18. Water and Waste Management / Anaerobic Treatment of Organic Waste

1. Typical Project Outline

- Recovery and application of methane through anaerobic treatment of organic wastes.

2. Applicability

(1) Methane recovery through anaerobic treatment of organic wastes that will be dumped to disposal sites in the absence of the project.

(2) Recovered methane is used for direct power generation and/or thermal energy purpose.

(3) Sludge after the treatment should be in aerobic condition as storage and transportation.

3. Methodology of Emission Reduction Calculation

The emission reduction from the project activity is determined as the differences between the GHG emissions of baseline scenario (methane are emitted to atmosphere without recovery) and project scenario (recovery and application of methane)[1]. Details of sources of each data in the following formulae are provided in "4. Data and Parameters for the Estimation".

$$ER_y = BE_y - PE_y$$

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 comprised of uncaptured methane emitted to the atmosphere from disposal sites and the CO_2 emissions from generation of electric power and/or thermal energy that will be replaced by electricity generated or thermal energy by methane captured.

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

$MG_{SWDS,y}$: Methane emission from landfill sites in the baseline ($t\text{-}CH_4/y$)

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

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

$BE_{EN,y}$: Baseline emissions from generation of energy displaced by the project activity ($t\text{-}CO_2/y$)

Determination of $MG_{SWDS,y}$:

Methane quantity from disposal sites (CH_4 quantity recovered and destroyed by the project) shall be determined by monitoring the quantity of degradable organic carbon reclaimed in the landfill in consideration of decomposition rate.

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

φ : Model correction factor to account for model uncertainties

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

OX : Oxidation rate

F : Fraction of CH_4 in LFG

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

MCF : CH_4 correction factor

$W_{j,x}$: 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 : Years in the time period in which waste is disposed at the SWDS, extending from the first year in the time period (x = 1) to year y (x = y).

y : Year of the period for which waste is disposed at the SWDS and methane emissions are calculated

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

j : Type of residual waste or types of waste in the MSW

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.

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

$MD_{SWDS,y}$: Methane quantity recovered from landfill by the project

AF : Methane fraction required for flare and combustion under the National Regulations before the project starts. It will be zero as developing countries mostly have no this regulation.

Determination of $BE_{EN,y}$:

It is determined by the quantity of electricity and thermal energy generated after by the project and corresponding CO_2 emission factors.

$$BE_{EN,y} = BE_{elec,y} + BE_{heat,y} = EG_{PJ,y} \times EF_{elec} + HG_{PJ,y}/\eta_{BL} \times EF_{fuel,BL} \div 10^3$$

$BE_{elec,y}$: Baseline emissions to generate the same amount of electricity generated by project activity in year y (t-CO_2/y)

$BE_{heat,y}$: Baseline emissions to generate the same amount of thermal energy produced by the project activity in year y(t-CO_2/y)

$EG_{PJ,y}$: Amount of electricity generated by the project in year y (MWh/y)

EF_{elec} : CO_2emission factor of the electricity (t-CO_2/MWh)

$HG_{PJ,y}$: Amount of thermal energy generated by the project in year y (TJ/y)

η_{BL} : Energy efficiency of the boiler/air heater used in the baseline scenario to generate the thermal energy. It will be "1" as a conservative value.

$EF_{fuel,BL}$: CO_2emission factor of the fuel i used in the baseline scenario (kg-CO_2/TJ)

(2) Calculation of Project Emission

The project emissions is comprised of the GHG emission from electricity and fuel consumption in the LFG recovery plants or power generating plants after the project starts as follows;

$$PE_y = PE_{EC,y} + PE_{FC,y} + PE_{Digest,y} + PE_{Tran,y} + PE_{Res,y}$$

PE_y : GHG emission from the project in year y (t-CO_2e/y)

$PE_{EC,y}$: GHG emission from electricity consumption by the project in year y (t-CO_2e/y)

$PE_{FC,y}$: GHG emission from fossil fuel consumption by the project in year y (t-CO_2e/y)

$PE_{Digest,y}$: GHG emission from anaerobic treatment system in year y (t-CO_2e/y)

$PE_{Tran,y}$: GHG emission from additional transportation of organic wastes and sludge in year y (t-CO_2e/y)

$PE_{Res,y}$: GHG emission from treatment of final sludge in year y (t-CO_2e/y)

Determination of $PE_{EC,y}$:

It is determined as follows.

$$PE_{EC,y} = EC_{PJ,y} \times EF_{elec}$$

$EC_{PJ,y}$: Amount of electricity consumption by the project in year y (MWh/year)

EF_{elec} : CO_2emission factor of the electricity (t-CO_2/MWh)

Determination of $PE_{FC,y}$:

It is determined as follows.

$$PE_{FC,y} = \sum_i \left(FC_{PJ,i,y} \times NCV_{fuel.,i} \times EF_{fuel,i} \div 10^6 \right)$$

$FC_{PJ,i,y}$: Amount of fuel consumption by the project in year y (t/year)

$NCV_{fuel,i}$: Net calorific value of the fuel i applied in the project (TJ/Gg = TJ/kt)

$EF_{fuel,i}$: CO_2 emission factor of the fuel i applied in the project (kg-CO_2/TJ)

Determination of $PE_{Digest,y}$:

It is determined as follows.

$$PE_{Digest,y} = MG_{PJ,y} \times GWP_{CH4} \times EF_{CH4,def}$$

$MG_{PJ,y}$: Methane generation from anaerobic treatment system (digester) (t-CH_4/y) : In the formula to calculate $MG_{SWDS,y}$, calculate the product by setting appropriate value of MCF_{PJ} for the project anaerobic treatment system instead of using MCFy.

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

$EF_{CH4,def}$: Leakage from biogas digesters (t-CH_4 leaked / t-CH_4 produced)

Determination of $PE_{Trans,y}$:

It is determined as follows.

$$PE_{Trans,y} = W_y \times DAF_W \times EF_{CO2,tran} + W_{Res,y} \times DAF_{Res} \times EF_{CO2,tran}$$

W_y : Amount of organic wastes being treated in year y (t/y)

$W_{Res,y}$: Amount of sludge in year y (t/y)

DAF_W : Average distance of routes of transporting organic wastes (km)

DAF_{Res} : Average distance of routes of transporting sludge (km)

$EF_{CO2,tran}$: CO_2 emission factor of the transport activities (g-CO_2/t-km)

Determination of $PE_{Res,y}$:

It is determined as follows.

$$PE_{Res,y} = MG_{PJ,y} \times GWP_{CH4} \times F_{SD,CH4,def}$$

$MG_{PJ,y}$: Methane generation from anaerobic treatment system (digester) in year y (t-CH_4/y) : In the formula to calculate $MG_{SWDS,y}$, calculate the product by setting appropriate value of MCF_{PJ} for the project anaerobic treatment system instead of using MCFy.

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

$F_{SD,CH4,def}$: Methane emission factor of sludge treatment

4. Data and Parameters for the Estimation

Data	Description	Data Sources	
		For baseline emission calculation	For project emission calculation
φ	Model correction factor to account for model uncertainties	0.80 (Default value: CDM Methodological Tool: Emissions from solid waste disposal sites)	1.0 (Default value: CDM Methodological Tool: Emissions from solid waste disposal sites)
F	Fraction of CH_4 in LFG	0.5 (Default value[2])	N/A
OX	Oxidation rate	Managed covered with oxidising material such as soil and compost: 0.1 Other landfill sites: 0 (Default value[3])	N/A
$DOC_{f,j}$	Fraction of degradable organic carbon (DOC) that can decompose in the waste type j	Default value of IPCC (Table 8, Appendix)	N/A
DOC_j	Fraction of degradable organic carbon (by weight) in the waste type j	Default value of IPCC (Table 8, Appendix)	N/A
MCF	CH_4 correction factor	Default value of IPCC (Table 9, Appendix)	N/A

[2] 2019 Refinement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories, Volume 5: Waste, p.3.14
[3] 2019 Refinement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories, Volume 5: Waste, Table 3.2

MCF_{PJ}	CH_4 correction factor for the project anaerobic treatment system	N/A	Default value of IPCC (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: i) Result of a feasibility study or other studies ii) Interview with disposal site managers iii) Estimation by truck scaling * 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: i) Result of a feasibility study or other studies ii) Result of a study on waste composition of the target city iii) Sampling survey at the landfill site iv) IPCC default value (waste composition by regions[4]) * Use planned average value after the project starts.	N/A
$W_{Res,y}$	Amount of sludge in year y(t/y)	N/A	A planned value
k_j	Decay rate for the waste type j (unit/y)	Default value of IPCC (Table 10, Appendix)	N/A
$EG_{PJ,y}$	Amount of electricity generated by the project in year y (MWh/y)	A planned value	N/A
$HG_{PJ,y}$	Amount of thermal energy generated by the project in year y (TJ/y)	A planned value	N/A
EF_{elec}	In the case of grid connection: CO_2 emission factor of the grid electricity ($t\text{-}CO_2/MWh$)	A default value (Table 3, "Energy Consumption", Appendix) If there is no default value applied or if there is another appropriate value, that value may be used.	
	In the case of captive power generation or mini-grid: CO_2 emission factor of the diesel power generation ($t\text{-}CO_2/MWh$)	A default value (Table 4, Appendix) If there is no default value applied or if there is another appropriate value, that value may be used.	
$NCV_{fuel,i}$	Net calorific value of fuel i applied in the project (TJ/Gg = TJ/kt)	N/A	An IPCC default value (Table 1, Appendix) If there is no default value applied or if there is another appropriate value, that value may be used.
$EF_{fuel,BL}$	CO_2 emission factor	An IPCC default value (Table 2, Appendix)	

[4] 2019 Refinement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories, Volume 5: Waste, Table 2.3 (Updated)

	of the fuel used in the baseline scenario (kg-CO_2/TJ)	If there is no default value applied or if there is another appropriate value, that value may be used.	
$EF_{fuel,i}$	CO_2 emission factor of the fuel i applied in the project (kg-CO_2/TJ)	An IPCC default value (Table 2, Appendix) If there is no default value applied or if there is another appropriate value, that value may be used.	
EC_{PJy}	Amount of electricity consumption by the project in year y (MWh/year)	N/A	A planned value
$FC_{PJ,i,y}$	Amount of fuel consumption by the project in year y (t/year)	N/A	A planned value
$MG_{PJ,y}$	Methane generation from anaerobic treatment system (digester) (t-CH_4/y)	N/A	A planned value
$EF_{CH4,def}$	Leakage from biogas digesters (t-CH_4 leaked / t-CH_4 produced)	N/A	0.1 (Default value: CDM Methodological Tool Project and leakage emissions from anaerobic digesters (Version 01.0.0))
DAF_W	Average distance of routes transporting organic wastes (km)	N/A	A planned value
DAF_{res}	Average distance of routes transporting sludge (km)	N/A	A planned value
$EF_{CO2,tran}$	CO_2emission factor of transport activity (g-CO_2/t-km)	N/A	Default value (Table 7, Appendix 1)
$F_{SD,CH4,def}$	Methane emission factor of sludge treatment	N/A	0.35 (Default value: CDM Methodological Tool Project and leakage emissions from anaerobic digesters (Version 01.0.0))

5. Others

(1) Project Boundary

The project boundary is the site where the project activity is being done, where the methane is captured and used.

(2) Leakage

Construction of power plants, replacement of facility: the indirect emissions potentially leading to leakage due to activities such as product manufacturing or materials transport in consideration of Life Cycle Assessment, LCA of disposal of waste at a solid waste disposal site. The contribution of this emission is relatively small and negligible compared with the GHG emission reduction after the project starts. This formula ignores the leakage because ACM0001 methodology also ignores it.

(3) Comparison with existing CDM methodologies

The logic of emission reduction calculation in the methodology is almost the same as that of the AMS-III.AO. (Methane recovery through controlled anaerobic digestion, Version 01). However, this methodology simplified the methodology by using default values as more as possible. Moreover, there is no limitation for the emission reduction in the methodology like the small-scale CDM methodologies did.

Also, "Guideline for National Greenhouse Inventory" (IPCC, 2006) explains that N_2O is not important and the estimation method has not been established, so it has not been added to the calculation method.

(4) Revision history

Version	Year/Month	Revisions
2.0	March 2014	• Separated 23. Intermediate treatment of waste (Ver 1.0) into Anaerobic Treatment of Organic Waste (Ver 2.0) and Composting of Organic Waste (Ver 2.0) • Added default values for combined margins and operating margins of CO2 emission factors of electricity
3.0	September 2019	• Prioritized the use of default values • Added instructions not to consider N_2O emissions
4.0	March 2023	• In the description of the calculation method and necessary data of baseline emissions, the words "before project implementation" was revised to use "the baseline scenario". The baseline scenario is the scenario that would have occurred in the absence of the project, such as continuation of the pre-project conditions. • Deleted the column "Ex-post" in "4. Data and Parameters Estimated and Need Monitoring": current version of Climate-FIT aims to quantify GHG emission reductions in the "planning phase").
5.0	March 2024	• The default value of Model correction factor (φ) was modified according to the CDM methodology tool. • The oxidation factor (OX) was set to the default value of IPCC 2019 (2019 Refinement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories). • The "Fraction of degradable organic carbon ($DOC_{f,j}$)" can be set for each waste type according to IPCC2019. • The source of the percentage of CH_4 in LFG (F) was modified to apply the value of IPCC2019. • Removed subscript y of each parameter, which implies monitoring for each year (since Climate-FIT is intended to quantify GHG emission reductions in the "planning phase"). • Revised the "Data sources" for Wx and wj to be more accessible based on the actual situation in the target countries. • The "Description" (name of parameter) for Wj,x, Wx, and wj were modified.