Revision to the approved consolidated baseline methodology ACM0001

"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 >

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; 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[1]; 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,

[1] 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.

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”).

Emission Reduction

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

$$ER_y = (MD_{project,y} - MD_{reg,y}) * GWP_{CH4} + EL_y \cdot CEF_{electricity,y} - ET_y * CEF_{thermal,y} \quad \textbf{(1)}$$

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)
$MD_{reg,y}$ [2]	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_y	net quantity of electricity exported during year y, in megawatt hours (MWh).
$CEF_{electricity,y}$,	CO_2 emissions intensity of the electricity displaced, in tCO_2e/MWh. This can estimated using either ACM0002 or AMSI.D, if the capacity is within the small scale threshold values, when grid electricity is used or displaced .
ET_y	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.
$CEF_{thermal,y}$	CO_2 emissions intensity of the fuel used to generate thermal/mechanical energy, in tCO_2e/TJ

$$EL_y = EL_{EX,LGFG} - EL_{IMP} \quad \textbf{(1a)}$$

where:

$EL_{EX,LFG}$	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.

[2] Reg = regulatory and contractual requirements

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

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.

The sum of the quantities fed to the flare, to the power plant and to the boiler must be compared annually with the total generated. The lowest value must be adopted as $MD_{project,y}$. The following procedure applies when the total generated is the highest.
The hours where the energy plant and the boiler are working should be monitored and no emission reduction could be claimed for methane destruction in the energy plant or the boiler when they are not working.

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

$$MD_{flared,y} = LFG_{flare,y} * w_{CH4,y} * D_{CH4} * FE \quad \textbf{(4)}$$

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

The flare efficiency shall be calculated as product of (i) fraction of time the gas is combusted in the flare; and (ii) the efficiency of the flaring process. Efficiency of the flaring process is defined as fraction of methane completely oxidized by the flaring process.

If an enclosed flare is used, the project participants shall measure and quantify the efficiency of the flare (% of methane completely oxidized by combustion in the flare) on a yearly basis, with the first measurement to be made at the time of installation. The measured value of the efficiency of the flare

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

shall be applicable for the period up to the next measurement. In case the yearly measurement of efficiency of the flare is not performed, the efficiency of the flare shall be a default value of 90%. If the last measured value of the efficiency of the flare is lower than 90%, then the last lower measured value shall be used.
For open flares, if the efficiency of the flare is not measured, a conservative destruction efficiency factor of 50% should be used.

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

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.

$$MD_{thermal,y} = LFG_{thermal,y} * w_{CH4,y} * D_{CH4} \quad (6)$$

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.

$$\mathrm{MD}_{\mathrm{total,y}} = \mathrm{LFG}_{\mathrm{total,y}} * \mathrm{w}_{\mathrm{CH4,y}} * \mathrm{D}_{\mathrm{CH4}} \quad (7)$$

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

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*[4].

Leakage

No leakage effects need to be accounted under this methodology.

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

Revision to the approved consolidated monitoring methodology ACM0001

"Consolidated monitoring methodology for landfill gas project activities"

Sources

This methodology is based on elements from the following approved proposals for monitoring methodologies:

- AM0002: Greenhouse Gas Emission Reductions through Landfill Gas Capture and Flaring where the Baseline is established by a Public Concession Contract (approved based on proposal NM0004 rev: Salvador da Bahia landfill gas project, whose project design document and baseline study, monitoring and verification plans were developed by ICF Consulting (version 03, June 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.

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

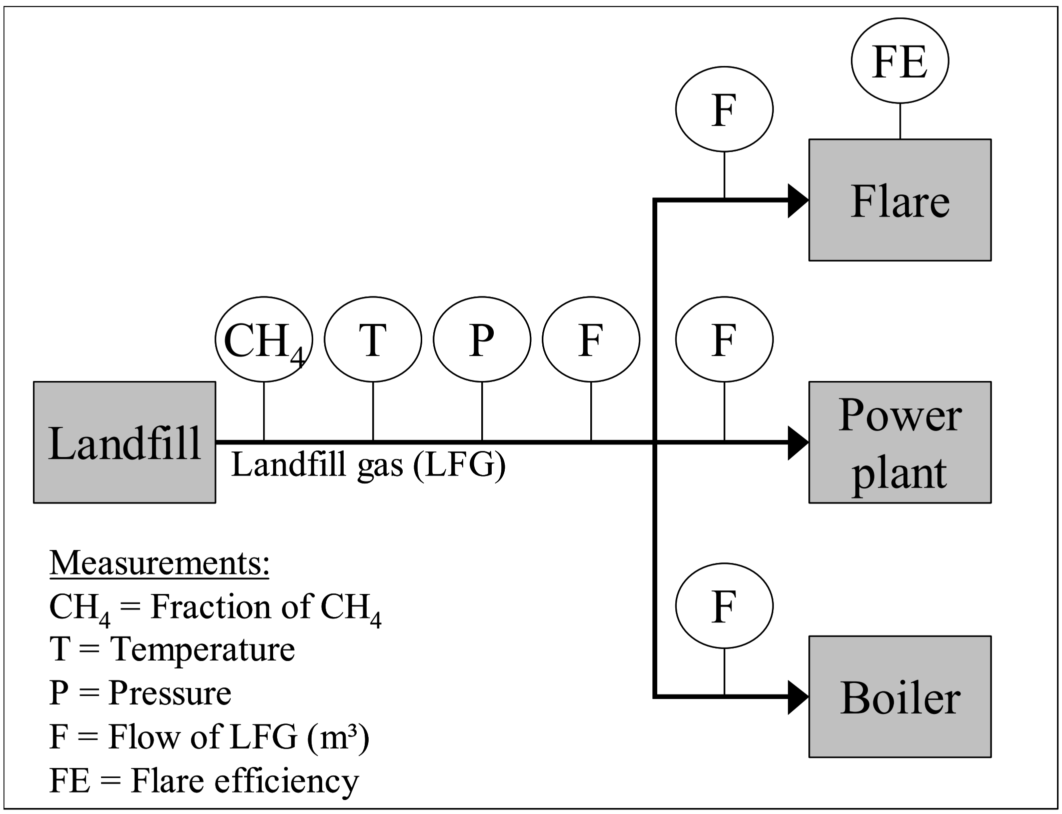
This monitoring methodology shall be used in conjunction with the approved baseline methodology ACM0001 ("Consolidated baseline methodology for landfill gas project activities").

[5] 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.

Monitoring Methodology

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

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 ($LFG_{flare,y}$), to the power plant ($LFG_{electricity,y}$) and to the boiler ($LFG_{thermal,y}$) are measured continuously. In the case where LFG is just flared, one flow meter can be used provided that the meter used is 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.).

- The flare efficiency (*FE*), measured as the fraction of time in which the gas is combusted in the flare multiplied by the efficiency of the flaring process. For this purpose, the methane content of the flare emissions should be analysed at least quarterly, and where necessary more frequent, to determine the fraction of methane destroyed within the flare.
- Temperature (*T*) and pressure (*p*) of the landfill gas are required to determine the density of methane in the landfill gas.
- The quantities 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 and the boiler.

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) or estimated (e)	Recording frequency	Proportion of data to be monitored	How will the data be archived? (electronic : e / paper : p)	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.
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.
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.
5. FE	Flare/combustion efficiency, determined by the operation hours (1) and the methane content in the exhaust gas (2)	%	m / c	(1) Continuously (2) Open flares shall be monitored quarterly, monthly if unstable. Enclosed flares shall be monitored yearly, with the first	n/a	Electronic	During the crediting period and two years after	1) The flare operation shall be continuously monitored by continuous measurement of operation time of flare using a run time meter connected to a flame detector or a flame continuous temperature controller, irrespective of whether the flare efficiency is monitored. (2) Periodic measurement of methane content of flare exhaust gas. (3) The enclosed flares shall be operated and maintained as per

ID number	Data variable	Data unit	Measured (m), calculated (c) or estimated (e)	Recording frequency	Proportion of data to be monitored	How will the data be archived? (electronic : e / paper : p)	For how long is archived data kept?	Comment
				measurement to be made at the time of installation.				the specifications prescribed by the manufacturer.
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.
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 normalized cubic meters.
9. $EL_{EX,LFG}$	Total amount of electricity exported out of the project	MWh	m	continuously	100%	Electronic	During the crediting period and two years after	Required to estimate the emission reductions from electricity generation from

ID number	Data variable	Data unit	Measured (m), calculated (c) or estimated (e)	Recording frequency	Proportion of data to be monitored	How will the data be archived? (electronic : e / paper : p)	For how long is archived data kept?	Comment
	boundary.							LFG, if credits are claimed.
1o. EL_{IMP}	Total amount of electricity imported 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.*	CO_2 emission intensity of the electricity and/or other energy carriers in ID 9.	t CO_2 / MWh	c	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.
12.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.
12. $CEF_{thermal,y}$	CO_2 emission intensity of the	t CO_2 / TJ	c	annually	100%	Electronic	During the crediting period and	

ID number	Data variable	Data unit	Measured (m), calculated (c) or estimated (e)	Recording frequency	Proportion of data to be monitored	How will the data be archived? (electronic : e / paper : p)	For how long is archived data kept?	Comment
	thermal energy						two years after	
13.	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.
14.	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 electricity plant when it is operational.
15.	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 boilerwhen 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. FE	Medium	Yes	Regular maintenance should ensure optimal operation of flares. For open flares efficiency of flare should be checked quarterly, with monthly checks if the efficiency shows significant deviations from previous values. The enclosed flares shall be operated and maintained as per the specifications prescribed by the manufacturer.
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	