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

[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.

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").

Emission Reduction[2]

The greenhouse gas emission reduction achieved by the project activity during a given year "y" (ER_y) is the difference between the amount of methane actually destroyed/combusted during the year ($MD_{project,y}$) and the amount of methane that would have been destroyed/combusted during the year in the absence of the project activity ($MD_{reg,y}$) [3], times the approved Global Warming Potential value for methane (GWP_{CH4}), plus the net quantity of electricity displaced during the year (EG_y) multiplied by the CO_2 emissions intensity of the electricity displaced ($CEF_{electricity,y}$)[4], plus the quantity of thermal energy displaced during the year (ET_y) multiplied by the CO_2 emissions intensity of the thermal energy displaced ($CEF_{thermal,y}$). Electricity and thermal energy emission reductions apply to case (c) only.

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

ER_y is measured in tonnes of CO_2 equivalents (tCO_2e). $MD_{project,y}$ and $MD_{reg,y}$ are measured in tonnes of methane (tCH_4). The approved Global Warming Potential value for methane (GWP_{CH4}) for the first commitment period is 21 tCO_2e/tCH_4. EG_y is measured in megawatt hours (MWh). The CO_2 emissions intensity, $CEF_{electricity,y}$, is measured in tonnes of CO_2 equivalents per megawatt hour (tCO_2e/MWh) and ET_y is measured in TeraJoules (TJ) and $CEF_{thermal,y}$ is measured in terms of tonnes of CO_2 equivalents per TJ (tCO_2e/TJ).

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.

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

[2]The Executive Board, at its twelfth meeting, requested the secretariat to prepare a technical paper, for consideration by the Panel on Methodologies of the Board, on the impact of oxidation of biogas in the calculation of emission reductions of methane (CH_4) for landfill gas project activities. The Board agreed that the Meth Panel shall prepare a recommendation on this issue to be presented to the Board, for its consideration, at its fifteenth meeting. This methodology might be revised in order to incorporate considerations by the Board on this issue. Any revisions shall not affect CDM project activities already registered using this current version of the methodology.

[3] Reg = regulatory and contractual requirements

[4] The emission factor for electricity displaced in the electricity grid should be determined by the methodology used for calculating emission reductions due to displacement of electricity to the grid.

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.

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

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

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).[5]

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

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.

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

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.

[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.

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*[6].

Leakage

No leakage effects need to be accounted under this methodology.

[6] 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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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[7]; 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.

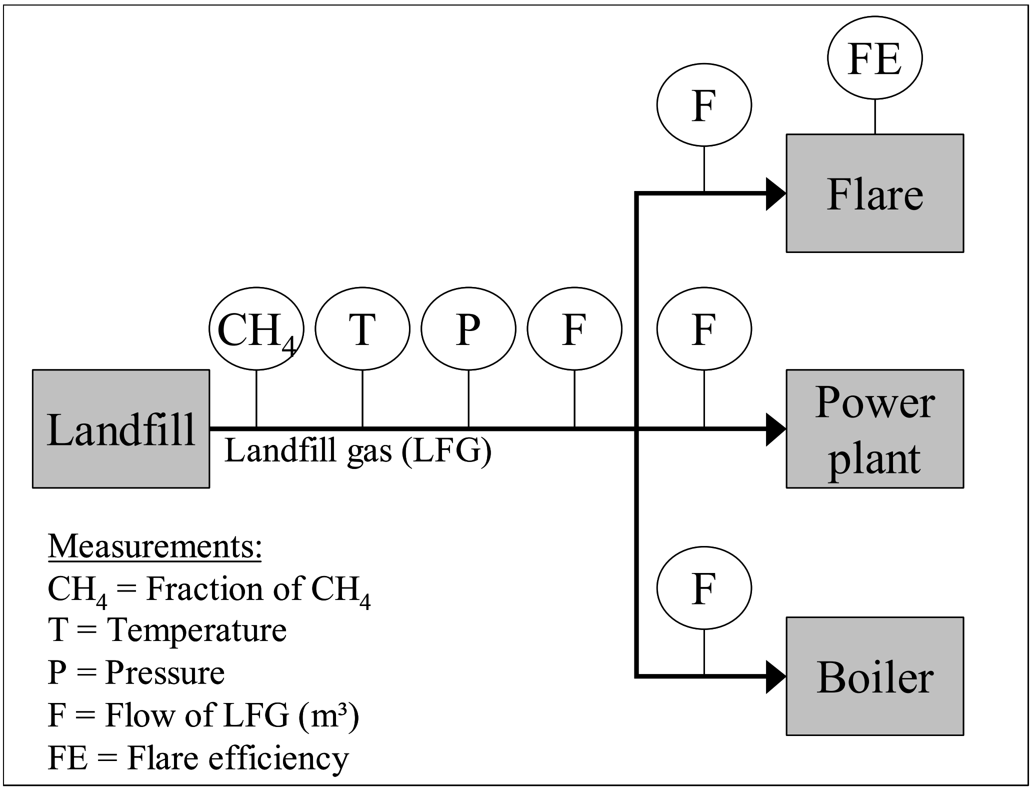
This monitoring methodology shall be used in conjunction with the approved baseline methodology ACM0001 ("Consolidated baseline methodology for landfill gas project activities").

[7] 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 ($MD_{flared,y}$) and the quantity of methane used to generate electricity ($MD_{electricity,y}$)/thermal energy ($MD_{thermal,y}$).

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.
- 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 of electricity or any other 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.
- Relevant regulations for LFG project activities shall be monitored. 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 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) quarterly, monthly if unstable	n/a	Electronic	During the crediting period and two years after	(1) Periodic measurement of methane content of flare exhaust gas. (2) Continuous measurement of operation time of flare (e.g. with temperature)
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}.

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
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}.
9.	Total amount of electricity and/or other energy carriers used in the project for gas pumping and heat transport (not derived from the gas)	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
10.*	CO_2 emission intensity of the electricity and/or other energy carriers in ID 9.	t CO_2 / MWh	c	annually	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
11.	Regulatory requirements relating to landfill gas projects	Test	n/a	annually	100%	Electronic	During the crediting period and two years after	Required for any changes to the adjustment factor (AF) or directly $MD_{reg,y}$

** Note: this can be calculated using the consolidated methodologies for grid-connected electricity generation from renewable sources (ACM0002).*

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. Flare efficiency should be checked quarterly, with monthly checks if the efficiency shows significant deviations from previous values.
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	