Monitoring report form for CDM project activity
(Version 06.0)

MONITORING REPORT

Title of the project activity	Douala Landfill gas recovery and flaring project	
UNFCCC reference number of the project activity	4175	
Version number of the PDD applicable to this monitoring report	1.7	
Version number of this monitoring report	1	
Completion date of this monitoring report	26/03/2018	
Monitoring period number	2	
Monitoring report number for this monitoring report	n/a	
Duration of this monitoring period	01/06/2015 to 31/12/2017	
Project participants	Hygiène et Salubrité du Cameroun (HYSACAM) Norwegian Ministry of Climate and Environment	
Host Party	Cameroon	
Sectoral scopes	13 : Waste handling and disposal	
Applied methodologies and standardized baselines	ACM0001 ver. 11 - Consolidated baseline and monitoring methodology for landfill gas project activities	
Amount of GHG emission reductions or net anthropogenic GHG removals achieved by the project activity in this monitoring period	Amount achieved before 1 January 2013	Amount achieved from 1 January 2013
	0	**191,692 tCO_2e**
Amount of GHG emission reductions or net anthropogenic GHG removals estimated ex ante for this monitoring period in the PDD	0	**338,959 tCO_2e**

SECTION A. Description of project activity

A.1. General description of project activity

The “Douala Landfill gas recovery and flaring project” contributes to a reduction of global warming as it involves the extraction of landfill gas (LFG) at the Douala landfill site in Cameroun by avoiding the uncontrolled release of LFG in the atmosphere. Landfill gas is a significant source of global warming as it contains a high share of the greenhouse gas methane CH_4.
The project activity consists of capturing, flaring and consequently destroying LFG in a highly efficient flaring station, which consist of (1) Cells capping/coverage (2) LFG extraction and collection system (3) LFG flaring and monitoring system.

Project construction began in January 2013[1]. The project has been operating since 13 May 2014.

In the effective monitoring period starting on 1st June 2015 the total GHG emission reductions amounted to 191,692 tonnes of CO_2e up to 31st December 2017.

A.2. Location of project activity

Host party: Cameroon

Region: Littoral Region

Nearby city: Douala (the project is located 10 km east of the city centre)

GPS coordinates: 4° 2'27.96"N, 9°46'55.03"E

Figure 1: Project activity location

A.3. Parties and project participants

Parties involved	Project participants	Indicate if the Party involved wishes to be considered as project participant (Yes/No)
Cameroon (host)	HYSACAM	No
Norway	Norwegian Ministry of Climate and Environment	No

[1] Cf. http://on.fb.me/11n1jvq

A.4. Reference to applied methodologies and standardized baselines

Title of the approved baseline and monitoring methodology:
ACM0001- “Consolidated baseline and monitoring methodology for landfill gas project activities” (Version 11 – EB47)

As per this methodology, the latest approved versions of the following tools were used:
- “Tool for the demonstration and assessment of additionality”, version 05.2, EB39;
- “Tool to determine project emissions from flaring gases containing methane”, version 01, EB28;
- “Tool to calculate baseline, project and/or leakage emissions from electricity consumption”, version 01, EB39;
- “Tool to determine methane emissions avoided from disposal of waste at a solid waste disposal site”, version 05, EB55;

A.5. Crediting period type and duration

Fixed crediting period: 30/06/2013 – 29/06/2023 (10 years).

SECTION B. Implementation of project activity

B.1. Description of implemented project activity

The project activity of capturing, flaring and consequently destroying LFG in a highly efficient flaring station involves the following equipment: (1) Cells capping/ coverage (2) LFG extraction and collection system (3) LFG flaring and monitoring system.

In addition, an off-grid captive power generator was installed to cover the electricity needs of the blower, flaring unit, control devices, monitoring installations, etc., in case of grid blackout.

Parts of the landfill surface have been capped to prevent LFG emissions from migrating and to limit water infiltration. The final cover comprises of compacted on-site materials, a geo-synthetic material with low permeability and drainage capacity and a final cover of on-site vegetable soil.

The collection of the LFG takes place with a series of vertical wells which help the collection of the LFG from deep points in the landfill body. Wells are drilled and then pipes are installed to the holes. After the installation of each well, the collected LFG via wells are transferred to the interconnected gas collection network which comprises of primary and secondary gas pipes.

The main pipe is connected to the intake pipe of the LFG blower that creates a pressure gradient in the piping system necessary for the extraction of the LFG. A cleaning system extracts the humidity from the collected LFG.

The LFG flaring system comprises of an enclosed high temperature flare operated by an electrical control system and equipped with a monitoring system for methane, oxygen, gas flow, pressure and temperature.

The gas flaring station is divided into three separate components:

- A blower
- A high-temperature flare system able to burn LFG at very low flow and methane contents
- Electrical control switchboard and gas analysis system equipped with a control panel. Specific control equipment is installed to measure LFG amount captured and destroyed by the flare as well as flow meters to monitor LFG flows, gas analyzers (CH_4, CO_2, and O_2), meters for pressure and temperature. The system also includes tele-control equipment for continuous monitoring as well as a computerized data registration and archiving system (“central control unit”).

Table 1: Flare specifications

Technology provider:	France Biogaz Environnement
Type	Enclosed; 1600 CiCH
Power	1,600 kW – 8000 kW
Capacity / flow level	300 - 1600 Nm^3/h LFG
Operation temperature:	500-1,200°C
Dimensions	Height: 7m, Diameter: 1,6m

The overall technology for the project activity has been implemented by the technology provider (FBE).

The landfill site was opened in 2003 and project construction began in January 2013. The LFG flaring system and its monitoring have been in operation since its start-up on 13/05/2014. The project has been operating since then.

Special events during monitoring period:

During this monitoring period, the project owner operated and regularly maintained the equipment according to the monitoring plan, and all staff was well trained.

During operation the flare was temporarily shut down (either automatically or manually), which were recorded as “events”. No emission reductions have been claimed during these periods.

In addition, several periods of malfunctioning of equipment occurred which were recorded as “events”. In these cases, the most conservative approach has been chosen which means no emission reductions have been claimed.

All noteworthy events that occurred during the monitoring period have been recorded and provided to the DOE under tab “2) events” of the Emission Reductions monitoring spreadsheet. No events or situations, which impact the applicability of the applied methodology occurred during this monitoring period.

B.2. Post-registration changes

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

n/a

B.2.2. Corrections

n/a

B.2.3 Changes to the start date of crediting period

[already approved during 1st verification] Following project implementation delays, the start date of the crediting period had been postponed by 2 years (from 01/07/2011 to 01/07/2013), in compliance with § 12.8.3.2. “Changes to the start date of the crediting period” of the CDM Project Standard.

B.2.4 Inclusion of monitoring plan

n/a

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

n/a

B.2.6. Changes to project design

n/a

SECTION C. Description of monitoring system

An internal CDM monitoring system has been developed that covers all the procedures required as per the approved methodology ACM0001 and registered monitoring plan.

1. The monitoring set-up defines three main monitoring points:
- Monitoring point 1: before flaring (landfill gas)
- Monitoring point 2: inside/after flaring (exhaust gas)
- Monitoring point 3: energy consumption

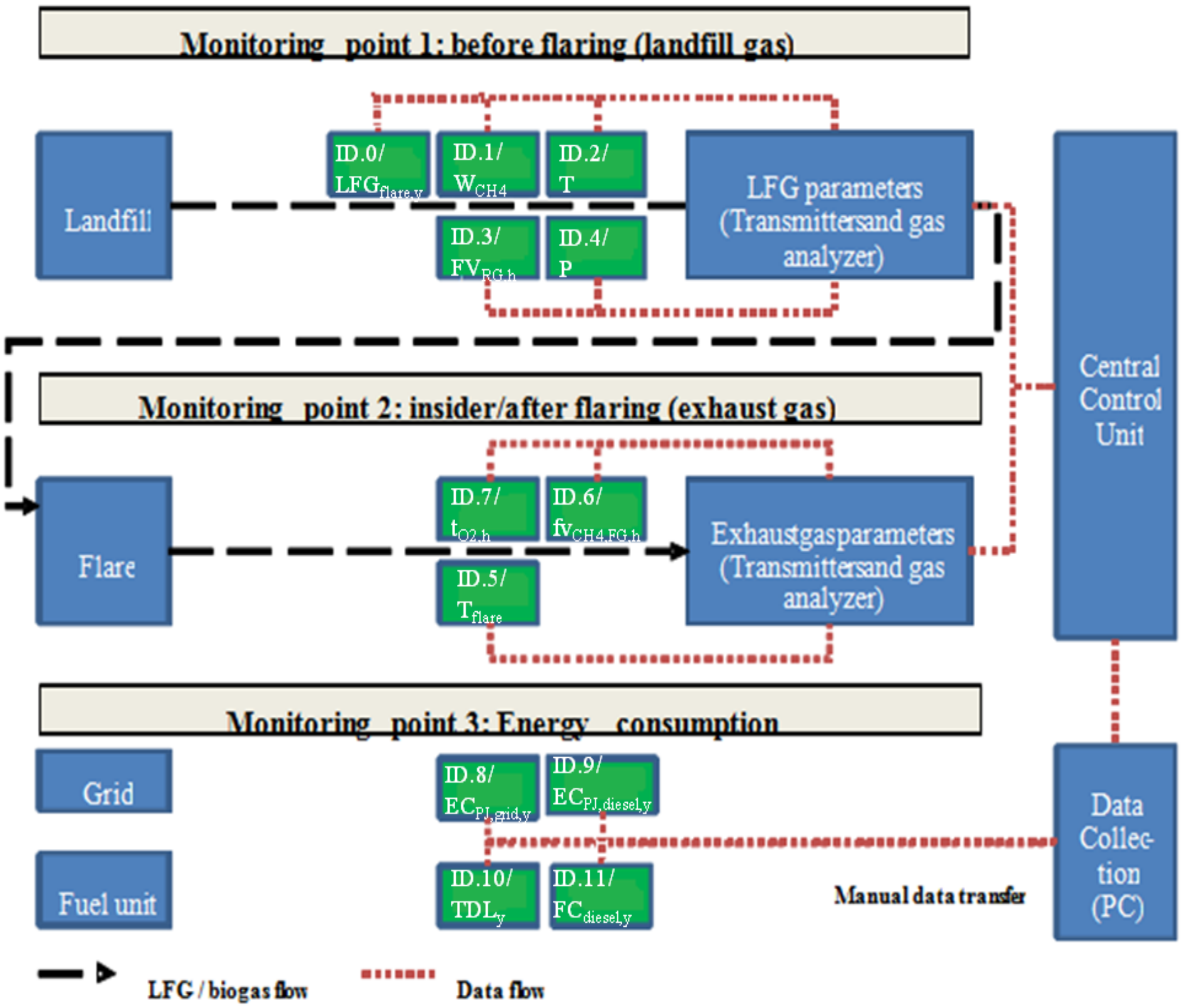

Figure 2: General monitoring set-up

2. The overall data collection procedure consists of 4 main steps:

Step 1 represents the initial (raw) data generation through monitoring instruments and its registration in the central control unit. All data is processed electronically. All measurements of gas flow, pressure, temperature, and gas concentration from monitoring points 1 (landfill gas) and 2 (exhaust gas) are transmitted via analog signals (in mA) to the central control unit. There the following data processing takes place: A conversion takes place from analog to digital values (in the digital control subsystem, DCS). Average minutely values are calculated and recorded based on the data streams received from both gas analyzers and other measurement instruments. The

DCS can store recorded data of the last 17 hours. The DCS collects and transmits all raw data to the computer where the data is stored in a database.
The user can access this data with the CLIPTOOL program. This program allows the creation of TXT files with all minutely data recorded. It creates a TXT file once a day.

Step 2 represents the data transfer to low-level .xls files. In this step the minutely recorded data of the day in the TXT file is transferred manually to the xls files by using a precise procedure.

Step 3 represents the data aggregation (and partly already calculation) in the low-level xls files. Cliptool program converts the flow to normal flow directly. The concentration, temperature and pressure are averaged. The parameter of flare temperature is treated as number of occurrences ≥ 500°C.

Step 4 represents the data calculation (and further aggregation) in the high-level file in xls (workbook). The workbook shows all relevant calculation steps required by the methodology and flaring tool[2] in order to further process and finally calculate the emission reductions. The results are aggregated over the complete monitoring period.

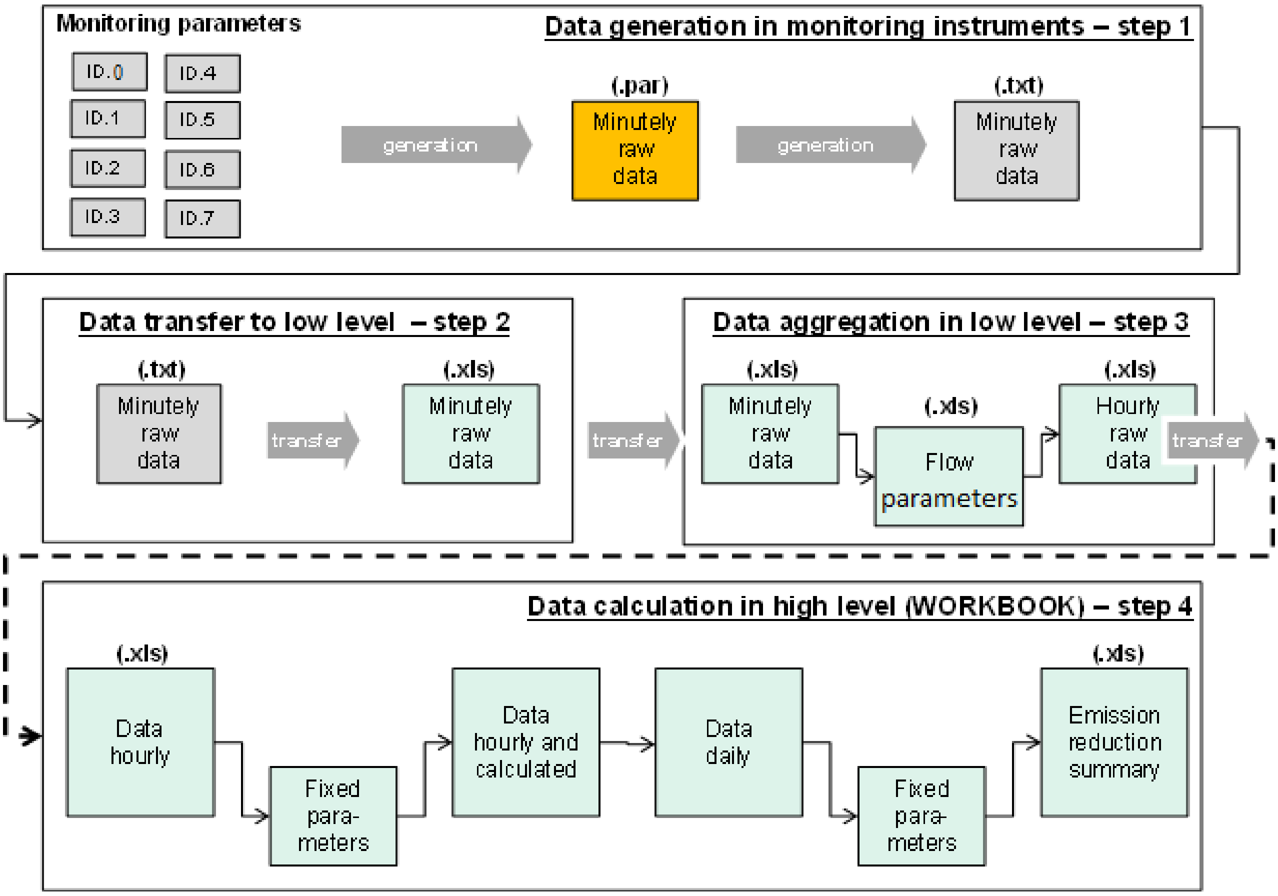

Figure 3: Data consolidation process

3. Data storage

The controllers are responsible for keeping all monitoring data electronically and in an external storage device (CD ROM). Records of all monitored parameters are stored at least 2 years after last issuance.
Data storage relevant for the monitoring parameters ID.0 – ID.7 are handled as follows:

- TXT files are generated and saved daily. Every day it is checked if the data from the day before was saved successfully in a TXT file.

[2] "Tool to determine project emissions from flaring gases containing methane"

- Low level files are generated and saved daily on the PC unit. Each low level file consists of an appropriate number of days.
- The high-level workbook file is updated and saved daily on the PC unit (meaning the overall corresponding emission reductions are automatically updated on a daily basis).
- All data for ID.0 – ID.7 is stored automatically on the PC unit and manually once a month to a CD-ROM as back-up. The CD-ROM includes all new TXT files, low-level files as well as the latest workbook file of the month.
- Data from ID.8 and ID.9 (electricity consumption) is recorded manually once per day. In addition, monthly invoices for power delivered by the grid to the plant and diesel purchased are received and can be used as cross-check.

A logbook is written all the time where observations and all other information necessary to document is included. This way, anomalies or periods with not normal operating conditions can be identified and explained. All events relevant for ER calculations are in addition transferred to the workbook.

4. Organization, roles and responsibilities

The project owner is HYSACAM and therefore responsible for the operation and monitoring of the project activity. The Executive Chief of Douala Landfill is responsible of the monitoring activities.

- The regular operation is under the responsibility of the Vice Chief.
- The regular LFG monitoring activities are handled by a dedicated responsible person for CDM Monitoring (CDM monitoring officer).

This person is responsible for operational activities of the LFG system and for daily monitoring activities, as well as reporting monitoring results.

The maintenance activities are handled by a dedicated responsible person for CDM Maintenance (CDM maintenance officer). This person is responsible for maintenance and calibration of the measurement equipment.

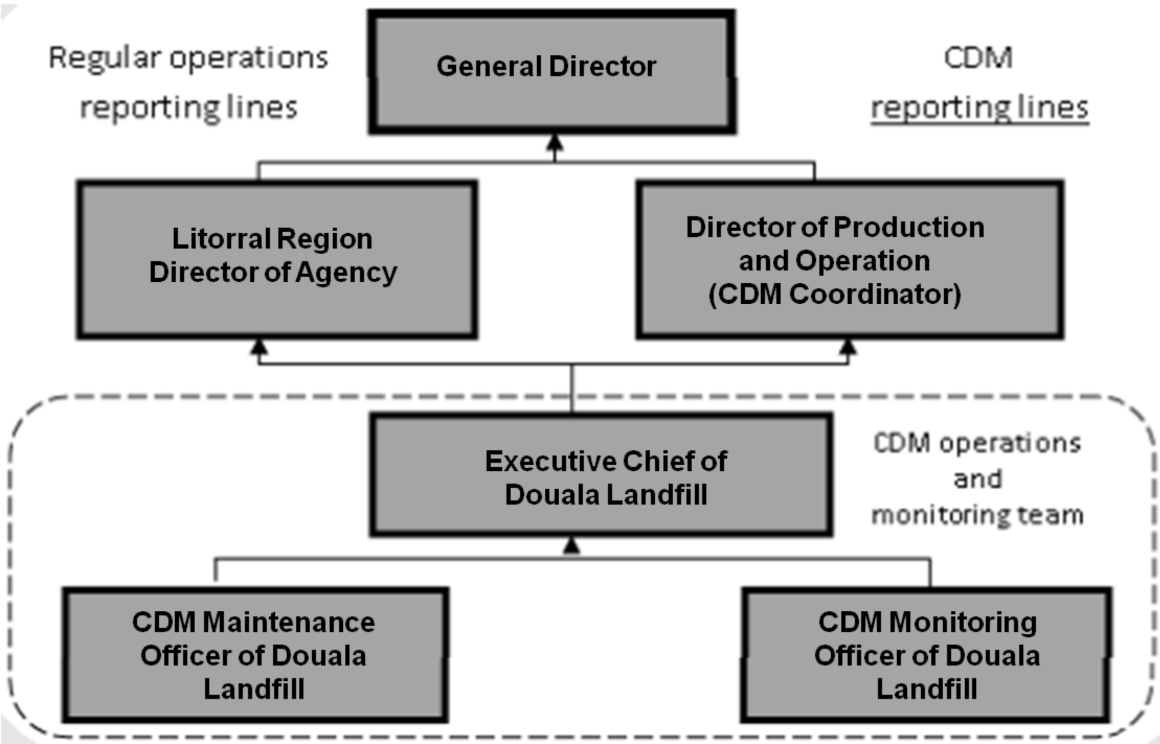

Figure 4: monitoring organization

5. Involvement of third parties

Support and consultancy regarding the CER obligations is provided by aera group. The monitoring team receives support through actions like training on CDM, monitoring methodology and monitoring procedures; continuous advice by CDM and technology experts; review of monitoring reports and providing internal toolbox meetings and training sessions.

6. Emergency procedures

In case of unforeseen problems or failures of the data recording system the operating staff will inform the CDM monitoring officer. In cases where no data is available due to failure of the monitoring equipment the CDM monitoring officer decides as soon as possible which actions shall be undertaken to minimize the amount of unregistered GHG emission reduction.

All staff members are well trained in how to deal with such an emergency situation. The risk of emergency cases shall be minimized. In case of failure of the monitoring equipment, the Executive Chief of Douala Landfill will be informed.

SECTION D. Data and parameters

D.1. Data and parameters fixed ex ante

Data / Parameter:	**Regulatory requirements relating to landfill gas**
Unit:	/
Description:	Regulatory requirements relating to landfill gas
Source of data:	Publicly available information of the host country's regulatory requirements relating to landfill gas
Value(s) applied):	0
Choice of data or measurement methods and procedures	The information though recorded annually, is used for changes to the adjustment factor (AF) or directly $MD_{BL,y}$ at renewal of the credit period. Relevant regulations for LFG project activities shall be updated at renewal of each credit period. Changes to regulation should be converted to the amount of methane that would have been destroyed/combusted during the year in the absence of the project activity ($MD_{BL,y}$). Project participants should explain how regulations are translated into that amount of gas.
Purpose of data/parameter:	Baseline emission calculation
Additional comment:	Since November 2010 Hysacam receives the official national environmental bulletin of Cameroon called "Journal officiel de la République du Cameroun" for its review (and if necessary for further action). In this bulletin updates to national environmental regulation are published. No changes to applicable regulation have occurred during the crediting period.

Data / Parameter:	**GWP_{CH4}**
Unit:	tCO_2e/tCH_4
Description:	Global Warming Potential of CH_4
Source of data:	IPCC
Value(s) applied):	25
Choice of data or measurement methods and procedures	As per - EB 69 Report Annex 3 and IPCC 2007 - Climate Change 2007: Working Group I: The Physical Science Basis (Contribution to Fourth Assessment Report of IPCC), Chapter 2, Table 2.14, p.212 http://www.ipcc.ch/publications_and_data/ar4/wg1/en/ch2s2-10-2.html#table-2-14

Purpose of data/parameter:	Baseline emission calculation
Additional comment:	Shall be updated according to any future COP/MOP decisions

Data / Parameter:	D_{CH4}
Unit:	tCH_4/m^3CH_4
Description:	Density of methane gas at normal conditions
Source of data:	"Tool to determine project emissions from flaring gases containing methane"
Value(s) applied):	0.0007168
Choice of data or measurement methods and procedures	At standard temperature and pressure (0 degree Celsius and 1,013 bar) the density of methane is 0.0007168 tCH_4.m3 CH_4
Purpose of data/parameter:	Baseline emission calculation
Additional comment:	Not used for the ex-ante estimation. Used to determine ex-post project emissions from biogas flaring.

Data / Parameter	$BE_{CH4,SWDS,y}$
Unit	tCO_2e
Description	Methane generation from the landfill in the absence of the project activity at year *y*
Source of data	"Tool to determine methane emissions avoided from disposal of waste at a solid waste disposal site"
Value(s) applied	Refer to B.6.4 Summary of the ex-ante estimation of emission reductions of the registered PDD.
Choice of data or Measurement methods and procedures	*Ex-ante* calculation according to the "Tool to determine methane emissions avoided from disposal of waste at a solid waste disposal site".
Purpose of data	Calculation of baseline emissions
Additional comment	Used for *ex ante* estimation of the amount of methane that would have been destroyed/combusted during the year, thus inapplicable to *ex-post* calculation.

Data / Parameter	**φ**
Unit	-
Description	Model correction factor to account for model uncertainties
Source of data	"Tool to determine methane emissions avoided from disposal of waste at a solid waste disposal site"
Value(s) applied	0.9
Choice of data or Measurement methods and procedures	-
Purpose of data	Calculation of baseline emissions
Additional comment	Oonk et el. (1994) have validated several landfill gas models based on 17 realized landfill gas projects. The mean relative error of multi-phase models was assessed to be 18%. Given the uncertainties associated with the model and in order to estimate emission reductions in a conservative manner, a discount of 10% is applied to the model results.

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	The type of cover of the solid waste disposal site has been assessed during the on-site visit by the technology provider. The IPCC 2006 Guidelines for National Greenhouse Gas Inventories have been used for the choice of the value to be applied.
Value(s) applied	0.1
Choice of data or Measurement methods and procedures	At the PK10, the cover material used is the local soil. The oxidation factor has been applied accordingly.
Purpose of data	Calculation of baseline emissions
Additional comment	-

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	The default value of 0.5 recommended by IPCC has been applied.
Purpose of data	Calculation of baseline emissions
Additional comment	This factor reflects the fact that some degradable organic carbon does not degrade, or degrades very slowly, under anaerobic conditions in the SWDS.

Data / Parameter	**DOC_f**
Unit	-
Description	Fraction of degradable organic carbon (DOC) that can decompose
Source of data	IPCC 2006 Guidelines for National Greenhouses Gas Inventories
Value(s) applied	0.5
Choice of data or Measurement methods and procedures	-
Purpose of data	Calculation of baseline emissions
Additional comment	-

Data / Parameter	**MCF**
Unit	-
Description	Methane Correction Factor
Source of data	IPCC 2006 Guidelines for National Greenhouse Gas Inventories
Value(s) applied	0.8
Choice of data or Measurement methods and procedures	The PK10 landfill site involves a controlled placement of waste (waste is directed to specific deposition areas and there is a degree of control of scavenging and fires). The technical specifications related to HYSACAM's contract with the CUD require: (i) cover material; (ii) mechanical compacting; and (iii) leveling of the waste. The value 0.8 has been chosen for the MCF between 2003 and 2011 since during that period these requirements were less applied. By 2012 landfill management will be fully optimized at PK10 according to the recommendations made by Biotecnogas in the feasibility report. Thus once optimization measures are applied, HYSACAM will be able to stick with the contractual specifications agreed with CUD. However, the conservative value of 0.8 is still applied for the MCF after 2012.

Purpose of data	Calculation of baseline emissions
Additional comment	The methane correction factor (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.

Data / Parameter	**DOC_j**
Unit	-
Description	Fraction of degradable organic carbon (by weight) in the waste type j
Source of data	IPCC 2006 Guidelines for National Greenhouse Gas Inventories (adapted from Volume 5, Tables 2.4 and 2.5)
Value(s) applied	(see table below)
Choice of data or Measurement methods and procedures	Values have been applied according to the “Tool to determine methane emissions avoided from disposal of waste at a solid waste disposal site” (version 05, EB 55).
Purpose of data	Calculation of baseline emissions
Additional comment	The values applied are for tropical (MAT > 20°C) wet (MAP > 1000 mm) conditions. This typically applies for Douala, where average rainfall is 4000 mm/year and average temperature 26.1°C (average data from *worldclimate.com*). Refer to Annex 3 for detailed information.

Waste Type *j*	**DOC_j (% wet waste)**	**DOC_j (% dry waste)**
Wood and wood products	43	50
Pulp, paper and Cardboard (other than sludge)	40	44
Food, food wastes, beverages and tobacco (other than sludge)	15	38
Textiles	24	30
Garden, yard and park waste	20	49
Glass, plastic, metal, other inert waste	0	0

Data / Parameter	**k_j**
Unit	-
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	(see table below)
Choice of data or Measurement methods and procedures	Values have been applied according to the “Tool to determine methane emissions avoided from disposal of waste at a solid waste disposal site” (version 05, EB 55).
Purpose of data	Calculation of baseline emissions
Additional comment	The values applied are for tropical (MAT > 20°C) wet (MAP > 1000 mm) conditions. This typically applies for Douala, where average rainfall is 4000 mm/year and average temperature 26.1°C (average data from *worldclimate.com*). Refer to Annex 3 for detailed information.

Waste Type *j*	**k**
Pulp, paper and cardboard	0.07
Garden, park waste and other (non-food) organic putrescibles	0.17
Textiles	0.07
Food, food waste, beverages and tobacco	0.4
Wood and straw waste	0.035
Glass, plastic, metal, other inert waste	0

Data / Parameter	**Wx**
Unit	tonnes

Description	The amount of waste disposed in the PK10 landfill in year x
Source of data	Biotecnogas on-site visit report of October 2009 HYSACAM internal records from 2010 onwards
Value(s) applied	(see table below)
Choice of data or Measurement methods and procedures	Biotecnogas values have been obtained during the on-site visit by evaluating the volume of waste contained in the landfill and applying a conservative compaction ratio of 0.85 t/m^3. Already collected waste has been inferred proportionally, and future waste has been computed by applying 5% yearly increments as to the Douala's demographic growth into account. As the amount of waste obtained are below HYSACAM's historical data (also reported in the Biotecnogas on-site visit report), they were chosen for ex-ante emission reduction calculation in a conservative approach.
Purpose of data	Calculation of baseline emissions
Additional comment	The PK10 landfill stops receiving waste in 2018.

Year	Solid Wastes disposed - Wx (tonnes)
2003	33,435
2004	122,606
2005	122,255
2006	174,782
2007	174,773
2008	245,534
2009	247,333
2010	275,171
2011	288,929
2012	303,376
2013	318,544
2014	334,472
2015	351,195
2016	368,755
2017	387,193
2018	0
2019	0
2020	0
2021	0

Data / Parameter	p_j
Unit	%
Description	Fraction of the waste type *j* in the Douala Municipal Waste
Source of data	Biotecnogas on-site visit report
Value(s) applied	(see table below)

Waste type *j* according to the on-site visit report	Waste type *j* according to UNFCCC categories	Proportion
Paper and cardboard	Pulp, paper and cardboard	1.87%
Textiles	Textiles	2%
Wood	Wood and wood products	1.5%
Garden	Garden, yard and park waste	9%
Alimentary	Food, food waste	55%
Other	Glass, plastic, metal, other inert waste	30.63%
TOTAL	TOTAL	100%

Choice of data or Measurement methods and procedures	These values have been determined by Biotecnogas in the *on-site visit report* based on a conservative adjustment of HYSACAM's historical data and take into account the controlled scavenging actions occurring on the landfill site, which consist in a manual selection by about 100 scavengers who collect approximately 25% of paper/cardboard. The "alimentary" category has been assimilated to the UNFCCC "food, food waste" category, "wood" has been assimilated to "wood and wood products", "paper and cardboard" to "pulp, paper and cardboard", and other wastes to "glass, plastic, metal, other inert waste".
Purpose of data	Calculation of baseline emissions
Additional comment	As per the "tool to determine project emissions from flaring gases containing methane", sampling to determine the different waste types is not necessary for *ex ante* estimations of baseline emissions.

Data / Parameter	**CE**
Unit	%
Description	LFG collection efficiency
Source of data	IPCC (2006), Guidelines for National Greenhouse Gas Inventories, Volume 5, Waste
Value(s) applied	70
Choice of data or Measurement methods and procedures	IPCC (2006) Volume 5, Chapter 3: Solid Waste Disposal, page 3-19 provides a percentage range of between 10% to 85% for Recovery Efficiency of LFG. Stating that *"In general, high recovery efficiencies can be related to closed SWDS, with reduced gas fluxes, well-designed and operated recovery and thicker and less permeable covers. Low efficiencies can be related to SWDS with large parts still being in exploitation and with e.g., temporary sandy covers."* A 70% value is therefore conservative for this project
Purpose of data	Calculation of baseline emissions
Additional comment	Factor needed to quantify *ex-ante* the project Baseline, Project Emissions and Emission Reductions.

Data / Parameter:	$EF_{EL,y}$
Unit:	tCO_2e/MWh
Description:	Carbon emission factor of electricity consumed
Source of data:	Calculated according to scenario C.III of the "Tool to calculate baseline, project and/or leakage emissions from electricity consumption"
Value(s) applied):	1.3
Choice of data or measurement methods and procedures	As per "Tool to calculate baseline, project and/or leakage emissions from electricity consumption"
Purpose of data/parameter:	Project emission calculation
Additional comment:	/

D.2. Data and parameters monitored

Monitoring point 1: before flaring (landfill gas)

Data / Parameter:	**ID.0 / $LFG_{flare,y}$**
Unit:	Nm^3
Description:	Amount of landfill gas flared at Normal Temperature and Pressure in year *y*
Measured/ Calculated / Default:	Measured
Source of data:	Flow meter
Value(s) of monitored parameter:	22,956,827
Monitoring equipment:	Measured with a pitot flow meter using a transducer, flanged across the biogas stainless steel piping transporting the biogas, just upstream the flare. The LFG quantity is normalized using its temperature and pressure values. Producer FUJI ELECTRIC Type/model FCX-AII / FKCP11V5AKDYYCA Serial number ACM0161F/ 0511803 Accuracy 0.1% - 0.5% Calibration frequency 12 months (+/- 1 month) Date of installation & first calibration 13/05/2014 Last calibration 02/06/2015, 15/04/2016 & 12/04/2017 Expiry date 11/04/2018
Measuring/ Reading/ Recording frequency:	Continuous recording (average value in a time interval not greater than an hour is used in the calculations of emission reductions)
Calculation method (if applicable):	Hourly aggregation
QA/QC procedures:	The flow meter is subject to a regular maintenance and testing regime to ensure accuracy. The values of the parameter are stored electronically and printed out on spreadsheets. Once a day the counter value is written on a paper document as a backup method in case of PC failure.
Purpose of data/parameter:	Baseline emission calculation
Additional comments:	In accordance with F-CDM-AM-Clar_Resp_ver 01 – AM_CLA_0028, a single flow meter is used (ID.3), considering that $LFG_{total,y} = LFG_{flare,y}$

Data / Parameter:	**ID.1 / w_{CH4}**
Unit:	m^3 CH_4 / m^3 LFG
Description:	Methane fraction in the landfill gas
Measured/ Calculated / Default:	Measured
Source of data:	Gas analyzer
Value(s) of monitored parameter:	48.1% (average)

Monitoring equipment:	The flare exhaust gas oxygen fraction is measured by a gas analyzer using a transducer. Producer FUJI ELECTRIC Type/model ZREABL31-RYRYY-YYYV1BE-YHYAA Serial number A2L8259T Accuracy 0.70% (as per actual manufacturer's specifications) Calibration frequency 12 months (+/- 1 month) Date of installation & first calibration 13/05/2014 Last calibration 02/06/2015, 15/04/2016 & 12/04/2017 Expiry date 11/04/2018
Measuring/ Reading/ Recording frequency:	Continuous measurement device programmed to automatically save values every minute.
Calculation method (if applicable):	Hourly aggregation
QA/QC procedures:	The analyzer is subject to a regular maintenance and calibration in accordance with the monitoring plan (a zero check and typical value check should be performed by comparison with standard gas). The data are stored automatically at a central control unit and transferred frequently to a PC for data collection and a backup hard drive. Additionally, every day it is checked if the server unit recorded the data from the day before successfully in a file. The values of the parameter are archived on hard copy.
Purpose of data/parameter:	Baseline emission calculation
Additional comments:	/

Data / Parameter:	**ID.2 / T**
Unit:	°C
Description:	Temperature of the landfill gas
Measured/ Calculated / Default:	Measured
Source of data:	Thermoresistance
Value(s) of monitored parameter:	(hourly data)
Monitoring equipment:	Measured continuously by a thermoresistance placed inside the stainless steel piping transporting the LFG Producer PYRO CONTROL-CHAUVIN ARNOUX Type/model DIN/DAN i- 1PTC Serial number KAX888 Accuracy 0.15°C Calibration frequency 12 months (+/- 1 month) Date of installation & first calibration 13/05/2014 Last calibration 02/06/2015, 15/04/2016 & 12/04/2017 Expiry date 12/04/2018
Measuring/ Reading/ Recording frequency:	Continuous measurement device programmed to automatically save values every minute.
Calculation method (if applicable):	Continuously and hourly aggregation

QA/QC procedures:	The thermoresistance is subject to a regular maintenance and calibration in accordance with manufacturer specifications or replaced if calibration is not possible. The data are stored automatically at a central control unit and transferred frequently to a PC for data collection and a backup hard drive. Additionally, every day it is checked if the server unit recorded the data from the day before successfully in a file. The values of the parameter are archived on hard copy.
Purpose of data/parameter:	Baseline emission calculation
Additional comments:	/

Data / Parameter:	**ID.3 / $FV_{RG,h}$**
Unit:	m^3/h
Description:	Volumetric flow rate of the residual gas in dry basis at normal conditions in the hour *h*
Measured/ Calculated / Default:	Measured
Source of data:	Flow meter.
Value(s) of monitored parameter:	(hourly data)
Monitoring equipment:	Measured with a turbine pitot flow meter using a transducer, flanged across the biogas stainless steel piping transporting the biogas, just upstream the flare. Producer FUJI ELECTRIC Type/model FCX-AII / FKCP11V5AKDYYCA Serial number ACM0161F/ 0511803 Accuracy 0.1% - 0.5% Calibration frequency 12 months (+/- 1 month) Date of installation & first calibration 13/05/2014 Last calibration 02/06/2015, 15/04/2016 & 12/04/2017 Expiry date 11/04/2018
Measuring/ Reading/ Recording frequency:	Continuous measurement device programmed to automatically save minutely values.
Calculation method (if applicable):	n/a
QA/QC procedures:	The flow meter is subject to a regular maintenance and calibration in accordance with manufacturer specifications. The data are stored automatically at a central control unit and transferred frequently to a PC for data collection and a backup hard drive. Additionally, every day it is checked if the server unit recorded the data from the day before successfully in a file.
Purpose of data/parameter:	Baseline emission calculation
Additional comments:	With respect to the quantity of LFG the monitored parameter ID.3 (volumetric flow rate of the residual gas in the hour) is the result of the following “simplification”: $LFG_{total,y} = LFG_{flare,y}$ which is by methodology definition the case if only flaring option is used. This is the case for the project activity. This means accordingly that $\sum FV_{RG,h} = LFG_{total,y} = LFG_{flare,y}$ and so only 1 instead of 3 parameters is needed.

Data / Parameter:	**ID.4 / P**
Unit:	Pa
Description:	Pressure of the landfill gas

Measured/ Calculated / Default:	Measured
Source of data:	Relative pressure meter
Value(s) of monitored parameter:	(hourly data)
Monitoring equipment:	Measured with relative pressure meter inserted into the stainless steel piping transporting the LFG. Producer FUJI ELECTRIC Type/model FCX-AII / FKHT02V5AKAYY0E Serial number ACM0420F/ C891740W Accuracy 0.20%(as per actual manufacturer's specifications) Calibration frequency 12 months (+/- 1 month) Date of installation & first calibration 13/05/2014 Last calibration 02/06/2015, 15/04/2016 & 12/04/2017 Expiry date 11/04/2018
Measuring/ Reading/ Recording frequency:	Continuous measurement device programmed to automatically save minutely values.
Calculation method (if applicable):	n/a
QA/QC procedures:	The pressure meter is subject to a regular maintenance and calibration in accordance with manufacturer specifications, or replaced if calibration is not possible. The data are stored automatically at a central control unit and transferred frequently to a PC for data collection and a backup hard drive. Additionally, every day it is checked if the server unit recorded the data from the day before successfully in a file. The values of the parameter are archived on hard copy.
Purpose of data/parameter:	Baseline emission calculation
Additional comments:	/

Monitoring point 2: insider/after flaring (exhaust gas)

Data / Parameter:	**ID.5 / T_{flare}**
Unit:	°C
Description:	Temperature in the exhaust gas of the flare
Measured/ Calculated / Default:	Measured
Source of data:	Thermocouple
Value(s) of monitored parameter:	(hourly data)

Monitoring equipment:	Measured continuously by a thermocouple placed inside the flare. Producer PYRO CONTROL-CHAUVIN ARNOUX Type/model K-DIN before 12/04/2017, now 1-TCK Serial number FBE-NK3-150624, replaced on 15/04/2016 by FBE-NK3-160415 (same model & specifications) and on 12/04/2017 by FBE-TBE-027401 (same make, model 1-TCK, unchanged accuracy)Accuracy 0.40% Calibration frequency 12 months (+/- 1 month) Date of installation & first calibration 13/05/2014 Last calibration 02/06/2015, 15/04/2016 & 12/04/2017 Expiry date 11/04/2018
Measuring/ Reading/ Recording frequency:	Continuous measurement device programmed to automatically save minutely values.
Calculation method (if applicable):	Hourly aggregation
QA/QC procedures:	The thermocouple is subject to a regular maintenance and calibration in accordance with manufacturer specifications, or replaced if calibration is not possible. The data are processed in the exhaust gas analyzer and stored automatically at a central control unit and transferred frequently to a PC for data collection and a back-up hard drive. Additionally, every day it is checked if the server unit recorded the data from the day before successfully in a file.
Purpose of data/parameter:	Baseline emission calculation
Additional comments:	Temperatures above 500 °C in the exhaust gas in the flare indicate that the flare is operating in a reliable way.

Data / Parameter:	**ID.6 / $fv_{CH4,FG,h}$**
Unit:	mg/m^3
Description:	Concentration of methane in the exhaust gas of the flare in dry basis at normal conditions in the hour h.
Measured/ Calculated / Default:	Measured
Source of data:	Gas analyzer (80% above flare)
Value(s) of monitored parameter:	(hourly data)
Monitoring equipment:	The flare exhaust gas methane fraction is measured by a gas analyzer using a transducer. A zero check and a typical value check is performed by comparison with standard gas. Producer FUJI ELECTRIC Type/model ZREABL31-RYRYY-YYYV1BE-YHYAA Serial number A2L8260T Accuracy 0.70% Calibration frequency 12 months (+/- 1 month) Date of installation & first calibration 13/05/2014 Last calibration 02/06/2015, 15/04/2016 & 12/04/2017 Expiry date 11/04/2018
Measuring/ Reading/ Recording frequency:	Continuous measurement device programmed to automatically record minutely values. -
Calculation method (if applicable):	Hourly aggregation

QA/QC procedures:	The analyzer is subject to a regular maintenance and calibration in accordance with the monitoring plan (A zero check and typical value check is performed by comparison with standard gas). The data are processed in the exhaust gas analyzer and stored automatically at a central control unit and transferred frequently to a PC for data collection and a back-up hard drive. Additionally, every day it is checked if the server unit recorded the data from the day before successfully in a file.
Purpose of data/parameter:	Baseline emission calculation
Additional comments:	In principle, the monitoring plan should also include the parameter $fv_{i,h}$ (volumetric fraction of component *i* in the residual gas in the hour *h* where *i* = CH_4, CO, CO_2, O_2,H_2, N_2). As suggested by the “tool to determine project emissions from flaring gases containing methane”, project participants may only measure the methane content of the residual gas and consider the remaining part as N_2 for simplification purposes. This approach is adopted by the project. Therefore, $fv_{i,h}$ is not monitored.

Data / Parameter:	**ID.7 / $t_{O2,h}$**
Unit:	-
Description:	Volumetric fraction of O_2 in the exhaust gas of the flare in the hour *h*
Measured/ Calculated / Default:	Measured
Source of data:	Gas analyzer
Value(s) of monitored parameter:	(hourly data)
Monitoring equipment:	The flare exhaust gas oxygen fraction is measured by a gas analyzer using a transducer. Producer FUJI ELECTRIC Type/model ZREABL31-RYRYY-YYYV1BE-YHYAA Serial number A2L8260T Accuracy 0.70% Calibration frequency 12 months (+/- 1 month) Date of installation & first calibration 13/05/2014 Last calibration 02/06/2015, 15/04/2016 & 12/04/2017 Expiry date 11/04/2018
Measuring/ Reading/ Recording frequency:	Continuous measurement device programmed to automatically save minutely values.
Calculation method (if applicable):	Hourly aggregation
QA/QC procedures:	The analyzer is subject to a regular maintenance and calibration in accordance with the monitoring plan (A zero check and typical value check should be performed by comparison with standard gas). The data are processed in the exhaust gas analyzer and stored automatically at a central control unit and transferred frequently to a PC for data collection and a back-up hard drive. Additionally, every day it is checked if the server unit recorded the data from the day before successfully in a file.
Purpose of data/parameter:	Baseline emission calculation
Additional comments:	Monitoring of this parameter is necessary since an enclosed flare is used and the option “continuous monitoring of the flare efficiency” is adopted.

Monitoring point 3: Energy consumption

Data / Parameter:	**ID.8 / $EC_{PJ,grid,y}$**
Unit:	MWh

Description:	Quantity of electricity consumed from the grid by the project activity during the year *y*
Measured/ Calculated / Default:	Measured
Source of data:	Power meter
Value(s) of monitored parameter:	62.34
Monitoring equipment:	Producer ENERDIS Type/model ULYS TDA80 Serial number AB4N400034 Accuracy 1% Calibration frequency 5 y Date of fabrication & initial calibration 04/2013 Date of installation & first calibration 13/05/2014 Last calibration 19/06/2014 Recommended verification 04/2018
Measuring/ Reading/ Recording frequency:	Measured continuously by a power meter. Data is aggregated monthly and yearly to a PC for data collection.
Calculation method (if applicable):	/
QA/QC procedures:	The power meter is subject to a regular maintenance and calibration to ensure accuracy. New power meter is calibrated. The equipment manufacturer states that such kind of equipment cannot work in a failure condition, thus no wrong measure would be recorded. The quantities shown on the displays are true and cannot be altered because the electricity meters are sealed. To prove that the logging procedure and database are correct, the total electricity has to be higher than the total electricity logged earlier and lower than the total electricity logged later.
Purpose of data/parameter:	Project emission calculation
Additional comments:	n/a

Data / Parameter:	**ID.9 / $EC_{PJ,diesel,y}$**
Unit:	MWh
Description:	Quantity of electricity produced in the diesel generator by the project activity during the year *y*
Measured/ Calculated / Default:	Measured (Calculated prior to 26/05/2015 installation)
Source of data:	Power meter
Value(s) of monitored parameter:	1.33
Monitoring equipment:	Producer ENERDIS Type/model ULYS TDA80 Serial number AB4O800192 Accuracy 1% Calibration frequency 5 y Date of fabrication & initial calibration 08/2014 First calibration 19/09/2014 Last calibration 26/05/2015 Recommended verification 08/2019
Measuring/ Reading/ Recording frequency:	Measured continuously by a power meter.

Calculation method (if applicable):	/
QA/QC procedures:	Power meter is subject to regular maintenance and testing to ensure accuracy. New power meter is calibrated. The equipment manufacturer states that such kind of equipment cannot work in a failure condition, thus no wrong measure would be recorded. Moreover, electricity meters are not subjected to wear and tear, so the power meter will not need any calibration further than the initial one. To prove that the logging procedure and database are correct, the total electricity has to be higher than the total electricity logged earlier and lower than the total electricity logged later. The quantities shown on the displays are true and cannot be altered because the electricity meters are sealed. The quantity of power generated is cross-checked with the quantity of fossil fuel consumed in the diesel generator through the default NCV and efficiency.
Purpose of data/parameter:	Project emission calculation
Additional comments:	Emergency genset capacity is 120kW (150 kVA) Olympian Power System, as inspected on-site (since 26/05/2015)

Data / Parameter:	**ID.10 / TDL_y**
Unit:	%
Description:	Average technical transmission and distribution losses for providing electricity
Measured/ Calculated / Default:	Default
Source of data:	As stated in the ‘Tool to calculate the emission factor for an electricity system’, EB 50, Version 2.
Value(s) of monitored parameter:	20
Monitoring equipment:	/
Measuring/ Reading/ Recording frequency:	/
Calculation method (if applicable):	/
QA/QC procedures:	/
Purpose of data/parameter:	Project emission calculation
Additional comments:	No reliable data on transmission and distribution losses are available within the host country, thus the default value provided by the tool is used.

D.3. Implementation of sampling plan

n/a

SECTION E. Calculation of emission reductions or net anthropogenic removals

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

Since the project activity excludes any power or thermal energy generation, the baseline emissions are calculated with the following simplified formula:

$$BE_y = MD_{project,y} * GWP_{CH4} \quad (1c)$$

Where:

BE_y	Baseline emissions in year *y* (tCO_2e)
$MD_{project,y}$	The amount of methane destroyed/combusted during year y, in tonnes of methane in project scenario calculated as per ACM0001 (tCH_4)
GWP_{CH4}	Global Warming Potential value of methane (tCO_2e/tCH_4)

Since the project activity does not include any electricity or thermal generation, nor pipeline feeding, $MD_{project,y}$ can be simplified as follows:

$$MD_{project,y} = MD_{flared,y} \quad (8b)$$

Where:

$MD_{project,y}$	The amount of methane destroyed/combusted during year y, in tonnes of methane in project scenario (tCH_4)
$MD_{flared,y}$	Quantity of methane destroyed by flaring (tCH_4), in year y

$MD_{flared,y}$ is determined as follows:

$$MD_{flared,y} = (LFG_{flare,y} * w_{CH4,y} * D_{CH4}) - (PE_{flare,y} / GWP_{CH4}) \quad (9)$$

Where:

$MD_{flared,y}$	Quantity of methane destroyed by flaring (tCH_4), in year y
$LFG_{flare,y}$	Quantity of the landfill gas fed to the flares during the year (Nm^3/yr)
$W_{CH4,y}$	Average methane fraction of the landfill gas measured during the year (in $m^3\ CH_4 / m^3$ LFG)
D_{CH4}	Methane density expressed in tonnes of methane per cubic meter of methane (tCH4 / m^3CH_4)
$PE_{flare,y}$	Project emissions from flaring of the residual gas stream in year y (tCO_2e) determined following the procedure described in the "Tool to determine project emissions from flaring gases containing methane"
GWP_{CH4}	Global Warming Potential methane (tCO_2/tCH_4)

Project emissions from flaring

According to the "tool to determine project emissions from flaring gases containing methane", EB 28, Appendix 13, project participant shall apply 7 steps to calculate project emissions from flaring ($PE_{flare,y}$)

Step 1: Determination of the mass flow rate ($FM_{RG,h}$) of the residual gas that is flared

Calculation of the mass flow rate of the residual gas in hour *h* $FM_{RG,h} = \rho_{RG,n,h} \times FV_{RG,h}$

$$FM_{RG,h} = \rho_{RG,n,h} \times FV_{RG,h} \quad \text{Step 1 - (1)}$$

Where:

Variable	SI Unit	Description
$FM_{RG,h}$	kg/h	Mass flow rate of the residual gas in hour *h*
$\rho_{RG,n,h}$	kg/m^3	Density of the residual gas at normal conditions in hour *h*
$FV_{RG,h}$	m^3/h	Volumetric flow rate of the residual gas in dry basis at normal conditions in the hour *h*

And:

$$\rho_{RG,n,h} = \frac{P_n}{\frac{R_u}{MM_{RG,h}} \times T_n}$$ Step 1 - (2)

Where:

Variable	SI Unit	Description
$\rho_{RG,n,h}$	kg/m^3	Density of the residual gas at normal conditions in hour *h*
P_n	Pa	Atmospheric pressure at normal conditions (101 325)
R_u	$Pa.m^3/kmol.K$	Universal ideal gas constant (8 314)
$MM_{RG,h}$	kg/kmol	Molecular mass of the residual gas in hour *h*
T_n	K	Temperature at normal conditions (273.15)

and

$$MM_{RG,h} = \sum_i \left(fv_{i,h} \times MM_i \right)$$ Step 1 - (3)

$$= fv_{CH_4,h} \times MM_{CH_4} + (1 - fv_{CH_4,h}) \times MM_{N_2}$$

Where:

Variable	SI Unit	Description
$MM_{RG,h}$	kg/kmol	Molecular mass of the residual gas in hour *h*
$fv_{i,h}$ $fv_{i,RG,h}$	-	Volumetric fraction of component *i* in the residual gas in the hour *h*
MM_i	kg/kmol	Molecular mass of residual gas component i
i		The components CH_4, N_2

As a simplified approach, only the volumetric fraction of methane is measured and the difference to 100% is considered as being nitrogen (N_2) as suggested by the tool.

$$fv_{N_2,h} = (1 - fv_{CH_4,h})$$

Step 2: Determination of the mass fraction of carbon, hydrogen, oxygen and nitrogen in the residual gas

$$fm_{j,h} = \frac{\sum_i fv_{i,h} \times AM_j \times NA_{j,i}}{MM_{RG,h}}$$ Step 2 - (4)

Where:

Variable	SI Unit	Description
$fm_{j,h}$	-	Mass fraction of element *j* in the residual gas in the hour *h*
$fv_{i,h}$	-	Volumetric fraction of component *i* in the residual gas in the hour *h*
AM_j	kg/kmol	Atomic mass of element *j*
$NA_{j,i}$	-	Number of atoms of element *j* in component *i*
$MM_{RG,h}$	kg/kmol	Molecular mass of the residual gas in hour *h*
j		The elements carbon, hydrogen, oxygen and nitrogen
i		The components CH_4, N_2

Step 3: Determination of the volumetric flowrate ($TV_{n,FG,h}$) of the exhaust gas on a dry basis

$$TV_{n,FG,h} = V_{n,FG,h} \times FM_{RG,h}$$ **Step 3 - (5)**

Where:

Variable	SI Unit	Description
$TV_{n,FG,h}$	m^3/h	Volumetric flow rate of the exhaust gas in dry basis at normal conditions in hour *h*
$V_{n,FG,h}$	m^3/kg residual gas	Volume of the exhaust gas of the flare in dry basis at normal conditions per kg of residual gas in hour *h*
$FM_{RG,h}$	kg residual gas/h	Mass flow rate of the residual gas in the hour *h*

Volume of the exhaust gas of the flare at normal conditions per kg of residual gas in the hour h, $V_{n,FG,h}$:

$$V_{n,FG,h} = V_{n,CO_2,h} + V_{n,O_2,h} + V_{n,N_2,h}$$ **Step 3 - (6)**

Where:

Variable	SI Unit	Description
$V_{n,FG,h}$	m^3/kg residual gas	Volume of the exhaust gas of the flare in dry basis at normal conditions per kg of residual gas in hour *h*
$V_{n,CO2,h}$	m^3/kg residual gas	Quantity of CO_2 volume free in the exhaust gas of the flare at normal conditions per kg of residual gas in the hour *h*
$V_{n,O2,h}$	m^3/kg residual gas	Quantity of O_2 volume free in the exhaust gas of the flare at normal conditions per kg of residual gas in the hour *h*
$V_{n,N2,h}$	m^3/kg residual gas	Quantity of N_2 volume free in the exhaust gas of the flare at normal conditions per kg of residual gas in the hour *h*

Quantity of CO_2 volume free in the exhaust gas of the flare at normal conditions per kg of residual gas in the hour h, $V_{n,CO2,h}$:

$$V_{n,CO_2,h} = \frac{fm_{C,h}}{AM_C} \times MV_n$$ **Step 3 - (9)**

Where:

Variable	SI Unit	Description
$V_{n,CO2,h}$	m^3/kg residual gas	Quantity of CO_2 volume free in the exhaust gas of the flare at normal conditions per kg of residual gas in the hour *h*
$fm_{C,h}$	-	Mass fraction of carbon in the residual gas in the hour *h*
AM_C	kg/kmol	Atomic mass of carbon
MV_n	m^3/kmol	Volume of one mole of any ideal gas at normal temperature and pressure (22.4 L/mol)

Quantity of O_2 volume free in the exhaust gas of the flare at normal conditions per kg of residual gas in the hour h, $V_{n,O2,h}$:

$$V_{n,O_2,h} = n_{O_2,h} \times MV_n$$ **Step 3 - (7)**

Where:

Variable	SI Unit	Description
$V_{n,O2,h}$	m^3/kg residual gas	Quantity of O_2 volume free in the exhaust gas of the flare at normal conditions per kg of residual gas in the hour *h*
$n_{O2,h}$	kmol/kg residual gas	Quantity of moles O_2 in the exhaust gas of the flare per kg residual gas flared in hour *h*
MV_n	m^3/kmol	Volume of one mole of any ideal gas at normal temperature and pressure (22.4 L/mol)

Quantity of N_2 volume free in the exhaust gas of the flare at normal conditions per kg of residual gas in the hour h, $V_{n,N2,h}$:

$$V_{n,N_2,h} = MV_n \times \left\{ \frac{fm_{N,h}}{200 \cdot AM_N} + \left(\frac{1 - MF_{O_2}}{MF_{O_2}} \right) \times \left(F_h + n_{O_2,h} \right) \right\}$$ **Step 3 - (8)**

Where:

Variable	SI Unit	Description
$V_{n,N2,h}$	m^3/kg residual gas	Quantity of N_2 volume free in the exhaust gas of the flare at normal conditions per kg of residual gas in the hour *h*
MV_n	m^3/kmol	Volume of one mole of any ideal gas at normal temperature and pressure (22.4 L/mol)
$fm_{N,h}$	-	Mass fraction of nitrogen in the residual gas in the hour *h*
AM_N	kg/kmol	Atomic mass of nitrogen
MF_{O2}	-	O_2 volumetric fraction of air
F_h	kmol/kg residual gas	Stochiometric quantity of moles of O_2 required for a complete oxidation of one kg residual gas in hour *h*
$n_{O2,h}$	kmol/kg residual gas	Quantity of moles O_2 in the exhaust gas of the flare per kg residual gas flared in hour *h*

Quantity of moles O_2 in the exhaust gas of the flare per kg residual gas flared in hour h, $n_{O2,h}$:

$$n_{O_2,h} = \frac{t_{O_2,h}}{\left(1 - \frac{t_{O_2h}}{MF_{O_2}}\right)} \times \left[\frac{fm_{C,h}}{AM_C} + \frac{fm_{N,h}}{2AM_N} + \left(\frac{1 - MF_{O_2}}{MF_{O_2}} \right) \times F_h \right]$$ **Step 3 - (10)**

Where:

Variable	SI Unit	Description
$n_{O2,h}$	kmol/kg residual gas	Quantity of moles O_2 in the exhaust gas of the flare per kg residual gas flared in hour *h*
$t_{O2,h}$	-	Volumetric fraction of O_2 in the exhaust gas in the hour *h*
MF_{O2}	-	Volumetric fraction of O_2 in the air (0.21)
F_h	kmol/kg residual gas	Stochiometric quantity of moles of O_2 required for a complete oxidation of one kg residual gas in hour *h*
$fm_{j,h}$	-	Mass fraction of element *j* in the residual gas in the hour *h* (from equation 4)
AM_j	kg/kmol	Atomic mass of element *j*
j		The elements carbon (index C) and nitrogen (index N)

Stochiometric quantity of moles of O_2 required for a complete oxidation of one kg residual gas in hour h, F_h:

$$F_h = \frac{fm_{C,h}}{AM_C} + \frac{fm_{H,h}}{4AM_H} - \frac{fm_{O,h}}{2AM_O}$$ **Step 3 - (11)**

Where:

Variable	SI Unit	Description
F_h	kmol/kg residual gas	Stochiometric quantity of moles of O_2 required for a complete oxidation of one kg residual gas in hour *h*
$fm_{j,h}$	-	Mass fraction of element *j* in the residual gas in the hour *h* (from equation 4)
AM_j	kg/kmol	Atomic mass of element *j*
j		The elements carbon (index C), hydrogen (index H) and oxygen (index O)

Step 4: Determination of methane mass flow rate in the exhaust gas on a dry basis

$$TM_{FG,h} = \frac{TV_{n,FG,h} \times fv_{CH_4,FG,h}}{1000000}$$ Step 4 - (12)

Where:

Variable	SI Unit	Description
$TM_{FG,h}$	kg/h	Mass flow rate of methane in the exhaust gas of the flare in dry basis at normal conditions in the hour *h*
$TV_{n,FG,h}$	m^3/h exhaust gas	Volumetric flow rate of the exhaust gas in dry basis at normal conditions in hour *h*
$fv_{CH4,FG,h}$	mg/m^3	Concentration of methane in the exhaust gas of the flare in dry basis at normal conditions in hour *h*

Step 5: Determination of methane mass flow rate in the residual gas on a dry basis

$$TM_{RG,h} = FV_{RG,h} \times fv_{CH_4,RG,h} \times \rho_{CH_4,n}$$ Step 5 - (13)

Where:

Variable	SI Unit	Description
$TM_{RG,h}$	kg/h	Mass flow rate of methane in the residual gas in the hour *h*
$FV_{RG,h}$	m^3/h	Volumetric flow rate of the residual gas in dry basis at normal conditions in hour *h*
$fv_{CH4,RG,h}$	-	Volumetric fraction of methane in the residual gas on dry basis in hour *h* (NB: this corresponds to $fv_{i,RG,h}$ where *i* refers to methane).
$\rho_{CH4,n}$	kg/m^3	Density of methane at normal conditions (0.7168)

Step 6: Determination of the hourly flare efficiency

In case of **enclosed flares and continuous monitoring** of the flare efficiency, the flare efficiency in the hour *h* ($\eta_{flare,h}$) is

• 0% if the temperature of the exhaust gas of the flare (T_{flare}) is below 500 °C during more than 20 minutes during the hour *h*.

• determined as follows in cases where the temperature of the exhaust gas of the flare (T_{flare}) is above 500 °C for more than 40 minutes during the hour *h* :

$$n_{flare,h} = 1 - \frac{TM_{FG,h}}{TM_{RG,h}}$$

Where:

Variable	SI Unit	Description
$\eta_{flare,h}$	-	Flare efficiency in the hour *h*
$TM_{FG,h}$	$TM_{FG,h}$	Methane mass flow rate in exhaust gas averaged in a period of time t (hour, two months or year)
$TM_{RG,h}$	$TM_{FG,h}$	Mass flow rate of methane in the residual gas in the hour *h*

Step 7: calculation of annual project emissions from flaring

Project emissions from flaring are calculated as the sum of emissions from each hour *h*, based on the methane flow rate in the residual gas ($TM_{RG,h}$) and the flare efficiency during each hour *h* ($\eta_{flare,h}$), as follows:

$$PE_{flare,y} = \sum_{h=1}^{8760} TM_{RG,h} \times (1 - \eta_{flare,h}) \times \frac{GWP_{CH4}}{1000}$$ Step 7 - (15)

Where:

$PE_{flare,y}$	Project emissions from flaring residual gas stream in year y (tCO_2e)
$TM_{RG,h}$	Mass flow rate of methane in the residual gas in the hour h (kg/h).
$n_{flare,h}$	Flare efficiency in hour h
GWP_{CH4}	Global Warming Potential methane (tCO_2e/tCH_4)

Calculated values (with fixed and monitored parameters according to the Tool to determine project emissions from flaring gases containing methane)

$FM_{RG,h}$	kg/h	Mass flow rate of the residual gas in hour *h*
$\rho_{RG,n,h}$	kg/m³	Density of the residual gas at normal conditions in hour *h*
$MM_{RG,h}$	kg/kmol	Molecular mass of the residual gas in hour *h*
$f_{m,j,h}$	-	Mass fraction of element j in the residual gas in hour *h*
j	-	The elements carbon, hydrogen, oxygen and nitrogen
$TV_{n,FG,h}$	m^3/h	Volumetric flow rate of the exhaust gas at normal conditions in hour *h*
$V_{n,FG,h}$	m^3/kg residual gas	Volume of the exhaust gas of the flare at normal conditions per kg of residual gas in hour *h*
$V_{n,FG,h}$	m^3/kg residual gas	Volume of the exhaust gas of the flare at normal conditions per kg of residual gas in the hour *h*
$V_{n,CO2,h}$	m^3/kg residual gas	Quantity of CO_2 volume free in the exhaust gas of the flare at normal conditions per kg of residual gas in the hour *h*
$V_{n,N2,h}$	m^3/kg residual gas	Quantity of N_2 volume free in the exhaust gas of the flare at normal conditions per kg of residual gas in the hour *h*
$V_{n,O2,h}$	m^3/kg residual gas	Quantity of O_2 volume free in the exhaust gas of the flare at normal conditions per kg of residual gas in the hour *h*
$n_{O2,h}$	kmol/kg residual gas	Quantity of moles O_2 in the exhaust gas of the flare per kg residual gas flared in hour *h*
F_h	kmol/kg residual gas	Stochiometric quantity of moles of O_2 required for a complete oxidation of one kg residual gas in hour *h*
$fm_{C,h}$	-	Mass fraction of carbon in the residual gas in the hour *h*
$TM_{FG,h}$	kg/h	Mass flow rate of methane in the exhaust gas of the flare at normal conditions in the hour *h*
$TM_{RG,h}$	kg/h	Mass flow rate of methane in the residual gas in the hour *h*
$\eta_{flare,h}$	-	Flare efficiency in the hour *h*

Table 2: Sample baseline emissions calculations applying summed-up values for the monitoring period (monthly)

Monitoring period	$LFG_{flare,month}$	W_{CH4}	$MD_{project,month}$	BE_{MD} – methane destroyed	**Total BE**
	(m^3)	(%)	(tCH_4)	(tCO_2e)	**(tCO_2e)**
June-15	568,547	52.6%	213.5	5,337	**5,337**
July-15	593,525	51.1%	216.3	5,408	**5,408**
August-15	627,580	53.7%	240.7	6,018	**6,018**
September-15	623,213	51.4%	214.4	5,359	**5,359**
October-15	686,430	51.3%	251.9	6,298	**6,298**

November-15	618,867	49.2%	215.2	5,380	**5,380**
December-15	657,478	50.6%	237.2	5,929	**5,929**
January-16	667,780	52.5%	250.4	6,260	**6,260**
February-16	742,169	47.7%	253.0	6,324	**6,324**
March-16	819,347	45.9%	264.4	6,609	**6,609**
April-16	778,115	48.2%	261.3	6,532	**6,532**
May-16	738,874	49.6%	261.3	6,532	**6,532**
June-16	795,735	44.4%	251.3	6,283	**6,283**
July-16	813,066	44.9%	260.2	6,505	**6,505**
August-16	761,696	45.4%	246.7	6,167	**6,167**
September-16	705,930	49.4%	248.7	6,218	**6,218**
October-16	833,964	46.7%	277.2	6,930	**6,930**
November-16	846,396	50.1%	302.8	7,571	**7,571**
December-16	905,285	49.9%	323.0	8,076	**8,076**
January-17	863,895	50.6%	312.5	7,812	**7,812**
February-17	740,219	52.9%	279.6	6,989	**6,989**
March-17	873,926	53.6%	330.4	8,259	**8,259**
April-17	823,870	55.5%	327.1	8,177	**8,177**
May-17	807,060	53.7%	309.5	7,736	**7,736**
June-17	674,245	56.2%	267.8	6,695	**6,695**
July-17	772,123	38.9%	211.8	5,295	**5,295**
August-17	552,274	44.4%	136.5	3,412	**3,412**
September-17	510,921	41.7%	104.7	2,618	**2,618**
October-17	878,400	39.1%	233.3	5,833	**5,833**
November-17	764,297	43.5%	214.8	5,371	**5,371**
December-17	911,601	25.0%	154.4	3,859	**3,859**
Total	**22,956,828**	**48.1%**	**7.672**	191,791	**191,791**

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

The project emissions from energy consumption are calculated according to the following approach:

$$PE_{EC,y} = \sum_{j} EC_{PJ,j,y} \times EF_{EL,j,y} \times \left(1 + TDL_{j,y}\right) \qquad \textbf{(17)}$$

Where:

$PE_{EC,y}$	Emissions from electricity consumption on-site due to the project activity in year *y* (tCO_2e)
$EC_{PJ,j,y}$	Quantity of electricity consumed by the project electricity consumption source j in year y (MWh/year)
$EF_{EL,j,y}$	Emission factor for electricity generation for source j in year y (tCO_2/MWh)
$TDL_{j,y}$	Average technical transmission and distribution losses for providing electricity for source *j* in year *y*

Table 3: Sample project emissions calculations applying summed-up values for the monitoring period (monthly)

Monitoring Period	**$EC_{PJ,grid,y}$ (MWh)**	**$EC_{PJ,diesel,y}$ (MWh)**	**PE (tCO_2)**
June-15	1.82	0.02	2.9
July-15	2.14	0.01	3.4
August-15	1.94	0.01	3.0
September-15	2.11	0.03	3.3
October-15	2.15	0.02	3.4
November-15	2.20	0.02	3.5

December-15	2.15	0.05	3.4
January-16	2.25	0.01	3.5
February-16	2.28	0.03	3.6
March-16	2.13	0.02	3.4
April-16	2.27	0.02	3.6
May-16	2.09	0.04	3.3
June-16	1.47	0.12	2.5
July-16	1.83	0.01	2.9
August-16	1.86	0.03	2.9
September-16	1.53	0.05	2.5
October-16	1.69	0.24	3.0
November-16	1.93	0.03	3.0
December-16	2.38	0.02	3.8
January-17	2.37	0.04	3.8
February-17	1.74	0.05	2.8
March-17	2.25	0.03	3.6
April-17	1.78	0.10	2.9
May-17	2.20	0.01	3.4
June-17	2.13	0.04	3.4
July-17	2.98	0.03	4.7
August-17	2.10	0.03	3.3
September-17	2.24	0.07	3.6
October-17	1.19	0.12	2.0
November-17	1.24	0.01	2.0
December-17	1.88	0.03	3.0
Total	**62.3**	**1.3**	**99.3**

E.3. Calculation of leakage emissions

n/a

E.4. Calculation emission reductions or net anthropogenic removals

The emission reductions ER can be calculated according to the following formula:

$$ER_y = BE_y - PE_y \qquad (1)$$

Where:

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

By manual calculation the results may differ slightly due to rounding effects to remain conservative.

	Baseline GHG emissions or baseline net GHG removals (t CO_2e)	Project GHG emissions or actual net GHG removals (t CO_2e)	Leakage GHG emissions (t CO_2e)	GHG emission reductions or net anthropogenic GHG removals (t CO_2e)		
				Before 01/01/2013	**From 01/01/2013**	**Total amount**
Total	191,791	99.33	0	-	191,692	191,692

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 ($t\ CO_2e$)
191,692	338,959

E.6. Remarks on increase in achieved emission reductions

The actual emission reduction achieved is lower to the expectations stated in the registered PDD. One reason is the delay of capping. Another reason is due to the fact that old waste was remodeled to prepare and do the capping. By doing so, LFG already produced by the waste was exposed and released.