the power plant(s) and to the boiler(s) (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 generated is the highest.~~
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 during non-operational hours of the energy plant or the boiler.

$$MD_{project,y} = MD_{flared,y} + MD_{electricity,y} + MD_{thermal,y} \quad \textbf{(3)}$$

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.

$$MD_{flared,y} = \{LFG_{flare,y} * w_{CH4,y} * D_{CH4}) - (PE_{flare,y} / \mathrm{GWP_{CH4}}) \quad \textbf{(4)}$$

Where $MD_{flared,y}$ is the quantity of methane destroyed by flaring, $LFG_{flare,y}$ is the quantity of landfill gas fed to the flare(s) during the year measured in cubic meters (m^3), $w_{CH4,y}$ is the average methane fraction of the landfill gas as measured[7] during the year and expressed as a fraction (in m^3 CH_4 / m^3 LFG), D_{CH4} is the methane density expressed in tonnes of methane per cubic meter of methane (tCH_4/m^3CH_4)[8] and $PE_{flare,y}$ are the 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.

$$MD_{electricity,y} = LFG_{electricity,y} * w_{CH4,y} * D_{CH4} \quad \textbf{(5)}$$

where $MD_{electricity,y}$ is the quantity of methane destroyed by generation of electricity and $LFG_{electricity,y}$ is the quantity of landfill gas fed into electricity generator.

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.

where $MD_{total,y}$ is the total quantity of methane generated and $LFG_{total,y}$ is the total quantity of landfill gas generated.

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:

[7] Methane fraction of the landfill gas to be measured on wet basis.
[8] At standard temperature and pressure (0 degree Celsius and 1,013 bar) the density of methane is 0.0007168 tCH_4/m^3CH_4.

$$CEF_{elec,BL,y} = \frac{EF_{fuel,BL}}{\varepsilon_{gen,BL} . NCV_{fuel,BL}} * 3.6 \qquad (6)$$

Where:

$EF_{fuel,BL}$ is the emission factor of baseline fossil fuel used, as identified in the baseline scenario identification procedure, expressed in tCO2/mass of volume unit.

$NCV_{fuel,BL}$ 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 GJ per unit of volume or mass

$\varepsilon_{gen,BL}$ is the 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 methodology ACM0002 ("Consolidated baseline methodology for grid-connected electricity generation from renewable sources"). If the thresholds for small-scale project activities apply, AMS-I.D may be used.

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

$$CEF_{therm,BL,y} = \frac{EF_{fuel,BL}}{\varepsilon_{boiler} \cdot NCV_{fuel,BL}} \qquad (7)$$

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 CO2 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.

Determination of $CEF_{elect, PR,y}$

Project participants may use a default emission factor of 1.3 tCO_2/MWh.

In cases where electricity is generated in an on-site fossil fuel fired power plant, project participants may estimate the emission factor as follows:

$$CEF_{elec,PR,y} = \frac{EF_{fuel,PR}}{\varepsilon_{gen,PR} . NCV_{fuel,PR}} * 3.6 \qquad \textbf{(8)}$$

Where:

$EF_{fuel,PR}$	is the emission factor of fossil fuel used in captive power plant expressed in tCO2/unit volume or mass unit
$NCV_{fuel,PR}$	is the net caloric value of the fossil fuel (TJ/ per unit volume of mass unit)
$\varepsilon_{gen,PR}$	is the efficiency of captive power generation plant.
3.6	equivalent of GJ energy in a MWh of electricity.

In cases where electricity is purchased from the grid, the emission factor shall be calculated according to methodology ACM0002 ("Consolidated baseline methodology for grid-connected electricity generation from renewable sources"). If electricity consumption is less than small scale threshold (60 GWh per annum), AMS-I.D may be used.

~~Project Boundary~~

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

~~Possible CO_2 emissions resulting from combustion of other fuels than the methane recovered should be accounted as project emissions. Such emissions may include fuel combustion due to pumping and collection of landfill gas or fuel combustion for transport of generated heat to the consumer locations. In addition, electricity required for the operation of the project activity, including transport of heat, should be accounted and monitored. Where the project activity involves electricity generation, only the net quantity of electricity fed into the grid should be used in equation (1) above to account for emission reductions due to displacement of electricity in other power plants. Where the project activity does not involve electricity generation, project participants should account for CO_2 emissions by multiplying the quantity of electricity required with the CO_2 emissions intensity of the electricity displaced ($CEF_{electricity,y}$).~~

~~Baseline~~

~~The baseline is the atmospheric release of the gas and the baseline methodology considers that some of the methane generated by the landfill may be captured and destroyed to comply with regulations or contractual requirements, or to address safety and odour concerns.~~

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*[9].

Leakage

No leakage effects need to be accounted under this methodology.

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

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- 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));
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For more information regarding the proposals and its considerations by the Executive Board please refer to the cases on http://cdm.unfccc.int/methodologies/PAmethodologies/approved.html.

The methodology also refers to the latest version of the *"Tool to determine project emissions from flaring gases containing Methane*[10]*"*.

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; or

b) The captured gas is used to produce energy (e.g. electricity/thermal energy[~~), but no emission reductions are claimed for displacing or avoiding energy from other sources~~[11]~~; or~~.]

c) ~~The captured gas is used to produce energy (e.g. electricity/thermal energy), and emission reductions are claimed for displacing or avoiding energy generation from other sources. In this case a baseline methodology for electricity and/or thermal energy displaced shall be provided or an approved one used, including the ACM0002 "Consolidated Methodology for Grid-Connected Power Generation from Renewable". If capacity of electricity generated is less than 15MW,~~

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

[11] Although in this case no emission reductions are claimed for displacing or avoiding energy from other sources, all possible financial revenues and/or emission leakages shall be taken into account in all the analysis performed.

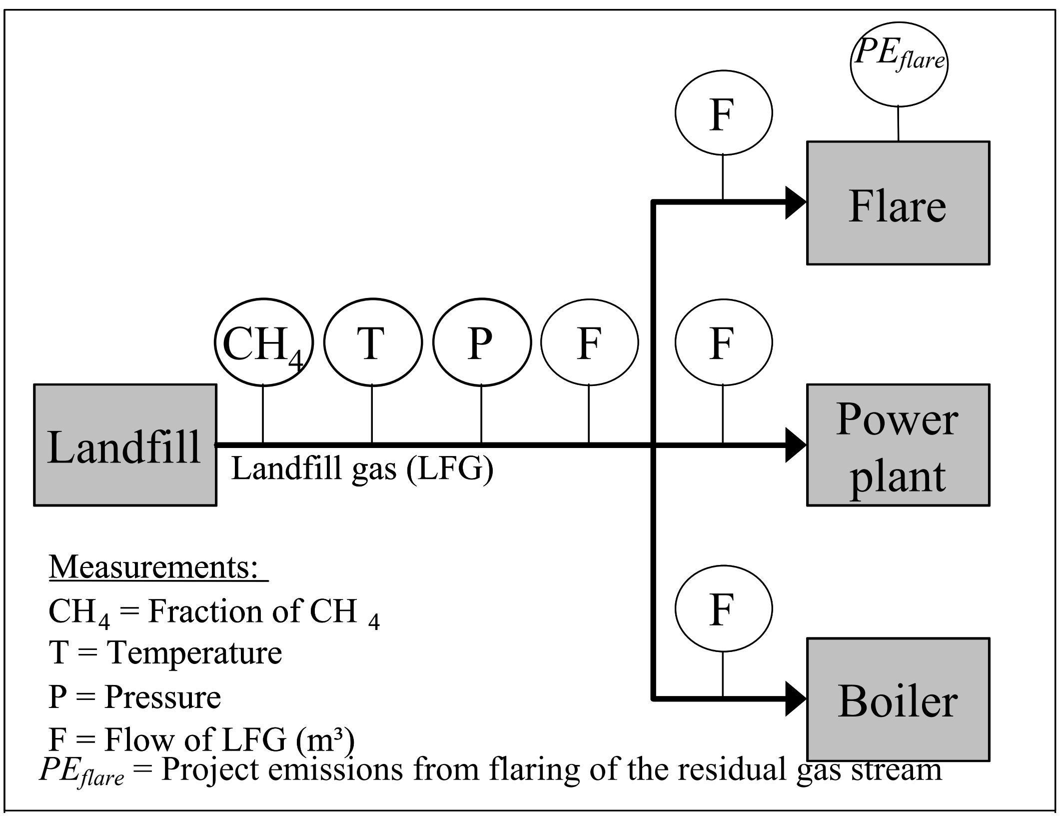
~~and/or thermal energy displaced is less than 54 TJ (15GWh), small-scale methodologies can be used.~~

This monitoring methodology shall be used in conjunction with the approved baseline methodology ACM0001 ("Consolidated baseline methodology for landfill gas project activities").

Monitoring Methodology

The monitoring methodology is based on direct measurement of the amount of landfill gas captured and destroyed at the flare platform(s) 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 ($MD_{thermal,y}$), 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)

($LFG_{electricity,y}$) 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 $LFG_{total,y}$, $LFG_{flare,y}$, $LFG_{electricity,y}$, 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 ($MD_{reg,y}$). 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 to be collected or used to monitor emissions from the project activity, and how this data will be archived

ID number	Data variable	Data unit	Measured (m) calculated (c) estimated (e)	Recording frequency	Proportion of data monitored	How will data be archived? (electronic/ paper)	For how long is archived data kept?	Comment
1. $LFG_{total,y}$	Total amount of landfill gas captured	m^3	m	Continuously/ periodically	100%	Electronic	During the crediting period and two years after	Measured by a flow meter. Data to be aggregated monthly and yearly.
2. $LFG_{flare,y}$	Amount of landfill gas flared	m^3	m	Continuously/ periodically	100%	Electronic	During the crediting period and two years after	Measured by a flow meter. Data to be aggregated monthly and yearly for each flare.
3. $LFG_{electricity,y}$	Amount of landfill gas combusted in power plant	m^3	m	Continuously/ periodically	100%	Electronic	During the crediting period and two years after	Measured by a flow meter. Data to be aggregated monthly and yearly for each power plant.
4. $LFG_{thermal,y}$	Amount of methane combusted in boiler	m^3	m	Continuously/ periodically	100%	Electronic	During the crediting period and two years after	Measured by a flow meter. Data to be aggregated monthly and yearly for each boiler.
5. $PE_{flare,y}$	Project emissions from flaring of the residual gas stream in year *y*	tCO_{2e}	m / c	See comments	n/a	Electronic	During the crediting period and two years after	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"*.

ID number	Data variable	Data unit	Measured (m) calculated (c) estimated (e)	Recording frequency	Proportion of data monitored	How will data be archived? (electronic/ paper)	For how long is archived data kept?	Comment
6. $w_{CH4,y}$	Methane fraction in the landfill gas	m^3 CH_4 / m^3 LFG	m	Continuously / periodically	100%	Electronic	During the crediting period and two years after	Preferably measured by continuous gas quality analyser. Methane fraction of the landfill gas to be measured on wet basis.
7. T	Temperature of the landfill gas	°C	m	continuously / periodically	100%	Electronic	During the crediting period and two years after	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.
8. p	Pressure of the landfill gas	Pa	m	continuously / periodically	100%	Electronic	During the Crediting period and two years after	Measured to determine the Density of methane D_{CH4}. No separate monitoring of pressure is necessary when using flow meters that automatically measure temperature and pressure, expressing LFG volumes in

ID number	Data variable	Data unit	Measured (m) calculated (c) estimated (e)	Recording frequency	Proportion of data monitored	How will data be archived? (electronic/ paper)	For how long is archived data kept?	Comment
								normalized cubic meters.
9.EL_{LFG}	~~Total~~ Net amount of electricity ~~exported out of the project boundary~~generated using LFG.	MWh	m	continuously	100%	Electronic	During the crediting period and two years after	Required to estimate the emission reductions from electricity generation from LFG, if credits are claimed.
10. ~~EL_{IMP}~~ EL_{PR}	Total amount of electricity ~~imported~~ required to meet project requirement	MWh	m	continuously	100%	Electronic	During the crediting period and two years after	Required to determine CO_2 emissions from use of electricity ~~or other energy carriers~~ to operate the project activity. The records of any electricity imported in the baseline too should be recorded at the start of project.
11. ET_{LFG}	Total amount of thermal energy generated using LFG	TJ	m	continuously	100%	Electronic	During the crediting period and two years after	Required to estimate the emission reductions from thermal energy generation from LFG, if credits are claimed
12. ET_{PR}	Total amount of	tonne	m	continuously	100%	Electronic	During the crediting period	Required to determine CO_2 emissions from use

ID number	Data variable	Data unit	Measured (m) calculated (c) estimated (e)	Recording frequency	Proportion of data monitored	How will data be archived? (electronic/ paper)	For how long is archived data kept?	Comment
	fossil fuel required to meet project requirement						and two years after	of energy carriers to operate the project activity.
13. $CEF_{elecy,BL}$	Carbon emission factor of electricity	tCO2/MWh	c	annually	100%	Electronic	During the crediting period and two years after	A default of 0.8 can be used if electricity in the baseline would have been produced using captive power plant. Else, equation 6 provides the estimation equation. In case the baseline source would have been grid, emission factor shall be estimated as described in ACM0002 or AMS I.D, as appropriate.
14. $EF_{fuel,BL}$	CO_2 emission factor of fossil fuel	tCO2/mass or volume	m	annually	100%	Electronic	During the crediting period and two years after	Fossil fuel that would have been used in the baseline captive power plant or thermal energy generation.
15. $NCV_{fuel,BL}$	Net calorific value of fossil fuel	GJ/mass of volume	m	annually	100%	Electronic	During the crediting period and two years after	For fossil fuel that would have been used in the baseline for thermal energy generation and/or electricity generation.

ID number	Data variable	Data unit	Measured (m) calculated (c) estimated (e)	Recording frequency	Proportion of data monitored	How will data be archived? (electronic/ paper)	For how long is archived data kept?	Comment
16. $\varepsilon_{gen,BL}$	efficiency		m	annually	100%	Electronic	During the crediting period and two years after	Efficiency of the baseline captive power plant
17. $CEF_{ther,BL,y}$	Carbon emission factor of thermal energy	tCO2/GJ	c	annually	100%	Electronic	During the crediting period and two years after	Carbon emission factor of the thermal energy produced in the baseline (equation (7)).
18. ε_{boiler}	efficiency		m	annually	100%	Electronic	During the crediting period and two years after	Efficiency of the baseline boiler for producing thermal energy. A default of 100% may be used in absence of data.
19. $CEF_{elec,y,PR,y}$	Carbon emission factor of electricity	tCO2/MWh	c	annually	100%	Electronic	During the crediting period and two years after	Carbon emission factor of electricity consumed during project activity.
21. $EF_{fuel,PR}$	CO_2 emission factor of fossil fuel	tCO2/mass or voulme	m	annually	100%	Electronic	During the crediting period and two years after	Fossil fuel that would have been used in the project captive power plant or thermal energy generation.
22. $NCV_{fuel,PR}$	Net calorific value of fossil fuel	GJ/mass of volume	m	annually	100%	Electronic	During the crediting period and two years after	For fossil fuel that would have been used in the project scenario for thermal energy generation and/or electricity generation.

ID number	Data variable	Data unit	Measured (m) calculated (c) estimated (e)	Recording frequency	Proportion of data monitored	How will data be archived? (electronic/ paper)	For how long is archived data kept?	Comment
~~11.*~~	~~CO_2 emission intensity of the electricity and/or other energy carriers in ID 9.~~	~~t CO_2 / MWh~~	~~e~~	~~As specified in AMS.1.D or ACM0002, which ever is applied.~~	~~100%~~	~~Electronic~~	~~During the crediting period and two years after~~	~~In case a specific source is displaced or used for imports, emission factor is estimated for that specific source.~~

ID number	Data variable	Data unit	Measured (m) calculated (c) estimated (e)	Recording frequency	Proportion of data monitored	How will data be archived? (electronic/ paper)	For how long is archived data kept?	Comment
23..ET_y	Thermal energy used in landfill during project.	TJ	m	annually	100%	Electronic	During the crediting period and two years after	The quantity of fossil fuel used to meet the energy requirements. If electricity is produced on site using fossil fuel, it is covered under this category. 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.
24. $CEF_{thermal,y}$	CO_2 emission intensity of the thermal energy	t CO_2 / TJ	c	annually	100%	Electronic	During the crediting period and two years after	
25.	Regulatory requirements relating to landfill gas projects	Test	n/a	At the renewal of crediting period.	100%	Electronic	During the crediting period and two years after	The information though recorded annually, is used for changes to the adjustment factor (AF) or directly $MD_{reg,y}$ at renewal of the credit period.
26.	Operation of the energy plant	Hours	m	annually	100%	Electronic	During the crediting period and two years after	This is monitored to ensure methane destruction is claimed for methane used in

ID number	Data variable	Data unit	Measured (m) calculated (c) estimated (e)	Recording frequency	Proportion of data monitored	How will data be archived? (electronic/ paper)	For how long is archived data kept?	Comment
								electricity plant when it is operational.
27.	Operation of the boiler	Hours	m	annually	100%	Electronic	During the crediting period and two years after	This is monitored to ensure methane destruction is claimed for methane used in boiler when it is operational.

** Note: this can be calculated using the consolidated methodologies for grid-connected electricity generation from renewable sources (ACM0002) or AMS I.D, if the generation capacity meets the small scale definition.*

***Quality control (QC) and quality assurance (QA) procedures to be undertaken for the items monitored**. (see tables above)*

Appropriate quality control and quality assurance procedures are needed for the monitoring equipment and the data collected.

Data	Uncertainty level of data (High/Medium/Low)	Are QA/QC procedures planned for these data?	Outline explanation how QA/QC procedures are planned
1. - 4. LFG_y	Low	Yes	Flow meters should be subject to a regular maintenance and testing regime to ensure accuracy.
5. $PE_{flare,y}$			The parameters used for determining the project emissions from flaring of the residual gas stream in year y ($PE_{flare,y}$) should use the QA/QC procedures as per the *“Tool to determine project emissions from flaring gases containing Methane”*.
6. $w_{CH4,y}$	Low	Yes	The gas analyser should be subject to a regular maintenance and testing regime to ensure accuracy.

Miscellaneous Parameters

Factor Used for Converting Methane to Carbon Dioxide Equivalents[1]

Factor used (tCO_2e/tCH_4)	Period Applicable	Source
21	1996-present	Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories

[1] This table is updated as reporting guidelines are modified.

Conversion Factors[1]

	Factor	Unit	Period Applicable	Description/Source
Methane Density	At standard temperature and pressure (0 degree Celsius and 1,013 bar) the density of methane is 0.0007168 tCH_4/m^3CH_4	tonnes CH_4/m^3CH_4	Default	