CLEAN DEVELOPMENT MECHANISM

AMS-III.AQ

Small-scale Methodology

Introduction of Bio-CNG in transportation applications

Version 02.0

Sectoral scope(s): 07

United Nations
Framework Convention on
Climate Change

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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)	Production of Biogenic Compressed Natural gas (Bio-CNG) from biomass and use in transportation applications. The Bio-CNG is derived from various sources such as biomass from dedicated plantations; waste water treatment; manure management; biomass residues etc.
Type of GHG emissions mitigation action	Renewable energy. Displacement of more-GHG-intensive fossil fuel used in vehicles

2. Scope, applicability, and entry into force

2.1. Scope

2. This methodology comprises activities for production of Biogenic Compressed Natural Gas (Bio-CNG) from biomass including biomass residues and cultivated biomass to be used in transportation applications. Biomass cultivated for production of the Bio-CNG should be sourced from dedicated plantations.

3. The project activity involves installation and operation of Bio-CNG plant that includes:

   (a) Anaerobic digester(s) to produce and recover biogas;

   (b) Biogas treatment system that includes processing, purification and compression of the biogas to obtain up-graded biogas such that methane content, its quality and the physical and chemical properties are equivalent to the CNG;

   (c) Filling stations, storage and transportation.

4. This methodology covers the use of Bio-CNG in various types of transportation applications such as Compressed Natural Gas (CNG) vehicles, modified vehicles. Examples include buses, trucks, three-wheeler, cars, jeeps, etc.

5. If the part of the recovered biogas is injected into a natural gas distribution grid, emission reduction for that component of the project activity can be claimed following the provisions in annex 1 of “AMS-III.H: Methane recovery in wastewater treatment”.

2.2. Applicability

6. This methodology is applicable if the methane content of the upgraded biogas is in accordance with relevant national regulations and in their absence a minimum of 96 per cent (by volume).

7. If the project activity utilizes biomass sourced from dedicated plantations, the applicability conditions prescribed in the methodological tool “project emissions from cultivation of biomass” shall apply.

8. The retailers, final users (where applicable) and the producer of the Bio-CNG are bound by a contract that states that the final consumers and retailers shall not claim emission reductions resulting from its consumption. Only the producer of the Bio-CNG can claim emission reductions under this methodology.

9. The export of Bio-CNG produced under this methodology is not allowed.

10. The digested residue waste leaving the reactor shall be handled aerobically and submitted to soil application, the proper procedures and conditions not resulting in the methane emissions shall be ensured; otherwise the emissions shall be taken into account as per relevant procedures of "AMS-III.AO: Methane recovery through controlled anaerobic digestion".

11. Measures are limited to those that result in emission reduction of less than or equal to 60 kt CO_2 equivalent annually. Where applicable the sum of the emission reductions from all Type III components of a project activity should comply with 60 kt CO_2 equivalent annually.

2.3. Entry into force

12. The date of entry into force is the date of the publication of the EB 79 meeting report on 1 June 2014.

3. Normative references

13. Project participants shall take into account the "General guidelines for SSC CDM methodologies", "Guidelines on the demonstration of additionality of small-scale project activities" provided at: <http://cdm.unfccc.int/methodologies/SSCmethodologies/approved.html> mutatis mutandis.

14. This methodology also refers to the latest approved versions of the following approved methodologies, guidelines[1] and tools:

    (a) "General guidance on leakage in biomass project activities";

    (b) "AMS-III.H: Methane recovery in wastewater treatment";

    (c) "AMS-III.AK: Biodiesel production and use for transport applications";

    (d) "AMS-III.AO: Methane recovery through controlled anaerobic digestion";

    (e) "Tool to calculate baseline, project and/or leakage emissions from electricity consumption";

    (f) "Project emissions from cultivation of biomass";

    (g) "Tool to calculate project or leakage CO_2 emissions from fossil fuel combustion"

    (h) "Upstream leakage emissions associated with fossil fuel use".

[1] Please refer to: <https://cdm.unfccc.int/Reference/index.html>.

4. Definitions

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

5. Baseline methodology

5.1. Project boundary

16. The spatial extent of the project boundary encompasses:

    (a) The Bio-CNG plant;

    (b) Where applicable, transportation of biomass from the point of their origin to Bio-CNG plant;

    (c) Where applicable, transportation Bio-CNG from biogas plant to filling stations where it is used by final consumers;

    (d) The land at which the cultivation of biomass used for the production of Bio-CNG and/or the area/region from where the waste organic matters for the production of Bio-CNG is sourced;

    (e) In cases where project participants carry out modification of gasoline vehicles to enable the use of Bio-CNG, the vehicles shall be included in the boundary.

5.2. Baseline emissions

17. Baseline emissions are calculated by using one of the two available approaches. Under approach 1 baseline emissions are calculated based on the amount of Bio-CNG produced and distributed, and it is applicable to project activities those are:

    (a) Use of Bio-CNG in modified diesel vehicles;[2] and/or

    (b) Use of Bio-CNG in modified gasoline vehicles when such vehicles are not included in the boundary.

18. Under approach 2 baseline emissions are calculated based on the quantity of Bio-CNG filled into converted gasoline vehicles and it is applicable to the project activities that are the production and use of Bio-CNG in modified gasoline vehicles when such vehicles are included in the boundary and are monitored. Approach 2 is not applicable to the modified diesel vehicles.

[2] In contrast to the conversion of gasoline (Otto cycle) vehicles to use natural gas or CNG as a fuel, the technologies for conversion of diesel engines will result in a variable efficiency drop (or variable specific fuel consumption) depending on the operational conditions (load and speed). Therefore, the efficiency drop varies according to the transportation service provided by the vehicles during their use. Approach 1 assumes that the diesel vehicles have been converted to run on natural gas, which is then considered being the baseline fuel.

5.2.1. Approach 1:

19. It is conservatively assumed that all Bio-CNG produced will displace CNG from fossil origin and the baseline emissions are calculated as follows:

$$BE_y = FS_{Bio-CNG,y} \times NCV_{Bio-CNG} \times EF_{Co2,CNG} \quad \text{Equation (1)}$$

Where:

BE_y = Total baseline emission in year *y* (t CO_2e)

$FS_{Bio-CNG,y}$ = Amount of Bio-CNG distributed/sold directly to retailers, filling stations by the project activity in year *y* (tonnes)

$EF_{Co2,CNG}$ = CO_2 emission factor of CNG (tCO_2e/GJ), determined using reliable local or national data. IPCC default values (lower value of 95 per cent confidence interval (CI)) shall be used only when country or project specific data are not available or demonstrably difficult to obtain. Values shall be updated if national values or IPCC values changes

$NCV_{Bio-CNG}$ = Net calorific value of Bio-CNG (GJ/tonne).
If it is demonstrated that the methane content of the Bio-CNG is minimum 96 per cent by volume then NCV of CNG shall be used. For NCV of CNG, reliable local or national data shall the used. IPCC default values shall be used only when country or project specific data are not available or demonstrably difficult to obtain. Values shall be updated if national values or IPCC values change

20. Under the condition of:

$$FS_{Bio-CNG,y} \leq FP_{Bio-CNG,y} \quad \text{Equation (2)}$$

Where:

$FP_{Bio-CNG,y}$ = Quantity of the Bio-CNG produced by the project activity in the year *y* (tonnes)

5.2.2. Approach 2:

21. In cases where the project activity also undertakes the conversion of gasoline vehicles including those vehicles in the project boundary, the baseline emission calculations are calculated as per equations 3 and 4 below.

$$FC_{gasoline,k,y} = FC_{Bio-CNG,k,y} \times \frac{NCV_{Bio-CNG}}{NCV_i} \times n \times f_{FO,gasoline} \quad \text{Equation (3)}$$

Where:

$FC_{gasoline,k,y}$ = Amount of gasoline of fossil origin which would have been consumed in the baseline by vehicle *k* in the year *y* (tonnes)

$FC_{Bio-CNG,k,y}$ = Bio-CNG consumed by the project vehicle *k* in the year *y* (tonnes)

$NCV_{Bio-CNG}$ = Net calorific value of Bio-CNG (GJ/tonne). The net calorific value of the Bio-CNG shall be determined based on direct measurement of a representative sample

NCV_i = Net calorific value of gasoline (GJ/tonne) that was used by project vehicle *k*. In case the gasoline is blended with biofuels the NCV of the blended gasoline shall be used. For *NCVi* reliable local or national data shall be used. IPCC default values (lower value of 95 per cent CI) shall be used only when country or project specific data are not available or demonstrably difficult to obtain. Values shall be updated if national values or IPCC values changes

n = Discount factor to account for the possible drop in the fuel efficiency of the retrofitted Bio-CNG vehicles. A default value of 0.95 shall be used for converted vehicles that previously used gasoline

$f_{FO,gasoline}$ = Fraction of gasoline of fossil fuel origin. 1.0 if pure gasoline has been displaced. In cases where national regulations require mandatory blending of the fuels with biofuels then the fraction of gasoline (on mass basis) in the blend should be applied

22. Total baseline emissions for approach 2 are calculated on an annual basis as below:

$$BE_y = \sum_k FC_{gasoline,k,y} \times NCV_{gasoline} \times EF_{CO2,gasoline}$$ Equation (4)

Where:

BE_y = Total baseline emission in year *y* (t CO_2e)

$NCV_{gasoline}$ = Net calorific value of gasoline (GJ/tonne), determined using reliable local or national data. IPCC default values (lower value of 95 per cent CI) shall be used only when country or project specific data are not available or demonstrably difficult to obtain. Values shall be updated if national values or IPCC values change

$EF_{CO2,gasoline}$ = CO_2 emission factor of gasoline (t CO_2e/GJ)

23. Under the condition of:

$$\sum FC_{Bio-CNG,k,y} \leq FP_{Bio-CNG,y}$$ Equation (5)

Where:

$FC_{Bio-CNG,k,y}$ = Total consumed Bio-CNG by all project vehicles in year *y* (tonnes)

24. In the cases where project proponents apply both approach 1 and 2, project proponents shall describe in the PDD how the double counting of emission reductions has been avoided.

5.3. Project emissions

25. The project emissions should be calculated as follows:

$$PE_y = PE_{elec,y} + PE_{fuel,y} + PE_{transport,y} + PE_{cultivation,y} + PE_{CH4,y} \quad \text{Equation (6)}$$

Where:

PE_y	=	Project emissions in year *y* (t CO_2e)
$PE_{elec,y}$	=	Project emissions due to electricity consumption in year *y* (t CO_2)
$PE_{fuel,y}$	=	Project emissions due to fossil fuels consumption in year *y* (t CO_2)
$PE_{transport,y}$	=	Project emissions from transportation of the biomass from the places of their origin to the biogas production site and where applicable, transportation Bio-CNG from biogas plant to filling stations where it is used by final consumers in year *y* (t CO_2)
$PE_{cultivation,y}$	=	Project emissions from biomass cultivation in a dedicated plantation in year *y* (t CO_2e)
$PE_{CH4,y}$	=	Project emissions due to the physical leakage of methane from the systems affected by the project activity for production, processing, purification, compression; storage and filling of the Bio-CNG in year *y* (t CO_2e)

5.3.1. Calculation of $PE_{elec,y}$

26. The emissions include electricity consumption (including auxiliary use) $PE_{elec,y}$ associated with the operation of Bio-CNG plant, calculated as per the parameter $PE_{EC,y}$ in the "Tool to calculate baseline, project and/or leakage emissions from electricity consumption".

5.3.2. Calculation of $PE_{fuel,y}$

27. The emissions include fossil fuel consumption (including auxiliary use) $PE_{fuel,y}$ associated with the operation of Bio-CNG plant, calculated as per the parameter $PE_{FC,j,y}$ in the "Tool to calculate project or leakage CO_2 emissions from fossil fuel combustion", where each combustion processes *j* in the tool should correspond to one of the fossil fuel consumption sources of the plant.

28. In cases where it is demonstrated that the energy requirements of the biogas production and treatment system and Bio-CNG plant are met only by renewable energy source the values of $PE_{elec,y}$ and $PE_{fuel,y}$ are considered as zero.

5.3.3. Calculation of $PE_{transport,y}$

29. Project emissions from transportation of the biomass and/or waste organic matters from the places of their origin to the biogas production site and where applicable, transportation Bio-CNG from biogas plant to filling stations where it is used by final consumers have to be accounted following the procedures in "AMS-III.AK: Biodiesel production and use for transport applications" if the transportation distance is more than 200 km, otherwise they can be neglected.

5.3.4. Calculation of $PE_{cultivation,y}$

30. If the project activity utilizes biomass sourced from dedicated plantations, project emissions from biomass cultivation shall be calculated as per the methodological tool "Project emissions from cultivation of biomass".

5.3.5. Calculation of $PE_{CH4,y}$

31. Project emissions associated with the physical leakage of methane from the systems affected by the project activity are calculated as follows:

$$PE_{CH4,y} = PE_{AD,y} + PE_{Bio-CNG,y} \quad \text{Equation (7)}$$

Where:

$PE_{AD,y}$ = CH_4 leakage emissions from the anaerobic digesters in year *y* (t CO_2e)

$PE_{Bio-CNG,y}$ = Project emissions of CH_4 from biogas and Bio-CNG processing, upgrading, purification, compression, storage and transportation (leaks and dissolved in wastewater) in year *y* (t CO_2e)

5.3.6. Methane emissions from physical leakage emissions from the anaerobic digesters ($PE_{AD,y}$)

32. Methane emissions due to physical leakages from the digester and recovery system ($PE_{AD,y}$) shall be estimated using a default factor of 0.05 m³ biogas leaked/m³ biogas produced. For ex ante estimation the expected biogas production of the digester may be used, for ex post calculations the effectively recovered biogas amount shall be used for the calculation.

5.3.7. Methane emissions from physical leakage due to the biogas treatment system ($PE_{Bio-CNG,y}$)

33. The following project emission sources shall be determined as per the relevant procedures in annex 1 of "AMS-III.H: Methane recovery in wastewater treatment":

(a) Methane emissions from the discharge of the upgrading equipment are determined;

(b) Fugitive methane emissions from leaks in compression equipment;

(c) Methane emissions due to the vent gases from upgrade equipment;

(d) Methane emissions related to physical leakage from filling operations shall be computed as per the procedures for calculating emissions from compressor leaks as per paragraph 32 b) above;

(e) Where applicable methane emissions associated with the physical leakage of the upgraded biogas from the dedicated pipelines;

(f) Where applicable methane emissions due to physical leakage from Bio-CNG/biogas filled bottles (e.g. mobile cascades) which are used for the storage and transportation of Bio-CNG/biogas.

34. The digested residue waste leaving the reactor shall be treated aerobically, and disposed in land properly, such as to avoid methane emissions. If disposed under anaerobic conditions (e.g. landfill) the methane emissions shall be estimated and discounted as project emissions following the relevant provisions in "AMS-III.AO: Methane recovery through controlled anaerobic digestion".

5.4. Leakage

35. Leakage emissions $LE_{BIOMASS,y}$ due to competing use of biomass shall be accounted for as per the approved "General guidance on leakage in biomass project.

36. The substitution of Bio-CNG for CNG from fossil origin reduces indirect ("upstream") emissions associated with the production of fossil CNG and is treated as negative leakage $LE_{PROCESS,y,CNG}$ that can be calculated as per the latest approved version of the tool "Upstream leakage emissions associated with fossil fuel use".

37. The substitution of Bio-CNG for gasoline reduces indirect ("upstream") emissions associated with the production of gasoline and is treated as negative leakage $LE_{PROCESS,y,GAS}$ (leakage emissions related to production and refining of the gasoline) that can be calculated using the latest approved version of the tool "Upstream leakage emissions associated with fossil fuel use".

38. Negative leakage emissions related to the avoided production of fossil fuel (CNG, gasoline) (t CO_2/yr) shall be calculated as per the equation below:

$$LE_{PROCESS,y,FF} = LE_{PROCESS,y,CNG} + LE_{PROCESS,y,GAS} \quad \text{Equation (8)}$$

Where:

$LE_{PROCESS,y,FF}$ = Leakage related to the avoided production of fossil fuel (t CO_2/yr)

5.5. Emission reductions

39. The emission reductions achieved by the project activity shall be calculated as the difference between the baseline emissions and the sum of the project emissions and leakage.

$$ER_y = BE_y - PE_y - LE_{BIOMASS,y} + LE_{PROCESS,y,FF} \quad \text{Equation (9)}$$

Where:

ER_y = Emission reductions in the year *y* (t CO_2e)

6. Monitoring methodology

40. Relevant parameters shall be monitored as indicated in the Tables below.

41. Parameters for determining project emissions from biomass cultivation shall be monitored as per relevant provisions of "AMS-III.T: Plant oil production and use for transport applications".

42. Parameters for calculating methane emissions from physical leakage of methane from the systems affected by the project activity for production, processing, purification, compression; storage and filling of the Bio-CNG shall be monitored as per the procedures prescribed in AMS-III.H.

43. Parameters for establishing methane emissions from residue waste disposed under anaerobic conditions shall be monitored as per relevant procedures of AMS-III.AO.

44. The applicable requirements specified in the "General guidelines for SSC CDM methodologies" (e.g. calibration requirements, sampling requirements) are also an integral part of the monitoring guidelines.

45. Evidence shall be provided to demonstrate that the modification of gasoline vehicles has been implemented.

46. In the case of approach 2, the filling stations must be equipped with the following devices/systems:[3]

    (a) Automatic Number Plate Recognition (ANPR); or Electronic Vehicle Identification (EVI);

    (b) Automatic locking and unlocking function of dispenser directly controlled by equipped device/system responsible for project vehicle identification to ensure that all the Bio-CNG that is produced is only consumed in the project vehicles;

    (c) System for logging of the data on quantity of Bio-CNG filled into identified project vehicles;

    (d) Natural gas analyzer capable of analysing ethane and propane to ensure that the gas delivered to the vehicle by the dispenser does not contain ethane or/and propane.

6.1. Parameters to be monitored

Data / Parameter table 1.

Data / Parameter:	$FC_{Bio\text{-}CNG,k,y}$
Data unit:	t
Description:	Bio-CNG consumed by the project vehicle *k* in the year *y*
Measurement procedures (if any):	Measurements of the amount of Bio-CNG filled into vehicles of the end users are undertaken using calibrated meters at the filling station site. Measurements results shall be cross-checked with production and sales data
Monitoring frequency:	Continuously
Any comment:	-

[3] The PPs are encouraged to propose a revision of the methodology for allowing/including other alternative procedures.

Data / Parameter table 2.

Data / Parameter:	**$FS_{Bio\text{-}CNG,y}$**
Data unit:	t
Description:	Amount of Bio-CNG distributed/sold directly to retailers, filling stations by the project activity in year *y*
Measurement procedures (if any):	Measurements of the amount of Bio-CNG distributed/sold to retailers/filling stations are undertaken using calibrated meters at the delivery section of Bio-CNG production site. Measurements results shall be cross checked with records for sold amount (e.g. invoices/receipts) and with the amount of biogas produced
Monitoring frequency:	Continuously or in batches
Any comment:	-

Data / Parameter table 3.

Data / Parameter:	**$FP_{Bio\text{-}CNG,y}$**
Data unit:	t
Description:	Quantity of the Bio-CNG produced by the project activity in the year *y*
Measurement procedures (if any):	Measurements are undertaken using calibrated meters at the outlet of the biogas upgrading section of the Bio-CNG production site
Monitoring frequency:	Continuously
Any comment:	-

Data / Parameter table 4.

Data / Parameter:	**$NCV_{Bio\text{-}CNG}$**
Data unit:	GJ/t
Description:	Net calorific value of Bio-CNG
Measurement procedures (if any):	Measured according to relevant national/international standards through sampling. Analysis has to be carried out by accredited laboratory
Monitoring frequency:	Monthly or as prescribed by the applied national/international standard
Any comment:	-

Data / Parameter table 5.

Data / Parameter:	**NCV_i**
Data unit:	GJ/t
Description:	Net calorific value of gasoline/blended gasoline that was used by project vehicle *k*
Measurement procedures (if any):	Measured according to relevant national/international standards. Analysis has to be carried out by accredited laboratory
Monitoring frequency:	At the validation, and annually during the crediting period
Any comment:	-

Data / Parameter table 6.

Data / Parameter:	$w_{CH4,y}$
Data unit:	%
Description:	Methane content in the Bio-CNG
Measurement procedures (if any):	The fraction of methane in the gas should be measured with a continuous analyzer or, alternatively, with periodical measurements at a 90/10 sampling confidence/precision level. It shall be measured using equipment that can directly measure methane content in the biogas - the estimation of methane content of biogas based on measurement of other constituents of biogas such as CO_2 is not permitted. The methane content measurement shall be carried out at the location where $FP_{Bio\text{-}CNG,y}$ is measured
Monitoring frequency:	Continuous/periodic
Any comment:	-

Data / Parameter table 7.

Data / Parameter:	$f_{FO,gasoline}$
Data unit:	%
Description:	Fraction of gasoline from fossil fuel origin in the displaced gasoline
Measurement procedures (if any):	As per the following options (in preferential order): (i) Data from the supplier of the gasoline; (ii) If it accrues to national regulations requiring mandatory blending of biofuels, the regulatory blend fraction may be used; (iii) If measured, it shall be according to relevant national/international standards through sampling
Monitoring frequency:	Continuously or in batches
Any comment:	-

6.2. Project activity under a programme of activities

47. The methodology is applicable to a programme of activities.

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Document information

Version	*Date*	*Description*
02.0	1 June 2014	EB 79, Annex 17 Revision to: (a) Expand the applicability of the methodology to: (i) Use of Bio-CNG in modified diesel vehicles; (ii) Injection of biogas into natural gas grid; (b) Include a reference to the methodological tool "Project emissions from cultivation of biomass".
01.0	26 November 2010	EB 58, Annex 18 Initial adoption.

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