# 23. Water and Waste Management / Semi-aerobic landfill

## 1. Typical Project Outline

- A project to introduce a new semi-aerobic landfill or to upgrade an existing landfill under anaerobic conditions to a semi-aerobic landfill.
- The semi-aerobic landfill is a final waste disposal site with a structure that allows air to circulate within the landfill layer by opening the end of the leachate collection pipes to the atmosphere, and thus keeping aerobic conditions inside the landfill.

## 2. Applicability

(1) A project which introduces a new semi-aerobic landfill.

(2) A project which improves an existing landfill under anaerobic conditions to a semi-aerobic landfill.

(3) The semi-aerobic landfill to be introduced must follow the basic structure and use of the landfill in order to maintain semi-aerobic conditions within the landfill. Here, with reference to IPCC2019[1], a semi-aerobic landfill shall be considered to be "well managed" if it is managed in a manner that meets all of the following conditions. If either condition is not met, this methodology is not applicable:

(i) equipped with permeable cover material, (ii) the leachate collection/drainage pipe outlets without cap (open to the atmosphere)[2], (iii) leachate collection/drainage pipe outlets without sunk, (iv) leachate regulating pond is installed, (v) gas ventilation system without cap, (vi) connection of leachate drainage pipe and gas ventilation pipe.

(4) The landfill site under the baseline scenario[3] shall be one of the following, referring to the definition in IPCC2019[1]:

1) Well managed and in anaerobic conditions with a landfill depth of greater than or equal to 5 meters (Methane Correction Factor (MCF) value 1.0): where waste dumping is controlled, and must implement (i) cover material and/or (ii) levelling of the waste and mechanical compacting.

2) Unmanaged landfill where the landfill depth is greater than or equal to 5 meters, or high water table at near ground level (MCF value 0.8): Landfill that does not meet 1) above, which have depths of greater than or equal to 5 meters or high water table at near ground level. Latter situation corresponds to filling inland water, such as pond, river or wetland, by waste.

*For landfills other than those listed above, this methodology is not applicable, because for these cases, the MCF value is below or nearly equal to the MCF value for semi-aerobic landfills (0.5), and no GHG emission reductions are obtained or are negligible.

(5) In the baseline scenario and in the project, landfill gas (LFG: gas generated from landfill sites) are released into the atmosphere without recovery.

## 3. Methodology of Emission Reduction Calculation

The emission reduction from the project activity is determined as the differences between GHG emissions of the landfill site under the baseline scenario and project scenario (semi-aerobic landfill site)[4].

Details of sources of each data in the following formulae are provided in “4. Data and Parameters for the Estimation”.

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[1] 2019 Refinement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories, Volume 5: Waste, Table 3.1 (Updated)

[2] Excludes cases where the water level in the regulating ponds rises during heavy rainfall or where storage of leachate is temporarily required.

[3] A scenario of how waste would be disposed if the semi-aerobic landfill were not introduced. The baseline scenario is the common landfill method/structure in the target country or the method/structure adopted in the most recently constructed landfill in the target country.

[4] The target year shall be a representative year under average operation or an annual average of multiple years.

$ER_y = BE_y - PE_y$

$ER_y$ : Emission reduction through the project in year y ($t\text{-}CO_2e/y$)

$BE_y$ : GHG emission from the baseline scenario in year y ($t\text{-}CO_2e/y$)

$PE_y$ : GHG emission from the project scenario in year y ($t\text{-}CO_2e/y$)

(1) Calculation of Baseline Emission

The baseline emissions are methane emitted to the atmosphere from the landfill site. In case there is methane quantity to be flared as required by National Regulations, the amount is subtracted from the amount of $CH_4$ emitted from the landfill site under the baseline scenario as follows.

$BE_y = (BE_{CH4,SWDS,y} - MF_{BL,y}) \times GWP_{CH4}$

$BE_{CH4,SWDS,y}$ : Amount of $CH_4$ emitted from the landfill site under the baseline scenario ($t\text{-}CH_4/y$) .

$MF_{BL,y}$ : Methane quantity to be flared as required by National Regulations under the baseline scenario ($t\text{-}CH_4/y$).

$GWP_{CH4}$ : Methane Global Warming Potential (=25 $t\text{-}CO_2/t\text{-}CH_4$)

Determination of $BE_{CH4,SWDS,y}$:

Methane quantity from landfill under the baseline scenario shall be determined by estimating the quantity of degradable organic carbon reclaimed in the landfill in consideration of decomposition rate.

$$BE_{CH4,SWDS,y} = \varphi \times (1 - OX) \times 16/12 \times F \times MCF_{BL} \times \sum_{x=1}^{y} \sum_{j} \left\{ W_{j,x} \times DOC_{f,j} \times DOC_j \times e^{-k_j(y-x)} \times (1 - e^{-k_j}) \right\}$$

$\varphi$ : Model correction factor to account for model uncertainties

$OX$ : Oxidation rate

$F$ : Fraction of $CH_4$ in LFG (Landfill gas)

$DOC_{f,j}$ : Fraction of degradable organic carbon (DOC) that can decompose in the waste type j

$MCF_{BL}$ : $CH_4$ correction factor of the landfill site under baseline scenario

$W_{j,x}$ : Annual quantity of the waste type j disposed in the landfill site in year x (t/y)

$DOC_j$ : Fraction of degradable organic carbon (by weight) in the waste type j

x : Year in the time period in which waste is disposed at the landfill site

y : Years of the calculation of emissions (e.g. in case of 10 years period, set 10)

$k_j$ : Decay rate for the waste type j (unit/y)

j : Types of waste (e.g. wood, paper, food, textile, garden wastes)

e : Base of natural logarithm

$W_{j,x}$ is determined as follows.

$W_{j,x} = W_x \times w_j$

$W_x$ : Annual quantity of the waste disposed in the landfill site in year x (t/y)

$w_j$ : Weight fraction of the waste type j in the waste disposed (weight basis) (%)

Determination of $MF_{BL,y}$:

It is determined by multiplying the methane quantity from landfill with the fraction of decomposed and combusted.

$MF_{BL,y} = MD_{PJ,y} \times AF$

$MD_{PJ,y}$ : Methane quantity recovered from landfill by the project which is equal to the amount of $CH_4$ generated from the landfill site under the baseline scenario (t-$CH_4$/y).

AF : Methane fraction required for flare and combustion under the National Regulations under the baseline scenario. It will be zero as developing countries mostly have no such regulation.

(2) Calculation of Project Emission

$CH_4$ quantity from landfill after implementation of the project shall be determined by estimating the quantity of degradable organic carbon reclaimed in the landfill in consideration of decomposition rate.

$$PE_{CH4,SWDS,y} = \varphi \times (1 - OX) \times 16/12 \times F \times MCF_{PJ} \times \sum_{x=1}^{y} \sum_{j} \{W_{j,x} \times DOC_{f,j} \times DOC_j \times e^{-k_j(y-x)} \times (1 - e^{-k_j})\} \times GWP_{CH4}$$

$MCF_{PJ}$ : $CH_4$ correction factor of the semi-aerobic landfill site

* Other parameters are same as the baseline emission calculation.

## 4. Data and Parameters for the Estimation

| Data | Description | Data Sources | |
|---|---|---|---|
| | | For baseline emission calculation | For project emission calculation |
| $\varphi_y$ | Model correction factor to account for model uncertainties | 0.9<br>(Default value: CDM AM0093 (Avoidance of landfill gas emissions by passive aeration of landfills, version 1.0)) | 1.0<br>(Default value: CDM Methodological Tool: Emissions from solid waste disposal sites) |
| F | Fraction of $CH_4$ in LFG (Landfill gas) | 0.5<br>(Default value[5]) | |
| OX | Oxidation rate | Managed covered with oxidising material such as soil and compost: 0.1<br>Other landfill sites: 0<br>(Default value[6]) | |
| $DOC_{f,j}$ | Fraction of degradable organic carbon (DOC) that can decompose in the waste type j | Default value (Table 8, Appendix) | |
| $DOC_j$ | Fraction of degradable organic carbon (by weight) in the waste type j | Default value (Table 8, Appendix) | |
| $MCF_{BL}$ | $CH_4$ correction factor of the landfill site under baseline scenario | Default value. For each condition described in “2. Applicability” (4), apply following values:<br>1) Well managed and in anaerobic conditions: 1.0<br>2) Unmanaged landfill where the landfill depth is greater than or equal to 5 meters, or high water table at near ground level: 0.8 | N/A |

[5] 2019 Refinement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories, Volume 5: Waste, p.3.14
[6] 2019 Refinement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories, Volume 5: Waste, Table 3.2

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|---|---|---|---|
| | | (Table 9, Appendix) | |
| $MCF_{PJ}$ | $CH_4$ correction factor of the semi-aerobic landfill site | N/A | Default value: 0.5<br>(Table 9, Appendix) |
| $W_x$ | Annual quantity of the waste disposed in the landfill site in year x (t/y) | Choose one of the following options considering availability:<br>i) Result of a feasibility study or other studies<br>ii) Interview with disposal site managers<br>iii) Estimation by truck scaling<br>* Use planned average amount of waste disposal after the project starts. | N/A |
| $w_j$ | Weight fraction of the waste type j in the waste disposed (weight basis) (%) | Choose one of the following options considering availability:<br>i) Result of a feasibility study or other studies<br>ii) Result of a study on waste composition of the target city<br>iii) Sampling survey at the landfill site<br>iv) IPCC default value (waste composition by regions[7])<br>* Use planned average value after the project starts. | N/A |
| $k_j$ | Decay rate for the waste type j (unit/y) | Default value (Table 10, Appendix) | N/A |

**5. Others**

(1) Project Boundary

The project boundary is within the landfill site.

(2) Leakage

Considering the lifecycle of the waste management, GHG emissions through production of materials for the facility and transportation would be regarded as leakages. However, these emissions are negligible, since contribution of these emissions is relatively small compared with the GHG emission reduction after the project starts. The leakages are not considered in the CDM methodology which is applicable for semi-aerobic landfill projects (AM0093).

(3) Comparison with existing CDM methodologies

The CDM methodology AM0093 (Avoidance of landfill gas emissions by passive aeration of landfills, Version 1.0) is a methodology used as a reference in developing this methodology.

The logic of emission reduction calculation in this methodology is mostly the same as that of AM0093. In the methodology, $N_2O$ emissions from semi-aerobic landfill site should be calculated (baseline $N_2O$ emissions does not need to be calculated), however, in this methodology calculation of $N_2O$ emissions are not required since these are relatively small amount.

[7] 2019 Refinement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories, Volume 5: Waste, Table 2.3 (Updated)

(4) Revision history

| Version | Year/Month | Revisions |
|---|---|---|
| 5.0 | March 2024 | • Newly developed. |