18. Solid Waste Intermediate Treatment/Anaerobic Treatment

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).

$$ER_y = BE_y - PE_y$$

ER_y : Emission reduction through the projet in a year y (t-CO_2e/y)

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

PE_y : GHG emission from the project scenario in a year y (t-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-CH_4/y)

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

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

$BE_{EN,y}$: Baseline emissions from generation of energy displaced by the project activity (t- 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.

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

φ_y : Model correction factor to account for model uncertainties

OX : Oxidation rate

F : Fraction of CH_4 in LFG

$DOC_{f,y}$: Fraction of degradable organic carbon (DOC) that can decompose

MCF_y : CH_4 correction factor

$W_{j,x}$: Average annual quantity of the waste type j disposed in the SWDS before the project starts (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 crediting period for which methane emissions are calculated (y is a consecutive period of 12 months)

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.

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

W_y : Average annual quantity of the waste disposed in the SWDS before the project starts (t/y)

w_j : Weight fraction of the waste type j in solid waste (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.

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

$BE_{elec,y}$: 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 (MH/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 absence of the project activity to generate the thermal energy.

It will be “1” as a conservative value.

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

$EF_{fuel,i}$: CO_2emission factor of the fuel i used in the absence of the project (t-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.

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

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

$NCV_{fuel,i}$: Net calorific value of the fuel i (TJ/t)

$EF_{fuel,i}$: CO_2 emission factor of the fuel i (t-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)

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_2emission 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)

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 Estimated and Need Monitoring

Data	Description	Data Sources			
		For baseline emission calculation		For baseline emission calculation	
		Ex-ante	Ex-post	Ex-ante	Ex-post
φ_y	Model correction factor to account for model uncertainties	0.75 （Default value: Methodological Tool: Emissions from solid waste disposal sites）		N/A	N/A
F	Fraction of CH_4 in LFG	0.5 (Default value: 2006 IPCC Guidelines for National Greenhouse Gas Inventories Volume 5 Waste)		N/A	N/A
OX	Oxidation rate	0.1 (Default value: Methodological Tool: Emissions from solid waste disposal sites)		N/A	N/A
$DOC_{f,y}$	Fraction of degradable organic carbon (DOC) that can decompose	0.5 (Default value: Methodological Tool: Emissions from solid waste disposal sites)		N/A	N/A
DOC_j	Fraction of degradable organic carbon (by weight) in the waste type j	Default value of IPCC（Table 9, Appendix）		N/A	N/A
MCF_y	CH_4 correction factor	Default value of IPCC (Table 10, Appendix)		N/A	N/A

W_y	Average annual quantity of waste disposed in the SWDS before the project starts (t/y)	From the following sources in the order of priority i) Interview with disposal site managers ii) Assumption as per design of the disposal sites		N/A	N/A
w_j	Weight fraction of the waste type j in solid waste (weight basis) (%)	From the following sources in the order of priority i) Interview with disposal site managers ii) Assumption as per design of the disposal sites		N/A	N/A
$W_{Res,y}$	Amount of sludge in year y(t/y)	N/A		A planned value	A monitored value
k_j	Decay rate for the waste type j (unit/y)	Default value of IPCC (Table 11, Appendix)		N/A	N/A
$EG_{PJ,y}$	Amount of electricity generated by the project in year y (MWh/y)	A planned value	A monitored value	N/A	N/A
$HG_{PJ,y}$	Amount of thermal energy generated by the project in year y (TJ/y)	A planned value	A monitored value	N/A	N/A
EF_{elec}	In the case of a grid CO_2 emission factor (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.			
	In the case of stand alone power generation or mini grid: CO_2 emission factor of diesel generator (t-CO_2/MWh)	A default value (Table 5, 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 used (TJ/t)	N/A	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.	
$EF_{fuel,i}$	CO_2 emission factor of fuel i (t-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	N/A	A planned value	A monitored value
$FC_{PJ,i,y}$	Amount of fuel consumption by the project in year y (t/year)	N/A	N/A	A planned value	A monitored value

$MG_{PJ,y}$	Methane generation from anaerobic treatment system (digester) (t-CH_4/y)	N/A	A planned value	A monitored value
$EF_{CH4,def}$	Leakage from biogas digesters (t-CH_4 leaked / t-CH_4 produced)	N/A	0.1 (Default value: 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	A monitored value (Confirm origin and destinations)
DAF_{res}	Average distance of routes transporting sludge (km)	N/A	A planned value	A monitored value (Confirm origin and destinations)
$EF_{CO2,tran}$	CO_2emission factor of transport activity (g-CO_2/t-km)	N/A	Default value (Table 8, Appendix 1)	
$F_{SD,CH4,def}$	Methane emission factor of sludge treatment	N/A	0.35 (Default value: 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.