Joint Crediting Mechanism Approved Methodology MM_AM001
"Power generation and avoidance of landfill gas emissions through combustion of municipal solid waste (MSW)"

A. Title of the methodology

Power generation and avoidance of landfill gas emissions through combustion of municipal solid waste (MSW), ver. 01.0

B. Terms and definitions

Terms	Definitions
Municipal solid waste (MSW)	A heterogeneous mix of different solid waste types, usually collected by municipalities or other local authorities. MSW includes household waste, garden/park waste and commercial/institutional waste.
Solid waste disposal site (SWDS)	Designated areas intended as the final storage place for solid waste.

C. Summary of the methodology

Items	Summary
GHG emission reduction measures	Installation of MSW incinerators avoids emissions of methane associated with disposed organic waste in a SWDS, and electricity generated by the project facility displaces electricity from a grid or captive power generator which is generated using fossil fuels resulting in GHG emission reductions.
Calculation of reference emissions	Reference emissions are calculated as a sum of the following emissions: ● CH_4 emissions from SWDS: Calculated from the amount of MSW and fraction of each waste type incinerated in the incinerator using the first order decay (FOD) model; and ● CO_2 emissions from a grid or captive power generator:

	Electricity generated by the project facility multiplied by the emission factor of displaced electricity.
Calculation of project emissions	Project emissions are calculated as a sum of the following emissions: ● CO_2 emissions from combustion of fossil carbon contained in MSW: The amount of MSW multiplied by the fraction of fossil carbon content and the conversion factor of carbon; ● N_2O emissions from combustion of waste: The amount of MSW multiplied by the N_2O emission factor associated with incineration; ● CO_2 emissions from electricity used to operate the project facility: Electricity used to operate the project facility multiplied by the emission factor of electricity; and ● CO_2 emissions from auxiliary fossil fuel consumption associated with incineration: The amount of fossil fuel consumption associated with incineration multiplied by the emission factor of the fossil fuel.
Monitoring parameters	● Quantity of MSW fed into incinerator (wet basis); ● Quantity of electricity generated by the project facility; ● Quantity of electricity consumed by the project facility; and ● Quantity of auxiliary fossil fuel consumed.

D. Eligibility criteria

This methodology is applicable to projects that satisfy all of the following criteria.

Criterion 1	The project newly installs an incinerator, waste heat recovery boiler, exhaust gas treatment equipment and turbine generator.
Criterion 2	The project incinerates municipal solid waste (MSW) which has been disposed at a SWDS where the generated landfill gas is not recovered, and generates electricity from steam produced in waste heat recovery boiler.
Criterion 3	There is a plan to operate the project facility for more than 5 years.

E. Emission Sources and GHG types

Reference emissions

Emission sources	GHG types
Decomposition of waste at a SWDS	CH_4
Electricity generation	CO_2
Project emissions	
Emission sources	GHG types
Combustion of fossil carbon contained in waste	CO_2
Incineration of waste	N_2O
Electricity use by the project facility	CO_2
Consumption of auxiliary fossil fuels needed to be added into incinerator	CO_2

F. Establishment and calculation of reference emissions

F.1. Establishment of reference emissions

A project which applies this methodology incinerates MSW and generates electricity. In Myanmar, MSW is usually disposed in open dump sites without recovering landfill gas. Although some initiatives exist to treat waste with alternative methods such as incinerating MSW, the cost of alternative treatment of waste hampers its installation. Therefore, without the financial assistance the alternative waste treatment facility would not be installed. As a result, BaU for MSW treatment is open dumping and BaU emissions are CH_4 emissions from decomposition of MSW at a SWDS and CO_2 emissions from fossil fuels combusted to generate electricity which would be displaced by the project. CH_4 emissions from decomposition of MSW at a SWDS are calculated based on a first order decay (FOD) model.
To assure net emission reductions, the model correction factor which accounts for uncertainty of the model to calculate emissions from decomposition of MSW is set conservatively. Therefore, the reference emissions are a summation of conservative CH_4 emissions from decomposition of MSW at a SWDS and CO_2 emissions from fossil fuels combusted to generate electricity which would be displaced by the project.

F.2. Calculation of reference emissions

$$RE_p = RE_{CH4,p} + RE_{elec,p}$$

Where:

RE_p = Reference emissions during the period *p* [tCO_2e/p]

$RE_{CH4,p}$ = Reference emissions from decomposition of MSW at a SWDS during the period

p [tCO_2e/p]

$RE_{elec,p}$ = Reference emissions from electricity generation during the period p [tCO_2e/p]

Reference emissions from decomposition of MSW at a SWDS during the period p ($RE_{CH4,p}$) is accounted only from the next calendar year after its disposal at a SWDS (or incineration) due to delay in generation of CH_4 from the time of disposal at a SWDS.

$$RE_{CH4,p} = \sum_{y=p\_start}^{p\_end}\left[\varphi \times (1-f) \times GWP_{CH4} \times (1-OX) \times \frac{16}{12} \times F \times DOC_f \times MCF \times \sum_{i=1}^{y-1}\sum_{j}\left\{W_i \times P_j \times DOC_j \times e^{-k_j(y-1-i)} \times \left(1-e^{-k_j}\right)\right\}\right]$$

Where:

$RE_{CH4,p}$ = Reference emissions from decomposition of MSW at a SWDS during the period p [tCO_2e/p]

y = The N^th year from the first disposal (or incineration), extending from the first year of the period p (y=p_start) to the last year of the period p (y=p_end). If y is equal to 1, methane generation cannot be accounted.

p_start = The N^th year from the first disposal (or incineration), which is the first year of the period p

p_end = The N^th year from the first disposal (or incineration), which is the last year of the period p

φ = Model correction factor to account for model uncertainties

f = Fraction of methane captured at a SWDS and flared, combusted or used in another manner that prevents the emissions of methane to the atmosphere

GWP_{CH4} = Global Warming Potential of methane [tCO_2e/tCH_4]

OX = Oxidation factor (reflecting the amount of methane from a SWDS that is oxidized in the soil or other material covering the waste)

$\frac{16}{12}$ = Conversion factor [tCH_4/tC]

F = Fraction of methane in the SWDS gas [volume fraction]

DOC_f = Fraction of degradable organic carbon (DOC) that decomposes under the specific conditions occurring in a SWDS [weight fraction]

MCF = Methane correction factor

i = The N^th year from the first disposal (or incineration), extending from the first year in the time period in which MSW is disposed at a SWDS (i = 1) to year y (i

= *y*)

W_i = Quantity of MSW fed into incinerator in the year *i* (wet basis) [t]

P_j = Fraction of the waste type *j* [weight fraction]

DOC_j = Fraction of degradable organic carbon in the waste type *j* [weight fraction]

k_j = Decay rate for the waste type *j* [1/yr]

j = Type of waste

$$RE_{elec,p} = EG_{elec,p} \times EF_{elec}$$

Where:

$RE_{elec,p}$ = Reference emissions from electricity generation during the period *p* [tCO_2e/p]

$EG_{elec,p}$ = Quantity of electricity generated by the project facility during the period *p* [MWh/p]

EF_{elec} = Emission factor for electricity generation [tCO_2e/MWh]

G. Calculation of project emissions

$$PE_p = PE_{COM\_CO2,p} + PE_{COM\_N2O,p} + PE_{EC,p} + PE_{FC,p}$$

Where:

PE_p = Project emissions during the period *p* [tCO_2e/p]

$PE_{COM\_CO2,p}$ = Project emissions of CO_2 from combustion of fossil carbon contained in waste associated with incineration during the period *p* [tCO_2e/p]

$PE_{COM\_N2O,p}$ = Project emissions of N_2O from combustion of waste associated with incineration during the period *p* [tCO_2e/p]

$PE_{EC,p}$ = Project emissions from electricity consumption by the project facility during the period *p* [tCO_2e/p]

$PE_{FC,p}$ = Project emissions from auxiliary fossil fuel consumption associated with incineration during the period *p* [tCO_2e/p]

$$PE_{COM\_CO2,p} = EFF_{COM} \times \frac{44}{12} \times \sum_{j}\left(\sum_{i=p\_start}^{p\_end} W_i \times P_j \times \frac{DC}{100} \times FCC_j \times FFC_j\right)$$

Where:

$PE_{COM\_CO2,p}$ = Project emissions of CO_2 from combustion of fossil carbon contained in waste associated with incineration during the period *p* [tCO_2e/p]

EFF_{COM} = Combustion efficiency of incinerator [fraction]

$\frac{44}{12}$ = Conversion factor [tCO_2/tC]

i = The N[th] year from the first incineration

p_start = The N[th] year from the first incineration, which is the first year of the period *p*

p_end = The N[th] year from the first incineration, which is the last year of the period *p*

W_i = Quantity of MSW fed into incinerator in the year *i* (wet basis) [t]

P_j = Fraction of the waste type *j* [weight fraction]

DC = Dry matter content of MSW [%]

FCC_j = Fraction of total carbon content in waste type *j* [tC/t]

FFC_j = Fraction of fossil carbon in total carbon content of waste type *j* [weight fraction]

j = Type of waste

$$PE_{COM\_N2O,p} = \sum_{i=p\_start}^{p\_end} W_i \times EF_{N2O} \times GWP_{N2O}$$

Where:

$PE_{COM\_N2O,p}$ = Project emissions of N_2O from combustion of waste associated with incineration during the period *p* [tCO_2e/p]

i = The N[th] year from the first incineration

p_start = The N[th] year from the first incineration, which is the first year of the period *p*

p_end = The N[th] year from the first incineration, which is the last year of the period *p*

W_i = Quantity of MSW fed into incinerator in the year *i* (wet basis) [t]

EF_{N2O} = Emission factor for N_2O associated with incineration [tN_2O/t waste]

GWP_{N2O} = Global Warming Potential of nitrous oxide [tCO_2e/tN_2O]

$$PE_{EC,p} = EC_p \times EF_{elec}$$

Where:

$PE_{EC,p}$ = Project emissions from electricity consumption by the project facility during the period *p* [tCO_2e/p]

EC_p = Quantity of electricity consumed by the project facility during the period *p* [MWh/p]

EF_{elec} = Emission factor for electricity generation [tCO_2e/MWh]

$$PE_{FC,p} = \sum_{fuel}\left(FC_{fuel,p} \times NCV_{fuel} \times EF_{CO2,fuel}\right)$$

Where:

$PE_{FC,p}$	=	Project emissions from auxiliary fossil fuel consumption associated with incineration during the period *p* [tCO_2e/p]
$FC_{fuel,p}$	=	Quantity of auxiliary fossil fuel consumed during the period *p* [kL or m^3/p]
NCV_{fuel}	=	Net calorific value of fuel [GJ/kL or m^3]
$EF_{CO2,fuel}$	=	CO_2 emission factor of fuel [tCO_2/GJ]
fuel	=	Type of fuel

H. Calculation of emissions reductions

$$ER_p = RE_p - PE_p$$

Where:

ER_p	=	Emission reductions during the period *p* [tCO_2e/p]
RE_p	=	Reference emissions during the period *p* [tCO_2e/p]
PE_p	=	Project emissions during the period *p* [tCO_2e/p]

I. Data and parameters fixed *ex ante*

The source of each data and parameter fixed *ex ante* is listed as below.

Parameter	Description of data	Source
φ	Model correction factor to account for model uncertainties Default value: 0.80 The conservative value was selected from the default values $\varphi_{default}$ in the tool.	CDM Methodological Tool “Emissions from solid waste disposal sites” (Version 07.0)
f	Fraction of methane captured at a SWDS and flared, combusted or used in another manner that prevents the emissions of methane to the atmosphere Default value: 0	Decided taking into consideration the situation in Myanmar
GWP_{CH4}	Global Warming Potential of methane [tCO_2e/tCH_4] Default value: 25	Table 2.14, of the errata to the contribution of Working Group I to the Fourth Assessment Report

		of the IPCC
OX	Oxidation factor (reflecting the amount of methane from a SWDS that is oxidized in the soil or other material covering the waste) Default value: 0.1	CDM Methodological Tool “Emissions from solid waste disposal sites” (Version 07.0)
F	Fraction of methane in the SWDS gas [volume fraction] Default value: 0.5	CDM Methodological Tool “Emissions from solid waste disposal sites” (Version 07.0)
DOC_f	Fraction of degradable organic carbon (DOC) that decomposes under the specific conditions occurring in a SWDS [weight fraction] Default value: 0.5	CDM Methodological Tool “Emissions from solid waste disposal sites” (Version 07.0)
MCF	Methane correction factor Select one of the followings taking into consideration the situation of the project. (1) In Yangon City: Default value of 0.8 The appropriate value was selected from the default values $MCF_{default}$ in the tool taking into consideration the situation in Yangon City. (2) In other places in Myanmar: (2)-1 In case of a water table above the bottom of the SWDS, estimate the MCF using the following equation. $$\mathrm{MCF} = \mathrm{MAX}\left\{\left(1-\frac{2}{\mathrm{d_y}}\right), \frac{\mathrm{h_{w,y}}}{\mathrm{d_y}}\right\}$$ $h_{w,y}$ = Height of water table measured from the base of the SWDS [m] d_y = Depth of the SWDS [m] (2)-2 In case that the SWDS does not have a water table above the bottom of the SWDS, select the applicable value from the following: ● 1.0 for anaerobic managed solid waste disposal sites. These have controlled placement of waste (i.e. waste directed to	CDM Methodological Tool “Emissions from solid waste disposal sites” (Version 07.0)

<table>
<tr><td></td><td>specific deposition areas, a degree of control of scavenging and a degree of control of fires) and will include at least one of the following: (i) cover material; (ii) mechanical compacting; or (iii) leveling of the waste;
● 0.5 for semi-aerobic managed solid waste disposal sites. These have controlled placement of waste and will include all of the following structures for introducing air to the waste layers: (i) permeable cover material; (ii) leachate drainage system; (iii) regulating pondage; and (iv) gas ventilation system;
● 0.8 for unmanaged solid waste disposal sites–deep. This comprises all SWDS not meeting the criteria of managed SWDS and which have depths of greater than or equal to 5 meters;
● 0.4 for unmanaged-shallow solid waste disposal sites or stockpiles that are considered SWDS. This comprises all SWDS not meeting the criteria of managed SWDS and which have depths of less than 5 meters. This includes stockpiles of solid waste that are considered SWDS.</td><td></td></tr>
<tr><td>DOC_j</td><td>Fraction of degradable organic carbon in the waste type j [weight fraction]
Default values for DOC_j:
<table>
<tr><td>Waste type j</td><td>DOC_j
[% of wet waste]</td></tr>
<tr><td>Wood and wood products</td><td>43</td></tr>
<tr><td>Pulp, paper and cardboard (other than sludge)</td><td>40</td></tr>
<tr><td>Food, food waste, beverages and tobacco (other than sludge)</td><td>15</td></tr>
<tr><td>Textiles</td><td>24</td></tr>
<tr><td>Garden, yard and park waste</td><td>20</td></tr>
<tr><td>Nappies</td><td>24</td></tr>
<tr><td>Glass, plastic, metal, other inert waste</td><td>0</td></tr>
</table></td><td>CDM Methodological Tool “Emissions from solid waste disposal sites” (Version 07.0) and Table 2.4, chapter 2, volume 5 of 2006 IPCC guidelines for National GHG Inventories</td></tr>
<tr><td>k_j</td><td>Decay rate for the waste type j [1/yr]
Default values for k_j:</td><td>CDM Methodological Tool “Emissions from solid</td></tr>
</table>

<table>
<tr>
<td></td>
<td>
<table>
<tr><td colspan="2">Waste type j</td><td>k_j [1/yr]</td></tr>
<tr><td rowspan="2">Slowly degrading</td><td>Pulp, paper, cardboard (other than sludge), textiles</td><td>0.07</td></tr>
<tr><td>Wood, wood products and straw</td><td>0.035</td></tr>
<tr><td>Moderately degrading</td><td>Other (nonfood) organic putrescible garden and park waste</td><td>0.17</td></tr>
<tr><td>Rapidly degrading</td><td>Food, food waste, sewage sludge, beverages and tobacco</td><td>0.40</td></tr>
</table>
The default values k_j for Tropical (Mean annual temperature>20 degree C) and Wet (Mean annual precipitation>1000mm) were selected taking into consideration the climate condition of Myanmar.
</td>
<td>waste disposal sites”
(Version 07.0)</td>
</tr>
<tr>
<td>P_j</td>
<td>Fraction of the waste type j [weight fraction]
Before the validation of a proposed project, take at least one sample in each season (both rainy and dry) from MSW transported to a SWDS within the same municipality where the project facility is to be constructed, weigh each waste fraction (measure on wet basis) taking into consideration the waste type j, as provided in the tables for FCC_j and FFC_j, and average each waste fraction j among the samples.</td>
<td>Study conducted by the project participants</td>
</tr>
<tr>
<td>EF_{elec}</td>
<td>Emission factor for electricity generation [tCO_2e/MWh]
Select one of the followings taking into consideration the situation of the project.
For grid electricity: The value available from PDD of the most recently registered CDM project hosted in Myanmar or the calculated value using the latest version of the “Tool to calculate the emission factor for an electricity system” under the CDM at the time of validation.
For captive electricity: The most recent value available from CDM approved small scale methodology AMS-I.A. at the time of validation.</td>
<td>For grid electricity: PDD of the most recently registered CDM project hosted in Myanmar or the latest version of the “Tool to calculate the emission factor for an electricity system” under the CDM at the time of validation
For captive electricity: CDM approved small scale methodology AMS-I.A.</td>
</tr>
<tr>
<td>EFF_{COM}</td>
<td>Combustion efficiency of incinerator [fraction]</td>
<td>Table 5.2, chapter 5,</td>
</tr>
</table>

<table>
<tr><td></td><td>Default value: 1 (100%)</td><td>volume 5 of 2006 IPCC guidelines for National GHG Inventories</td></tr>
<tr><td>FCC_j</td><td>Fraction of total carbon content in waste type j [tC/t]
Default values for FCC_j:
<table>
<tr><th>Waste type j</th><th>FCC_j
[% of dry weight]</th></tr>
<tr><td>Paper/cardboard</td><td>50</td></tr>
<tr><td>Textiles</td><td>50</td></tr>
<tr><td>Food waste</td><td>50</td></tr>
<tr><td>Wood</td><td>54</td></tr>
<tr><td>Garden and Park waste</td><td>55</td></tr>
<tr><td>Nappies</td><td>90</td></tr>
<tr><td>Rubber and Leather</td><td>67</td></tr>
<tr><td>Plastics</td><td>85</td></tr>
<tr><td>Metal*</td><td>NA</td></tr>
<tr><td>Glass*</td><td>NA</td></tr>
<tr><td>Other, inert waste</td><td>5</td></tr>
</table>
*Metal and glass contain some carbon of fossil origin. Combustion of significant amounts of glass or metal is not common.</td><td>CDM approved consolidated baseline and monitoring methodology ACM0022 “Alternative waste treatment processes” (Version 02.0)</td></tr>
<tr><td>FFC_j</td><td>Fraction of fossil carbon in total carbon content of waste type j [weight fraction]
Default values for FFC_j:
<table>
<tr><th>Waste type j</th><th>FFC_j (%)</th></tr>
<tr><td>Paper/cardboard</td><td>5</td></tr>
<tr><td>Textiles</td><td>50</td></tr>
<tr><td>Food waste</td><td>-</td></tr>
<tr><td>Wood</td><td>-</td></tr>
<tr><td>Garden and Park waste</td><td>0</td></tr>
<tr><td>Nappies</td><td>10</td></tr>
<tr><td>Rubber and Leather</td><td>20</td></tr>
<tr><td>Plastics</td><td>100</td></tr>
<tr><td>Metal*</td><td>NA</td></tr>
<tr><td>Glass*</td><td>NA</td></tr>
<tr><td>Other, inert waste</td><td>100</td></tr>
</table>
*Metal and glass contain some carbon of fossil origin. Combustion of significant amounts of glass or metal is not common.</td><td>CDM approved consolidated baseline and monitoring methodology ACM0022 “Alternative waste treatment processes” (Version 02.0)</td></tr>
<tr><td>DC</td><td>Dry matter content of MSW [%]
Before the validation of a proposed project, take at least one sample in each season (both rainy and dry) from MSW transported to a SWDS within the same municipality where the project facility is to be</td><td>Study conducted by the project participants</td></tr>
</table>

	constructed, weigh each sample in wet and dry basis, calculate the fraction of dry matter content for each sample, and average the values obtained.	
EF_{N2O}	Emission factor for N_2O associated with incineration [tN_2O/t waste] Select one of the following default values taking into consideration the situation of the project. Default values for EF_{N2O}: <table><tr><th>Type of waste</th><th>Technology / Management practice</th><th>EF_{N2O} [tN_2O/t waste wet basis]</th></tr><tr><td>MSW</td><td>Continuous and semicontinuous incinerators</td><td>$1.21*50*10^{-6}$</td></tr><tr><td>MSW</td><td>Batch-type incinerators</td><td>$1.21*60*10^{-6}$</td></tr></table>	CDM approved consolidated baseline and monitoring methodology ACM0022 “Alternative waste treatment processes” (Version 02.0) and Table 5.6, chapter 5, volume 5 of 2006 IPCC Guidelines for National GHG Inventories
GWP_{N2O}	Global Warming Potential of nitrous oxide [tCO_2e/tN_2O] Default value: 298	Table 2.14, of the errata to the contribution of Working Group I to the Fourth Assessment Report of the IPCC
NCV_{fuel}	Net calorific value of fuel [GJ/kL or m^3] Decide from the specifications described on invoices or other commercial/contractual evidence.	Invoices or other commercial/contractual evidence
$EF_{CO2,fuel}$	CO_2 emission factor of fuel [tCO_2/GJ] Select a value for the fuel combusted by the project from the IPCC default values at the upper limit of the uncertainty at a 95% confidence interval.	Table 1.4, chapter 1, volume 2 of 2006 IPCC Guidelines for National GHG Inventories. Upper value is applied.

History of the document

Version	Date	Contents revised
01.0	25 June 2018	Electronic decision by the Joint Committee Initial approval.