Monitoring report form for CDM project activity
(Version 07.0)

Complete this form in accordance with the instructions attached at the end of this form.

MONITORING REPORT		
Title of the project activity	Oeste de Caucaia Landfill Project Activity	
UNFCCC reference number of the project activity	10261	
Version number of the PDD applicable to this monitoring report	4	
Version number of this monitoring report	1	
Completion date of this monitoring report	26/11/2020	
Monitoring period number	1	
Duration of this monitoring period	22/04/2016 – 21/12/2017	
Monitoring report number for this monitoring period	1	
Project participants	GNR Fortaleza Valorização de Biogás Ltda.	
Host Party	Brazil	
Applied methodologies and standardized baselines	ACM0001: Flaring or use of landfill gas	
Sectoral scopes	13: Waste handling and disposal	
Amount of GHG emission reductions or net anthropogenic GHG removals achieved by the project activity in this monitoring period	Amount achieved before 1 January 2013	Amount achieved from 1 January 2013
	0	43,786 tCO_2e
Amount of GHG emission reductions or net anthropogenic GHG removals estimated ex ante for this monitoring period in the PDD	235,062 tCO_2e[1]	

[1] Calculated using the PDD estimation of emission reductions to be achieved in 2016 (317,093 tCO_2e) times the number of days in this monitoring period for this year (254 days) divided by the number of days in the year, plus emission reductions estimated in 2017 (497,834 tCO_2e) times the number of days in this monitoring period for this year (11 days) divided by the number of days in the year under the crediting period.

SECTION A. Description of project activity

A.1. General description of project activity

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The primary objective of the Oeste de Caucaia Landfill Project Activity is to prevent greenhouse gases emissions by the Oeste de Caucaia Landfill through the capture, purification and injection of the landfill gas into a distribution grid, displacing the use of natural gas. The Oeste de Caucaia - Ecofor landfill is a municipal solid waste (MSW) disposal site located in Caucaia, Brazil.

The landfill is owned by the municipality of Caucaia and is operated since 2003 by ECOFOR under a 20-year concession. A passive LFG capture system was operational before the implementation of the CDM Project Activity. GNR Fortaleza Valorização de Biogás Ltda. is the project activity implementer. Applying the state-of-the-art on LFG capture technology, a collecting system was installed to avoid the free emission of methane to the atmosphere. A detailed description of the equipment is provided in Section B.1.

The complete implementation of the project includes capturing the LFG and sending it to the upgrading facility before being injected to the natural gas distribution grid of CEGÁS – Companhia de Gás do Ceará (local natural gas supplier). CEGÁS receives the upgraded gas from Oeste de Caucaia Landfill Project through a natural gas distribution grid, therefore mixing it with natural gas. This type of project, *i.e.*, landfill gas upgrading to natural gas and injection into a natural gas distribution grid is not usual in Brazil.

This monitoring report covers the period from 22/04/2016 to 21/12/2017, when only the LFG capture and flaring systems were operational.

The total emission reductions achieved during this monitored period is **43,786 tCO2e.**

A.2. Location of project activity

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The Oeste de Caucaia Landfill is located is located in the municipality of Caucaia, Ceará state, north-eastern region of Brazil (Figure 1). The geographic coordinates (Figure 2) of the site where the project has been implemented are:

Latitude: 3°47'20.29"South
Longitude: 38°40'24.99"West

Figure 1 - Caucaia location (Source: http://pt.wikipedia.org)

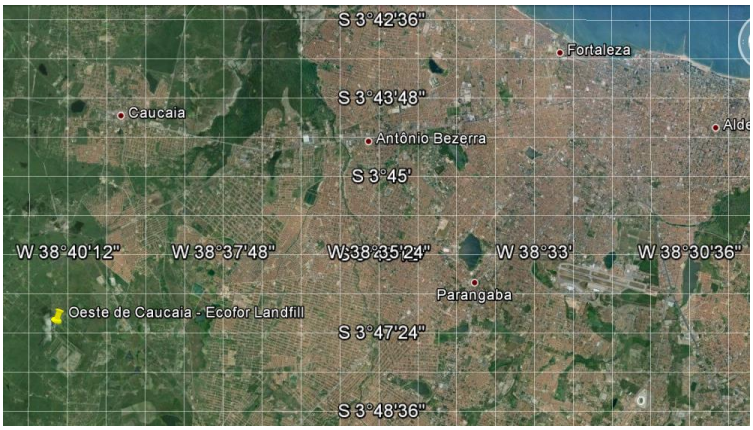

Figure 2 - Oeste de Caucaia Landfill location (Source: adapted from Google Earth)

A.3. Parties and project participants

Parties involved	Project participants	Indicate if the Party involved wishes to be considered as project participant (Yes/No)
Brazil	Private entity – GNR Fortaleza Valorização de Biogás Ltda.	No

This monitoring report was developed and reviewed by:

Consultancy	Project Proponent (Project Participant)
BENG	GNR Fortaleza Valorização de Biogás Ltda
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A.4. References to applied methodologies and standardized baselines

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Oeste de Caucaia Landfill Project Activity applies the ACM0001 methodology – "Flaring or use of landfill gas"[2] (version 15.0.0) and the following methodological tools:

- TOOL06 - "Project emissions from flaring" (version 02.0.0)[3];
- TOOL05 - "Tool to calculate baseline, project and/or leakage emissions from electricity consumption" (version 01)[4];
- TOOL07 - "Tool to calculate the emission factor for an electricity system" (version 4.0)[5];
- TOOL03 - "Tool to calculate project or leakage CO2 emissions from fossil fuel combustion" (version 02)[6];
- TOOL04 - "Emissions from solid waste disposal sites" (version 07.0)[7];

[2] Available at: <https://cdm.unfccc.int/methodologies/DB/JPYB4DYQUXQPZLBDVPHA87479EMY9M>. Accessed on: 06/10/2020.

[3] Available at: <https://cdm.unfccc.int/methodologies/PAmethodologies/tools/am-tool-06-v3.0.pdf/history_view>. Accessed on: 06/10/2020.

[4] Available at: <https://cdm.unfccc.int/methodologies/PAmethodologies/tools/am-tool-05-v3.0.pdf/history_view>. Accessed on: 06/10/2020.

[5] Available at: <https://cdm.unfccc.int/methodologies/PAmethodologies/tools/am-tool-07-v7.0.pdf/history_view>. Accessed on: 06/10/2020.

[6] Available at: <https://cdm.unfccc.int/methodologies/PAmethodologies/tools/am-tool-03-v3.pdf/history_view>. Accessed on: 06/10/2020.

- TOOL02 - “Combined tool to identify the baseline scenario and demonstrate additionality” (version 05.0.0)[8];
- TOOL08 - “Tool to determine the mass flow of a greenhouse gas in a gaseous stream” (version 02.0.0)[9];
- TOOL09 - “Tool to determine the baseline efficiency of thermal or electric energy generation systems” (version 01)[10];
- TOOL10 - “Tool to determine the remaining lifetime of equipment” (version 01)[11];
- TOOL12 - “Project and leakage emissions from transportation of freight” (version 01.1.0)[12];
- TOOL11 - “Assessment of the validity of the original/current baseline and update of the baseline at the renewal of the crediting period” (version 03.0.1)[13].

The “Tool to determine the baseline efficiency of thermal or electric energy generation systems”, “Tool to determine the remaining lifetime of equipment” and the methodological tool “Project and leakage emissions from transportation of freight” are not applicable to the project activity, and therefore are not used. Similarly, the methodological tool “Assessment of the validity of the original/current baseline and update of the baseline at the renewal of the crediting period” was not used since the PDD corresponds to the first crediting period of the proposed CDM Project Activity.

A.5. Crediting period type and duration

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Renewable
The crediting period corresponding to the monitoring period covered in this monitoring report goes from 22/04/2016 to 22/04/2023.

SECTION B. Implementation of project activity

B.1. Description of implemented project activity

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As per the registered PDD, Oeste de Caucaia Landfill Project Activity was implemented in phases. To date only the phase I has been operational. However, this monitoring report refers only to the period immediately prior to the upgrading gas facility start-up, when only the flares were operational.

In summary, the technology applied by the project consists of:
- Gas extraction wells with wellhead flow control and monitoring;
- A wellfield gas conveyance system (“laterals” and “header”);
- A Gas Station and an upgrading gas facility;
- A flaring system; and,
- A pipeline to inject the upgraded gas into the natural gas distribution grid.

Collecting System

[7] Available at: <https://cdm.unfccc.int/methodologies/PAmethodologies/tools/am-tool-04-v8.0.pdf/history_view>. Accessed on: 06/10/2020.
[8] Available at: <https://cdm.unfccc.int/methodologies/PAmethodologies/tools/am-tool-02-v7.0.pdf/history_view>. Accessed on: 06/10/2020.
[9] Available at: <https://cdm.unfccc.int/methodologies/PAmethodologies/tools/am-tool-08-v3.0.pdf/history_view>. Accessed on: 06/10/2020.
[10] Available at: <https://cdm.unfccc.int/methodologies/PAmethodologies/tools/am-tool-09-v3.0.pdf/history_view>. Accessed on: 06/10/2020.
[11] Available at: <https://cdm.unfccc.int/methodologies/PAmethodologies/tools/am-tool-10-v1.pdf/history_view>. Accessed on: 06/10/2020.
[12] Available at: <https://cdm.unfccc.int/methodologies/PAmethodologies/tools/am-tool-12-v1.1.0.pdf/history_view>. Accessed on: 06/10/2020.
[13] Available at: <https://cdm.unfccc.int/methodologies/PAmethodologies/tools/am-tool-11-v3.0.1.pdf/history_view>. Accessed on: 06/10/2020.

The Oeste de Caucaia Landfill Project involved the perforation of new vertical wells as well as the installation of wellheads on top of them to collect the LFG emitted directly to the atmosphere in the baseline. An example of wellhead and the detail of its construction are shown in Figure 3

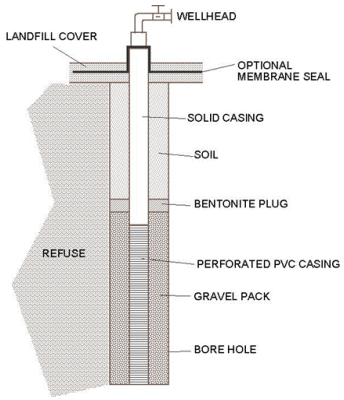

Figure 3 – Internal detail of a well and wellhead (source: USEPA, 1996[14])

New wells have been drilled in order to guarantee the efficiency of the controlled drainage of the landfill as well as of the LFG collection. Phase 1 involved the installation of 22 vertical wells and 64 horizontal extraction wells[15].

Flow-control and monitoring wellheads are employed at every gas extraction well, to allow precise regulation/adjustment of the gas flow at each well. Gas quality monitoring and flow adjustment is important to ensure that the system is "balanced" (i.e. gas extraction matches gas production so that atmospheric air is not introduced into the landfill).

A network of LFG header piping connects the horizontal collectors and vertical extraction wells, and direct the LFG to the LFG processing plant or (if the plant is down or there is excess LFG) the blower and flaring station for methane destruction.

The collection system became operational in 10/12/2015[16].

Gas Station and Upgrading gas facility

The Gas Station is the facility where the gas is suctioned from the landfill and where the gas receives the proper treatment, depending on the final use of the gas. Usually, the Gas Station is composed by blowers and condensate knock-outs. The project has 2 blowers, with a capacity of 5,000Nm³/hour each (Table 1).

Table 1 – Technical specification of the blowers.

Blowers (SP-203/204)	# of Units	2
	Manufacturer	Jonh Zink
	Model	12604
	Serial numbers	0514110-37597 0514109-37597
	Maximum capacity	5365 Nm³/h

14 USEPA – United States Environmental Agency; *Turning a Liability into an Asset: a Landfill Gas-to-Energy Project Development Handbook*; LMOP – Landfill Methane Outreach Program, 1996

15 In accordance with the gas capture project by Landtec, in a corporate presentation of provided by project owner

16 In accordance with in accordance with the environmental permit SEMACE No. 70/2015 which authorized the entry into operation of the system.

Prior to the injection of the landfill gas to the natural gas distribution grid, it is treated in the upgrading facility, where most of the non-methane gases are removed from the stream.
The gas station and the upgrading facility became operational in 12/2015 and in 12/2017, respectively.

Flare System

Whenever LFG exceeds the processing capacity of the purification plant or the plant is not operational the gas is sent to the flaring system. The project has one open flare, with a capacity of 8,200 Nm³/hour (Table 2).

Table 2 – Technical specification of the flare.

Flare	Manufacturer		John Zink
	Type		Elevated Flare
	Commissioning date		10/12/2015
	Model		ZEF 16''X45'
	Serial number		BF – 9149501
	Year of manufacturing		2014
	Nominal gas flow	LFG	8,200 Nm³/h
		Upgraded LFG	4,100 Nm³/h
	Minimum methane content	LFG	50 - 60%
		Upgraded LFG	97%
	Lowest operation temperature		100 ºF

The flare system and became operational in 12/2015.

Upgraded gas pipeline

The upgraded gas will be transported to the injection point through a pipeline. Within the landfill area the gas is collected using a *Flex Steel* pipeline. From the landfill border until CEGÁS pipeline (consumer), a *Carbon Steel* pipeline is used. This technology reduces the environmental impacts observed in a conventional mechanical construction once less machines are used during its construction.

Gas pipeline became fully operational in 12/2017, when CEGAS started to distribute the upgraded biogas produced by the project.

This monitoring report claims emission reductions achieved before the start-up of the upgrading gas facility, or rather, emission reductions achieved by burning the captured LFG using the open flare. Most of this monitoring period the system has been in normal operation. There were a few days with significant down period and those were listed in a separate spreadsheet and have no impact on the methodology applicability.

It is the first monitoring period of the project and no CERs have been issued yet.

B.2. Post-registration changes

B.2.1. Temporary deviations from the registered monitoring plan, applied methodologies, standardized baselines or other methodological regulatory documents

>>
Not applicable. This section is intentionally left blank.

B.2.2. Corrections

>>
Not applicable. This section is intentionally left blank.

B.2.3. Changes to the start date of the crediting period

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Not applicable. This section is intentionally left blank.

B.2.4. Inclusion of monitoring plan

>>
Not applicable. This section is intentionally left blank.

B.2.5. Permanent changes to the registered monitoring plan, or permanent deviation of monitoring from the applied methodologies, standardized baselines, or other methodological regulatory documents

>>
Not applicable. This section is intentionally left blank.

B.2.6. Changes to project design

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Along with this verification, it is being proposed a project design change in the registered PDD. A new PDD version (version 5, dated 20/11/2020) is being submitted along with this Monitoring Report (ISSUANCE TRACK).
The post-registration change consisted of adding one more site to the proposed CDM Project Activity corresponding to the landfill expansion. This amendment is foreseen in paragraph 241. (f) of the CDM Project Standard.
The amount of waste deposited at the project site was also updated according to the most recent data monitored by the project proponent, which were not available during the validation of the Project Activity. No significant difference can be observed with respect to the information provided in the first registered version of the PDD, but emission reductions were revised accordingly. Nonetheless, this update resulted in a more conservative ex-ante estimative, since there will be no increase in the *ex-ante* estimated LFG generation capacity.

B.2.7. Changes specific to afforestation or reforestation project activity

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Not applicable. This section is intentionally left blank.

SECTION C. Description of monitoring system

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The monitoring of project activity will follow the requirements established in ACM0001 and referred tools. All data monitored will be available at the time of the verification and will be archived electronically for two years after the end of the crediting period or the last issuance of CERs, whichever occurs later.

The project is equipped with meters which collect the following data:

(i) Landfill gas (LFG) sent to flare;
(ii) LFG sent to the upgrading system;
(iii) Biomethane resulted from upgrading process; and,
(iv) Biomethane which does not reach the required parameters to be delivered to the NG distribution system and, for this reason, is flared.

Since the flow meters already measures the volumetric flow rate of the residual gas at normal conditions, the parameters "*Temperature of the landfill gas*" (T) and "*Pressure of the landfill gas*" (P) have not been measured for normalizing purposes.

The below table presents the main technical characteristics of the monitoring equipment.

Table 3 – Technical specification of the monitoring equipment.

Type	Manufacturer	Model	Serial number	Range
LFG Flow inlet direct to Flare	ABB	FMT500-IG	V14224-002969	1 - 24,000 Nm^3/h
LFG Temperature	WARME	WTT-6001	TI.3244	0 - 80ºC
LFG Pressure	ROSEMOUNT	3051	2593163	0 - 500 mbar
Methane Fraction in LFG	ABB	PGC-1000	T170268182	0-100%

Whenever a delay in the calibration of measuring equipment was observed during the monitored period, the procedures defined in paragraph 369 of the CDM validation and verification standard for project activities were adopted.

SECTION D. Data and parameters

D.1. Data and parameters fixed ex ante

ACM0001

Data/Parameter	OX_{top_layer}
Unit	Dimensionless
Description	Fraction of methane that would be oxidized in the top layer of the SWDS in the baseline
Source of data	Consistent with how oxidation is accounted for in the methodological tool "Emissions from solid waste disposal sites"
Value(s) applied	0.1
Choice of data or measurement methods and procedures	As per the applicable tool
Purpose of data/parameter	Calculation of baseline emissions
Additional comments	Applicable to section 5.4.1. of the registered PDD (baseline emissions of methane from the SWDS, $BE_{CH4,y}$)

Data/Parameter	GWP_{CH4}
Unit	t_{CO2e}/t_{CH4}
Description	Global Warming Potential of CH_4
Source of data	IPCC
Value(s) applied	25 for the second commitment period. Shall be updated according to any future COP/MOP decisions
Choice of data or measurement methods and procedures	As per the applicable methodology
Purpose of data/parameter	Calculation of baseline emissions
Additional comments	-

Data/Parameter	NCV_{CH4}
Unit	TJ/t_{CH4}

Description	Net calorific value of methane at reference conditions
Source of data	Technical literature
Value(s) applied	0.0504
Choice of data or measurement methods and procedures	As per the applicable methodology
Purpose of data/parameter	Calculation of baseline emissions
Additional comments	-

Data/Parameter	η_{PJ}
Unit	Dimensionless
Description	Efficiency of the LFG capture system that will be installed in the project activity
Source of data	-
Value(s) applied	50%.
Choice of data or measurement methods and procedures	Default value provided by the applicable methodology
Purpose of data/parameter	Calculation of baseline emissions
Additional comments	Applicable to Step A.1.1

Tool Emissions from solid waste disposal sites

Data/Parameter	$\varphi_{default}$
Unit	-
Description	Default value for the model correction factor to account for model uncertainties
Source of data	-
Value(s) applied	0.75
Choice of data or measurement methods and procedures	As per the applicable methodological tool *"Emissions from solid waste disposal sites"*. This parameter is used to determine the baseline emissions following the procedures related to *Application A*. Further, the project is located at Caucaia municipality (next to Fortaleza), Ceará state (northeast region of Brazil) which possesses humid/wet weather conditions[17]: MAT = 26.6ºC. MAP = 1.643mm. Therefore, the value correspondent to this condition as presented in Table 3 of the methodology is chosen.
Purpose of data/parameter	Calculation of baseline emissions
Additional comments	As per Table 3 since the project participants have chosen to apply Option 1 to determine this parameter.

Data/Parameter	f_y
Unit	-
Description	Fraction of methane captured at the SWDS and flared, combusted or used in another manner that prevents the emissions of methane to the atmosphere in year *y*
Source of data	ACM0001
Value(s) applied	0

[17] The climatic conditions are based on long-term averages from 1973 to 1990 and were taken from EMBRAPA - Brazilian Agricultural Research Company, available at http://www.bdclima.cnpm.embrapa.br/resultados/balanco.php?UF=&COD=43.

Choice of data or measurement methods and procedures	In accordance with the ACM0001 methodology this value is to be assigned since the amount of LFG that would have been captured and destroyed is already accounted for in Equation 2 (of the registered PDD). As per the applicable methodological tool *"Emissions from solid waste disposal sites"*, for application A, this parameter is determined once for the crediting period ($f_y = f$).
Purpose of data/parameter	Calculation of baseline emissions
Additional comments	-

Data/Parameter	OX
Unit	-
Description	Oxidation factor (reflecting the amount of methane from SWDS that is oxidized in the soil or other material covering the waste)
Source of data	Based on an extensive review of published literature on this subject, including the IPCC 2006 Guidelines for National Greenhouse Gas Inventories
Value(s) applied	0
Choice of data or measurement methods and procedures	As per the applicable methodological tool *"Emissions from solid waste disposal sites"*
Purpose of data/parameter	Calculation of baseline emissions
Additional comments	As per the AM_CLA_0259 clarification request final response, it was opted not to account for this effect while determining the ex-ante estimative of baseline emissions.

Data/Parameter	F
Unit	-
Description	Fraction of methane in the SWDS gas (volume fraction)
Source of data	IPCC 2006 Guidelines for National Greenhouse Gas Inventories
Value(s) applied	0.5
Choice of data or measurement methods and procedures	As per the applicable methodological tool *"Emissions from solid waste disposal sites"*
Purpose of data/parameter	Calculation of baseline emissions
Additional comments	Upon biodegradation, organic material is converted to a mixture of methane and carbon dioxide.

Data/Parameter	$DOC_{f,default}$
Unit	Weight fraction
Description	Default value for the fraction of degradable organic carbon (DOC) in MSW that decomposes in the SWDS
Source of data	IPCC 2006 Guidelines for National Greenhouse Gas Inventories*"*
Value(s) applied	0.5
Choice of data or measurement methods and procedures	The proposed project activity corresponds to *Application A* described in the applicable methodological tool *"Emissions from solid waste disposal sites"*. Therefore, in accordance with the requirements set out by tool, the default value was chosen.
Purpose of data/parameter	Calculation of baseline emissions
Additional comments	This factor reflects the fact that some of the degradable organic carbon does not degrade, or degrades very slowly, in the SWDS.

Data/Parameter	$MCF_{default}$
Unit	-
Description	Methane correction factor

Source of data	IPCC 2006 Guidelines for National Greenhouse Gas Inventories
Value(s) applied	1.0
Choice of data or measurement methods and procedures	The proposed project activity matches *Application A* described in the tool *"Emissions from solid waste disposal sites"*. The Oeste de Caucaia Lanfill meets the criteria of managed SWDS. Hence, the value corresponding to anaerobic **managed solid waste disposal sites** is chosen.
Purpose of data/parameter	Calculation of baseline emissions
Additional comments	-

Data/Parameter	DOC_j
Unit	-
Description	Fraction of degradable organic carbon in the waste type *j* (weight fraction)
Source of data	IPCC 2006 Guidelines for National Greenhouse Gas Inventories (adapted from Volume 5, Tables 2.4 and 2.5)
Value(s) applied	***DOC_j (% wet waste)*** / ***Waste type j*** 43% / Wood and wood products 40% / Pulp, paper and cardboard 15% / Food, food waste, beverages and tobacco 24% / Textiles 20% / Garden, yard and park waste 0% / Glass, plastic, metal, other inert waste
Choice of data or measurement methods and procedures	Values for MSW, as per Table 6 of the methodological tool *"Emissions from solid waste disposal sites"*.
Purpose of data/parameter	Calculation of baseline emissions
Additional comments	-

Data/Parameter	k_j
Unit	1/yr
Description	Decay rate for the waste type *j*
Source of data	IPCC 2006 Guidelines for National Greenhouse Gas Inventories (adapted from Volume 5, Table 3.3)
Value(s) applied	***Waste type j*** / ***k_j*** **Slowly degrading** / Pulp, paper, cardboard (other than sludge), textiles / 0.07 **Slowly degrading** / Wood, wood products and straw / 0.035 **Moderately degrading** / Other (non-food) organic putrescible garden and park waste / 0.17 **Rapidly degrading** / Food, food waste, sewage sludge, beverages and tobacco / 0.40
Choice of data or measurement methods and procedures	As per Table 7 of the methodological tool *"Emissions from solid waste disposal sites"*.
Purpose of data/parameter	Calculation of baseline emissions
Additional comments	The project is located at Caucaia municipality (next to Fortaleza), Ceará state (northeast region of Brazil) which possesses humid/wet weather conditions[17]: MAT = 26.6ºC MAP = 1.643mm

Data/Parameter	W_x
Unit	T
Description	Total amount of waste disposed in a SWDS in year *x*
Source of data	Data from ECOFOR, which manages the landfill
Value(s) applied	Large amount of data. Please refer to the CERs calculation spreadsheet

Choice of data or measurement methods and procedures	ECOFOR is the institution responsible for waste management of the landfill.
Purpose of data/parameter	Calculation of baseline emissions
Additional comments	This parameter does not need to be monitored during the crediting period since is corresponds to Application A of the methodological tool "*Emissions from solid waste disposal sites"*.

"Tool to determine the mass flow of a greenhouse gas in a gaseous stream"

Data/Parameter	Ru
Unit	$Pa.m^3/kmol.K$
Description	Universal ideal gases constant
Source of data	As per the applicable tool
Value(s) applied	8,314
Choice of data or measurement methods and procedures	-
Purpose of data/parameter	Calculation of project emissions
Additional comments	Used for $F_{CH4,sent\_flare,y}$ and $F_{CH4,NG,y}$ following Options C and A, respectively.

Data/Parameter	MMi
Unit	kg/kmol
Description	Molecular mass of greenhouse gas *i*
Source of data	Tool
Value(s) applied	16.04 (for methane)
Choice of data or measurement methods and procedures	-
Purpose of data/parameter	Calculation of project emissions
Additional comments	Used for $F_{CH4,sent\_flare,y}$ and $F_{CH4,NG,y}$ following Options C and A, respectively

Data/Parameter	MM_k
Unit	kg/kmol
Description	Molecular mass of gas *k (k = N_2)*
Source of data	As per the tool
Value(s) applied	28.01
Choice of data or measurement methods and procedures	According to ACM0001, the simplification offered in the tool for calculating the molecular mass of the gaseous stream ($MM_{t,db}$) is valid. Thus, the volumetric fraction of the greenhouse gas (CH_4) is considered and the difference to 100% is considered as pure nitrogen.
Purpose of data/parameter	Calculation of baseline emissions
Additional comments	Not used in the case of the proposed project activity.

Data/Parameter	Pn
Unit	Pa
Description	Total pressure at normal conditions
Source of data	As per the tool
Value(s) applied	101,325
Choice of data or measurement methods and procedures	-

Purpose of data/parameter	Calculation of baseline and project emissions
Additional comments	Used for $F_{CH4,sent\_flare,y}$ following Option C.

Data/Parameter	Tn
Unit	K
Description	Temperature at normal conditions
Source of data	As per the tool
Value(s) applied	273.15
Choice of data or measurement methods and procedures	-
Purpose of data/parameter	Calculation of baseline and project emissions
Additional comments	Used for $F_{CH4,sent\_flare,y}$ following Option C.

"Tool to calculate the emission factor for an electricity system"

Data/Parameter	$FC_{i,m,y}$, $FC_{i,y}$, $FC_{i,k,y}$, $FC_{i,n,y}$ and $FC_{i,n,h}$
Unit	mass or volume unit
Description	Amount of fuel type i consumed by power plant/unit m, k or n (or in the project electricity system in case of FCi,y) in year y or hour h
Source of data	Official publications (data from ONS), IPCC default values and default values provided by the *"Tool to calculate the emission factor for an electricity system"*
Value(s) applied	Large amount of data. Please refer to the emission factor calculation spreadsheet which is attached to the PDD.
Choice of data or measurement methods and procedures	The *ex-ante* calculation vintage of this parameter was chosen as per the procedures of the *"Tool to calculate the emission factor for an electricity system"*.
Purpose of data/parameter	Calculation of the project emissions due to electricity consumption
Additional comments	For methodological choices details, please refer to section E.6.1. of the registered PDD.

Data/Parameter	$EF_{CO2,i,y}$ and $EF_{CO2,m,i,y}$
Unit	tCO_2/GJ
Description	CO_2 emission factor of fossil fuel type *i* used in power unit *m* in year *y*
Source of data	IPCC default values at the lower limit of the uncertainty at a 95% confidence interval as provided in table 1.4 of Chapter1 of Vol. 2 (Energy) of the 2006 IPCC Guidelines on National GHG Inventories
Value(s) applied	Large amount of data. Please refer to the emission factor calculation spreadsheet which is attached to the PDD.
Choice of data or measurement methods and procedures	As per the recommendation of the *"Tool to calculate the emission factor for an electricity system"*. IPCC default values are being used since this information is neither provided by fuel suppliers nor regional and/or local default values are publicly available.
Purpose of data/parameter	Calculation of the project emissions due to electricity consumption
Additional comments	-

Data/Parameter	$EG_{m,y}$ and $EG_{k,y}$
Unit	MWh
Description	Net electricity generated by power plant/unit *m* or *k* in year *y*
Source of data	Official publications. Data from the Electric System National Operator was used.
Value(s) applied	Large amount of data. Please refer to the emission factor calculation spreadsheet which is attached to the PDD.

Choice of data or measurement methods and procedures	Once for each crediting period using the most recent three historical years for which data is available at the time of submission of the PDD to the DOE for validation (*ex-ante* option).
Purpose of data/parameter	Calculation of the project emissions due to electricity consumption
Additional comments	For methodological choices details, please refer to section E.6.1. of the registered PDD

Data/Parameter	$\eta_{m,y}$
Unit	-
Description	Average net energy conversion efficiency of power unit *m* in year *y*
Source of data	Default values provided in Annex 1 of the *"Tool to calculate the emission factor for an electricity system"*
Value(s) applied	Large amount of data. Please refer to the emission factor calculation spreadsheet which is attached to the PDD.
Choice of data or measurement methods and procedures	As per the recommendation of the *"Tool to calculate the emission factor for an electricity system"*.
Purpose of data/parameter	Calculation of the project emissions due to electricity consumption
Additional comments	For methodological choices details, please refer to section E.6.1.of the registered PDD

Data/Parameter	$EF_{grid,OM-adj,y}$
Unit	tCO_2/MWh
Description	Simple adjusted operating margin CO_2 emission factor in year *y*
Source of data	Official publications (data from ONS), IPCC default values and default values provided by the *"Tool to calculate the emission factor for an electricity system"*
Value(s) applied	0.3612
Choice of data or measurement methods and procedures	The *ex-ante* calculation vintage of this parameter was chosen as per the procedures of the *"Tool to calculate the emission factor for an electricity system"*.
Purpose of data/parameter	Calculation of the project emissions due to electricity consumption
Additional comments	For methodological choices details, please refer to section E.6.1. of the registered PDD

Data/Parameter	$EF_{BM,2013}$
Unit	tCO_2/MWh
Description	Build Margin CO_2 emission factor in year *y*
Source of data	Official publications (data from ONS), IPCC default values and default values provided by the *"Tool to calculate the emission factor for an electricity system"*
Value(s) applied	0.2850
Choice of data or measurement methods and procedures	The *ex-ante* calculation vintage of this parameter was chosen as per the procedures of the *"Tool to calculate the emission factor for an electricity system"*.
Purpose of data/parameter	Calculation of the project emissions due to electricity consumption
Additional comments	For methodological choices details, please refer to section E.6.1. of the registered PDD

D.2. Data and parameters monitored

The following monitored parameters, listed in the registered PDD, will not be used in this monitoring period and thus not presented in the tables below since have been not used in the calculation of emission reductions:

- Volumetric flow of the gaseous stream in time interval *t* on a wet basis ($V_{t,wb}$);
- Volumetric fraction of greenhouse gas *i* in a time interval *t* on a wet basis ($v_{i,t,wb}$);
- Quantity of fuel type *i* combusted in process *j* during the year y ($FC_{i,j,y}$), when *i* corresponds to any fossil fuel used to generate electricity since electricity consumed by the plant is from the grid;
- Weighted average net calorific value of fuel type *i* in year *y* ($NCV_{,i,y}$), when *i* corresponds to any fossil fuel used to generate electricity since electricity consumed by the plant is from the grid;
- Weighted average CO_2 emission factor of fuel type *i* in year *y* ($EF_{CO2,i,y}$), when *i* corresponds to any fossil fuel used to generate electricity since electricity consumed by the plant is from the grid;

ACM0001

Data/Parameter	Management of SWDS
Unit	-
Description	Management of SWDS
Measured/calculated/ default	-
Source of data	Use different sources of data: - Original design of the landfill; - Technical specifications for the management of the SWDS; - Local or national regulations
Value(s) of monitored parameter	-
Monitoring equipment	-
Measuring/reading/recording frequency	Annually
Calculation method (if applicable)	-
QA/QC procedures	Project participants should refer to the original design of the landfill to ensure that any practice to increase methane generation have been occurring prior to the implementation of the project activity Any change in the management of the SWDS after the implementation of the project activity should be justified by referring to technical or regulatory specifications
Purpose of data/parameter	Calculation of baseline emissions
Additional comments	-

Data/Parameter	$Op_{j,h}$
Unit	-
Description	Operation of the equipment that consumes the LFG

Measured/calculated/ default	In the context of the proposed project activity, equipment unit *j* using *the LFG* consists of the LFG upgrading facility and a flare. Hence, the following parameters are to be used to ensure that the plant is operating in hour *h*: *For the LFG upgrading facility* • Products generated. Monitor the generation of upgraded LFG which is sold to the consumer. This information can be cross-checked with invoices; *For the flaring system* • Flame. Flame detection system is used to ensure that the equipment is in operation; $Op_{j,h}$=0 when: • No products are generated in the hour h • Flame is not detected continuously in hour h (instantaneous measurements are made at least every minute); Otherwise, $Op_{j,h}$=1
Source of data	Project Participants
Value(s) of monitored parameter	-
Monitoring equipment	Flame detection system / Flares temperature meters
Measuring/reading/recording frequency	Hourly
Calculation method (if applicable)	Not applicable
QA/QC procedures	Flow meters and flame detectors shall be subject to a regular maintenance and testing regime to ensure accuracy. Calibration shall be according to manufacturers' specifications. Accuracy of the flow meters and flame detectors is described in the monitoring tables of parameters $V_{t,db}$ and $Flame_m$, respectively.
Purpose of data/parameter	Calculation of baseline emissions
Additional comments	This is monitored to ensure methane destruction is claimed for methane used in the upgrading LFG facility when it is operational

Data/Parameter	$EG_{EC,y}$
Unit	MWh
Description	Amount of electricity consumed by the project activity in year y
Measured/calculated/ default	Measured
Source of data	Electricity meters
Value(s) of monitored parameter	The CERs calculation spreadsheet includes all records of measurement data of this parameter during the considered monitoring period.
Monitoring equipment	Manufacturer: Landis Gyr Model: E750 Serial Number: 4262353 Accuracy class: C/D Meter calibration and maintenance under the responsibility of the local electricity distribution company.
Measuring/reading/recording frequency	Continuously, aggregated at least annually
Calculation method (if applicable)	-
QA/QC procedures	Electricity meter will be subject to regular maintenance and testing to ensure accuracy. The calibration periodicity will be in accordance with the manufacturer recommendation. The accuracy of the equipment, as per the manufacturer specification is 1% (Accuracy class 1%).
Purpose of data/parameter	Calculation of project emissions

Additional comments	This parameter is required for calculating project emissions from electricity consumption due to an alternative waste treatment process *t* ($PE_{EC,y}$) using the "*Tool to calculate baseline, project and/or leakage emissions from electricity consumption*". In accordance with ACM0001, this parameter is equivalent to $EC_{PJ,k,y}$ in the tool.

"Tool to determine the mass flow of a greenhouse gas in a gaseous stream"

Data/Parameter	$V_{t,db}$
Unit	m³ dry gas/h
Description	Volumetric flow of the gaseous stream in time interval *t* on a dry basis
Measured/calculated/ default	Measured
Source of data	Onsite measurements
Value(s) of monitored parameter	The CERs calculation spreadsheet includes all records of measurement data of this parameter during the considered monitoring period.
Monitoring equipment	Instrument: LFG Flow inlet direct to Flare; TAG: FIT 206; Manufacturer: SAGE; Model: ; Serial number: ; Starting period: 22/04/2016; Finishing period: 04/12/2017; Calibration frequency: 3 years; Date of Calibration: 05/11/2015; Validity: 04/11/2020
Measuring/reading/recording frequency	Continuous, aggregated at least hourly.
Calculation method (if applicable)	-
QA/QC procedures	Periodic calibration against a primary device provided by an independent accredited laboratory is mandatory. Calibration and frequency of calibration is according to manufacturer's specification.
Purpose of data/parameter	Calculation of baseline and project emissions
Additional comments	This parameter will be monitored in Option A, in order to calculate $F_{CH4,NG}$ and $F_{CH4,sent\_flare,y}$ (upgraded gas that does not reach specifications to be sent to the NG pipeline).

Data/Parameter	$v_{i,t,db}$
Unit	m³ gas *i*/m^3 dry gas
Description	Volumetric fraction of greenhouse gas *i* in time interval *t* on a dry basis
Measured/calculated/ default	Measured
Source of data	Onsite measurement
Value(s) of monitored parameter	The CERs calculation spreadsheet includes all records of measurement data of this parameter during the considered monitoring period.
Monitoring equipment	Information to be provided during the verification
Measuring/reading/recording frequency	Continuous, aggregated at least hourly.
Calculation method (if applicable)	-
QA/QC procedures	Calibration should include zero verification with an inert gas (e.g. N_2) and at least one reading verification with a standard gas (single calibration gas or mixture calibration gas). All calibration gases must have a certificate provided by the manufacturer and must be under their validity period.
Purpose of data/parameter	Calculation of baseline and project emissions
Additional comments	This parameter will be monitored in Option A, in order to calculate $F_{CH4,NG}$ and $F_{CH4,sent\_flare,y}$ (upgraded gas that does not reach specifications to be sent to the NG pipeline).

Data/Parameter	T_t
Unit	K
Description	Temperature of the gaseous stream in time interval *t*

Measured/calculated/ default	Measured
Source of data	Onsite measurements
Value(s) of monitored parameter	The CERs calculation spreadsheet includes all records of measurement data of this parameter during the considered monitoring period.
Monitoring equipment	Information to be provided during the verification
Measuring/reading/recording frequency	Continuous, aggregated at least hourly.
Calculation method (if applicable)	-
QA/QC procedures	Periodic calibration against a primary device provided by an independent accredited laboratory is mandatory. Calibration and frequency of calibration is according to manufacturer's specifications
Purpose of data/parameter	Calculation of baseline and project emissions
Additional comments	Provided all parameters are converted to normal conditions during the monitoring process, this parameter may not be needed except for moisture content determination and therefore it should be metered only when performing such measurements (with same frequency). However, if the applicability condition related to the gaseous stream flow temperature being below 60ºC is adopted, this parameter must be monitored continuously to assure the applicability condition is met. Applicable to Options A and C in order to determine $F_{CH4,NG}$ and $F_{CH4,sent\_flare,y}$ parameters, respectively.

Data/Parameter	P_t
Unit	Pa
Description	Pressure of the gaseous stream in time interval *t*
Measured/calculated/ default	Measured
Source of data	Onsite measurements
Value(s) of monitored parameter	The CERs calculation spreadsheet includes all records of measurement data of this parameter during the considered monitoring period.
Monitoring equipment	Information to be provided during the verification
Measuring/reading/recording frequency	Continuous, aggregated at least hourly.
Calculation method (if applicable)	-
QA/QC procedures	Periodic calibration against a primary device must be performed periodically and records of calibration procedures must be kept available as well as the primary device and its calibration certificate. Pressure transducers (either capacitive or resistive) must be calibrated monthly.
Purpose of data/parameter	Calculation of baseline emissions
Additional comments	Provided all parameters are converted to normal conditions during the monitoring process, this parameter may not be needed except for moisture content determination and therefore it should be metered only when performing such measurements (with same frequency). Applicable to Option A and C in order to determine $F_{CH4,NG}$ and $F_{CH4,sent\_flare,y}$ parameters, respectively.

"Project emissions from flaring"

Data/Parameter	$Flame_m$
Unit	Flame on or Flame off
Description	Flame detection of flare in the minute *m*
Measured/calculated/ default	The CERs calculation spreadsheet includes all records of measurement data of this parameter during the considered monitoring period.

Source of data	Project participants
Value(s) of monitored parameter	The CERs calculation spreadsheet includes all records of measurement data of this parameter during the considered monitoring period.
Monitoring equipment	Flame detector
Measuring/reading/recording frequency	Once per minute. Detection of flame recorder as a minute that the flame was on, otherwise recorded as a minute that the flame was off
Calculation method (if applicable)	-
QA/QC procedures	Equipment shall be maintained and calibrated in accordance with manufacturer's recommendations. It will be replaced after 10,000 operating hours. The spectral range of the equipment is 190 – 270nm and its maximum sensitivity is 210 ± 10nm.
Purpose of data/parameter	Calculation of project emissions
Additional comments	-

"Tool to calculate baseline, project and/or leakage emissions from electricity consumption"

Data/Parameter	$TDL_{project, y}$
Unit	%
Description	Average technical transmission and distribution losses for providing electricity to source j in year y
Measured/calculated/ default	Default
Source of data	ANEEL Report[18]
Value(s) of monitored parameter	2016:11.85% 2017: 13.95%
Monitoring equipment	-
Measuring/reading/recording frequency	Annually. In the absence of data from the relevant year, most recent figures should be used, but not older than 5 years.
Calculation method (if applicable)	-
QA/QC procedures	-
Purpose of data/parameter	Calculation of project emissions
Additional comments	Official source is used. Aneel is the Brazilian electricity regulatory agency.

"Tool to determine project emissions from fossil fuel combustion"

Data/Parameter	$FC_{i,j,y}$
Unit	kg/yr
Description	Quantity of fuel type *i* combusted in process *j* during the year y (*i* = LPG)
Measured/calculated/ default	Measured
Source of data	Sales receipt
Value(s) of monitored parameter	The CERs calculation spreadsheet includes all records of measurement data of this parameter during the considered monitoring period.
Monitoring equipment	Internal records related to LPG purchase.
Measuring/reading/recording frequency	At every purchase of LPG

[18] Publicly available in Portuguese at https://www.aneel.gov.br/metodologia-distribuicao/-/asset_publisher/e2INtBH4EC4e/content/perdas/654800?inheritRedirect=false&redirect=http%3A%2F%2Fwww.aneel.gov.br%2Fmetodologia-distribuicao%3Fp_p_id%3D101_INSTANCE_e2INtBH4EC4e%26p_p_lifecycle%3D0%26p_p_state%3Dnormal%26p_p_mode%3Dview%26p_p_col_id%3Dcolumn-2%26p_p_col_pos%3D3%26p_p_col_count%3D4

Calculation method (if applicable)	-
QA/QC procedures	The consistency of metered fuel consumption quantities is to be cross-checked by an annual energy balance that is based on purchased quantities and stock changes. Where the purchased fuel invoices can be identified specifically for the CDM project, the metered fuel consumption quantities should also be cross-checked with available purchase invoices from the financial records.
Purpose of data/parameter	Calculation of project emissions
Additional comments	Conservatively, it shall be considered that all LPG purchase will be used.

Data/Parameter	$NCV_{,i,y}$
Unit	GJ/kg
Description	Weighted average net calorific value of fuel type *i* in year *y* (*i* = LPG)
Measured/calculated/ default	Default
Source of data	Brazilian Energy Balance
Value(s) of monitored parameter	0.0465
Monitoring equipment	-
Measuring/reading/recording frequency	Review appropriateness of values annually
Calculation method (if applicable)	-
QA/QC procedures	Verify if the value is within the uncertainty range of the IPCC default values as provided in Table 1.2, Vol. 2 of the 2006 IPCC Guidelines. If the values fall below this range collect additional information from the testing laboratory to justify the outcome or conduct additional measurements. The laboratories in a), b) or c) should have ISO17025 accreditation or justify that they can comply with similar quality standards.
Purpose of data/parameter	Calculation of project emissions from fossil fuel consumption for the flare ignition.
Additional comments	Option c) is used since a liquid fuel is considered and is based on well documented reliable sources (*i.e.* Brazilian Energy Balance). Information used with the purpose of calculating expected emission reductions is in accordance with the values provided in 2006 IPCC Guidelines.

Data/Parameter	$EF_{CO2,i,y}$
Unit	tCO_2/GJ
Description	Weighted average CO_2 emission factor of fuel type *i* in year *y* (*i* = LPG)
Measured/calculated/ default	Default
Source of data	d) IPCC default values at the upper limit of the uncertainty at 95% confidence interval as provided in Table 1.2 of Chapter 1 of Vol.2 (Energy) of the 2006 IPCC Guidelines on National GHG Inventories
Value(s) of monitored parameter	0.0656
Monitoring equipment	-
Measuring/reading/recording frequency	Any future revisions of the IPCC Guidelines should be taken into account.
Calculation method (if applicable)	-
QA/QC procedures	Not applicable since IPCC default value is used.
Purpose of data/parameter	Calculation of project emissions
Additional comments	-

Data/Parameter	$EF_{CO2,i,y}$
Unit	tCO_2/TJ
Description	Weighted average CO_2 emission factor of fuel type *i* in year *y* (*i* = natural gas)
Measured/calculated/ default	Default
Source of data	IPCC default values at the upper limit of the uncertainty at 95% confidence interval as provided In Table 1.2 of Chapter 1 of Vol.2 (Energy) of the 2006 IPCC Guidelines on National GHG Inventories
Value(s) of monitored parameter	58.3
Monitoring equipment	-
Measuring/reading/recording frequency	Any future revisions of the IPCC Guidelines should be taken into account.
Calculation method (if applicable)	-
QA/QC procedures	-
Purpose of data/parameter	Calculation of baseline emissions
Additional comments	Option d) is used since the source mentioned in option a) is not available. Further the fuel considered – *i.e.* natural gas - is not liquid. Therefore, option c) could not be used. This parameter is used to determine $EF_{CO2,NG,y}$ from ACM0001. Following the procedures of the methodology, it is to be determined using the "*Tool to determine project emissions from fossil fuel combustion"*.

D.3. Implementation of sampling plan

>>

Not applicable. This section is intentionally left blank.

SECTION E. Calculation of emission reductions or net anthropogenic removals

E.1. Calculation of baseline emissions or baseline net removals

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This section describes the methods used for the calculation of baseline emissions. As per the requirements, sample calculations for all formulae used are provided considering baseline emissions achieved by the CDM Project Activity during 05/2016.

The table below summarizes the results of baseline emissions calculated for the monitoring period.

	DEVIATION applied	BE,y	BECH4,y	BENG,y	FCH4PJ,y	FCH4BL,y	FCH4flared,y	FCH4NG,y	% CH4	FCH4 sentflare,y	Total methane for Consumer	Total methane to Flare	FCH4RG,t	PEflare,y
	(yes/no)	tCO2	tCO2	tCO2	tCH4	tCH4	tCH4	tCH4	%	tCH4	Nm^3CH4	Nm^3CH4	kg	tCO2
04/2016	Yes	1,201	1,201	0	69	14	69	0	54%	137	0	191,517	137,279	1,716
05/2016	Yes	2,238	2,238	0	128	26	128	0	40%	256	0	356,818	255,767	3,197
06/2016	Yes	131	131	0	7	1	7	0	14%	15	0	20,883	14,969	187
07/2016	Yes	1,423	1,423	0	81	16	81	0	51%	163	0	226,942	162,672	2,033
08/2016	Yes	4,050	4,050	0	231	46	231	0	51%	463	0	645,706	462,842	5,786
09/2016	Yes	3,431	3,431	0	196	39	196	0	52%	392	0	547,014	392,100	4,901
10/2016	Yes	3,295	3,295	0	188	38	188	0	50%	377	0	525,416	376,618	4,708
11/2016	Yes	2,647	2,647	0	151	30	151	0	50%	302	0	421,976	302,472	3,781
12/2016	Yes	3,418	3,418	0	195	39	195	0	51%	391	0	544,934	390,609	4,883
01/2017	Yes	7,345	7,345	0	420	84	420	0	55%	839	0	1,171,097	839,442	10,493
02/2017	Yes	7,278	7,278	0	416	83	416	0	53%	832	0	1,160,321	831,718	10,396
03/2017	Yes	3,531	3,531	0	202	40	202	0	53%	404	0	563,014	403,569	5,045
04/2017	Yes	487	487	0	28	6	28	0	55%	56	0	77,606	55,628	695
05/2017	Yes	0	0	0	0	0	0	0	0%	0	0	0	0	0
06/2017	Yes	3,021	3,021	0	173	35	173	0	54%	345	0	481,680	345,268	4,316
07/2017	Yes	1	1	0	0	0	0	0	42%	0	0	135	97	1
08/2017	Yes	320	320	0	18	4	18	0	52%	37	0	51,058	36,599	457
09/2017	Yes	163	163	0	9	2	9	0	53%	19	0	26,042	18,667	233

Baseline emissions for the proposed project activity are determined according to the following equation:

$BE_y = BE_{CH4,y} + BE_{EC,y} + BE_{HG,y} + BE_{NG,y}$ **Equation 1**

Where,

BE_y = Baseline emissions in year *y* (t CO_2e/yr)
$BE_{CH4,y}$ = Baseline emissions of methane from the SWDS in year *y* (t CO_2e/yr)
$BE_{EC,y}$ = Baseline emissions associated with electricity generation in year *y* (t CO_2/yr)
$BE_{HG4,y}$ = Baseline emissions associated with heat generation in year *y* (t CO_2/yr)
$BE_{NG,y}$ = Baseline emissions associated with natural gas use in year *y* (t CO_2/yr)

Baseline emissions associated with heat generation in year *y* ($BE_{HG,y}$) and electricity generation in year *y* ($BE_{EC,y}$) are not applicable to the proposed project activity.

Sample calculation:
$BE_y = BE_{CH4,y} + BE_{NG,y}$
$BE_y = 2,238 + 0 = 2,238\ tCO_2e$

Baseline emissions of methane from the SWDS ($BE_{CH4,y}$) are determined, based on the amount of methane that is captured under the project activity and the amount that would be captured and destroyed in the baseline (such as due to regulations). In addition, the effect of methane oxidation that is present in the baseline and absent in the project is taken into account[19].

$$BE_{CH4,y} = \left(\left(1 - OX_{top\_layer}\right) \times F_{CH4PJ,y} - F_{CH4BL,y}\right) \quad GWP_{CH4}$$ **Equation 2**

Where,

$BE_{CH4,y}$ = Baseline emissions of methane from the SWDS in year *y* (t CO_2e/yr)
OX_{top_layer} = Fraction of methane in the LFG that would be oxidized in the top layer of the SWDS in the baseline (dimensionless)
$F_{CH4,PJ,y}$ = Amount of methane in the LFG which is flared and/or used in the project activity in year *y* (t CH_4/yr)
$F_{CH4,BL,y}$ = Amount of methane in the LFG that would be flared in the baseline in year *y* (t CH_4/yr)
GWP_{CH4} = Global warming potential of CH_4 (t CO_2e/t CH_4)

Sample calculations
$BE_{CH4,y} = ((1 – OX_{top\_layer}) * F_{CH4,PJy} - F_{CH4,BLy}) * GWP_{CH4}$
$BE_{CH4,y} = ((1 – 0.1) * 128 - 26) * 25 = 2,238\ tCO_2e$

During the crediting period, $F_{CH4,PJ,y}$ is determined as the sum of the quantities of methane flared and forwarded to the natural gas distribution network, considering the following equation:

[19] $OX_{top\text{-}layer}$ is the fraction of the methane in the LFG that would oxidize in the top layer of the SWDS in the absence of the project activity. Under the project activity, this effect is reduced as a part of the LFG is captured and does not pass through the top layer of the SWDS. This oxidation effect is also accounted for in the methodological tool "Emissions from solid waste disposal sites". In addition to this effect, the installation of a LFG capture system under the project activity may result in the suction of additional air into the SWDS. In some cases, such as with a high suction pressure, the air may decrease the amount of methane that is generated under the project activity. However, in most circumstances where the LFG is captured and used this effect was considered to be very small, as the operators of the SWDS have in most cases an incentive to main a high methane concentration in the LFG. For this reason, this effect is neglected as a conservative assumption.

$F_{CH4,PJ,y} = F_{CH4,flared,y} + F_{CH4,EL,y} + F_{CH4,HG,y} + F_{CH4,NG,y}$ **Equation 3**

Where,

$F_{CH4,PJ,y}$ = Amount of methane in the LFG which is flared and/or used in the project activity in year *y* (tCH_4/yr)
$F_{CH4,flared,y}$ = Amount of methane in the LFG which is destroyed by flaring in year *y* (tCH_4/yr)
$F_{CH4,EL,y}$ = Amount of methane in the LFG which is used for electricity generation in year *y* (tCH_4/yr)
$F_{CH4,HG,y}$ = Amount of methane in the LFG which is used for heat generation in year *y* (tCH_4/yr)
$F_{CH4,NG,y}$ = Amount of methane in the LFG which is sent to the natural gas distribution network and/or to the trucks in year *y* (tCH_4/yr)

In the case of the project activity, $F_{CH4,HG,y}$ and $F_{CH4,EL,y}$ are zero since neither heat nor electricity will be generated using the biogas.

Sample calculations

$F_{CH4,PJ,y} = F_{CH4,flared,y} + F_{CH4,EL,y} + F_{CH4,HG,y} + F_{CH4,NG,y}$
$F_{CH4,PJ,y} = 128 + 0 = 128\ tCO_2e$

The determination of $F_{CH4,NG,y}$ is done using the *"Tool to determine the mass flow of a greenhouse gas in a gaseous stream"*. Since the proposed project activity is under conception and it is not known if temperature/pressure will be hourly monitored in all metering points, the PDD presents the most possible scenario for biogas and methane monitoring. In spite of the options chosen at the time of the project verification, monitoring will be followed according to ACM0001 and the "Tool to determine the mass flow of a greenhouse gas in a gaseous stream".
Then, the most plausible scenario for $F_{CH4,NG,y}$ determination is **Option A** of the Tool (*i.e.*, biogas mass flow and volumetric fraction of methane measured in dry basis). Then, $F_{CH4,NG,y} = F_{i,t}$.
While considering this option, it is necessary to demonstrate that the gaseous stream is dry by:

(a) Measuring the moisture content of the gaseous stream ($C_{H2O,t,db,n}$) and demonstrate that this is less or equal to 0.05 kg H_2O/m^3 dry gas; or
(b) Demonstrating that the temperature of the gaseous stream (T_t) is less than 60°C (333.15 K) at the flow measurement point.

If it cannot be demonstrated that the gaseous stream is dry, then the flow measurement should be assumed to be on a wet basis and the corresponding option available in the tool should be applied instead.

$$F_{i,t} = V_{t,db} \times v_{i,t,db} \times \rho_{i,t}$$ **Equation 4**

And:

$$\rho_{i,t} = \frac{P_t \times MM_i}{R_u \times T_t}$$ **Equation 5**

Where:

$F_{i,t}$ = Mass flow of greenhouse gas *i* in the gaseous stream in time interval *t* (kg gas/h);
$V_{t,db}$ = Volumetric flow of the gaseous stream in time interval *t* on a dry basis (m^3 wet gas/h);
$v_{i,t,db}$ = Volumetric fraction of greenhouse gas *i* in the gaseous stream in time interval *t* on a dry basis (m^3 gas *i* /m^3 dry gas);
$\rho_{i,t}$ = Density of greenhouse gas *i* in the gaseous stream in time interval t (kg gas *i*/m^3 gas *i*);
P_t = Absolute pressure of the gaseous stream in time interval *t* (Pa);
MM_i = Molecular mass of greenhouse gas *i* (kg/kmol);
R_u = Universal ideal gases constant ($Pa.m^3/kmol.K$);
T_t = Temperature of the gaseous stream in time interval *t* (K).

$F_{CH4,flared,y}$ is determined as the difference between the amount of methane supplied to the flare(s) and any methane emissions from the flare(s), as follows:

$$F_{CH4,flared,y} = F_{CH4,sent\_flare,y} \quad \frac{PE_{flare,y}}{GWP_{CH4}}$$ **Equation 6**

Where,

$F_{CH4,flared,y}$ = Amount of methane in the LFG which is destroyed by flaring in year *y* (t CH_4/yr)
$F_{CH4,sent\_flare,y}$ = Amount of methane in the LFG which is sent to the flare in year *y* (t CH_4/yr)
$PE_{flare,y}$ = Project emissions from flaring of the residual gas stream in year *y* (t CO_2e/yr)
GWP_{CH4} = Global warming potential of CH_4 (t CO_2e/t CH_4)

$F_{CH4,sent\_flare,y}$ is determined directly using the *"Tool to determine the mass flow of a greenhouse gas in a gaseous stream"*, applying the requirements described above where the gaseous stream the tool shall be applied to is the LFG delivery pipeline to the flare.

To calculate $F_{CH4,sent\_flare,y}$ for the flare, **Option C** is the most plausible monitoring scenario (*i.e.*, LFG and volumetric fraction of methane measured in wet basis). Then, $F_{CH4,sent\_flare,y} = F_{i,t}$.

$$\mathrm{F_{i,t}} = V_{t,wb,n} \times v_{i,t,wb} \times \rho_{i,n}$$ **Equation 7**

And:

$$\rho_{i,n} = \frac{P_n \times MM_i}{R_u \times T_n}$$ **Equation 8**

Where:

Fi,t = Mass flow of greenhouse gas *i* in the gaseous stream in time interval *t* (kg gas/h);
Vt,wb, n = Volumetric flow of the gaseous stream in time interval *t* on a wet basis at normal conditions (m³ wet gas/h);
vi,t,wb = Volumetric fraction of greenhouse gas *i* in the gaseous stream in time interval *t* on a wet basis (m³ gas *i* /m³ wet gas);
ρi,n = Density of greenhouse gas *i* in the gaseous stream at normal conditions (kg gas *i*/m³ wet gas *i*);
Pn = Absolute pressure at normal conditions (Pa);
Tn = Temperature at normal conditions (K);
MMi = Molecular mass of greenhouse gas *i* (kg/kmol);
Ru = Universal ideal gases constant (Pa.m3/kmol.K).

The following equation should be used to convert the volumetric flow of the gaseous stream from actual conditions to normal conditions of temperature and pressure:

$$V_{t,wb,n} = V_{t,wb} \times [(T_n / T_t) \times (P_t / P_n)]$$ **Equation 9**

Where:

Vt,wb,n = Volumetric flow of the gaseous stream in a time interval *t* on a wet basis at normal conditions (m3 wet gas/h);
Vt,wb = Volumetric flow of the gaseous stream in time interval *t* on a wet basis (m³ wet gas/h);
Pt = Pressure of the gaseous stream in time interval *t* (Pa);
Tt = Temperature of the gaseous stream in time interval *t* (K);
Pn = Absolute pressure at normal conditions (Pa);
T_n = Temperature at normal conditions (K).

It is important mentioning that the upgraded gas that does not reach specifications to be delivered in the NG pipeline will be flared. For the determination of biogas resulted from the upgrade system return that will be flared, Option A is the most plausible scenario to be applied (volume flow of

biomethane and volumetric flow of methane measured in dry basis) following equations 4 and 5 above.

The biogas upgrading plant was not operational during this monitoring period. Hence, the captured biogas was totally forwarded to the flaring system.

Project Emissions from flaring:

Project emissions are related to the amount of methane not destroyed in the flare and are determined following the procedures of the methodological tool "*Project emissions from flaring*". The project is equipped with an open flare. In this sense, Oeste de Caucaia Landfill Project adopts the default flare efficiency. The calculation of flare efficiency will be made by the following steps:

STEP 1: Determination of the methane mass flow of the residual gas;

The mass flow of methane in the residual gaseous stream in the minute *m* ($F_{CH4,m}$) will be determined using the procedures set out by the "*Tool to determine the mass flow of a greenhouse gas in a gaseous stream*" and the following requirements apply:

- The gaseous stream tool shall be applied to the residual gas;
- The flow of the gaseous stream shall be measured continuously;
- CH_4 is the greenhouse gas *i* for which the mass flow should be determined;
- The simplification offered for calculating the molecular mass of the gaseous stream is valid (equations 3 and 17 in the tool); and
- The time interval *t* for which mass flow should be calculated is every minute *m*.

$F_{CH4,m}$, which is measured as the mass flow during minute *m*, shall then be used to determine the mass of methane in kilograms fed to the flare in minute *m* ($F_{CH4,RG,m}$). This parameter corresponds to $F_{CH4,sent\_flare,y}$. Therefore, the same methodological approaches apply to both parameters (Option C of the tool described above).

However, the upgraded gas, which does not reach quality specifications to be delivered into the NG pipeline, will be flared. In this case, Option A of the tool will be applied as explained above. Please refer to methodological explanations for the ex-post determination of $F_{CH4,sent\_flare,y}$ and monitoring equipment in section B.7.3.

STEP 2: Determination of flare efficiency

The Oeste de Caucaia Landfill Project installed an open flare. Therefore, in accordance with the methodological tool, the flare efficiency in the minute *m* ($\eta_{flare,m}$) is 50% when the flame is detected in minute *m* ($Flame_m$), otherwise $\eta_{flare,m}$ is 0%.

STEP 3: Calculation of project emissions from flaring

Project emissions from flaring are calculated as the sum of emissions from each minute *m* in year *y*, based on the methane flow rate in the residual gas ($F_{CH4,RG,m}$) and the flare efficiency ($\eta_{flare,m}$), as follows:

$$PE_{flare,y} = GWP_{CH_4} \times \sum_{m=1}^{525600} F_{CH4,RG,m} \cdot \left(1 - \eta_{flare,m}\right) \times 10^{-3} \qquad \textbf{Equation 10}$$

Where,

$PE_{flare,y}$ = Project emissions from flaring of the residual gas stream in year *y* (tCO_2e)
GWP_{CH4} = Global Warming Potential (tCO_2e/tCH_4) valid for the commitment period
$F_{CH4,RG,m}$ = Mass flow of methane in the residual gas in the minute *m* (kg)
$\eta_{flare,m}$ = Flare efficiency in the minute *m*

Sample calculation

$PE_{flare,y} = GWP_{CH4} * \sum F_{CH4,RG,m} * (1 - \eta_{flare,m}).10^{-3}$

$PE_{flare,y} = 25 * 255{,}767 * (1 - 0.5).10^{-3} = 3{,}197\ tCO_2e$

Baseline emissions associated with natural gas use ($BE_{NG,y}$)

$BE_{NG,y}$ is estimated as follows:

$$\mathrm{BE}_{\mathrm{NG,y}} = 0.0504 \times F_{CH4,NG,y} \times EF_{CO2,NG,y}$$ **Equation 11**

Where,

$BE_{NG,y}$ = Baseline emissions associated with natural gas use in year *y* (t CO_2/yr)

$EF_{CO2,NG,y}$ = Average CO_2 emission factor of natural gas in the natural gas network or in trucks in year *y* (tCO_2/TJ)

$F_{CH4,NG,y}$ = Amount of methane in the LFG which is sent to the natural gas distribution network or in trucks in year *y* (tCH_4/yr)

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

Sample calculation

$BE_{NG,y} = 0.0504 * F_{CH4NG,y} * EF_{CO2,NG,y}$

$BE_{NG,y} = 0.0504 * 0 * 58.3 = 0\ tCO_2e$

Finally, the determination of the amount of methane in the LFG that would be flared in the baseline ($F_{CH4,BL,y}$) is calculated following the provisions of Case 3 of the ACM0001, as per the registered PDD. In accordance with the ACM0001 methodology, under *Case 3*, $F_{CH4,BL,y} = F_{CH4,BL,sys,y}$ and the following equation applies:

$F_{CH4,BL,sys,y} = 0.2 \times F_{CH4,PJ,y}$ **Equation 12**

Sample calculation

$F_{CH4,BL,sys,y} = F_{CH4,BL,y} = 0.2 * F_{CH4,PJ,y}$

$F_{CH4,BL,y} = 0.2 * 128 = 26\ tCO_2e$

E.2. Calculation of project emissions or actual net removals

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This section describes the methods used for the calculation of project emissions. As per the requirements, sample calculations for all formulae used are provided considering project emissions occurring as a consequence of the implementation of the CDM Project Activity during 05/2016.

The table below summarizes the results of project emissions calculated for the monitoring period.

	DEVIATION applied	PE,y	PEEC1	PEFC,j	ECPJ1	FCi,j
	(yes/no)	tCO2	tCO2	tCO2	MWh	Kg
04/2016	Yes	4.62	4.62	0	12.38	0
05/2016	Yes	7.20	7.20	0	17.63	0
06/2016	Yes	7.20	7.20	0	17.63	0
07/2016	Yes	6.60	6.60	0	18.26	0
08/2016	Yes	6.86	6.86	0	19.00	0
09/2016	Yes	6.68	6.68	0	18.50	0
10/2016	Yes	6.93	6.93	0	19.17	0
11/2016	Yes	6.00	6.00	0	16.61	0
12/2016	Yes	6.09	6.09	0	16.84	0
01/2017	Yes	8.76	8.76	0	23.80	0
02/2017	Yes	9.15	9.15	0	24.86	0
03/2017	Yes	11.94	11.94	0	32.43	0
04/2017	Yes	11.29	11.29	0	30.67	0
05/2017	Yes	12.57	12.57	0	30.80	0
06/2017	Yes	13.42	13.42	0	36.46	0
07/2017	Yes	16.11	16.11	0	43.76	0
08/2017	Yes	33.26	33.26	0	90.33	0
09/2017	Yes	19.14	19.14	0	52.00	0

Sources of project emissions are electricity and fossil fuel consumption, as presented in the equation below:

$$PE_y = PE_{EC,y} + PE_{FC,y} + PE_{DT,y} \quad \textbf{Equation 13}$$

Where,

$PE_{EC,y}$ = Emissions from consumption of electricity due to the project activity in year *y* (t CO_2/yr);
$PE_{FC,y}$ = Emissions from consumption of fossil fuels due to the project activity, for purpose other than electricity generation, in year *y* (t CO_2/yr);
$PE_{DT,y}$ = Emissions from the distribution of compressed/liquefied LFG using trucks, in year *y* (tCO_2/yr).

The proposed project activity will not make use of trucks to distribute compressed/liquefied LFG. On the contrary, it will inject the purified LFG directly into the natural gas distribution grid. Therefore, there are no project emissions associated with the distribution of compressed/liquefied LFG using trucks and $PE_{DT,y}$ is **zero.**

Sample calculation
$PE_y = PE_{EC,y} + PE_{FC,y}$
$PE_y = 7.2 + 0 = 7.2\ tCO_2e$

The project emissions from electricity consumption ($PE_{EC.y}$) is calculated following the procedures set out by the *"Tool to estimate the baseline, project and/or leakage emissions from electricity consumption"*. During the crediting period, electricity is purchased from the grid and is consumed for the operation of the active LFG collection system and LFG upgrading facility.

Therefore, Option **A.1** of the "*Tool to calculate baseline, project and/or leakage emissions from electricity consumption"* is used. Under this option, project emissions from consumption of electricity from the grid are calculated based on the power consumed by the project activity and the emission factor of the grid, adjusted for transmission losses, using the following formula:

$$\mathrm{PE}_{\mathrm{EC,grid\,y}} = \sum_{\mathrm{j}} \mathrm{EC}_{\mathrm{PJ,j,y}} \times \mathrm{EF}_{\mathrm{EL,j,y}} \times \left(1 + \mathrm{TDL}_{\mathrm{j,y}}\right) \quad \textbf{Equation 14}$$

Where,

$PE_{EC,grid,\,y}$ = Project emissions from electricity consumption from the grid by the project activity during the year *y* (tCO_2/year);
$EC_{PJ,y}$ = Quantity of electricity consumed by the project electricity consumption source *j* in year *y* (MWh)
$EF_{EL,\,j,\,,y}$ = Emission factor for electricity generation for source *j* in year (tCO_2/MWh)
$TDL_{j,\,y}$ = Average technical transmission and distribution losses for providing electricity to source *j* in year *y*
j = Sources of electricity consumption in the project

The Emission Factor for electricity consumed from the grid was determined according to the procedures of the *"Tool for calculation of emission factor for electricity systems"* and is fixed as per the registered PDD. The transmission and distribution losses were updated considering the most recent information made publicly available by ANEEL.

Sample calculation
$PE_{EC,grid,\,y} = EC_{PJ,y} * EF_{EL,\,j,\,,y} * (\,1 + TDL_{j,\,y})$
$PE_{EC,grid,\,y} = 17.63 * 0.3231 * (\,1 + 14\%) = 7.20\ tCO_2e$

Emissions from consumption of fossil fuels ($PE_{FC,y}$)

Project emissions resulting from combustion of fossil fuels are related to LPG consumption for flare ignition. This source of project emission is determined in accordance with procedures of the *"Tool to calculate project or leakage emissions from fossil fuel combustion"* using the following formulae:

$PE_{FC,j,y} = SUM(FC_{i,j,y} * COEF_{i,y})$ **Equation 15**

Where,

$PE_{FC,j,y}$ = Are the CO_2 emissions from fossil fuel combustion in process *j* during the year *y* (tCO_2/yr);

$FC_{i,j,y}$ = Is the quantity of fuel type *i* combusted in process *j* during the year *y* (mass or volume unit/yr);

$COEF_{i,y}$ = Is the CO_2 emission coefficient of fuel type *i* in year *y* (tCO_2/mass or volume unit)

i = Are the fuel types combusted in process *j* during the year *y*

Sample calculation

$PE_{FC,j,y} = SUM(FC_{i,j,y} * COEF_{i,y})$

$PE_{FC,j,y} = SUM(0 * ((0.0465*0.0656)/1000) = 0\ tCO_2e$

E.3. Calculation of leakage emissions

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According to ACM0001 there is no need to account for leakage. Hence, LE_y = 0 tCO_2e

E.4. Calculation of emission reductions or net anthropogenic removals

	Baseline GHG emissions or baseline net GHG removals (t CO_2e)	Project GHG emissions or actual net GHG removals (t CO_2e)	Leakage GHG emissions (t CO_2e)	GHG emission reductions or net anthropogenic GHG removals (t CO_2e)		
				Before 01/01/2013	From 01/01/2013	Total amount
Total	43,980	194	0	0	43,786	43,786

E.5. Comparison of emission reductions or net anthropogenic removals achieved with estimates in the registered PDD

Amount achieved during this monitoring period (t CO_2e)	Amount estimated ex ante for this monitoring period in the PDD (t CO_2e)
43,786	235,062

E.5.1. Explanation of calculation of "amount estimated ex ante for this monitoring period in the PDD"

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Calculated using the PDD estimation of emission reductions to be achieved in 2016 (317,093 tCO_2e) times the number of days in this monitoring period for this year (254 days) divided by the number of days in the year, plus emission reductions estimated in 2017 (497,834 tCO_2e) times the number of days in this monitoring period for this year (11 days) divided by the number of days in the year under the crediting period.

E.6. Remarks on increase in achieved emission reductions

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Not applicable. This section is intentionally left blank.

E.7. Remarks on scale of small-scale project activity

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Not applicable. This section is intentionally left blank.

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Document information

Version	*Date*	*Description*
07.0	31 May 2019	Revision to: • Ensure consistency with version 02.0 of the "CDM project standard for project activities" (CDM-EB93-A04-STAN); • Add a section on remarks on the observance of the scale limit of small-scale project activity during the crediting period; • Add "changes specific to afforestation or reforestation project activity" as a possible post-registration changes; • Clarify the reporting of net anthropogenic GHG removals for A/R project activities between two commitment periods; • Make editorial improvements.
06.0	7 June 2017	Revision to: • Ensure consistency with version 01.0 of the "CDM project standard for project activities" (CDM-EB93-A04-STAN); • Make editorial improvements.
05.1	4 May 2015	Editorial revision to correct version numbering.
05.0	1 April 2015	Revisions to: • Include provisions related to delayed submission of a monitoring plan; • Provisions related to the Host Party; • Remove reference to programme of activities; • Overall editorial improvement.
04.0	25 June 2014	Revisions to: • Include the Attachment: Instructions for filling out the monitoring report form (these instructions supersede the "Guideline: Completing the monitoring report form" (Version 04.0)); • Include provisions related to standardized baselines; • Add contact information on a responsible person(s)/ entity(ies) for completing the CDM-MR-FORM in A.6 and Appendix 1; • Change the reference number from *F-CDM-MR* to *CDM-MR-FORM*; • Editorial improvement.
03.2	5 November 2013	Editorial revision to correct table in page 1.
03.1	2 January 2013	Editorial revision to correct table in section E.5.

Version	*Date*	*Description*
03.0	3 December 2012	Revision required to introduce a provision on reporting actual emission reductions or net GHG removals by sinks for the period up to 31 December 2012 and the period from 1 January 2013 onwards (EB 70, Annex 11).
02.0	13 March 2012	Revision required to ensure consistency with the "Guidelines for completing the monitoring report form" (EB 66, Annex 20).
01.0	28 May 2010	EB 54, Annex 34. Initial adoption.