Revision to the approved baseline methodology AM0002

"Greenhouse gas emission reductions through landfill gas capture and flaring where the baseline is established by a public concession contract"

Source

This methodology is based on Salvador da Bahia Landfill Gas Project by VEGA Bahia Tratamento de Residuos S.A., Municipio de Salvador, Estado da Bahia, Brazil whose Baseline study, Monitoring and Verification Plan and Project Design Document were prepared by ICF Consulting (version 03, June 2003). For more information regarding the proposal and its consideration by the Executive Board please refer to case ""NM0004: Salvador da Bahia landfill gas project" 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 and flaring project activities where:
- There exists a contractual agreement that makes the operator responsible for all aspects of the landfill design, construction, operation, maintenance and monitoring;
- The contract was awarded through a competitive bidding process;
- The contract stipulates the amount of landfill gas (expressed in cubic meters) to be collected and flared annually by the landfill operator;
- The stipulated amount of landfill gas to be flared reflects performance among the top 20% in the previous five years for landfills operating under similar social, economic, environmental and technological circumstances; and
- No generation of electricity using captured landfill gas occurs or is planned.

It is assumed that the amount of landfill gas to be collected and flared under the terms of the contract meets or exceeds any regulatory requirements. The landfill is also assumed to meet all other environmental regulations and conditions of its operating permit. The Designated Operational Entity verifying the emission reductions achieved will need to check whether there have been changes to environmental regulations that become effective during the crediting period and that increase the required amount of landfill gas flaring. In the event of such changes to environmental regulations, the baseline will need to be adjusted appropriately.

Emission reduction

The greenhouse gas emission reduction achieved by the project activity is the difference between the amount of methane actually destroyed and the amount of methane required to be flared under the terms of the contract. The greenhouse gas emission reduction is expressed in terms of CO_2 equivalents using the approved Global Warming Potential value[1] for the relevant period.

Specifically, the greenhouse gas emission reduction (ER_y) achieved by the project activity during a given year (y) is equal to the methane emission reduction (ER_CH4_y) due to the project activity during that year multiplied by a conversion factor (CF) and by the approved Global Warming Potential value for methane (GWP_CH4).

$$ER_y = ER\_CH4_y * D_{CH4} \sout{CF} * GWP\_CH4$$

ER_y is the greenhouse gas emission reduction measured in tonnes of CO_2 equivalents (tonnes CO_2e). ER_CH4_y is the methane emission reduction measured in cubic metres (m^3(STP) CH_4) of methane. **D_{CH4} is the methane density expressed in tonnes of methane per cubic meter of methane (tCH_4/m^3CH_4)[2].** ~~The conversion factor (CF) is the tonnes of methane per cubic metre of methane at standard temperature and pressure (0.000662 tonnes CH_4/m^3(STP) CH_4).~~ The Global Warming Potential converts 1 tonne of methane to tonnes of CO_2 equivalents (tonnes CO_2e/tonne CH_4). The approved Global Warming Potential value for methane for the first commitment period is 21 tonnes CO_2e/tonnes CH_4. Thus, $GWP\_CH_4 = 21$ until December 31, 2012.

The methane emission reduction (ER_CH4_y) due to the project activity is calculated as the difference between amount of methane actually captured and flared less the amount of methane captured and flared in the baseline, which is the amount specified by the contract corrected for the quantity of waste received.

$$ER\_CH4_y = CH4_{flared,y} – CH4_{baseline,y}$$

$CH4_{flared,y}$ is determined by monitoring the quantity of methane actually flared using the approved monitoring methodology. $CH4_{flared,y}$ is measured in cubic metres (Nm^3).

$$\mathbf{CH4_{flared,y} = LFG_{flare,y} * w_{CH4,y} * FE}$$

$LFG_{flare,y}$ 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 time the flare is operation during the year and of the methane destroyed).

Project proponents wishing to request verification and certification of emission reductions for periods less than one year should determine $CH4_{flared,y}$ based on quantity of landfill gas flared during the period measured in cubic meters (m^3).

$CH4_{baseline,y}$ is the quantity of methane required to be flared under the provisions of the contract adjusted for the quantity of waste actually received and the actual methane content of the landfill gas (these adjustments are discussed in the next section).

[1] Global Warming Potential values used shall be those provided by the Intergovernmental Panel on Climate Change in its Second Assessment Report (“1995 IPCC GWP values”).
[2] At standard temperature and pressure (0 degree Celsius and 1,013 bar) the density of methane is 0.0007168 tCH4/m3CH4

Baseline

It is assumed that the contract specifies both the quantity of waste projected to be disposed at the landfill during each year ($WASTE_{contract,y}$) and the quantity of landfill gas (LFG) required to be flared during each year. The amount of methane required to be flared each year ($CH4_{contract,y}$) is the quantity of LFG required to be flared as per the contract multiplied by an appropriate methane content to give a conservative baseline.

The quantity of methane projected to be generated during a given year ($CH4_{projected,y}$) is estimated using the following First Order Decay model for landfill gas generation.

$$CH4_{projected,y} = k * L_0 * \sum_{t=0,y} WASTE_{contract,t} * e^{-k(t-y)}$$

Where L_0 is the methane generation rate (Nm_3/tonne WASTE) and k is the decay rate. These variables vary with the circumstances of the landfill; L_0 depends upon the organic fraction of the waste that enters the landfill and k depends on the temperature and humidity of the landfill. The validation process should ensure that values of L_0 and k appropriate to the landfill are used[3].

The quantity of landfill gas projected to be generated during a given year ($LFG_{projected,y}$)is calculated from the quantity of methane projected for that year and the methane content of the landfill gas assumed by the contract ($CH_4/LFG_{contract}$).

$$LFG_{projected,y} = CH4_{projected,y} / CH_4/LFG_{contract}$$

The quantity of methane required to be flared during each year ($CH4_{contract,y}$) as specified in the contract is calculated as follows:

$$CH4_{contract,y} = LFG_{projected,y} * CH_4/LFG_{contract} * FD_y$$

Where FD_y is the fraction of landfill gas captured and flared as specified by the contract.

Note that to use this methodology, the project activity must demonstrate that the quantity of methane required to be flared during each year ($CH4_{contract,y}$) reflects performance among the top 20% in the previous five years for landfills operating under similar social, economic, environmental and technological circumstances.

[3] In the case of the Salvador da Bahia Landfill project actvity the landfill receives waste with a high organic content (about 60% food and green waste) yielding a value of L0 = 180 Nm3/tonne WASTE. Although the landfill will be completely covered, Brazilian conditions are quite favorable to biodegradation kinetic, so a value of k = 0.12 (a half lifetime of 6 years) was chosen. Note that plastic wastes are excluded in calculating the values of L0 and k. The values of L_0 and k are assumed to remain fixed because the quantity of waste specified in the contract is used to establish the baseline.

The baseline quantity of methane flared ($CH4_{baseline,y}$) is the quantity specified in the contract ($CH4_{contract,y}$) adjusted for the quantity of waste actually received and the actual methane content of the landfill gas.[4]

$$CH4_{baseline,y} = CH4_{contract,y} * (WASTE_{actual,y}/WASTE_{contract,y}) * ([CH_4/LFG_{actual}]/[CH_4/LFG_{contract}])$$

Project proponents wishing to request verification and certification of emission reductions for periods less than one year should estimate $CH4_{projected,y}$ based on quantity of waste projected to be disposed at the landfill during this period ($WASTE_{contract,a}$, which should replace $WASTE_{contract,y}$ in all equations). If this quantity of waste is not specified in the contract, it is possible to estimate this quantity by multiplying the fraction of the period from a year by the annual quantity of waste projected to be disposed at the landfill specified in the contract.

$$WASTE_{contract,a} = WASTE_{contract,y} * R$$

where:

$WASTE_{contract,a}$ is the quantity of waste projected to be disposed in the landfill during the period

$WASTE_{contract,y}$ is the quantity of waste projected to be disposed in the landfill annually as specified by the contract.

R is the fraction of the period from a year

Adjustments to $CH4_{baseline,y}$ should be done at the end of the period with actual waste received during this period ($WASTE_{actual,a}$, which should replace $WASTE_{actual,y}$ in all equations) and actual monitored methane content in landfill gas.

Additionality

If the actual quantity of methane flared is greater than the baseline quantity flared, the project activity is additional. The emissions reductions will be zero if the project activity is not additional.

Since the baseline quantity flared is determined by the contractual requirement, which is established through a competitive bidding process the baseline reflects what would occur in the absence of the project activity.

The project activity should also state whether there are any other additional economic considerations to be taken into account (e.g. such as additional costs relating to the project activity or that no additional revenues are expected).

[4] In the case of the Salvador da Bahia Landfill the actual methane content of the landfill gas is 57% (CH_4/LFG_{actual} = 0.57) and the methane content of the landfill gas assumed in the contract is 50% ($CH_4/LFG_{contract}$ = 0.50), so the last term is 1.14 (0.57/0.50).

Leakage

The only source of leakage is the emissions resulting from generating the electricity used to pump the landfill gas in the additional collection equipment. The electricity emissions during a given year (EE_y) are the project activity's share of the emissions associated with the electricity used for pumping during the year (EP_y).

$$EE_y = [(CH4_{flared,y} – CH4_{baseline,y})/CH4_{baseline,y}] * EP_y * EC_y/1000$$

Where EP_y is the metered electricity use by the pumping equipment for the collection system during the year in kWh and EC_y is the emissions coefficient for the electricity used measured in kg CO_2e/kWh.[5] The emissions coefficient needs to be estimated using an appropriate methodology given the source of the electricity supply.

[5] Division by 1000 converts the emissions to metric tonnes of CO_2e.

Revision to the approved monitoring methodology AM0002

"Greenhouse gas emission reductions through landfill gas capture and flaring where the baseline is established by a public concession contract"

Source

This monitoring methodology is based on Salvador da Bahia Landfill Gas Project by VEGA Bahia Tratamento de Residuos S.A., Municipio de Salvador, Estado da Bahia, Brazil whose Baseline study, Monitoring and Verification Plan and Project Design Document were prepared by ICF Consulting (version 03, June 2003). For more information regarding the proposal and its consideration by the Executive Board please refer to case "NM0004: Salvador da Bahia landfill gas project" on <http://cdm.unfccc.int/methodologies/PAmethodologies/approved.html>.

Applicability

This monitoring methodology can be used for project activities that reduce greenhouse gas emissions through Landfill Gas Capture and Flaring where the Baseline is established by a Public Concession Contract.

Monitoring Methodology

Monitoring methodology is based on direct measurement of the amount of landfill gas captured and destroyed at the flare platform as shown in Figure 1. The monitoring plan provides for continuous measurement of the quantity and quality of LFG burned. The main variables that need to be monitored are the quantity of waste actually received at the landfill ($WASTE_{actual,y}$) and the quantity of methane actually flared ($CH4_{flared,y}$). They are monitored as follows:

Waste actually received: The amount of waste actually received at the landfill is monitored directly at the weigh bridge. That measurement is already used for waste disposal activity invoicing.

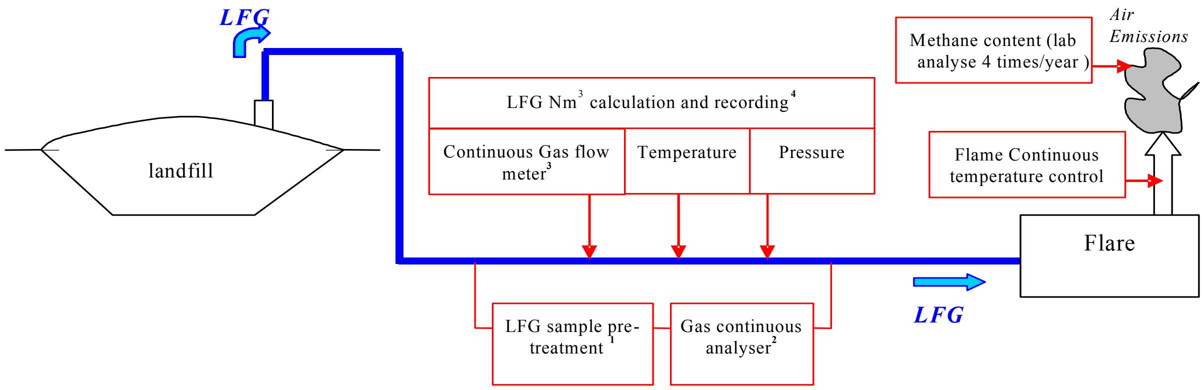
Methane collected and flared: As shown in Figure 1 the amount of methane actually flared will be determined by monitoring the:

- amount of landfill gas collected [m^3 - using a continuous flow meter and monitoring of temperature and pressure]
- percentage of landfill gas that is methane [% - using a continuous analyser]
- flare working hours [hours - using a run time meter **connected to a flame detector or a flame continuous temperature controller**]
- **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.**
- **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 proces~~fraction of methane destroyeds. For this purpose, the methane content of the flare emissions should be analysed at least quarterly.**
- **Temperature (T) and pressure (P) of the landfill gas are required to determine the density of methane in the landfill gas.**

~~In addition, the methane content of the flare emissions will be analysed quarterly.~~

To estimate leakage the electricity used by the pumping equipment for the collection system needs to be metered.

Figure 1
Monitoring Plan



This monitoring methodology provides for direct and continuous measurement of the actual quantity of landfill gas flared and of the methane content of the landfill gas flared using a continuous flow meter and a continuous methane analyser. The continuous methane analyser is important 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 monitoring methodology is commonly used on landfills with gas to energy plant where it is necessary to have a strict control of the fuel for the energy plant. 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	Data type	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
2.1	Waste disposal	Annual waste landfilled	[metric tonnes]	m	Daily	100%	Daily : e Monthly : p	Project lifetime	Measured at weigh bridge
2.2	LFG	Amount of methane flared	[t CH4]	m	Continuous	100%	Daily : e Monthly : p	Project lifetime	Measured by continuous gas quality analyzer and flow meter, or complementary method (% CH4, Sm^3/h of LFG, LFG temperature and pressure, flare temperature, flare working hours)
2.3	**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)**
2.4	**$w_{CH4,y}$**	**Methane fraction in the landfill gas**	**m^3 CH4 / m^3 LFG**	**m**	**continuously / periodically**	**100%**	**electronic**	**During the crediting period and two years after**	**Preferably measured by continuous gas quality analyser.**
2.5	**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 DCH4.**

2.6	**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 DCH4.**
2.~~3~~**7**	LFG	Total amount of methane flared	[t CH4]	c	Daily	n/a	Daily : e Monthly : p	Project lifetime	
2.~~4~~**8**	LFG	Amount of methane flaring required in baseline	[t CH4]	c	Annually	n/a	Annually : e & p	Project lifetime	Contractual amount adjusted by real waste received and predetermined methane content of the landfill gas
2.~~5~~**9**	LFG	Amount of methane collected in addition to requirement	[t CH4]	c	Annually	n/a	Annually : e & p	Project lifetime	
2.~~6~~**10**	Emission Reduction	Annual Carbon Dioxide Equivalent Avoided	[t CO2e]	c	Annually	n/a	Annually : e & p	Project lifetime	

Data to be collected or used to monitor leakage, and how this data will be archived

ID	Data type	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
3.1	Electricity	Total amount electricity used for gas pumping	[kWh]	m	Continuously	100%	Daily : e Monthly : p	Project lifetime	
3.2	Emission factor	Greenhouse gas emissions per kWh of electricity used	kg CO_2e/ kWh	c or e	Annually	n/a	Annually : p	Project lifetime	Emission factor will need to be calculated using an approved methodology and may require data from the electricity supplier

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 why QA/QC procedures are or are not being planned.
2.1	Low	Yes	Already included in Landfill ISO 9000/14000 certification. Specific procedure for calibration
2.2	Low	Yes	Will be included in Landfill ISO 9000 / 14000 certification. Specific procedure to be developed for measurement equipment calibration and maintenance, as well as for calculation module
2.3	**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.**
2.4	**Low**	**Yes**	**The gas analyser should be subject to a regular maintenance and testing regime to ensure accuracy.**
2.5	Low (calculated)	Yes	Will be included in Landfill ISO 9000 / 14000 certification scope
2.6	Low (calculated)	Yes	Will be included in Landfill ISO 9000 / 14000 certification scope
2.7	Low (calculated)	Yes	Will be included in Landfill ISO 9000 / 14000 certification scope
2.8	Low (calculated)	Yes	Will be included in Landfill ISO 9000 / 14000 certification scope
3.1	Low	Yes	Will be included in Landfill ISO 9000 / 14000 certification scope
3.2	Medium (calculated)	Yes	Will use an approved methodology for determining the emission factor for the electricity consumed

Baseline Data

The following tables provide data used to calculate the emission reductions.

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

Factor used (CO_2e/CH_4)	Period Applicable	Source
21	1996-2012	Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories

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

Conversion Factor[1]

Factor	unit	Period Applicable	Description/Source
0.000662	tonnes CH_4/m^3(STP) CH_4	default	

[1] This table is updated as more scientific information becomes available or reporting guidelines are modified.