Joint Crediting Mechanism Approved Methodology VN_AM004

"Anaerobic digestion of organic waste for biogas utilization within wholesale markets"

A. Title of the methodology

Anaerobic digestion of organic waste for biogas utilization within wholesale markets. (Version 1.10)

B. Terms and definitions

Terms	Definitions
Air tightness test	A test to confirm that there is no leakage from the gas tanks and its connecting pipes once continuous anaerobic digesters have been installed. The test is conducted based on JIS B8266, ISO 16528-1 or ASME Boiler and Pressure Vessel Code.
Biogas	Gases generated from anaerobic digesters.
Continuous anaerobic digester	A biogas recovery system through continuous methane fermentation process from undiluted organic waste. The system consists of conditioning tanks and methane fermentation tanks, inside temperature of which are controlled to keep mesophilous condition.
Organic waste	Solid waste that contains degradable organic matter. This may include, for example, food waste, plant waste and sludge from wastewater treatment plants.
Periodical check	A periodical maintenance operation done by the manufacturer or an agent who is authorized by the manufacturer to maintain the waste management facility performance (not including partial replacement or overhaul).
Waste management facility	A set of facilities such as management buildings, waste receiving/storage areas, continuous anaerobic digesters, storage tanks and residuals treatment equipment (if any) located within a wholesale market to treat waste for biogas generation.

C. Summary of the methodology

Items	Summary
GHG emission reduction measures	This methodology comprises measures to avoid the emissions of methane to the atmosphere from organic waste that have been left to decay anaerobically at a Solid Waste Disposal Site (SWDS) and to introduce renewable energy technologies that supply users with biogas that displaces fossil fuel use.
Calculation of reference emissions	1. For avoidance of methane emissions, the reference emissions are calculated based on the weight of organic waste prevented from disposal at the SWDS using first-order decay (FOD) model. 2. For renewable energy technologies that displace technologies using fossil fuel, the reference emissions are calculated based on the monitored amount of biogas supplied, Net Calorific Value (NCV) of the biogas and CO_2 emission factor of the reference fossil fuel.
Calculation of project emissions	Project emissions are calculated on the basis of monitored electricity consumption.
Monitoring parameters	● Amount of organic waste prevented from disposal in the SWDS excluding sludge ● Amount of processed biogas supplied to heat generation equipments

D. Eligibility criteria

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

Criterion 1	The project installs continuous anaerobic digesters within a wholesale market whose organic wastes have been disposed at a SWDS where the generated landfill gas is not recovered, and utilizes generated biogas for heat generation.
Criterion 2	The waste management facility to which the project continuous anaerobic digesters are installed is equipped with a device to remove hydrogen sulphide from the biogas before the generated gas is fed into the gas holders and tanks.
Criterion 3	Air tightness test is conducted at least once before starting operation of the continuous anaerobic digesters.
Criterion 4	Plan to avoid methane emissions from the residuals from project anaerobic

	digestion is prepared (e.g. including economic use such as sold as fertilizer or other appropriate treatment).
Criterion 5	Periodical check at least once a year is planned.

E. Emission Sources and GHG types

Reference emissions	
Emission sources	GHG types
Methane emissions from decay of organic waste	CH_4
Fossil fuel consumption by the heat generation equipments	CO_2
Project emissions	
Emission sources	GHG types
~~Grid e~~Electricity consumption by the waste management facility	CO_2

F. Establishment and calculation of reference emissions

F.1. Establishment of reference emissions

Reference emissions consist of two types of emission sources:

1) Methane emissions from decay of organic waste at SWDS
2) Fossil fuel consumption by the heat generation equipments

1) Calculation of reference emissions from decay of organic waste at SWDS

Organic waste from wholesale markets is typically landfilled at SWDSs and anaerobically digested which leads to methane emissions to the atmosphere. The reference emissions from decay of organic waste are calculated using the FOD model adopted in the 2006 IPCC Guidelines for National Greenhouse Gas Inventories.

2) Calculation of reference emissions from fossil fuel consumption by the heat generation equipments

The generated biogas from anaerobic digesters replaces the fossil fuel which is used for heat generation by the heat generation equipments within the wholesale market. The reference emissions from fossil fuel consumption are calculated by multiplying the amount of biogas supplied to the heat generation equipments, the NCV of the biogas and CO_2 emission factor of the reference fossil fuel.

[Net emission reductions]
Net emission reductions are achieved in this methodology by setting the default DOC value conservatively in line with 2006 IPCC Guidelines for National Greenhouse Gas Inventories as the followings:

- Food waste, which has the lowest DOC value among organic waste types, is assumed to represent the organic waste from wholesale markets
- Default DOC value of 8%, which is the lower value of the range 8-20% for food waste, is applied

F.2. Calculation of reference emissions

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

Where

RE_p	Reference emissions during the period *p* [tCO_2/p]
$RE_{CH4,p}$	Reference emissions from decay of organic waste during the period *p* [tCO_2/p]
$RE_{FF,p}$	Reference emissions from fossil fuel consumption for heat generation during the period *p* [tCO_2/p]

Reference emissions from decay of organic waste during the period *p* ($RE_{CH4,p}$) is accounted only after 13 months have passed from the first disposal at the SWDS due to delay in generation of CH_4 from the time of disposal at the SWDS.

$$RE_{CH4,p} = \sum_{m=p\_start}^{p\_end} \left\{ (1-f) \times GWP_{CH4} \times (1-OX) \times \frac{16}{12} \times F \times DOC_f \times MCF \times \sum_{x=1}^{m-13} W_x \times DOC \times e^{-\frac{k}{12}(m-13-x)} \times \left(1 - e^{-\frac{k}{12}}\right) \right\}$$

Where

$RE_{CH4,p}$	Reference emissions from decay of organic waste during the period *p* [tCO_2/p]
f	Fraction of methane captured at the SWDS and flared, combusted or used in another manner that prevents the emissions of methane to the atmosphere
GWP_{CH4}	Global warming potential (GWP) of methane
OX	Oxidation factor (reflecting the amount of methane from SWDS that is oxidized in

	the soil or other material covering the waste)
16/12	Molecular weight ratio of methane and carbon
F	Fraction of methane in the SWDS gas [volume fraction]
DOC_f	Fraction of degradable organic carbon (DOC) that decomposes under specific conditions occurring in the SWDS [weight fraction]
MCF	Methane correction factor
W_x	Amount of organic waste prevented from disposal in the SWDS in month *x* [t]
DOC	Fraction of degradable organic carbon (by weight) [weight fraction]
k	Decay rate [1/year]
x	Months in the time period in which waste is disposed at the SWDS, extending from the first month in the time period (*x*=1) to month *m* (*x*=*m*)
m	The N^{th} month from the first disposal at the SWDS, extending from the first month of the period *p* (*m*=*p_start*) to the last month of the period p (*m*=*p_end*)
p_start	The N^{th} month from the first disposal, which is the first month of the period *p*. If that month is smaller than 14 and *p_end* is larger than 13, *p_start* is set at 14 because CH_4 generation can be accounted only after 13 months have passed since the first disposal at the SWDS.
p_end	The N^{th} month from the first disposal, which is the last month of the period *p*. If *p_end* is smaller than 14, CH_4 generation cannot be accounted.

$$RE_{FF,p} = RE_{BG,p} \times NCV_{BG} \times EF_{CO2,i}$$

Where

$RE_{FF,p}$	Reference emissions from fossil fuel usage for heat generation during the period *p* [tCO_2/p]
$RE_{BG,p}$	Amount of processed biogas supplied to heat generation equipments during the period *p* [t/p]
NCV_{BG}	Net calorific value of the processed biogas [GJ/t]
$EF_{CO2,i}$	CO_2 emission factor of fossil fuel *i* [tCO_2/GJ]
i	Type of fossil fuel *i* consumed by the heat generation equipments

G. Calculation of project emissions

$$PE_p = PEC_p \times EF_{elec}$$

Where

PE_p	Project emissions during the period *p* [tCO_2/p]
PEC_p	Amount of electricity consumption by the waste management facility during the period *p* [MWh/p]
EF_{elec}	CO_2 emission factor of the electricity consumed [tCO_2/MWh]

H. Calculation of emissions reductions

$$ER_p = RE_p - PE_p$$

Where

ER_p	GHG emission reductions during the period *p* [tCO_2/p]
RE_p	Reference emissions during the period *p* [tCO_2/p]
PE_p	Project emissions during the period *p* [tCO_2/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
EF_{elec}	CO_2 emissions factor of the electricity consumed [tCO_2/MWh] When project waste management facility consumes only grid electricity or captive electricity, the project participant applies the CO_2 emission factor respectively. When project waste management facility may consume both grid electricity and captive electricity, the project participant applies the CO_2 emission factor with higher~~lower~~ value. [CO_2 emission factor] For grid electricity: The most recent value available from the source stated in this table at the time of validation	[Grid electricity] Ministry of Natural Resources and Environment (MONRE), Vietnamese DNA for CDM unless otherwise instructed by the Joint Committee. [Captive electricity] For the option a) Specification of the captive power generation system provided by the manufacturer ($\eta_{elec,CG}$ [%]). CO_2 emission factor of the fossil fuel type used in the captive power generation

	For captive electricity, it is determined based on the following options: a) Calculated from its power generation efficiency ($\eta_{elec,CG}$ [%]) obtained from manufacturer's specification The power generation efficiency based on lower heating value (LHV) of the captive power generation system from the manufacturer's specification is applied; $$EF_{elec} = 3.6 \times \frac{100}{\eta_{elec,CG}} \times EF_{fuel,CG}$$ b) Calculated from measured data The power generation efficiency calculated from monitored data of the amount of fuel input for power generation ($FC_{PJ,CG,p}$) and the amount of electricity generated ($EG_{PJ,CG,p}$) during the monitoring period *p* is applied. The measurement is conducted with the monitoring equipment to which calibration certificate is issued by an entity accredited under national/international standards; $$EF_{elec} = FC_{PJ,CG,p} \times NCV_{fuel,CG} \times EF_{fuel,CG} \times \frac{1}{EG_{PJ,CG,p}}$$ Where: $NCV_{fuel,CG}$: Net calorific value of fuel consumed by the captive power generation system [GJ/mass or volume] Note: In case the captive electricity generation system meets all of the following conditions, the value in the following table may be applied to EF_{elec} depending on the consumed	system ($EF_{fuel,CG}$ [tCO_2/GJ]) For the option b) Generated and supplied electricity by the captive power generation system ($EG_{PJ,CG,p}$ [MWh/p]). Fuel amount consumed by the captive power generation system ($FC_{PJ,CG,p}$ [mass or volume/p]). Net calorific value ($NCV_{fuel,CG}$ [GJ/mass or volume]) and CO_2 emission factor ($EF_{fuel,CG}$ [tCO_2/GJ]) of the fuel consumed by the captive power generation system in order of preference: 1) values provided by the fuel supplier; 2) measurement by the project participants; 3) regional or national default values; 4) IPCC default values provided in tables 1.2 and 1.4 of Ch.1 Vol.2 of 2006 IPCC Guidelines on National GHG Inventories. Higher value is applied. [Captive electricity with diesel fuel] CDM approved small scale methodology: AMS-I.A. [Captive electricity with natural

	fuel type. ● The system is non-renewable generation system ● Electricity generation capacity of the system is less than or equal to 15 MW fuel type | Diesel fuel | Natural gas EF_{elec} | 0.98 *1 | 0.6 ~~,46~~ *12 ~~*1 The most recent value at the time of validation is applied.~~ *12 The value is calculated with the equation in the option a) above. The higher~~lower~~ value of default effective CO_2 emission factor for natural gas (0.05~~4~~83 tCO_2/GJ), and ~~the most efficient value of~~ default efficiency for off-grid gas turbine systems (~~42~~35%) are applied.~~[CO_2 emission factor]~~ ~~For grid electricity: The most recent value available from the source stated in this table at the time of validation~~ ~~For captive electricity: 0.8* [tCO_2/MWh]~~ ~~*The most recent value available from CDM approved small scale methodology AMS-I.A at the time of validation is applied.~~	gas] 2006 IPCC Guidelines on National GHG Inventories for the source of EF of natural gas. CDM Methodological tool "Determining the baseline efficiency of thermal or electric energy generation systems version02.0" for the default efficiency for off-grid power plants.~~CDM approved small scale methodology AMS-I.A~~
$EF_{CO2,i}$	CO_2 emission factor of the fossil fuel *i* [tCO_2/GJ] If the project supplies the biogas to the existing heat generation equipments, CO_2 emission factor of the fossil fuel *i* which has been used in the existing equipments is applied. If the project supplies the biogas to new equipments, the CO_2 emission factor of natural gas is applied.	Country specific data or IPCC default value from "2006 IPCC Guidelines for National Greenhouse Gas Inventories". Lower limit value of the default CO_2 emission factor is applied.

<table>
<tr><td>f</td><td>Fraction of methane captured at the SWDS and flared, combusted or used in another manner that prevents the emissions of methane to the atmosphere
f=0</td><td>Default value in the methodology</td></tr>
<tr><td>GWP_{CH4}</td><td>Global Warming Potential of methane (100-yr value)
GWP_{CH4}=25</td><td>IPCC Fourth Assessment Report (2.10.2 Direct Global Warming Potentials, Table 2.14)</td></tr>
<tr><td>OX</td><td>Oxidation factor (reflecting the amount of methane from SWDS that is oxidized in the soil or other material covering the waste)
Value of either 0.1 or 0 is applied to OX depending on the type of SWDS.
<table>
<tr><th>Type of SWDS</th><th>OX default values</th></tr>
<tr><td>Managed[1], unmanaged and uncategorised SWDS</td><td>0</td></tr>
<tr><td>Managed covered with CH_4 oxidising material[2]</td><td>0.1</td></tr>
</table>
[1] Managed but not covered with aerated material
[2] Examples: soil, compost</td><td>2006 IPCC guidelines for National Greenhouse Gas Inventories (Volume 3, Table 3.2)</td></tr>
<tr><td>F</td><td>Fraction of methane in the SWDS gas [volume fraction]
F=0.5</td><td>2006 IPCC guidelines for National Greenhouse Gas Inventories (Volume 5, Chapter 3, “FRACTION OF CH4 IN GENERATED LANDFILL GAS (F)”)</td></tr>
<tr><td>DOC_f</td><td>Fraction of degradable organic carbon (DOC) that decomposes under specific conditions occurring in the SWDS [weight fraction]
DOC_f=0.5</td><td>2006 IPCC guidelines for National Greenhouse Gas Inventories (Volume 5, Table 2.4 and 2.5)</td></tr>
<tr><td>MCF</td><td>Methane correction factor</td><td>2006 IPCC guidelines for National Greenhouse Gas Inventories (Volume 5, Table</td></tr>
</table>

	<table><tr><th>Type of SWDS</th><th>Value</th></tr><tr><td>Anaerobic managed SWDS</td><td>1.0</td></tr><tr><td>Semi-aerobic managed SWDS</td><td>0.5</td></tr><tr><td>Unmanaged SWDS-deep</td><td>0.8</td></tr><tr><td>Unmanaged-shallow SWDS or stockpiles that are considered SWDS</td><td>0.4</td></tr></table> In Ho Chi Minh City, Type of SWDSs is Anaerobic managed SWDS.	3.1)
DOC	Fraction of degradable organic carbon (by weight) [weight fraction] DOC =0.08 Lower value of the range 8-20% for food waste set in IPCC 2006 Guidelines for National Greenhouse Gas Inventories is applied.	2006 IPCC Guidelines for National Greenhouse Gas Inventories (Volume 5, Tables 2.4 and 2.5)
k	Decay rate [1/year] k=0.4	2006 IPCC Guidelines for National Greenhouse Gas Inventories (Volume 5, Table 3.3)
NCV_{BG}	Net calorific value of the biogas [GJ/t] NCV_{BG} = 50.4	2006 IPCC Guidelines for National Greenhouse Gas Inventories (Volume 2, Table 1.2)

History of the document

Version	Date	Contents revised
01.1	10 October 2017	JC6 ● Revision of methods to determine CO_2 emission factor for consumed electricity in section I
01.0	4 August 2015	JC4, Annex 1 Initial approval.