Monitoring report form for CDM project activity
(Version 09.0)

MONITORING REPORT			
Title of the project activity	São João Landfill Gas to Energy Project (SJ)		
UNFCCC reference number of the project activity	0373		
Version number of the PDD applicable to this monitoring report	5.2 (01/10/2019)		
Version number of this monitoring report	1.0		
Completion date of this monitoring report	02/03/2022		
Monitoring period number	19th monitoring report of the first crediting period		
Duration of this monitoring period	16/05/2012 to 21/05/2014		
Monitoring report number for this monitoring period	Not applicable		
Project participants	1. Prefeitura Municipal de São Paulo (Municipality of São Paulo) 2. Biogás Energia Ambiental S.A. 3. KfW Bankengruppe 4. Mercuria Energy Trading SA		
Host Party	Brazil		
Applied methodologies and standardized baselines	ACM0001 – “Flaring or use of landfill gas” (version 18.1)		
Sectoral scopes	1. Energy industries (renewable / non-renewable sources) 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
	88,674	187,094	0
Amount of GHG emission reductions or net anthropogenic GHG removals estimated ex ante for this monitoring period in the PDD	268,569		

SECTION A. Description of project activity

A.1. General description of project activity

São João Landfill Gas-to-Energy CDM Project Activity (SJ) is a project designed to explore the landfill gas (LFG) produced in "Aterro Sanitário Sítio São João", which is one of the biggest landfills in Brazil.

The landfill is in the metropolitan area of São Paulo, Brazil's biggest city and financial center of the country. With population of around 11 million citizens, São Paulo generates nearly 20.1 ktonnes of waste daily[1].

SJ's goal is to explore São João's LFG for electricity generation. Although the landfill has been designed according to modern practices, the designed solution for the LFG at the time of the landfill's conception was to collect it through passive venting, eventually flaring it at the head of the wells, which is not efficient in terms of methane destruction.

The project is fully operational and is composed by three enclosed flares, a powerhouse with 25.60 MW of installed capacity (16 engines with 1,600 kW capacity each[2]) and a transmission system with approximately 30 km. By using that transmission system, the project can dispatch electricity into the Brazilian Interconnected Grid ("SIN" from the Portuguese "Sistema Interligado Nacional").

SJ also purchases LFG from CTL ("Central de Tratamento de Resíduos Leste"), also a CDM Project Activity (Ref. # 5947), to comply with the electricity amount settled in its power purchase agreement.

As discussed in the post-registration change (PRC), approved on 12/11/2019, all emission reductions generated from LFG purchase from CTL belong to CTL[3]. Detailed information regarding PRCs conducted in the first crediting period of project is presented in appendix 7 of the applicable registered PDD.

Additionally, SJ provides major contribution towards sustainable development due to:

- Renewable energy generation.
- Methane emission reductions through flaring and generating electricity, avoiding global warming, and reducing explosion risks at the landfill site.
- Replicability of technology and know-how in the host country.
- Jobs creation, mainly during implementation and operation phases.
- Increase of local income since revenues from certified emission reductions (CERs) are shared with the project participant "Prefeitura Municipal de Sao Paulo" (PMSP, the Municipality of São Paulo), increasing cash flow towards investments such as rubbish damps recovery, waste management awareness and other environmental benefits.

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[1] Data from 2012. Information from the Integrated Management Plan of Sao Paulo Municipal Solid Waste (MSW).

[2] 1.54 MW installed capacity for each engine was considered in the first crediting period based on the nameplate of the equipment and site specifications. However, during this second crediting period, the DOE required the consideration of the installed capacity exactly according to the nameplate of the equipment. A post-registration change was approved to reflect this "correction". Please refer to timeline presented in annex 7.

[3] Term of Agreement signed by Ecourbis and São João Energia Ambiental on 31/07/2015. The document states that Ecourbis and São João Energia Ambiental agree that CERs from LFG produced at Ecourbis Landfill inside the expansion area will belong exclusively to Ecourbis, i.e., CTL's ownership.

A.2. Location of project activity

*São João landfill is in the east part of São Paulo, state of Sao Paulo, Brazil, at Estrada de Sapopemba, km 33 (see Figure 1 and Figure 2 for exact geographical location).

Figure 1 – São Paulo location (Source: http://pt.wikipedia.org)

The geographic coordinates of the project site are:

- Latitude, -23.6362°
- Longitude, -46.4141°

Figure 2 – Sao Joao Landfill geographical 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)
Brazil	Public entity - Prefeitura Municipal de São Paulo (Municipality of São Paulo)	No
	Private entity - Biogás Energia Ambiental S.A.	
Germany	Private entity - KfW Bankengruppe	No
Switzerland	Private entity - Mercuria Energy Trading SA	No

A.4. References to applied methodologies and standardized baselines

São João Landfill Gas to Energy Project applies the following methodology and tools:

- ACM0001 methodology – “Flaring or use of landfill gas” (version 18.1).
- TOOL02: “Combined tool to identify the baseline scenario and demonstrate additionality” (version 7.0).
- TOOL04: “Emissions from solid waste disposal sites” (version 08.0).
- TOOL05: “Baseline, project and/or leakage emissions from electricity consumption and monitoring of electricity generation” (version 03.0).
- TOOL06: “Project emissions from flaring” (version 02.0).
- TOOL07: “Tool to calculate the emission factor for an electricity system” (version 07.0).
- TOOL08: “Tool to determine the mass flow of a greenhouse gas in a gaseous stream” (version 03.0).
- TOOL11: “Assessment of the validity of the original/current baseline and update of the baseline at the renewal of a crediting period” (version 03.0.1).

A.5. Crediting period type and duration

Renewable: 7 years, 0 month (first crediting period, 22/05/2007 - 21/05/2014).

SECTION B. Implementation of project activity

B.1. Description of implemented project activity

The installation of the SJ was carried out in three phases in 2007 and 2008.

First, the LFG collecting, and flaring system was installed. From May 2007 to March 2008, the SJ was limited to LFG flaring, as confirmed by the approved monitoring and verification reports issued for the period.

The LFG degassing system includes more than 30 km of high-density polyethylene pipes connected to the about 160 landfill wells; 4 blowers to provide suction for extracting the LFG; facilities for gas purification, and 3 flares with capacity to process up to 15,000 Nm^3 of LFG per hour.

The LFG is extracted from the landfill through the gas wells and transported to the gas plant by the pipelines for treatment before use as fuel for power generation or flaring for destruction. During transportation, there might occur the formation of condensate, due to temperature gradients, requiring drainage of the pipeline to condensate shafts placed along the pipeline. Once in the gas plant, the LFG is cooled to remove moisture. The removal of condensates from the LFG flow is a critical step in the gas treatment process, in the case LFG is used as fuel. LFG condensates contain silica components that can form deposits in the gas pipes and, damage the gas engines ultimately. Once the condensates are removed, the LFG is heated again by passing through a second heat exchanger, or economizer, to a temperature of around 25 °C, away enough from the dew point of 4 °C to avoid further condensation.

As additional precaution, a demister was also installed as an extra-guarantee of the LFG quality as fuel for gas engines. The demister is a stainless-steel high-density filter which separates liquid particles from the LFG. All liquid removed off the LFG is drained to a condensate shaft.

Blowers are used to provide correct suction pressure into the pipeline system for transportation of the LFG extracted from the landfill up to the gas plant. Flow capacity and pressure are adjusted by electrical motors with frequency control. Blowers are also equipped with necessary safety equipment as well as noise reducing housing.

Sophisticated gas analysing and gas measuring instruments are used on the pressure side of the gas plant to ensure safety, and best operating controls. Once analysed and properly measured, the LFG can be used as a fuel for the gas engines which drive electrical generators. Any occasional surplus of the LFG will be burned off in the flares.

The whole LFG collecting process and gas plant is controlled by an electrical control system with a PLC (Programmable Logical Controller) and a SCADA system (visualization of the process on a personal computer), making remote control possible. All the measured process signals are processed by the PLC to feed input signals for the gas-coolers, blowers, flares, and gas-engines.

The second implementation phase of the São João LFGE Project started in June 2007, after the start-up of the gas plant once the engineering for the Power Plant was properly developed to provide information for the procurement of all equipment and services.

The first registered PDD version was developed assuming the use of a set of 14 engines Model CAT 3516.

Once the Power Plant was operational, the PPs invested in the acquisition of two additional CAT 3516 engines, total power capacity of 25.60 MW.

The power upgrade configures the third phase of the project, which became operational in October 2008 and, since then SJ operates as follows:

1. Engine: CAT 3520, capacity 1.60 MW
2. Engine Units: 16
3. Installed Capacity: 16 X 1.60 MWe = 25.60 MWe

Table 1 summarizes the equipment under operational.

Table 1 – Technical description of project's equipment.				
	Blower	**Flare**	**El. Generator**	**Diesel Generator**
Manufacturer	Continental Blower LLC	Hofstetter	Caterpillar	Caterpillar
Model	151A.05	Efficiency 5000	CAT3516	CAT3406
Quantity	4	3	16	1
Capacity per unit	3,000 - 7,000 scfm	Min: 500Nm3/h Max: 5,000Nm3/h	1,600 kW	400KW/500KVA
Reference	Technical Data Sheet Continental Blower LLC	Hofstetter's operating instructions	Caterpillar's gas engine technical data and equipment tag	Equipment tag

B.2. Post-registration changes

The summarized record of the project actions, post-registration changes and steps to renew crediting period is presented in Table 2.

Table 2 - Summary of project actions and changes	
Date	**Action**
02/07/2006	Project CDM Registration.
28/05/2010	Approval of the PRC due to the change in the installed capacity from 20 MW to 24.64 MW (1.6 MW generator standard capacity and site specifications, resulting in 1.54MW).
09/04/2011	Approval of monitoring plan review, changing the recording frequency of parameter "Regulatory requirements relating to landfill gas projects".
30/09/2013	Signature of the contract for LFG purchase between SJ (buyer) and Ecourbis Ambiental S.A. (CTL landfill PP, seller).
02/04/2014	Submission of the request for renewal of the crediting period of the project.
03/04/2014	Start of CTL's LFG supply to SJ
12/09/2014	The CDM Executive Board (EB) request for additional clarification during the request for review period of the crediting period renewal. Clarification was required for: - compliance of monitoring according to ACM0001 (v.14.0), as there were 3 flares and 16 generators, but only two flow meters (one to monitor LFG sent to flares and another to LFG sent to electricity generators). - application of zero for $F_{CH4,BL,y}$, although there was "a passive system and methane

	was burned in an controlled manner".
16/10/2014	PPs clarification submission regarding item b) from the request for review received on 12/09/2014.
27/10/2014	Withdrawal of the request for renewal of the crediting period.
20/03/2015	The CDM EB clarification response of AM_CLA_0265 (item b from the request for review received on 12/09/2014), which indicates that "If there was a capture then the situation to be considered is 'case 3' and the adjustment factor needs to be calculated using any of the options provided in the methodology".
31/07/2015	Signature of the agreement term between SJ and Ecourbis Ambiental S.A., regarding the CERs ownership from CTL landfill required during the post-registration change of CTL project activity (# 5947).
07/01/2016	PPs request for deviation submission due to item a) from the request for review received on 12/09/2014.
02/08/2016	Approval of the M-DEV-493[4] (Deviation from the ACM0001 with regards to the individually monitoring of the LFG flow forwarded to equipment, flare and/or generator - used by the proposed CDM Project Activity).
12/11/2019	Approval of the PRC-0373-001[5] (corrections of the installed capacity of the project and the inclusion of the biogas purchase from CTL).

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

The following temporary deviation, described in the monitoring plant of the applicable PDD (approved on 12/11/2019, see PRC-0373-001), will be applied in this monitoring report.

For the period from 16/05/2012 to 05/11/2018, monitoring parameters were continuous monitored and conservatively registered in five minutes interval, as allowed by *TOOL06* (version 1). Therefore, up to 05/11/2018, PP monitored as established in the registered monitoring plan, instead of minutebasis required by the updated version of the tool.

Following §231 of the CDM Project Standard for Project Activities (version 2.0), the PP proposed the following conservative alternative approach to ensure that GHG emission reductions or net anthropogenic GHG removals will not be overestimated because of the deviation:

- Apply -10% for the entire baseline emissions and +10% in project emissions during the period of the temporary deviation. A double 10 percent discount factor (10% reduction in baseline emissions AND 10% increase in project emissions) is a very conservative approach, while the maximum permissive equivalent error of metering equipment is 1.81%[6].

[4] URL: https://cdm.unfccc.int/Projects/DB/DNV-CUK1145141778.29/CP/S9YNGYNKQVY66Z4JGD3BOIC85WFX25/view (accessed on 19/01/2022).

[5] URL: https://cdm.unfccc.int/PRCContainer/DB/prcp442529138/view (accessed on 19/01/2022).

[6] Equivalent error based on the root of the square sum of equipment accuracy (1% for methane analyzer and 1.5% for gas flow).

- The discount above will be applied for period from 16/05/2012 to 21/05/2014 within the first crediting period.

B.2.2. Corrections

The following corrections - approved on 12/11/2019 (see PRC-0373-001), are applicable to this monitoring report.

The installed capacity of the project based on the nameplate of equipment, i.e., the standard capacity (and not considering site specifications), i.e., instead of 1.54 MW each of the 16 generating units, 1.60 MW, resulting in 25.60 MW total installed capacity.

In addition, technical description of project's equipment (blower, flare, electricity generator and diesel generator) was included to detail information regarding manufacturer, model, quantities, capacity, and source of information (information reproduced in Table 1).

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

Start date of the project activity and, consequently, of the crediting period, changed from "30/06/2006 – 29/06/2013" to "22/05/2007 – 21/05/2014".

The change was communicated in the monitoring report (version 07, dated 27/02/2008) of the first request for issuance (monitoring period: 22/05/2007 – 30/06/2007).

To the best of the PPs understanding, as at the time there was no approval date definition or post-registration change process, the change was approved at the issuance date, i.e., on 23/06/2008.

B.2.4. Inclusion of monitoring plan

Not applicable.

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

The following permanent changes to the monitoring plan - approved on 12/11/2019 (see PRC-0373-001), are applicable to this monitoring report.

In 03/04/2014, SJ started to purchase biogas from CTL as the plant did not reach the performance as expected and necessity to comply with the power purchase agreement.

CTL is already a CDM project (ref. # 5947) and, as described in its registered PDD and Validation Report, all emission reduction generated from the biogas delivered by CTL will be claimed only by CTL.

To reach the quantity of methane flared/used ($F_{CH4,PJ,y}$), measurement from the gas mixture (CTL + SJ) and CTL will be considered.

As all possible losses in the process will be accounted for SJ, emission reductions will never be overestimated. Regarding emission reductions due to electricity generation supplied to the grid, it will be proportionally discounted from the CTL's measurement from the total methane. Therefore, the total methane measurement sent to flares (FIT524, FIT544 and FIT564) and engines (FIR800) will be discounted proportionally to the measurement of methane collected by CTL.

Following § 239 of the CDM Project Standard (v.2.0), to apply the permanent changes, the following discount factor AND conservative approach will be adopted by the Project Participants:

- Apply discount factor based on the equipment accuracy as established in manufacturer's specification. Then, discount will be applied twice (methane and flow measurement): 1% discount will be applied on methane measurement (A100) and gas flow sent to generators (FIR 800), and 1.5% discount on gas flow sent to flares (FIT524, FIT544 and FIT564).
- Adopting a conservative approach by using values rounded down (truncated) for data instantaneously generated and registered in the PLC system, then no decimal places of gas flow, for example, will be considered while calculating emission reductions.

The discount above will be applied for period from 01/01/2014 to 21/05/2014 within the first crediting period.

B.2.6. Changes to project design

The CDM project activity was registered on 02/07/2006 using ACM0001 version 2.

Since SJ registration, ACM0001 has been revised many times and at its 18th version the time of PRC-0373-001 submission (2019), i.e., over 1 new version per year in the period.

In the registered PDD, the estimated methane generation was based on the quantity of waste deposited in the landfill up to 2006. The amount of waste only changed up to 2009, the closing year the landfill. But the estimation method in ACM0001 changed a lot. Version 2 of ACM0001 did not prescribe a method to calculate methane generation and, therefore, according to the registered PDD, an IPCC method[7] and simplified equation was used to estimate quantity of methane:

$$Q_{T,x} = kR_x L_o e^{-k(T-x)}$$ **Equation 1**

Where:

$Q_{T,x}$ = amount of methane generated in current year (T) by the waste

$R_{x,k}$ = methane generation rate constant (1/yr), 0.105 was applied

R_x = the amount of waste disposed in year X

L_0 = methane generation potential (t/t of refuse), 0.065 was applied

[7] Revised 1996 IPCC Guidelines for National GHG Inventories: Reference Manual (Chapter 6 - Waste).

x = the year of waste input

T = current year

On 29/09/2006, the first version of TOOL04 was published and, the methane generation calculation considers many parameters based on the quantity and type of waste, temperature and moisture conditions, methane correction factors based, model correction factor to account for model uncertainties, fraction of degradable organic carbon and other parameters not considered at the time of the project conception and registration of the PDD.

As the project activity was a pioneering project, no similar projects were operational at that time to compare performance. This obviously had influence in the expected methane generation and electricity generation as can be seen in the following figures.

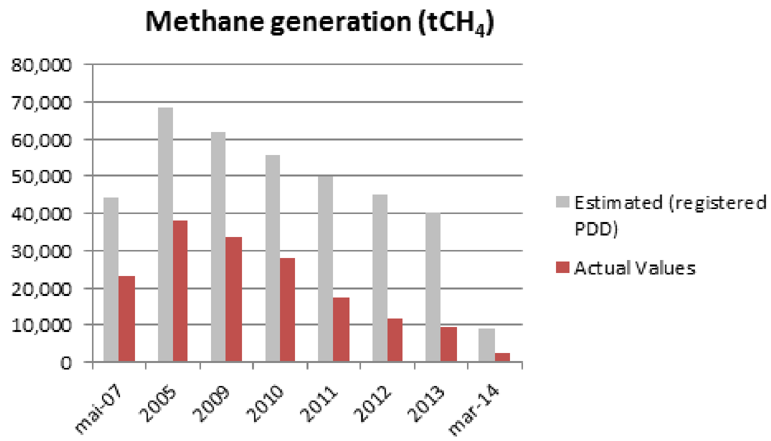


Figure 3 – SJ's methane generation, estimated and actual performance

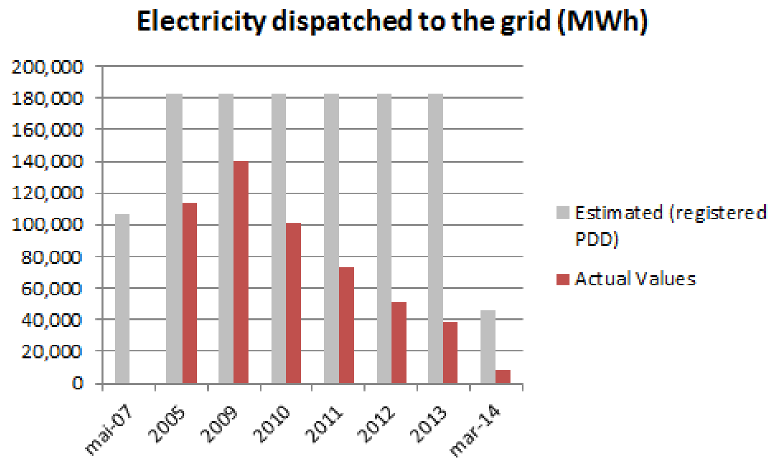


Figure 4 – SJ's electricity dispatched into the grid – estimated and actual performance

As can be seen in the figures above, the project generated 56.3% less CH_4 and 57.9% less electricity than estimated.

Therefore, the PPs decided in 2013 to purchase LFG from CTL in order comply with the signed PPA and, in April 2014 CTL started to provide LFG to SJ. This change also impacted the CTL, which also requested a PRC.

To demonstrate that methods for methane estimation and assumed parameters have strong influence on the observed difference, methane generations was estimated for the first crediting period, based on the applicable approved methodology (ACM0001, version 18.1 and TOOL04).

As can be seen in the Table 3, if current version of ACM0001 and TOOL04 was considered at the time of the project registration, amount of methane would be 206,371tCH_4 during the first crediting period of the project, and not 374,228 tCH_4 as estimated in the registered PDD (minus 44.9% difference).

Table 3 - Total Methane Generated in landfill (t_{CH4})

Year	First registered PDD (ACM0001, v.02)	Estimate (ACM0001, v. 18.1 and TOOL04)
2007[8]	44,324	26,276
2008	68,410	49,313
2009	61,591	39,438
2010	55,452	30,041
2011	49,925	23,503
2012	44,949	18,898
2013	40,468	15,602
2014[9]	9,109	3,300
TOTAL	**374,228**	**206,371**

In summary, there are two reasons that lead to less methane and, consequently, emission reductions generation than estimated in the registered PDD:

- Simplified methods and factors available at the time of the project registration.
- Pioneering of this type of project since this type of technology was not established in the Host Country at that time.

According to §241 of the CDM Project Standard for Project Activities, the project activity applies the following options:

(e) Changes to the technologies/measures that result in the same technologies/measures as in the originally registered technologies/measures as per the definition of “the same technologies” in paragraph 44(b) above.

[8] 22/05/2007 to 31/12/2007
[9] 01/01/2014 to 21/05/2014

The biogas purchase from CTL results in the same technology as it provides the same output (electricityand flared methane) by using the same conversion process as well as the same managing practices.

(j) Voluntary update of the applied methodologies or the other applied methodological regulatory documents to a later valid version of them, or voluntary change to other methodologies, provided all requirements in the updated/changed methodologies and the other applied methodological regulatory documents are met.

Due to several changes from the version of ACM0001 used in the registered PDD (version 2) to the applicable version at the time of PRC submission, i.e., version 18.1, the PPs decided to voluntarily update the methodology under the process of post-registration change.

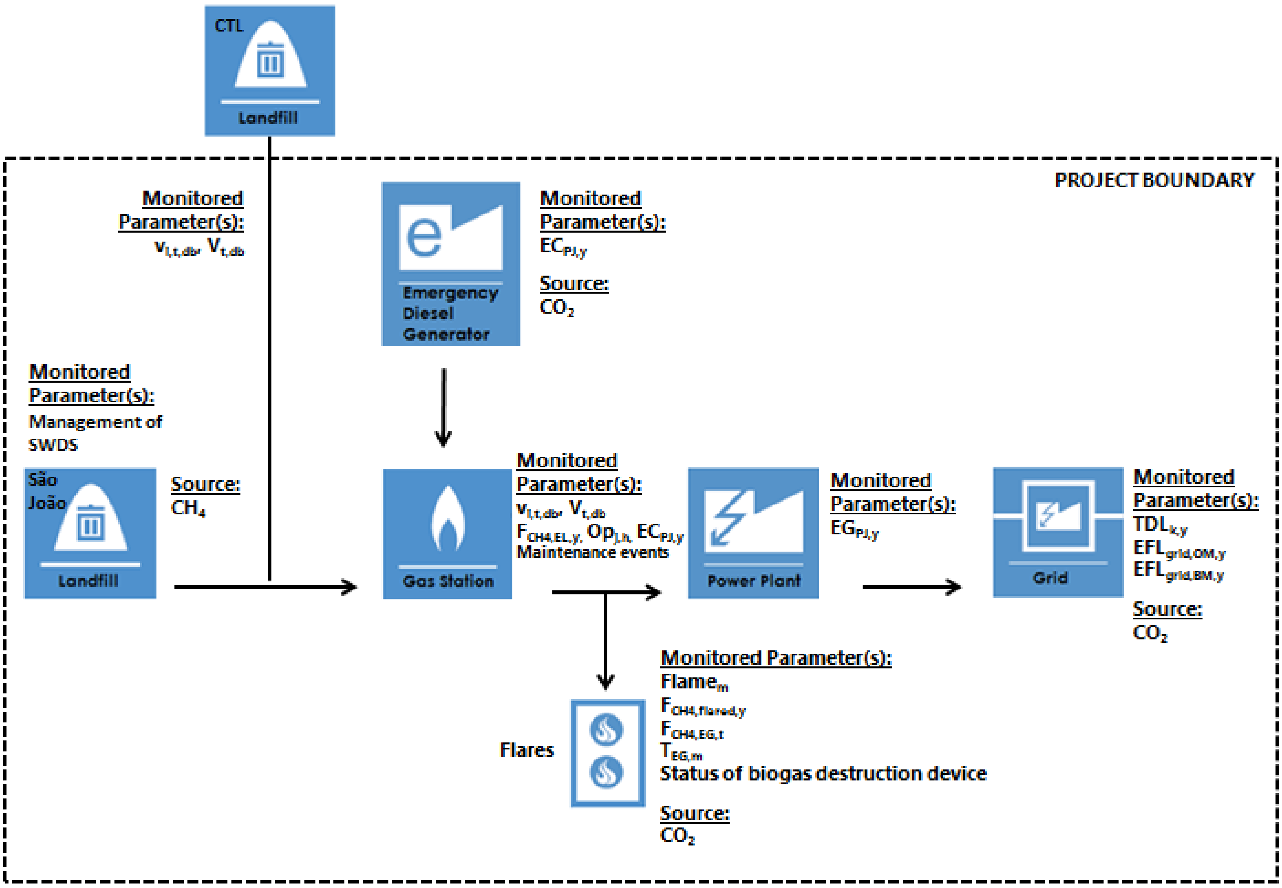
This update was required as changes required during the renewal of the crediting period were not required in the previous version of the methodology and referred tools.

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

Not applicable.

SECTION C. Description of monitoring system

Figure 5 displays simplified diagrams of monitoring equipment.



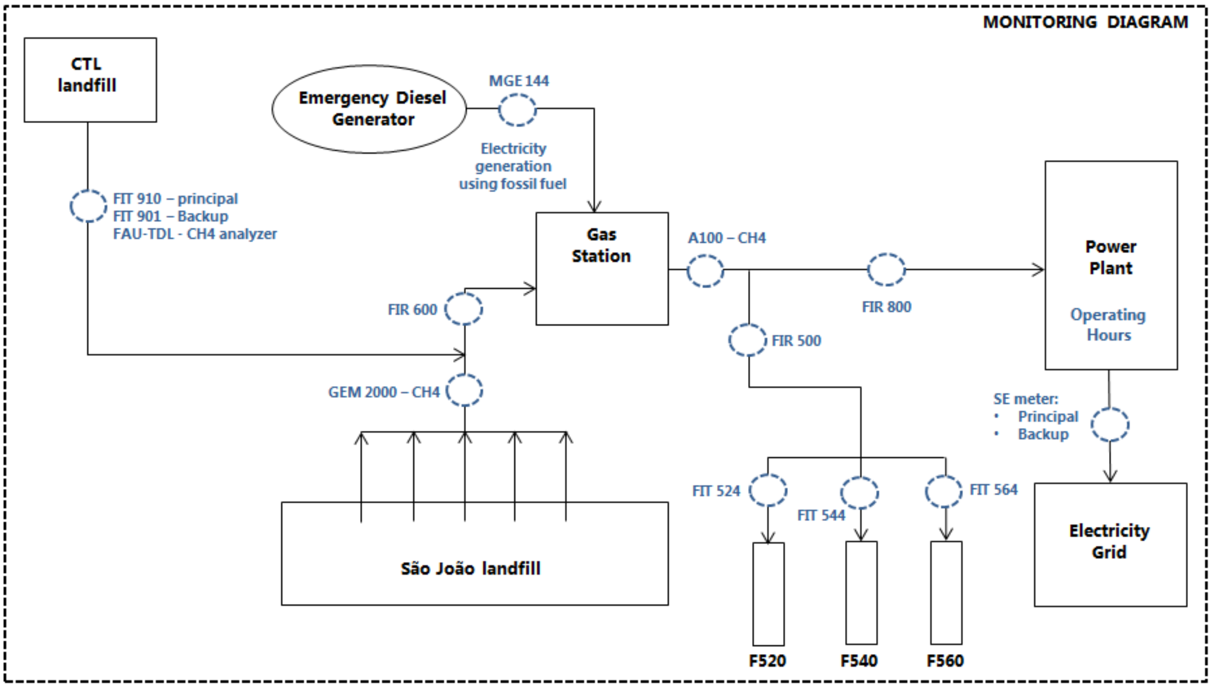


Figure 5 - Simplified diagrams of monitoring equipment

Where:

- FIR600, flow meter - register the total amount of LFG captured.
- FIR500, flow meter - register the total amount of LFG flared.
- FIR800, flow meter - register the total amount of LFG combusted in the power plant.
- Gas analyzer, measure the methane fraction in the landfill.
- FIT524, FIT544 and FIT564, flow meters, pressure, and temperature transmitters.
- PLC System Monitoring - Diesel Generator.
- Electricity meter at the substation.

Besides, the following procedures will be carried out while performing monitoring activities related to the proposed project activity.

(a) Data transmission, processing, and storage

The variables described are automatically registered in a supervisory computer system.

The PPs developed the following actions to protect the monitoring system:

- The PLC is not connected to the Internet; thus, the risk of virus infection is minimized.
- Only authorized persons have access to the data base of the system.
- Antivirus programs are installed at the system.
- Data backup
  - A weekly CD backup of the Supervisory System in external hard disk.
  - A weekly backup of the Supervisory System's hard disk is made by the server.
  - The Operational Environment Unit downloads regularly the primary data for the elaboration of the monitoring report.

Data was previously collected in a 5-minute interval following the previous version of TOOL06, but since November 2018, the system was updated to consider 1-minute interval. This update was made since the project is under renewal of the crediting period and 1-minute interval is required by the updated version of TOOL06.

From 03/04/2014 onwards, there will be three measurements from CTL, SJ and CTL+SJ for methane measurement.

CTL's methane analyser is under CTL's responsibility, including its maintenance and calibration as established in its registered monitoring plan. Methane measurement equipment of SJ (GEM2000) and CTL+SJ (A100) are under SJ's responsibility, as well as their calibration.

Despite GEM2000 measuring SJ's methane only, the analyser to be considered for emission reduction calculation is A100. GEM2000 is not a fixed meter and, therefore, SJ's methane is measured by sampling, 3 times a day and daily average is considered for cross-checking purposes. Also, uncertainty of GEM2000 is higher (+/- 3.0%) when compared to A100 analyser (1.0%). Therefore, GEM2000 will be used for cross-checking purposes only and A100 will be used for emission reductions calculation.

Both A100 from SJ and CTL's analyzer measurements are continuous and integrated once per minute. As we have methane measurement from the CTL+SJ and from CTL, it is possible unequivocally determine the quantity of methane generated in SJ, which is sent to flares. If any loss occurs in the flow from SJ, it will be accounted to São João (because CTL is measured and SJ + CTL is measured). Then, methane from SJ will never be overestimated, but may be conservatively underestimated.

LFG production at PA5947 (CTL) is not controlled by PA0373 (SJ), but LFG purchased from PA5947 is fully monitored, and is not accounted in PA0373's CERs calculation.

As described in the PDD (sections B.2, B.6.1, B.7.3 and appendix 7), PA0373 emission reductions will be calculated by applying discounts on readings proportionally to CH4 mass balance from LFG purchased from CTL (Figure 6).

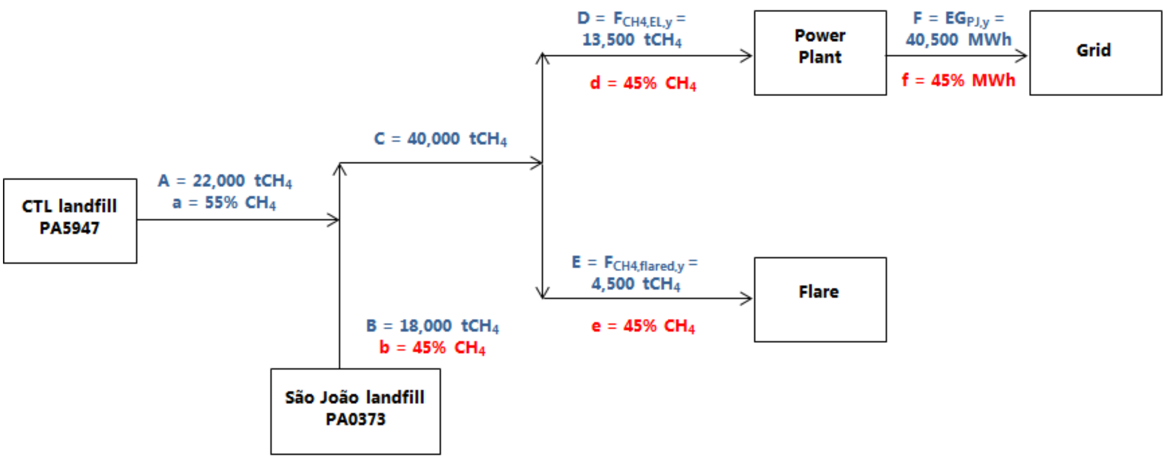


Figure 6 – Example of mass balance

It is worth mentioning that both landfills - PA0373 and PA5947, are independent and materially separated projects and operate fully segregated cells.

In the case of project emissions from flaring, LFG flow will be measured by FIT524, FIT544 and FIT564 and will be considered for emission reduction purposes if flares operate under adequate operational conditions of temperature and flow as established by the manufacturer, i.e., 1,000 - 1,200ºC temperature and 500 - 5,000 Nm^3/h flow rate.

Readings from FIT500 is not used for emission reduction calculations but for cross-checking purposes only. All measurement will be discounted proportionally to the measurement of methane collected by CTL.

In the case of baseline emissions of methane from SWDS, LFG flow will be measured by FIT524, FIT544 and FIT564 (flares), as well as FIR800, which is allowed to use a single flow meter (and not one for each equipment which consumes LFG) as established by ACM0001.

All measurement will be discounted proportionally to the measurement of LFG collected by CTL.

In the case of baseline emissions from electricity generation, exported electricity from energy meters – provided by the power utility (AES Eletropaulo) – will be also discounted proportionally to the measurement of LFG collected by CTL.

It is important mentioning that a discount factor based on the equipment accuracy and a conservative approach for emission reductions calculation will be considered following §239 of the CDM Project Standard (refer to Appendix 7 of the registered PDD for details).

All data monitored and required for verification and issuance be kept and archived electronically for two years after the end of the crediting period or the last issuance of CERs, whichever occurs later.

(b) Responsibilities

From the point of view of the plant operation, positions, and roles for this CDM project activity are well defined. Duties, personnel replacement in the case of non-availability of the Operation Manager and O&M Coordinator and hiring requirements for job positions are determined in documented procedures presented in the functional organogram and responsibility matrix.

(c) Quality Assurance & Quality control

All parameters monitored inside LFG Station, including reading, transmitting and registration routine are under the Operation Manager and O&M Coordinator's responsibility. Every week, all data registered is downloaded from the PLC and a complete check to identify non-conformities, such as unread registrations or troubles with the PLC (non-conformities happen mainly due to electricity blackouts) is made. All non-conformities raised are promptly compared with operational events, registered by operators in the Operation Diary.

Operators are oriented to perform a "Print-Screen" of the PLC Controlling System Panel every three hours. The picture printed presents all monitoring parameters and is saved in the computer's hard disk.

The Backup Data Procedure includes the management of the operational system and data record, as well as backup procedures. The Procedure for Calibration of Gases Analyzer Panel – Methane and Oxygen establishes procedures for calibration of the gas analyzer panel and the Operation Manual for the Gas Plant Startup establishes procedures to startup the gas plant after blackouts of power electricity supply from concessionary.

(d) Training

All training was supplied to operators and technical assistants before the project's implementation. Before performing its activities, every new operator has performed proper training, including:

- How to operate and start the plant.
- Reading instruments and recording of reports.
- Verification and calibration of gas analyzer.
- Maintenance of equipment.
- Data Protection Measures.

SECTION D. Data and parameters

D.1. Data and parameters fixed ex ante

Data and parameter fixed ex-ante, table 1

Data/Parameter	OX_{top_layer}
Unit	Dimensionless
Description	Fraction of methane that would be oxidized in the top layer of the SWDS in the baseline
Source of data	Consistent with how oxidation is accounted for in TOOL04
Value(s) applied	0.1
Choice of data or measurement methods and procedures	As per the applicable tool
Purpose of data/parameter	Calculation of baseline emissions
Additional comments	-

Data and parameter fixed ex-ante, table 2

Data/Parameter	$F_{CH4,BL,y}$
Unit	tCH_4 /yr
Description	Amount of methane in the LFG that would be flared in the baseline in year y
Source of data	Information of the host country's regulatory requirements relating to LFG, contractual requirements, or requirements to address safety and odour concerns as well as records of the project site previously to the implementation of the proposed CDM Project Activity
Value(s) applied	24,720 (average during the crediting period)

Choice of data or measurement methods and procedures	There was no regulatory and/or contractual requirement to destroy methane and a there was a LFG capture and destruction system installed prior to the implementation of the project activity.
Purpose of data/parameter	Calculation of baseline emissions
Additional comments	In the case of the proposed project activity Case 3 is applicable

Data and parameter fixed ex-ante, table 3

Data/Parameter	GPW_{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 the applicable tool
Purpose of data/parameter	Calculation of baseline emissions
Additional comments	-

Data and parameter fixed ex-ante, table 4

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

TOOL04: “Emissions from solid waste disposal sites”

Data and parameter fixed ex-ante, table 5

Data/Parameter	$\varphi_{default}$

Unit	-
Description	Default value for the model correction factor to account for model uncertainties
Source of data	-
Value(s) applied	0.75
Choice of data or measurement methods and procedures	As per *TOOL04*. This parameter is used to determine the baseline emissions following the procedures related to *Application A*. Further, the project is located at São Paulo state (southeast region of Brazil) with tropical weather conditions[10] (MAT > 20ºC, MAP > 1,000 mm)
Purpose of data/parameter	Calculation of baseline emissions
Additional comments	As per Option 1 of the tool.

Data and parameter fixed ex-ante, table 6

Data/Parameter	f_y
Unit	-
Description	Fraction of methane captured at the SWDS and flared, combusted or used in another manner that prevents the emissions of methane to the atmosphere in year *y*
Source of data	ACM0001
Value(s) applied	0
Choice of data or measurement methods and procedures	In accordance with the ACM0001 methodology this value is to be assigned since the amount of LFG that would have been captured and destroyed is already accounted for in Equation 2. As per *TOOL04*, for application A, this parameter is determined once for the crediting period ($f_y = f$).
Purpose of data/parameter	Calculation of baseline emissions
Additional comments	-

Data and parameter fixed ex-ante, table 7

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)

[10] The climatic conditions from CEPAGRI ("*Centro de Pesquisas Meteorológicas e Climáticas Aplicadas a Agricultura*"). URL: http://www.cpa.unicamp.br/outras-informacoes/clima_muni_565.html (accessed at validation).

Source of data	Based on an extensive review of published literature on this subject, including the IPCC 2006 Guidelines for National Greenhouse Gas Inventories
Value(s) applied	0
Choice of data or measurement methods and procedures	As per *TOOL04*
Purpose of data/parameter	Calculation of baseline emissions
Additional comments	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. For ex-ante calculations this effect was accounted when determining emission reductions as per ACM0001 formulae. Please refer to AM_CLA_0259. Although clarification refers to ACM0001 (version 15.0) and TOOL04 (version 6.0.1), it is also applied to the project since equations do not change in the updated version of methodology and tool.

Data and parameter fixed ex-ante, table 8

Data/Parameter	***F***
Unit	-
Description	Fraction of methane in the SWDS gas (volume fraction)
Source of data	IPCC 2006 Guidelines for National Greenhouse Gas Inventories
Value(s) applied	0.5
Choice of data or measurement methods and procedures	As per *TOOL04*
Purpose of data/parameter	Calculation of baseline emissions
Additional comments	Upon biodegradation, organic material is converted to a mixture of methane and carbon dioxide.

Data and parameter fixed ex-ante, table 9

Data/Parameter	$DOC_{t,default}$
Unit	Weight fraction
Description	Default value for the fraction of degradable organic carbon (DOC) in MSW that decomposes in the SWDS

Source of data	IPCC 2006 Guidelines for National Greenhouse Gas Inventories
Value(s) applied	0.5
Choice of data or measurement methods and procedures	The proposed project activity corresponds to *Application A* described in *TOOL04*. Therefore, in accordance with the requirements set out by tool, the default value was chosen.
Purpose of data/parameter	Calculation of baseline emissions
Additional comments	This factor reflects the fact that some of the degradable organic carbon does not degrade, or degrades very slowly, in the SWDS.

Data and parameter fixed ex-ante, table 10

Data/Parameter	$MCF_{default}$
Unit	-
Description	Methane correction factor
Source of data	IPCC 2006 Guidelines for National Greenhouse Gas Inventories
Value(s) applied	1
Choice of data or measurement methods and procedures	The proposed project activity matches *Application A* described in *TOOL04*. The São João Landfill meets the criteria of managed SWDS. Hence, the value corresponding to anaerobic managed solid waste disposal sites is chosen.
Purpose of data/parameter	Calculation of baseline emissions
Additional comments	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 and parameter fixed ex-ante, table 11

Data/Parameter	DOC_j
Unit	-
Description	Fraction of degradable organic carbon in the waste type *j* (weight fraction)
Source of data	IPCC 2006 Guidelines for National Greenhouse Gas Inventories (adapted from Volume 5, Tables 2.4 and 2.5)

<table>
<tr><td>Value(s) applied</td><td>
<table>
<tr><th>DOC_j (% wet waste)</th><th>Waste type j</th></tr>
<tr><td>43%</td><td>Wood and wood products</td></tr>
<tr><td>40%</td><td>Pulp, paper, and cardboard</td></tr>
<tr><td>15%</td><td>Food, food waste,beverages and tobacco</td></tr>
<tr><td>24%</td><td>Textiles</td></tr>
<tr><td>20%</td><td>Garden, yard, and park waste</td></tr>
<tr><td>0%</td><td>Glass, plastic, metal, other inert waste</td></tr>
</table>
</td></tr>
<tr><td>Choice of data or measurement methods and procedures</td><td>Values for MSW, as per Table 6 of TOOL04.</td></tr>
<tr><td>Purpose of data/parameter</td><td>Calculation of baseline emissions</td></tr>
<tr><td>Additional comments</td><td>-</td></tr>
</table>

Data and parameter fixed ex-ante, table 12

<table>
<tr><td>Data/Parameter</td><td>k_J</td></tr>
<tr><td>Unit</td><td>1/yr</td></tr>
<tr><td>Description</td><td>Decay rate for the waste type j</td></tr>
<tr><td>Source of data</td><td>IPCC 2006 Guidelines for National Greenhouse Gas Inventories (adapted from Volume 5, Table 3.3)</td></tr>
<tr><td>Value(s) applied</td><td>
<table>
<tr><th colspan="2">Waste type j</th><th>k_j</th></tr>
<tr><td rowspan="2">Slowly degrading</td><td>Pulp, paper and cardboard (other than sludge), textiles</td><td>0.07</td></tr>
<tr><td>Wood, wood products and straw</td><td>0.035</td></tr>
<tr><td>Moderately degrading</td><td>Other (non-food) organic putrescible garden and park waste</td><td>0.17</td></tr>
<tr><td>Rapidly degrading</td><td>Food, food waste,beverages and tobacco</td><td>0.40</td></tr>
</table>
</td></tr>
<tr><td>Choice of data or measurement methods and procedures</td><td>As per Table 7 of TOOL04.</td></tr>
<tr><td>Purpose of data/parameter</td><td>Calculation of baseline emissions</td></tr>
</table>

Additional comments	The project is located at São Paulo state (Southeastern region of Brazil) which possesses tropical weather conditions: MAT > 20ºC MAP > 1,000mm

Data and parameter fixed ex-ante, table 13

Data/Parameter	W_x
Unit	tonnes
Description	Total amount of waste disposed in a SWDS in year x
Source of data	ECOURBIS
Value(s) applied	Large amount of data. Please refer to the CERs calculation spreadsheet at validation
Choice of data or measurement methods and procedures	ECOURBIS is the landfill operator. This company recorded the amount of waste deposited at the project site and still today manages the landfill area.
Purpose of data/parameter	Calculation of baseline emissions
Additional comments	This parameter does not need to be monitored during the crediting period since the landfill was closed in 2009.

TOOL06: "Project emissions from flaring"

Data and parameter fixed ex-ante, table 14

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 specification for temperature and flow rate and maintenance schedule
Source of data	Flare manufacturer
Value(s) applied	(a) Minimum and maximum inlet flow rate, if necessary, converted to flow rate at reference conditions or heat flux: Min. – 500 Nm^3/h / Max. 2,500 Nm^3/h for each flare (b) Minimum and maximum temperature: 800ºC – 1,300ºC (c) Maintenance schedule: every 365 days
Choice of data or measurement methods and procedures	The flare specifications set by the manufacturer.

Purpose of data/parameter	Calculation of baseline emissions
Additional comments	-

TOOL08: "Tool to determine the mass flow of a greenhouse gas in a gaseous stream"

Data and parameter fixed ex-ante, table 15

Data/Parameter	***Ru***
Unit	Pa•m³/kmol/K
Description	Universal ideal gases constant
Source of data	As per the applicable tool
Value(s) applied	8,314
Choice of data or measurement methods and procedures	-
Purpose of data/parameter	Calculation of baseline emissions
Additional comments	-

Data and parameter fixed ex-ante, table 16

Data/Parameter	***Pn***
Unit	Pa
Description	Atmospheric pressure at normal conditions
Source of data	As per the applicable tool
Value(s) applied	101,325
Choice of data or measurement methods and procedures	-
Purpose of data/parameter	Calculation of baseline emissions
Additional comments	-

Data and parameter fixed ex-ante, table 17

Data/Parameter	***Tn***
Unit	K
Description	Temperature at normal conditions
Source of data	As per the applicable tool

Value(s) applied	273.15
Choice of data or measurement methods and procedures	-
Purpose of data/parameter	Calculation of baseline emissions
Additional comments	-

Data and parameter fixed ex-ante, table 18

Data/Parameter	***MMi***
Unit	kg/kmol
Description	Molecular mass of greenhouse gas i
Source of data	As per the applicable tool
Value(s) applied	16.04
Choice of data or measurement methods and procedures	-
Purpose of data/parameter	Calculation of baseline emissions
Additional comments	Applicable for CH4

TOOL07: "Tool to calculate the emission factor for an electricity system"

Data and parameter fixed ex-ante, table 19

Data/Parameter	$EF_{BM,2009}$
Unit	tCO_2/MWh
Description	Build Margin CO_2 emission factor in year *y*
Source of data	The Brazilian DNA. Official source of data
Value(s) applied	0.1370 based on the most recent information available (2018)
Choice of data or measurement methods and procedures	According to TOOL07.
Purpose of data/parameter	Calculation of baseline emissions
Additional comments	For methodological choices details, please refer to section B.6.1.

TOOL05: "Tool to calculate baseline, project and/or leakage emissions from electricity consumption"

Data and parameter fixed ex-ante, table 20

Data/Parameter	***$EF_{EL,j,k}$***
Unit	tCO_2/MWh
Description	Emission factor for electricity generation for source *j* in year k
Source of data	*Default value from TOOL05*
Value(s) applied	1.3
Choice of data or measurement methods and procedures	Conservative default value provided by Option B2 of the tool.
Purpose of data/parameter	Calculation of project emissions due to electricity consumption from the diesel generator
Additional comments	-

D.2. Data and parameters monitored

Data and parameter monitored, table 1

Data/Parameter	***Management of SWDS***
Unit	-
Description	Management of SWDS
Measured/calculated/ default	-
Source of data	- Original design of the landfill. - Technical specifications for the management of the SWDS. - Local or national regulations.
Value(s) of monitored parameter	There was no change in the management of the solid waste disposal site.
Monitoring equipment	Project participants should refer to the original design of the landfill to ensure that any practice to increase methane generation have been occurring prior to the implementation of the project activity. Any change in the management of the SWDS after the implementation of the project activity should be justified by referring to technical or regulatory specifications.
Measuring/reading/recording frequency	Annually
Calculation method (if applicable)	-

QA/QC procedures	-
Purpose of data/parameter	Calculation of baseline emissions
Additional comments	-

Data and parameter monitored, table 2

Data/Parameter	$Op_{j,h}$
Unit	-
Description	Operation of the equipment that consumes the LFG
Measured/calculated/ default	measured
Source of data	Project participants
Value(s) of monitored parameter	Large amount of data, see CER calculation spreadsheets
Monitoring equipment	In the context of the proposed project activity, equipment unit *j* using *the LFG* consists of the LFG upgrading facility and flares. Hence, the following parameters are to be used to ensure that the plant is operating in hour *h*: *For the electricity generation facility* - Products generated. Monitoring of electricity dispatched to the grid according to local utility. *For the flaring system* - Temperature: according to the manufacturer's technical record, the combustion temperature varies from 1,000 to 1,200°C. Temperature shall varies between this range. $Op_{j,h}$ = 0 when: - No products are generated in the hour h - Flame is not detected continuously in hour *h* (instantaneous measurements are made at least every minute); Otherwise, $Op_{j,h}$=1
Measuring/reading/recording frequency	Hourly
Calculation method (if applicable)	-
QA/QC procedures	Flow meters and flame detectors shall be subject to a regular maintenance and testing regime to ensure accuracy. Calibration shall be according to manufacturers' specifications. Accuracy of the electricity meters and flame detectors are described in the monitoring tables of respective parameters.
Purpose of data/parameter	Calculation of baseline emissions

Additional comments	This is monitored to ensure methane destruction is claimed for methane used to generate electricity when the power plant is operational.

Data and parameter monitored, table 3

Data/Parameter	$EG_{PJ,y}$
Unit	MWh
Description	Net amount of electricity generated using LFG in year y
Measured/calculated/ default	-
Source of data	PLC data records
Value(s) of monitored parameter	Large amount of data, see CER calculation spreadsheets
Monitoring equipment	The data is measured by electricity meters installed at the project site and local substation. Data is continuously monitored and hourly recording. AES Eletropaulo sends the registered data for the project participants. Double-check of electricity dispatched is conducted between SJ's PLC data records and AES Eletropaulo's system to identify possible discrepancies. However, data from AES Eletropaulo is always used for invoice purposes and, therefore, it is considered for calculation of emission reductions. To determine the SJ's electricity generation and dispatch to the grid, AES Eletropaulo readings will be proportionally accounted based on the CH_4 mass balance from CTL and SJ. No emission reductions will be claimed (neither in flaring nor in power generation) from the use of LFG purchased from CTL.
Measuring/reading/recording frequency	Continuous
Calculation method (if applicable)	-
QA/QC procedures	Electricity meters are subjected to regular maintenance and testing to ensure accuracy following the procedures from the National Electric System Operator ("ONS" from the Portuguese Operador Nacional do Sistema Elétrico), sub-module 12.3. Currently, calibration is conducted at every 5 years and will be changed in case of any future revisions from ONS. The accuracy of the equipment, as per the manufacturer specification is 0.2S (accuracy class 0.2%).
Purpose of data/parameter	Calculation of baseline emissions

Additional comments	In accordance with ACM0001, this parameter is equivalent to *ECBL,k,y* in the tool. For ex-ante estimative, the amount of LFG collected and forwarded to the power plant was used to calculate the electricity generated during the crediting period. During periodic verifications, this parameter is to be directly measured using electricity meter.

TOOL08: "Tool to determine the mass flow of a greenhouse gas in a gaseous stream"

Data and parameter monitored, table 4

Data/Parameter	$V_{t,db}$
Unit	m^3 dry gas/h
Description	Volumetric flow of the gaseous stream in time interval *t* on a dry basis
Measured/calculated/ default	-
Source of data	PLC data records
Value(s) of monitored parameter	Large amount of data, see CER calculation spreadsheets
Monitoring equipment	Data is continuously measured by flow meters located in flares and generators. Measurements of the flow are recorded electronically by PLC for each minute and aggregated for control and ER purposes. Flow meters are detailed below. In case of any failure, flow meters will be replaced.

Meter	Measurement	Manufacturer	Accuracy (%)	Calibration freq.
FIT 524	Flow flare F520	Endress+Hauser	1.5	5 years
FIT 544	Flow flare F540	Endress+Hauser	1.5	5 years
FIT 564	Flow flare F560	Endress+Hauser	1.5	5 years
FIR 500	Total gas to flares – cross check	Incontrol	1.0	5 years
FIR 800	Total gas to engines	Incontrol	1.0	5 years
FIR 600	Total gas to gas station	Incontrol	1.0	5 years
FIT 910	CTL flow – principal	Incontrol	1.0	5 years
FIT 901	CTL flow - backup	Incontrol	1.0	5 years

Measuring/reading/recording frequency	Measured
Calculation method (if applicable)	-
QA/QC procedures	Flow meters are subjected to a regular maintenance and testing regime to ensure accuracy in compliance with national laws. Regular maintenance is made following general guidelines from the manufacturer. - Monitoring under responsibility of the BLFGE Manager. - Automatic readings of temperature and pressure are made by sensors/transmitters connected to the flowmeter; data is used to convert the gas-flow to Nm3, thus no separate monitoring of pressure and temperature is necessary. - In case of frequent failure or high discrepancy readings, equipment will be displaced. Periodic calibration provided by an independent accredited laboratory and according to manufacturers' recommendations. To determine the amount of LFG generated, CTL's landfill gas will be discounted from the total LFG based on meter flow measurements. No emission reductions will be claimed (neither in flaring nor in power generation) from the use of LFG purchase from CTL. Also, discount factors will be adopted as determined in Appendix 7. Invoices can be used for cross checking purposes, if applicable.
Purpose of data/parameter	Calculation of baseline emissions
Additional comments	This parameter is used to determine the flow of methane in the LFG sent to the electricity generation facility ($F_{CH4,EL,y}$) and sent to the enclosed flares ($F_{CH4,flared,y}$).

Data and parameter monitored, table 5

Data/Parameter	$V_{i,t,dp}$
Unit	m^3 gas *i*/m^3 dry gas
Description	Volumetric fraction of greenhouse gas *i* in a time interval *t* on a dry basis
Measured/calculated/ default	-
Source of data	PLC data records
Value(s) of monitored parameter	Large amount of data, see CER calculation spreadsheets

<table>
<tr><td>Monitoring equipment</td><td>
There are three methane analyzers: CTL, SJ and CTL+SJ. CTL's methane analyzer is under CTL's responsibility, including its maintenance and calibration as established in its monitoring plan. Methane measurement equipment of SJ (GEM2000) and CTL+SJ (A100) are under SJ's responsibility as well as their calibration.
<table>
<tr><th>Meter</th><th>Manufacturer</th><th>Measurement</th><th>Accuracy (%)</th><th>Calibration freq.</th></tr>
<tr><td>GEM2000</td><td>Landtec</td><td>Gas analyzer (SJ)</td><td>3.0</td><td rowspan="2">Weekly by the project developer.
Yearly by a third-party company.</td></tr>
<tr><td>FIT 910</td><td>Rosemount – NUK</td><td>Gas analyzer (SJ + CTL)</td><td>1.0</td></tr>
<tr><td>FIT 901</td><td>Landtec</td><td>Gas analyzer (CTL)</td><td>1.0</td><td>Yearly by CTL</td></tr>
</table>
GEM2000 is not a fixed meter and, therefore, SJ's methane is measured by sampling: conducted 3 times a day and daily average is considered for cross-checking purposes. Also, uncertainty of GEM2000 is higher (+/- 3.0%) when compared to A100 analyzer (1.0%). Therefore, GEM2000 will be used for cross-checking purposes only and A100 will be used for emission reductions calculation. Both A100 from SJ and CTL's analyzer measurements are continuous and integrated once per minute.
To determine baseline emissions from the SWDS, only SJ's methane will be accounted based on the flow and concentration measurements (mass balance). No emission reductions will be claimed (neither in flaring nor in power generation) from the use of LFG purchase from CTL. Additionally, discount factors will be adopted as determined in Appendix 7.
</td></tr>
<tr><td>Measuring/reading/recording frequency</td><td>Continuous for CTL and CTL+SJ methane analyzers
Sampling for cross-checking SJ methane analyzer</td></tr>
<tr><td>Calculation method (if applicable)</td><td>-</td></tr>
<tr><td>QA/QC procedures</td><td>Gas analyzers are subjected to a regular maintenance and testing regime to ensure accuracy. In case of frequent failure or high discrepancy readings, they will be replaced.</td></tr>
<tr><td>Purpose of data/parameter</td><td>Calculation of baseline emissions</td></tr>
<tr><td>Additional comments</td><td>This parameter is used to determine the flow of methane in the LFG sent to the electricity generation facility ($FCH4,EL,y$).</td></tr>
</table>

Data and parameter monitored, table 6

Data/Parameter	***Tt***
Unit	°C
Description	Temperature of the gaseous stream in time interval t

Measured/calculated/ default	-
Source of data	PLC data records
Value(s) of monitored parameter	Large amount of data, see CER calculation spreadsheets
Monitoring equipment	Instruments with recordable electronic signal (analogical or digital).
Measuring/reading/recording frequency	Continuous
Calculation method (if applicable)	-
QA/QC procedures	During verification, it will be confirmed that all parameters are converted to normal conditions during the monitoring process.
Purpose of data/parameter	Calculation of baseline emissions
Additional comments	Applicability condition while applying option b) of *TOOL08* (gaseous stream flow temperature below 60ºC).

Data and parameter monitored, table 7

Data/Parameter	***Status of LFG destruction device***
Unit	-
Description	Operational status of LFG destruction devices
Measured/calculated/ default	Measured
Source of data	PLC data records
Value(s) of monitored parameter	Large amount of data, see CER calculation spreadsheets
Monitoring equipment	Monitoring and documenting is undertaken by recording the energy production from methane captured or the operation of the flare by means of a flame detector and thermocouples to demonstrate the actual destruction of methane. Emission reductions will not accrue for periods in which the destruction device is not operational.
Measuring/reading/recording frequency	Continuous
Calculation method (if applicable)	-

QA/QC procedures	Thermocouple's calibration will be provided during verification in order to demonstrate that flares are operating properly.
Purpose of data/parameter	Calculation of baseline emissions
Additional comments	For Flame detector devices refer to TOOL06

TOOL06: "Project emissions from flaring"

Data and parameter monitored, table 8

Data/Parameter	$T_{EG,m}$
Unit	°C
Description	Temperature in the exhaust gas of the enclosed flare in minute m
Measured/calculated/ default	-
Source of data	PLC data records
Value(s) of monitored parameter	Large amount of data, see CER calculation spreadsheets
Monitoring equipment	Data is measured by thermocouples installed in each flare and the reading frequency is continuously. Measurements of the temperature of the exhaust gas are recorded electronically by PLC at least each minute. Data is archived electronically. In case of frequent failure or high reading discrepancy, it will be displaced.
Measuring/reading/recording frequency	Continuous
Calculation method (if applicable)	-
QA/QC procedures	Temperature measurement equipment should be replaced or calibrated in accordance with their maintenance schedule. Thermocouple respects the demands from Standard EN 60584. In case of failure, they will be replaced accordingly.
Purpose of data/parameter	Calculation of baseline emissions
Additional comments	-

Data and parameter monitored, table 9

Data/Parameter	$Flame_m$
Unit	Flame on or flame off
Description	Flame detection of flare in the minute m

Measured/calculated/ default	-
Source of data	PLC data records
Value(s) of monitored parameter	Large amount of data, see CER calculation spreadsheets
Monitoring equipment	According to the operating manual from the flare manufacturer, there is a UV sensor and a burner control unit for automatic ignition and flame monitoring. The UV-sensor detects the flame and gives a signal to the automatic control burner. As soon as the flame has been burning for a given retention time, the automatic burner control opens the main gas valve. Then, valve that controls the flow of gas sent to flare enclosure automatically closes whenever no flame is detected by sensors.
Measuring/reading/recording frequency	Once per minute. Detection of flame recorder as a minute that the flame was on, otherwise recorded as a minute that the flame was off depending on the flow of gas inside the flare enclosure.
Calculation method (if applicable)	-
QA/QC procedures	No calibration is required. Nonetheless, due to safety reasons, tests are conducted to ensure the sensor of the valve is functioning well.
Purpose of data/parameter	Calculation of baseline emissions
Additional comments	-

Data and parameter monitored, table 10

Data/Parameter	$\textit{\textbf{Maintenance}}_y$
Unit	Calendar dates
Description	Maintenance events completed in year y
Measured/calculated/ default	-
Source of data	Project participants
Value(s) of monitored parameter	Maintenance events carried out regularly (records/evidences of events supplied during verification)
Monitoring equipment	Record the date that maintenance events were competed in year y. Records of maintenance logs must 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.
Measuring/reading/recording frequency	Annual

Calculation method (if applicable)	-
QA/QC procedures	Records must be kept in a maintenance log for two years beyond the life of the flare.
Purpose of data/parameter	Monitoring of this parameter is required for the case of enclosed flares and the project participant selects Option B to determine the flare efficiency. These dates are required so that they can be compared to the maintenance schedule to check that maintenance events were completed within the minimum time between maintenance events specified by the manufacturer ($SPEC_{flare}$).
Additional comments	-

TOOL07: "Tool to calculate the emission factor for an electricity system"

Data and parameter monitored, table 11

Data/Parameter	$EF_{grid,OM,y}$
Unit	tCO_2/MWh
Description	Simple adjusted operating margin CO2 emission factor in year y
Measured/calculated/ default	Calculated
Source of data	The Brazilian DNA. Official source of data
Value(s) of monitored parameter	<table><tr><td>Year</td><td>EF_{BM} (tCO_2/MWh)</td><td>EF_{OM} (tCO_2/MWh)</td><td>EF_{CM} * (tCO_2/MWh)</td></tr><tr><td>2012</td><td>0.2010</td><td>0.4185</td><td>0.3098</td></tr><tr><td>2013</td><td>0.2713</td><td>0.4653</td><td>0.3683</td></tr><tr><td>2014</td><td>0.2963</td><td>0.5224</td><td>0.4094</td></tr></table>
Monitoring equipment	According to TOOL07.
Measuring/reading/recording frequency	Annually
Calculation method (if applicable)	-
QA/QC procedures	Official source of data
Purpose of data/parameter	Calculation of baseline emissions
Additional comments	For methodological choices details, please refer to section B.6.1.

TOOL05: "*Baseline, project and/or leakage emissions from electricity consumption and monitoring of electricity generation*"

Data and parameter monitored, table 12

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	calculated
Source of data	Local measurements and Eletropaulo's records
Value(s) of monitored parameter	Eletropaulo 2012 11.06% Eletropaulo 2013 10.05% Eletropaulo 2014 9.06%
Monitoring equipment	Historically measured difference between measurements conducted at the site and in the Eletropaulo substation, or official source of data.
Measuring/reading/recording frequency	Annually. In the absence of data from the relevant year, most recent figures should be used, but not older than 5 years.
Calculation method (if applicable)	-
QA/QC procedures	During verification, it will be confirmed that all parameters are converted to normal conditions during the monitoring process.
Purpose of data/parameter	Calculation of baseline emissions
Additional comments	Conservatively this figure is also used for $TDL_{i,y}$ when calculation project emissions due to electricity consumption from the diesel generator.

Data and parameter monitored, table 13

Data/Parameter	***$EC_{PJ,y}$***
Unit	MWh
Description	Quantity of electricity consumed by the project electricity consumption source j in year y
Measured/calculated/ default	measured
Source of data	PLC data records
Value(s) of monitored parameter	Large amount of data, see CER calculation spreadsheets

Monitoring equipment	The electricity consumed by the plant is monitored through hours of operation from generator while applying the maximum output capacity of the generator 400kW, as a volume meter is not usual given the little consumption and capacity of generator. While adopting the maximum oil consumption capacity (110,6l/h) from manufacturer's specification, and applying diesel oil NCV and EF, it results in lower project emissions than when considering the installed capacity. Therefore, the approach considered by the PP is very conservative. Manufacturer: ABB Type: MGE 144 Accuracy class: 0.5% Calibration frequency: 5 years
Measuring/reading/recording frequency	The reading frequency from the electricity meter is continuously and the recording frequency is hourly.
Calculation method (if applicable)	-
QA/QC procedures	As there is no diesel volume meter, 1.3tCO2e/MWh default value is used to calculate PE emissions. Calculated as per the "Tool to calculate baseline, project and/or leakage emissions from electricity consumption".
Purpose of data/parameter	Calculation of baseline emissions
Additional comments	The project has one backup diesel generator in case of power supply interruption located at the landfill. Generator is not used for electricity generation to the grid.

D.3. Implementation of sampling plan

Not applicable.

SECTION E. Calculation of emission reductions or net anthropogenic removals

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

Baseline Emissions (BE_y)

Baseline emissions for the proposed project activity are determined according to Equation 2.

$$BE_y = BE_{CH4,y} + BE_{EC,y} + BE_{HG,y} + BE_{NG,y} \quad \textbf{Equation 2}$$

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)

$BE_{HG4,y}$ = Baseline emissions associated with heat generation in year y (tCO_2/yr)

$BE_{NG,y}$ = Baseline emissions associated with natural gas use in year y (tCO_2/yr)

Baseline emissions associated with heat generation in year y ($BE_{HG,y}$) and natural gas use in year y ($BE_{NG,y}$) are not applicable to the proposed project activity.

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

Baseline emissions of methane from the SWDS are determined, based on the amount of methane captured under the project activity and the amount that would be captured and destroyed in the baseline. In addition, the effect of methane oxidation, present in the baseline scenario but absent in the project scenario, is considered[11].

$$BE_{CH4,y} = \left(\left(1 - OX_{top\_layer}\right) \times F_{CH4,PJ,y} - F_{CH4,BL,y}\right) \times GWP_{CH4} \quad \textbf{Equation 3}$$

Where:

$BE_{CH4,y}$ = Baseline emissions of methane from the SWDS in year y ($t\ CO_2e/yr$)

OX_{top_layer} = Fraction of methane in the LFG that would be oxidized in the top layer of the SWDS in the baseline (dimensionless)

$F_{CH4,PJ,y}$ = Amount of methane in the LFG which is flared and/or used in the project activity in year y ($t\ CH_4/yr$)

$F_{CH4,BL,y}$ = Amount of methane in the LFG that would be flared in the baseline in year y ($t\ CH_4/yr$)

GWP_{CH4} = Global warming potential of CH_4 ($t\ CO_2e/t\ CH_4$)

Ex post determination of flared methane in LFG ($F_{CH4,PJ,y}$)

During the crediting period, $F_{CH4,PJ,y}$ is determined as the sum of the quantities of methane flared and used in power plant(s), boiler(s), air heater(s), glass melting furnace(s), kiln(s) and natural gas distribution, as follows:

$$F_{CH4,PJ,y} = F_{CH4,flared,y} + F_{CH4,EL,y} + F_{CH4,HG,y} + F_{CH4,NG,y} \quad \textbf{Equation 4}$$

[11] Low operating cost and must run resources typically include hydro, geothermal, wind, low-cost biomass, nuclear and solar generation.

Where:

$F_{CH4,PJ,y}$ =	Amount of methane in the LFG which is flared and/or used in the project activity in year *y* (t CH_4/yr)
$F_{CH4,flared,y}$ =	Amount of methane in the LFG which is destroyed by flaring in year *y* (t CH_4/yr)
$F_{CH4,EL,y}$ =	Amount of methane in the LFG which is used for electricity generation in year *y* (t CH_4/yr)
$F_{CH4,HG,y}$ =	Amount of methane in the LFG which is used for heat generation in year *y* (t CH_4/yr)
$F_{CH4,NG,y}$ =	Amount of methane in the LFG which is sent to the natural gas distribution network and/or dedicated pipeline and/or to the trucks in year *y* (t CH_4/yr)

In the case of the project activity, $F_{CH4,HG,y}$ = $F_{CH4,NG,y}$ = 0, since the project activity neither generates heat nor distributes natural gas. Therefore, $F_{CH4,PJ,y} = F_{CH4,flared,y} + F_{CH4,EL,y}$.

A discount factor shall be applied in monitored $F_{CH4,PJ,y}$ based on equipment accuracy. Then, 1.0% accuracy of methane analyzer and 1% gas flow to generators shall be discounted to calculate $F_{CH4,EL,y}$; 1.0% accuracy of methane analyzer and analyzer and 1.5% discount on gas flow to flares shall be applied to calculate $F_{CH4,flared,y}$ (refer to item B.2.5).

According to ACM0001, $F_{CH4,EL,y}$ shall be determined using TOOL08 and monitoring the working hours of the power plant(s), boiler(s), air heater(s), glass melting furnace(s) and kiln(s), so that no emission reduction are claimed for methane destruction during non-working hours. This is considered by monitoring the hours that the equipment utilizing the LFG is operating in year *y* ($Op_{j,h,y}$), as follows:

(a) As per the gaseous stream tool, if the LFG is used for multiple purposes (e.g., flaring or energy generation), and all methane destruction devices are verified to be operational (e.g., by means of flame detectors records, energy generated), a single flow meter may be used to record the flow into multiple destruction devices. The destruction efficiency of the least efficient among the destruction devices shall be used as the destruction efficiency for all destruction devices monitored by this flow meter. If there are any periods for which one or more destruction devices are not operational, paragraph 5 (a) and (b) of the Appendix of the "Tool to determine the mass flow of a greenhouse gas in a gaseous stream" tool shall be followed.

(b) CH_4 is the greenhouse gas for which the mass flow should be determined.

(c) The flow of the gaseous stream should be measured on continuous basis.

(d) The simplification offered for calculating the molecular mass of the gaseous stream is valid (equations 3 or 17 in the tool); and

(e) The mass flow will be summed to a yearly unit basis (tCH4/yr)

For calculating $F_{CH4,EL,y}$, Option A of the Tool has been selected (i.e., volume flow measured in dry basis and volumetric fraction measured in dry basis).

The demonstration that the gaseous stream is dry follows alternative b) of the tool is used since it is forecasted that the temperature of the gaseous stream (T_t) is less than 60°C (333.15 K) at the flow measurement point.

The mass flow of greenhouse gas *i* ($F_{i,t}$) is determined as follows:

$$F_{i,t} = V_{t,db} \times V_{i,t,db} \times \rho_{i,t} \quad \textbf{Equation 5}$$

$$\rho_{i,t} = (P_t \times MM_i) \div (R_u \times T_t) \quad \textbf{Equation 6}$$

Where:

$F_{i,t}$ = Mass flow of CH_4 in the gaseous stream (gas sent to electricity generation facility) in time interval *t* (kg gas/h)

$V_{t,db}$ = Volumetric flow of the gaseous stream in time interval *t* on a dry basis (m^3 dry gas/h) – of the gas sent to electricity generation facility

$v_{i,t,db}$ = Volumetric fraction of CH_4 in the gaseous stream in time interval *t* on a dry basis (m^3 gas *i*/m^3 dry gas)

$\rho_{i,n}$ = Density of CH_4 in the gaseous stream in time interval t (kg gas *i*/m^3 gas *i*)

P_t = Absolute pressure of the gaseous stream in time interval t (Pa)

T_t = Temperature of the gaseous stream in time interval t (K)

MM_i = Molecular mass of CH_4 (kg/kmol)

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

The flow meters installed convert automatically the volumetric flow of the gaseous stream from actual conditions to normal conditions of temperature and pressure.

It is important mentioning that the amount of LFG and methane from CTL will be discounted from the emission reduction calculation to avoid double counting. Therefore, the total methane measurement sent to flares and engines will be discounted proportionally to the measurement of methane collected by CTL.

Amount of methane destroyed by flaring ($F_{CH4,flared,y}$)

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

$$F_{CH4,flared,y} = F_{CH4,sent\_flare,y} - (PE_{flare,y} \div GWP_{CH4}) \quad \textbf{Equation 7}$$

Where:

$F_{CH4,flared,y}$ = Amount of methane in the LFG which is destroyed by flaring in year *y* (t CH_4/yr)

$F_{CH4,sent\_flare,y}$ = Amount of methane in the LFG which is sent to the flare in year *y* (t CH_4/yr)

$PE_{flare,y}$ = Project emissions from flaring of the residual gas stream in year *y* (t CO_2e/yr)

GWP_{CH4} = Global warming potential of CH_4 (t CO_2e/t CH_4)

$F_{CH4,sent\_flare,y}$ is determined directly using *TOOL08* and will be performed separately for each flare, which the sum will be used for emission reductions calculation.

Similarly to the option used to determine $F_{CH4,EL,y}$, $F_{CH4,sent\_flare,y}$ is calculated using "option A" of the Tool is selected (*i.e.*, volume flow measured in dry basis and volumetric fraction measured in dry basis).

Hence, the mass flow of greenhouse gas *i* ($F_{i,t}$) is determined using Equation 5 and Equation 6, considering the flow of gas sent to the enclosed flares.

Project Emissions from flaring ($PE_{flare,y}$)

Project emissions from flaring are related to the amount of methane not destroyed in the flares and will be calculated according to *TOOL06*.

As LFG is flared through more than one flare, $PE_{flare,y}$ is the sum of the emissions for each flare.

The project has installed enclosed flares and efficiency will be calculated from monitored data. The calculation of flare efficiency will be made by the following steps.

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

The mass flow of methane in the residual gaseous stream in the minute *m* ($F_{CH4,m}$) will be determined using the procedures set out by *TOOL08*, the following requirements apply:

- The gaseous stream tool shall be applied to the residual gas.
- The flow of the gaseous stream shall be measured continuously.
- CH_4 is the greenhouse gas *i* for which the mass flow should be determined.
- The simplification to calculate 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. Please note that this parameter corresponds to $F_{CH4,sent\_flare,y}$. Therefore, the same methodological approaches apply to both parameters (Option A of the tool). Data is collected in a 1-minute interval as required by the tool.

STEP 2: Determination of flare efficiency

The project has installed enclosed flares and “option A” will be used. The flare efficiency for the minute m ($\eta_{flare,m}$) is 90% when the following two conditions are 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; and
2. The flame is detected in minute m ($Flame_m$).

Otherwise, flare efficiency is set to 0%.

The tool also requires that low height flares shall be adjusted, as a conservative approach, by subtracting 0.1 from the efficiency. According to definitions from the tool, a low height flare is an enclosed flare for which the flame enclosure has a height between 10 and two times the diameter of the enclosure.

Since the project flares have 2.069m diameter and 8.126 m height, its height is between the indicated range (2 x 3.098m = 6.196m and 10 x 3.098m = 30,980m). Therefore, the project flares are classified as low height flares and efficiency to be used is 80%, *i.e.*, 90% by default minus 10% discount for low height flares.

STEP 3: Calculation of project emissions from flaring

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

$$PE_{flare,y} = GWP_{CH4}\ X \sum_{m=1}^{525600} F_{CH4,RG,m} \cdot \left(1-\eta_{flare,m}\right) X\ 10^{3}$$ **Equation 8**

Where:

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

Methane that would have been captured and destroyed in the baseline ($F_{CH4,BL,y}$)

NBR 13896/97, the technical standard of ABNT (acronym from the Portuguese “Associação Brasileira de Normas Técnicas”, in free translation, Brazilian Association of Technical Standards, founding member of ISO), sets out the requirements for the development design, implementation and, operation of landfills, aiming at minimizing gaseous emissions and promoting its capture and correct management. However, its use is not mandatory and the norm neither specifies the amount of methane to be destroyed nor the system that shall be put in place. In addition, there is no federal/state/local law requiring the destruction of the methane.

Previously to the implementation of the proposed CDM Project Activity there was a passive system and methane was burned in an uncontrolled manner (Figure 8).

Hence, in the case of SJ, "*case 3*" of ACM0001 is applicable (*i.e.,* there is no technical requirement to destroy methane and there was an existing LFG capture and destruction system).

Figure 7 – Project site before the implementation of the CDM project activity

Since there is no monitored or historical data on the amount of methane that was captured in the year prior to the implementation of the project, the following equation applies:

$$F_{CH4,BL,sys,y} = 0.2\ x\ F_{CH4,PJ,y}$$ **Equation 9**

Where:

$F_{CH4,BL,sys,y}$ =	Amount of methane in the LFG that would be flared in the baseline in year *y* for the case of an existing LFG capture system (t CH_4/yr)
$F_{CH4,PJ,y}$ =	Amount of methane in the LFG which is captured in the project activity in year *y* (t CH_4/yr)

Baseline emissions associated with electricity generation ($BE_{EC,y}$)

The baseline emissions associated with electricity generation in year *y* ($BE_{EC,y}$) shall be calculated using *TOOL05*, as follows:

- 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* ($EG_{PJ,y}$).

Considering the approach provided by the tool, baseline emissions are then calculated using the generic approach based on the quantity of electricity dispatched into the national electricity system, emission factor for electricity generation and, a factor to account transmission losses.

$$BE_{EC,y} = \sum EC_{BL,k,y} \ x \ EF_{EL,k,l} \ x \ (1 + TDL_{k,y})$$ **Equation 10**

Where:

$EC_{BL,k,y}$ =	Net amount of electricity generated using LFG in year *y* (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

The Emission Factor is calculated according to *TOOL07.* The Tool considers the determination of the emission factor for the grid to which the project activity is connected as the core data to be determined in the baseline scenario. Thus, $EF_{EL,k,,y} = EF_{grid,CM,y}$.

The Emission Factor is calculated as the *Combined Margin (CM)*, comprised by two components: the *Build Margin (BM)* and the *Operation Margin (OM)*. The BM evaluates the contribution of the power plants which would have been built if the project plant would not have been implemented. The OM evaluates the contribution of the power plants which would have been dispatched in the absence of the project activity.

TOOL07 presents the following steps to calculate the Emission Factor:

EF calculation, STEP 1 - Identify the relevant electricity systems

According to the tool, "If the DNA of the host country has published a delineation of the project electricity system and connected electricity systems, these delineations should be used. If such delineations are not available, project participants should define the project electricity system and any connected electricity system and justify and document their assumptions in the CDM-PDD".

The Brazilian DNA published Resolution #8, issued on 26/05/2008, defines the SIN a single system that covers all the five macro-geographical regions of the country (North, Northeast, South, Southeast and Midwest).

EF calculation, STEP 2 – Choose whether to include off-grid power plants in the project electricity system (optional).

Option I of the tool is chosen, off-grid power plants are <u>not</u> included in the project electricity system.

EF calculation, STEP 3 - Select a method to determine the operating margin (OM).

The calculation of the operating margin emission factor ($EF_{grid,OM,y}$) is based on one of the following methods:

(a) Simple OM, or

(b) Simple adjusted OM, or

(c) Dispatch data analysis OM, or

(d) Average OM.

The simple operating margin, method (a), can only be used where low-cost/must-run resources[12] constitute less than 50% of total grid generation in: 1) average of 5 most recent years, or 2) based on long-term normal hydroelectricity production, not applicable in the case of the SIN.

The fourth alternative, method (d), an average operating margin, is an oversimplification and does not reflect in any way the impact of the project activity on the operating margin, also not applicable.

Methods (b) and (c) are applicable, but the dispatch data analysis method requires time and resources consuming hourly monitoring of electricity and, therefore, to reduce data demand, method (b), simple adjusted operating margin, is applied chosen.

The Brazilian DNA regularly publishes applicable emission factors calculated in accordance with TOOL07[13]. Therefore, the ex-post data vintage is considered, i.e., $EF_{grid,OM,y}$, $EF_{grid,BM,y}$ will be directly sourced from the Brazilian DNA (steps 4 and 5).

In terms of vintage of data for BM, Project Participants can choose between one of the following two options:

- Option 1: For the first crediting period, calculate the build margin emission factor ex ante based on the most recent information available on units already built for sample group m at the time of CDM-PDD submission to the DOE for validation. For the second crediting period, the build margin emission factor should be updated based on the most recent information available on units already built at the time of submission of the request for renewal of the crediting period to the DOE. For the third crediting period, the build margin emission factor calculated for the second crediting period should be used. This option does not require monitoring the emission factor during the crediting period.
- Option 2: For the first crediting period, the build margin emission factor shall be updated annually, ex-post, including those units built up to the year of registration of the project activity or, if information up to the year of registration is not yet available, including those units built up to the latest year for which information is available. For the second crediting period, the build margin emissions factor shall be calculated ex-ante, as described in “option 1”. For the third crediting period, the build margin emission factor calculated for the second crediting period should be used.

Project Participants select option 1, *i.e.*, the *ex-ante* data vintage based on the build margin emission factor made available by the Brazilian DNA.

Emission factor STEP 6 – Calculate the combined margin (CM) emissions factor

The calculation of the combined margin (CM) emission factor is based on one of the following methods:

(a) Weighted average CM; or

(b) Simplified CM.

[12] Low operating cost and must run resources typically include hydro, geothermal, wind, low-cost biomass, nuclear and solar generation.

[13] Most recent available emission factors calculated according to methods (b), (c) and (d) are available at URL: https://www.gov.br/mcti/pt-br/acompanhe-o-mcti/cgcl/clima/paginas (accessed on January 2022).

Since power grid is not located in LDC/SIDs/URC and the weighted average CM method (option A) is the preferred option, this method was considered. The combined margin emissions factor is calculated as follows:

$$EF_{grid,CM,y} = EF_{grid,OM,y}\ x\ w_{OM} + EF_{grid,BM,y}\ x\ w_{BM}$$ **Equation 11**

Where:

$EF_{grid,BM,y}$ = Build margin CO_2 emission factor in year y (tCO_2/MWh)

$EF_{grid,OM,y}$ = Operating margin CO_2 emission factor in year y (tCO_2/MWh)

w_{OM} = Weighting of operating margin emissions factor (%)

w_{BM} = Weighting of build margin emissions factor (%)

According to TOOL07, values adopted for w_{OM} and w_{BM} are 0.5 and 0.5 for the first crediting period and, 0.25 and 0.75 for the second crediting period, respectively.

See appendix 1 for sample calculations for all formulae used to calculate baseline GHG emissions, applying actual values. Spreadsheets to the monitoring present full calculations for this monitoring period.

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

Project emissions are calculated as follows:

$$PE_y = PE_{EC,y} + PE_{FC,y} + PE_{DT,y} + PE_{SP,y}$$ **Equation 12**

Where:

PE_y = Project emissions in year *y* (t CO2/yr)

$PE_{EC,y}$ = Emissions from consumption of electricity due to the project activity in year *y* (t CO2/yr)

$PE_{FC,y}$ = Emissions from consumption of fossil fuels due to the project activity, for purpose other than electricity generation, in year *y* (t CO2/yr)

$PE_{DT,y}$ = Emissions from the distribution of compressed/liquefied LFG using trucks, in year y (t CO2/yr)

$PE_{SP,y}$ = Emissions from the supply of LFG to consumers through a dedicated pipeline, in year y (t CO2/yr)

$PE_{FC,y}$, $PE_{DT,y}$ and $PE_{SP,y}$ are not applicable to the proposed project activity. During the crediting period, electricity from a diesel generator may be consumed whenever the electricity generation facility stops and, for emergency purposes.

Emissions from consumption of electricity due to the project activity ($PE_{EC,y}$)

Project emissions from electricity consumption ($PE_{EC,y}$) will be calculated following the procedures set out by *TOOL05*. Project emissions from consumption of electricity from the diesel generator are calculated based on the electricity consumed by the project activity and, in the case of the project activity, a conservative default value for the emission factor (1.3tCO2/MWh), adjusted for transmission losses as follows:

$$PE_{EC,j,y} = \sum_{j} EC_{PJ,j,y} \; x \; EF_{EL,j,y} \; x \; (1 + TFL_{j,y})$$ **Equation 13**

Where:

$PE_{EC,j,y}$ = Project emissions from electricity consumption from source j by the project activity during the year *y* (tCO2/year);

$EC_{PJ,y}$ = Quantity of electricity consumed by the project electricity consumption source *j* in year *y* (MWh)

$EF_{EL,j,,y}$ = Emission factor for electricity generation for source *j* in year (tCO2/MWh)

$TDL_{j,y}$ = Average technical transmission and distribution losses for providing electricity to source *j* in year *y*

j = Sources of electricity consumption in the project

Electricity sources *j* corresponds to all the sources of electricity consumed for the operation of the LFG capture system and transportation of the LFG to the flares.

Since the diesel generator is located inside SJ, there are no transmission losses and, therefore, *TDLj, y* is zero, unlike baseline emissions which *TDL* is based on the power utility losses.

See appendix 1 for sample calculations for all formulae used to calculate project GHG emissions, applying actual values. Spreadsheets to the monitoring report present full calculations for this monitoring period.

E.3. Calculation of leakage emissions

According with ACM0001 there is no need to account for leakage.

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

Emission reductions will be calculated applying Equation 14.

$$ER_y = BE_y - PE_y$$ **Equation 14**

Where:

ER_y = Emission reductions during the year *y* (tCO2e)

BE_y = Baseline emissions in year *y* (tCO2e)

PE_y = Project emissions in year *y* (tCO2e)

	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	275,961	193	0	88,674	187,094	0	275,768

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)
275,768	268,569[14]

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

The calculation of the estimated ex ante emission reductions for this monitoring report in the registered PDD has a few errors. For example, a) the total emission reductions estimated for the year 2012 is calculated with baseline emissions for only 7 months, and b) the calculation of the baseline emissions for the year 2014 is correctly calculated only up to 21/05/2014, but the same share is applied again in the total emission reductions. For that reason, the PPs submit with the

[14] See section E.5.1

present monitoring report a revised version of the emission reductions spreadsheet used in the renewal of the crediting period.

Table 4 displays the revised estimated ex ante emission reductions in the CERs calculation spreadsheet submitted with the registered PDD.

Table 4 – Estimated and achieved emission reductions in the monitoring period

Project activity: São João Landfill Gas to Energy (Ref. # 0373)

Monitoring period: 16/05/2012 to 21/05/14 (both days included)

year	from	to	days	share of days in year
2012	16-May-12	31-Dec-12	230	63.0%
2013	01-Jan-13	31-Dec-13	365	100.0%
2014	01-Jan-14	21-May-14	141	38.6%
Estimated ERs in the registered PDD		→→→→→→→	Estimated ERs in the monitoring period	
year	total		year	total
2012	91,634		2012 (from 16-May)	57,742
2013	129,685		2013	129,685
2014 (up to 24-May)	15,089		2014 (up to 24-May)	15,089
Total	**236,408**		**Total**	**202,516**
Revised estimated ERs		→→→→→→→	Revised estimated ERs in the monitoring period	
year	total		year	total
2012	157,108		2012 (from 16-May)	99,000
2013	129,685		2013	129,685
2014 (up to 24-May)	39,885		2014 (up to 24-May)	39,885
Total	**326,678**		**Total**	**268,569**
			Achieved ERs in the monitoring period	
			year	total
			2012 (from 16-May)	88,674
			2013	135,790
			2014 (up to 24-May)	51,304
			Total	**275,768**
			difference = (estim. - achiev.) ÷ estim. =	2.7%

E.6. Remarks on increase in achieved emission reductions

Achieved emission reductions is only 2.7% higher than the estimated. The increase is reasonable and acceptable, considering the improved experience and capacity of personal and, the complex operational variables and nature of the project activity.

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

Not applicable.

Appendix 1 – Sample calculations for all formulae used to calculate baseline emissions, project emissions and emission reductions[15].

Table 5 – Sample calculations

Project activity:	São João Landfill Gas to Energy (Ref. # 0373)	
Monitoring period:	16/05/2012 to 21/05/14 (both days included)	
(red)	← parameter fixed ex-ante	
(orange)	← calculated	
(green)	← monitored parameter	
	SAMPLE CALCULATION FOR MAY 2012 (16 TO 31 MAY 2012)	**Equation # in the MR**
	$BE_y = BE_{CH4,y} + BE_{EC,y} + BE_{HG,y} + BE_{NG,y}$	Equation 2
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)	
$BE_{HG4,y}$ =	Baseline emissions associated with heat generation in year y (tCO_2/yr)	
$BE_{NG,y}$ =	Baseline emissions associated with natural gas use in year y (tCO_2/yr)	
where,		
(1) BE_y =	5,783.9	← minus 10% due to approved temporary deviation
$BE_{CH4,y}$ =	5,868.3	
$BE_{EC,y}$ =	558.3	
$BE_{HG4,y}$ =	0.0	
$BE_{NG,y}$ =	0.0	
(1)	(approved temporary deviation) 10% discount in the baseline emissions from 22/05/2014 to 04/11/2018	
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	$BE_{CH4,y} = \left((1 - OX_{top\_layer}) \times F_{CH4,PJ,y} - F_{CH4,BL,y}\right) \times GWP_{CH4}$	Equation 3
where,		
$BE_{CH4,y}$ =	Baseline emissions of methane from the SWDS in year y (t CO2e/yr)	
OX_{top_layer} =	Fraction of methane in the LFG that would be oxidized in the top layer of the SWDS in the baseline (dimensionless)	
$F_{CH4,PJ,y}$ =	Amount of methane in the LFG which is flared and/or used in the project activity in year y (t CH4/yr)	
$F_{CH4,BL,y}$ =	Amount of methane in the LFG that would be flared in the baseline in year y (t CH4/yr)	
GWP_{CH4} =	Global warming potential of CH4 (t CO2e/t CH4)	
$BE_{CH4,y}$ =	5,868.3	*check GWP input (change for commitment period)
OX_{top_layer} =	0.1	
$F_{CH4,PJ,y}$ =	399.2	
$F_{CH4,BL,y}$ =	79.8	
(2) GWP_{CH4} =	21.0	
(3) GWP_{CH4} =	25.0	
(2)	applicable from 16/05/2012 to 31/12/2012	
(3)	applicable from 01/01/2013 to 21/05/2014	
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	$F_{CH4,PJ,y} = F_{CH4,flared,y} + F_{CH4,EL,y} + F_{CH4,HG,y} + F_{CH4,NG,y}$	Equation 4
where,		
$F_{CH4,PJ,y}$ =	Amount of methane in the LFG which is flared and/or used in the project activity in year y (t CH_4/yr)	
$F_{CH4,flared,y}$ =	Amount of methane in the LFG which is destroyed by flaring in year y (t CH_4/yr)	
$F_{CH4,EL,y}$ =	Amount of methane in the LFG which is used for electricity generation in year y (t CH_4/yr)	
$F_{CH4,HG,y}$ =	Amount of methane in the LFG which is used for heat generation in year y (t CH_4/yr)	
$F_{CH4,NG,y}$ =	Amount of methane in the LFG which is sent to the natural gas distribution network in year *y* (t CH_4/yr)	
$F_{CH4,PJ,y}$ =	399.2	
(4) $F_{CH4,flared,y}$ =	1.9	
(4) $F_{CH4,EL,y}$ =	397.3	
$F_{CH4,HG,y}$ =	0.0	
$F_{CH4,NG,y}$ =	0.0	
(4)	(approved permanent change) A discount factor applied in monitored $F_{CH4,PJ,y}$ based on equipment accuracy. Then, 1.0% accuracy of methane analyzer and 1% gas flow to generators discounted to calculate $F_{CH4,EL,y}$; 1.0% accuracy of methane analyzer and analyzer and 1.5% discounted on gas flow to flares applied to calculate $F_{CH4,flared,y}$	

[15] All monthly emission reduction calculation spreadsheets, submitted with this monitoring report, contain full data and calculations, as displayed in Table 5.

	$F_{i,t} = V_{t,db} \times V_{i,t,db} \times \rho_{i,t}$	Equation 5
	$\rho_{i,t} = (P_t \times MM_i) \div (R_u \times T_t)$	Equation 6
where,		
$F_{i,t}$ =	Mass flow of CH4 in the gaseous stream (gas sent to electricity generation facility) in time interval t (kg gas/h)	
$V_{t,db}$ =	Volumetric flow of the gaseous stream in time interval *t* on a dry basis (m^3 dry gas/h)	
$v_{i,t,db}$ =	Volumetric fraction of CH_4 in the gaseous stream in time interval *t* on a dry basis (m^3 gas *i* /m^3 dry gas)	
$\rho_{i,n}$ =	Density of CH_4 in the gaseous stream in time interval t (kg gas *i* /m^3 gas *i*)	
P_t =	Absolute pressure of the gaseous stream in time interval t (Pa)	
T_t =	Temperature of the gaseous stream in time interval t (K)	
MM_i =	Molecular mass of CH_4 (kg/kmol)	
R_u =	Universal ideal gases constant (Pa.m^3/kmol.K)	
$F_{CH4,EL,y} = F_{CH4,t}$ =	397,321.4	
$F_{CH4,sent\_flare,y} = F_{CH4,t}$ =	1,880.9	
$V_{t,db,EL}$ =	1,134,789.7	← minus 1% due to approved permanent change
$V_{i,t,db,EL}$ =	48.92%	← minus 1% due to approved permanent change
$V_{t,db,sent\_flare}$ =	5,318.4	← minus 1.5% due to approved permanent change
$V_{i,t,db,sent\_flare}$ =	49.42%	← minus 1% due to approved permanent change
$\rho_{i,n}$ =	0.7157	
P_t =	101,325	
T_t =	273.15	
MM_i =	16.04	
R_u =	8,314	
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	$F_{CH4,flared,y} = F_{CH4,sent\_flare,y} - (PE_{flare,y} \div GWP_{CH4})$	Equation 7
where,		
$F_{CH4,flared,y}$ =	Amount of methane in the LFG which is destroyed by flaring in year y (t CH4/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)	
$F_{CH4,flared,y}$ =	1.9	*check GWP input (change for commitment period)
$F_{CH4,sent\_flare,y}$ =	1.9	
$PE_{flare,y}$ =	0.01	
(2) GWP_{CH4} =	21.0	
(3) GWP_{CH4} =	25.0	
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	$PE_{flare,y} = GWP_{CH4}\ X \sum_{m=1}^{525600} F_{CH4,RG,m} \cdot (1 - \eta_{flare,m}) X\ 10^3$	Equation 8
where,		
$PE_{flare,y}$ =	Project emissions from flaring of the residual gas stream in year *y* (tCO_2e)	
GWP_{CH4} =	Global Warming Potential (tCO_2e/tCH_4)	
$F_{CH4,RG,m}$ =	Mass flow of methane in the residual gas in the minute *m* (kg)	
$\eta_{flare,m}$ =	Flare efficiency in the minute m	
$PE_{flare,y}$ =	0.01	*check GWP input (change for commitment period)
(2) GWP_{CH4} =	21.0	
(3) GWP_{CH4} =	25.0	
$F_{CH4,RG,m} = F_{CH4,sent\_flare,y}$ =	1.9	
$\eta_{flare,m}$ =	80.0%	
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	$F_{CH4,BL,sys,y} = 0.2\ x\ F_{CH4,PJ,y}$	Equation 9
where,		
$F_{CH4,BL,sys,y}$ =	Methane in LFG that would be flared in the baseline in year *y*, existing LFG capture system (t CH4/yr)	
$F_{CH4,PJ,y}$ =	Methane in the LFG which is captured in the project activity in year *y* (t CH4/yr)	
$F_{CH4,BL,sys,y}$ =	80	
$F_{CH4,PJ,y}$ =	399	

	$BE_{EC,y} = \sum EC_{BL,k,y} \; x \; EF_{EL,k,l} \; x \; (1 + TDL_{k,y})$	Equation 10
where,		
$BE_{EC,y}$ =	Baseline emissions associated with electricity generation in year y (tCO_2/yr)	
$EC_{BL,k,y}$ =	Net amount of electricity generated using LFG in year *y* (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	
$BE_{EC,y}$ =	558.30	
$EC_{BL,k,y}$ =	1,981.99	
$EF_{EL,k,y}$ =	0.3098	
$TDL_{k,y}$ =	9.06%	
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	$EF_{grid,CM,y} = EF_{grid,OM,y} \; x \; w_{OM} + EF_{grid,BM,y} \; x \; w_{BM}$	Equation 11
where,		
$EF_{EL,k,y} = EF_{grid,CM,y}$ =	Combined margin CO_2 emission factor in year y (tCO_2/MWh)	
$EF_{grid,BM,y}$ =	Build margin CO_2 emission factor in year y (tCO_2/MWh)	
$EF_{grid,OM,y}$ =	Operating margin CO_2 emission factor in year y (tCO_2/MWh)	
w_{OM} =	Weighting of operating margin emissions factor (%)	
w_{BM} =	Weighting of build margin emissions factor (%)	
$EF_{grid,CM,y}$ =	0.3098	
$EF_{grid,BM,y}$ =	0.2010	*check input (change for year)
$EF_{grid,OM,y}$ =	0.4185	*check input (change for year)
w_{OM} =	50.0%	
w_{BM} =	50.0%	
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	$PE_y = PE_{EC,y} + PE_{FC,y} + PE_{DT,y} + PE_{SP,y}$	Equation 12
where,		
PE_y =	Project emissions in year *y* (t CO2/yr)	
$PE_{EC,y}$ =	Emissions from consumption of electricity due to the project activity in year *y* (t CO2/yr)	
$PE_{FC,y}$ =	Emissions from consumption of fossil fuels, other than electricity generation, in year *y* (t CO2/yr)	
$PE_{DT,y}$ =	Emissions from the distribution of compressed/liquefied LFG using trucks, in year y (t CO2/yr)	
$PE_{SP,y}$ =	Emissions from the supply of LFG to consumers through a dedicated pipeline, in year y (t CO2/yr)	
PE_y =	14.42	
$PE_{EC,y}$ =	14.42	
$PE_{FC,y}$ =	0.00	
$PE_{DT,y}$ =	0.00	
$PE_{SP,y}$ =	0.00	
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	$PE_{EC,j,y} = \sum_j EC_{PJ,j,y} \; x \; EF_{EL,j,y} \; x \; (1 + TFL_{j,y})$	Equation 13
where,		
$PE_{EC,j,y}$ =	Project emissions from electricity consumption during the year *y* (tCO2/year);	
$EC_{PJ,y}$ =	Quantity of electricity consumed by the project electricity consumption source *j* in year *y* (MWh)	
$EF_{EL,j,y}$ =	Emission factor for electricity generation for source *j* in year (tCO2/MWh)	
$TDL_{j,y}$ =	Average technical transmission and distribution losses for providing electricity to source *j* in year *y*	
j =	Sources of electricity consumption in the project	
$PE_{EC,y}$ =	14.42	
$PE_{EC,grid,y}$ =	0	
$EC_{PJ,grid,y}$ =	0.00	
$EF_{EL,grid,y}$ =	0.0653	*check input (change for year)
$TDL_{grid,y}$ =	11.06%	*check input (change for year)
$PE_{EC,diesel,y}$ =	14.42	
$EC_{PJ,diesel,y}$ =	11.09	
$EF_{EL,diesel,y}$ =	1.30	
$TDL_{j,y}$ =	0%	
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	$ER_y = BE_y - PE_y$	Equation 14
where,		
ER_y =	Emission reductions during the year *y* (tCO2e)	
BE_y =	Baseline emissions in year *y* (tCO2e)	
PE_y =	Project emissions in year *y* (tCO2e)	
ER_y =	5,769.5	
BE_y =	5,783.9	
PE_y =	14.4	

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Document information

Version	Date	Description
09.0	8 October 2021	Revision to: • Ensure consistency with version 03.0 of the “CDM project standard for project activities” (CDM-EB93-A04-STAN).
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.

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