CLEAN DEVELOPMENT MECHANISM

AMS-III.G.

Small-scale Methodology

Landfill methane recovery

Version 10.0

Sectoral scope(s): 01 and 13

United Nations
Framework Convention on
Climate Change

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1. Introduction

1. The following table describes the key elements of the methodology:

Table 1. Methodology key elements

Typical project(s)	Capture and combustion of methane from landfills used for disposal of residues including municipal, industrial and other solid wastes containing biodegradable organic matter
Type of GHG emissions mitigation action	Greenhouse gas (GHG) destruction. Destruction of methane and displacement of more-GHG-intensive energy generation

2. Scope, applicability, and entry into force

2.1. Scope

2. This methodology comprises measures to capture and combust methane from landfills (i.e. solid waste disposal sites) used for the disposal of residues from human activities including municipal, industrial, and other solid wastes containing biodegradable organic matter.

2.2. Applicability

3. Different options to utilise the recovered landfill gas as detailed in paragraph 4 of "AMS-III.H.: Methane recovery in wastewater treatment" (version 19.0) are eligible for use under this methodology. The relevant procedures in AMS-III.H. shall be followed in this regard.

4. Measures are limited to those that result in aggregate emission reductions of less than or equal to 60 kt CO_2 equivalent annually from all Type III components of the project activity.

5. The proposed project activity does not reduce the amount of organic waste that would have been recycled in the absence of the project activity.

6. This methodology is not applicable if the management of the solid waste disposal site (SWDS) in the project activity is deliberately changed in order to increase methane generation compared to the situation prior to the implementation of the project activity (e.g. other than to meet a technical or regulatory requirement). Such changes may include, for example, the addition of liquids to a SWDS, pre-treating waste to seed it with bacteria for the purpose of increasing the rate of anaerobic degradation of the SWDS or changing the shape of the SWDS to increase methane production.

2.3. Entry into force

7. The date of entry into force is the date of the publication of the EB 103 meeting report on 14 June 2019.

2.4. Applicability of sectoral scopes

8. For validation and verification of CDM projects and programme of activities by a designated operation entity (DOE) using this methodology:

   (a) If the recovered Land Fill Gas (LFG) is only flared and not used for any other purpose, the application of sectoral scope 13 is mandatory;

   (b) If the recovered LFG is used for any purpose other than flaring, then application of sectoral scope 13 and sectoral scope 1 is mandatory.

3. Normative references

9. Project participants shall apply the "General guidelines for SSC CDM methodologies" and the "Guidelines on the demonstration of additionality of small-scale project activities" at <http://cdm.unfccc.int/Reference/Guidclarif/index.html#meth> mutatis mutandis.

10. This methodology also refers to the latest approved versions of the following approved methodologies and methodological tools:

   (a) "ACM0001: Flaring or use of landfill gas";

   (b) "AMS-I.D.: Grid connected renewable electricity generation";

   (c) "AMS-III.H.: Methane recovery in wastewater treatment";

   (d) "Emissions from solid waste disposal sites";

   (e) "Tool to calculate baseline, project and/or leakage emissions from electricity consumption";

   (f) "Tool to calculate project or leakage CO_2 emissions from fossil fuel combustion";

   (g) "Project emissions from flaring";

   (h) "Tool to determine the baseline efficiency of thermal or electric energy generation systems";

   (i) "Positive lists of technologies".

4. Definitions

11. The definitions contained in the Glossary of CDM terms shall apply.

5. Baseline methodology

5.1. Project boundary

12. The project boundary is the physical, geographical site of the landfill where the gas is captured and destroyed/used.

5.2. Simplified additionality and baseline

13. Project proponent may apply the following simplified procedure for additionality demonstration and baseline:

    (a) Demonstrate additionality by referring to the requirements in methodological tool "Positive lists of technologies".

    (b) If the LFG is used for heat and electricity generation within the project boundary, that component of the project activity may use a corresponding methodology under Type I project activities:

        (i) If all or part of the electricity generated by the project activity is exported to the grid, the baseline scenario for all or the part of the electricity exported to the grid is assumed to be electricity generation in existing and/or new grid-connected power plants. If all or part of the electricity is supplied to off-grid application, the baseline electricity generation equipment is assumed to correspond to the default emission factor from Option B2 of the "Tool to calculate baseline, project and/or leakage emissions from electricity consumption";

        (ii) The baseline scenario for heat is assumed to be a new natural-gas-fired heat generation equipment with a default baseline efficiency of 100 per cent or with a default baseline efficiency as provided in Option F of the "Tool to determine the baseline efficiency of thermal or electric energy generation systems".

5.3. Baseline scenario and baseline emissions

14. The baseline scenario is the situation where, in the absence of the project activity, biomass and other organic matter are left to decay within the project boundary, and methane is emitted to the atmosphere, possibly with capture of LFG and destruction through flaring to comply with regulations or contractual requirements. Baseline emissions shall exclude methane emissions that would have to be removed to comply with national or local safety requirements or legal regulations. In addition, the effect of methane oxidation that is present in the baseline and absent in the project shall be taken into account:[1]

$$BE_y = \eta_{\mathrm{PJ}} \times BE_{CH4,SWDS,y} - (1 - \mathrm{OX}) \times F_{CH4,BL,y} \times GWP_{CH4} \qquad \text{Equation (1)}$$

[1] $OX_{top\text{-}layer}$ is the fraction of the methane in the LFG that would oxidize in the top layer of the SWDS in the absence of the project activity. Under the project activity, this effect is reduced as a portion of the LFG is captured and does not pass through the top layer of the SWDS. This oxidation effect is also accounted for in the methodological tool "Emissions from solid waste disposal sites". In addition to this effect, the installation of an LFG capture system under the project activity may result in the suction of additional air into the SWDS. In some cases, for example when the suction pressure is high, this air may cause a reduction in the amount of methane that is generated under the project activity. However, in most circumstances where the LFG is captured and used, this effect is considered to be very small, as the operators of SWDS have an incentive in most cases to achieve a high methane concentration in the LFG. For this reason, this effect is neglected for conservativeness.

Where:

$BE_{CH4,SWDS,y}$ = Methane emission potential of a solid waste disposal site (in t CO_2e), calculated using the methodological tool "Emissions from solid waste disposal sites". This tool may be used:

- With the factor "f=0.0" because the amount of LFG that would have been captured and destroyed is already accounted for in this equation;
- With the definition of year x as 'the year since the landfill started receiving wastes, x runs from the first year of landfill operation (x=1) to the year for which emissions are calculated (x=y)'.

The amount of waste type *j* deposited each year *x* ($W_{j,x}$) shall be determined by sampling (as specified in the above-mentioned tool), in the case that waste is generated during the crediting period. Alternatively, for existing SWDS, if the pre-existing amount and composition of the wastes in the landfill are unknown, they can be estimated by using parameters related to the serviced population or industrial activity, or by comparison with other landfills with similar conditions at regional or national level

OX = Oxidation factor (reflecting the amount of methane from SWDS that is oxidised in the soil or other material covering the waste) (dimensionless). A default value of 0.1 may be used

η_{PJ} = Efficiency of the LFG capture system that will be installed in the project activity. It is used for ex ante estimation only. A default value of 50 per cent may be used

$F_{CH4,BL,y}$ = Methane emissions that would be captured and destroyed to comply with national or local safety requirement or legal regulations in the year *y* (t CH_4). The relevant procedures in "ACM0001: Flaring or use of landfill gas" may be followed, as well as taking into account the compliance with the relevant local laws and regulation if such laws and regulations exist

GWP_{CH4} = Global Warming Potential for methane (value of 21)

5.4. Project emissions

15. Project emissions consist of:

(a) CO_2 emissions from fossil fuel or electricity used by the project activity facilities ($PE_{power,y}$);

(b) Emissions from flaring or combustion of the gas stream ($PE_{flare,y}$);

(c) Emissions from the landfill gas upgrading process ($PE_{process,y}$), where applicable.

$$PE_y = PE_{Power,y} + PE_{flare,y} + PE_{process,y}$$ Equation (2)

Where:

PE_y = Project emissions in year *y* (t CO_2e)

$PE_{Power,y}$ = Emissions from the use of fossil fuel or electricity for the operation of the installed facilities in the year *y* (t CO_2e)

$PE_{flare,y}$ = Emissions from flaring or combustion of the landfill gas stream in the year *y* (t CO_2e)

$PE_{process,y}$ = Emissions from the landfill gas upgrading process in the year *y* (t CO_2e), determined by following the relevant procedures described in annex 1 of AMS-III.H.

16. Project emissions from electricity consumption are determined as per the procedures described in the "Tool to calculate baseline, project and/or leakage emissions from electricity consumption", "AMS-I.D.: Grid connected renewable electricity generation". For project emissions from fossil fuel consumption, the "Tool to calculate project or leakage CO_2 emissions from fossil fuel combustion" shall be used. The emission factor for the fossil fuel shall be used (t CO_2/tonne). Local values are to be used, if local values are difficult to obtain, IPCC default values may be used. If recovered landfill gas is used to power auxiliary equipment of the project activities (e.g. landfill gas extraction, cleaning, compression) it should be taken into account accordingly, using zero as its emission factor and energy used for such purpose is not eligible for a SSC CDM Type I project component.

17. If flaring (single or multiple) is used to destroy all or part of the recovered landfill gas, project emissions from flaring in year *y* ($PE_{flare,y}$ in t CO_2e) shall be determined for each flare following the procedure described in the methodological tool "Project emissions from flaring".

5.5. Leakage

18. If the methane recovery technology is equipment transferred from another activity, leakage effects are to be considered.

5.6. Emission reductions

19. The emission reduction achieved by the project activity can be estimated ex ante in the project design document (PDD) by:

$$ER_{y,estimated} = BE_y - PE_y - LE_y$$ Equation (3)

20. The actual emission reduction achieved by the project activity during the crediting period will be calculated using the amount of methane recovered and destroyed/gainfully used by the project activity, calculated as:

$$ER_{y,calculated} = (1 - OX) \times (F_{CH4,PJ,y} - F_{CH4,BL,y}) \times GWP_{CH4} - PE_y - LE_y \quad \text{Equation (4)}$$

Where:

$F_{CH4,PJ,y}$ = Methane captured and destroyed/gainfully used by the project activity in the year *y* (tCH_4)

$$F_{CH4,PJ,y} = D_{CH4,y} \times w_{CH4,y} \times \sum_i LFG_{i,y} \quad \text{Equation (5)}$$

Where:

$LFG_{i,y}$ = Landfill gas destroyed via method *i* (flaring, fuelling, combustion, injection to a grid, etc.) in year *y* (m^3LFG). The flow or volume measurement shall be made either on a dry basis or at the same humidity as $w_{CH4,y}$

$w_{CH4,y}$ = Methane content in landfill gas in year *y* (volume fraction, m^3CH_4/m^3LFG). Landfill gas composition shall be measured either on a dry basis or at the same humidity as used to determine $LFG_{i,y}$

$D_{CH4,y}$ = Density of methane at the temperature and pressure of the landfill gas in year *y* (tonnes/m^3). If $LFG_{i,y}$ is reported at normal conditions of temperature and pressure, the density of methane is also determined at normal conditions

21. For project activities that utilize the recovered methane for power generation, $F_{CH4,PJ,y}$ may be calculated as follows, based on the amount of monitored electricity generation, without monitoring methane flow and concentration:

$$F_{CH4,PJ,y} = \frac{EG_y \ x \ 3600}{NCV_{CH4} \ x \ EE_y} \ x \ D_{CH4} \ x \ GWP_{CH4} \quad \text{Equation (6)}$$

Where:

EG_y = Electricity generation in year *y* (MWh)

3600 = Conversion factor (1 MWh = 3600 MJ)

NCV_{CH4} = NCV of methane (MJ/Nm3) use default value: 35.9 MJ/Nm3

EE_y = Energy Conversion Efficiency of the project equipment determined from one of the following options:

- Specification provided by the equipment manufacturer specifically for biogas fuel only if the equipment is designed to utilize biogas as fuel. If the specification provides a range of efficiency values, the highest value of the range shall be used for the calculation
- Default efficiency of 40 per cent

22. Project proponents shall provide evidence to a validating designated operational entity (DOE) that only the landfill gas recovered in the project is used for power generation; no other gas or fuels except a start-up fuel[2] are used.

23. The methods to be used for the integration of the values calculated from the above in equations to obtain the results for one year of measurements within the confidence level, as well as the methods and instruments used for metering, recording and processing the data obtained, shall be described in the project design document and monitored during the crediting period. Projects measuring methane content in the LFG using sampling shall follow the "Guidelines for sampling and surveys for CDM project activities and programme of activities" applying confidence/precision of 90/10.

24. Project activities where a portion of the recovered landfill gas is destroyed through flaring and the other portion is used for energy may consider applying the flare efficiency value to the portion of the landfill gas used for energy if separate measurements of the respective flows are not performed. When the amount of methane combusted for energy and the amount that is flared are monitored separately, or when only the landfill gas flow to the flare is monitored and the landfill gas used for energy is calculated based on electricity generation, a destruction efficiency of 100 per cent can be used for the amount that is combusted for energy.[3]

6. Monitoring methodology

25. Flow meters, sampling devices and gas analysers shall be subject to regular maintenance, testing and calibration to ensure accuracy.

26. Relevant parameters shall be monitored as indicated in the tables below. The applicable requirements specified in the "General guidelines for SSC CDM methodologies" (e.g. calibration requirements, sampling requirements) are also an integral part of the monitoring guidelines specified below and therefore shall be applied by the project participants.

[2] If a fuel is defined as a start-up fuel, it should not represent more than 1 per cent of the total fuel utilized in the process, on energy basis.

[3] The energy component shall be either developed under a Type I SSC methodology or included in the project boundary with the energy output being monitored.

6.1. Parameters for monitoring during the crediting period

Data / Parameter table 1.

Data / Parameter:	$PE_{power,y}$
Data unit:	t CO_2e
Description:	Parameters related to emissions from electricity and/or fuel consumption
Measurement procedures:	As per the procedure in AMS-I.D. Electricity consumption is directly metered, or alternatively is determined by assuming that all relevant electrical equipment operate at full rated capacity, plus 10 per cent to account for distribution losses, for 8760 hours per year
Monitoring frequency:	-
Any comment:	-

Data / Parameter table 2.

Data / Parameter:	$PE_{flare,y}$
Data unit:	t CO_2e
Description:	Emissions from flaring or combustion of the landfill gas stream in the year *y*
Measurement procedures:	As per the methodological tool "Project emissions from flaring"
Monitoring frequency:	-
Any comment:	-

Data / Parameter table 3.

Data / Parameter:	$PE_{process,y}$
Data unit:	t CO_2e
Description:	Emissions from the landfill gas upgrading process
Measurement procedures:	As per the relevant provisions in AMS-III.H.
Monitoring frequency:	-
Any comment:	-

Data / Parameter table 4.

Data / Parameter:	$LFG_{i,y}$
Data unit:	m^3
Description:	Landfill gas destroyed via method *i* in year *y*

Measurement procedures:	In all cases, the amount of landfill gas recovered, fuelled, flared or otherwise utilized (e.g. injected into a natural gas distribution grid or distributed via a dedicated piped network) shall be monitored ex post, using continuous flow meters. The methane content measurement shall be carried out close to a location in the system where the landfill gas flow, temperature and pressure measurements are carried out, and at the same humidity content (dry or at known or measured/corrected for humidity content)
Monitoring frequency:	Continuous flow measurement with accumulated volume recording (e.g. hourly/daily accumulated reading)
Any comment:	-

Data / Parameter table 5.

Data / Parameter:	$w_{CH4,y}$
Data unit:	%, volume basis
Description:	Methane content in landfill gas in the year *y*
Measurement procedures:	The fraction of methane in the gas should be measured with a continuous analyser (values are recorded with the same frequency as the flow) or, alternatively, with periodical measurements at a 90/10 confidence/precision level. It shall be measured using equipment that can directly measure methane content in the landfill gas - the estimation of methane content of landfill gas based on measurement of other constituents of landfill gas such as CO_2 is not permitted. The methane content measurement shall be carried out close to the location in the system where the landfill gas flow, temperature and pressure measurements are carried out, and at the same humidity content (dry or at known or measured/corrected for humidity content)
Monitoring frequency:	-
Any comment:	-

Data / Parameter table 6.

Data / Parameter:	***T***
Data unit:	^{o}C
Description:	Temperature of the landfill gas
Measurement procedures:	The temperature of the gas is required to determine the density of the methane combusted. If the landfill gas flow meter employed measures flow, pressure and temperature and displays or outputs the normalised flow of landfill gas, then there is no need for separate monitoring of pressure and temperature of the landfill gas. Otherwise, landfill gas temperature measurement shall be made close to where the gas flow is measured
Monitoring frequency:	Shall be measured at the same time when methane content in landfill gas ($w_{CH4,y}$) is measured
Any comment:	-

Data / Parameter table 7.

Data / Parameter:	***P***
Data unit:	Pa
Description:	Pressure of the landfill gas
Measurement procedures:	The pressure of the gas is required to determine the density of the methane combusted. If the landfill gas flow meter employed measures flow, pressure and temperature and displays or outputs the normalised flow of landfill gas, then there is no need for separate monitoring of pressure and temperature of the landfill gas. Otherwise, the landfill gas pressure measurement shall be made close to where the gas flow is measured
Monitoring frequency:	Shall be measured at the same time when methane content in landfill gas ($w_{CH4,y}$) is measured
Any comment:	-

Data / Parameter table 8.

Data / Parameter:	EG_y
Data unit:	MWh
Description:	Electricity generation in year *y*
Measurement procedures:	Only required for project activities which utilize the recovered methane for power generation as per paragraph 20 above
Monitoring frequency:	-
Any comment:	-

Data / Parameter table 9.

Data / Parameter:	EE_y
Data unit:	%
Description:	Energy Conversion Efficiency of the project equipment
Measurement procedures:	As per paragraph 21 above. Specification provided by the equipment manufacturer. The equipment shall be designed to utilize biogas as fuel, and the efficiency specification is for biogas. If the specification provides a range of efficiency values, the highest value of the range shall be used for the calculation
Monitoring frequency:	-
Any comment:	-

7. Project activity under a Programme of Activities

27. The methodology is applicable to a programme of activities. No additional leakage estimations are necessary other than that indicated under the leakage section above.

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Document information

Version	*Date*	*Description*
10.0	14 June 2019	EB 103, Annex 7 Revision to include reference to methodological tool "TOOL32: Positive lists of technologies".
09.0	28 November 2014	EB 81, Annex 32 Revision to: • Adopt additionality simplifications which are applicable to equivalent small-scale methodologies AMS-III.D., AMS-III.E., AMS-III.G. and input received from stakeholder; • Adopt supressed demand scenario that is applicable to equivalent large- scale methodology "ACM0014: Treatment of wastewater".
08.0	13 September 2012	EB 69, Annex 24 To include: (i) oxidation factor and a landfill gas collection efficiency factor in line with ACM0001 "Flaring or use of landfill gas"; and (ii) an alternative method for determining methane destruction through monitoring of electricity generation.
07.0	29 September 2011	EB 63, Annex 21 To cover among others, more types of gainful use of landfill gas.
06.0	14 March 2008	EB 38, Annex 12 • To exclude the consideration of landfill gas collection efficiency in the ex ante calculation of emission reduction; • To include the possibility for pipeline transport of the recovered landfill gas.
05.0	27 July 2007	EB 33, Annex 20 To include emissions from the pre-existing waste in the baseline calculations.
04.0	15 December 2006	EB 28, Annex 21 To take into account the 2006 IPCC Guidelines for National Greenhouse Gas Inventories as well as to include a revision of the parameters of the first order decay (FOD) model as per the Methodological tool titled "Tool to determine methane emissions avoided from dumping waste at a solid waste disposal site".
03.0	21 July 2006	EB 25, Annex 26 To clarify the procedure for estimating the baseline emissions as well as the procedure for estimating ex-ante emission reductions to be provided in the Project Design Document (CDM-SSC-PDD).

Version	*Date*	*Description*
02.0	12 May 2006	EB 24, Meeting Report, Para. 64 Introduced the interim applicability condition i.e. 25 $ktCO_2e/y$ limit from all Type III categories.
01.0	24 February 2006	EB 23, Annex 21 Initial adoption.

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