21. Water and Waste Management/ Sludge Treatment (Methane Recovery or Composting)

1. Typical Project Outline

・ Methane recovery and application from treatment of sludge or composting sludge of waste treatment systems.

2. Applicability

(1) In the baseline scenario, methane is emitted from sludge.

(2) Sludge is composted and the compost is used in aerobic condition or the recovered methane are used for power or/and thermal generation.

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 methane from sludge treatment systems or composting the sludge)[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 projet in year y (t-CO_2e/y)

BE_y : GHG emission from the baseline scenario in year y (t-CO_2e/y)

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

(1) Calculation of Baseline Emission

The baseline emissions cover emissions from the following sources.

- Methane emitted to the atmosphere from sludge treatment sites in the baseline scenario
- CO_2 emissions from generation of electric power and/or thermal energy, using technologies under the baseline scenario, that will be replaced by electricity or thermal energy generated by the project.

$$BE_y = BE_{sl,y} + BE_{EN,y}$$

$BE_{sl,y}$: Methane emission from sludge treatment sites in the baseline scenario in year y (t-CO_2e/y)

$BE_{EN,y}$: CO_2 emissions from generation of electric power and/or thermal energy that will be replaced by electricity or thermal energy generated by the project in year y (t-CO_2e/y)

Determination of $BE_{sl,y}$:

It is determined by multiplying the volume of the sludge by CH_4 correction factor of the disposal site, degradable organic content of the untreated sludge, fraction of DOC dissimilated to biogas, model correction factor, fraction of CH_4 in biogas, and methane global warming potential.

$$BE_{sl,y} = (S_{PJ,BG,y} + S_{PJ,CP,y}) \times MCF_{sl,BL,y} \times DOC_s \times UF_{BL} \times DOC_f \times F \times 16/12 \times GWP_{CH4}$$

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

$S_{PJ,BG,y}$: Amount of sludge treated in the project for the biogas system in year y (t/y)

$S_{PJ,CP,y}$: Amount of sludge treated in the project for the composting facility in year y (t/y)

$MCF_{sl,BL}$: CH_4 correction factor sludge treatment in the baseline scenario

DOC_s : Degradable organic content of the untreated sludge

UF_{BL} : Model correction factor to account for model uncertainties for the baseline

DOC_f : Fraction of DOC dissimilated to biogas

F : Fraction of methane in the biogas

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

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.

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

$BE_{elec,y}$: 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 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_2 emission factor of fuel i for the boiler in the baseline scenario (kg-CO_2/TJ)

(2) Calculation of Project Emission

The project emissions cover the following sources.

- Methane leakage from methane recovery system (not applicable for the project not involving methane recovery)
- Methane leakage from composting process (not applicable for the project not involving composting)
- CO_2 emissions from consumption of electric power and/or thermal energy by the project.

$$PE_y = PE_{sl,y} + PE_{co,y} + PE_{EN,y}$$

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

$PE_{sl,y}$: Methane leakage from the methane recovery system in year y (t-CO_2e/y)

$PE_{co,y}$: Methane leakage from the composting system in year y (t-CO_2e/y)

$PE_{EN,y}$: CO_2 emissions from consumption of electricity and fossil fuels in year y (t-CO_2e/y)

Determination of $PE_{sl,y}$:

It is determined as follows.

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

$MG_{PJ,y}$: Amount of methane recovered in year y (t-CH_4/y)

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

$EF_{CH4,def}$: Methane leakage factor of methane recovery system (t-CH_4 leaked / t-CH_4 produced)

Determination of $MG_{PJ,y}$:

It is determined as follows.

$MG_{PJ,y} = S_{PJ,BG,y} \times MCF_{sl,PJ,y} \times DOC_s \times UF_{PJ} \times DOC_f \times F \times 16/12$

$MCF_{sl,PJ}$: CH_4 correction factor for the sludge treatment system in the project

DOC_s : Degradable organic content of the untreated sludge (dry-based)

UF_{PJ} : Model correction factor to account for model uncertainties for the project

DOC_f : Fraction of DOC dissimilated to biogas

F : Methane content of the biogas

Determination of $PE_{co,y}$:

It is determined as follows.

$PE_{co,y} = S_{PJ,CP,y} \times \left(EF_{co,CH4,def} \times GWP_{CH4} + EF_{co,N2O,def} \times GWP_{N2O} \right)$

$EF_{co,CH4,def}$: Methane leakage factor of composting process (t-CH_4/t-sludge)

$EF_{co,N2O,def}$: Nitrous oxide leakage factor of composting process (t-N_2O/t-sludge)

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

GWP_{N2O} : Global Warming Potential of N_2O (=298 t-CO_2/t-N_2O)

Determination of $PE_{EN,y}$:

It is determined by multiplying amount of electricity and fossil fuels consumed by their corresponding emission factors.

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

$EC_{PJ,y}$: Electricity consumed by the project in year y (MWh/y)

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

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

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

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

4. Data and Parameters for the Estimation

Data	Description	Data Sources	
		For baseline emission calculation	For project emission calculation
$EC_{PJ,y}$	Electricity consumed by the project in year y (MWh/y)	N/A	A planned value

EF_{elec}	In the case of grid connection: CO_2 emission factor of the grid electricity (t-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-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.	
$FC_{PJ,i,y}$	Amount of fuel i consumed by the project in year y (t/year)	N/A	A planned value
$NCV_{fuel,i}$	Net calorific value of fuel i used in the projecti (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 of fuel for the boiler in the baseline scenario (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.	N/A
$EF_{fuel,i}$	CO_2 emission factor of fuel i used in the project (kg-CO_2/TJ)	N/A	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.
$S_{PJ,BG,y}$	Amount of sludge treated in the project for the biogas system in year y (t/y)	A planned value	A planned value
$S_{PJ,CP,y}$	Amount of sludge treated in the project for the composting facility in year y (t/y)	A planned value	A planned value
$MCF_{sl,BL}$	CH_4 correction factor for the sludge treatment system in the baseline scenario	Default value of IPCC (Table 9, Appendix)	N/A
$MCF_{sl,PJ}$	CH_4 correction factor for the sludge treatment system in the project	N/A	Default value of IPCC (Table 10, Appendix)
UF_{BL}	Model correction factor to account for model uncertainties for the baseline	0.89 (Default value of CDM AMS III.H. ver.19.0)	N/A
UF_{PJ}	Model correction factor to account for model uncertainties for the project	N/A	1.12 (Default value of CDM AMS III.H. ver.19.0)
DOC_s	Degradable organic content of the untreated sludge	An IPCC default value（Table 11, Appendix） If there is no default value applied or if there is another appropriate value, that value may be used.	
DOC_f	Fraction of DOC	0.5	

	dissimilated to biogas	(Default value[2])	
F	Methane content of biogas	0.5 (Default value[3])	
$EF_{co,CH4,def}$	Methane leakage factor of composting process (t-CH_4/t-sludge)	N/A	0.01 (Default value[4])
$EF_{co,N2O,def}$	Nitrous oxide leakage factor of composting process (t-N_2O/t-sludge)	N/A	0.0006 (Default value[4])
$EG_{PJ,y}$	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
$EF_{CH4,def}$	Methane leakage factor of methane recovery system (t-CH_4 leaked / t-CH_4 produced)	N/A	0.1 (Default value: CDM Methodological Tool Project and leakage emissions from anaerobic digesters)

5. Others

(1) Project Boundary

The project boundary is the site where the project activity is being done, where the sludge are treated.

(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. Therefore, this methodology ignores the leakage provided that the technology is using equipment not transferred from another activity.

(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.F (Avoidance of methane emissions through composting, Version 11) and 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.

(4) Revision history

Version	Year/Month	Revisions
2.0	March 2014	• Changed the methodology name from “25. Sewerage (Ver 1.0)” to “Sludge treatment (methane recovery or composting)”

[2] 2019 Refinement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories, Volume 5: Waste, Table 3.0 (New)
[3] 2019 Refinement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories, Volume 5: Waste, p.3.14
[4] 2006 IPCC Guidelines for National Greenhouse Gas Inventories, Volume 5: Waste, Table 4.1

		• Deleted CH_4 emissions from combustion of methane from sludge as it rarely happens in developing countries • Added default values for combined margins and operating margins of CO_2 emission factors of electricity
3.0	September 2019	• Prioritized the use of default values • Added N_2O emissions from project emission from composting process
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	• Corrected the value of Model correction factor (UF) to default values of CDM methodology AMS III.H. • The source of the CH_4 producing capacity ($BO_{o,ww}$) was corrected to apply IPCC 2019. • 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").