Indicative simplified baseline and monitoring methodologies
for selected small-scale CDM project activity categories

TYPE III - OTHER PROJECT ACTIVITIES

Project participants shall apply the general guidelines to SSC CDM methodologies, attachment A to Appendix B provided at <http://cdm.unfccc.int/methodologies/SSCmethodologies/approved.html> *mutatis mutandis.*

III.AX. Methane oxidation layer (MOL) for solid waste disposal sites

Technology/measure

1. This methodology is applicable to project activities involving the construction of a methane oxidation layer (MOL)[1] on top of a municipal solid waste disposal site (SWDS) with low residual surface methane emission (less than 4 L $CH_4.m^{-2}.h^{-1}$). The purpose is to avoid the release of methane through biological oxidation in the MOL.

2. The project activity does not recover or combust methane (unlike AMS-III.G "Landfill Methane Recovery"), and does not undertake controlled combustion of the waste (unlike AMS-III.E "Avoidance of methane production from decay of biomass through controlled combustion, gasification or mechanical/thermal treatment") or avoid methane production through composting (unlike AMS-III.F "Avoidance of methane emissions through composting").

3. This methodology is applicable as a landfill management concept where landfill gas collection and treatment is not applicable due to either low concentration of landfill gas (less than 4 L $CH_4.m^{-2}.h^{-1}$) or due to other reasons which make the installation of a gas collecting system impractical. In order to verify whether this applicability condition is met project proponents shall make the *ex ante* baseline estimation as per the procedures of paragraph 9 below, divided by the surface area of the SWDS.

4. This project activity is only eligible for SWDS (or individual cells of a SWDS) that are no longer receiving wastes for disposal. This methodology is not applicable in case a legal regulation is in place requiring the surface covering with methane oxidizing materials. The methodology is also not applicable at SWDS (or individual cells of a SWDS) with an active gas extraction system.

5. Measures are limited to those that result in annual emission reduction of 60 $ktCO_2$ equivalent or less.

[1] The MOL consists of methane oxidising material (MOM) which is biologically and mechanically processed biomass known as 'refined stabilized biomass' (SB). SB is compost or a compost-like product available from mechanical biological treatment (MBT) plants or aerobic composting facilities. For the production of methane oxidising material, SB is used as raw material and submitted to refinement and maturation in order to fulfil the technical requirements for MOL application. A gas distribution layer is placed below the MOM.

Boundary

6. The project boundary is the physical, geographical site:

(a) Where the application of MOL takes place (solid waste disposal site);

(b) Where the production of MOM (refinement of SB material) takes place; and

(c) Where the transportation of MOM to the SWDS occurs.

Baseline

7. The baseline scenario is the situation where, in the absence of the project activity, decomposing biomass and other organic components disposed at waste disposal sites, decay anaerobically and emit methane to the atmosphere. Baseline emissions shall exclude emissions of methane that would have to be captured, fuelled or flared in order to comply with national or local safety requirement or legal regulations.

***Ex ante* estimation**

8. *Ex ante* estimation of the baseline emissions.

$$BE_y = BE_{CH4,SWDS,y} * Af_{MOL,y} \quad (1)$$

Where:

BE_y	Baseline emissions in year *y* (tCO_2e)
$BE_{CH4,SWDS,y}$	Methane generation from the SWDS in the absence of the project activity at year *y*, see below
$Af_{MOL,y}$	Area fraction of the SWDS that will be covered with MOL up to year *y*. $Af_{MOL,y}$ = 1, in case the MOL application in year *y* is complete (i.e. covers the entire SWDS area)

9. $BE_{CH4,SWDS,y}$ may be determined *ex ante* using one of the following options:

(a) Calculated as per the "Tool to determine methane emissions avoided from disposal of waste at a solid waste disposal site" (tCO_2e). The oxidation factor (reflecting the amount of methane from SWDS that is oxidised in the soil or other material covering the waste), will be the value OX = 0.1, irrespective of whether the SWDS is covered with a top layer or not. This is to consider a natural methane oxidation effect in the surface layer of the landfill. Furthermore, the tool shall use the years *x* running from the first year of waste disposal (*x*=1) to the year in which disposal activity stopped (e.g. for a landfill disposal of 20 years *x* runs from *x*=1 to *x*=20). If the pre-existing amount and composition of the waste in the SWDS are unknown, they can be estimated by using parameters related to the attended population or industrial activity, or by comparison with other SWDS with similar conditions in the region;

(b) Determined through a baseline campaign using the flux chambers sampling and measurement method as described in Table 1.

***Ex post* baseline calculation**

10. Calculation of baseline emissions of the SWDS under the MOL (before oxidation).

$$BE_y = E_{CH4,bottom,y} * GWP_{CH4} * (1 - OX) * CF \quad \textbf{(2)}$$

Where:

$E_{CH4,bottom,y}$	Average calculated total methane emissions of the SWDS under the MOL (before oxidation) in year *y* considering all sampling campaign results in year *y* (tCH_4)
GWP_{CH4}	Global Warming Potential (GWP) of methane (value of 21 shall be used)
CF	Correction factor for conservativeness (value of 0.89 may be applied[2])

$$E_{CH4,bottom} = \frac{16}{12} * 365 * 10^{-6} * \sum_i F_{CH4,bottom,i} * A_i \quad \textbf{(3)}$$

Where:

$E_{CH4,bottom}$	Calculated total methane emissions of the SWDS under the MOL (before oxidation) as annual emission value based on one sampling campaign (tCH_4/a)
$F_{CH4,bottom,i}$	Calculated methane emission flux of the SWDS under the MOL (before oxidation) in zone *i* ($g\ C.m^{-2}.d^{-1}$)
A_i	Area of zone *i* (m^2)
i	Number of SWDS zones which are covered with MOL

The sampling area zones as well as the number of sampling points must be selected in a way that ensures a representative monitoring of the entire MOL/SWDS area.

$$F_{CH4,bottom,i} = Average(F_{CH4,bottom,i,n}) \quad \textbf{(4)}$$

Where:

$F_{CH4,bottom,i,n}$	Calculated methane emissions flux of the SWDS under the MOL (before oxidation) zone *i* at sampling point *n* ($g\ C.m^{-2}.d^{-1}$)
n	Number of sampling points in the MOL covered SWDS at area zone *i*

Calculation of methane emissions of the SWDS under the MOL.

[2] The factor CF = 0.89 refers to an estimated uncertainty range of 40 % for the sampling and measurement method.

$$F_{CH4,bottom,i,n} = \frac{C_{CH4,bottom,i,n}}{C_{CH4,bottom,i,n} + C_{CO2,bottom,i,n}} * (F_{CO2,surface,i,n} + F_{CH4,surface,i,n}) \quad (5)$$

Where:

$C_{CH4,bottom,i,n}$	Measured volume fraction of methane in the middle of the distribution layer in zone *i* at sampling point *n* (fraction)
$C_{CO2,bottom,i,n}$	Measured volume fraction of carbon dioxide in the middle of the distribution layer in zone *i* at sampling point *n* (fraction)
$F_{CO2,surface,i,n}$	Measured carbon dioxide emissions on the surface of the MOL in zone *i* at sampling point *n* ($g\ C.m^{-2}.d^{-1}$)
$F_{CH4,surface,i,n}$	Measured methane emissions on the surface of the MOL in zone *i* at sampling point *n* ($g\ C.m^{-2}.d^{-1}$)

Leakage

11. No leakage calculation is required.

Project activity emissions

12. Project activity emissions consist of:

(a) CO_2 emissions due to incremental transportation distances;

(b) CO_2 emissions from electricity and/or fossil fuel consumption by the project activity facilities;

(c) Residual methane emissions from SWDS covered by MOL.

$$PE_y = PE_{y,transp} + PE_{y,power} + PE_{y,MOL} \quad (6)$$

Where:

PE_y	Project activity emissions in the year *y* (tCO_2e)
$PE_{y,transp}$	Emissions from incremental transportation in the year *y* (tCO_2e)
$PE_{y,power}$	Emissions from electricity or fossil fuel consumption in the year *y* (tCO_2e)
$PE_{y,MOL}$	Residual methane emissions of the SWDS from MOL covered areas (after oxidation) in the year *y* (tCO_2e)

13. Project emissions due to incremental transport distances ($PE_{y,transp}$) are calculated based on the incremental distances:

(a) Between the collection site of SB and the SB refinement facility as compared to the baseline SB disposal site;

(b) Between the SB refinement facility and the SWDS site for MOL application;

(c) For transportation of excess material from SB refinement facility;

(d) For transportation of the distribution material (for the distribution layer) to the SWDS site for MOL application.

$$PE_{y,transp} = \sum_{m} EF_{CO2} * (Q_{y,m} / CT_{y,m}) * DAF_m \quad \textbf{(7)}$$

Where:

EF_{CO2}	CO_2 emission factor from fuel use due to transportation (tCO_2/km, IPCC default values or local values may be used)
$Q_{y,m}$	Quantity of material m transported in the year *y* (tonnes)
$CT_{y,m}$	Average truck capacity for transportation of material *m* (tonnes/truck)
DAF_m	Average distance for material *m* transportation (km/truck)
m	Transported type of material (SB, MOM, excess and distribution material)

14. For the calculation of project emissions from electricity and/or fossil fuel consumption by the project activity facilities ($PE_{y,power}$) all the energy consumption of all equipment/devices installed by the project activity shall be included e.g. energy used for turning of maturing piles, screening, blending etc. Emission factors for grid electricity used shall be calculated as described in AMS-I.D "Grid connected renewable electricity generation". In case renewable energy is used for power supply, $PE_{y,power}$ =0. For project activity emissions from fossil fuel consumption the "Tool to calculate project or leakage CO_2 emissions from fossil fuel combustion" should be used.

15. Residual methane emissions of the covered SWDS in the year *y* (tCO_2e) considering the methane emissions that are not oxidised when passing the MOL.

***Ex ante* calculation of $PE_{y,MOL}$**

$$PE_{y,MOL} = BE_y * \left(1 - OX_{MOL,y}\right) \quad \textbf{(8)}$$

For the *ex ante* calculation an oxidation factor ($OX_{MOL,y}$) of 90% may be used.

***Ex post* calculation of $PE_{y,MOL}$**

$$PE_{y,MOL} = E_{CH4,surface,y} * GWP_{CH4} * CF \quad \textbf{(9)}$$

Where:

$E_{CH4,surface,y}$	Average measured methane emissions at the surface of the MOL in all covered SWDS areas considering all sampling campaigns in year *y* (t CH_4)
CF	Correction factor for conservativeness – 1.12 should be applied[3]

$$E_{CH4,surface} = \frac{16}{12} * 365 * 10^{-6} * \sum_i F_{CH4,surface,i} * A_i \qquad \textbf{(10)}$$

Where:

$E_{CH4,surface}$	Total measured methane emissions at the surface of the MOL in all covered SWDS areas as annual emission value based on one sampling campaign (tCH_4/a)
$F_{CH4,surface,i}$	Measured methane emission flux on the surface of the MOL in SWDS zone *i* ($g\ C.m^{-2}.d^{-1}$)
A_i	Area of zone *i* (m^2)
i	Number of SWDS zone which are covered by MOL

$$F_{CH4,surface,i} = Average(F_{CH4,surface,i,n}) \qquad \textbf{(11)}$$

Where:

$F_{CH4,surface,i,n}$	Measured methane emission flux on the surface of the MOL in SWDS zone *i* at sampling point *n* ($g\ C.m^{-2}.d^{-1}$)
n	Number of sampling points of the MOL covered area of the SWDS

Emission reductions

16. Emission reductions achieved by the project activity in each year will be assessed *ex post* through direct measurement and can be calculated as the difference between the baseline emission and the sum of project emissions plus leakage.

17. The emission reductions are calculated as follows:

$$ER_y = BE_y - PE_y - LE_y \qquad \textbf{(12)}$$

Where:

ER_y	Emission reduction in the year *y* (tCO_2e)
LE_y	Leakage emissions in year *y* (tCO_2e)

[3] The factor CF = 1.12 refers to an estimated uncertainty range of 40% in the sampling and measurement method.

Monitoring

18. Relevant parameters shall be monitored as indicated in the Table 1 below. The applicable requirements specified in the "General Guidelines to SSC CDM methodologies" (e.g. calibration requirements, sampling requirements) are also an integral part of the monitoring guidelines specified below and therefore shall be referred by the project participants.

Table 1: Parameters for monitoring during the crediting period

Parameter	Description	Unit	Monitoring/ recording frequency	Measurement methods and procedures
Parameters related to methane oxidising material quality			Once per 500 t produced MOM	The following parameters should be analyzed prior to the application (placement) as MOL: (a) RA – Respiration Activity (mg O_2/kg dry matter) of MOM before application as MOL (In case respiration activity after seven days, i.e. RA_7 is used, it must be ≤ 8 mgO_2/g dry matter); (b) TOC (total organic carbon – must be > 4 % dry mass); (c) Ammonium concentration (must be < 350 ppm dry matter); (d) Nitrite (have to be not detectable).

Parameter	Description	Unit	Monitoring/ recording frequency	Measurement methods and procedures
				Respiration activity (e.g. RA_7 according to OENORM S2027-1 or RA_4 according to German standard) characterizes the biological reactivity of any kind of solid organic material. This parameter directly correlates to methane generation and is linked to the methane oxidation performance. The RA_7 determination is carried out to the MOM prior to its application as MOL. It may be conducted using the measurement procedure given in the Austrian OENORM or any equivalent national/international standard applicable at the project site. In case the obtained value is higher than RA_7 = 8 mg O_2/kg dry matter, the MOM shall not be used as MOL. Biological and chemical parameters such as TOC, ammonium and nitrite have to be analyzed using common laboratory analysis methods in accordance to national or international standards, which should be referred to in the PDD. For example, EPA publication SW-846 (Test methods for evaluating solid waste), which summarizes the laboratory standards including methods for TOC (9060), Nitrite (1685/1686), and ammonium (1689/1690) may be used

Parameter	Description	Unit	Monitoring/ recording frequency	Measurement methods and procedures
Parameters related to MOL construction properties			Once per 500 m^2 constructed MOL	The following parameters shall be determined in order to assure an effective oxidation of Methane in the MOL. These parameters shall only be determined during the application (placement) of the MOL: (a) Thickness of MOL and gas distribution layer/balancing layer during application (m) – shall be between 1.2-2.5 m for MOL and 0.3-0.5 m for distribution layer. In order to sustain the biological process the temperature in the lower part of the MOL should not permanently fall under 15°C. Hence in cold climate conditions a larger thickness is required to avoid low temperatures; (b) Minimum air-filled pore volume at field moisture capacity shall be > 15 vol %. The MOL shall not be compacted during application, thus the site should be monitored in a way to avoid any heavy traffic from vehicles and machinery over the MOL. The thickness of the MOL and gas distribution layer shall be tested in accordance to national or international standards in landfill technology which commonly require a geodetic measurement in a 10 x 10 m grid over the landfill cap. The air-filled pore volume should be determined in accordance to national or international standards in soil science or soil mechanics such as ASTM, ISO or DIN, (for example ASTM publication F1815-11 “Standard methods”)

Parameter	Description	Unit	Monitoring/ recording frequency	Measurement methods and procedures
Parameters related to methane oxidation performance			Gas compositions below MOL at least monthly. Gas fluxes at the surface at least every three month (once per season), or whenever the gas composition varies by more than 5% or the temperature falls below 10°C, see explanation at procedures	The following parameters should be analyzed to assure a correct measurement of methane oxidation in the MOL: (a) $C_{CH4,bottom,i,n}$ – Measured volume fraction of methane in the middle of the distribution layer in zone *i* at sampling point *n* (fraction); (b) $C_{CO2,bottom,i,n}$ – Measured volume fraction of carbon dioxide in the middle of the distribution layer in zone *i* at sampling point *n* (fraction); (c) $F_{CH4,surface,i,n}$ – Measured methane emissions on the surface of the MOL in zone *i* at sampling point *n* ($g\ C.m^{-2}.d^{-1}$); (d) $F_{CO2,surface,i,n}$ – Measured carbon dioxide emissions on the surface of the MOL in zone *i* at sampling point *n* ($g\ C.m^{-2}.d^{-1}$); (e) $C_{CH4,bottom,i,n}$, $C_{CO2,bottom,i,n}$ - the measured methane and carbon dioxide concentration below the MOL (i.e. on top/above the waste) are parameters required to calculate the carbon balance for determination of the baseline emissions. They shall be measured using a common gas measurement

Parameter	Description	Unit	Monitoring/ recording frequency	Measurement methods and procedures
				device. Measurement takes place in pre-installed lances penetrating through the MOL and ending in the middle of the gas distribution layer (under the MOL) in zone *i* at sampling point *n* in order to ensure sufficient homogenization of both, CH_4 and CO_2 concentrations and to avoid incorrect measurements. The lances are applied near to the sampling points where the flux measurement chamber will be placed during the monitoring of surface emissions. The concentration measurements shall be conducted once per month. This frequency considers that in the low gas generation phase (with advanced age of the SWDS) the gas generation does not usually undergo quick changes. Rather changes may be expected from different weather conditions (wet/dry, hot/cold), which are appropriately captured by monthly measurements; (f) $F_{CH4,surface,i,n}$, $F_{CO2,surface,i,n}$ - these parameters reflect the total landfill gas emissions (surface emissions on top of the MOL). They are measured in flux chambers by following the latest

Parameter	Description	Unit	Monitoring/ recording frequency	Measurement methods and procedures
				version of the "Guidance on monitoring landfill gas surface emissions";[4] project participants may also use other equivalent national or international guidelines. Measurements should be done regularly once in three months (preferably related to season). Additional measurement sessions are required in case either the gas production of the landfill or the methane oxidation effect of the MOL changes. This is the case, if the average monitored CH_4 concentrations below the MOL have varied by more than 5 Vol.-% or if the temperature in the lower part of the MOL drops below 10°C
Parameters related to gas distribution layer				The gas distribution layer placed below the methane oxidation material shall be of a thickness of 0.3 to 0.5 m. This layer consists of a stable, coarse material which allows landfill gas to migrate easily and be uniformly distributed through the MOL. Useful materials are lime free gravel with a size between 16 and 32 mm or similar materials

[4] See "Guidance on the monitoring of Landfill Gas "LFTGN03, EA 2004 at <http://www.environment-agency.gov.uk/business/sectors/108918.aspx>.

Parameter	Description	Unit	Monitoring/ recording frequency	Measurement methods and procedures
$Q_{y,m}$	Quantity of material *m* (i.e. SB, MOM, excess or distribution material transported in the year *y*	tons	Monthly, based on daily records	On-site data sheets of daily operations records and monthly integrated, using weigh bridge
$CT_{y,m}$	Average truck capacity for transportation of material m	tons/truck		On-site measurement
DAF_m	Average distance for material m transportation	km/truck	Annually	On-site measurement of travelled distances
	Parameters related to emissions from electricity and/or fuel consumption			As per the procedure in the “Tool to calculate baseline, project and/or leakage emissions from electricity consumption” and/or the “Tool to calculate project or leakage CO2 emissions from fossil fuel combustion”
T	Temperature inside the MOL	°C	Monthly	On-site measurement in pre installed 20 mm lances penetrating the MOL and ending in the lower half of the layer

Project activity under a programme of activities

This methodology is applicable to programme of activities.

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History of the document

Version	Date	Nature of revision
01	EB 65, Annex 24 25 November 2011	Initial adoption.
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