



Approved baseline and monitoring methodology AM0039

“Methane emissions reduction from organic waste water and bioorganic solid waste using co-composting”

I. SOURCE AND APPLICABILITY

Source

This methodology is based on the project activity “Methane abatement through composting”, whose baseline and monitoring methodology and project design document were prepared by “Danish Energy Management A/S”.

For more information regarding the proposal and its consideration by the Executive Board please refer to case NM0147: “Methane emission reduction from organic waste water” on <http://cdm.unfccc.int/goto/MPappmeth>.

This methodology also refers to the latest version of the:

- (i) “Tool for the demonstration and assessment of additionality”
- (ii) “Tool to determine methane emissions avoided from dumping waste at a solid waste disposal site”.

Selected approach from paragraph 48 of the CDM modalities and procedures

“Actual or historical emissions, as applicable”

Applicability

The methodology is applicable to project activities that avoid methane emissions:

- Resulting from anaerobic degradation of the organic wastewater in open lagoons or storage tanks; and
- From natural decay of bioorganic solid waste in landfills.

The methodology is applicable under the following conditions:

- Organic wastewater and bioorganic solid waste can be generated at separate locations;
- The bioorganic solid waste can be of a single type or multiple types mixed in different proportions. The proportions and characteristics of different types of bioorganic waste processed in the project activity can be determined, in order to apply a multiphase landfill gas generation model to estimate the quantity of landfill gas that would have been generated in the absence of the project activity;
- Project activities shall employ co-composting process for treatment of the organic wastewater and the bioorganic waste;
- The anaerobic lagoons or storage tanks utilized for the treatment of the organic wastewater, which is processed in the project co-composting activity, in the baseline shall meet the following conditions:
 - The monthly average ambient temperatures are greater than 10 °C ;(the methodology is applicable even if some of the months during year have monthly average ambient temperature less than 10 °C, but in such cases only months where monthly average ambient temperature are greater than 10 °C shall be included in estimation of methane emissions)



- Depth of the wastewater anaerobic lagoon or storage tank is greater than 1 m;
- Residence time of the organic matter should be at least 30 days.

NOTE: The methodology is not applicable to waste streams from manure management.

This methodology is only applicable if the baseline is:

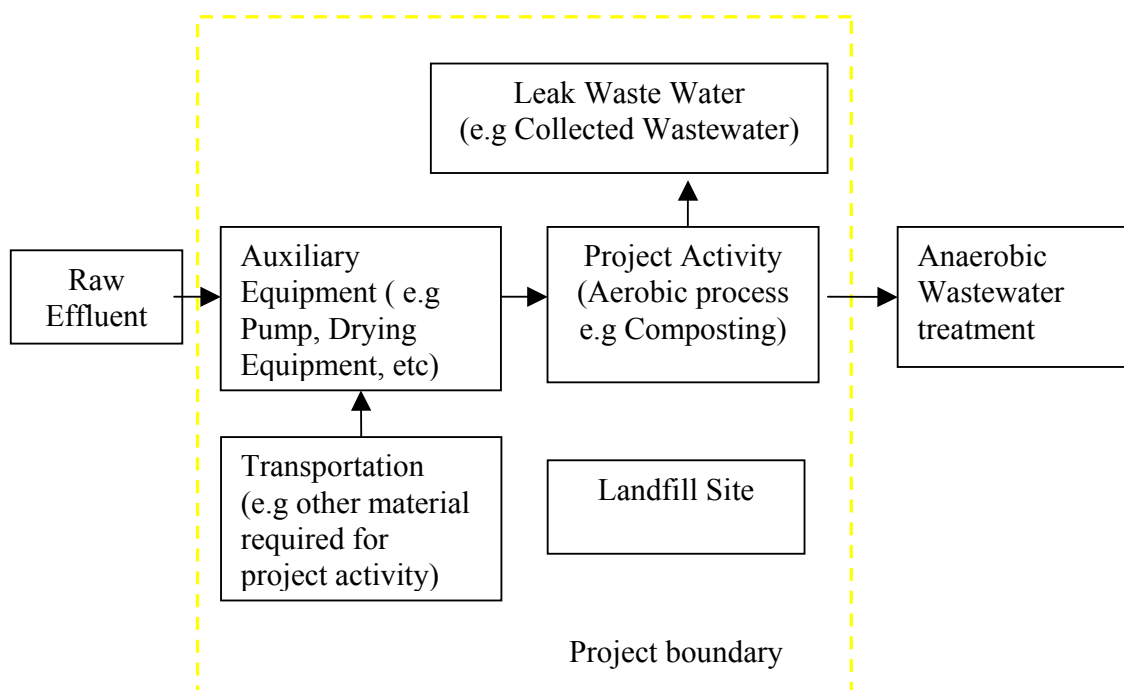
- Landfilling of the bioorganic solid waste; and
- An existing or new to be built anaerobic lagoon or open tanks for the treatment of organic wastewater.

II. BASELINE METHODOLOGY

Project boundary

The project boundary includes all GHG emission sources from anaerobic process including open lagoons or storage tanks treating organic wastewater, the landfill site where the bioorganic solid waste would be disposed of in the absence of project activity, the proposed aerobic process, transportation and auxiliary equipment.

Project boundary is graphically represented in the following block diagram.





Emissions sources included in or excluded from the project boundary are shown in Table 1.

Table 1: Summary of gases and sources included in the project boundary

	Source	Gas	Included?	Justification / Explanation
Baseline	Biomass disposed in unmanaged landfills	CO ₂	No	CO ₂ emissions from biomass decay in landfills is considered GHG neutral.
		CH ₄	Yes	Methane emission from biomass decay in the landfills
		N ₂ O	No	Not significant. Excluded for simplification and conservativeness.
	Open Lagoons	CO ₂	No	CO ₂ emissions from biomass source are considered GHG neutral.
		CH ₄	Yes	Methane emission from anaerobic process
		N ₂ O	No	Not significant. Excluded for simplification and conservativeness.
	Transportation	CO ₂	Yes	Emission from combustion of fossil fuel in transport vehicles.
		CH ₄	No	Not significant. Excluded for simplification and conservativeness
		N ₂ O	No	Not significant. Excluded for simplification and conservativeness
	Auxiliary Equipment	CO ₂	Yes	Emission from Grid Electricity or Fossil fuel
		CH ₄	No	Not significant. Excluded for simplification and conservativeness
		N ₂ O	No	Not significant. Excluded for simplification and conservativeness
Project Activity	Composting process	CO ₂	No	CO ₂ emissions from composting process is considered GHG neutral.
		CH ₄	Yes	Methane emissions from anaerobic pockets during composting process
		N ₂ O	Yes	N ₂ O emissions from loss of N ₂ O-N during composting process and during application of the compost
	Leaked Waste Water	CO ₂	No	CO ₂ emission from biomass source and considered GHG neutral.
		CH ₄	Yes	Methane emission from anaerobic process of wastewater collected after the project activity.
		N ₂ O	No	Not significant, excluded for simplification
	Additional Transportation due to Project Activity	CO ₂	Yes	Emission from combustion of fossil fuel in transport vehicles.
		CH ₄	No	Not significant, excluded for simplification
		N ₂ O	No	Not significant, excluded for simplification
	Auxiliary Equipment	CO ₂	Yes	Emission from Grid Electricity or Fossil fuel
		CH ₄	No	Not significant, excluded for simplification
		N ₂ O	No	Not significant, excluded for simplification



Procedure for the selection of the most plausible baseline scenario

The most plausible baseline scenario is determined through the application of the steps described below. The most plausible baseline scenario shall be determined for, both, the fate of organic wastewater and the bioorganic solid waste separately.

Step 1: Draw up a list of possible realistic and credible alternatives for the treatment of the organic wastewater and bioorganic solid waste

Alternatives to be analysed should include, *inter alia*:

For organic wastewater:

- Continuation of current practice of using anaerobic lagoons or open storage tanks without methane recovery and flaring;
- Anaerobic lagoons or storage tanks with methane recovery and flaring;
- Anaerobic lagoons or storage tanks with methane recovery and utilization for electricity or heat generation;
- Building of a new anaerobic lagoon or open storage tanks without methane recovery and flaring;
- Building of a new anaerobic lagoon or open storage tanks with methane recovery and flaring;
- Using the organic wastewater for co-composting (The project activity implemented without CDM)
- Other treatment options provided in table 6.3, Volume 5, chapter 6 of the IPCC 2006 guidelines for greenhouse gas inventory.
- Other treatment options provided in table 6.3, Volume 5, chapter 6 of the IPCC 2006 guidelines for greenhouse gas inventory.

For bioorganic solid waste:

- Waste used for co-composting (the project activity implemented without CDM);
- Uncontrolled open burning;
- Waste returned to the plantation for mulching;
- Waste incinerated in controlled conditions or used for energy purposes including power generation;
- Waste disposed on a landfill without the capture of landfill gas;
- Waste disposed on a landfill where landfill gas is captured and flared;
- Waste disposed on a landfill where landfill gas is captured and electricity generated;
- Waste disposed on a landfill where landfill gas is captured and delivered to nearby industries for heat generation.

Step 2: Eliminate alternatives that are not complying with applicable laws and regulations

Eliminate alternatives that are not in compliance with all applicable legal and regulatory requirements. Apply Sub-step 1b of the latest version of the “Tool for demonstration assessment and of additionality” agreed by the CDM Executive Board.

***Step 3: Eliminate alternatives that face prohibitive barriers***

Scenarios that face prohibitive barriers should be eliminated by applying step 3 of the latest version of the “Tool for demonstration assessment and of additionality” agreed by the CDM Executive Board.

Step 4: Compare economic attractiveness of remaining alternatives

Compare the economic attractiveness without revenues from CERs for all alternatives that are remaining by applying Step 2 of the latest version of the “Tool for demonstration and assessment of additionality” agreed by the CDM Executive Board. The economic investment analysis shall use the IRR analysis, and explicitly state the following parameters:

- Incremental investment costs;
- O&M costs and
- All other costs of implementing the technology of the each alternative option;
- All revenues generated by the implementation of the technology except carbon revenues.

Compare the IRR of the different alternatives and select the most cost-effective alternative (i.e. with the highest IRR) as the baseline scenario. Include a sensitivity analysis applying Sub-step 2d of the latest version of the “Tool for demonstration assessment and of additionality” agreed by the CDM Executive Board. The investment analysis provides a valid argument that the most cost-effective scenario is the baseline scenario if it consistently supports (for a realistic range of assumptions) this conclusion. In case the sensitivity analysis is not fully conclusive, select the baseline scenario alternative with least emissions among the alternatives that are the most economically attractive according to the investment analysis and the sensitivity analysis.

Step 5: Assessment whether the identified baseline scenario is common practice

In the case where the baseline is a new to be built open lagoon or open storage tank demonstrate whether the identified baseline scenario is common practice (defined as at least 50% of the waste water treatment systems constructed during the last 5 years) in the relevant geographical area for similar industry (for example, municipal waste water, agro industry, pulp and paper). This group should at least comprise of 10 similar activities.

This methodology is only applicable if:

- The most plausible baseline scenario for treatment of the wastewater is the continuation of the use of open anaerobic lagoons or storage tanks throughout the crediting period or building of new anaerobic lagoons or open storage tanks; and
- The most plausible baseline of the treating bioorganic waste is landfilling.



Additionality

The additionality of the project activity shall be demonstrated and assessed using the latest version of the “**Tool for the demonstration and assessment of additionality**” agreed by the CDM Executive Board¹.

Baseline emissions

The following types of baseline emissions will be accounted under this methodology:

- Methane (CH₄) emissions from waste water in anaerobic lagoons or open storage tanks;
- Methane (CH₄) emissions from decay of bioorganic solid waste in disposal sites;
- CO₂ emissions from transportation of organic wastewater and bioorganic solid waste;
- CO₂ emissions from fossil fuels used for energy requirements and
- CO₂ emissions from grid electricity consumption.

Total baseline emissions are expressed as:

$$BE_y = BE_{CH_4,WW,y} + BE_{CH_4,SW,y} + BE_{CO_2,Trans,y} + BE_{CO_2,FF,y} + BE_{CO_2,Elec,y} \quad (1)$$

Where:

BE_y	Is the total baseline emissions during the year y , (tCO ₂ e)
$BE_{CH_4,WW,y}$	Is the baseline methane emissions from existing open lagoon or open storage tanks during the year y (tCO ₂ e)
$BE_{CH_4,SW,y}$	Is the baseline methane emissions from decay of bio-organic solid waste during the year y (tCO ₂ e)
$BE_{CO_2,Trans,y}$	Is the baseline CO ₂ emissions from transportation of organic wastewater and bioorganic solid waste during the year y (tCO ₂ e)
$BE_{CO_2,FF,y}$	Is the baseline CO ₂ emissions from use of fossil fuels during the year y (tCO ₂)
$BE_{CO_2,Elec,y}$	Is the baseline CO ₂ emissions from grid electricity consumption during the year y (tCO ₂)

The above emissions shall be calculated as explained below:

(a) Methane (CH₄) emissions from wastewater in open storage systems ($BE_{CH_4,WW,y}$)

The baseline methane emissions from anaerobic lagoons or storage tanks are estimated based on the chemical oxygen demand (COD) of the effluent that would enter the lagoon in the absence of the project activity, the maximum methane producing capacity (B_o) and a methane conversion factor (MCF) that expresses what proportion of the effluent would be anaerobically digested in the open lagoons.

These CH₄ emissions from wastewater should be calculated according to following procedure :

$$BE_{CH_4,WW,m} = COD_{available,m} \cdot B_o \cdot MCF_{baseline} \cdot GWP_{CH_4} \quad (2)$$

¹ Please refer to: <<http://cdm.unfccc.int/methodologies/PAmethodologies/approved.html>>



Where:

$BE_{CH_4, WW, m}$	Is the baseline monthly methane emissions from wastewater (tCO ₂ e)
$COD_{available, m}$	Is the monthly Chemical Oxygen Demand available for conversion which is equal to the monthly COD of the wastewater used for co-composting $COD_{baseline, m}$ plus COD carried on from the previous month (tCOD)
$COD_{baseline, m}$	Is the monthly Chemical Oxygen Demand of effluent entering anaerobic lagoons or storage tanks (measured in the project activity) (tCOD)
B_o	Is the maximum methane producing capacity of the inlet effluent (tCH ₄ /tCOD)
$MCF_{baseline}$	Is the methane conversion factor of the baseline storage system (fraction)
GWP_{CH_4}	Is the Global Warming Potential of methane, default value 21

$COD_{baseline, m}$ is to be directly measured in the project as the baseline activity level since the effluent that goes into the anaerobic lagoon or storage tanks in the baseline situation is the same as the one that goes into the project. $COD_{baseline, m}$ is calculated as the product of $COD_{c, baseline}$ concentration (kgCOD/m³) in the wastewater input to the project and the flow rate F_{dig} (m³/month).

In case there is an effluent from the lagoons where the wastewater does not reside for at least 30 days in the baseline, $COD_{baseline}$ values should be adjusted by multiplying $COD_{baseline}$ by the following factor AD:

$$AD = 1 - \left(\frac{COD_{a, out}}{COD_{a, in}} \right) \quad (3)$$

Where:

$COD_{a, out}$	Is the COD that leaves the lagoon with the effluent that does not reside for at least 30 days
$COD_{a, in}$	Is the COD that enters the lagoon

$COD_{a, out}$ and $COD_{a, in}$ should be based on one year historical data

The amount of organic matter available for conversion to methane $COD_{available, m}$ is assumed to be equal to the amount of organic matter produced during the month ($COD_{baseline, m}$ input to the project) plus the organic matter that may remain in the system from previous months.

The amount of organic matter consumed during the month is equal to the amount available for conversion $COD_{available, m}$ multiplied by $MCF_{monthly}$.

The amount of organic matter carried over from one month to the next equals to the amount available for conversion minus the amount consumed and minus the amount removed from the anaerobic lagoon or storage tank. In the case of the emptying of the anaerobic lagoon or storage tank, the accumulation of organic matter restarts with the next inflow.

Carry on calculations are limited to a maximum of one year. In case the residence time is less than one-year carry-on calculations are limited to this period where the organic wastewater resides in the anaerobic lagoon or storage tank. Project participants should provide evidence of the residence time of the organic matter in the anaerobic lagoon or storage tank.

In the case where the baseline is a new to be built anaerobic lagoon or storage tank, the residence time should be verified based on a literature review of country/region to establish an average lagoon depth for a particular industry. If such literature does not exist, conduct a survey within the industry based on a control



group of the five most recently built lagoon systems identified in the lagoon systems identified in the common practice test of the baseline scenario selection procedure (step 5). Alternatively the project developer shall discount 20% of the CERs.

The default IPCC value for B_0 , the maximum amount of CH_4 that can be produced from a given quantity of wastewater, is 0.25 kg CH_4 /kg COD. Taking into account the uncertainty of this estimate, project participants should use a value of 0.21 kg CH_4 /kg COD² as a conservative assumption for B_0 .

$MCF_{baseline,m}$ is estimated as the product of the fraction of anaerobic degradation due to depth (f_d) and the fraction of anaerobic degradation due to temperature (f_t):

$$MCF_{baseline,m} = f_d \cdot f_{t,monthly} \cdot 0.89 \quad (4)$$

Where:

f_d Is the fraction of anaerobic degradation due to depth as per Table 1

f_t Is the fraction of anaerobic degradation due to temperature

0.89 Is an uncertainty conservativeness factor (for an uncertainty range of 30% to 50%) to account for the fact that the equation used to estimate $f_{t,monthly}$ assumes full anaerobic degradation at 30 °C

	Deep > 5m	Medium depth 1–5m	Small depth <1m
Fraction of degradation under anaerobic conditions due to depth of anaerobic lagoons or storage tank	70%	50%	0

In the case where the baseline is a new to be built anaerobic lagoon or storage tank, the depth should be verified based on a literature review of country/region to establish an average lagoon depth for a particular industry. If such literature does not exist, conduct a survey within the industry based on a control group of the five most recently built lagoon systems identified in the lagoon systems identified in the common practice test of the baseline scenario identification procedure (step 5). If the average depth of lagoons within the industry is at least 5 meters, the 70% factor can be used. Alternatively the 50% value can be chosen as a default value.

Establish for the specific location what the lowest cost option is for the lagoon in terms of surface and depth. Take into account legal requirements and the ground water level at the project site, e.g., if legal requirements state that lagoons must be at least 2 meters above ground water level, you can only use the 70% factor if the ground water is at least 7 meters deep, and if cost analysis shows that a lagoon of more than 5 meters is the most cost effective option.

² Lowest value provided by IPCC Good Practice guidance, 2000, Page 5.19



$f_{t,monthly}$ is calculated as follows:

$$f_{t,monthly} = \exp \left[\frac{E \cdot (T_2 - T_1)}{R \cdot T_1 \cdot T_2} \right] \quad (5)$$

Where:

$f_{t,monthly}$	Anaerobic degradation factor due to temperature
E	Activation energy constant (15,175 cal/mol)
T_2	Ambient temperature (Kelvin) for the climate
T_1	303.16 (273.16° + 30°)
R	Ideal gas constant (1.987 cal/ K mol).

The factor ' $f_{t,monthly}$ ' represents the proportion of organic matter that is biologically available for conversion to methane based upon the temperature of the system. The assumed temperature is equal to the ambient temperature. The value of f_t to be used cannot exceed unity.

Monthly values for $f_{t,monthly}$ is calculated as follows:

- (1) The monthly average temperature for the area is obtained from published national weather service information.
- (2) Monthly temperatures are used to calculate a monthly van't Hoff – Arrhenius ' $f_{t,monthly}$ ' factor above.

A minimum temperature of 10 °C is used. Months where the average temperature is less than 10 °C, $f_{t,monthly} = 0$. The value of $f_{t,monthly}$ to be used cannot exceed unity.

It is the possible to calculate the MCF both monthly and annual.

Annual MCF can be estimated from the following equation:

$$MCF_{annual} = \frac{\sum_{m=1}^{12} CH_{4,m}}{B_o \cdot \sum_{m=1}^{12} COD_{baseline,m}} \quad (6)$$

Monthly baseline CH_4 emissions ($BE_{CH_4,WW,m, WW,m}$) shall be aggregated into annual emissions as follows:

$$BE_{CH_4,WW,y} = \sum_{m=1}^{12} BE_{CH_4,WW,m} \quad (7)$$

Where:

$BE_{CH_4,WW,y}$	Is the estimated annual methane production in tCO ₂ e, during the year y
$BE_{CH_4,WW,m}$	Is the estimated monthly methane production in tCO ₂ e

(b) Methane (CH_4) emissions from decay of bioorganic solid waste in disposal sites ($BE_{CH_4,SW,y}$)



The amount of methane that would be generated each year in absence of project activity ($BE_{CH_4,SW,y}$) is calculated as per the following equation:

$$BE_{CH_4,SW,y} = BE_{CH_4,SWDS,y} - MD_{reg} \quad (8)$$

Where:

$BE_{CH_4,SWDS,y}$ Methane generation from the landfill in the absence of the project activity at year “y” calculated as per the “*Tool to determine methane emissions avoided from dumping waste at a solid waste disposal site*”. The tool estimates methane generation adjusted for, using adjustment factor (f) any landfill gas in the baseline that would have been captured and destroyed to comply with relevant regulations or contractual requirements, or to address safety and odour concerns. As this is already accounted for in equation 8, “f” in the tool shall be assigned a value 0.

MD_{reg}

In cases where regulatory or contractual requirements do not specify $MD_{reg,y}$, an Adjustment Factor (AF) shall be used and justified, taking into account the project context. In doing so, the project participant should take into account that some of the methane generated by the landfill may be captured and destroyed to comply with other relevant regulations or contractual requirements, or to address safety and odour concerns.

$$MD_{reg,y} = BE_{CH_4,SW,y} \cdot MB_y \cdot AF \quad (9)$$

Where:

AF is Adjustment Factor for $BE_{CH_4,SW,y}$ (%)

AF is defined as the ratio of the destruction efficiency of the collection and destruction system mandated by regulatory or contractual requirement to that of the collection and destruction system in the project activity. The ‘Adjustment Factor’ shall be revised at the start of each new crediting period taking into account the amount of GHG flaring that occurs as part of common industry practice and/or regulation at that point in the future. In some situations the landfill gas may be collected and destroyed previous to implementation of project activity for reasons other than regulation or contracts. The project participants provide clear data/estimation procedure to estimate the fraction of such landfill gas destroyed and report in the CDM-PDD.

(c) CO_2 emissions from transportation of organic wastewater and bioorganic solid waste ($BE_{CO_2,FF,y}$)

The baseline emissions from transportation are to be calculated using distance travelled by trucks and the fuel emission factor, as follows:

$$BE_{CO_2,Trans,y} = \sum_i N_{vehicles,i,y} \cdot Dist_{i,y} \cdot FC_{i,Trans} \cdot NCV_i \cdot EF_{CO_2,i} \quad (10)$$

Where:

$N_{vehicles,i,y}$ Is the number of vehicle trips used for transportation, with similar loading capacity
 $Dist_{i,y}$ Is the average distance per trip travelled by transportation vehicles type i in the baseline scenario during the year y (km)
 FC_i Is the vehicle fuel consumption in volume or mass units per km for vehicle type i



NCV_i Is the net calorific value of fuel type *i* in TJ per volume or mass units
 EF_{CO₂,i} Is the CO₂ emission factor of the fossil fuel type *i* used in transportation vehicles,
 (tCO₂e/TJ)

(d) CO₂ emissions from fossil fuels used for energy requirements ($BE_{CO_2,FF,y}$)

CO₂ emissions from fossil fuel used in the baseline for energy requirements such as heating shall be calculated as follows:

$$BE_{CO_2,FF,y} = \sum_i FC_{i,y} \cdot NCV_i \cdot EF_{CO_2,i} \quad (11)$$

Where:

FC_{i,y} Is the baseline fossil fuels consumed of type *i* for energy requirements during the year *y* in mass or volume units
 NCV_i Is the Net Calorific Value (energy content) in TJ of fuel type *i*, per mass unit or volume unit
 EF_{CO₂i} Is the CO₂ emission factor per unit of energy of the fuel *i* (tCO₂e/TJ)

Where available, local values of NCV_i and EF_{CO₂,i} should be used. If no such values are available, country-specific values (see e.g. IPCC Good Practice Guidance) are preferable to latest version of IPCC Guidelines.

(e) CO₂ emissions from grid electricity consumption ($BE_{CO_2,Elec,y}$)

In case electricity is consumed for energy requirements in the baseline, CO₂ emissions from electricity consumption shall be calculated as follows:

$$BE_{CO_2,Elec,y} = EC_y \cdot EF_{GridElec,y} \quad (12)$$

Where:

EC_y is the baseline electricity consumption during the year *y* (MWh)
 EF_{GridElec,y} is the grid electricity emission factor for the year *y* (tCO₂/MWh)

In cases where electricity is purchased from the grid, the emission factor EF_{GridElec,y} should be calculated according to the “Tool for calculation of emission factor for electricity systems”³.

Project emissions

The following types of project emissions will be accounted under this methodology:

- N₂O emissions from composting process
- CH₄ emissions from composting process
- CH₄ emissions from leaked waste water
- CO₂ emissions from transportation
- CO₂ emissions from fossil fuels consumption
- CO₂ emissions from grid electricity consumption

³ Please refer to <http://cdm.unfccc.int/goto/MPappmeth>



Total project emissions are expressed as:

$$PE_y = PE_{N_2O,Comp,y} + PE_{CH_4,Comp,y} + PE_{CH_4,Bww,y} + PE_{CO_2,Trans,y} + PE_{CO_2,FF,y} + PE_{CO_2,Elec,y} \quad (13)$$

Where:

PE_y	Is the total project emissions during the year y , (tCO ₂ e)
$PE_{N_2O,Comp,y}$	Is the N ₂ O emissions from composting of bio-organic solid waste during the year y (tCO ₂ e)
$PE_{CH_4,Comp,y}$	Is the CH ₄ emissions from composting of bio-organic solid waste during the year y (tCO ₂ e)
$PE_{CH_4,Bww,y}$	Is the CH ₄ emissions from leaked waste water discharged after the project activity during the year y (tCO ₂ e)
$PE_{CO_2,Trans,y}$	Is the CO ₂ emissions from transportation in the project situation during the year y (tCO ₂ e)
$PE_{CO_2,FF,y}$	Is the CO ₂ emissions from use of fossil fuels in the project situation during the year y (tCO ₂)
$PE_{CO_2,Elec,y}$	Is the CO ₂ emissions from grid electricity consumption in project situation during the year y (tCO ₂)

The above emissions shall be calculated as explained below:

(a) *N₂O emissions from composting ($PE_{N_2O,Comp,y}$):*

N₂O emissions from composting during the year y are calculated as follows:

During the storage of waste in collection containers as part of the composting process itself and during the application of compost, N₂O emissions might occur. Project Participants should use a default N₂O emission factor of 0.043 kg N₂O per tonne of compost and calculate emissions as follows⁴:

$$PE_{N_2O,Comp,y} = Q_{Compost,y} \cdot EF_{N_2O,Comp} \cdot GWP_{N_2O} \quad (14)$$

Where:

$Q_{Compost,y}$	is the total quantity of compost produced during the year y , (tons of compost)
$EF_{N_2O,Comp}$	is the emission factor for N ₂ O emissions from composting process (tN ₂ O/ton of compost)
GWP_{N_2O}	is the global warming potential of N ₂ O, default value 310

(b) *CH₄ emissions from composting ($PE_{CH_4,Comp,y}$):*

During the composting process, aerobic conditions are neither completely reached in all areas nor at all times. Pockets of anaerobic conditions – isolated areas in the composting heap where oxygen concentrations are so low that the biodegradation process turns anaerobic – may occur. The emission

⁴ Manfred K. Schenk, Stefan Appel, Diemo Daum, “N₂O emissions during composting of organic waste”, Institute of Plant Nutrition University of Hannover, 1997. Based upon Schenk⁴ and others, a total loss of 42 mg N₂O-N per kg composted dry matter can be expected (from which 26.9 mg N₂O during the composting process). The dry matter content of compost is around 50% up to 65%. Assuming 650 kg dry matter per ton of compost and 42 mg N₂O-N, and given the molecular relation of 44/28 for N₂O-N, an emission factor of 0.043 kg N₂O / tonne compost results.



behavior of such pockets is comparable to the anaerobic situation in a landfill. This is a potential emission source for methane similar to anaerobic conditions, which occur in unmanaged landfills. Through predetermined sampling procedures the percentage of waste that degrades under anaerobic conditions can be determined. Using this percentage, project methane emissions from composting process are calculated, as follows:

$$PE_{CH_4,Comp,y} = PE_{CH_4,Anaerobic,y} \cdot GWP_{CH_4} \cdot S_{a,y} \quad (15)$$

Where:

- $PE_{CH_4,Anaerobic,y}$ Is the quantity of methane that would be generated from anaerobic pockets in the composting process, during the year y (tCH₄)
- GWP_{CH_4} Is the global warming potential of CH₄, default value 21
- $S_{a,y}$ Is the share of waste that degrades under anaerobic conditions in the composting plant during the year y (%)

The amount of methane that is generated in anaerobic pockets ($PE_{CH_4,Anaerobic,y}$) is calculated for each year with a multi-phase model. The model is based on a first order decay equation. It differentiates between the different types of waste j with respectively different decay rates k_j (fast, moderate, slow) and fraction of degradable organic carbon (DOC _{j}). The model calculates the methane generation based on the actual waste streams $A_{project,j,x}$ disposed in the most recent year (y) and all previous years since the project start ($x=1$ to $x=y$). The amount of methane produced is calculated as follows:

$$PE_{CH_4,Anaerobic,y} = \varphi \cdot \frac{16}{12} \cdot F \cdot DOC_f \cdot MCF \cdot GWP_{CH_4} \cdot \sum_{x=1}^y \sum_{j=A}^D A_{project,j,x} \cdot DOC_j \cdot (1 - e^{-k_j}) \cdot e^{-k_j(y-x)} \quad (16)$$

Variables used in the above equation are analogous to those of equation 8.

Project participants should use 0.8 as default MCF, unless they can demonstrate that the project-scenario is an aerobic composting of the solid biomass waste with a much lower MCF value.

Calculation of $S_{a,y}$:

$S_{a,y}$ is determined by a combination of measurements and calculations. Bokhorst et al⁵ and Richard et al⁶ show that if oxygen content is below 5% - 7.5%, aerobic composting processes are replaced by anaerobic processes. To determine the oxygen content during the process, project participants shall measure the oxygen content according to a predetermined sampling scheme and frequency.

These measurements should be undertaken for each year of the crediting period and recorded each year.

The percentage of the measurements that show oxygen content below 10%⁷ is presumed to be equal to the

⁵ Jan Bokhorst. Coen ter Berg – Mest & Compost Behandelen beoordelen & Toepassen (Eng: Manure & Compost – Treatment, judgement and use), Louis Bolk Instituut, Handbook under number LD8, Oktober 2001

⁶ Tom Richard, Peter B. Woodbury, Cornell composting, operating fact sheet 4 of 10, Boyce Thompson Institute for Plant Research at Cornell University Cornell University

⁷ By adding 20% uncertainty to the maximum value of 7.5% from the research literature mentioned above, 10% is selected as a conservative value.



share of waste that degrades under anaerobic conditions (i.e. that degrades as if it were landfilled), hence the emissions caused by this share are calculated as project emissions *ex-post* on an annual basis:

$$S_{a,y} = SOD_y / S_{total,y}$$

Where:

SOD_y Is the number of samples in year y with an oxygen deficiency (i.e. oxygen content below 10%)

$S_{total,y}$ Is the total number of samples taken in year y , where $S_{total,y}$ should be chosen in a manner that ensures the estimation of $S_{a,y}$ with 20% uncertainty at a 95% confidence level.

(c) CH_4 emissions from the leaked wastewater ($PE_{CH_4,bww,y}$):

Projects such as composting will usually have no wastewater discharge but there is a possibility that a small quantity of leaked wastewater is collected from windrows or as a balance of waste water and this leak wastewater may cause CH_4 emissions.

CH_4 emissions from leak and/or balance of waste water shall be calculated as follows.

$$PE_{CH_4,BWW,y} = COD_{outlet,total,y} \cdot B_o \cdot MCF_{outlet} \cdot GWP_{CH_4} \quad (17)$$

Where:

$PE_{CH_4,BWW,y}$ Is the project methane emissions from wastewater during the year y (tCO₂e)

$COD_{outlet,total,y}$ Is the outlet total COD of the wastewater during the year y (tCOD)

B_o Is the outlet maximum methane producing capacity of wastewater (tCH₄/tCOD)

MCF_{outlet} Is the methane conversion factor of the storage system (fraction)

GWP_{CH_4} Is the Global Warming Potential of methane

MCF_{outlet} is to be estimated in the same manner as that of $MCF_{baseline,m}$ in the baseline.

(d) CO_2 emissions from transportation ($PE_{CO_2,Trans,y}$):

The project emissions from transportation are to be calculated using the total distance and local, national or latest version of IPCC Guidelines default values for transportation fuel, as follows:

$$PE_{CO_2,Trans,y} = \sum_i N_{vehicles,i,y} \cdot Dist_{i,y} \cdot FC_i \cdot NCV_i \cdot EF_{CO_2,i} \quad (18)$$

Where:

$N_{vehicles,i,y}$ Is the number of vehicle trips used for transportation, with similar loading capacity

$Dist_{i,y}$ Is the average distance per trip travelled by transportation vehicles type i in the project scenario during the year y (km)

FC_i Is the vehicle fuel consumption in volume or mass units per km for vehicle type i

NCV_i Is the net calorific value of fuel type i in TJ per volume or mass units

$EF_{CO_2,i}$ Is the CO₂ emission factor of the fossil fuel type i used in transportation vehicles, (tCO₂e/TJ)

*(e) CO₂ emissions from fossil fuels used for energy requirements ($PE_{CO_2,FF,y}$)*

CO₂ emissions from fossil fuel used in the project for energy requirements such as heating shall be calculated as follows:

$$PE_{CO_2,FF,y} = \sum_i FC_{i,project,y} \cdot NCV_i \cdot EF_{CO_2,i} \quad (19)$$

Where:

$FC_{i,project,y}$ Is the fossil fuels consumed of type i for energy requirements during the year y in mass or volume units

NCV_i Is the Net Calorific Value (energy content) in TJ of fuel type i , per mass unit or volume unit

EF_{CO_2i} Is the CO₂ emission factor per unit of energy of the fuel i . (tCO₂e/TJ)

Where available, local values of NCV_i and $EF_{CO_2,i}$ should be used. If no such values are available, country-specific values (see e.g. IPCC Good Practice Guidance) are preferable to latest version of IPCC Guidelines world-wide default values.

(f) CO₂ emissions from electricity consumption ($PE_{CO_2,Elec,y}$):

In case electricity is consumed for energy requirements in the baseline, CO₂ emissions from electricity consumption shall be calculated as follows:

$$PE_{CO_2,Elec,y} = EC_{project,y} \cdot EF_{GridElec,y} \quad (20)$$

Where:

$EC_{project,y}$ Is the project electricity consumption during the year y (MWh)

$EF_{GridElec,y}$ Is the grid electricity emission factor for the year y (tCO₂/MWh)

In cases where electricity is purchased from the grid, the emission factor $EF_{GridElec,y}$ should be calculated according to “Tool for calculation of emission factor for electricity systems”.

Leakage

No leakage effects need to be accounted under this methodology.

**Emission reductions**

Emission reductions are calculated as follows:

$$ER_y = BE_y - PE_y - LE_y \quad (21)$$

Where:

ER_y = Emission reductions during the year *y* (tCO₂/yr)

BE_y = Baseline emissions during the year *y* (tCO₂/yr)

PE_y = Project emissions during the year *y* (tCO₂/yr)

LE_y = Leakage emissions during the year *y* (tCO₂/yr)

Changes Required For Methodology Implementation In 2nd And 3rd Crediting Periods

Project participants shall check for updates of default values of IPCC used in this methodology. In case the default values are revised by IPCC, project participants shall use only revised values during methodology implementation in 2nd and 3rd crediting periods.

Data and parameters not monitored

Data / parameter:	Dist_v
Data unit:	Km
Description:	Total distance travelled in a year
Source of data:	Host facility
Measurement procedures (if any):	Based on estimation of actual distance used for transportation in the baseline.
QA/QC procedures:	
Any comment:	Estimate by an expert.

Data / parameter:	FC_{i,v}
Data unit:	tons or m ³ (mass or volume units)
Description:	Amount of fossil fuels consumed in the baseline
Source of data:	Host facility
Measurement procedures (if any):	Based on the onsite data sheets recorded prior to the project implementation
QA/QC procedures:	
Any comment:	



Data / parameter:	EC_v
Data unit:	MWh
Description:	Amount of electricity consumed in the baseline
Source of data:	Host facility
Measurement procedures (if any):	Based on the on-site record for power meter readings.
QA/QC procedures:	
Any comment:	

Data / parameter:	EF_{GridElec,v}
Data unit:	tCO ₂ e/MWh
Description:	Grid electricity emission factor
Source of data:	Host facility
Measurement procedures (if any):	Obtained from the latest local statistics or calculated <i>ex ante</i> using latest version of approved tool “Tool for calculation of emission factor for electricity systems”.
QA/QC procedures:	
Any comment:	Applicable for both for baseline and project situation

Data / parameter:	COD_{a,out}
Data unit:	tCOD
Description:	COD of the effluent that leaves the lagoon in the baseline situation
Source of data:	Host facility
Measurement procedures (if any):	Obtained from the most recent year prior to the implementation of the project activity
QA/QC procedures:	
Any comment:	

Data / parameter:	COD_{a,in}
Data unit:	tCOD
Description:	COD that enters the lagoon in the baseline situation
Source of data:	Host facility
Measurement procedures (if any):	Obtained from the most recent year prior to the implementation of the project activity
QA/QC procedures:	
Any comment:	



III. MONITORING METHODOLOGY

Monitoring procedures

Baseline emissions

The following parameters have been included in the monitoring plan for baseline emissions.

1. $COD_{inlet,total,y}$: Total COD of the organic wastewater produced by the process during the year y
2. F : Fraction of methane in landfill gas

All other data items used in the methodology procedure are either not monitored or obtained from IPCC default values. IPCC default values are provided in respective procedures in this methodology.

Project emissions

The following parameters have been included in the monitoring plan for project emissions.

1. $COD_{outlet,total,y}$: COD of the effluent at the outlet of the project activity
2. $A_{project,j,x}$: Amount of organic waste type j , used in co-composting
3. $Dist_{project,y}$: Distance travelled by transportation vehicles
4. $FC_{i,project,y}$: Amount of fossil fuels consumed by the project for thermal energy requirements
5. $EC_{project,y}$: Amount of electricity consumed by the project for auxiliary equipment
6. SOD : Number of samples per year with Oxygen deficiency
7. S_{total} : Number of total samples
8. $Q_{compost,y}$: Amount of compost produced in a year

All other data items used in the methodology procedure are either not monitored or obtained from IPCC default values. IPCC default values are provided in respective procedures in this methodology.

All the above data items are measured in the host facility. All data will be available for 2 years after the crediting period. Other data and parameters in the methodology are obtained from IPCC. Default values are provided in the methodology procedure. More details on the above parameters are provided in the table below.

Leakage

Monitoring of leakage is not applicable under this methodology.

**Data and parameters monitored****Baseline emissions:**

Data / parameter:	COD_{baseline,m}
Data unit:	tons of COD
Description:	COD at the inlet of the project activity
Source of data:	Host facility
Measurement procedures (if any):	Calculated as the product of COD concentration in ton COD/m ³ in the wastewater input to the project activity and the flow rate of wastewater in m ³ /year.
Monitoring frequency:	Monthly
QA/QC procedures:	COD concentration is to be measured monthly using sampling techniques and flow rate is to be measured continuously. Sampling to be carried out adhering to internationally recognized procedures. Flow meters undergo maintenance/calibration subject to appropriate industry standards.
Any comment:	

Data / parameter:	F
Data unit:	fraction
Description:	Fraction of methane in landfill gas
Source of data:	On-site measurements
Measurement procedures (if any):	
Monitoring frequency:	Annually
QA/QC procedures:	
Any comment:	This parameter to be used in the order of preference as below. 1. Annually measured value, 2. Measured at once before prior to the start of the project activity 3. default value of 0.5.

Project emissions:

Data / parameter:	COD_{outlet,total,v}
Data unit:	tons of COD
Description:	COD at the outlet of the project activity
Source of data:	Host facility
Measurement procedures (if any):	Calculated as the product of COD concentration in ton COD/m ³ in the wastewater outlet from the project activity and the flow rate of wastewater in m ³ /year.
Monitoring frequency:	Monthly
QA/QC procedures:	COD is measured using sampling techniques. Sampling will be carried out adhering to internationally recognized procedures. Flow meters undergo maintenance/calibration subject to appropriate industry standards.
Any comment:	



Data / parameter:	$A_{\text{project},i,x}$
Data unit:	tonnes
Description:	Amount of organic waste type j disposed in landfill in the year x
Source of data:	Host facility
Measurement procedures (if any):	On-site data sheets recorded monthly using weigh bridge
Monitoring frequency:	Monthly
QA/QC procedures:	Weighbridge will be subject to periodic calibration (in accordance with stipulation of the weighbridge supplier).
Any comment:	

Data / parameter:	$\text{Dist}_{i,y}$
Data unit:	km
Description:	Distance travelled per trip during the year y
Source of data:	Host facility
Measurement procedures (if any):	Based on the estimation of actual distance used for transportation in the project activity.
Monitoring frequency:	Yearly
QA/QC procedures:	
Any comment:	

Data / parameter:	$\text{FC}_{i,\text{project},y}$
Data unit:	tons or m^3 (mass or volume units)
Description:	Fossil fuels of type i consumed by the project for energy requirements during the year y ,
Source of data:	Host facility
Measurement procedures (if any):	On-site data sheets recorded according to the monitoring frequency
Monitoring frequency:	Monthly
QA/QC procedures:	Data will be acquired based on measurement of quantity of fuel used. Measurement equipment / meters will be calibrated according to the suppliers specifications
Any comment:	



Data / parameter:	FC_{i,trans,y}
Data unit:	tons or m ³ (mass or volume units)
Description:	Fossil fuels of type <i>i</i> consumed by the project for transportation during the year <i>y</i> ,
Source of data:	Host facility
Measurement procedures (if any):	On-site data sheets recorded according to the monitoring frequency
Monitoring frequency:	Monthly
QA/QC procedures:	Data will be acquired based on measurement of quantity of fuel used. Measurement equipment / meters will be calibrated according to the suppliers specifications.
Any comment:	

Data / parameter:	N_{vehicles,i,y}
Data unit:	Number
Description:	Number of vehicle trips used for transportation, of fuel type <i>i</i> , during the year <i>y</i> ,
Source of data:	Host facility
Measurement procedures (if any):	On-site monitoring records
Monitoring frequency:	Daily
QA/QC procedures:	
Any comment:	Applicable for both project situation and baseline situation.

Data / parameter:	EC_{Project,y}
Data unit:	MWh
Description:	Amount of electricity consumed
Source of data:	Host facility
Measurement procedures (if any):	On-site data sheets recorded according to the monitoring frequency
Monitoring frequency:	Continuously
QA/QC procedures:	Data will be acquired based on measurement of electricity consumed. Meters will be calibrated according to the suppliers specification.
Any comment:	

Data / parameter:	EF_{GridElec,y}
Data unit:	tCO ₂ e/MWh
Description:	Grid electricity emission factor during the project situation
Source of data:	Host facility
Measurement procedures (if any):	Calculated as per the most recent version of the approved tool “Tool for calculation of emission factor for electricity systems”.
Monitoring frequency:	Yearly
QA/QC procedures:	Data obtained from latest local / regional statistics and calculated as per “Tool for calculation of emission factor for electricity systems”
Any comment:	



Data / parameter:	SOD_y
Data unit:	Number
Description:	Number of samples with Oxygen deficiency
Source of data:	Host facility
Measurement procedures (if any):	Samples with Oxygen content less than 10%. Measurement itself to be done by using a standardised mobile gas detection instrument.
Monitoring frequency:	Depends on the frequency of S _{total,y}
QA/QC procedures:	O ₂ measurement instrument will be subjected to periodic calibration (in accordance with stipulation of instrument supplier). A statistically significant sampling procedure will be setup that consists of multiple measurements throughout different stages of the composting process according to a predetermined pattern (depths and scatter).
Any comment:	

Data / parameter:	S_{total,y}
Data unit:	Number
Description:	Total number of samples
Source of data:	Host facility
Measurement procedures (if any):	Total number of samples taken in year y. Measurement itself to be done by using a standardised mobile gas detection instrument.
Monitoring frequency:	S _{total,y} should be chosen in a manner that ensures estimation of S _{a,y} with 20% uncertainty at 95% confidence level
QA/QC procedures:	O ₂ measurement instrument will be subjected to periodic calibration (in accordance with stipulation of instrument supplier). A statistically significant sampling procedure will be setup that consists of multiple measurements throughout different stages of the composting process according to a predetermined pattern (depths and scatter).
Any comment:	

Data / parameter:	Q_{compost,y}
Data unit:	tons
Description:	Quantity of compost produced during the year y
Source of data:	Host facility
Measurement procedures (if any):	On-site data sheets recorded according to the monitoring frequency
Monitoring frequency:	Monthly
QA/QC procedures:	Weighed on calibrated scale; also cross check with sales of compost
Any comment:	
