Verified Carbon Standard

METHODOLOGY FOR THE AVOIDANCE OF GREENHOUSE GAS EMISSIONS THROUGH COMPOSTING OF FOOD WASTE USING INSECTS

Document Prepared by One Earth Fund, Inc.

Title	Avoidance of greenhouse gas emissions through composting of food waste using insects
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Type	Methodology
Sectoral Scope	Sectoral scopes: 1 Agriculture and 5 Food
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Relationship to Approved or Pending Methodologies

Approved and pending methodologies under the VCS and approved GHG programs, that fall under the sectoral scope 1 and 5, were reviewed to determine whether an existing methodology could be reasonably revised to meet the objective of the proposed methodology. Thirteen methodologies were identified and are set out in Table 1 below. None were found to meet the objective of the proposed methodology.

Table 1: Similar Methodologies

Methodology	Title	GHG Program	Comments
VM0018	Energy Efficiency and Solid Waste Diversion Activities within a Sustainable Community	VCS	This methodology provides a procedure to determine the net CO_2, N_2O and CH_4 emissions reductions associated with grouped projects that focus on energy efficiency and solid waste diversion activities for an assortment of facilities within a set territory.
VMR0003	Revision to AMS-III.Y to Include Use of Organic Bedding Material	VCS	This methodology revision applies to CDM small-scale methodology AMS-III.Y, "Methane avoidance through the separation of solids from wastewater or manure treatment systems." Project proponents must apply this methodology revision in conjunction with the latest version of AMS-III.Y.
Version 1.1	Organic Waste Composting Project Protocol	CAR	The Reserve Organic Waste Composting Project Protocol provides guidance to account for, report, and verify GHG emission reductions associated with the diversion of eligible organic wastes away from anaerobic landfill disposal systems and to composting operations where the material degrades in a controlled aerobic process
Version 2.1	Organic Waste Digestion Project Protocol.	CAR	The Reserve Organic Waste Digestion Project Protocol provides guidance to account for, report, and verify GHG emission reductions associated with the diversion of organic waste and/or wastewater away from anaerobic treatment and disposal systems and to a biogas control system

Methodology	Title	GHG Program	Comments
			(BCS). For the purposes of this protocol, a biogas control system consists of an anaerobic digester, a biogas collection and monitoring system, and one or more biogas destruction devices.
Version 1.0	Methodology for Compost Additions to Grazed Grasslands	ACR	This document contains a methodology to account for the carbon sequestration and avoided GHG emissions related to compost additions to Grazed Grasslands.
AMS-III.F	Avoidance of methane emissions through composting	CDM	This methodology comprises measures to avoid the emissions of methane to the atmosphere from biomass or other organic matter that would have otherwise been left to decay anaerobically in a solid waste disposal site (SWDS), or in an animal waste management system (AWMS), or in a wastewater treatment system (WWTS). In the project activity, controlled aerobic treatment by composting of biomass is introduced. The project activity does not recover or combust landfill gas from the disposal site (unlike AMS-III.G "Landfill methane recovery") and does not undertake controlled combustion of the waste that is not treated biologically in a first step (unlike AMS-III.E "Avoidance of methane production from decay of biomass through controlled combustion, gasification or mechanical/thermal treatment"). Project activities that recover biogas from wastewater treatment shall use the methodology AMS-III.H "Methane recovery in wastewater treatment." Project activities involving co- digestion of organic matters shall apply the methodology AMS-III.AO "Methane recovery through controlled anaerobic digestion." Measures are limited to those that result in emission reductions of less than or equal to 60 kt CO_2 equivalent annually.

Methodology	Title	GHG Program	Comments
			This is an older CDM methodology and has limited flexibility for additionality analysis
AMS-III.R	Methane recovery in agricultural activities at households/small farm level -- Version 3.0	CDM	This project category comprises recovery and destruction of methane from manure and wastes from agricultural activities that would be decaying anaerobically emitting methane to the atmosphere in the absence of the project activity. Methane emissions are prevented by: (a) Installing methane recovery and combustion system to an existing source of methane emissions; or (b) Changing the management practice of a biogenic waste or raw material in order to achieve the controlled anaerobic digestion equipped with methane recovery and combustion system. The category is limited to measures at individual households or small farms (e.g., installation of a domestic biogas digester). Methane recovery systems that achieve an annual emission reduction of less than or equal to five tonnes of CO_2e per system are included in this category. Systems with annual emission reduction higher than five tonnes of CO_2e are eligible under AMS-III.D "Methane recovery in animal manure management systems."
AMS-III.Y	Methane avoidance through the separation of solids from wastewater or manure treatment systems - Version 4.0	CDM	This methodology comprises technologies and measures that avoid or reduce methane production from anaerobic wastewater treatment systems and anaerobic manure management systems through the removal of (volatile) solids from the wastewater or manure slurry stream. The separated solids shall be further treated, used, or disposed of in a manner resulting in lower methane emissions.

Methodology	Title	GHG Program	Comments
			The project activity does not recover and combust biogas, i.e. the baseline wastewater, or manure treatment plant, as well as the project system, are not equipped with methane recovery system. Project activities which recover and combust biogas from manure management systems shall consider AMS-III.D or AMS-III.R. Project activities which recover and combust biogas from wastewater treatment systems shall consider AMS-III.H. Project activities that substitute anaerobic wastewater treatment systems with aerobic wastewater treatment system shall consider AMS-III.I
AMS- III.AF	Avoidance of methane emissions through excavation and composting of partially decayed municipal solid waste (MSW) - Version 1.0	CDM	This methodology comprises measures to avoid emissions of methane to the atmosphere from MSW that is already deposited in a closed solid waste disposal site (SWDS) without methane recovery. In the project activity, methane emissions will be avoided by applying the following sequential measure/steps: (a) Aerobic pre-treatment by aerating the existing SWDS to achieve a safe operation environment for the subsequent excavation. (b) Excavating the MSW from the SWDS and separation into inert and non-inert materials; the excavation phase has to commence immediately after the pre-aeration phase, i.e., without significant time lag. Composting the non-inert material and proper soil application of the compost.
AMS- III.AJ	Recovery and recycling of materials from solid wastes - Version 7.0	CDM	This methodology comprises activities for the recovery and recycling of materials in municipal solid waste (MSW)1 to process them into intermediate or finished products, displacing the production of virgin materials in dedicated facilities, thereby resulting in avoidance of energy use. For paper and cardboard

Methodology	Title	GHG Program	Comments
			recycling, if the baseline scenario is the decay in a disposal site, the avoided methane emissions may be claimed. The methodology covers the emissions associated with: (a) Production of virgin pellets of plastics consisting of either high density polyethylene (HDPE), low density polyethylene (LDPE), Polyethylene Terephthalate (PET) or Polypropylene (PP). For the sake of this methodology, "plastic" means HDPE, LDPE, PET and PP, unless otherwise specified. (b) Production of container glass using virgin input ("container glass" hereafter) that is displaced by the recycled container glass ("container glass cullet" hereafter) due to the project activity.(c) Production of metals (i.e., aluminum and steel) from mined ore or virgin raw materials that is displaced by the recycled metals due to the project activity
AMS- III.AO	Methane recovery through controlled anaerobic digestion- Version 1.0	CDM	This methodology comprises measures to avoid the emissions of methane to the atmosphere from biomass or other organic matter that would have otherwise been left to decay anaerobically in a solid waste disposal site (SWDS), or in an animal waste management system (AWMS), or in a wastewater treatment system (WWTS). In the project activity, controlled biological treatment of biomass or other organic matters is introduced through anaerobic digestion in closed reactors equipped with biogas recovery and combustion/flaring system
AM0080	Mitigation of greenhouse gases emissions with the treatment of wastewater in aerobic wastewater treatment plants --- Version 1.0	CDM	This methodology is applicable to project activities that implement a new aerobic wastewater treatment plant for the treatment of domestic and/or industrial wastewater
ACM- 0022	Alternative waste treatment processes --- Version 2.0	CDM	This methodology applies to project activities where fresh

Methodology	Title	GHG Program	Comments
			waste, originally intended for disposal in a solid waste disposal site (SWDS), is treated using any (combination) of waste treatment options. The project activity avoids emissions of methane associated with disposing of the organic waste in an SWDS with or without a partial landfill gas (LFG) capture system. The applicable waste is: glass, aluminum, ferrous metals and plastics from waste sorting stages or run-off wastewater

CONTENTS

1 SOURCES

This methodology is based upon the approaches used in the following methodology:

- CDM AMS-III.F, EB92, Annex 11, Version 12.0, 4 November 2016, “Avoidance of methane emissions through composting”,

And uses the latest version of the following tools in addition to this methodology where applicable:

- CDM am-tool-02-v7, 22 September 2017., “Combined tool to identify the baseline scenario and demonstrate additionality”,
- CDM am-tool-04-v8, 4 May 2017, “Emissions from solid waste disposal sites”, and
- CDM am-tool-13-v2, 22 September 2017, “Project and leakage emissions from composting”,

This methodology also uses the methods in the following regulation:

- U.S. EPA, Mandatory Greenhouse Gas Reporting Rule (MRR), 40 CFR Part 98, Subpart HH.

2 SUMMARY DESCRIPTION OF THE METHODOLOGY

Additionality and Crediting Method	
Additionality	Activity Method
Crediting Baseline	Project Method

The methodology applies to food waste that is diverted to a landfill. Approximately 54%(1) of the food grown is discarded during processing. After processing, approximately 46% (1) of food is discarded or disposed of prior to consumption and is either lost during preparation or left as uneaten food.(3) The proposed methodology demonstrates the accounting procedure for the reduction in methane emissions from landfills by diverting food waste to a composting facility that uses a compositing by insect-based process to produce a usable compost for other applications such as fertilizer for local gardens and landscaping. Composting using an insect-based process is more efficient than traditional composting processes using windrows. The

insect-based process takes less time to convert food waste to compost, using less area for the process and can be operated indoors on a year-round basis.

3 DEFINITIONS

3.1 Acronyms

CDM
Clean Development Mechanism.

EPA
US Environmental Protection Agency

WARM
EPA Waste Reduction Model

3.2 Defined Terms

Biomass waste
Material derived from plant or animal products that are normally discarded. Biomass waste encompasses a wide array of materials derived from agricultural, agro-industrial, and timber residues, as well as municipal and industrial wastes.

Food Waste
Biomass waste derived from food processing.

Green Waste
Biomass waste is derived generally from gardens and landscaping. In local communities, residential green waste can include food scraps as well as garden or landscape trimmings.

Landfill
A site for the disposal of waste materials. Landfills are carefully designed structures built into or on top of the ground in which trash is isolated from the surrounding environment. Modern landfills are well-engineered facilities designed to receive specific kinds of waste, including municipal solid waste (MSW), construction and demolition debris (C&D) and hazardous waste.

Mixed Waste
Any combination of waste types with different properties. Typically, commercial, and municipal wastes are mixtures of plastics, metals, glass, biodegradable waste including paper and textiles along with other nondescript refuse.

4 APPLICABILITY CONDITIONS

This methodology is applicable under the following conditions:

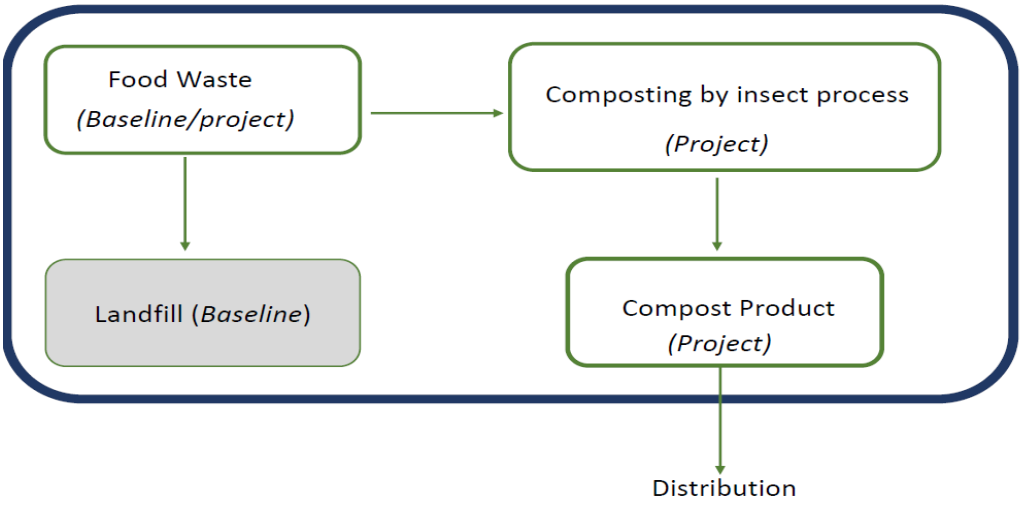
1) Project activities that compost food, food waste, agricultural waste, and/or waste from agro-industrial activities
2) The location and characteristics of the disposal site of the food and biomass waste in the baseline condition must be known, in such a way as to allow the estimation of its GHG emissions.
3) For food waste diverted from a landfill, the following requirements must be confirmed at the beginning of each crediting period:
   a) Establish that waste identified in the baseline scenario could be accommodated by the identified landfills for the duration of the crediting period; or
   b) Establish that it is common practice in the region to dispose of the waste in landfills.
4) The project participants must clearly define the geographical boundary of the project and document it in the project documents.
5) The project is located in North America.

This methodology is not applicable under the following conditions:

1) Project activities that include composting of mixed waste.

5 PROJECT BOUNDARY

The spatial extent of the project boundary encompasses the food waste composting by insect processing facility and the final compost product. The baseline includes disposal of the food waste to a landfill and is included in the project boundary. The project boundary includes the landfill where the food waste would be disposed.



The greenhouse gases (GHG) included in or excluded from the project boundary are below.

Table 2: GHG Sources Included in or Excluded from the Project Boundary

Source		Gas	Included?	Justification/Explanation
Baseline	Food Waste Landfill Emissions	CO_2	No	To be conservative only CO_2 emissions generated from conversion of food waste methane are included in the project .
		CH_4	Yes	Main source of emissions from landfills
		N_2O	Optional	Account for less than 3% of emissions from a landfill(1).
Project	Emissions from Processing Cells	CO_2	Yes	Main emissions from composting using insects
		CH_4	NO	Unconsumed food waste emissions from food waste in process cells are de minimis, and therefore excluded.
		N_2O	Yes	Emissions from composting using insects
	Electricity Consumption	CO_2	No	Main emissions associated with electricity generation
		CH_4	No	De minimis, therefore excluded.
		N_2O	No	De minimis, therefore excluded.

6 BASELINE SCENARIO

The baseline scenario is the situation when the food waste would be sent to a landfill. The baseline emissions are the amount of methane emitted from the decay of the degradable organic carbon in the food waste.

7 ADDITIONALITY

This methodology uses a standardized method to determine additionality. Particularly, the methodology includes an activity method applying Option A, activity penetration, for the demonstration of additionality.

Step 1: Regulatory Surplus

Project proponents must demonstrate regulatory surplus in accordance with the rules and requirements regarding regulatory surplus set out in the latest version of the *VCS Standard*. The project must not be mandated by any law, statute, or other regulatory framework, any systematically enforced law, statute, or other regulatory framework.

Step 2: Positive List

Projects that meet all of the applicability conditions of this methodology located in the North America are deemed additional. Justification for the activity method/positive list is provided in Appendix 1. This methodology may be expanded to include global activites is there is a market and specific emissions factors are available or can be calculated from local test data.

8 QUANTIFICATION OF GHG EMISSIONS REDUCTIONS AND REMOVALS

8.1 Baseline Emissions

Baseline emissions are the GHG emissions from the disposal of food waste to a landfill. Baseline emissions can be calculated by one of two quantification options. Option 1 or 2 are for projects within the United States and Canada. Option 1 uses the latest version of an EPA WARM model that was first released in 1998 and is updated with new supporting data and information every two to three years. Option 2 uses the estimation methods in EPA's Mandatory Greenhouse Gas Reporting Rule (MRR) 40 CFR Part 98 Subpart HH, Municipal Solid Waste Landfills.

Option 1

This option uses the latest version of an EPA Waste Reduction Model (WARM),tool to supplement outputs if limited information is available to calculate the baseline emissions. The EPA created WARM to help solid waste planners and organizations track and voluntarily report greenhouse gas (GHG) emissions reductions, energy savings, and economic impacts from several different waste management practices. WARM calculates and totals these impacts from baseline and alternative waste management practices such as source reduction, recycling, anaerobic digestion, combustion, composting and landfilling. WARM version 15 was released in May 2019. For more information on the WARM model see Appendix 2.

$$BEy = \text{Output of EPA WARM model} \quad (1)$$

Option 2

This option can be used if more detailed information is available for the baseline information. Methane emissions can be calculated using Equation 2 which is based on the U.S. Environmental Protection Agency (EPA), Mandatory Greenhouse Gas Reporting Rule (MRR), 40 CFR Part 98, Subpart HH as follows:

$$G_{CH4} = \sum_{x=S}^{T-1} \left\{ W_x * MCF * DOC * DOC_F * F * \frac{16}{12} * \left(e^{-k(T-x-1)} - e^{-k(T-x)} \right) \right\} \quad (2)$$

Where:

G_{CH4}	=	Modeled methane generation rate in reporting year T (metric tons CH_4).
x	=	Year in which waste was disposed
S	=	Start year of calculation. Use the year 1960 or the opening year of the landfill, whichever is more recent
T	=	Reporting year for which emissions are calculated
W_X	=	Quantity of waste disposed in the landfill in year × from measurement data, tipping fee receipts, or other company records (metric tons, as received (wet weight)).
MCF	=	Methane correction factor (fraction). Use the default value of 1 unless there is active aeration of waste within the landfill during the reporting year. If there is active aeration of waste within the landfill during the reporting year, use either the default value of 1 or select an alternative value no less than 0.5 based on site-specific aeration parameters.
DOC	=	Degradable organic carbon from Table HH-1 of this subpart [fraction (metric tons C/metric ton waste)](Appendix 3)
DOC_F	=	Fraction of DOC dissimilated (fraction). Use the default value of 0.5.
F	=	Fraction by volume of CH_4 in landfill gas from measurement data for the current reporting year, if available (fraction, dry basis, corrected to 0% oxygen); otherwise, use the default of 0.5.
k	=	Rate constant from Table HH-1 to this subpart (yr^{-1}). Select the most applicable k value for the majority of the past 10 years (or operating life, whichever is shorter)

G_{CH4} is the modelled methane emissions per year and should be converted to CO_2(t/yr) using the GWP for methane or:

$$BE_{CO2} = G_{CH4} \times GWP \quad (3)$$

Where:

BE_{CO2}	=	Baseline emissions, metric tons CO_2
G_{CH4}	=	Modeled methane generation rate in reporting year T (metric tons CH_4).
GWP	=	Global warming potential for methane (9)

8.2 Project Emissions

Project emissions calculations are based on the current version of the CDM Methodological tool 13 'Project and leakage emissions from composting, v2.0'.

The project emissions from composting ($PE_{y,}$) are determined as follows:

$$PE_y = PE_{EC,y} + PE_{EF,y} + PE_{CH4,y} + PE_{N2O,y} \quad (4)$$

Where:

$PE_{,y}$	=	Project emissions associated with composting in year y (t CO_2e/yr)
$PE_{EC,y}$	=	Project emissions from electricity consumption associated with composting in year y (t CO_2/yr)
$PE_{FC,y}$	=	Project emissions from fossil fuel consumption associated with composting in year y (t CO_2/yr)

$PE_{CH4,y}$ = Project emissions of methane from the composting process in year y (t CO_2e/yr)

$PE_{N2O,y}$ = Project emissions of nitrous oxide from the composting process in year y(t CO_2e/yr)

The project emissions associated with use of fossil fueled based electricity and direct use of a fossil fuel, e.g. natural gas are defined in equation (5) and (6). The project emissions from the insect composting processes are defined in equation (7) and (8).

$$PE_{EC,y} = EC \times EF_{EC,default} \quad (5)$$

$$PE_{FC,y} = FC \times EF_{FC,default} \quad (6)$$

$$PE_{CH4,y} = Qy \times EF_{CH4,y} \times GWP_{CH4} \quad (7)$$

$$PE_{N2O,y} = Qy \times EF_{N2O,y} \times GWP_{N2O} \quad (8)$$

Further:

$$PE_{EC,y} = EC \times EF_{EC,default} \quad (5)$$

Where:

$PE_{EC,y}$ = Project emissions from electricity consumption associated with composting in year y (t CO_2/yr)

EC = The electricity consumed by the project in kilowatt hours (KwH)

$EF_{EC,default}$ = The emissions factor for the electricity provided to the project using the e-GRID factors

And

$$PE_{FC,y} = FC \times EF_{FC,default} \quad (6)$$

Where:

$PE_{FC,y}$ = Project emissions from fossil fuel consumption associated with composting in year y (t CO_2/yr)

FC = The fossil fuel consumed, e.g. natural gas

$EF_{FC,default}$ = The emissions factor for the associated fossil fuel

And

$$PE_{CH4,y} = Qy \times EF_{CH4,y} \times GWP_{CH4} \quad (7)$$

Where:

$PE_{CH4,y}$ = Project emissions of methane from the composting process in year y (t CO_2e/yr)

Qy = Mass (t CO_2e/yr) in year y of food waste processed

$EF_{CH4,y}$ = Emissions factor for methane emissions from the composting by insects

GWP_{CH4} Global warming potential of methane

And

$$PE_{N2O,y} = Qy \times EF_{N2O,y} \times GWP_{N2O} \quad (8)$$

Where:

$PE_{N20,y}$ = Project emissions of nitrous oxide from the composting process in year y (t CO_2e/yr)
Qy = Mass (t CO_2e/yr) in year y of food waste processed
$EF_{N20,y}$ = Emissions factor for nitrous oxide emissions from the composting by insects
GWP_{N20} Global warming potential of methane

8.3 Leakage

For this methodology, leakage is set as zero. There are no anticipated sources of emissions outside the project boundary that would be attributable to the project activity.

8.4 Net GHG Emission Reductions and Removals

Net GHG emission reductions and removals are calculated as follows:

$$ER_y = BE_y - PE_y - LE_y \quad (9)$$

Where:

ER_Y = Net GHG emissions reductions and removals in year y (tCO_2e)
BE_Y = Baseline emissions in year y (tCO_2e)
PE_y = Project emissions in year y (tCO_2e)
LE_y = Leakage in year y (tCO_2e)

9 MONITORING

9.1 Data and Parameters Available at Validation

The data and parameters that will be determined or available at validation and remain fixed throughout the project crediting period are below. The data and parameters monitored during the project period are included in Section 9.2 (Data and Parameters Monitored) below.

Data / Parameter	MCF
Data unit	Fraction
Description	Methane correction factor (fraction).
Equations	2
Source of data	40 CFR Part 98 Subpart HH

Value applied	1
Justification of choice of data or description of measurement methods and procedures applied	Methane correction factor (fraction). Use the default value of 1 unless there is active aeration of waste within the landfill during the reporting year. If there is active aeration of waste within the landfill during the reporting year, use either the default value of 1 or select an alternative value no less than 0.5 based on site-specific aeration parameters.
Purpose of Data	Calculation of baseline emissions
Comments	N/A

Data / Parameter	DOC
Data unit	Metric tons C/metric ton waste
Description	Degradable organic carbon from Table HH-1 of subpart HH [fraction (metric tons C/metric ton waste)].
Equations	1
Source of data	40 CFR Part 98 Subpart HH
Value applied	See Table HH-1
Justification of choice of data or description of measurement methods and procedures applied	Well reviewed government source, 40 CFR Part 98 Subpart HH
Purpose of Data	Calculation of baseline emissions
Comments	N/A

Data / Parameter	DOC_f
Data unit	Fraction
Description	Fraction of DOC dissimilated (fraction).
Equations	1
Source of data	40 CFR Part 98 Subpart HH

Value applied	0.5
Justification of choice of data or description of measurement methods and procedures applied	Well reviewed government source, 40 CFR Part 98 Subpart HH
Purpose of Data	Calculation of baseline emissions
Comments	N/A

Data / Parameter	F
Data unit	Fraction
Description	Fraction by volume of CH4 in landfill gas from measurement data for the current reporting year,
Equations	1
Source of data	40 CFR Part 98 Subpart HH
Value applied	f if available (fraction, dry basis, corrected to 0% oxygen); otherwise, use the default of 0.5.
Justification of choice of data or description of measurement methods and procedures applied	Well reviewed government source and methods, 40 CFR Part 98 Subpart HH
Purpose of Data	Calculation of baseline emissions
Comments	N/A

Data / Parameter	k
Data unit	yr^{-1}
Description	Rate constant
Equations	1
Source of data	40 CFR Part 98 Subpart HH

Value applied	See Table HH-1
Justification of choice of data or description of measurement methods and procedures applied	From Table HH-1 (yr−1). Select the most applicable k value for the majority of the past 10 years (or operating life, whichever is shorter)
Purpose of Data	Calculation of baseline emissions
Comments	N/A

Data / Parameter	GWP_{CH4}
Data unit	unitless
Description	Global Warming Potential of methane
Equations	2
Source of data	UNFCCC Fourth Assessment Report (9)
Value applied	25
Justification of choice of data or description of measurement methods and procedures applied	This is the GWP recommended by Verra
Purpose of Data	Calculation of baseline emissions
Comments	N/A

Data / Parameter	GWP_{N2O}
Data unit	8
Description	Global Warming Potential of nitrous oxide
Equations	
Source of data	UNFCCC Fourth Assessment Report (9)
Value applied	298

Justification of choice of data or description of measurement methods and procedures applied	This is the GWP recommended by Verra
Purpose of Data	Calculation of baseline emissions
Comments	N/A

Data / Parameter	F
Data unit	Fraction
Description	Fraction of methane in the landfill gas (volume fraction)
Equations	2
Source of data	CDM, Tool 04, Methodological tool Emissions from solid waste disposal sites, v.8.0
Value applied	
Justification of choice of data or description of measurement methods and procedures applied	UNFCCC approved global methodology
Purpose of Data	Calculation of baseline emissions
Comments	N/A

Data / Parameter	EF_{EC}
Data unit	lb CO_2/MWH
Description	The emissions factor for the electricity provided to the project using the EPA e-GRID factors
Equations	5
Source of data	EPA e-GRID
Value applied	See e-GRID tables

Justification of choice of data or description of measurement methods and procedures applied	Well reviewed and regularly revised government resource
Purpose of Data	Calculation of project emissions
Comments	N/A

Data / Parameter	$EF_{FC,default}$
Data unit	Varies by fuel
Description	The emissions factor for the fossil fuel, e.g., natural gas
Equations	6
Source of data	US DOE EIA
Value applied	
Justification of choice of data or description of measurement methods and procedures applied	Well reviewed and regularly revised government resource
Purpose of Data	Calculation of project emissions
Comments	N/A

Data / Parameter	$EF_{CH4,y}$
Data unit	
Description	Emissions factor for methane emissions from the composting by insects
Equations	7
Source of data	Appendix
Value applied	0.00063

Justification of choice of data or description of measurement methods and procedures applied	Summary data from publications and research project(2)
Purpose of Data	Calculation of project emissions
Comments	N/A

Data / Parameter	$EF\ N_2O,y$
Data unit	
Description	Emissions factor for nitrous oxide emissions from the composting by insects
Equations	8
Source of data	Summary data from publications and research project(2)
Value applied	0.0000633
Justification of choice of data or description of measurement methods and procedures applied	
Purpose of Data	Calculation of project emissions
Comments	N/A

9.2 Data and Parameters Monitored

Monitoring involves an annual assessment of the amount of waste composted. For all monitored parameters, there are also options to use default values except for the total weight of food waste (or feed).

Operating parameters that need to be monitored will be identified during pilot testing and added to this section.

Data / Parameter:	Wx
Data unit:	metric ton

Description:	Quantity of waste disposed
Equations	2
Source of data:	40 CFR Part 98 Sub-part HH
Description of measurement methods and procedures to be applied:	Quantity of waste disposed in the landfill in year × from measurement data, tipping fee receipts, or other company records (metric tons, as received (wet weight)).
Frequency of monitoring/recording:	daily
QA/QC procedures to be applied:	Monthly calibration checks, and QA/QC provided by manufacturer
Purpose of data:	Calculation of baseline emissions
Calculation method:	Weigh belt or similar
Comments:	N/A

Data / Parameter:	Qy
Data unit:	Kg or mt/yr
Description:	Quantity of waste composted in year y (wet basis)
Equations	7,8
Source of data:	Use a weighbridge or any other applicable and calibrated weighing device, e.g. belt-scales
Description of measurement methods and procedures to be applied:	
Frequency of monitoring/recording:	Daily or as used.
QA/QC procedures to be applied:	Weighbridge or any other applicable weighing device is subject to periodic calibration (in accordance with the stipulation of the weighing device supplier)

Purpose of data:	Calculation of project emissions
Calculation method:	N/A
Comments:	Missing data protocols should be used similar to California or Federal regulations. No credits may be generated for missing data for more than 72 hours.

9.3 Description of the Monitoring Plan

The project proponent must detail the procedures for collecting, recording, compiling, analyzing and reporting all data and parameters as listed in Section 9.2.

All data collected as part of monitoring must be kept electronically for at least for two years after the end of the last project crediting period. All data must be monitored unless indicated otherwise in the tables above. All direct measurements must be conducted with calibrated measurement equipment according to relevant industry standards. Where direct measurements are not applied, project participants must demonstrate that the values used for the project are reasonably conservative, considering the uncertainty associated with these values.

Quality assurance/quality control procedures must also be applied to add confidence that all measurements and calculations have been made correctly. These may include but are not limited to:

- Protecting records of monitored data (hard copy and electronic storage)
- Checking data integrity on a regular and periodic basis (manual assessment, comparing redundant metered data, calibration records for metered data, and detection of outstanding data/records)
- Comparing current estimates with previous estimates to identify any abnormal readings
- Providing sufficient training to project participants to install and maintain project devices
- Establishing minimum experience and requirements for operators in charge of project and monitoring
- Performing calculations to make sure no mathematical errors have been made.

10 REFERENCES

1. Global Food Wastage – Causes and impact on natural resources https://www.greenfacts.org/en/food-wastage/l-2/index.htm
2. Black Soldier Fly biowaste treatment – Assessment of global warming potential, Adeline Mertenat, Stefan Diener, Christian Zurbrügg, Waste Management 84 (2019) 173–181
3. U. S Environmental Protection Agency (EPA), Waste Reduction Model (WARM); https://www.epa.gov/warm
4. U.S. EPA,, Mandatory Greenhouse Gas Reporting Rule (MRR), 40 CFR Part 98, Subpart HH; https://www.epa.gov/ghgreporting/resources-subpart-ghg-reporting
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APPENDIX 1: JUSTIFICATION OF ACTIVITY METHOD

The Positive List

The activity method is used for demonstrating Step 2 of the additionality analysis. Option A, as described in the VCS Standard is used to establish the positive list. The only baseline scenarios that are reasonable to consider are (1) the continued disposal of food waste in landfills and (2) the large-scale adoption of this technology in the future, with a greater than 5% penetration of the technology which exceeds the eligibility threshold.

The methodology must demonstrate that the project activity has achieved a low level of penetration relative to its maximum adoption potential, using the following equation:

$$AP_y = OA_y / MAP_y \quad \text{(A-1)}$$

Where:

APy	=	Activity penetration of the project activity in year y (percentage)
OAy	=	Observed adoption of the project activity in year y (e.g., total number of instances installed at a given date in year y, or amount of energy supplied in year y)
MAPy	=	Maximum adoption potential of the project activity in year y (e.g., total number of instances that potentially could have been installed at a given date in year y, or the amount of energy that potentially could have been supplied in year y)

The maximum adoption potential is the total adoption of a project activity that could currently be achieved given current resource availability, technological capability, level of service, implementation potential, total demand, market access and other relevant factors within the methodology's applicable geographically defined market which is North America. The maximum adoption potential does not consider market price, cost of adoption, consumer education, cultural or behavioral barriers, and laws, statutes, regulatory frameworks, or policies.

Maximum adoption potential is constrained by numerous factors limiting the total adoption of a project activity. The following list provides further specification with

respect to factors that do, and do not, need to be considered in determining maximum adoption potential:

- Resource availability is the limitation imposed by the supply of raw materials or energy resources to the activity.
- Technological capability is the limitation imposed by the technical efficiency of the project activity.
- Level of service is the limitation imposed by the technical reliability or quality of the service provided by the project activity relative to its alternatives.
- Implementation potential is the limitation imposed by the availability of appropriate locations for implementing the project activity.
- Total demand is the limitation imposed by demand for the product or service provided by, or associated with, the project activity and all relevant alternative sources of the product or service.
- Market access is the limitation imposed by current infrastructure and the degree to which the outputs of project activity can be practically supplied to the market.
- Market price is the limitation imposed by the current price achievable for outputs from the project activity.
- Cost of adoption is the limitation imposed by the cost of switching to the project activity from an alternative activity.
- Consumer education is the public knowledge or awareness of the activity and its benefits.
- Behavioral or cultural barriers are limitations resulting from social or cultural inertia with respect to the adoption of the project activity.

The methodology proposed creates compost from food waste by using insects.

Compost is organic matter that has been decomposed using a variety of composting processes. These processes recycle various organic materials otherwise regarded as waste products to produce a soil conditioner among other uses. The composting processes include anaerobic digestion, aerated static piles and wind rows, mechanical biologic treatment, and aerobic composting that can be in-vessel or on the ground piles. The source material for composting is green waste (leaves, grass, small branches), food waste, and sometimes sludges. The process of aerobic composting can occur in open piles and windrows, or in vessels of various shapes and sizes.

Creating compost using insects is a part of the overall composting industry and detailed information on insect composting could not be found.

EPA began collecting and reporting data on the generation and disposition of waste in the United States more than 30 years ago (https://www.epa.gov/smm). The Agency uses this information to measure the success of materials management programs across the country and to characterize the national waste stream. The data in Table 1 shows selected data from EPA since 1960 showing waste diversion from MSW landfills to recycling, composting, and energy recovery. EPA also noted that in general, composting data is not readily available because composting facilities are not required by the states to report amount and type of waste processed. Also, some states reported difficulties in collecting data from registered large-scale composting facilities. Many states reported that there are institutional or other small composting facilities that are not registered through the state. The market analysis was not impacted by the limited data from some states and small-scale facilities.

In 2017 ~10% of the reported waste generated was diverted to composting. Of that waste composted, no insect composting operations were identified.

Generation, Recycling, Composting, Combustion with Energy Recovery and Landfilling of MSW (millions of short tons)

Activity	1960	1970	1980	1990	2000	2005	2010	2014	2015	2017*
Generation	88.1	121.1	151.6	208.3	243.5	253.7	251.1	259.0	262.4	267.69
Recycling	5.6	8.0	14.5	29.0	53.0	59.2	65.3	66.6	67.8	67.18
Composting*	neg.	neg.	neg.	4.2	16.5	20.6	20.2	23.0	23.4	26.99
Combustion/energy recovery	0.0	0.5	2.8	29.8	33.7	31.7	29.3	33.2	33.5	34.03
Landfilling/other disposal	82.5	112.6	134.3	145.3	140.3	142.2	136.3	136.2	137.7	139.59

* Composting of yard trimmings, food and other MSW organic material. Does not include backyard composting

** The most recent data

In a report from 2014, the Institute for Local Self-Reliance, BioCycle, the University of Washington et.al. authored a report where they surveyed state agencies to identify composting operations. Of the 4,914 composting operations identified in the U.S., about 71% compost only yard trimmings (based on 44 states reporting.). This 2014 survey identified a total of 3,453 yard trimmings composting facilities in the US. In 2006, 3,357 permitted facilities were reported. Over this ~10-year span the number of facilities has remained nearly constant. Most facilities process less than 5,000 short tons/year. Permitted facilities are only a part of the composting operations in any state. In 2015 ~8.9% of the reported waste generated was diverted to composting and 71% of the facilities only compost yard waste.

In 2017 Biocycle authored a new study that showed an increase to 4,713 composting facilities, and 57% composted only yard waste. Of the remaining facilities, 5% composted

yard and food waste or 236 facilities. Food waste was not listed separately in either summary.

EPA published new data in 2017, ~10% of the waste generated was diverted to composting. and ~10% of that is listed as food waste which includes other municipal waste organics for composting or 2.57 million tons. (https://www.epa.gov/sites/production/files/2019-11/documents/2017_facts_and_figures_fact_sheet_final.pdf)

Using the 2015 data, and assuming the remaining compost facilities all have insect composting operations results in an ~3% market penetration, below the market activity penetration threshold of 5%. Using the 2017 data, and assuming all 236 facilities have insect composting operations results in an ~4% market penetration, again below the market activity penetration threshold of 5%. The market penetration would be lower if all of the unregistered and small-scale composting facilities could be included. Composting using insects is not part of the composting market as confirmed by literature searches and consultation with composting organizations.

Therefore, the project activity may be deemed additional.

Since 2015, global recycling markets have changed substantially, and many Asian countries have stopped accepting recycled materials. The quantity of recycled material has decreased increasing waste/recycle landfilled. Landfills are filling up at a faster rate than in the past because the US is not able to export waste to other countries as it has in the past, e.g. China.. (https://www.washingtonpost.com/news/energy-environment/wp/2018/06/20/a-giant-wave-of-plastic-garbage-could-flood-the-u-s-in-10-years-a-study-says/)

APPENDIX 2: EPA WASTE REDUCTION MODEL

Documentation Chapters for Greenhouse Gas Emission, Energy and Economic Factors Used in the Waste Reduction Model (WARM) (https://www.epa.gov/warm/documentation-chapters-greenhouse-gas-emission-energy-and-economic-factors-used-waste-reduction)

These documents provide background documentation for the greenhouse gas, energy and economic factors in EPA's Waste Reduction Model (WARM). The WARM documentation chapters are grouped into several files based on chapter topic:

1. User's Guide WARM version 15 – provides an overview for users who may be new to the tool or need some basic knowledge about downloading and modeling scenarios in WARM version 15
2. User's Guide WARM version 15 Excel – provides an overview for users of the Excel-based tool for WARM version 15. This guide is the same as the guide found on the first sheet of the WARM Excel tool
3. Background - includes chapters covering WARM Background and Overview, Definitions and Acronyms, Recent Updates in WARM, Forest Carbon Storage and Transportation Assumptions
4. Management Practices - includes chapters covering Source Reduction, Recycling, Anaerobic Digestion, Composting, Combustion, Landfilling, Energy Impacts and Economic Impacts
5. Containers, Packaging and Non-Durable Goods Materials - includes chapters covering Glass, Metals, Paper Products, Plastics, and Polylactide (PLA) Biopolymer
6. Organic Materials - includes chapters covering Food Waste and Yard Trimmings
7. Electronics - includes chapter covering Electronics
8. Tires - includes chapter covering Tires
9. Construction Materials - includes chapters covering Asphalt Concrete, Asphalt Shingles, Carpet, Clay Bricks, Concrete, Drywall, Fiberglass Insulation, Fly Ash, Vinyl Flooring, Wood Flooring, and Wood Products

APPENDIX 3: 40 CFR PART 98 SUBPART HH TABLE HH-1

40 CFR §98 establishes mandatory greenhouse gas (GHG) reporting requirements for owners and operators of certain facilities Subpart HH applies to municipal solid waste (MSW) landfills. Table HH-1 provides the emissions factors for the calculation of the baseline.

Table HH-1 to Subpart HH of Part 98—Emissions Factors, Oxidation Factors and Methods

Factor	Default value	Units
DOC and k values—Bulk waste option		
DOC (bulk waste)	0.20	Weight fraction, wet basis.
k (precipitation plus recirculated leachate[a] <20 inches/year)	0.02	yr−1
k (precipitation plus recirculated leachate[a] 20-40 inches/year)	0.038	yr−1
k (precipitation plus recirculated leachate[a] >40 inches/year)	0.057	yr−1
DOC and k values—Modified bulk MSW option		
DOC (bulk MSW, excluding inerts and C&D waste)	0.31	Weight fraction, wet basis.
DOC (inerts, e.g., glass, plastics, metal, concrete)	0.00	Weight fraction, wet basis.
DOC (C&D waste)	0.08	Weight fraction, wet basis.
k (bulk MSW, excluding inerts and C&D waste)	0.02 to 0.057[b]	yr−1
k (inerts, e.g., glass, plastics, metal, concrete)	0.00	yr−1
k (C&D waste)	0.02 to 0.04[b]	yr−1
DOC and k values—Waste composition option		
DOC (food waste)	0.15	Weight fraction, wet basis.
DOC (garden)	0.2	Weight fraction, wet basis.
DOC (paper)	0.4	Weight fraction, wet basis.
DOC (wood and straw)	0.43	Weight fraction, wet basis.
DOC (textiles)	0.24	Weight fraction, wet basis.
DOC (diapers)	0.24	Weight fraction, wet basis.
DOC (sewage sludge)	0.05	Weight fraction, wet basis.
DOC (inerts, e.g., glass, plastics, metal, cement)	0.00	Weight fraction, wet basis.
k (food waste)	0.06 to 0.185[c]	yr−1
k (garden)	0.05 to 0.10[c]	yr−1
k (paper)	0.04 to 0.06[c]	yr−1
k (wood and straw)	0.02 to 0.03[c]	yr−1

k (textiles)	0.04 to 0.06[c]	yr−1
k (diapers)	0.05 to 0.10[c]	yr−1
k (sewage sludge)	0.06 to 0.185[c]	yr−1
k (inerts e.g., glass, plastics, metal, concrete)	0.00	yr−1
Other parameters—All MSW landfills		
MCF	1.	
DOCF	0.5	
F	0.5	
OX	See Table HH-4 of this subpart	
DE	0.99	

a) Recirculated leachate (in inches/year) is the total volume of leachate recirculated from company records or engineering estimates divided by the area of the portion of the landfill containing waste with appropriate unit conversions. Alternatively, landfills that use leachate recirculation can elect to use the k value of 0.057 rather than calculating the recirculated leachate rate.

b) Use the lesser value when precipitation plus recirculated leachate is less than 20 inches/year. Use the greater value when precipitation plus recirculated leachate is greater than 40 inches/year. Use the average of the range of values when precipitation plus recirculated leachate is 20 to 40 inches/year (inclusive). Alternatively, landfills that use leachate recirculation can elect to use the greater value rather than calculating the recirculated leachate rate.

c) Use the lesser value when the potential evapotranspiration rate exceeds the mean annual precipitation rate plus recirculated leachate. Use the greater value when the potential evapotranspiration rate does not exceed the mean annual precipitation rate plus recirculated leachate. Alternatively, landfills that use leachate recirculation can elect to use the greater value rather than assessing the potential evapotranspiration rate or recirculated leachate rate. [75 FR 66473, Oct. 28, 2010, as amended at 78 FR 71970, Nov. 29, 2013]