17. Solid Waste Management/Landfill (Methane Recovery)

1. Typical Project Outline

・ Recovery of landfill gas (LFG) from landfills or waste disposal sites.

2. Applicability

(1) LFG recovery from disposal sites where anaerobic and aerobic treatments are occurred.

(2) Recovered LFG are used for direct power generation or thermal energy purpose.

(3) Landfills completed or disposal sites in use are targeted.

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 (LFG are emitted to atmosphere without recovery) and project scenario (recovery and application of LFG).

$$ER_y = BE_y - PE_y$$

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 landfill 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 LFG-fueled power plants or boilers.

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

$MD_{PJ,y}$: Methane recovered and destroyed by the project (t-CH_4/y) (≒methane emission from landfill sites in the baseline)

$MF_{BL,y}$: Methane quantity to be flared as required by National Regulations before the project starts (t-CH_4/y). It shall be “0” as developing countries have very limited regulations on CH_4 emissions.

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 $MD_{PJ,y}$:

Methane quantity from landfill (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.

$$MD_{PJ,y} = \eta_{PJ} \times BE_{CH4,SWDS,y}$$

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

η_{PJ} : Efficiency of LFG recovery (%)

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.

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

$MD_{PJ,y}$: 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 (t-CO_2/y)

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

$EG_{PJ,y}$: Amount of electricity generated by the project (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 (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.

$\mathrm{EF_{fuel,i}}$: CO_2 emission factor of the fuel 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;

$$\mathrm{PE_y = PE_{EC,y} + PE_{FC,y}}$$

$\mathrm{PE_y}$: GHG emission from the project in year y (t-CO_2/y)

$\mathrm{PE_{EC,y}}$: GHG emission from electricity consumption by the project in year y (t-CO_2/y)

$\mathrm{PE_{FC,y}}$: GHG emission from fossil fuel consumption by the project in year y (t-CO_2/y)

Determination of $\mathrm{PE_{EC,y}}$:

It is determined as follows.

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

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

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

Determination of $\mathrm{PE_{FC,y}}$:

It is determined as follows.

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

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

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

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

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
η_{PJ}	Efficiency of LFG recovery (%)	0.5 (Default value: AMS-III.G: Landfill methane recovery)		N/A	N/A
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

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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
$w_{j,x}$	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
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 (MWh/y)	A planned value	A monitored value	N/A	N/A
$HG_{PJ,y}$	Amount of thermal energy generated by the project (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	N/A	N/A	An IPCC default value (Table 1, Appendix) If there is no default value applied or if there	

	of the fuel i used (TJ/t)			is another appropriate value, that value may be used.	
$EF_{fuel,i}$	CO_2 emission factor of the 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.			
$EC_{PJ,y}$	Amount of electricity consumption by the project (MWh/year)	N/A	N/A	A planned value	A monitored value
$FC_{PJ,i,y}$	Amount of fuel consumption by the project (t/year)	N/A	N/A	A planned value	A monitored value

5. Others

(1) Project Boundary

The project boundary is the site where the project activity is being done, where the gas is captured and destroyed/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. The methodology ignores the leakage because ACM0001 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 ACM 0001. 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.