Monitoring report form for CDM project activity

(Version 08.0)

MONITORING REPORT			
Title of the project activity	Zone 3 Landfill Gas Project		
UNFCCC reference number of the project activity	9303		
Version number of the PDD applicable to this monitoring report	02		
Version number of this monitoring report	01		
Completion date of this monitoring report	14/08/2021		
Monitoring period number	1st Period Number		
Duration of this monitoring period	26/07/2014 – 25/07/2021		
Monitoring report number for this monitoring period	1		
Project participants	Industrias de Biogás S.A. ALLCOT AG		
Host Party	Guatemala		
Applied methodologies and standardized baselines	ACM0001 ver.13-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 until 31 December 2020	Amount achieved from 1 January 2021
	0	293,142	49,758
Amount of GHG emission reductions or net anthropogenic GHG removals estimated ex ante for this monitoring period in the PDD	1,170,467 tCO_2		

SECTION A. Description of project activity

A.1. General description of project activity

The project activity collects the landfill gas generated from 19 hectares of the site in areas that are accessible for the installation of the required equipment and combusts the gas in two state-of-the-art high temperature flares stack (1000ºC and 0.3 seconds retention time). The project also utilizes the landfill gas to generate electrical energy. The energy generated is being sold under two power purchase agreements to the local distribution network.

The landfill is the primary location for disposal of municipal solid waste by the municipality of Guatemala and private individuals. The site is located in a narrow gorge cut by the Barranca River and is now entirely encompassed by the growth of Guatemala City. One side of the site is low cost housing and the other is under development for industrial use. An older area of the site has been built with low cost housing and a school operated and funded by a non-governmental organization. A recycling center was constructed but its operation failed and the plant and machinery were removed from the site in 2005.

The project activity consists in the capture, flare and generation of electricity through the use of landfill gas (LFG) produced at Zone 3 Landfill site located in Guatemala City and hence, reduce GHG emissions at the site.

Baseline scenario

The site has been used for waste disposal and is projected to continue accepting waste in the future.
The current situation before the project implementation is the complete atmospheric release of landfill gas, as the site contains no control for capture of landfill gas. Hence, baseline scenario is the atmospheric release of the landfill gas and no use of the electricity is needed.

Greenhouse emissions reduction

The project is expected to reduce an annual average of 141,597 tCO2 and a total of 991,181 tCO2 for the first crediting period of 7 years, by reducing methane emissions in flares and electricity generators and by displacing of electricity generated by power plants connected the Guatemalan National Interconnected System (Sistema Nacional Interconectado or SIN).

Contribution to sustainable development.

The project contributes with the international efforts of climate change mitigation and also has several positive social and environmental local impacts by the following aspects:

- Capture and destruction of a part of the landfill gas generated by the site improving the local and global environment,
- Reduction of odors at the landfill site and nearby regions,
- The project contributes to the development of the area through the provision of electrical energy,
- The project creates employment and develop local technical expertise,
- The project contributes financial and social benefits to the local population, and
- The project involves the local technical college and serves as a technical demonstration of many engineering principles for the students. A financial contribution is provided to local educational, health, environmental and small scale business development projects.

A.2. Location of project activity

The project is located in Guatemala City, Zona 3. The site is now surrounded by Guatemala City on all sides.

The site is located in the Barranca Canyon which is bounded to the West by Zone 7 Colonia Landivar and to the East by Zone 3. The site is intersected by Calle 30 running between Zone 3 and Zone 7.

The waste disposal is currently progressing in a Northerly direction in the continuation of the Barranca Canyon. An old area of the landfill, to the South of Calle 30, has been developed with a mixture of commercial, industrial and residential property.

The site is located at 14.6247º and -90.5322º. The satellite image below shows the location of the site within Guatemala City:

Picture 1: Location of the site within Guatemala City

A.3. Parties and project participants

Parties involved	Project participants	Indicate if the Party involved wishes to be considered as project participant (Yes/No)
Guatemala	Industrias de Biogás S.A.	Yes
Switzerland	ALLCOT AG	Yes

A.4. References to applied methodologies and standardized baselines

The baseline and monitoring methodology used for the proposed project activity is the approved consolidated baseline methodology *ACM0001-ver 13.0.0: "Flaring or use of landfill gas".* Also

the next methodological tools have been checked:

- Emissions from solid waste disposal sites"- Version 06.0.1
  This tool can be used for two types of applications. In this project Application A is used as the CDM project activity mitigates methane emissions from a specific existing SWDS.

- "Combined tool to identify the baseline scenario and demonstrate additionality" – Version 05.0.0.
  This tool is applicable as the potential alternative scenarios to the proposed project activity available to project participants cannot be implemented in parallel to the proposed project activity.

- "Tool to determine the mass flow of a greenhouse gas in a gaseous stream" – Version 2.0.0.
  This tool applies as the flow and composition of residual or flared gases or exhaust gases are measured for the determination of baseline project emissions.

- "Project emissions from flaring" – Version 02.0.0.
  This tool is applicable to enclosed or open flares. In this case, enclosed flares will be used. Also this tool is applicable as methane is the components with the highest concentration in the flammable residual gas and the source of the residual gas is from a biogenic source (landfill gas). Besides, applicability conditions from the "Tool to determine the mass flow of a greenhouse gas in a gaseous stream" also apply.

- "Tool to calculate baseline, project and/or leakage emissions from electricity consumption" – Version 1.
  This tool is used as auxiliary electricity is consumed in the project activity as well as in the baseline.

- "Tool to calculate the emission factor for an electricity system" - Version 03.0.0.
  This tool is applied to estimate the OM, BM and/or CM in baseline calculation as the project activity will substitute part of the grid electricity completely located in a non-Annex I country.

- "Tool to calculate project or leakage CO_2 emissions from fossil fuel combustion" – Version 02. This tool is not applicable as it only applies in cases where CO_2 emissions from fossil fuel combustion are calculated based on the quantity of fuel combusted and its properties and there is no fossil fuel consumption under this project activity.
- "Tool to determine remaining lifetime of equipment"
  This tool is not applicable as project activity doesn't involve the replacement of existing equipment with new equipment or retrofit existing equipment as part of energy efficiency improvement activities.

- "Tool to determine the baseline efficiency of thermal or electric energy generation systems" This tool is not applicable the project activity doesn't improve the energy efficiency of an existing system through retrofits or replacement of the existing system by a new system.

A.5. Crediting period type and duration

1st Crediting Period: 26/07/2014 – 25/07/2021. 7 years – renewable crediting period.

(Changed requested from the original crediting period: 01/03/2013 - 28/02/2020)

SECTION B. Implementation of project activity

B.1. Description of implemented project activity

The project activity has the objective to capture, flare and generate electricity through the use of landfill gas (LFG) produced at Zone 3 Landfill site located in Guatemala City and hence, reduce GHG emissions at the site.

The project activity:

1) Captures landfill gas from the Zone 3 landfill site.
2) Uses captured landfill gas to generate electricity that is provided to the grid.
3) Oxidises methane not used for electricity generation to carbon dioxide by combustion with atmospheric oxygen in open flares.

For an appropriate design, construction, installation, collection and operation of the LFG plant, it was necessary to cover different settings to ensure the capture and flaring of the biogas generated and the electricity production. The installations of the LFG capture and collection and destruction system are composed by the following sub-systems:

- Collection: consists of a set of wells installed into the refuse, where the LFG is extracted from the inside.

- Extraction and piping: conformed by a network of pipes and equipment to extract the LFG to the power generation and/or to the flare units.

- Monitoring, analysis and cleaning of biogas: An automatic system assures a stable flow for the methane gas previous to be introduced to the power generation and/or to the flare units.

- Electricity production: Four engines are used for electricity generation, the first, with a capacity of 1,059 kW was installed on 22/03/2015 and the subsequent three engines, with a capacity of 1062 kW were installed at the project site on 02/06/2017. The electricity produced using the LFG recovered is used for project activity self-consumption purposes as well as for its selling to the local distribution network under a power purchase agreement.

- Flaring: Two high temperature enclosed flares stack (1,100ºC and 0.3 seconds retention time, nominal flow of 400-2,000 Nmc/h LFG50) were considered in the initial design as per registered PDD but by the time being the installation of only one flare system with these specifications has been needed in order to destroy the methane gas that is not sent to the power generation plant. Flare efficiency ($\eta_{flare,h}$) is measured hourly as its average value during this monitoring period is 93.16%.

The technology that has been implemented is environmentally safe and it prevents emissions to be released. The project contributes to sustainable development, including technological and know- how transfer to the host party by means of employing local people during the construction and operation phases of the project, which are adequately trained and develop technical and practical knowledge that might be reproduced later on for other projects that will be taking place in the country.

B.2. Post-registration changes

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

No temporary deviation from the registered monitoring plan, applied methodologies, standardized baselines or other methodological regulatory documents has been applied during this monitoring period.

B.2.2. Corrections

The new version of the PDD comply with all the parameters of the Monitoring Plan as per registered PDD. However, some names of ex-post parameters presented in the monitoring plan of the currently registered PDD have been updated in different names and descriptions depending where are they measured for better understanding and clarification of the monitoring system. These new parameters names that have been updated are the following:

Original name and description of the parameter as per PDD	**New name and description of the parameter in this MR**
For gaseous stream sent to flares:	
$V_{t,db}$ (Volumetric flow of the gaseous stream in time interval t on a dry basis)	$\mathbf{V_{t,db\_flare}}$ (Volumetric flow of the gaseous stream sent to the flare in time interval t on a dry basis)
$V_{i,t,db}$ (Volumetric fraction of greenhouse gas i in the gaseous stream in time interval t on a dry basis)	$\mathbf{V_{i,t,db\_flare}}$ (Volumetric fraction of greenhouse gas i in the gaseous stream sent to flare in time interval t on a dry basis)
T_t (Temperature of the gaseous stream in time interval t)	$\mathbf{T_{t\_flare}}$ (Temperature of the gaseous stream sent to the flare in time interval t)
P_t (Absolute pressure of the gaseous stream in time interval t)	$\mathbf{P_{t\_flare}}$ (Absolute pressure of the gaseous stream sent to the flare in time interval t)
For gaseous stream sent to electric engines:	
$V_{t,db}$ (Volumetric flow of the gaseous stream in time interval t on a dry basis)	$\mathbf{V_{t,db\_electricity}}$ (Volumetric flow of the gaseous stream used for electricity generation in time interval t on a dry basis)
$V_{i,t,db}$ (Volumetric fraction of greenhouse gas i in the gaseous stream in time interval t on a dry basis)	$\mathbf{V_{i,t,db\_electricity}}$ (Volumetric fraction of greenhouse gas i in the gaseous stream used for electricity generation in time interval t on a dry basis)
T_t (Temperature of the gaseous stream in time interval t)	$\mathbf{T_{t\_electricity}}$ (Temperature of the gaseous stream used for electricity generation in time interval t)
P_t (Absolute pressure of the gaseous stream in time interval t)	$\mathbf{P_{t\_electricity}}$ (Absolute pressure of the gaseous stream used for electricity generation in time interval t)
At the residual gas:	
$V_{RG,m}$ (Volumetric flow of the residual gas on a dry basis at reference conditions in the minute m)	$\mathbf{V_{RG,m}}$ **(=$\mathbf{V_{t,db\_flare}}$)**
$v_{i,RG,m}$ (Volumetric fraction of component i in the residual gas on a dry basis at minute m where i = CH4, CO, CO2, O2, H2, H2S, NH3 and N2.)	$\mathbf{V_{i,RG,m}}$ **(=$\mathbf{V_{i,t,db\_flare}}$)**

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

Change to the start date of the crediting period was approved by the Board on 19/02/2021 as Post Registration Change by the process track of Prior approval as per PRC-9303-001:

The original start date stated in the registered PDD as crediting period start date (01/03/2013) was delayed and the starting date when the project initiated its operation was in 26/07/2014 that match with the first date when the raw data records are available. The commissioning date of the main project equipment were the following:

Engine 1: 22/03/2015
Engine 2: 02/06/2017
Engine 3: 02/06/2017
Engine 4: 02/06/2017

Thus, the original crediting period (01/03/2013 – 28/02/2020) has been changed to 26/07/2014 – 25/07/2021.

This delay is due to the fact that the first acquisitions of the biogas collection and use equipment were made in 07/04/2014, due to the procedures required by the Ministry of Energy and Mines (MEN as per its Spanish acronym) of the Republic of Guatemala for renewable energy projects of less than 5 MW considered Generators of Renewable Distribution (GDR as per its Spanish acronym).

The General Directorate of Energy (DGE as per its Spanish acronym) of the MEN establishes that the project be developed in three phases, planning, execution and commercial operation. During the planning phase, the respective studies and procedures are prepared to obtain the approval of the renewable energy project before the MEN and the National Electric Energy Commission (CNEE as per its Spanish acronym), period in which equipment cannot be imported until the DGE and the MEN issue the project approval resolution. During this period, it was required to expand the environmental impact study including a list of tariff items of equipment necessary for the collection, thermal oxidation of biogas and generation of electrical energy, in such a way that the processes of procedures before the regulatory entities caused a delay in the start of the project execution. The execution stage was completed in 6 months.

Evidence of this delay is the “Resolution No 1175-2014/DIGARN/UCA/RMHH/aetf” issued on 27/03/2014 by the Environmental Quality Unit of the General Direction of Environmental Management and Natural Resources of the Ministry of Environment and Natural Resources of the Government of Guatemala.

During this delay in the starting date of operation, there was not changes in the baseline emissions as the quantity of waste received by the landfill remained the same as per the Authorization Letter of the municipality of Guatemala to receive an average of 3,300 tons per day for the Zone 3 Landfill.

Additionally, no changes in the technical requirements and normative for landfill operation occurred in terms of biogas destruction as the current applicable technical normative “No DRPSA-004-2018” issued on 02/05/2018 by the Ministry of Public Health and Social Assistance. General Direction of Regulation, Surveillance and Health Control. Department of Regulation of Health and Environment Programs only oblige to include a collection and control system for the biogas generated in its Article 10 and 17.

According the normative, this collection and control system must include, as minimum:

- Design of the System to foresee protection measures for the works to collect the generated gases

- Design of the system that guarantees the effective collection of the gases generated, so that the methane concentration in the areas destined for final disposal does not exceed, at any time, when percent.
- Projected location of the works that do not represent a sanitary risk in relation to other hydro sanitary systems or sources of water supply for human consumption.
- It is not intended to use the system to combine and / or dilute leachates and / or wastewater
- The hydraulic capacity of the system has been designed according to the determined maximum flow rates.
- The system has an appropriate and pertinent operation manual
- The system has an appropriate and pertinent maintenance manual

Considering this, the recovery, destruction and/or use of the biogas generated in the landfill site is not recommended neither required by the current technical normative applicable.

B.2.4. Inclusion of monitoring plan

No post-registration change to include a monitoring plan into the PDD has been submitted during this monitoring period.

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

No permanent changes to the registered monitoring plan, or permanent deviation of monitoring from the applied methodologies, standardized baselines, or other methodological regulatory documents have been applied during this monitoring period.

B.2.6. Changes to project design

(a) Changes that have been approved by the Board as applicable from the period prior to this monitoring period

There are not changes that have been approved by the Board as applicable from the period prior to this monitoring period.

(b) Changes that have been approved by the Board as applicable from this monitoring period

The following design change was approved by the Board on 19/02/2021 by the process track of Prior approval as per PRC-9303-001:

The change to the project design is a decrease in the electricity generation capacity specified in the registered PDD – at the registered PDD, the capacity is 4.8 MW and the change decreases the capacity to 4.245 MW.

The decision for this increase occurred after the investment decision and validation of the project activity. It was taken due to a commercial decision. Therefore, instead of four engines of 1.2 MW each as it was planeed as per registered PDD, it was implemented one engine of 1,059 kW on 22/03/2015 and three engines of 1,061 kW (each) on 02/06/2017.

The models of electricity generation engines finally installed are the following:

1 unit of JGC 320 GS-B.L BOREALIA GUATEMALA with an electricity output of 1059 kW.

3 units of JGC 320 GS-L.L TS JGC 320 C81 480V with an electrical output of 1061 kW.

Due the difference between the capacity of the engines, the financial analysis has been updated considering the real purchase price and the generation of the equipment finally installed. As can be seen in the section B.4 of the updated PDD (PRC version), the project still complies with the financial additionality requirements and the IRR of the project scenario without CERs revenues (-4.09%) is below the benchmark established for Guatemala (12.5%).

(c) Changes that are being submitted with this monitoring report as part of the request for issuance (post-registration changes - issuance track) as applicable from this monitoring period.

There are not changes that are being submitted with this monitoring report as part of the request for issuance (post-registration changes - issuance track) as applicable from this monitoring period.

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

Not applicable.

SECTION C. Description of monitoring system

According to methodology ACM0001 version 13, the project boundary of the project activity shall include the site where the LFG is captured and, as applicable:

- Sites where the LFG is flared or used (in this case: flare and power plant);
- Power generation sources connected to the grid, which are supplying electricity to the project activity.

The parameters monitored in the project activity are the following:

Op_{jh}	Operation hours of each power generator
Flame	Flame detection of flare in the minute m
$Maintenance_y$	Maintenance events completed in year Y
$EG_{PJ}1_{,y}$	Amount of electricity generated by engine 1 using LFG by the Project activity in year Y
$EG_{PJ}2_{,y}$	Amount of electricity generated by engine 2 using LFG by the Project activity in year Y
$EG_{PJ}3_{,y}$	Amount of electricity generated by engine 3 using LFG by the Project activity in year Y
$EG_{PJ}4_{,y}$	Amount of electricity generated by engine 4 using LFG by the Project activity in year Y
$EG_{PJ}PPA1_{,y}$	Amount of electricity generated using LFG by the Project activity in year Y under PPA 1
$EG_{PJ}PPA2_{,y}$	Amount of electricity generated using LFG by the Project activity in year Y under PPA 2
$EG_{EC,y}$	Amount of electricity consumed by the Project activity in year Y
$V_{t,db}$	Volumetric Flow of the gaseous stream in time Interval t on a dry basis
$V_{i,t,db}$	Volumetric fraction of greenhouse gas / in the gaseous stream in time Interval t on a dry basis
P_t	Absolute pressure of the gaseous stream in time Interval t
T_t	Temperature of the gaseous stream in time Interval t with t = hour /minute and i = CH_4

<u>Residual gas:</u>

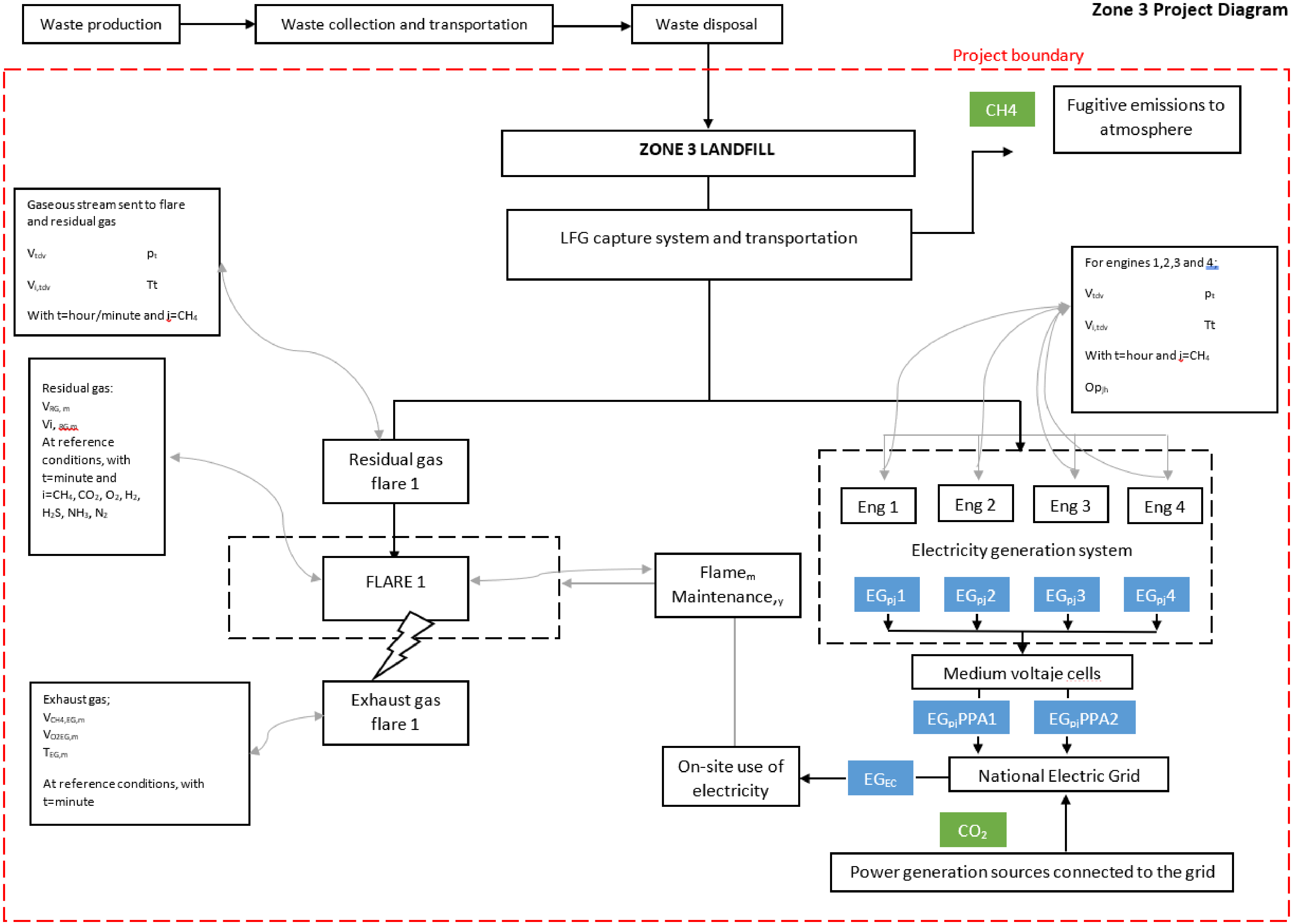
$V_{RG,m}$	Volumetric Flow of the residual gas on a dry basis at reference conditions in the minute m
$V_{I,RG,m}$	Volumetric fraction of component i in the residual gas on a dry basis at minute m where i = CH_4, CO, CO_2, O_2, H_2, H_2S, NH_3 and N_2 At reference conditions, with t = minute and i = CH_4, CO, CO_2, O_2, H_2, H_2S, NH_3 and N_2

<u>Exhaust gas:</u>

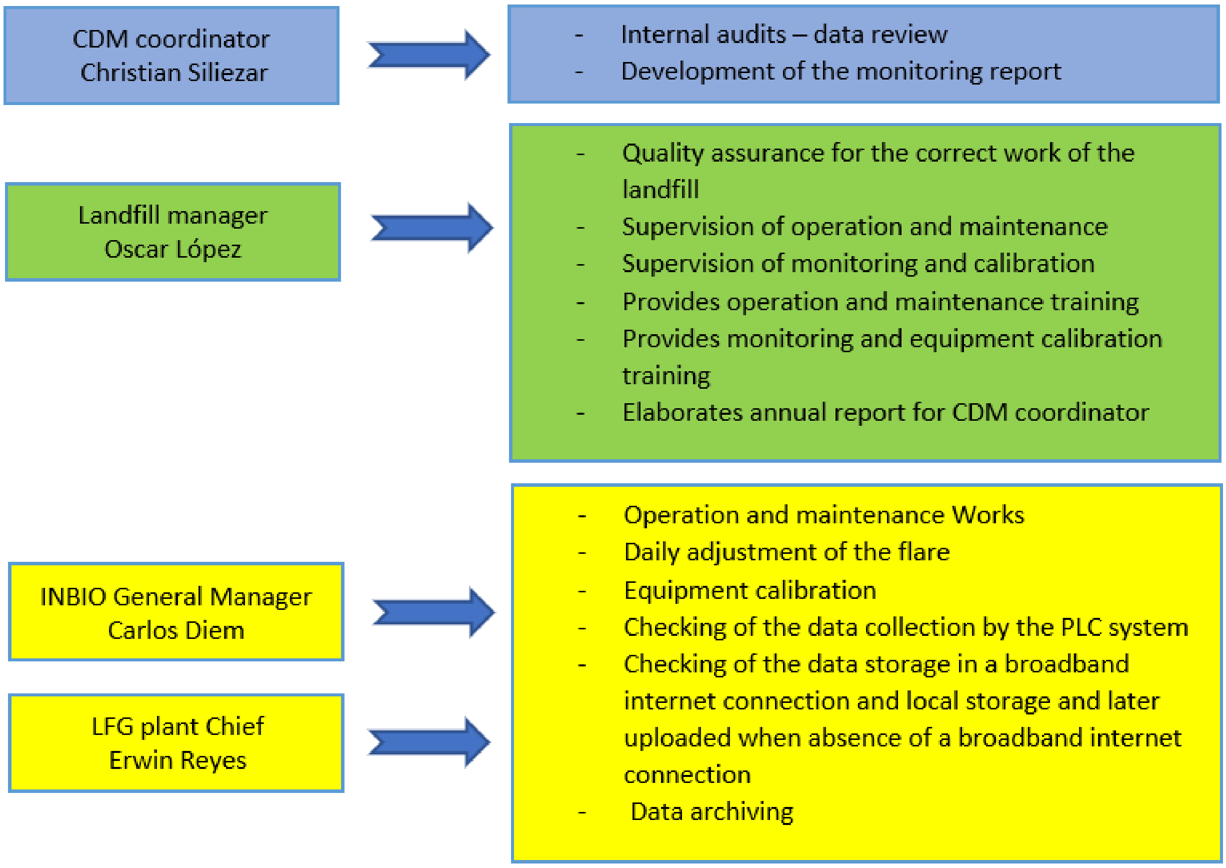
$Fc_{CH4,EG,m}$	Concentration of methane in the exhaust gas of the flare on a dry basis at reference conditions in the minute m
$V_{O2,EG,m}$	Volumetric fraction of O_2 in the exhaust gas on a dry basis at reference conditions in the minute m

The flow chart of the project, including the main equipment, energy and biogas flows and the monitored parameters, is the following:

Zone 3 Project Diagram



Roles and Responsibilities in the Monitoring Plan:



Data collection and recording:

Please see the parameters monitored as well as the location of the measurement equipment at the flow diagram above.
Daily readings of all field meters are documented in paper worksheets. Additionally, all data collected is recorded in electronic files and backups are made regularly. Data from the different measuring instruments is collected by a central PLC (Programmable Logic Controller) and uploaded to a web storage facility.
All parameters are measured continuously and logged at one minute intervals or one hour interval according to the methodological requirements detailed in section E. The data is uploaded to the web server at five (5) minute intervals when there is a broadband internet connection available. In the absence of a broadband internet connection the data is stored locally and uploaded when a connection becomes available. The PLC system includes an uninterruptable power supply to maintain data integrity in the event of grid power failure.

Quality control and quality assurance procedures

Internal audits are carried out by the CDM coordinator in order to check any deviation. Any divergence is investigated and dealt by the landfill manager, recorded for future reference. This ensures data reliability and accuracy.

Equipment calibration and maintenance

Flow meters, gas analyzers, other critical CDM project equipment will be subject to regular maintenance and testing according to technical specifications from the manufactures to ensure

accuracy and good performance. Equipment calibration will be conducted periodically according by the landfill operator and results will be supervised by landfill manager. Calibration checks will be recorded by the PLC and will be achieved during the monitoring period and 2 years after.

Training

For all employees involved in the CDM project, a Training Plan was created to provide them the skills necessary to conduct their work in a safe manner and, ensuring the success of the project activity. The Training content included operation and maintenance works, and also issues regarding CDM monitoring (data monitoring, collection, management, equipment calibration, etc.).

Technical service supplier provided introduction and trainings to the staff on the instalment, operation and maintenance of monitoring equipment. Also, an operating manual was developed for use by the project staff. This include all of the requirements for maintenance of the equipment, calibration of the data analysers, data handling and quality assurance and emergency procedures. Periodic updates of the operating manual are required.

SECTION D. Data and parameters

D.1. Data and parameters fixed ex ante

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	
Value(s) applied	Consistent with how oxidation is accounted for in the methodological tool “Emissions from solid waste disposal sites”, as indicated in methodology ACM0001 version 13.0.0
Choice of data or measurement methods and procedures	0.1
Purpose of data/parameter	
Additional comments	Applicable to Step A of the methodology ACM0001 version 13.0.0. Note that this parameter would correspond as well as parameter OX indicated in the “Emissions from solid waste disposal sites”.

Data/Parameter	$F_{CH4,BL,x-1}$
Unit	t CH_4/yr
Description	Historical amount of methane in the LFG which is captured and destroyed in the year prior to the implementation of the project activity
Source of data	Information recorded by the SWDS operator
Value(s) applied	0
Choice of data or measurement methods and procedures	In the baseline scenario, LFG in zone 3 landfill is not captured but released to the atmosphere as no regulation related to this matter are applicable.
Purpose of data/parameter	
Additional comments	-

Data/Parameter	**GWP_{CH4}**
Unit	t CO_2e/t CH_4
Description	Global warming potential of CH4
Source of data	IPCC
Value(s) applied	25
Choice of data or measurement methods and procedures	Default data provided by methodology. The value has been updated as per PDD due the new Global Warming Potential for CH4 has been updated by the UNFCCC for the second commitment period from 21 to 25.
Purpose of data/parameter	
Additional comments	-

Data/Parameter	**NCV_{CH4}**
Unit	TJ/t CH_4
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	Default data provided by methodology.
Purpose of data/parameter	
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 to be applied as a conservative assumption when project specific efficiency of the LFG capture system is not available. Applicable to Step A.1.1
Purpose of data/parameter	
Additional comments	-

Data and parameters available at validation according to methodological tool "Emissions from solid waste disposal sites" version 06.0.1:

Data/Parameter	**$w_{j,x}$**
Unit	t
Description	Amount of solid waste type j disposed in the SWDS in the year x
Source of data	"Report of the pump test and pre-feasibility study for landfill gas recovery and utilization at the el Trébol landfill, Guatemala" 2005, from SCS engineers.
Value(s) applied	Please see Appendix 4.

Choice of data or measurement methods and procedures	As no historical records of waste disposal rates exist at Zone 3 landfill, waste input data have been provided by a third party study carried out by SCS Engineers Inc. (SCS) under contract to USAID and the US Environmental Protection Agency Landfill Methane Outreach Program in 2005, which was based on Parsons Report from 1999. Data from this report are project specific value and hence are considered to be the most adequate.
Purpose of data/parameter	
Additional comments	-

Data/Parameter	φ_y
Unit	-
Description	Default value for the model correction factor to account for model uncertainties.
Source of data	Methodological tool "Emissions from solid waste disposal sites".
Value(s) applied	0.75
Choice of data or measurement methods and procedures	Default value Application A.
Purpose of data/parameter	
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	0.1
Choice of data or measurement methods and procedures	When methane passes through the top-layer, part of it is oxidized by methanotrophic bacteria to produce CO2. The oxidation factor represents the proportion of methane that is oxidized to CO2. This should be distinguished from the methane correction factor (MCF) which is to account for the situation that ambient air might intrude into the SWDS and prevent methane from being formed in the upper layer of SWDS
Purpose of data/parameter	
Additional comments	-

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	A default value of 0.5 is recommended by IPCC.
Purpose of data/parameter	
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	This factor reflects the fact that some degradable organic carbon does not
Purpose of data/parameter	
Additional comments	Upon biodegradation, organic material is converted to a mixture of methane and carbon dioxide

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	A value of 1.0 for anaerobic managed solid waste disposal sites has been chosen, as the landfill has a controlled placement of waste. Wastes are directed to specific deposition areas and is covered by excavation soil, compacted and levelled daily with heavy machines. The landfill will have with a degree of control of scavenging and a degree of control of fires.
Purpose of data/parameter	
Additional comments	MCF accounts for the fact that unmanaged SWDS produce less methane from a given amount of waste than managed SWDS, because a larger fraction of waste decomposes aerobically in the top layers of unmanaged SWDS.

<table>
<tr><td>Data/Parameter</td><td>DOC_j</td></tr>
<tr><td>Unit</td><td>-</td></tr>
<tr><td>Description</td><td>Fraction of degradable organic carbon in the waste type j (weight fraction)</td></tr>
<tr><td>Source of data</td><td>IPCC 2006 Guidelines for National Greenhouse Gas Inventories (adapted from Volume 5, Tables 2.4 and 2.5)</td></tr>
<tr><td>Value(s) applied</td><td>For MSW, the following values for the different waste types j should be applied:
Table 4 Default values for DOC_j
<table>
<tr><th>Waste type j</th><th>DOC_j
(% wet waste)</th></tr>
<tr><td>Wood and wood products</td><td>43</td></tr>
<tr><td>Pulp, paper and cardboard (other than sludge)</td><td>40</td></tr>
<tr><td>Food, food waste, beverages and tobacco (other than sludge)</td><td>15</td></tr>
<tr><td>Textiles</td><td>24</td></tr>
<tr><td>Garden, yard and park waste</td><td>20</td></tr>
<tr><td>Glass, plastic, metal, other inert waste</td><td>0</td></tr>
</table>
</td></tr>
<tr><td>Choice of data or measurement methods and procedures</td><td>As per methodological tool “Emissions from solid disposal sites”.</td></tr>
</table>

Purpose of data/parameter	
Additional comments	The percentages listed in table above are based on a wet waste basis which are concentrations in the waste as it is delivered to the SWDS. The IPCC Guidelines also specify DOC values on a dry waste basis, which are the concentrations after complete removal of all moist from the waste, which is not believed practical for this situation

Data/Parameter	$\mathbf{k_j}$
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	Slowly degrading – Pulp, paper, cardboard (other than sludge), textiles: 0.04 Slowly degrading – Wood, wood products and straw: 0.02 Moderately degrading – Other (non-food) organic putrescible garden and park waste: 0.05 Rapidly degrading – Food, food waste, sewage sludge, beverages and tobacco: 0.06
Choice of data or measurement methods and procedures	According to Mean Annual Precipitation (MAP) = 1,188 mm Mean Annual Temperature (MAT) = 18 ºC Potential Evapotranspiration (PET) = 1,500 mm Hence, Boreal and temperature (MAT≤20ºC) and Dry (MAP/PET<1) values are chosen for parameter k.
Purpose of data/parameter	
Additional comments	Climatic conditions of the project site are provided by www.worldclimate.com for data.

Data/Parameter	$\mathbf{f_y}$
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	Historic data on the amount captured
Value(s) applied	0
Choice of data or measurement methods and procedures	Provided by the tool.
Purpose of data/parameter	
Additional comments	f_y in the tool shall be assigned a value of 0 because the amount of LFG that would have been captured and destroyed is already accounted for in equation 2 of this methodology.

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	Historic data on the amount captured
Value(s) applied	0
Choice of data or measurement methods and procedures	Provided by the tool.
Purpose of data/parameter	
Additional comments	f_y in the tool shall be assigned a value of 0 because the amount of LFG that would have been captured and destroyed is already accounted for in equation 2 of this methodology.

Data and parameters available at validation according to "Tool to calculate baseline, project and/or leakage emissions from electricity consumption" version 1:

Data/Parameter	$EF_{grid,CM,y}$
Unit	tCO_2/MWh
Description	Combined margin emission factor for the grid in year y
Source of data	Calculate the combined margin emission factor, using the procedures in the latest approved version of the "Tool to calculate the emission factor for an electricity system".
Value(s) applied	0.602
Choice of data or measurement methods and procedures	As per the "Tool to calculate the emission factor for an electricity system".
Purpose of data/parameter	
Additional comments	-.

Data and parameters available at validation according tool "Project emissions from flaring" version 02.0.0

Parameter	SI Unit	Description	Value
MM_{CH4}	kg/kmol	Molecular mass of methane	16.04
MM_{CO}	kg/kmol	Molecular mass of carbon monoxide	28.01
MM_{CO2}	kg/kmol	Molecular mass of carbon dioxide	44.01
MM_{O2}	kg/kmol	Molecular mass of oxygen	32.00
MM_{H2}	kg/kmol	Molecular mass of hydrogen	2.02
MM_{N2}	kg/kmol	Molecular mass of nitrogen	28.02
AM_C	kg/kmol (g/mol)	Atomic mass of carbon	12.00
AM_H	kg/kmol (g/mol)	Atomic mass of hydrogen	1.01
AM_O	kg/kmol (g/mol)	Atomic mass of oxygen	16.00
AM_N	kg/kmol (g/mol)	Atomic mass of nitrogen	14.01
P_{ref}	Pa	Atmospheric pressure at reference conditions	101 325
R_u	$Pa.m^3/kmol.K$	Universal ideal gas constant	0.008314472
T_{ref}	K	Temperature at reference conditions	273.15
$v_{O2,air}$	Dimensionless	O_2 volumetric fraction of air	0.21
GWP_{CH4}	tCO_2/tCH_4	Global warming potential of methane valid for the commitment period	21 (for the first commitment period)
MV_n	$m^3/Kmol$	Volume of one mole of any ideal gas at reference conditions	22.414
$\rho_{CH4,n}$	kg/m^3	Density of methane gas at reference conditions	0.716
$NA_{i,j}$	Dimensionless	Number of atoms of element j in component i, depending on molecular structure	
VM_{ref}	m^3 / kmol	Volume of one mole of any ideal gas at reference temperature and pressure	22.4

Data/Parameter	$SPEC_{flare}$
Unit	Temperature- ºC Flow rate or heat flux – kg/h or m3/h Maintenance schedule - number of days
Description	Manufacturer's flare specifications for temperature, flow rate and maintenance schedule.
Source of data	Flare manufacturer
Value(s) applied	1,100ºC 2,000 m3/h Maintenance schedule according to the service plan ("Plan de servicio")
Choice of data or measurement methods and procedures	The flare specifications set by the manufacturer for the correct operation of the flare for the following parameters are: (a) Minimum and maximum inlet flow rate: 600 - 2,000 Nm3/h (b) Minimum and maximum operating temperature: 800-1,200 ºC (c) Maximum duration in days between maintenance events: 90 days
Purpose of data/parameter	
Additional comments	Applicable in case of enclosed flares.

Data and parameters available at validation according "Tool to determine the mass flow of a greenhouse gas in a gaseous stream" version 2.0.0

Data/Parameter	Ru
Unit	Pa.m³/kmol.K
Description	Universal ideal gases constant
Source of data	"Tool to determine the mass flow of a greenhouse gas in a gaseous stream"
Value(s) applied	0.008314472
Choice of data or measurement methods and procedures	Constant as per "Tool to determine the mass flow of a greenhouse gas in
Purpose of data/parameter	
Additional comments	-

Data/Parameter	Ru
Unit	Pa.m³/kmol.K
Description	Universal ideal gases constant
Source of data	"Tool to determine the mass flow of a greenhouse gas in a gaseous stream"
Value(s) applied	0.008314472
Choice of data or measurement methods and procedures	Constant as per "Tool to determine the mass flow of a greenhouse gas in a gaseous stream".
Purpose of data/parameter	
Additional comments	-

Data/Parameter	MM_i
Unit	kg/kmol
Description	Molecular mass of greenhouse gas i
Source of data	"Tool to determine the mass flow of a greenhouse gas in a gaseous stream"
Value(s) applied	$MMCH_4$ = 16.04 kg/kmol
Choice of data or measurement methods and procedures	Constant as per "Tool to determine the mass flow of a greenhouse gas in a gaseous stream". Note that the methane (CH_4) contained in the LFG will constitute the main greenhouse gas to be monitored
Purpose of data/parameter	
Additional comments	-

Data/Parameter	MM_i
Unit	kg/kmol
Description	Molecular mass of greenhouse gas i
Source of data	"Tool to determine the mass flow of a greenhouse gas in a gaseous stream"
Value(s) applied	$MMCH_4$ = 16.04 kg/kmol
Choice of data or measurement methods and procedures	Constant as per "Tool to determine the mass flow of a greenhouse gas in a gaseous stream". Note that the methane (CH_4) contained in the LFG will constitute the main greenhouse gas to be monitored
Purpose of data/parameter	
Additional comments	-
Data/Parameter	MM_k
Unit	kg/kmol

<table>
<tr><td>Description</td><td>Molecular mass of gas k</td></tr>
<tr><td>Source of data</td><td>“Tool to determine the mass flow of a greenhouse gas in a gaseous stream”</td></tr>
<tr><td>Value(s) applied</td><td>
<table>
<tr><th>Compound</th><th>Structure</th><th>Molecular mass (kg / kmol)</th></tr>
<tr><td>Nitrogen</td><td>N_2</td><td>28.01</td></tr>
<tr><td>Oxygen</td><td>O_2</td><td>32.00</td></tr>
<tr><td>Carbon monoxide</td><td>CO</td><td>28.01</td></tr>
<tr><td>Hydrogen</td><td>H_2</td><td>2.02</td></tr>
<tr><td>Nitric oxide</td><td>NO</td><td>30.01</td></tr>
<tr><td>Nitrogen dioxide</td><td>NO_2</td><td>46.01</td></tr>
<tr><td>Sulfur dioxide</td><td>SO_2</td><td>64.06</td></tr>
</table>
</td></tr>
<tr><td>Choice of data or measurement methods and procedures</td><td>Constant as per “Tool to determine the mass flow of a greenhouse gas in a gaseous stream”.</td></tr>
<tr><td>Purpose of data/parameter</td><td></td></tr>
<tr><td>Additional comments</td><td>-</td></tr>
</table>

Data/Parameter	**P_n**
Unit	Pa
Description	Total pressure at normal conditions
Source of data	“Tool to determine the mass flow of a greenhouse gas in a gaseous stream”
Value(s) applied	101,325 Pa
Choice of data or measurement methods and procedures	Constant as per “Tool to determine the mass flow of a greenhouse gas in
Purpose of data/parameter	
Additional comments	-

Data/Parameter	**T_n**
Unit	K
Description	Temperature at normal conditions
Source of data	“Tool to determine the mass flow of a greenhouse gas in a gaseous stream”
Value(s) applied	273.15 K
Choice of data or measurement methods and procedures	Constant as per “Tool to determine the mass flow of a greenhouse gas in
Purpose of data/parameter	
Additional comments	-

D.2. Data and parameters monitored

Data/Parameter	**Management of SWDS**
Unit	-
Description	Management of SWDS
Measured/calculated/ default	Measured
Source of data	Technical specifications for the management of the SWDS
Value(s) of monitored parameter	The management of SWDS remains as per the description in the PDD.

Monitoring equipment	Not applicable
Measuring/reading/recording frequency	Project participants refer to the original design of the landfill to ensure that any practice to increase methane generation not occur after the implementation of the project activity. Any change in the management of the SWDS after the implementation of the project activity will need to be justified by referring to technical or regulatory specifications. Monitoring frequency: Annually
Calculation method (if applicable)	Not applicable
QA/QC procedures	-
Purpose of data/parameter	Baseline emissions calculation
Additional comments	-

Data/Parameter	**$Op_{j,h}$**
Unit	Hours
Description	Operation of the equipment that consumes the LFG (Flare and 4 power generators).
Measured/calculated/ default	Measured
Source of data	On-site measurements
Value(s) of monitored parameter	Ex-ante values: 8,000 h/yr for power generators Ex-post measured value during this monitoring period: Opflare,h: 1,117.00 h Opengine1,h: 14,306.00 h Opengine2,h: 28,510.00 h Opengine3,h: 28,793.00 h Opengine4,h: 18,546.00 h
Monitoring equipment	Flame detector, Hour meter
Measuring/reading/recording frequency	Hourly
Calculation method (if applicable)	For each equipment unit j using the LFG monitor that the plant is operating in hour h by the monitoring any one or more of the following three parameters: ▪ Temperature. Determine the location for temperature measurements and minimum operational temperature based on manufacturer's specifications of the burning equipment. Document and justify the location and minimum threshold in the PDD. ▪ Flame. Flame detection system is used to ensure that the equipment is in operation. ▪ Products generated. Monitor the generation of steam for the case of boilers and air-heaters and glass for the case of glass melting furnaces. This option is not applicable to brick kilns. As per technical specifications of the manufacturer, the installed engines include a working hours meter, as well as an output electricity meter. Hence, in this case, Opj,h=0 when: ▪ Hours meter detects a non-working hour, or ▪ No electricity is generated the power engine as per electricity meters monitoring. ▪ Otherwise, Opj,h=1
QA/QC procedures	Hour meters are subject to regular maintenance and testing regime to ensure accuracy.
Purpose of data/parameter	Baseline and project emissions calculation
Additional comments	-

<table>
<tr><td>Data/Parameter</td><td>$EGP_{J,y}$</td></tr>
<tr><td>Unit</td><td>MWh</td></tr>
<tr><td>Description</td><td>Amount of electricity generated using LFG by the project activity in year y</td></tr>
<tr><td>Measured/calculated/ default</td><td>Measured</td></tr>
<tr><td>Source of data</td><td>Electricity meters</td></tr>
<tr><td>Value(s) of monitored parameter</td><td>104,609.99 MWh</td></tr>
<tr><td>Monitoring equipment</td><td>Model: PowerLogic™ ION8650.
Manufacturer: Scheneider Electric
Manufacturer calibration frequency: 1 year

List of electricity of installed meters:
<table>
<tr><th>MODEL</th><th>SERIAL NUMBER</th><th>DESCRIPTION AND LOCATION</th></tr>
<tr><td>M850B0C0E6E1A1A</td><td>MW-15014543-01</td><td>BIOGAS GENERAL SERVICES (MAIN)</td></tr>
<tr><td>M8650B0C0E6E1A1A</td><td>MW-1403A059-01</td><td>BIOGAS DELIVERY POINT 1 (MAIN)</td></tr>
<tr><td>M8650B0C0E6E1A1A</td><td>MW-1710A140-02</td><td>BIOGAS DELIVERY POINT 1 (BACKUP)</td></tr>
<tr><td>M8650B0C0E6E1A1A</td><td>MW-1609A154-02</td><td>BIOGAS DELIVERY POINT 2 (MAIN)</td></tr>
<tr><td>M8650B0C0H6E1A1A</td><td>MW-1507A940-02</td><td>BIOGAS DELIVERY POINT 2 (BACKUP)</td></tr>
<tr><td>M8650B0C0E6E1A1A</td><td>MW-15014330-01</td><td>ENGINE 1 (MAIN)</td></tr>
<tr><td>M8650B0C0E6E1A1A</td><td>MW-1501A331-01</td><td>ENGINE 1 (BACKUP)</td></tr>
<tr><td>M8650A0C0H6E1A1A</td><td>MW-1702A739-02</td><td>ENGINE 2 (MAIN)</td></tr>
<tr><td>M8650C0C0H6E1A1A</td><td>MW-1611B138-02</td><td>ENGINE 2 (BACKUP)</td></tr>
<tr><td>M8650A0C0H6E1A1A</td><td>MW-1702A738-02</td><td>ENGINE 3 (MAIN)</td></tr>
<tr><td>M8650C0C0H6E1A1A</td><td>MW-1611B137-02</td><td>ENGINE 3 (BACKUP)</td></tr>
<tr><td>M8650A0C0H6E1A1A</td><td>MW-1702A737-02</td><td>ENGINE 4 (MAIN)</td></tr>
<tr><td>M8650C0C0H6E1A1A</td><td>MW-1611B135-02</td><td>ENGINE 4 (BACKUP)</td></tr>
</table></td></tr>
<tr><td>Measuring/reading/recording frequency</td><td>Monitor net electricity generation by the project activity using LFG. Monitoring frequency: Continuous</td></tr>
<tr><td>Calculation method (if applicable)</td><td>Not applicable</td></tr>
<tr><td>QA/QC procedures</td><td>Electricity meters are subject to regular maintenance in accordance with “maintenance schedule” provided from electricity meters supplier.
Also meters are calibrated once a year in accordance to national calibration standards.</td></tr>
<tr><td>Purpose of data/parameter</td><td>Baseline emissions calculation</td></tr>
<tr><td>Additional comments</td><td>Main and back up bidirectional electricity meters are installed just before the connexion to the grid. Meters are crosschecked with electricity company monthly bills.</td></tr>
</table>

Data/Parameter	**$EG_{EC,y}$ (equivalent to $EC_{PJ,j,y}$)**
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	168.95 MWh

Monitoring equipment	Model: PowerLogic™ ION8650. Manufacturer: Scheneider Electric Manufacturer calibration frequency: 1 year
Measuring/reading/recording frequency	Continuous
Calculation method (if applicable)	Not applicable
QA/QC procedures	Electricity meter is subject to regular (in accordance with stipulation of the meter supplier) maintenance and testing to ensure accuracy. The readings are double checked by the electricity distribution company.
Purpose of data/parameter	Project emissions calculation
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".

Data and parameters to be monitored according to "Tool to calculate baseline, project and/or leakage emissions from electricity consumption" version 1, scenario A:

Data/Parameter	**$TDL_{k,y}$**
Unit	%
Description	Average technical transmission and distribution losses for providing electricity to source k in year y
Measured/calculated/ default	Default
Source of data	The World Bank. Electric power transmission and distribution losses (% of output). IEA Statistics © OECD/IEA 2018. Guatemala. Most recent year: 2014 (https://data.worldbank.org/indicator/eg.elc.loss.zs?most_recent_year_desc=true)
Value(s) of monitored parameter	9%
Monitoring equipment	Not applicable
Measuring/reading/recording frequency	As scenario A is chosen, first option is applied "use recent, accurate and reliable data available within the host country".
Calculation method (if applicable)	Not applicable
QA/QC procedures	Default data is checked annually in order to ensure the use of the most recent, accurate and reliable data available, according to the Tool.
Purpose of data/parameter	Baseline and project emissions calculation
Additional comments	Not applicable

Data and parameters to be monitored according to "Tool to determine the mass flow of a greenhouse gas in a gaseous stream" version 02.0.0, Option A:

For gaseous stream sent to the flare:

Data/Parameter	**V_{t,db_flare}**
Unit	m^3 dry gas/h

Description	Volumetric flow of the gaseous stream sent to the flare in time interval t on a dry basis
Measured/calculated/ default	Measured
Source of data	Flowmeter
Value(s) of monitored parameter	707,149 m3
Monitoring equipment	Brand: Rosemut. Emerson Process Management Model: 485 Annubar® Flow meter 485G050CSHPS1T10007RL Serial number: 139543 Manufacturer calibration frequency: 10 years Installation date: 15/07/2014 Calibration certificate: 01/04/2014, valid until 01/04/2024 Next calibration certificate: 01/04/2024
Measuring/reading/recording frequency	Continuous (each hour and each minute m)
Calculation method (if applicable)	The value of the monitored value shown in this table is the result of the accumulated flow in which raw data in the same time interval accomplish the following two operational conditions at the same time: • Condition 1: Operation of the flare that consumes the LFG: Tflare between 900 and 1200 ºC • Condition 2: V_{t,db_flare} between 400 and 2000 Nm3/h
QA/QC procedures	Periodic calibration against a primary device provided by an independent accredited laboratory is carried out as it is mandatory according to the tool. Calibration and frequency of calibration is carried out according to manufacturer's specifications
Purpose of data/parameter	Baseline and project emission calculation
Additional comments	This parameter is measured before the flare.

Data/Parameter	$\mathbf{V_{i,t,db\_flare}}$
Unit	m³ gas i /m³ dry gas
Description	Volumetric fraction of greenhouse gas i in the gaseous stream sent to flare in time interval t on a dry basis
Measured/calculated/ default	Measured
Source of data	Continuous gas analyser operating in dry basis. On-site measurements using a continuous gas analyser
Value(s) of monitored parameter	44.46%

Monitoring equipment	**Equipment 1:** Brand: Siemens Model: ULTRAMAT 23 Gas N1E3649 Serial number: 7MB2335-2HD10-6AA3 Manufacturer calibration frequency: 1 year (calibration gas CH4, O2), 2 years (CH4, O2 sensor) Installation date: 15/07/2014 Calibration certificate: 24/04/2014, serial 4510079628, valid until 24/04/2016 Next calibration certificate: 30/04/2020 **Equipment 2:** Brand: Landtec Model: BIOGAS 5000 Portable Gas Analyzer G504774 Serial number: BIOGAS 5000 Maximum permissible error: +-0.5 % CH4, O2 Manufacturer calibration frequency: 6 months Installation date: 15/07/2017 Calibration certificate: 14/01/2020, serial G504774_9/38293, valid until 14/06/2017 Next calibration certificate: 14/07/2021
Measuring/reading/recording frequency	Continuous (each hour and each minute m)
Calculation method (if applicable)	The value of the monitored value shown in this table is the result of the weighted average in which raw data in the same time interval accomplish the following two operational conditions at the same time: • Condition 1: Operation of the flare that consumes the LFG: Tflare between 900 and 1200 ºC • Condition 2: V_{t,db_flare} between 400 and 2000 Nm3/h
QA/QC procedures	Calibration includes 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 has a certificate provided by the manufacturer and is under their validity period.
Purpose of data/parameter	Baseline and project emissions calculation
Additional comments	Not applicable

Data/Parameter	T_{t_flare}
Unit	K
Description	Temperature of the gaseous stream sent to the flare in time interval t
Measured/calculated/ default	Measured but not used in the calculation. The flow meters automatically measure temperature and pressure, expressing LFG volumes in normalized cubic meters (Nm3).
Source of data	Temperature sensor
Value(s) of monitored parameter	306.93 K
Monitoring equipment	Brand: ELSI Model: Thermorresistance G1.U10-P20-B0150-S00 PT100 Serial number: 14-03625 Manufacturer calibration frequency: 1 year Installation date: 15/07/2014 Calibration certificate: 03/04/2014, serial 14/0128, valid until 03/04/2015 Next calibration certificate: 30/04/2020
Measuring/reading/recording frequency	Continuous (each hour and each minute m)
Calculation method (if applicable)	The value of the monitored value shown in this table is the result of the weighted average. The flow meters automatically measure temperature and pressure, expressing LFG volumes in normalized cubic meters (Nm3).

QA/QC procedures	Periodic calibration against a primary device provided by an independent accredited laboratory is carried out as it is mandatory according to the tool. Calibration and frequency of calibration is carried out according to manufacturer's specifications.
Purpose of data/parameter	Not used in the baseline or project emissions calculation.
Additional comments	No separate monitoring of temperature is necessary when using flow meters that automatically measure temperature and pressure, expressing LFG volumes in normalized cubic meters (Nm3).

Data/Parameter	**P_{t_flare}**
Unit	Pa
Description	Absolute pressure of the gaseous stream sent to the flare in time interval t
Measured/calculated/ default	4,313.74 Pa. Measured but not used in the calculation. The flow meters automatically measure temperature and pressure, expressing LFG volumes in normalized cubic meters (Nm3).
Source of data	Pressure transmitter
Value(s) of monitored parameter	Not used. The flow meters automatically measure temperature and pressure, expressing LFG volumes in normalized cubic meters (Nm3).
Monitoring equipment	**Equipment 1:** Brand: ABB Model: Pressure transmitter 2600T Serial number: 3K646614011066 **Equipment 2:** Brand: ABB Model: Pressure transmitter 2600T Serial number: 3K6614011305 **Equipment 3:** Brand: ABB Model: Pressure transmitter 2600T Serial number: 3K646614011070 **Equipment 4:** Brand: ABB Model: Pressure transmitter 2600T Serial number: 3K646614011070
Monitoring equipment	**Equipment 5:** Brand: ABB Model: Pressure transmitter 2600T Serial number: 3K646614011313 **Equipment 6:** Brand: ABB Model: Pressure transmitter 2600T Serial number: 3K646614011303 **Equipment 7:** Brand: ABB Model: Pressure transmitter 2600T Serial number: 3K646614011307

Monitoring equipment	**Equipment 8:** Brand: ABB Model: Pressure transmitter 2600T Serial number: 3K646614011312 **Equipment 9:** Brand: ABB Model: Pressure transmitter 2600T Serial number: 3K646614011067 **Equipment 10:** Brand: ABB Model: Pressure transmitter 2600T Serial number: 3K646614011309 **Equipment 11:** Brand: ABB Model: Pressure transmitter 2600T Serial number: 3K6466DSHESSB2A1 **Equipment 12:** Brand: ABB Model: Pressure transmitter 2600T Serial number: 3K646614011311
Measuring/reading/recording frequency	Continuous (each hour and each minute m)
Calculation method (if applicable)	The value of the monitored value shown in this table is the result of the weighted average. The flow meters automatically measure temperature and pressure, expressing LFG volumes in normalized cubic meters (Nm3).
QA/QC procedures	Annual calibration against a primary device is performed and records of calibration procedures will be kept available as well as primary device and its calibration certificate
Purpose of data/parameter	Not used. The flow meters automatically measure temperature and pressure, expressing LFG volumes in normalized cubic meters (Nm3).
Additional comments	This parameter will be monitored unless equipment gives the pressure value already converted to normal conditions.

For gaseous stream sent to electric engines:

Data/Parameter	$V_{t,db\_electricity}$
Unit	m³ dry gas/h
Description	Volumetric flow of the gaseous stream used for electricity generation in time interval t on a dry basis
Measured/calculated/ default	Calculated
Source of data	Flow meter
Value(s) of monitored parameter	44,842.683 m3 Engine 1: 8,317,754 m3 Engine 2: 13,337,201 m3 Engine 3: 13,995,864 m3 Engine 4: 9,191,864 m3

Monitoring equipment	**Engine 1:** <u>Equipment 1:</u> Brand: Rosemut. Emerson Process Management Model: 485 Annubar® Flow meter 485G040ESHPS1T10007RL series 139545 Serial number: 485G040ESHPS Manufacturer calibration frequency: 10 years Installation date: 15/07/2014 Calibration certificate: 01/04/2014, valid until 01/04/2024 Next calibration certificate: 01/04/2024 <u>Equipment 2:</u> Brand: Rosemut. Emerson Process Management Model: 485 Annubar® Flow meter 485G030ESHPS1T10007RL, series 139542 Serial number: 485G030CSHPC Manufacturer calibration frequency: 10 years Installation date: 15/07/2014 Calibration certificate: 01/04/2024, valid until 01/04/2024 Next calibration certificate: 01/04/2024 **Engine 2:** <u>Equipment 1:</u> Brand: Rosemut. Emerson Process Management Model: 485 Annubar® Flow meter 485G040ESHPS1T10007RL series 139544 Serial number: 485G040ESHPS Manufacturer calibration frequency: 10 years Installation date: 15/07/2014 Calibration certificate: 01/04/2014, valid until 01/04/2024 Next calibration certificate: 01/04/2024 <u>Equipment 2:</u> Brand: Rosemut. Emerson Process Management Model: 485 Annubar® Flow meter 485G030ZSHPS1T10007RLJ6 series 174558 Serial number: 485G030CSHPC Manufacturer calibration frequency: 10 years Installation date: 15/07/2016 Calibration certificate: 01/06/2016 valid until 01/06/2026 Next calibration certificate: 01/06/2026

	Engine 3: Equipment 1: Brand: Rosemut. Emerson Process Management Model: 485 Annubar® Flow meter 485G040CSHPS1T10007RLJ6 series 174555 Serial number: 485G040ESHPS Manufacturer calibration frequency: 10 years Installation date: 15/07/2016 Calibration certificate: 01/06/2016, valid until 01/06/2026 Next calibration certificate: 01/06/2026 Equipment 2: Brand: Rosemut. Emerson Process Management Model: 485 Annubar® Flow meter 485G030ZSHPS1T10007RLJ6 series 174557 Serial number: 485G030CSHPC Manufacturer calibration frequency: 10 years Installation date: 15/07/2016 Calibration certificate: 01/06/2016, valid until 01/06/2026 Next calibration certificate: 01/06/2026 **Engine 4:** Equipment 1: Brand: Rosemut. Emerson Process Management Model: 485 Annubar® Flow meter 485G040CSHPS1T10007RLJ6 series 174556 Serial number: 485G040ESHPS Manufacturer calibration frequency: 10 years Installation date: 15/07/2016 Calibration certificate: 01/06/2016, valid until 01/06/2026 Next calibration certificate: 01/06/2026 Equipment 2: Brand: Rosemut. Emerson Process Management Model: 485 Annubar® Flow meter 485G030ZSHPS1T10007RLJ6 series 174559 Serial number: 485G030CSHPC Manufacturer calibration frequency: 10 years Installation date: 15/07/2016 Calibration certificate: 01/06/2016, valid until 01/06/2026 Next calibration certificate: 01/06/2026
Measuring/reading/recording frequency	Continuous (each hour)
Calculation method (if applicable)	The value of the monitored value shown in this table is the result of the sum of the different measured flows at the entrance of each of the four electric engines in which raw data in the same time interval accomplish the following operational condition: • Condition 1: Vt,db_electricity between 400 and 2000 Nm3/h
QA/QC procedures	Periodic calibration against a primary device provided by an independent accredited laboratory is carried out as it is mandatory according to the tool. Calibration and frequency of calibration is carried out according to manufacturer's specifications.
Purpose of data/parameter	Baseline emissions calculation
Additional comments	Not applicable

Data/Parameter	**$V_{i,t,db\_electricity}$**
Unit	m³ gas i /m³ dry gas
Description	Volumetric fraction of greenhouse gas i in the gaseous stream used for electricity generation in time interval t on a dry basis
Measured/calculated/ default	Calculated
Source of data	On-site measurements using a continuous gas analyzer
Value(s) of monitored parameter	37.94% Engine 1: 27.47% Engine 2: 41.60% Engine 3: 41.81% Engine 4: 40.87%
Monitoring equipment	Not applicable (calculated)
Measuring/reading/recording frequency	Continuous (each hour)
Calculation method (if applicable)	The value of the monitored value shown in this table is the result of the average of the different volumetric fractions of CH4 for the biogas stream sent to each engine calculated using the weighted average of the parameter Vi,t,db in which raw data in the same time interval accomplish the following operational conditions at the same time: • Condition 1: Vt,db_engine1 between 400 and 2000 Nm3/h • Condition 1: Vt,db_engine2 between 400 and 2000 Nm3/h • Condition 1: Vt,db_engine3 between 400 and 2000 Nm3/h • Condition 1: Vt,db_engine4 between 400 and 2000 Nm3/h
QA/QC procedures	Not applicable
Purpose of data/parameter	Baseline emissions calculation
Additional comments	Not applicable

Data/Parameter	**$T_{t\_electricity}$**
Unit	K
Description	Temperature of the gaseous stream used for electricity generation in time interval t
Measured/calculated/ default	Measured but not used in the calculation. The flow meters automatically measure temperature and pressure, expressing LFG volumes in normalized cubic meters (Nm3).
Source of data	Temperature sensor

Value(s) of monitored parameter	Engine 1: 318.06 Engine 2: 289.48 Engine 3: 289.94 Engine 4: 289.90

Monitoring equipment	**Engine 1:** <u>Equipment 1:</u> Brand: ELSI Model: Thermorresistance G1.U10-P20-B0150-S00 series PT100 Serial number: 13-27965 Manufacturer calibration frequency: 1 year Installation date: 15/07/2014 Calibration certificate: 03/04/2014, serial number 14/0126, valid until 03/04/2015 Next calibration certificate: 30/04/2020 <u>Equipment 2:</u> Brand: ELSI Model: Thermorresistance G1.U10-P20-B0150-S00 series PT100 Serial number: 14-03691 Manufacturer calibration frequency: 1 year Installation date: 15/07/2014 Calibration certificate: 03/04/2014, serial number 14/0129, valid until 03/04/2015 Next calibration certificate: 30/04/2020 **Engine 2:** <u>Equipment 1:</u> Brand: ELSI Model: Thermorresistance G1.U10-P20-B0150-S00 series PT100 Serial number: 14-03686 Manufacturer calibration frequency: 1 year Installation date: 15/07/2014 Calibration certificate: 03/04/2014, serial number 14/0127, valid until 03/04/2015 Next calibration certificate: 30/04/2020 <u>Equipment 2:</u> Brand: ELSI Model: Thermorresistance G1.U10-P20-B0150-S00 series PT100 Serial number: 16-08221 Manufacturer calibration frequency: 1 year Installation date: 15/07/2016 Calibration certificate: 15/07/2016, serial number 16/0297, valid until 15/07/2017 Next calibration certificate: 30/04/2020

	Engine 3: <u>Equipment 1:</u> Brand: ELSI Model: Thermorresistance G1.U10-P20-B0150-S00 series PT100 Serial number: 15-03316 Manufacturer calibration frequency: 1 year Installation date: 15/07/2016 Calibration certificate: 15/07/2016, serial number 16/0302, valid until 15/07/2017 Next calibration certificate: 30/04/2020 <u>Equipment 2:</u> Brand: ELSI Model: Thermorresistance G1.U10-P20-B0150-S00 series PT100 Serial number: 16-08377 Manufacturer calibration frequency: 1 year Installation date: 15/07/2016 Calibration certificate: 15/07/2016, serial number 16/0298, valid until 15/07/2017 Next calibration certificate: 30/04/2020 **Engine 4:** <u>Equipment 1:</u> Brand: ELSI Model: Thermorresistance G1.U10-P20-B0150-S00 series PT100 Serial number: 16-08099 Manufacturer calibration frequency: 1 year Installation date: 15/07/2016 Calibration certificate: 15/07/2016, serial number 16/0303, valid until 15/07/2017 Next calibration certificate: 30/04/2020 <u>Equipment 2:</u> Brand: ELSI Model: Thermorresistance G1.U10-P20-B0150-S00 series PT100 Serial number: 16-08255 Manufacturer calibration frequency: 1 year Installation date: 15/07/2016 Calibration certificate: 15/07/2016, serial number 16/0299, valid until 15/07/2017 Next calibration certificate: 30/04/2020
Measuring/reading/recording frequency	Continuous (each hour and each minute m)
Calculation method (if applicable)	The value of the monitored value shown in this table is the result of the weighted average. The flow meters automatically measure temperature and pressure, expressing LFG volumes in normalized cubic meters (Nm3).
QA/QC procedures	Periodic calibration against a primary device provided by an independent accredited laboratory is carried out as it is mandatory according to the tool. Calibration and frequency of calibration is carried out according to manufacturer's specifications.
Purpose of data/parameter	Not used in the baseline or project emissions calculation.
Additional comments	No separate monitoring of temperature is necessary when using flow meters that automatically measure temperature and pressure, expressing LFG volumes in normalized cubic meters (Nm3).

Data/Parameter	$P_{t\_electricity}$
Unit	Pa
Description	Absolute pressure of the gaseous stream used for electricity generation in time interval t
Measured/calculated/ default	Engine 1: 125,662.54 Pa. Engine 2: 145,401.69 Pa. Engine 3: 144,683.45 Pa Engine 4: 157,196.90 Pa. Measured but not used in the calculation. The flow meters automatically measure temperature and pressure, expressing LFG volumes in normalized cubic meters (Nm3).
Source of data	Pressure transmitter
Value(s) of monitored parameter	Not used. The flow meters automatically measure temperature and pressure, expressing LFG volumes in normalized cubic meters (Nm3).
Monitoring equipment	**Equipment 1:** Brand: ABB Model: Pressure transmitter 2600T Serial number: 3K646614011066 **Equipment 2:** Brand: ABB Model: Pressure transmitter 2600T Serial number: 3K6614011305 **Equipment 3:** Brand: ABB Model: Pressure transmitter 2600T Serial number: 3K646614011070 **Equipment 4:** Brand: ABB Model: Pressure transmitter 2600T Serial number: 3K646614011070
Monitoring equipment	**Equipment 5:** Brand: ABB Model: Pressure transmitter 2600T Serial number: 3K646614011313 **Equipment 6:** Brand: ABB Model: Pressure transmitter 2600T Serial number: 3K646614011303 **Equipment 7:** Brand: ABB Model: Pressure transmitter 2600T Serial number: 3K646614011307

Monitoring equipment	**Equipment 8:** Brand: ABB Model: Pressure transmitter 2600T Serial number: 3K646614011312 **Equipment 9:** Brand: ABB Model: Pressure transmitter 2600T Serial number: 3K646614011067 **Equipment 10:** Brand: ABB Model: Pressure transmitter 2600T Serial number: 3K646614011309 **Equipment 11:** Brand: ABB Model: Pressure transmitter 2600T Serial number: 3K6466DSHESSB2A1 **Equipment 12:** Brand: ABB Model: Pressure transmitter 2600T Serial number: 3K646614011311
Measuring/reading/recording frequency	Continuous (each hour and each minute m)
Calculation method (if applicable)	The value of the monitored value shown in this table is the result of the weighted average. The flow meters automatically measure temperature and pressure, expressing LFG volumes in normalized cubic meters (Nm3).
QA/QC procedures	Annual calibration against a primary device is performed and records of calibration procedures will be kept available as well as primary device and its calibration certificate
Purpose of data/parameter	Not used. The flow meters automatically measure temperature and pressure, expressing LFG volumes in normalized cubic meters (Nm3).
Additional comments	This parameter will be monitored unless equipment gives the pressure value already converted to normal conditions.

Data and parameters to be monitored according to tool "Project emissions from flaring" version 02.0.0, Option B.2:

At the residual gas:

Data/Parameter	**$V_{RG,m}$ (=V_{t,db_flare})**
Unit	m^3
Description	Volumetric flow of the residual gas on a dry basis at reference conditions in the minute m
Measured/calculated/ default	Measured
Source of data	Flow meter
Value(s) of monitored parameter	707,149 m3
Monitoring equipment	Brand: Rosemut. Emerson Process Management Model: 485 Annubar® Flow meter 485G050CSHPS1T10007RL Serial number: 139543 Manufacturer calibration frequency: 10 years Installation date: 15/07/2014 Calibration certificate: 01/04/2014, valid until 01/04/2024 Next calibration certificate: 01/04/2024
Measuring/reading/recording frequency	Continuous (each hour and each minute m)
Calculation method (if applicable)	The value of the monitored value shown in this table is the result of the accumulated flow in which raw data in the same time interval accomplish the following two operational conditions at the same time: • Condition 1: Operation of the flare that consumes the LFG: Tflare between 900 and 1200 ºC • Condition 2: V_{t,db_flare} between 400 and 2000 Nm3/h
QA/QC procedures	Periodic calibration against a primary device provided by an independent accredited laboratory is carried out as it is mandatory according to the tool. Calibration and frequency of calibration is carried out according to manufacturer's specifications
Purpose of data/parameter	Baseline and project emission calculation
Additional comments	This parameter is measured before the flare.

Data/Parameter	**$V_{i,RG,m}$ (=V_{i,t,db_flare})**
Unit	-
Description	Volumetric fraction of component i in the residual gas on a dry basis at minute m where i = CH4, CO, CO2, O2, H2, H2S, NH3 and N2.
Measured/calculated/ default	Measured
Source of data	Continuous gas analyser operating in dry basis. On-site measurements using a continuous gas analyser
Value(s) of monitored parameter	44.46%

Monitoring equipment	**Equipment 1:** Brand: Siemens Model: ULTRAMAT 23 Gas N1E3649 Serial number: 7MB2335-2HD10-6AA3 Manufacturer calibration frequency: 1 year (calibration gas CH4, O2), 2 years (CH4, O2 sensor) Installation date: 15/07/2014 Calibration certificate: 24/04/2014, serial 4510079628, valid until 24/04/2016 Next calibration certificate: 30/04/2020 **Equipment 2:** Brand: Landtec Model: BIOGAS 5000 Portable Gas Analyzer G504774 Serial number: BIOGAS 5000 Maximum permissible error: +-0.5 % CH4, O2 Manufacturer calibration frequency: 6 months Installation date: 15/07/2017 Calibration certificate: 14/01/2020, serial G504774_9/38293, valid until 14/06/2017 Next calibration certificate: 14/07/2021
Measuring/reading/recording frequency	Continuous (each hour and each minute m)
Calculation method (if applicable)	The value of the monitored value shown in this table is the result of the weighted average in which raw data in the same time interval accomplish the following two operational conditions at the same time: • Condition 1: Operation of the flare that consumes the LFG: Tflare between 900 and 1200 ºC • Condition 2: V_{t,db_flare} between 400 and 2000 Nm3/h
QA/QC procedures	Calibration includes 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 has a certificate provided by the manufacturer and is under their validity period.
Purpose of data/parameter	Baseline and project emissions calculation
Additional comments	Not applicable

At the exhaust gas:

Data/Parameter	$T_{EG,m}$
Unit	°C
Description	Temperature in the exhaust gas of the enclosed flare (n) in minute m
Measured/calculated/ default	Measured
Source of data	Temperature sensor
Value(s) of monitored parameter	869.83 °C

Monitoring equipment	**Equipment 1:** Brand: ELSI Model: Thermorresistance U10-P80-B015S00 Serial number: 1XPT1001EC751 **Equipment 2:** Brand: ELSI Model: Thermorresistance PT100 Serial number: 1XPT100IEC751 **Equipment 3:** Brand: ELSI Model: Thermorresistance U10-P80-B015S00 Serial number: 1XPT1001EC751 **Equipment 4:** Brand: ELSI Model: Thermorresistance PT100 Serial number: 1XPT100IEC751
Measuring/reading/recording frequency	Each minute
Calculation method (if applicable)	The value of the monitored value shown in this table is the result of the weighted average in which raw data in the same time interval accomplish the following operational condition: • Condition 1: Operation of the flare that consumes the LFG: Tflare between 900 and 1200 ºC
QA/QC procedures	Measurements outside the operational temperature specified by the manufacturer may indicate that the flare is not functioning correctly and may require maintenance. Suitable monitoring ports for the monitoring of the temperature of the flare are provided by the manufacturers. Temperature measurement equipment will be replaced or calibrated in accordance with their maintenance schedule.
Purpose of data/parameter	Project emissions calculation
Additional comments	Unexpected changes such as a sudden increase/drop in temperature can occur for different reasons. These events will be noted in the site records along with any corrective action that was implemented to correct the issue. This parameter is measured in the exhaust gas released by the enclosed flare.

Data/Parameter	$v_{O2,EG,m}$
Unit	-
Description	Volumetric fraction of O2 in the exhaust gas on a dry basis at reference conditions in the minute m
Measured/calculated/ default	Measured
Source of data	Continuous gas analyser
Value(s) of monitored parameter	12.3 %

Monitoring equipment	Brand: Siemens Model: ULTRAMAT 23 Gas Analyzer, series N1E3650 Serial number: 7MB2335-2HD10-6AA3 Manufacturer calibration frequency: 1 year (calibration gas CH4, O2), 2 years (CH4, O2 sensor) Installation date: 15/07/2014 Calibration certificate: 24/04/2014, serial 4510079628, valid until 24/04/2016 Next calibration certificate: 30/04/2020
Measuring/reading/recording frequency	Continuously. Values to be averaged on a minute basis
Calculation method (if applicable)	The value of the monitored value shown in this table is the result of the weighted average in which raw data in the same time interval accomplish the following operational condition: • Condition 1: Operation of the flare that consumes the LFG: Tflare between 900 and 1200 ºC
QA/QC procedures	The point of measurement is in the upper section of the flare (80% of total flare height). Analysers are annually calibrated according to manufacturer's recommendation. A zero check and a typical value check is performed by comparison with a certified gas
Purpose of data/parameter	Project emissions calculation
Additional comments	Monitoring of this parameter is only applicable in case of enclosed flares and continuous monitoring of the flare efficiency.

Data/Parameter	$fc_{CH4,EG,m}$
Unit	mg/m^3
Description	Concentration of methane in the exhaust gas of the flare (n) on a dry basis at reference conditions in the minute m
Measured/calculated/ default	Measured
Source of data	Continuous gas analyser
Value(s) of monitored parameter	46.80 mg/m^3
Monitoring equipment	Brand: Siemens Model: ULTRAMAT 23 Gas Analyzer, series N1E3650 Serial number: 7MB2335-2HD10-6AA3 Manufacturer calibration frequency: 1 year (calibration gas CH4, O2), 2 years (CH4, O2 sensor) Installation date: 15/07/2014 Calibration certificate: 24/04/2014, serial 4510079628, valid until 24/04/2016 Next calibration certificate: 30/04/2020
Measuring/reading/recording frequency	Continuously. Values to be averaged on a minute basis
Calculation method (if applicable)	The value of the monitored value shown in this table is the result of the weighted average in which raw data in the same time interval accomplish the following operational condition: Condition 1: Operation of the flare that consumes the LFG: Tflare between 900 and 1200 ºC
QA/QC procedures	The point of measurement is in the upper section of the flare in order that the measurement is of the gas after consumption has taken place (80% of total flare height). Analysers are annually calibrated according to manufacturer's recommendation. A zero check and a typical value check is performed by comparison with a standard gas

Purpose of data/parameter	Project emissions calculation
Additional comments	Monitoring of this parameter is only applicable in case of enclosed flares and continuous monitoring of the flare efficiency.

Data/Parameter	**$Flame_m$**
Unit	Flame on or Flame off
Description	Flame detection of flare in the minute m
Measured/calculated/ default	Measured
Source of data	Optical flame detector
Value(s) of monitored parameter	1,177.00 hours
Monitoring equipment	Optical flame detector
Measuring/reading/recording frequency	Monitoring frequency: Once per minute.
Calculation method (if applicable)	Additionally, two operational conditions are used to check the operational time under the manufacturer conditions of the flare: • Condition 1: Operation of the flare that consumes the LFG: Tflare between 900 and 1200 ºC • Condition 2: Vt,db_flare between 400 and 2000 Nm3/h
QA/QC procedures	Detection of flame recorded as a minute that the flame was on, otherwise recorded as a minute that the flame was off. Equipment is maintained and calibrated in accordance with manufacturer's recommendations.
Purpose of data/parameter	Project emissions calculation
Additional comments	Not applicable.

Data/Parameter	**$Maintenance_y$**
Unit	Calendar dates
Description	Maintenance events completed in year y
Measured/calculated/ default	Not applicable
Source of data	Manufacturer's specifications
Value(s) of monitored parameter	Please see maintenance check registry.
Monitoring equipment	Not applicable
Measuring/reading/recording frequency	Monitoring frequency: Annual
Calculation method (if applicable)	Not applicable
QA/QC procedures	Date that maintenance events were completed are recorded. Records of maintenance logs include all aspects of the maintenance including the details of the person(s) undertaking the work, parts replaced, or needing to be replaced, source of replacement parts, serial numbers, and calibration certificates. Records are kept in a maintenance log for two years beyond the life of the flare.
Purpose of data/parameter	Not applicable

Additional comments	Not applicable

D.3. Implementation of sampling plan

No sampling plan has been performed during this monitoring period.

SECTION E. Calculation of emission reductions or net anthropogenic removals

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

In this case, the baseline scenario is the release of the LFG to the atmosphere and the electricity demand being acquired from the national grid system.

The objective of the project activity is to avoid methane emissions to the atmosphere by installing an efficient landfill gas collection and flaring system and generating electricity with the captured LFG which will be exported to the grid. In conclusion, the project activity avoids emissions by:

- Capturing and destroying LFG methane in flares and in power generators.
- Reducing equivalent carbon dioxide emissions by displacement of electricity mix in the Guatemalan National Grid.

Baseline emissions are determined according to equation 1 of ACM0001 and comprise the following sources:

(A) Methane emissions from the SWDS in the absence of the project activity;
(B) Electricity generation using fossil fuels or supplied by the grid in the absence of the project activity;

$$BE_y = BE_{CH4,y} + BE_{EC,y} \qquad \text{ACM0001 (1)}$$

Where:

BE_y = Baseline emissions in year *y* (tCO_2e/yr)
$BE_{CH4,y}$ = Baseline emissions of methane from the SWDS in year *y* (tCO_2e/yr)
$BE_{EC,y}$ = Baseline emissions associated with electricity generation in year *y* (tCO_2/yr)

Note that baseline emissions associated with heat generation and with natural gas are equal to zero, since it is not part of the project activity ($BE_{HG,y} = BE_{NG,y} = 0$).

Step A: Baseline emissions of methane from the SWDS ($BE_{CH4,y}$)

Baseline emissions of methane from the SWDS are determined as follows, 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 (which is zero). In addition, the effect of methane oxidation (OX_{top_layer}) that is present in the baseline and absent in the project is taken into account:

$$BE_{CH4,y} = (1 - OX_{top\_layer}) \times (F_{CH4,PJ,y} - F_{CH4,BL,y}) \times GWP_{CH4} \qquad \text{ACM0001 (2)}$$

Where:

$BE_{CH4,y}$ = Baseline emissions of LFG from the SWDS in year *y* (tCO_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* (tCH_4/yr)
$F_{CH4,BL,y}$ = Amount of methane in the LFG that would be flared in the baseline in year *y* (tCH_4/yr)
GWP_{CH4} = Global warming potential of CH4 (tCO_2e/ tCH_4)

Step A.1: Ex-post determination of $F_{CH4,PJ,y}$

During the crediting period, $F_{CH4,PJ,y}$ is determined as the sum of the quantities of methane flared and used in the power plant. Therefore:

$$F_{CH4,PJ,y} = F_{CH4,flared,y} + F_{CH4,EL,y}$$ ACM0001 (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)

Amount of methane in the LFG which is used for electricity generation ($F_{CH4,EL,y}$)

$F_{CH4,EL,y}$, is determined using the "Tool to determine the mass flow of a greenhouse gas in a gaseous stream" and monitoring the working hours of the power plant(s), so that no emission reductions are claimed for methane destruction during nonworking hours.

The tool provides following 6 options for measuring mass flow of a greenhouse gas *i* in a gaseous stream ($F_{i,t} = F_{CH4,EL,y}$):

Option	Flow of gaseous stream	Volumetric fraction
A	Volume flow – dry basis	Dry or wet basis
B	Volume flow – wet basis	Dry basis
C	Volume flow – wet basis	Wet basis
D	Mass flow – dry basis	Dry or wet basis
E	Mass flow – wet basis	Dry basis
F	Mass flow – wet basis	Wet basis

Considering the measure meters used in this project, the Option A (*volume flow dry basis and volumetric fraction dry basis*) is applied for measuring $F_{i,t}$, in this case $F_{CH4,EL,y}$. Under Option A, flow measurement on a dry basis is not doable for a wet gaseous stream. Therefore, it is necessary to demonstrate that the gaseous stream is dry to use this option. There are two ways to do this:

a) Measure 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;

b) Demonstrate that the temperature of the gaseous stream (T_t) is less than 60ºC (333.15 K) at the flow measurement point.

For the project activity, temperature under 60ºC (option b) will be demonstrated and absolute humidity will not be measured.

The mass flow of methane ($F_{i,t}$) will be determined for the mass flow of methane sent to each electric engine (see flow diagram in Section B.3), as follows:

$$F_{i,t} = V_{t,db} * v_{i,t,db} * \rho_{i,t} \quad \text{with} \quad \rho_{i,t} = \frac{P_t * MM_i}{R_u * T_t}$$

Tool (5) and (6)

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 (m³ dry gas/h)
$v_{i,t,db}$ = Volumetric fraction of greenhouse gas i in the gaseous stream in a time interval t on a dry basis (m³ gas i/m³ dry gas)
$\rho_{i,t}$ = Density of greenhouse gas i in the gaseous stream in time interval t (kg gas i/m³ 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)

As per methodology ACM0001, the following requirements apply:

- $F_{CH4,EL,y}$ is calculated as the sum of mass flows to each item of electricity generation,
- CH_4 is the greenhouse gas for which the mass flow is determined (hence i= CH_4),
- The simplification offered for calculating the molecular mass of the gaseous stream is valid (equations 3 or 17 in the tool),
- The mass flow should be calculated on an hourly basis for each hour h in year y (hence t = hour), and
- The mass flow calculated for hour h is 0 if the equipment is not working in hour h ($O_{pj,h}$=not working), the hourly values are then summed to a yearly unit basis.

Hence in this step the parameters that will need to be monitored are $O_{pj,h}$; $V_{t,db}$; $v_{i,t,db}$; P_t and T_t for gaseous streams going to each electric engine, t=hour and i=CH_4.

Amount of methane in the LFG which is destroyed by flaring ($F_{CH4,flared,y}$)

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

$$F_{CH4,flared,y} = F_{CH4,sent\_flare,y} - \frac{PE_{flare,y}}{GWP_{CH4}}$$

ACM0001 (4)

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 using the "Tool to determine the mass flow of a greenhouse gas in a gaseous stream". As for $F_{CH4,EL,y}$ determination, the same Option A (*volume flow dry basis and volumetric fraction dry basis*) is applied for measuring $F_{i,t}$, in this case $F_{CH4,sent\_flare,y.}$

  Under Option A, flow measurement on a dry basis is not doable for a wet gaseous stream. Therefore, it is necessary to demonstrate that the gaseous stream is dry to use this option. There are two ways to do this:

  a) Measure 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;

  b) Demonstrate that the temperature of the gaseous stream (T_t) is less than 60ºC (333.15 K) at the flow measurement point.

For the project activity, temperature under 60ºC (option b) will be demonstrated and absolute humidity will not be measured.

In this case, the tool shall be applied to the LFG delivery pipeline to the flares (see flow diagram in Section B.3), as follows:

$$F_{i,t} = V_{t,db} * v_{i,t,db} * \rho_{i,t} \quad \text{with} \quad \rho_{i,t} = \frac{P_t * MM_i}{R_u * T_t} \qquad \text{Tool (5) and (6)}$$

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 (m³ dry gas/h)
$v_{i,t,db}$	= Volumetric fraction of greenhouse gas i in the gaseous stream in a time interval t on a dry basis (m³ gas i/m³ dry gas)
$\rho_{i,t}$	= Density of greenhouse gas i in the gaseous stream in time interval t (kg gas i/m³ 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.m³/kmol.K)
T_t	= Temperature of the gaseous stream in time interval t (K)

The following requirements apply:

- $F_{CH4,sent\_flare,y}$ is calculated as the sum of mass flows to each flare,
- CH_4 is the greenhouse gas for which the mass flow is determined (hence i= CH_4),
- The simplification offered for calculating the molecular mass of the gaseous stream is valid (equations 3 or 17 in the tool),
- The mass flow should be calculated on an hourly basis for each hour h in year y (hence t= hour),
- The mass flow calculated for hour h is 0 if the flare is not working in hour h, the hourly values are then summed to a yearly unit basis.

Hence in this step the parameters that will need to be monitored are $V_{t,db}$; $v_{i,t,db}$; P_t and T_t for gaseous stream going to flare, being t=hour and i=CH_4.

- **$PE_{flare,y}$** shall be determined using the tool "Project emissions from flaring".

This tool provides procedures to calculate project emissions from flaring of a residual gas. This tool is applicable to our project activity as enclosed flares will be installed and methane is the component with the highest concentration in the flammable residual gas, which comes from a biogenic source (landfill gas).

The calculation procedure in this tool determines the project emissions from flaring the residual gas ($PE_{flare,y}$) based on the flare efficiency ($\eta_{flare,m}$) and the mass flow of methane to the flare ($F_{CH4,RG,m}$). The flare efficiency is determined for each minute m of year y based either on monitored data or default values.

The project emissions calculation procedure is given in the following steps:

STEP 1: Determination of the methane mass flow of the residual gas;
STEP 2: Determination of the flare efficiency;
STEP 3: Calculation of project emissions from flaring.

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

The "Tool to determine the mass flow of a greenhouse gas in a gaseous stream" shall be used to determine the mass flow of methane in the residual gaseous stream in the minute *m* parameter ($F_{CH4,m}$).

As for $F_{CH4,sent\_flare,y}$, *Option 2 "Simplified calculation without measurement of the moisture content*" and *option A* (*volume flow dry basis and volumetric fraction dry basis*) are selected to calculate the mass flow of methane in the residual gaseous stream, which corresponds to the amount of methane sent to flare ($F_{CH4,sent\_flare,y}$) explained before.

Also, the following requirements apply to $F_{CH4,RG,t}$:

- The gaseous stream tool shall be applied to the residual gas (which is equivalent to the gaseous stream sent to flare);
- 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 ($F_{CH4,RG,m}$). $F_{CH4,m}$ shall be determined on a dry basis.

STEP 2: Determination of the flare efficiency

The flare efficiency depends on the efficiency of combustion in the flare and the time that the flare is operating. For determining the efficiency of combustion of enclosed flares there is the option to apply a default value or determine the efficiency based on monitored data. The time the flare is operating is determined by monitoring the flame using a flame detector and, for the case of enclosed flares, in addition the monitoring requirements provided by the manufacturer's specifications for operating conditions shall be met.

Project participants may choose between the following two options to determine the enclosed flare efficiency for minute m ($\eta_{flare,m}$):

- *Option A: Apply a default value for flare efficiency.*

- *Option B: Measure the flare efficiency.*

In this case, flare efficiency will be measured and hence, *Option B: Measure the flare efficiency* is chosen. As the flare efficiency in the minute *m* is a measured value ($\eta_{flare,m} = \eta_{flare,calc,m}$) the next conditions must be met to demonstrate that the flare is operating:

(1) The temperature of the flare ($T_{EG.m}$) and the flow rate of the residual gas to the flare ($F_{RG,m}$) is within the manufacturer's specification for the flare ($SPEC_{flare}$) in minute m;

(2) The flame is detected in minute m ($Flame_m$); and Otherwise $\eta_{flare,m}$ is 0%.

When applying Option B, the project participants may choose to determine $\eta_{flare,calc,m}$ using either Option B.1 or Option B.2. Under Option B.1 the measurement is conducted by an accredited entity on a biannual basis and under Option B.2 the flare efficiency is measured in each minute. Option B.2 is chosen.

Under Option B.2, the flare efficiency ($\eta_{flare,calc,m}$) is determined based on monitoring the methane content in the exhaust gas, the residual gas, and the air used in the combustion process during the minute m in year y, as follows:

$$\eta_{flare,calc,m} = 1 - \frac{F_{CH4,EG,m}}{F_{CH4,RG,m}} \quad \text{Tool (2)}$$

Where:

$\eta_{flare,calc,m}$	= Flare efficiency in the minute m
$F_{CH4,EG,m}$	= Mass flow of methane in the exhaust gas of the flare on a dry basis at reference conditions in the minute m (kg)
$F_{CH4,RG,m}$	= Mass flow of methane in the residual gas on a dry basis at reference conditions in the minute m (kg)

$F_{CH4,RG,m}$ is calculated according to Step 1 and $F_{CH4,EG,m}$ is determined according to Steps 2.1 - 2.4 below:

Step 2.1: Determine the methane mass flow in the exhaust gas on a dry basis

The mass flow of methane in the exhaust gas is determined based on the volumetric flow of the exhaust gas and the measured concentration of methane in the exhaust gas, as follows:

$$F_{CH4,EG,m} = V_{EG,m} * fc_{CH4,EG,m} * 10^{-6} \quad \text{Tool (3)}$$

Where:

$F_{CH4,EG,m}$	= Mass flow of methane in the exhaust gas of the flare on a dry basis at reference conditions in the minute *m* (kg)
$V_{EG,m}$	= Volumetric flow of the exhaust gas of the flare on a dry basis at reference conditions in minute *m* (m^3)
$fc_{CH4,EG,m}$	= Concentration of methane in the exhaust gas of the flare on a dry basis at reference conditions in minute *m* (mg/m^3)

Step 2.2: Determine the volumetric flow of the exhaust gas ($V_{EG,m}$)

Determine the average volume flow of the exhaust gas in minute *m* based on a stoichiometric calculation of the combustion process. This depends on the chemical composition of the residual gas, the amount of air supplied to combust it and the composition of the exhaust gas. It is calculated as follows:

$V_{EG,m} = Q_{EG,m} * M_{RG,m}$ Tool (4)

Where:

$V_{EG,m}$ = Volumetric flow of the exhaust gas on a dry basis at reference conditions in minute *m* (m^3)

$Q_{EG,m}$ = Volume of the exhaust gas on a dry basis at reference conditions per kilogram of residual gas on a dry basis at reference conditions in minute *m* (m^3 exhaust gas/kg residual gas)

$M_{RG,m}$ = Mass flow of the residual gas on a dry basis at reference conditions in the minute *m* (kg)

Step 2.3: Determine the mass flow of the residual gas (MRG,m)

Project participants select to calculate $M_{RG,m}$ based on the volumetric flow and the density of the residual gas. The density of the residual gas is determined based on the volumetric fraction of all components in the gas.

$M_{RG,m} = \rho_{RG,ref,m} * V_{RG,m}$ Tool (5)

Where:

$M_{RG,m}$ = Mass flow of the residual gas on a dry basis at reference conditions in minute *m* (kg)

$\rho_{RG,ref,m}$ = Density of the residual gas at reference conditions in minute *m* (kg/m^3)

$V_{RG,m}$ = Volumetric flow of the residual gas on a dry basis at reference conditions in the minute *m* (m^3),

$$\rho_{RG,ref,m} = \frac{P_{ref}}{\frac{R_u}{MM_{RG,m}} \times T_{ref}}$$ Tool (6)

Where:

$\rho_{RG,ref,m}$ = Density of the residual gas at reference conditions in minute m (kg/m^3)

P_{ref} = Atmospheric pressure at reference conditions (Pa)

R_u = Universal ideal gas constant ($Pa.m^3/kmol.K$)

$MM_{RG,m}$ = Molecular mass of the residual gas in minute m (kg/kmol)

T_{ref} = Temperature at reference conditions (K)

Use the equation below to calculate $MM_{RG,m}$. When applying this equation, the project participant chooses to use the measured volumetric fraction of each component i of the residual gas. The next equation applies, irrespective of which option is selected.

$$MM_{RG,m} = \sum_i (v_{i,RG,m} \times MM_i)$$ Tool (7)

Where:

$MM_{RG,m}$ = Molecular mass of the residual gas in minute m (kg/kmol)

MM_i = Molecular mass of residual gas component i (kg/kmol)

$v_{i,RG,m}$ = Volumetric fraction of component i in the residual gas on a dry basis at reference conditions in the hour h.

i = Components of the residual gas (where i = CH_4, CO, CO_2, O_2, H_2, H_2S, NH_3 and N_2).

Step 2.4: Determine the volume of the exhaust gas on a dry basis at reference conditions per kilogram of residual gas (QEG,m)

$Q_{EG,m} = Q_{CO2,EG,m} + Q_{O2,EG,m} + Q_{N2,EG,m}$ Tool (8)

Where:

$Q_{EG,m}$ = Volume of the exhaust gas on a dry basis per kg of residual gas on a dry basis at reference conditions in the minute m (m^3/kg residual gas)

$Q_{CO2,EG,m}$ = Quantity of CO_2 volume in the exhaust gas per kg of residual gas on a dry basis at reference conditions in the minute m (m^3/kg residual gas)

$Q_{N2,EG,m}$ = Quantity of N_2 volume in the exhaust gas per kg of residual gas on a dry basis at reference conditions in the minute m (m^3/kg residual gas)

$Q_{O2,EG,m}$ = Quantity of O_2 volume in the exhaust gas per kg of residual gas on a dry basis at reference conditions in the minute m (m^3/kg residual gas)

With

$Q_{O2,EG,m} = n_{O2,EG,m} * VM_{ref}$ Tool (9)

Where:

$Q_{O2,EG,m}$ = Quantity of O_2 volume in the exhaust gas per kg of residual gas on a dry basis at reference conditions in the minute m (m^3/kg residual gas)

$n_{O2,EG,m}$ = Quantity of O_2 (moles) in the exhaust gas per kg of residual gas flared on a dry basis at reference conditions in minute m (kmol/kg residual gas)

VM_{ref} = Volume of one mole of any ideal gas at reference temperature and pressure (m^3/kmol)

$$Q_{N2,EG,m} = VM_{ref} \times \left\{ \frac{MF_{N,RG,m}}{2 \times AM_N} + \left(\frac{1 - v_{O2,air}}{v_{O_2,air}} \right) \times \left[F_{O2,RG,m} + n_{O2,EG,m} \right] \right\}$$ Tool (10)

Where:

$Q_{N2,EG,m}$ = Quantity of N_2 (volume) in the exhaust gas per kg of residual gas on a dry basis at reference conditions in the minute m (m^3/kg residual gas)

VM_{ref} = Volume of one mole of any ideal gas at reference temperature and pressure (m^3/kmol)

$MF_{N,RG,m}$ = Mass fraction of nitrogen in the residual gas in the minute m

AM_N = Atomic mass of nitrogen (kg/kmol)

$v_{O2,air}$ = Volumetric fraction of O_2 in air

$F_{O2,RG,m}$ = Stochiometric quantity of moles of O_2 required for a complete oxidation of one kg residual gas in minute m (kmol/kg residual gas)

$n_{O2,EG,m}$ = Quantity of O_2 (moles) in the exhaust gas per kg of residual gas flared on a dry basis at reference conditions in minute m (kmol/kg residual gas)

$$Q_{CO_2,EG,m} = \frac{MF_{C,RG,m}}{AM_C} \times VM_{ref}$$ Tool (11)

Where:

$Q_{CO2,EG,m}$ = Quantity of CO_2 volume in the exhaust gas per kg of residual gas on a dry basis at reference conditions in the minute m (m^3/kg residual gas)

$MF_{C,RG,m}$	= Mass fraction of carbon in the residual gas in the minute m
AM_C	= Atomic mass of carbon (kg/kmol)
VM_{ref}	= Volume of one mole of any ideal gas at reference temperature and pressure (m^3/kmol)

$$n_{O2,EG,m} = \frac{v_{O_2,EG,m}}{\left(1-\left(v_{O_2,EG,m}/v_{O_2,air}\right)\right)} \cdot \left[\frac{MF_{C,RG,m}}{AM_C} + \frac{MF_{N,RG,m}}{2 \times AM_N} + \left(\frac{1-v_{O_2,air}}{v_{O_2,air}}\right) \times F_{O2,RG,m}\right] \quad \text{Tool (12)}$$

Where:

$n_{O2,EG,m}$	= Quantity of O_2 (moles) in the exhaust gas per kg of residual gas flared on a dry basis at reference conditions in minute m (kmol/kg residual gas)
$v_{O2,EG,m}$	= Volumetric fraction of O_2 in the exhaust gas on a dry basis at reference conditions in the minute m
$v_{O2,air}$	= Volumetric fraction of O_2 in the air
$M_{FC,RG,m}$	= Mass fraction of carbon in the residual gas in the minute m
AM_C	= Atomic mass of carbon (kg/kmol)
$MF_{N,RG,m}$	= Mass fraction of nitrogen in the residual gas in the minute m
AM_N	= Atomic mass of nitrogen (kg/kmol)
$F_{O2,RG,m}$	= Stochiometric quantity of moles of O_2 required for a complete oxidation of one kg residual gas in minute m (kmol/kg residual gas)

$$F_{O2,RG,m} = \frac{MF_{C,RG,m}}{AM_C} + \frac{MF_{H,RG,m}}{4AM_H} - \frac{MF_{O,RG,m}}{2AM_O} \quad \text{Tool (13)}$$

Where:

$F_{O2,RG,m}$	= Stochiometric quantity of moles of O_2 required for a complete oxidation of one kg residual gas in minute m (kmol/kg residual gas)
$MF_{C,RG,m}$	= Mass fraction of carbon in the residual gas in the minute m
AM_C	= Atomic mass of carbon (kg/kmol)
$MF_{O,RG,m}$	= Mass fraction of oxygen in the residual gas in the minute m
AM_O	= Atomic mass of oxygen (kg/kmol)
$MF_{H,RG,m}$	= Mass fraction of hydrogen in the residual gas in the minute m
AM_H	= Atomic mass of hydrogen (kg/kmol)

Determine the mass fractions of carbon, hydrogen, oxygen and nitrogen in the residual gas, using the volumetric fraction of component i in the residual gas and applying the equation below. In applying this equation, the project participants have chosen option a) "use the measured volumetric fraction of each component *i* of the residual gas", being *i* CH_4, CO, CO_2, O_2, H_2, H_2S, NH_3 and N_2.

$$MF_{j,RG,m} = \frac{\sum_i v_{i,RG,m} \times AM_j \times NA_{j,i}}{MM_{RG,m}} \quad \text{Tool (14)}$$

Where:

$MF_{j,RG,m}$	= Mass fraction of element j in the residual gas in the minute m
$v_{i,RG,m}$	= Volumetric fraction of component i in the residual gas on a dry basis in the minute m
AM_j	= Atomic mass of element j (kg/kmol)
$NA_{j,i}$	= Number of atoms of element j in component i
$MM_{RG,m}$	= Molecular mass of the residual gas in minute m (kg/kmol)
j	= elements C, O, H and N

i	= Component of residual gas (where i = CH_4, CO, CO_2, O_2, H_2, H_2S, NH_3 and N_2).

Step 3: Calculation of project emissions from flaring

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

$$PE_{flare,y} = GWP_{CH4} \times \sum_{m=1}^{525600} F_{CH4,RG,m} \times \left(1 - \eta_{flare,m}\right) \times 10^{-3}$$ Tool (15)

Where:

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

Hence in this step the next parameters will need to be monitored:

- At the residual gas: $P_{m,\ flame}$; $T_{m,\ flame}$; $V_{RG,m,flame}$; $v_{i,RG,m,flame}$, with m = minute and i=CH_4, CO, CO_2, O_2, H_2, H_2S, NH_3, N_2.
- At the exhaust gas: $fc_{CH4,EG,m}$; $V_{O2,EG,m}$; $T_{EG,m}$, with m = minute.
- At the flare: $Op_{j,h}$; $Flame_m$

Step A.1.1: Ex ante estimation of $F_{CH4,PJ,y}$

An ex ante estimate of $F_{CH4,PJ,y}$ is required to estimate baseline emission of methane from the SWDS (according to equation ACM0001 (2)) in order to estimate the emission reductions of the proposed project activity in the CDM-PDD. It is determined as follows:

$$F_{CH4,PJ,y} = \eta_{PJ} \times BE_{CH4,SWDS,y} / GWP_{CH4}$$ ACM0001 (5)

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)
$BE_{CH4,SWDS,y}$	= Amount of methane in the LFG that is generated from the SWDS in the baseline scenario in year y (t CO_2e/yr)
η_{PJ}	= Efficiency of the LFG capture system that will be installed in the project activity
GWP_{CH4}	= Global warming potential of CH_4 (t CO_2e/t CH_4)

$BE_{CH4,SWDS,y}$ is determined using the methodological tool "Emissions from solid waste disposal sites" and taken into account the following when applying the tool:

- f_y in the tool shall be assigned a value of 0 because the amount of LFG that would have been captured and destroyed is already accounted for in equation 2 of this methodology;
- In the tool, x begins with the year that the SWDS started receiving wastes (e.g. the first year of SWDS operation); and

- Sampling to determine the fractions of different waste types is not necessary because the waste composition can be obtained from previous studies.

The amount of methane generated by the site annually is calculated as follows:

Tool (1)

$$BE_{CH4,SWDS,y} = \varphi_y \cdot (1-f_y) \cdot GWP_{CH4} \cdot (1-OX) \cdot \frac{16}{12} \cdot F \cdot DOC_{f,y} \cdot MCF_y \cdot \sum_{x=1}^{y} \sum_{j} W_{j,x} \cdot DOC_j \cdot e^{-k_j(y-x)} * (1-e^{k_j})$$

Where, for the yearly model:

$BE_{CH4,SWDS,y}$	=	Baseline, project or leakage methane emissions occurring in year y generated from waste disposal at a SWDS during a time period ending in year y (t CO_2e / yr)
x	=	Years in the time period in which waste is disposed at the SWDS, extending from the first year in the time period ($x = 1$) to year y ($x = y$).
y	=	Year of the crediting period for which methane emissions are calculated (y is a consecutive period of 12 months)
$DOC_{f,y}$	=	Fraction of degradable organic carbon (DOC) that decomposes under the specific conditions occurring in the SWDS for year y (weight fraction)
$W_{j,x}$	=	Amount of solid waste type j disposed or prevented from disposal in the SWDS in the year x (t)
φ_y	=	Model correction factor to account for model uncertainties for year y
f_y	=	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
GWP_{CH4}	=	Global Warming Potential of methane
OX	=	Oxidation factor (reflecting the amount of methane from SWDS that is oxidised in the soil or other material covering the waste)
F	=	Fraction of methane in the SWDS gas (volume fraction)
MCF_y	=	Methane correction factor for year y
DOC_j	=	Fraction of degradable organic carbon in the waste type j (weight fraction)
k_j	=	Decay rate for the waste type j (1 / yr)
j	=	Type of residual waste or types of waste in the MSW

Under the tool "Emissions from solid waste disposal sites", application A is chosen as "*The CDM project activity mitigates methane emissions from a specific existing SWDS".* So, the amount of wastes is based on information from the SWDS, collected by SGS engineers' study from 2005. The model correction factor (φ_y) is determined based on default value (option 1), for Application A, 0.75. More detailed ex-ante calculations of emission reductions are provided in Appendix 4.

Step A.2: Determination of FCH4,BL,y

This step provides a procedure to determine the amount of methane that would have been captured and destroyed (by flaring) in the baseline due to regulatory or contractual requirements, or to address safety and odour concerns (collectively referred to as requirement in this step). In Zone 3 landfill the LFG is not captured but released to the atmosphere as no regulation related to this matter are applicable in Guatemala and there are no safety and odour contractual requirements between the project developer and the municipality (see provided evidence). Therefore, *"Case 1: No requirements to destroy methane exists and no existing LGF capture system*" applies. In this situation:

$F_{CH4,BL,y} = 0$ Tool (6)

Where:

$F_{CH4,BL,y}$ = Amount of methane in the LFG that would be flared in the baseline in year y (tCH_4/yr)

Step B: Baseline emissions associated with electricity generation (BEEC,y)

The baseline emissions associated with electricity generation in year y ($BE_{EC,y}$) shall be calculated using the "Tool to calculate baseline, project and/or leakage emissions from electricity consumption".
When applying the tool:

- The electricity sources k in the tool correspond to the sources of electricity generated identified in the selection of the most plausible baseline scenario; and
- $EC_{BL,k,y}$ in the tool is equivalent to the net amount of electricity generated using LFG in year y ($EG_{PJ,y}$).

In the absence of the project activity, this electricity would have been produced by power plants connected to the grid. Hence, scenario A described in the Tool applies for the calculation in the following equation:

$$BE_{EC,y} = \sum_{k} EC_{BL,k} * EF_{EL,k,y} * \left(1 + TDL_{k,y}\right) \qquad \text{Tool (2)}$$

Where

$BE_{EC,y}$	= Baseline emissions from electricity generated in year y (tCO_2/yr) $EC_{BL,k}$ = Quantity of electricity generated in year *y* using LFG (MWh/yr)
$EF_{EL,k,y}$	= Emission factor for electricity generation for source *k* in year *y* (tCO_2/MWh)
$TDL_{k,y}$	= Average technical transmission and distribution losses for providing electricity to source k in year y
k	= Sources of electricity generated in the baseline

Following the option A1 of the scenario A, the $EF_{EL,k,y}$ will be determined by following the "Tool to calculate the emission factor for an electricity system" and $EF_{EL,k,y}$ = $EF_{grid,CM,y}$. This calculation is presented in appendix 4 and results in a value of 0.602 tCO_2/MWh, which will be a fixed value during the first crediting period.

Also, the default value of 9.00 % has been used for $TDL_{k,y}$, according to host country specific data[1].

Step C: Baseline emissions associated with heat generation (BEHG,y)

Step not taken since it will not be covered any heat generation in this project activity.

Step D: Baseline emissions associated with natural gas use (BENG,y)

Step not taken since it will not be covered any natural gas use from LFG in this project activity.

[1] Source: https://data.worldbank.org/indicator/eg.elc.loss.zs?most_recent_year_desc=true

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

According to the methodology ACM0001, project emissions are calculated as follows:

$PE_y = PE_{EC,y} + PE_{FC,y}$ ACM0001 (22)

Source: https://data.worldbank.org/indicator/eg.elc.loss.zs?most_recent_year_desc=true

Where:

PEy	= Project emissions in year y (tCO_2/yr)
$PE_{EC,y}$	= Emissions from consumption of electricity due to project activity in year y (tCO_2/yr)
$PE_{FC,j,y}$	= Emissions from consumption of fossil fuels due to the project activity, for purpose other than electricity generation, in year y (t CO_2/yr). As no fossil fuels will be used due to the implementation of the project activity, this value is zero (0).

Hence, $PE_y = PE_{EC,y}$.

The project emissions from consumption of electricity by the project activity ($PE_{EC,y}$) shall be calculated using the "Tool to calculate baseline, project and/or leakage emissions from electricity consumption".

When applying the tool:

- $EC_{PJ,k,y}$ in the tool is equivalent to the amount of electricity consumed by the project activity in year y ($EC_{PJ,y}$); and
- If in the baseline a proportion of LFG is destroyed ($F_{CH4,BL,y} > 0$), then the electricity consumption in the tool ($EC_{PJ,j,y}$) should refer to the net quantity of electricity consumption (i.e. the increase due to the project activity). The determination of the amount of electricity consumed in the baseline shall be transparently documented in the CDM-PDD.

$$PE_{EC,y} = \sum_k EC_{PJ,j,y} * EF_{EL,j,y} * (1 + TDL_{j,y})$$ Tool (1)

E.3. Calculation of leakage emissions

No leakage effects are accounted for under this methodology

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

Emission reductions are calculated as follows:

$ER_y = BE_y - PE_y$ ACM0001 (23)

Where:

ER_y = Emission reductions in year y (tCO_2e/yr)
BE_y = Baseline emissions in year y (tCO_2e/yr)
PE_y = Project emissions in year y (tCO_2/yr)

As the energy component is intended to be implemented since the first year of the project activity, then the energy component is not excluded from the ex-ante estimation of baseline emissions or the determination of the baseline or demonstration of additionality.

	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 until 31/12/2020	From 01/01/2021	Total amount
Total	343,012	111	0	0	293,142	49,758	342,901

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)
342,901	1,170,467

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

Below is the table used for the calculation of the amount estimated ex ante for this monitoring period in the PDD. These calculations can be found in the Excel spreadsheet used for the ERs calculations "210809_ER Spreadsheet_1stMP_Zone 3_v5"

Item		Values estimated in ex-ante calculation of registered PDD	Actual values achieved during this monitoring period
Year 2014	*From*	26/07/2014	26/07/2014
	To	31/12/2014	31/12/2014
	Days	159	159
	Emission reductions or GHG removals by sinks (t CO_2e)	65,203	2,018
	tCO2e/day	**410.08**	**12.69**
Year 2015	*From*	01/01/2015	01/01/2015
	To	31/12/2015	31/12/2015

	Days	365	365
	Emission reductions or GHG removals by sinks (t CO_2e)	155,886	12,320
	tCO2e/day	**427.08**	**33.75**
Year 2016	*From*	01/01/2016	01/01/2016
	To	31/12/2016	31/12/2016
	Days	365	365
	Emission reductions or GHG removals by sinks (t CO_2e)	161,355	22,816
	tCO2e/day	**442.07**	**62.51**
Year 2017	*From*	01/01/2017	01/01/2017
	To	31/12/2017	31/12/2017
	Days	365	365
	Emission reductions or GHG removals by sinks (t CO_2e)	166,963	26,067
	tCO2e/day	**457.43**	**71.42**
Year 2018	*From*	01/01/2018	01/01/2018
	To	31/12/2018	31/12/2018
	Days	365	365
	Emission reductions or GHG removals by sinks (t CO_2e)	169,839	76,233
	tCO2e/day	**465.31**	**208.86**
Year 2019	*From*	01/01/2019	01/01/2019
	To	31/12/2019	31/12/2019
	Days	365	365
	Emission reductions or GHG removals by sinks (t CO_2e)	172,911	81,757
	tCO2e/day	**473.73**	**223.99**
Year 2020	*From*	01/01/2020	01/01/2020
	To	31/12/2020	31/12/2020
	Days	365	365
	Emission reductions or GHG removals by sinks (t CO_2e)	176,181	71,931
	tCO2e/day	**482.69**	**197.07**
Year 2021	*From*	01/01/2021	01/01/2021
	To	25/07/2021	25/07/2021
	Days	206	206
	Emission reductions or GHG removals by sinks (t CO_2e)	102,129	49,758
	tCO2e/day	**495.77**	**241.55**

E.6. Remarks on increase in achieved emission reductions

The amount of ERs estimated ex ante as per PDD was 1,170,467 t CO_2e, compared with the 342,901 t CO_2e obtained during this monitoring period. Therefore, there is an issuance success of 29% compared with the PDD values.

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

The project is a large-scale project activity so this section is not applicable.

- - - - -

Document information

Version	Date	Description
08.0	6 April 2021	Revision to: • Reflect the "Clarification: Regulatory requirements under temporary measures for post-2020 cases" (CDM-EB109-A01-CLAR).
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.

Decision Class: Regulatory
Document Type: Form
Business Function: Issuance
Keywords: monitoring report