CLEAN DEVELOPMENT MECHANISM

ACM0024

Large-Scale Consolidated Methodology

Natural gas substitution by biogenic methane produced from the anaerobic digestion of organic waste

Version 01.0

Sectoral scope(s): 1 and 13

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1. Introduction

1. The following table describes the key elements of the methodology:

Table 1. Methodology key elements

Typical project(s)	This methodology applies to project activities where organic waste (e.g. vinasse, organic MSW, etc.) is treated by anaerobic digestion. The resulted output is upgraded and used to replace natural gas in a natural gas distribution system
Type of GHG emissions mitigation action	Carbon dioxide. Displacement of use of natural gas

2. Scope, applicability, and entry into force

2.1. Scope

2. This methodology applies to project activities where organic waste is treated by anaerobic digestion and biogas is upgraded and used to replace natural gas. The project activity may claim emission reductions for displacing natural gas in a natural gas distribution system, which includes transportation by trucks and/or pipelines, with upgraded biogas.

2.2. Applicability

3. The project activity involves the construction of an anaerobic digester and a biogas processing facility.

4. The waste treated by anaerobic digestion is organic waste excluding hospital waste.

5. The project does not reduce the amount of waste that would be recycled in the absence of the project activity. Detailed justifications shall be provided and documented in the CDM-PDD for demonstrating that the project activity does not reduce the amount of waste that would be recycled in the absence of the project activity.

6. Resulting digestate is further stabilized aerobically (e.g. composted), applied to land or sent to a solid waste disposal site (SWDS). If the resulting digestate is further stabilized through composting, the run-off wastewater, if any, shall be further treated aerobically.

7. Neither organic waste nor products and by-products from the anaerobic digester established under the project activity are stored on-site under anaerobic conditions.

8. In addition, the applicability conditions included in the tools referred to below apply.

9. Finally, the methodology is only applicable if the procedure for the selection of the most plausible baseline scenario, as outlined below, results in that the baseline scenario is the supply of natural gas to a natural gas distribution system.

2.3. Entry into force

10. The date of entry into force is the date of the publication of the EB 77 meeting report on 21 February 2014.

3. Normative references

11. This baseline and monitoring methodology is based on the following proposed new methodologies:

    (a) "NM0367: Fossil natural gas substitution by renewable natural gas produced from the anaerobic digestion of organic waste";

    (b) "NM0368: Renewable natural gas production from vinasse anaerobic digestion".

12. This methodology also refers to the latest approved versions of the following tools and methodologies:

    (c) The methodological tool "Combined tool to identify the baseline scenario and demonstrate additionality";

    (d) The methodological tool "Tool to calculate project or leakage CO_2 emissions from fossil fuel combustion";

    (e) The methodological tool "Project and leakage emissions from transportation of freight";

    (f) The methodological tool "Upstream leakage emissions associated with fossil fuel use";

    (g) The methodological tool "Assessment of the validity of the original/current baseline and update of the baseline at the renewal of the crediting period";

    (h) The methodological tool "Project and leakage emissions from anaerobic digestion";

13. For more information regarding the proposed new methodology and the tools as well as their consideration by the Executive Board (hereinafter referred to as the Board) of the clean development mechanism (CDM) please refer to <http://cdm.unfccc.int/methodologies/PAmethodologies/index.html>.

4. Definitions

14. The definitions contained in the Glossary of CDM terms shall apply.

15. For the purpose of this methodology, the following definitions apply:

    (a) **Anaerobic digester** - equipment that is used to generate biogas from liquid or solid waste through anaerobic digestion. The digester is covered or encapsulated to enable biogas capture for flaring, heat and/or power generation or feeding biogas into a natural gas distribution system. The following types of digesters are considered:

(i) Covered anaerobic lagoons: anaerobic lagoons that are covered with a flexible membrane to capture methane produced during the digestion process. Covered anaerobic lagoons are typically used for high volume effluent such as animal manure and organic industrial effluent like starch industry effluent;

(ii) Conventional digesters: digesters that are operated similar to a covered anaerobic lagoon, with no mixing or liquid and biogas recirculation;

(iii) High rate digesters, such as up-flow anaerobic sludge blanket (UASB) reactors, anaerobic filter bed reactors and fluidized bed reactors;

(iv) Two stage digesters: anaerobic digestion takes place in a two stage process, solubilization of particulate matter occurs and volatile acids are formed in the first stage digester. The second stage is carried out in a separate digester, at a neutral pH and a longer solid retention time;

(b) **Anaerobic digestion** - degradation and stabilization of organic materials by the action of anaerobic bacteria that result in production of methane and carbon dioxide. Typical organic materials that undergo anaerobic digestion are municipal solid waste (MSW), animal manure, wastewater, organic industrial effluent and bio-solids from aerobic wastewater treatment plants;

(c) **Anaerobic lagoon** - a treatment system consisting of a deep earthen basin with sufficient volume to permit sedimentation of settable solids, to digest retained sludge, and to anaerobically reduce some of the soluble organic substrate. Anaerobic lagoons are not aerated, heated, or mixed and anaerobic conditions prevail except possibly for a shallow surface layer in which excess undigested grease and scum are concentrated;

(d) **Biogas** - gas generated from a digester. Typically, the composition of the gas is 50 to 70 per cent CH_4 and 30 to 50 per cent CO_2, with traces of H2S and NH3 (1 to 5 per cent).

(e) **Biomass** - biomass is non-fossilized and biodegradable organic material originating from plants, animals and microorganisms. This includes products, by-products, residues and waste from slaughterhouses, cattle-raising, agriculture, forestry and related industries as well as the non-fossilized and biodegradable organic fractions of industrial and municipal wastes. Biomass also includes gases and liquids recovered from the decomposition of non-fossilized and biodegradable organic material;

(f) **Composting** - a process of biodegradation of waste under aerobic (oxygen-rich) conditions. Waste that can be composted must contain solid biodegradable organic material. Composting converts biodegradable organic carbon to mostly carbon dioxide (CO_2) and a residue (compost) that can be used as a fertilizer. Other outputs from composting can include, inter alia, methane (CH_4), nitrous oxide (N_2O), and run-off wastewater (in case of co-composting);

(g) **Digestate** - spent contents of an anaerobic digester. Digestate may be liquid, semi-solid or solid. Digestate may be further stabilized aerobically (e.g. composted), applied to land, sent to a solid waste disposal site (SWDS), or kept in a storage or evaporation pond;

(h) **Fresh waste** - solid waste that is intended for disposal in a SWDS but has not yet been disposed. This may comprise MSW and excludes old waste and hazardous waste;

(i) **Organic waste** - waste (fresh waste, animal waste, wastewater) that contains degradable organic matter. This may include, for example, domestic waste, commercial waste, animal manure, wastewater, organic industrial waste (such as sludge from wastewater treatment plants) and MSW;

(j) **Run-off wastewater** - wastewater that is generated as a by-product from a waste treatment plant established under the project activity. This term does not refer to wastewater that is used as feed in an anaerobic digester or co-composting plant established under the project activity;

(k) **Solid waste disposal site (SWDS)** - designated areas intended as the final storage place for solid waste. Stockpiles are considered a SWDS if: (a) their volume to surface area ratio is 1.5 or larger; and if (b) a visual inspection by the DOE confirms that the material is exposed to anaerobic conditions (i.e. it has a low porosity and is moist);

(l) **Upgraded biogas** – biogas upgraded to natural gas quality.

5. Baseline methodology

5.1. Project boundary

16. The spatial extent of the project boundary encompasses:

(a) The site where the organic waste is treated/disposed of in the baseline;

(b) The site where the organic waste is treated using anaerobic digestion and the biogas is upgraded;

(c) The biogenic methane transmission/transportation system from the biogas processing facility to the pipelines/networks.

17. The GHGs included in or excluded from the project boundary are listed in Table 2.

Table 2. Emission sources included in or excluded from the project boundary

Source		Gas	Included	Justification/Explanation
Baseline	Emissions from the use of natural gas	CO_2	Yes	An important emission source. This is the main source of emissions in the baseline due to natural gas consumption
		CH_4	No	Excluded for simplification and conservativeness
		N_2O	No	Excluded for simplification and conservativeness

	Source	Gas	Included	Justification/Explanation
Project activity	Emissions from anaerobic digestion of organic waste (e.g. vinasse)	CO_2	Yes	An important project emission source
		CH_4	Yes	An important project emission source
		N_2O	No	Low emissions. Negligible
	Emissions from the transmission/ transportation of biogenic methane	CO_2	Yes	An important project emission source
		CH_4	Yes	An important project emission source
		N_2O	No	Low emissions. Negligible

5.2. Selection of the baseline scenario and demonstration of additionality

18. Identify the baseline scenario and demonstrate additionality using the "Combined tool to identify the baseline scenario and demonstrate additionality" and following the requirements below.

19. When applying Sub-step 1a. of the tool, alternative scenarios should be separately determined for the following components:

(a) Supply of fuel to a natural gas distribution system;

(b) Use/treatment of organic waste in the absence of the project activity.

20. The alternative scenarios for the supply of fuel to a natural gas distribution system in the absence of the project activity shall include, but not be limited to:

(a) S1: Continuation of the current practice with fossil natural gas supply to the natural gas distribution system;

(b) S2: The proposed project activity undertaken without being registered as a CDM project activity.

21. The alternative scenarios for use/treatment of the organic waste in the absence of the project activity shall include, but not be limited to:

(a) B1: The proposed project activity not undertaken as a CDM project activity;

(b) B2: The organic waste is dumped or left to decay mainly under aerobic conditions. This applies, for example, to dumping and decay of organic waste on fields;

(c) B3: The organic waste is dumped or left to decay under anaerobic conditions. This applies, for example, to landfills which are deeper than five meters. This also applies when organic waste is stock-piled or left to decay on fields;

(d) B4: The organic waste is burnt in an uncontrolled manner without utilizing it for energy purposes;

(e) B5: The organic waste used for electric power or heat generation at the project site in new and/or existing plants;

(f) B6: The organic waste is used for electric power or heat generation at other sites in new and/or existing plants;

(g) B7: The organic waste is used for other energy purposes, such as the generation of biofuels;

(h) B8: The organic waste is used for non-energy purposes, for example as fertilizer or as feedstock in processes (e.g. in the pulp and paper industry);

(i) B9: The organic waste is purchased from a market, or organic waste retailers, or the primary source of the organic waste and/or their fate in the absence of the project activity cannot be clearly identified.

5.3. Baseline emissions

22. The baseline emissions include CO_2 emissions from the combustion of natural gas that would be supplied into the natural gas distribution system instead of the biogenic methane produced by the project activity.

$$BE_y = 0.0504 \times F_{CH4,NG,y} \times EF_{CO2,NG,y}$$ Equation (1)

Where:

BE_y	=	Baseline emissions in year *y* (t CO_2e)
$F_{CH4,NG,y}$	=	Amount of biogenic methane which is sent to the natural gas distribution network in year *y* (t CH_4)
$EF_{CO2,NG,y}$	=	Average CO_2 emission factor of natural gas in the natural gas distribution system in year *y* (t CO_2e/TJ)
0.0504	=	Net calorific value of methane at reference conditions (TJ/t CH_4)

23. $EF_{CO2,NG,y}$ is determined using the “Tool to calculate project or leakage CO_2 emissions from fossil fuel combustion”.

5.4. Project emissions

24. Project emissions can occur from the following sources:

(a) Project emission from anaerobic digestion of organic waste;

(b) Project emission from the losses while upgrading the biogas and transmission/transportation from the project site to the natural gas distribution system;

(c) Project emission from the transportation of biogenic methane by trucks;

$$PE_y = PE_{AD,y} + PE_{LO,y} + PE_{TR,y}$$ Equation (2)

Where:

PE_y	=	Project emissions in year *y* (t CO_2e)
$PE_{AD,y}$	=	Project emission from anaerobic digestion of organic waste in year *y* (t CO_2)
$PE_{LO,y}$	=	Project emission from the losses while upgrading the biogas and transmission/transportation from the project site to the natural gas distribution system in year *y* (t CO_2e)
$PE_{TR,y}$	=	Project emission from the transportation of biogenic methane by trucks in year *y* (t CO_2e)

5.4.1. Project emission from anaerobic digestion of organic waste($PE_{AD,y}$)

25. $PE_{AD,y}$ is calculated according to section II (project emissions procedure) of the methodological tool "Project and leakage emissions from anaerobic digesters". When estimating the parameters $PE_{EC,y}$ and $PE_{FC,y}$ in the tool, the sources of electricity and fossil fuel consumption shall include processing, upgrading and compressing the biogas into the natural gas distribution system.

5.4.2. Project emission from the losses while upgrading the biogas and transmission/transportation from the project site to the natural gas distribution system ($PE_{LO,y}$)

$$PE_{LO,y} = (F_{CH4,BD,y} - F_{CH4,NG,y}) \times GWP_{CH4}$$ Equation (3)

Where:

$PE_{LO,y}$	=	Project emission from the losses while upgrading the biogas and transmission/transportation from the project site to the natural gas distribution system in year *y* (t CO_2e)
$F_{CH4,NG,y}$	=	Amount of biogenic methane which is sent to the natural gas distribution system after upgrading in year *y* (t CH_4)
$F_{CH4,BD,y}$	=	Amount of methane produced from the anaerobic digester before upgrading (t CH_4)
GWP_{CH4}	=	Global warming potential of CH_4 (t CO_2/t CH_4)

5.4.3. Project emission from the transportation of biogenic methane by trucks ($PE_{TR,y}$)

26. In cases where the biogas is transported by trucks, incremental transport related emissions shall be accounted for using the methodological tool "Project and leakage emissions from transportation of freight". When applying the tool:

    (a) Transportation activity *f* in the tool corresponds to the distribution of the biogas from the processing plant to the natural gas distribution system;

    (b) The freight transported is the upgraded biogas.

5.5. Leakage

27. The leakage may occur from increase transportation for waste in the project activity.

$$LE_y = LE_{US,y} + LE_{AD,y} + LE_{OWU,y} \quad \text{Equation (4)}$$

Where:

LE_y	=	Leakage emissions in year *y* (t CO_2/y)
$LE_{US,y}$	=	Leakage upstream emissions associated with fossil natural gas use in the baseline in year *y* (tCO_2e)
$LE_{AD,y}$	=	Leakage emissions associated with the anaerobic digester
$LE_{OWU,y}$	=	Leakage emissions related to the organic waste use in the baseline

28. Please note that the leakage emissions shall not be less than zero. If LE_y is less than zero, consider it as zero.

5.5.1. Leakage upstream emissions associated with fossil natural gas use (*$LE_{US,y}$*)

29. $LE_{US,y}$ is calculated according to the methodological tool “Upstream leakage emissions associated with fossil fuel use”. This methodology permits negative values for $LE_{US,y}$. When applying the tool the default emission factor for natural gas should be used. The amount of fossil natural gas used in the baseline is calculated as follows:

$$FC_{BL,NG,y} = 0.0504 \times F_{CH4,NG,y} \quad \text{Equation (5)}$$

Where:

$F_{BL,NG,y}$	=	Amount of natural gas used in the baseline situation in year *y* (TJ/yr)
$F_{CH4,NG,y}$	=	Amount of biogenic methane which is sent to the natural gas distribution system in year *y* (t CH_4/yr)
0.0504	=	Net calorific value of methane at reference conditions (TJ/t CH_4)

5.5.2. Leakage emissions associated with the anaerobic digester(*$LE_{AD,y}$*)

30. $LE_{AD,y}$ is calculated according to section III (leakage emissions procedure) of the methodological tool “Project and leakage emissions from anaerobic digesters”.

5.5.3. Leakage emissions related to the organic waste use in the baseline (*$LE_{OWU,y}$*)

31. If in the baseline the organic waste is dumped and left to decay, land-filled or burnt without energy generation (B2, B3, B4), leakage can be neglected.

32. If in the baseline, the organic waste is composted and in the project activity the resulting digestate is also composted, leakage can be neglected.

33. If the baseline of the organic waste is none of the above, project participant shall evaluate ex ante if there is a surplus of the biomass in the region of the project activity,

which is not utilised. If it is demonstrated at the beginning of each crediting period that the quantity of available biomass in the region, is at least 25 per cent larger than the quantity of biomass that is utilised including the project activity, then this source of leakage can be neglected.

34. If the leakage cannot be neglected as per paragraphs above project participants shall calculate leakage emissions as follows:

$$LE_{OWU,y} = EF_{CO2,LE} \times \sum_{n} BR_{LE,n,y} \times NCV_{BR,n,y}$$ Equation (6)

Where:

$LE_{OWU,y}$	=	Leakage emissions related to the organic waste use in the baseline in year *y* (t CO_2)
$EF_{CO2,LE}$	=	CO_2 emission factor of the most carbon intensive fossil fuel used in the country (t CO_2/GJ)
$BR_{LE,n,y}$	=	Quantity of biomass residues of category n used in the CDM project activity in year *y*, for which leakage cannot be neglected (tonnes on dry-basis)
$NCV_{BR,n,y}$	=	Net calorific value of biomass residue of category *n* in year *y* (GJ/tonne on dry-basis)
n	=	Biomass residue category
y	=	Year of the crediting period

5.6. Emission reductions

35. Emission reductions are calculated as follows:

$$ER_y = BE_y - PE_y - LE_y$$ Equation (7)

Where:

ER_y	=	Emission reductions in year *y* (t CO_2e)
BE_y	=	Baseline emission in year *y* (t CO_2e)
PE_y	=	Project emissions in year *y* (t CO_2e)
LE_y	=	Leakage in year *y* (t CO_2e)

36. In the case that the overall emission reductions in a year are negative through application of the leakage emissions, CERs are not issued to project participants for the year concerned and in subsequent years, until emission reductions from subsequent years have compensated the quantity of negative emission reductions from the year concerned. For example, if negative emission reductions of 30 tCO_2e occur in the year *t* and positive emission reductions of 100 tCO_2e occur in the year t+1, only 70 CERs are issued for the year t+1.

5.7. Changes required for methodology implementation in 2nd and 3rd crediting periods

37. Refer to the latest approved version of the tool "Assessment of the validity of the original/current baseline and update of the baseline at the renewal of the crediting period".

5.8. Data and parameters not monitored

38. In addition to the parameters listed here, the provisions on data and parameters not monitored in the tools referred to in this methodology apply.

Data / Parameter table 1.

Data / Parameter:	**GWP_{CH4}**
Data unit:	t CO_2e/t CH_4
Description:	Global warming potential of methane
Source of data:	IPCC
Value to be applied:	25. Shall be updated for future commitment periods according to any future COP/MOP decisions
Any comment:	-

Data / Parameter table 2.

Data / Parameter:	**$NCV_{BR,n,y}$**
Data unit:	GJ/tonnes on dry-basis
Description:	Net calorific value of biomass residues of category n in year *y*
Source of data:	Either conduct measurements or use accurate and reliable local or national data where available. Where such data is not available, use IPCC default net calorific values (country-specific, if available) if they are deemed to reasonably represent local circumstances. Choose the values in a conservative manner and justify the choice
Measurement procedures (if any):	Measurements shall be carried out at reputed laboratories and according to relevant international standards
Any comment:	-

6. Monitoring methodology

6.1. Archival of monitoring information

39. All data collected as part of monitoring should be archived electronically and be kept at least for two years after the end of the last crediting period. One hundred per cent of the data should be monitored if not indicated otherwise in the tables below.

6.2. Monitoring and QA/QC information

40. In the CDM-PDD, project proponents have to provide information concerning the system in place to ensure the quality of the data. It should include the actions to be undertaken

to constitute and to maintain the needed measurement equipment to satisfy the requirements concerning the quality of the data:

(a) The inventory, identification and the description of the measurement equipment used;

(b) The description of the QA/QC procedures for monitoring;

(c) The organizational structure and the responsibilities;

(d) The calibration and verification of the measurement equipment;

(e) The connecting of standard equipment to data logging devices;

(f) The process of recording data entries.

6.3. Monitoring provisions in the CDM tools

41. The monitoring provisions in the tools referred to in this methodology apply.

6.4. Data and parameters monitored

Data / Parameter table 3.

Data / Parameter:	$F_{CH4,NG,y}$
Data unit:	t CH_4
Description:	Amount of biogenic methane which is sent to the natural gas distribution system after upgrading in year *y*
Source of data:	Measured
Measurement procedures (if any):	-
Monitoring frequency:	Parameter monitored continuously but aggregated annually for calculations
QA/QC procedures:	Flow meters will undergo maintenance/calibration subject to appropriate industry standards. The frequency of calibration and control procedures would be different for each application. This maintenance/calibration practice should be clearly stated in the CDM-PDD Cross-check the measurement with sales records of biogas.
Any comment:	-

Data / Parameter table 4.

Data / Parameter:	$F_{CH4,BD,y}$
Data unit:	t CH_4
Description:	Amount of methane produced in the anaerobic digester before upgrading
Source of data:	Measured

Measurement procedures (if any):	In accordance with the methodological tool "Project and leakage emissions from anaerobic digesters"
Monitoring frequency:	In accordance with the methodological tool "Project and leakage emissions from anaerobic digesters"
QA/QC procedures:	In accordance with the methodological tool "Project and leakage emissions from anaerobic digesters"
Any comment:	-

Data / Parameter table 5.

Data / Parameter:	$\mathbf{EF_{CO2,NG,y}}$
Data unit:	t CO_2e/TJ
Description:	Average CO_2e emission factor of the natural gas in the natural gas distribution system in year *y*
Source of data:	Determined using the "Tool to calculate project or leakage CO_2 emissions from fossil fuel combustion"
Measurement procedures (if any):	-
Monitoring frequency:	-
QA/QC procedures:	-
Any comment:	-

Data / Parameter table 6.

Data / Parameter:	$\mathbf{BR_{LE,n,y}}$
Data unit:	tonnes on dry-basis
Description:	Quantity of biomass residues of category n used in the CDM project activity in year y, for which leakage cannot be neglected
Source of data:	On-site measurements
Measurement procedures (if any):	Use weight meters. Adjust for the moisture content in order to determine the quantity of dry biomass
Monitoring frequency:	Data monitored continuously and aggregated as appropriate, to calculate emissions reductions
QA/QC procedures:	Cross-check the measurements based on purchased quantities and stock changes
Any comment:	-

Data / Parameter table 7.

Data / Parameter:	$\mathbf{EF_{CO2,LE}}$
Data unit:	t CO_2/GJ
Description:	CO_2 emission factor of the most carbon intensive fossil fuel used in the country

Source of data:	Identify the most carbon intensive fuel type from the national communication, other literature sources (e.g. IEA). Possibly consult with the national agency responsible for the national communication/GHG inventory. If available, use national default values for the CO_2 emission factor. Otherwise, IPCC default values may be used
Measurement procedures (if any):	-
Monitoring frequency:	Annually
QA/QC procedures:	-
Any comment:	-

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