Project design document form
(Version 11.0)

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

BASIC INFORMATION	
Title of the project activity	CTR Rosario Landfill Gas Project
Scale of the project activity	☒ Large-scale ☐ Small-scale
Version number of the PDD	08
Completion date of the PDD	29/04/2020
Project participants	Vital Engenharia Ambiental S.A.
Host Party	Brazil
Applied methodologies and standardized baselines	ACM0001: Flaring or use of landfill gas, version 19.0;
Sectoral scopes	Sectoral Scope: 1 - Energy industries (renewable - / non-renewable sources) Sectoral Scope: 13 - Waste handling and disposal
Estimated amount of annual average GHG emission reductions	73,221 tCO2e

SECTION A. Description of project activity

A.1. Purpose and general description of project activity

>>

The proposed project activity has the objective to capture, flare and generate electricity through the use of landfill gas (LFG)[1] produced in anaerobic conditions into the landfill called "C*entral de Tratamento de Resíduos Rosario*" (hereinafter referred to as *CTR Rosario*) located in the municipality of Rosario in the state of Maranhão, Brazil.

The project activity will result in greenhouse gas (GHG) emission reduction from the CTR Rosario through two ways:

- Burning CH_4 in flares and/or group generators;
- The amount of electricity generated in the project activity will be dispatched to the Brazilian national grid, avoiding the dispatch of an equal amount of energy produced by fossil-fuelled thermal plants to that grid. The initiative avoids CO_2 emissions and contributes to the regional and national sustainable development.

The Project Activity is the same as the one before proposed PRC:

- It is the same Project Participant (Vital Engenharia Ambiental S.A.);
- It is located in the same physical/geographical location;

Prior to the implementation of the project activity, the scenario for LFG destruction was the partial released to atmosphere through the exiting LFG passive capture system and partial LFG combustion in gas wells. Regarding the electricity generation, the baseline scenario is the generation in existing and/or new grid-connected power plants.

The baseline scenario is the scenario existing prior to the implementation of the project activity.

The estimate of:

- Annual average is 73,221 tCO_2e;
- Total GHG emission reduction is 512,549 tCO_2e.

The project activity will be to capture and to flare the LFG and to generate electricity through the implementation of a power generation plant using LFG. The generation installed capacity during the first crediting period will be expected to be 3.000 MW (3 x 1.000 MW).

The project constructed an efficient capture, collection and flaring system to burn CH_4 (a greenhouse gas), and this reduced odours and adverse environmental impacts. Moreover, it installs generators that combusts the LFG to produce electricity, using part of the electricity for self-consumption and the other part is exported to the grid. The flares are kept in operation due to LFG excess, periods when electricity will not be produced or other operational considerations. The LFG power plant is expected to install 3.000 MW (3 x 1.000 MW).

The LFG capture and collection systems and flaring station consists on a LFG pipeline grid and a flaring station, equipped with flares, centrifugal blowers, and all other supporting mechanical and electrical subsystems and appurtenances necessary to run the system. The power generation facility comprises of LFG engine generator sets of high-performance standards. The engine-generator sets are the primary equipment to combust the collected LFG once they are installed. A fraction of the

[1] The gas is generated by the decomposition of waste in a solid waste disposal sites (SWDS). LFG is mainly composed of methane, carbon dioxide and small fractions of ammonia and hydrogen sulphide.

collected LFG is diverted to flares, which is used to combust any gas in excess of the fuel demand for the engines, as well as a contingency backup.

The landfill started the operation in August 2013, receiving solid waste (type Class II-A Inert and Class II-B Non-inert)[2], according to Operation License nº 1049272/2018 process number nº 171800/2017- *Secretaria de Estado do Meio Ambiente e Recursos Naturais – SEMA* (responsible agency to issue environmental licences in Maranhão State) dated of 06/04/2018 valid up to 06/04/2022.

Contribution of the Project Activity to Sustainable Development:

The project will make a strong contribution to sustainable development in Brazil. In addition to reducing emissions of GHGs and generating clean electricity, the Project will provide other sustainable development benefits as follows:

a) Contribution to the environment:

Electrical generation in the project will displace electricity generated by fossil fuel-fired power plants.

b) Contribution to the improvement of working conditions and employment creation:

During the operational phase, which will take place 24 hours/day, 7 days/week, there will be new jobs created locally for duties related to construction, operations and maintenance, landscaping, plumbing, monitoring and security personnel. These people will be fully trained by CTR Rosario on their duties and tasks. Local manpower will be used in the project implementation, which entails installation of vertical wells, horizontal collection system and assembly and operation of equipment such as blowers, flares, and group-generators.

c) Contribution to income generation:

In addition to the local jobs created during its implementation and operation, the project will pay taxes to the municipality.

A.2. Location of project activity

>>

Host Party:
- Brazil

Region/State/Province:
- Maranhão

City/Town/Community:
- Rosario

Physical/Geographical location:
CTR Rosario is located at Fazenda Arapixi - zona industrial, Buenos aires, Rosario (city), Maranhão (State), Brazil.

Geo-coordinates: Latitude: 02° 54' 53.64" S and Longitude: 44° 16' 26.50" W
Decimal coordinates: Latitude: -2.914900° Longitude: -44.274028°

[2] According to definition of the Brazilian Association of Technical Norms (ABNT NBR 10004) http://www.aslaa.com.br/legislacoes/NBR%20n%2010004-2004.pdf

Figure 1 - Geographical position of Rosario city, inside of Maranhão State in Brazil

Source: IBGE Cidades (http://www.ibge.gov.br/cidadesat/topwindow.htm?1)

Figure 2 – Implementation phase at CTR Rosario

A.3. Technologies/measures

>>

According to the executive project, the landfill will be operated under anaerobic conditions adopting the following conditions:

- Landfill surface every day covered;
- Mechanical compacting;
- Leveling of the waste.

In the proposed project activity, the used technology will be the improvement of biogas collection and flare produced in the landfill, through the installation of an active recovery system composed for:

- Collection system;
- Biogas transport pipe system;
- Gas suction and flare system (located in the Biogas Station).
- A power generation plant will also be installed.

Collection system

The biogas collection infrastructure of landfill is based in vertical drains. Those elements will be connected to a collection pipe that will accomplish the transport of gas to control stations (manifolds), used to control the drains loss of load.

Figure 3 - Example of installation of the LFG capturing system

(Source: CTR Rosario)

CTR Rosario intends to install and improve drains directly in the landfill. A covering layer will be installed around the drains to avoid the exhaust gases.

The top of the existing and new vertical drains will be equipped with headstocks. This element is important because it makes the connection between the drain and pipe collection. The headstocks are made of HDPE or similar ø 200 mm to 1 m in length. In the body of the head, a derivation of HDPE or similar ø 50 to 200 mm will be installed and attached to a butterfly valve which is connected to a hose ø 70 mm to 300 mm of HDPE or similar, which is finally connected to the tubing of collection.

Figure 4 - Vertical wells/drains.

(Source: CTR Rosario)

Figure 5 - Transmission pipelines

(Source: CTR Rosario)

The collection pipe will be built using HDPE or similar. The sizing of the piping was done considering the maximum production of landfill gas that can reach. Activities will be intense welding tubing to connect each station of the adjustment. The pipe will be covered with materials that do not pose any possibility of damage to the material.

Removers of condensate will be provided to drain humidity from the LFG. These removers are constructed at points of lower elevation of the tubing and collection stations, located before the adjustment. The condensate removed will be returned to the landfill, through pumps installed at the base of the removers.

All drains will be connected to the adjustment of station located around the landfill, through the collection pipes. The basic functions of the stations will promote the systematic control and monitoring of the characteristics of biogas extracted. Each station will have an adjustment of additional condensate remover, valves and regulating valves-drawer.

<u>Transport System</u>

The transmission pipeline is the last step of the collecting system. It transports the collected LFG to the flare. The transmission pipeline might be connected to all gas regulation stations around the landfill.

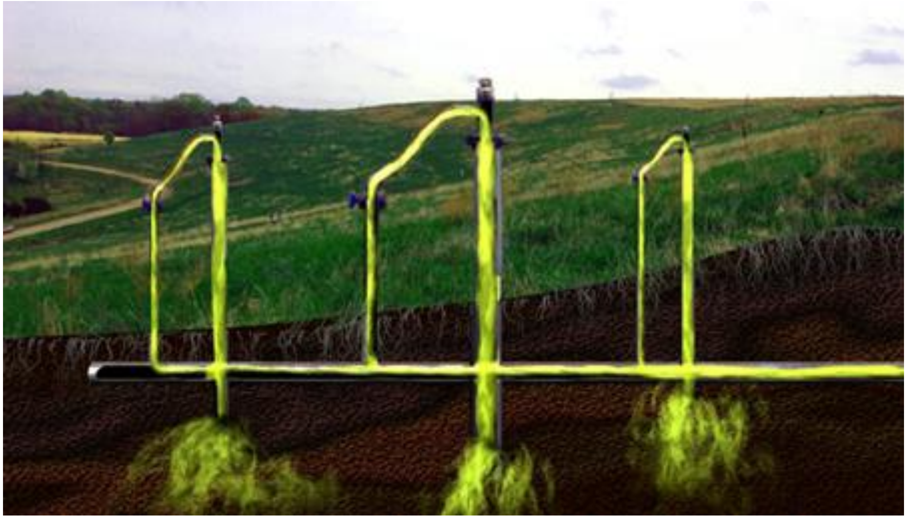

Figure 6 - Illustrative of transport system

(Source: Landfill Methane Outreach Program – EPA)

Blowering System

The blowering system is responsible to give negative pressure to the landfill, blowing the gas to the pipeline. The dimensioning of the blowers will depend on flow of the landfill gas which may range between 1,000 to 3,000 Nm^3/h per each blower and the installed capacity around 37 kW for each equipment.

In order to preserve the operation of the blowers, a dewatering system is installed to remove the condensate. This equipment is a single knock-out dewatering component.

Figure 7 - Example of blower system

(Source: John Zink)

Flare System

The destruction of the methane content in the LFG collected will be made via open flares.

The Flaring Station, responsible for methane destruction by combustion usually has:

- Open flare(s);
- Blower(s);
- Safety valve(s) on/off;
- Remover(s) of condensate;
- Gas Analyzer(s);
- Meter(s) for pressure;
- Meter(s) for flow;
- Meter(s) for temperature.

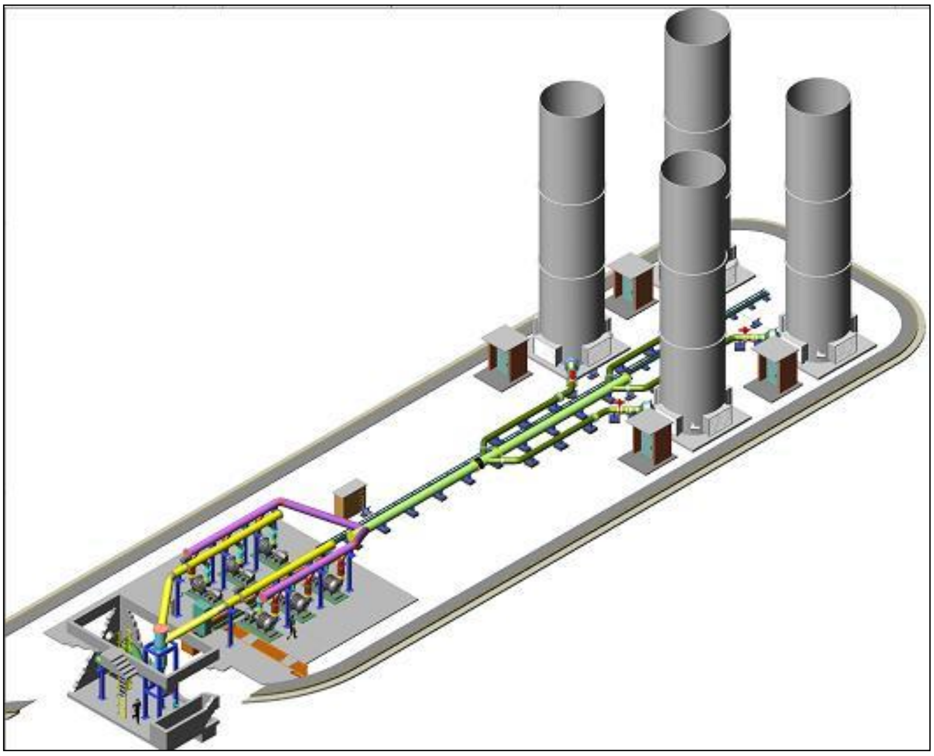

Figure 8 – Example of a Flaring station for a Landfill Gas Project.

Biogas Station

The collection of gas within the landfill will be made by applying a pressure differential in each drain. The depressurization system shall be composed of a group of centrifugal multi-stage blowers, connected in parallel with the central collector. The depressurization of the system will depend on the pressure of operation of flares. In addition, the biogas station will have the following:

- Safety valve on/off;
- Remover of condensate;
- Gas analyzer;
- Meter flow.

Figure 9 - Example of LFG plant

(Source: Santo Filho, 2013[3])

The biogas station will have, even a system of destruction of methane through flares. This system will be composed initially by 1 open flare and can get other units, according to the generation of gas. The flare is constructed in a vertical cylindrical combustion chamber, where the biogas is flared at a constant temperature, controlled by the admission of air, and with a minimum residence time.

Power generation

The power generation system will be comprised of around 3.0 MW. The electricity generated by the project will be supplied to the grid.

This kind of technology is still not widely applied in Brazil. The publication named "Reducing the uncertainty of methane recovered (R) in greenhouse gas inventories from waste sector and of adjustment factor (AF) in landfill gas projects under the Clean Development Mechanism[4]" states that:

> *"…all of Brazilian landfills with collection and destruction system (active system) are implemented projects under the CDM…".*

Additionally, the PP carried out a survey in order to verify the existence of any landfill with LFG collection and destruction active system not register as a CDM Project. The result of this survey concludes that there is no similar project activities developed without CDM benefits.

Very few landfills have already installed equipment for flaring and combustion LFG. Therefore, the company will need engineers and other specialists with experience in this area to advice the company while implementing the project. These professionals will also train local operators and engineers on operations and maintenance of the facilities.

The project activity considered 1.000 MW the installed capacity per generator group.

---

[3] Master dissertation: "*Potential for energy recovery from landfill gas through MSW in Brazil*". Available at: http://www.teses.usp.br/teses/disponiveis/86/86131/tde-16022014-170905/pt-br.php

[4] Source: MAGALHÃES, G.HC.; ALVES, J.W.S.; SANTO FILHO. F.; COSTA, R.M.; KELSON. M. Reducing the uncertainty of methane recovered (R) in greenhouse gas inventories from waste sector and of adjustment factor (AF) in landfill gas projects under the clean development mechanism (2010). Page 174. (http://ghg.org.ua/fileadmin/user_upload/book/Proceedengs_UncWork.pdf), accessed on 25/06/2012.

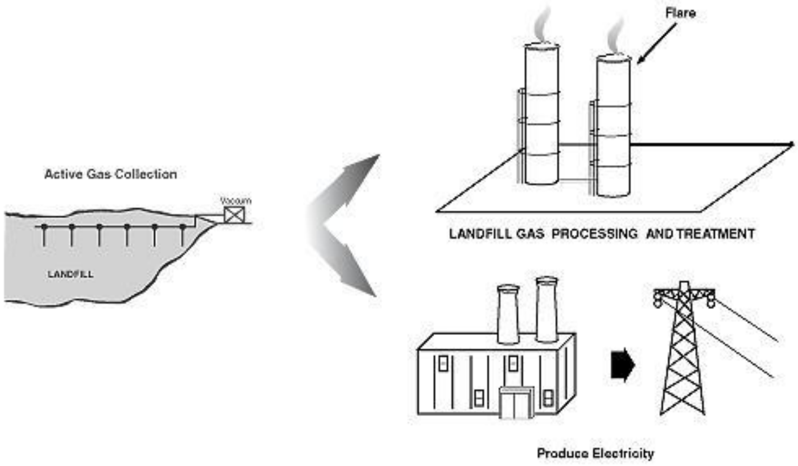

Figure 10 – Power generation diagram

It is important to clarify that the authorization to generate electricity to Brazilian Electricity Regulatory Agency (ANEEL) has not been request yet.

The estimated number of group generators and the expected output is shown on the table below:

Table 1 - Electricity generation

Year	Number of engines installed (unit)	Installed capacity (MW)*	Net electricity generated in the plant (MWh)
2014	0	0	0
2015	0	0	0
2016	0	0	0
2017	0	0	0
2018	0	0	0
2019	2	2.000	15,768
2020	3	3.000	23,652

[1] Definition of net capacity is the maximum capacity at the plant minus the amount of electricity that is consumed by the group generators;
[2] The plant load factor is 90%.
Note: The final equipment that will be chosen (as well as the final installed capacity) may vary depending on the availability of the generation equipment on the market at the time of actual implementation.

The lifetime of the equipments is 25 years and it was based on "Tool to determine the remaining lifetime of equipment Version 01 – Option (c) Default Values" (Electric Generators, air cooled)[5]. The equipments that will be installed in the project site will be all new.

The only equipments in operation under the existing scenario prior to the implementation of the project activity are the vertical drains which venting the LFG through passive LFG capture system. For active capture system, these exiting vertical drains will be improved to increase the LFG capture efficiency, according to described above.

[5] The lifetime of the equipments is also supported by the International Energy Agency (IEA) World energy model – Methodology and assumptions, page 13.

The baseline scenario is the same scenario of the scenario exiting prior to the implementation of the project activity.

The load factor is 90% based on manufacturer's specification[6].

Technology will have to come from the Europe and USA. Hence, technology transfer will occur from countries with strict environmental legislative requirements and environmentally sound technologies.

The technology for biogas collection, flaring and power generation can be considered state of art in the Brazilian sanitation context, because all equipment involved has the highest level of development, and the technology used to combust LFG to produce electricity is not a usual business practice in Brazil, as demonstrated in Section B.5.

The monitoring equipments and their location in the systems along with the balance of the system are presented below:

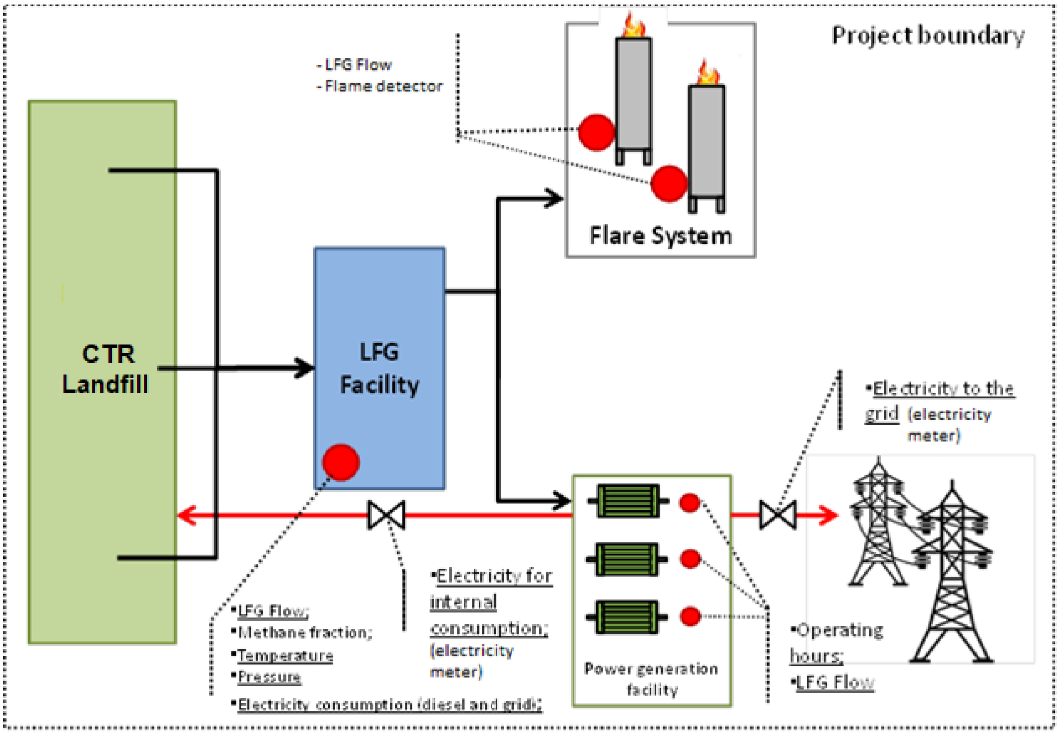

Figure 11 - Technologies and measures of the project activity

A.4. Parties and project participants

Parties involved	Project participants	Indicate if the Party involved wishes to be considered as project participant (Yes/No)
Brazil (host)	Vital Engenharia Ambiental S.A. (private entity)	No

A.5. Public funding of project activity

>>
There is no public funding involved in the project activity.

[6] The document will be available to DOE in validation visit.

A.6. History of project activity

>>

The proposed CDM project activity is not a project activity that has been deregistered, nor included as a component project activity (CPA) in a registered CDM programme of activities (PoA).

A.7. Debundling

>>

Not applicable.

SECTION B. Application of methodologies and standardized baselines

B.1. References to methodologies and standardized baselines

>>

- Large-scale Consolidated Methodology ACM0001: "Flaring or use of landfill gas" (Version 19.0)[7];
- TOOL02 Methodological tool: "Combined tool to identify the baseline scenario and demonstrate additionality" (Version 07.0)[8];
- TOOL03 Methodological tool: "Tool to calculate project or leakage CO_2 emissions from fossil fuel combustion" (Version 03.0)[9].
- TOOL04 Methodological tool: "Emissions from solid waste disposal sites" (Version 08.0)[10];
- TOOL05 Methodological tool: "Baseline, project and/or leakage emissions from electricity consumption and monitoring of electricity generation" (Version 03.0)[11];
- TOOL06 Methodological tool: "Project emissions from flaring" (Version 03.0)[12];
- TOOL07 Methodological tool: "Tool to calculate the emission factor for an electricity system" (Version 07.0)[13];
- TOOL08 Methodological tool: "Tool to determine the mass flow of a greenhouse gas in a gaseous stream" (Version 03.0)[14];
- TOOL09 Methodological tool: "Determining the baseline efficiency of thermal or electric energy generation systems" (Version 02.0)[15];
- TOOL10 Methodological Tool: "Tool to determine the remaining lifetime of equipment" (Version 01)[16];
- TOOL12 Methodological tool: "Project and leakage emissions from transportation of freight" (Version 01.1.0)[17];
- TOOL32 Methodological tool: "Positive lists of technologies" (Version 02.0)[18].

B.2. Applicability of methodologies and standardized baselines

>>

---

[7] https://cdm.unfccc.int/methodologies/DB/JPYB4DYQUXQPZLBDVPHA87479EMY9M

[8] https://cdm.unfccc.int/methodologies/PAmethodologies/tools/am-tool-02-v7.0.pdf

[9] https://cdm.unfccc.int/methodologies/PAmethodologies/tools/am-tool-03-v3.pdf

[10] https://cdm.unfccc.int/methodologies/PAmethodologies/tools/am-tool-04-v8.0.pdf

[11] https://cdm.unfccc.int/methodologies/PAmethodologies/tools/am-tool-05-v3.0.pdf

[12] https://cdm.unfccc.int/methodologies/PAmethodologies/tools/am-tool-06-v3.0.pdf

[13] https://cdm.unfccc.int/methodologies/PAmethodologies/tools/am-tool-07-v7.0.pdf

[14] https://cdm.unfccc.int/methodologies/PAmethodologies/tools/am-tool-08-v3.0.pdf

[15] https://cdm.unfccc.int/methodologies/PAmethodologies/tools/am-tool-09-v2.0.pdf

[16] https://cdm.unfccc.int/methodologies/PAmethodologies/tools/am-tool-10-v1.pdf

[17] https://cdm.unfccc.int/methodologies/PAmethodologies/tools/am-tool-12-v1.1.0.pdf

[18] https://cdm.unfccc.int/methodologies/PAmethodologies/tools/am-tool-32-v2.0.pdf

The methodology ACM0001 is applicable for project activities that comprise one of the following scenarios:

- The captured gas is flared; and/or
- The captured gas is used to produce energy (e.g. electricity/thermal energy);

The methodology ACM0001: "Flaring or use of landfill gas" is applicable to project activities which:

"...

(a) Install a new LFG capture system in an existing or new (Greenfield) SWDS where no LFG capture system was or would have been installed prior to the implementation of the project activity; or

(b) Make an investment into an existing LFG capture system to increase the recovery rate or change the use of the captured LFG, provided that:

(i) The captured LFG was vented or flared and not used prior to the implementation of the project activity; and

(ii) In the case of an existing active LFG capture system for which the amount of LFG cannot be collected separately from the project system after the implementation of the project activity and its efficiency is not impacted on by the project system: historical data on the amount of LFG capture and flared is available;

(c) Flare the LFG and/or use the captured LFG in any (combination) of the following ways:

(i) Generating electricity;

(ii) Generating heat in a boiler, air heater or kiln (brick firing only) or glass melting furnace;[19] *and/or*

(iii) Supplying the LFG to consumers through a natural gas distribution network;

(iv) Supplying compressed/liquefied LFG to consumers using trucks;[20]

(v) Supplying the LFG to consumers through a dedicated pipeline;

(d) Do not reduce the amount of organic waste that would be recycled in the absence of the project activity.

Justification: - Part 1

The methodology **is applicable** because it will be made an investment into an existing LFG capture system to increase the recovery rate (collection efficiency) and change the use of the captured LFG (also electricity generation). The captured LFG was only vented and partially flared in open flares and not used prior to the implementation of the project activity.

In the project activity, the LFG will be flared and will generate electricity.

Moreover, the amount of organic waste will be the same in the project activity as well as in the absence of the project activity. A declaration letter issued by the PP has been made available to the DOE.

"...

[19] For claiming emission reductions for other heat generation equipment (including other products in kilns), project participants may submit a revision to this methodology.

[20] In case other means of transportation are used a revision to this methodology may be requested.

The methodology is only applicable if the application of the procedure to identify the baseline scenario confirms that the most plausible baseline scenario is:

(a) Atmospheric release of the LFG or capture of LFG and destruction through flaring to comply with regulations or contractual requirements, to address safety and odour concerns, or for other reasons; and

(b) In the case that the LFG is used in the project activity for generating electricity and/or generating heat in a boiler, air heater, glass melting furnace or kiln:

(i) For electricity generation: that electricity would be generated in the grid or in captive fossil fuel fired power plants; and/or

(ii) For heat generation: that heat would be generated using fossil fuels in equipment located within the project boundary;

This methodology is not applicable:

(c) In combination with other approved methodologies. For instance, ACM0001 cannot be used to claim emission reductions for the displacement of fossil fuels in a kiln or glass melting furnace, where the purpose of the CDM project activity is to implement energy efficiency measures at a kiln or glass melting furnace;

(d) If the management of the SWDS in the project activity is deliberately changed during the crediting in order to increase methane generation compared to the situation prior to the implementation of the project activity.

...”

Justification: - Part 2
According to Section B.4 and B.5, the methodology is applicable because:

- The most plausible baseline scenario is released the LFG to atmosphere from the SWDS, and;
- The electricity would be generated in the grid.

Moreover, there is neither a combination with other approved methodologies nor change in management of the landfill due to the project activity (e.g. addition of liquids, pre-treating waste or changing the shape of the landfill to increase the Methane Correction Factor).

<u>The tool “Emissions from solid waste disposal sites”</u> is **applicable** to the project activity because the CDM project activity mitigates methane emissions from a specific existing SWDS (Application A).

<u>The tool to calculate “Baseline, project and/or leakage emissions from electricity consumption and monitoring of electricity generation”</u> is **applicable** to the project activity following one out of the three scenarios below applied to the sources of electricity consumption:

- Scenario A: Electricity consumption from the grid. The electricity is purchased from the grid only, and either no captive power plant(s) is/are installed at the site of electricity consumption or, if any captive power plant exists on site, it is either not operating or it is not physically able to provide electricity to the electricity consumer;
- Scenario B: Electricity consumption from (an) off-grid fossil fuel fired captive power plant(s). One or more fossil fuel fired captive power plants are installed at the site of the electricity consumer and supply the consumer with electricity. The captive power plant(s) is/are not connected to the electricity grid; or
- Scenario C: Electricity consumption from the grid and (a) fossil fuel fired captive power plant(s). One or more fossil fuel fired captive power plants operate at the site of the electricity consumer. The captive power plant(s) can provide electricity to the electricity consumer. The

captive power plant(s) is/are also connected to the electricity grid. Hence, the electricity consumer can be provided with electricity from the captive power plant(s) and the grid.

As for the monitoring of the amount of electricity generated in the project scenario, only if one out of the following three project scenarios applies to the recipient of the electricity generated:

a) Scenario I: Electricity is supplied to the grid;
b) Scenario II: Electricity is supplied to consumers/electricity consuming facilities; or
c) Scenario III: Electricity is supplied to the grid and consumers/electricity consuming facilities.

Justification:
The tool is applicable according to Scenario A and Scenario B stated above since the project activity includes electricity consumption from the grid when electricity generated by the LFG power plant is not operational.

Also, Scenario I is applicable since the project activity includes electricity generation to the grid.

The tool "Project emissions from flaring" is **applicable** to the project activity since the project activity uses enclosed and/or open flares and project participant documents the same in the PDD including the type of flare used in the project activity. Tool is applicable to the flaring of flammable greenhouse gases where:

- Methane is the component with the highest concentration in the flammable residual gas; and
- The source of the residual gas is coal mine methane or a gas from a biogenic source (e.g. biogas, landfill gas or wastewater treatment gas).
- The flares used in the project site operate according to the specifications provided by the manufacturer.

Justification:
Since methane is the component with the highest concentration in the flammable residual gas from waste anaerobic degradation generating LFG and flares used in the project site operate according to the specifications provided by the manufacturer, the tool is available.

The "Tool to determine the mass flow of a greenhouse gas in a gaseous stream" is **applicable** to the project activity because the applicable methodology (ACM0001) demands measuring flow and composition of residual and exhaust gases for the determination of baseline and project emissions.

The "Tool to determining the baseline efficiency of thermal or electric energy generation systems" is **not applicable** to the project activity since there is no thermal or electric energy generation in the baseline scenario. Also, the project activity does not involve the improvement of the energy efficiency through retrofits or replacement of the existing system by a new system.

The "Tool to determine the remaining lifetime of equipment" is **not applicable** since the project activity do not involve the replacement of existing equipment with new equipment or retrofit of existing equipment as part of energy efficiency improvement activities.

LFG use equipment was not in operation prior to the implementation of the project activity.

The "Project and leakage emissions from transportation of freight" is **not applicable** since the project activity do not involve the transportation of freight.

The "Tool to calculate the emission factor for an electricity system" is **applicable** since the project activity demands electricity that is provided by the grid. This tool is also referred to in the "Tool to calculate project and/or leakage emissions from electricity consumption and monitoring of electricity generation" for the purpose of calculating project and leakage emissions in case where a project activity consumes electricity from the grid or results in increase of consumption of electricity from the grid outside the project boundary.

The methodological tool "Determining the baseline efficiency of thermal or electric energy generation systems" is **not applicable** to the project activity since there is no thermal or electric energy generation in the baseline scenario. Also, the project activity does not involve the improvement of the energy efficiency through retrofits or replacement of the existing system by a new system.

The methodological tool "Combined tool to identify the baseline scenario and demonstrate additionality" is **not applicable** since demonstration of additionality is not applicable/required for the registered CDM project activity. Simplified procedure to identify the baseline scenario and demonstrate additionality of ACM0001 has been used.

The methodological tool "Tool to calculate project or leakage CO_2 emissions from fossil fuel combustion" is **not applicable** due to the absence of fossil fuel consumption by the project activity.

B.3. Project boundary, sources and greenhouse gases (GHGs)

>>

Source		Gas	Included	Justification/Explanation
Baseline	Emissions from decomposition of waste at the SWDS site	CH_4	Yes	The major source of emissions in the baseline
		N_2O	No	N_2O emissions are small compared to CH_4 emissions from SWDS. This is conservative
		CO_2	No	CO_2 emissions from decomposition of organic waste are not accounted since the CO_2 is also released under the project activity
	Emissions from electricity generation	CO_2	Yes	Major emission source if power generation is included in the project activity
		CH_4	No	Excluded for simplification. This is conservative
		N_2O	No	Excluded for simplification. This is conservative

Source		Gas	Included	Justification/Explanation
	Emissions from heat generation	CO_2	No	Major emission source if heat generation is included in the project activity
		CH_4	No	Excluded for simplification. This is conservative
		N_2O	No	Excluded for simplification. This is conservative
	Emissions from the use of natural gas	CO_2	No	Excluded for simplification. This is conservative
		CH_4	No	Major emission source if supply of LFG through a natural gas distribution network, dedicated pipeline or using trucks is included in the project activity
		N_2O	No	Excluded for simplification. This is conservative
Project activity	Emissions from fossil fuel consumption for purposes other than electricity generation or transportation due to the project activity	CO_2	No	May be an important emission source
		CH_4	No	Excluded for simplification. This emission source is assumed to be very small
		N_2O	No	Excluded for simplification. This emission source is assumed to be very small
	Emissions from electricity consumption due to the project activity	CO_2	Yes	May be an important emission source

Source		Gas	Included	Justification/Explanation
		CH_4	No	Excluded for simplification. This emission source is assumed to be very small
		N_2O	No	Excluded for simplification. This emission source is assumed to be very small
	Emissions from flaring	CO_2	No	Emissions are considered negligible
		CH_4	Yes	May be an important emission source
		N_2O	No	Emissions are considered negligible
	Emissions from distribution of LFG using trucks and dedicated pipelines	CO_2	No	May be an important emission source
		CH_4	No	May be an important emission source
		N_2O	No	Emissions are considered negligible

The project boundary of the project activity shall include the site where the LFG is captured and, as applicable:

(a) Sites where the LFG is flared or used (e.g. flare, power plant, boiler, air heater, glass melting furnace, kiln, natural gas distribution network, dedicated pipeline or biogas processing facility); (applicable)

(b) Captive power plant(s) (including emergency diesel generators) or power generation sources connected to the grid, which are supplying electricity to the project activity; (not applicable)

(c) Captive power plant(s) (including emergency diesel generators) or power generation sources connected to the grid, which are supplying electricity in the baseline that is displaced by electricity generated by captured LFG in the project activity; (applicable)

(d) Heat generation equipment or sources which are supplying heat in the baseline that is displaced by heat generated by captured LFG in the project activity; and (not applicable)

(e) The transportation of the compressed/liquefied LFG from the biogas processing facility to consumers. (not applicable).

The flow diagram is presented below:

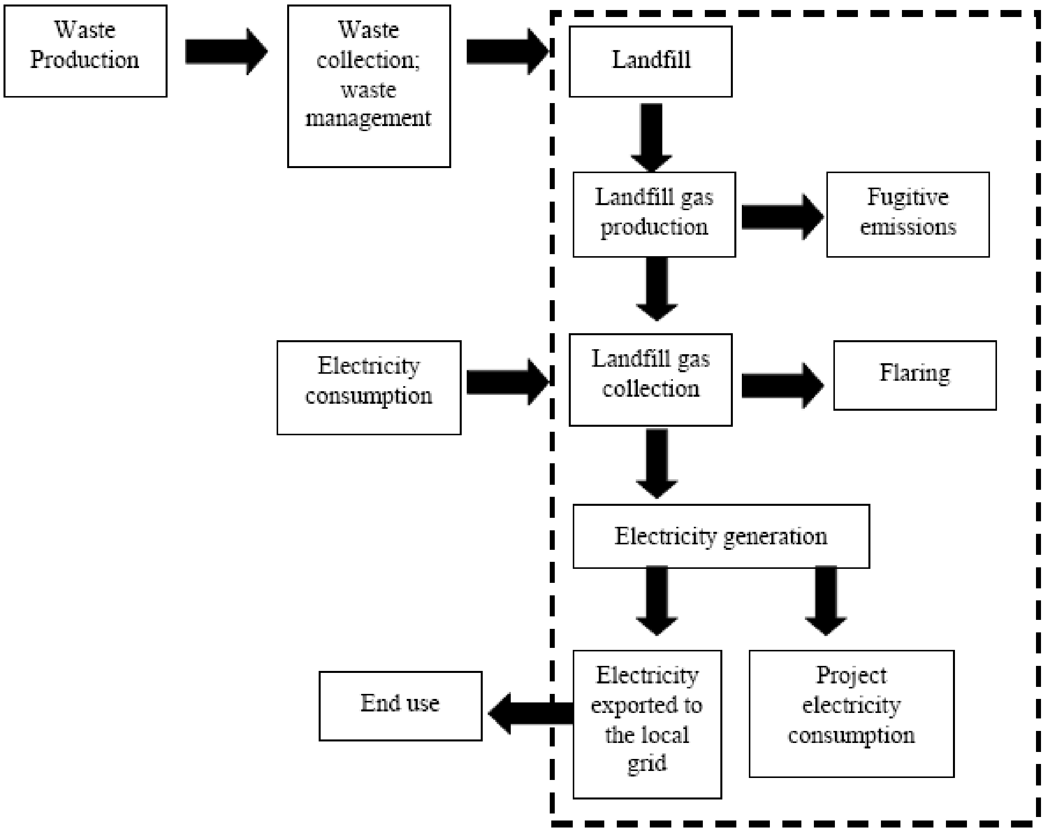

Figure 12 – Flow diagram project boundary

B.4. Establishment and description of baseline scenario

>>

The baseline scenario for the project activity is identified using step 1 of the 'Combined tool to identify the baseline scenario and demonstrate additionality", as agreed in ACM0001 "Flaring or use of landfill gas".

Realistic and credible alternatives to the project activity that can be part of the baseline scenario are defined through the following sub-steps:

STEP 0: Demonstration that a proposed project activity is the First-of-its-kind.

This step is not applied because the proposed project activity is not the First-of-its-kind.

Outcome of Step 0: The proposed project activity is not the First-of-its-kind.

Step 1: Identification of alternative scenarios

This Step serves to identify all alternative scenarios to the proposed CDM project activity(s) which can be the baseline scenario.

The project participants will monitor all relevant policies and circumstances at the beginning of each crediting period and adjust the baseline accordingly.

Step 1a: Define alternative scenarios to the proposed CDM project activity

The identified alternatives for the destruction of LFG in the absence of the project activity are:

LFG1	The project activity implemented without being registered as a CDM project activity (capture, flaring and use of LFG);
LFG2	Atmospheric release of the LFG or capture of LFG in a managed SWDS and destruction through flaring to comply with regulations or contractual requirements, to address safety and odour concerns, or for other reasons;

Thus, the remaining real alternatives for the destruction of LFG are LFG1, LFG2.

The EIA (Environmental Impact Assessment) does not cover recycling, treatment or incineration of organic waste, alternatives LFG3, LFG4, LFG5 and LFG6 should not be considered.

Alternative (a): For electricity generation, the realistic and credible alternatives are:

E1	Electricity generation from LFG, undertaken without being registered as CDM project activity;
E3	Electricity generation in existing and/or new grid-connected power plants.

In the absence of project activity, no captive electricity consumption would be necessary. Thus, the alternative scenario E2 should not be considered.

According to the project activity configuration, there will be no heat generation. Therefore, all alternative scenarios addressing these possibilities should not be considered.

Thus, the remaining real alternatives to the project activity are E1 and E3.

The combinations of the project activity compose the following scenarios:

Scenarios	Combination	Comments
1	LFG1 + E1	Possible
2	LFG1 + E3	Possible
3	LFG2 + E1	This alternative is not plausible because to generate electricity in the project activity, it is necessary to implement the capture, flaring and use of LFG.
4	LFG2 + E3	Possible

Outcome of Step 1a:

Three realistic and credible alternative scenarios to the project activity were identified:

- Scenario 1 (LFG1 + E1);
- Scenario 2 (LFG1 + E3);
- Scenario 4 (LFG2 + E3);

Step 1b: Consistency with mandatory applicable laws and regulations

All alternative scenarios identified in Step *1a* comply with all applicable laws and regulations. Brazil's New National Solid Waste Policy (NSWP),[21] ratified by the President on 02/08/2010 after 19 years under discussion. The NSWP does not request the LFG capture and/or flare and there is not forecast to approve any regulation or policy in the next years with this requirement. The laws and regulations applicable for the electricity generation component are law 8987/95 and law 9074/95[22].

The scenario 4 which is, a continuation of the current situation of the landfill (baseline scenario) represents the business as usual practice for the project site as well as for most of the landfills in Brazil.

[21] http://www.planalto.gov.br/ccivil_03/_ato2007-2010/2010/lei/l12305.htm, accessed on 16/07/2019.

[22] http://www.aneel.gov.br, accessed on 16/07/2019.

The project participant will monitor all relevant policies and circumstances at the beginning of each crediting period and adjust the baseline accordingly.

Outcome of Step 1b: Three realistic and credible alternative scenarios to the project activity are in compliance with mandatory legislation and regulations. The alternatives scenarios remain the same.

- Scenario 1 (LFG1 + E1);
- Scenario 2 (LFG1 + E3);
- Scenario 4 (LFG2 + E3);

B.5. Demonstration of additionality

>>
It is crucial to consider that the simplified procedure to identify the baseline scenario and demonstrate additionality of ACM0001 is considered for the crediting period for the project activity. According to TOOL32 Methodological tool: "Positive lists of technologies", as the proposed installed capacity of the project activity is 3 MW, the project activity is automatically additional.

The additionality of the project activities and PoAs is demonstrated as follows:

"The project activities and PoAs at new or existing landfills (greenfield or brownfield) are deemed automatically additional, if it is demonstrated that prior to the implementation of the project activities and PoAs the landfill gas (LFG) was only vented and/or flared (in the case of brownfield projects) or would have been only vented and/or flared (in the case of greenfield projects) but not utilized for energy generation, and that under the project activities and PoAs any of the following conditions are met:

(a) The LFG is used to generate electricity in one or several power plants with a total nameplate capacity that equals or is below 10 MW;
(b) The LFG is used to generate heat for internal or external consumption;
(c) The LFG is flared.

B.6. Estimation of emission reductions

B.6.1. Explanation of methodological choices

>>
Baseline emission calculation

The baseline emission was calculated according to the following formula:

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

Where:

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

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

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

Where:

$BE_{CH4,y}$	=	Baseline emissions of LFG 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)

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

During the crediting period, the $\mathbf{F_{CH4,PJ,y}}$ will be determined as follows:

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

Where:

$F_{CH4,PJ,y}$	=	Amount of methane in the LFG which is flared and/or used in the project activity in year y (tCH_4/yr)
$F_{CH4,flared,y}$	=	Amount of methane in the LFG which is destroyed by flaring in year y (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 (tCH_4/yr)

$F_{CH4,EL,y}$, $F_{CH4,HG,y}$ and $F_{CH4,NG,y}$ are determined using the “Tool to determine the mass flow of a greenhouse gas in a gaseous stream” and monitoring the working hours of the power plant(s), 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 taken into account by monitoring the hours that the equipment utilizing the LFG is operating in year *y* ($Op_{j,h,y}$).

The following requirements apply:

(e) 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;

(f) CH_4 is the greenhouse gas for which the mass flow should be determined;

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

(h) The mass flow should be calculated on an hourly basis for each hour *h* in year *y*;

(i) The mass flow calculated for hour *h* is 0 if the equipment is not working in hour *h* ($Op_{j,h}$=not working), the hourly values are then summed to a yearly unit basis.

The amount of methane destroyed by flaring ($F_{CH4,flared,y}$) will be determined as follows:

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

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)

$F_{CH4,sent\_flare,y}$ will be determined directly using the “Tool to determine the mass flow of a greenhouse gas in a gaseous stream”, applying the requirements described below. The tool shall be applied to the gaseous stream flowing in the LFG delivery pipeline to each flare.

According to “Tool to determine the mass flow of a greenhouse gas in a gaseous stream” the following options will be considered for the present project activity:

- Option A (Volume flow in dry basis and volumetric fraction in dry basis) when the temperature of the gaseous stream is less than 60ºC (333.15 K) at the flow measurement point

  And

- Option B (Volume flow in wet basis and volumetric fraction in dry basis) when the temperature of the gaseous stream is higher than 60ºC (333.15 K) at the flow measurement point.

Option A

Flow measurement on a dry basis is not doable for a wet gaseous stream. Therefore, it is necessary to demonstrate that the gaseous stream is dry to use this option. The demonstration will be made as following:

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

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

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

With

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

Where:

$F_{i,t}$	= Mass flow of greenhouse gas *i* in the gaseous stream in time interval *t* (kg gas/h)
$V_{t,db}$	= Volumetric flow of the gaseous stream in time interval *t* on a dry basis (m^3 dry gas/h)
$v_{i,t,db}$	= Volumetric fraction of greenhouse gas *i* in the gaseous stream in a time interval *t* on a dry basis (m^3 gas *i*/m^3 dry gas)
$\rho_{i,t}$	= Density of greenhouse gas i in the gaseous stream in time interval *t* (kg gas *i*/m^3 gas *i*)
P_t	= Absolute pressure of the gaseous stream in time interval *t* (Pa)

MM_i = Molecular mass of greenhouse gas *i* (kg/kmol)
R_u = Universal ideal gases constant (8,314 Pa.m^3/kmol.K)
T_t = Temperature of the gaseous stream in time interval *t* (K)

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

Option B

The mass flow of greenhouse gas *i* ($F_{i,t}$) is determined using equations used to Option A. The volumetric flow of the gaseous stream in time interval *t* on a dry basis ($V_{t,db}$) is determined by converting the measured volumetric flow from wet basis to dry basis as follows:

$$V_{t,tb} = V_{t,wb} / (1 + v_{H2O,t,db})$$

Where:
$V_{t,db}$ = Volumetric flow of the gaseous stream in time interval *t* on a dry basis (m^3 dry gas/h)
$V_{t,wb}$ = Volumetric flow of the gaseous stream in time interval *t* on a wet basis (m^3 wet gas/h)
$v_{H2O,t,db}$ = Volumetric fraction of H_2O in the gaseous stream in time interval *t* on a dry basis (m^3 H_2O/m^3 dry gas)

The volumetric fraction of H_2O in time interval *t* on a dry basis ($v_{H2O,t,db}$) is estimated according to following equation.

$$v_{H2O,t,db} = \frac{m_{H2O,t,db} * MM_{t,db}}{MM_{H2O}}$$

Where:
$v_{H2O,t,db}$ = Volumetric fraction of H_2O in the gaseous stream in time interval *t* on a dry basis (m^3 H_2O/m^3 dry gas)
$m_{H2O,t,db}$ = Absolute humidity in the gaseous stream in time interval *t* on a dry basis (kg H_2O/kg dry gas)
$MM_{t,db}$ = Molecular mass of the gaseous stream in time interval *t* on a dry basis (kg dry gas/kmol dry gas)
MM_{H2O} = Molecular mass of H_2O (kg H_2O/kmol H_2O)

The absolute humidity of the gaseous stream (mH_2O,t,db) will be determined using Option 2 (simplified calculation without measurement of the moisture content):

Option 2: Simplified calculation without measurement of the moisture content

This option provides a simple and conservative approach to determine the absolute humidity by assuming the gaseous stream is dry or saturated depending on which is the conservative situation[23].

Concerning the project activity, the conservative situation will be to assume that the gaseous stream is saturated, then $m_{H2O,t,db}$ is assumed to equal the saturation absolute humidity ($m_{H2O,t,db,sat}$) and calculated using the following equation.

[23] An assumption that the gaseous stream is saturated is conservative for the situation that the mass flow of greenhouse gas *i* is underestimated (applicable for calculating baseline emissions). Conversely, an assumption that the gas stream is dry is conservative for the situation that the greenhouse gas *i* is overestimated (applicable for calculating project emissions).

$$m_{H2O,t,db,Sat} = \frac{p_{H2O,t,Sat} * MM_{H2O}}{(P_t - p_{H2O,t,Sat}) * MM_{t,db}}$$

Where:

$m_{H2O,t,db,sat}$	= Saturation absolute humidity in time interval *t* on a dry basis (kg H_2O/kg dry gas)
$p_{H20,t,Sat}$	= Saturation pressure of H_2O at temperature Tt in time interval t (Pa)
T_t	= Temperature of the gaseous stream in time interval *t* (K)
P_t	= Absolute pressure of the gaseous stream in time interval *t* (Pa)
MM_{H2O}	= Molecular mass of H_2O (kg H_2O/kmol H_2O)
$MM_{t,db}$	= Molecular mass of the gaseous stream in a time interval *t* on a dry basis (kg dry gas/kmol dry gas)

Parameter $MM_{t,db}$ is estimated using the following equation.

$$MM_{t,db} = \sum_k (v_{k,t,db} * MM_k)$$

Where:

$MM_{t,db}$	= Molecular mass of the gaseous stream in time interval *t* on a dry basis (kg dry gas/kmol dry gas)
$v_{k,t,db}$	= Volumetric fraction of gas *k* in the gaseous stream in time interval *t* on a dry basis (m^3 gas k/m^3 dry gas)
MM_k	= Molecular mass of gas *k* (kg/kmol)
k	= All gases, except H_2O, contained in the gaseous stream (e.g. N_2 and CH_4,). See available simplification below

The determination of the molecular mass of the gaseous stream ($MM_{t,db}$) requires measuring the volumetric fraction of all gases (*k*) in the gaseous stream. However, as a simplification, in the case of the project activity, the volumetric fraction of the methane that is a greenhouse gas and considered in the emission reduction calculation in the underlying methodology must be monitored and the difference to 100% may be considered as pure nitrogen. The simplification is not acceptable if it is differently specified in the underlying methodology.

$PE_{flare,y}$ shall be determined using the methodological tool “Project emissions from flaring”. If LFG is flared through more than one flare, then $PE_{flare,y}$ is the sum of the emissions for each flare determined separately.

Open flare(s) will been installed in the project activity.

To determine the project emissions from flaring gases was used the tool “Project emissions from flaring”. The project emissions calculation procedure is given in the following steps:

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

Step 1: Determination of the methane mass flow in the residual gas

The “Tool to determine the mass flow of a greenhouse gas in a gaseous stream” shall be used to determine the following parameter:

Parameter	SI Unit	Description
$F_{CH4,m}$	kg	Mass flow of methane in the residual gaseous stream in the minute m

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;
- CH4 is the greenhouse gas i for which the mass flow should be determined;
- The simplification offered for calculating the molecular mass of the gaseous stream is valid (equations 3 and 17 in the tool); and
- The time interval t for which mass flow should be calculated is every minute m

$F_{CH4,m}$, which is measured as the mass flow during minute m, shall then be used to determine the mass of methane in kilograms fed to the flare in minute m ($F_{CH4,RG,m}$). $F_{CH4,m}$ shall be determined on a dry basis.

The option chosen for the "Tool to determine the mass flow of a greenhouse gas in a gaseous stream" by the project participant is option A. However, during the project operational monitoring, If not demonstrated that the temperature of the gaseous stream (T_t) is less than 60ºC (dry basis), then the flow measurement should be assumed to be on a wet basis and the option B should be applied instead.

Step 2: Determination of flare efficiency

Open flare

In the case of open flares, the flare efficiency in the minute *m* ($\eta_{flare,m}$) is 50% when the flame is detected in the minute *m* ($Flame_m$), otherwise $\eta_{flare,m}$ is 0%.

Enclosed flare

In the case of enclosed flares, project participants may choose between the following two options to determine the flare efficiency for minute *m* ($\eta_{flare,m}$).

Option A: Apply a default value for flare efficiency.

Option B: Measure the flare efficiency.

Option A: Default value

The flare efficiency for the minute m ($n_{flare,m}$) 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 $n_{flare,m}$ is 0%.

For enclosed flares that are defined as low height flares, the flare efficiency shall be adjusted, as a conservative approach, by subtracting 10 percentile points. For example, the default value applied shall be 80%, rather than 90%.

Option B: Measured flare efficiency

The flare efficiency in the minute *m* is a measured value ($\eta_{flare,m} = \eta_{flare,calc,m}$) when the following three conditions are met to demonstrate that the flare is operating:

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

Option B.1: Biannual measurement of the flare efficiency

The calculated flare efficiency $\eta_{flare,calc,m}$ is determined as the average of two measurements of the flare efficiency made in year *y* ($\eta_{flare,calc,y}$), adjusted by an uncertainty factor of 5 percentile points as follows:

$$\eta_{flare,calc,y} = 1 - \frac{1}{n}\sum_{t=1}^{n}\left(\frac{F_{CH4,EG,t}}{F_{CH4,RG,t}}\right) - 0.05$$

Where:

$\eta_{flare,calc,y}$	=	Flare efficiency in the year y
$F_{CH4,EG,t}$	=	Mass flow of methane in the exhaust gas of the flare on a dry basis at reference conditions in the time period t (kg)
$F_{CH4,RG,t}$	=	Mass flow of methane in the residual gas on a dry basis at reference conditions in the time period t (kg)
t	=	The two time periods in year y during which the flare efficiency is measured, each a minimum of one hour and separated by at least six months

$F_{CH4,EG,t}$ is measured according to an appropriate national or international standard. $F_{CH4,RG,t}$ is calculated according to Step 1, and consists of the sum of methane flow in the minutes *m* that make up the time period *t*.

For enclosed flares that are defined as low height flares, the flare efficiency in the minute m($\eta_{flare,m}$) shall be adjusted, as a conservative approach, by subtracting 10 percentile points from the efficiency. For example, if the measured value was 99%, then the value to be used shall correspond to 89%.

Step 3: Calculation of project emissions from flaring

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

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

Where:

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

Table 2 - Parameters used in the Tool "Project emissions from flaring"

Parameter	Description	Value	Unit
P_{ref}	Atmospheric pressure at reference conditions	101,325	Pa
R_u	Universal ideal gas constant	8,314	$Pa.m^3/kmol.K$
T_{ref}	Temperature at reference conditions	273.15	K
GWP_{CH4}	Global warming potential of methane valid for the commitment period	25[24]	tCO_2/tCH_4
$\rho_{CH4,n}$	Density of methane at reference conditions	0.716	kg/m^3

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

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

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

Where:

$F_{CH4,PJ,y}$	=	Amount of methane in the LFG which is flared and/or used in the project activity in year *y* (tCH_4/yr)
$BE_{CH4,SWDS,y}$	=	Amount of methane in the LFG that is generated from the SWDS in the baseline scenario in year *y* (tCO_2e/yr)
η_{PJ}	=	Efficiency of the LFG capture system that will be installed in the project activity
GWP_{CH4}	=	Global warming potential of CH_4 (tCO_2e/tCH_4)

$BE_{CH4,SWDS,y}$ is determined using the methodological tool "Emissions from solid waste disposal sites". The calculation of $BE_{CH4,SWDS,y}$ according the tool is:

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

Where:

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

[24] Default value of 25 from IPCC. Shall be updated according to any future COP/MOP decisions.

MCF_y		Methane correction factor for year *y*
DOC_j	=	Fraction of degradable organic carbon in the waste type *j* (weight fraction)
k_j	=	Decay rate for the waste type *j* (1 / yr)
J	=	Type of residual waste or types of waste in the MSW

According to ACM0001 methodology, the parameter f_y in the methodological tool "Emissions from solid waste disposal sites" shall be assigned a value of 0 (zero) because the amount of LFG that would have been captured and destroyed is already accounted for in equation 2 of this methodology. Also, according to ACM0001 methodology, the parameter *X* begins with the year that the SWDS started receiving wastes. For this reason, the parameter f_y and *X* will not be monitored.

Step A.2: Determination of $F_{CH4,BL,y}$

In the baseline there are no regulatory or contractual requirements, or to address safety and odour concerns to capture and destroy LFG. Thus, the case of the project activity for determining methane captured and destroyed in the baseline is **Case 3** because there is existing LFG capture system (passive system), however there is no requirement to destroy methane. In this case:

$$F_{CH4,BL,y} = F_{CH4,BL,sys,y} = F_{CH4,sent\_flare,y}$$

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

The amount of methane captured with the existing system will be monitored along with the amount captured under the project activity and there is no historic data on the amount of methane that was captured in the year prior to the implementation of the project activity. Thus, the situation to determine $F_{CH4,BL,y}$ is:

If there is no monitored or historic data on the amount of methane that was captured in the year prior to the implementation of the project situation, then:

$F_{CH4,BL,sys,y} = 20\% \times F_{CH4,PJ,y}$; or

$F_{CH4,BL,y} = 20\% \times F_{CH4,PJ,y}$

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

$$BE_{EC,y} = \sum_k EC_{BL,k,y} \times EF_{EL,k,y} \times (1 + TDL_{k,y})$$

Where:

$BE_{EC,y}$	=	Baseline emissions from electricity generation in year *y* (tCO_2/yr)
$EC_{BL,k,y} = EG_{PJ,y}$	=	Net amount of electricity generated using LFG in year y (MWh/yr)
$EF_{EL,k,y}$[25]	=	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*.

[25] According to the "*Tool to calculate project or leakage CO_2 emissions from fossil fuel combustion*", $EF_{EL,k,y} = EF_{grid,CM,y}$

The baseline emissions associated with electricity generation in year y ($BE_{EC,y}$) shall be calculated using the "Methodological tool: Baseline, project and/or leakage emissions from electricity consumption and monitoring of electricity generation".

Emission Factor calculation

The project emissions derived from fossil fuels used for electricity consumption from grid connected power plants are estimated and guided using the “Methodological tool: Baseline, project and/or leakage emissions from electricity consumption and monitoring of electricity generation”. The combined margin emission factor was calculated by the “Tool to calculate the emission factor for an electricity system”, as follows:

Step 1. Identify the relevant electric power system

For the purpose of determining the electricity emission factors, a project electricity system is defined by the spatial extent of the power plants that are physically connected through transmission and distribution lines to the project activity (e.g. the renewable power plant location or the consumers where electricity is being saved) and that can be dispatched without signification transmission constraints.

The Brazilian DNA published an official delineation of the project electricity system in Brazil, considering a national interconnected system.[26]

Step 2. Choose whether to include off-grid power plants in the project electricity system (optional)

Option I: Only grid power plants are included in the calculation.

The Brazilian DNA is responsible for calculating the emission factors and it is not included in calculation the off-grid power plants.

Step 3. Select a method to determined 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 Brazilian DNA is responsible for calculating the OM emission factor in Brazil. It uses the method c) Dispatch data analysis OM.

For the dispatch data analysis OM, it is necessary to use the year in which the project activity displaces grid electricity and to update the emission factor annually during monitoring.

Step 4. Calculate the operating margin emission factor according to the selected method

The dispatch data analysis OM emission factor ($EF_{grid,OM-DD,y}$) is determined based on the power units that are actually dispatched at the margin during each hour h where the project is displacing electricity. This approach is not applicable to historical data and, thus, requires annual monitoring of $EF_{grid,OM-DD,y}$.

[26] DNA Resolution n°8 was published on 26/05/2008 on http://www.mctic.gov.br/mctic/export/sites/institucional/ciencia/SEPED/clima/arquivos/legislacao_cimgc/Resolucao-n-8-de-26-de-maio-de-2008.pdf, accessed on 16/07/2019.

The emission factor is calculated as follows:

$$EF_{grid,OM-DD,y} = \frac{\sum_{h} EG_{PJ,h} \cdot EF_{EL,DD,h}}{EG_{PJ,y}}$$

Where:

$EF_{grid,OM-DD,y}$	=	Dispatch data analysis operating margin CO_2 emission factor in year *y* (tCO_2/MWh)
$EG_{PJ,h}$	=	Electricity displaced by the project activity in hour *h* m of year *y* (MWh)
$EF_{EL,DD,h}$	=	CO_2 emission factor for power units in the top of the dispatch order in hour *h* in year *y* (tCO_2/MWh)
$EG_{PJ,y}$	=	Total electricity displaced by the project activity in year *y* (MWh)
h	=	hours in year y in which the project activity is displacing grid electricity
y	=	Year in **w**hich the project activity is displacing grid electricity

Step 5. Calculate the build margin (BM) emission factor

The Brazilian DNA is responsible for calculating the BM emission factor in Brazil.

In terms of vintage of data, 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 should 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 factor shall be calculated ex-ante, as described in option 1 above. For the third crediting period, the build margin emission factor calculated for the second crediting period should be used.

The *Option 2* was chosen for the proposed project.

The build margin emissions factor is the generation-weighted average emission factor (tCO_2/MWh) of all power units m during the most recent year y for which power generation data is available, calculated as follows:

$$EF_{grid,BM,y} = \frac{\sum_{m} EG_{m,y} \times EF_{EL,m,y}}{\sum_{m} EG_{m,y}}$$

Step 6. Calculate the combined margin emissions factor

The option a) weighted average CM was used to calculate the combined margin (CM).

$$EF_{grid,CM,y} = EF_{grid,OM,y} \times w_{OM} + EF_{grid,BM,y} \times w_{BM}$$

The default weights are as follows: w_{OM} = 0.5 and w_{BM} = 0.5, fixed for the first crediting period. That gives:

The build margin CO_2 emission factor will be ex-post.

Therefore, the combined margin CO_2 emission factor will be ex-post.

Project emissions:

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

Where:

PE_y	=	Project emissions in year *y* ($t\ CO_2/yr$)
$PE_{EC,y}$	=	Emissions from consumption of electricity due to the project activity in year *y* ($t\ CO_2/yr$)

$PE_{FC,y}$	=	Emissions from consumption of fossil fuels due to the project activity, for purpose other than electricity generation, in year *y* (t CO_2/yr)
$PE_{DT,y}$	=	Emissions from the distribution of compressed/liquefied LFG using trucks, in year y (t CO2/yr)
$PE_{SP,y}$	=	Emissions from the supply of LFG to consumers through a dedicated pipeline, in year *y* (t CO_2/yr)

Calculation of $PE_{EC,y}$ – project emission from consumption of electricity

According to "*Methodological tool: Baseline, project and/or leakage emissions from electricity consumption and monitoring of electricity generation"*, the project emission from consumption of electricity will be from two sources:

- $PE_{EC1,y}$ - Grid (Brazilian interconnected electric system);
- $PE_{EC2,y}$ - Diesel generator(s) (off-grid captive power plant)

Thus,

$$PE_{EC,y} = PE_{EC1,y} + PE_{EC2,y}$$

$PE_{EC1,y}$ - Project emission from electricity consumption from the grid

As electricity will be consumed from the grid, the option A1 of the scenario A was chosen, as follows:

> *Option A1: Calculate the combined margin emission factor of the applicable electricity system, using the procedures of the "Tool to calculate the emission factor for an electricity system" ($EF_{EL,j/k/l,y} = EF_{grid,CM,y}$).*

Thus, the project emission is calculated as following:

$$PE_{EC1,y} = EC_{PJ1,y} \times EF_{grid,CM,y} \times (1 + TDL_y)$$

Where:

$EC_{PJ1,y}$	= quantity of electricity consumed from the grid by the project activity during the year y (MWh);
$EF_{grid,CM,y}$	= the emission factor for the grid in year y (tCO_2/MWh);
TDL_y	= average technical transmission and distribution losses in the grid in year y for the voltage level at which electricity is obtained from the grid at the project site.

$PE_{EC2,y}$ - Project emission from electricity consumption from an off-grid captive power plant (diesel generator(s))

As electricity will be consumed from diesel generators (off-grid captive power plant), a conservative approach was adopted and the option B2 of the scenario B was chosen because: "The electricity consumption source is a project or leakage electricity consumption source". Therefore, the value used will be 1.3[27] tCO_2/MWh for project emission from diesel generator(s).

$$PE_{EC2,y} = EC_{PJ2,y} \times EF_{diesel\_generator,y} \times (1 + TDL_y)$$

[27] According to the default value of the tool "Baseline, project and/or leakage emissions from electricity consumption and monitoring of electricity generation".

Where:

$EC_{PJ2,y}$	= quantity of electricity consumed from diesel generator by the project activity during the year y (MWh);
$EF_{diesel\_generator,y}$	= the emission factor for the diesel generator in year y (tCO_2/MWh);
TDL_y	= average technical transmission and distribution losses in the grid in year y for the voltage level at which electricity is obtained from the grid at the project site.

Leakage:

In accordance with the ACM0001, no leakage effects need to be accounted.

Emission Reduction

Emission reductions are calculated as follows:

$$ER_y = BE_y - PE_y,$$

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

Open flare(s) will been installed in the project activity.

B.6.2. Data and parameters fixed ex ante

The following ex ante parameters, listed in the registered project activity, will not be used in this project activity and thus not presented in the tables below since have been not used in the calculation of emission reductions:

- Manufacturer’s flare specifications for temperature, flow rate and maintenance schedule ($SPEC_{flare}$)

Data / Parameter	OX_{top_layer}
Unit	Dimensionless
Description	Fraction of methane that would be oxidized in the top layer of the SWDS in the baseline
Source of data	Consistent with how oxidation is accounted for in the methodological tool “Emissions from solid waste disposal sites”
Value(s) applied	0.1
Choice of data or Measurement methods and procedures	Default value used, according to ACM0001
Purpose of data	Calculation of baseline emission
Additional comment	Applicable to Step A

Data / Parameter	GWP_{CH4}
Unit	t CO_2e/t CH_4
Description	Global warming potential of CH_4

Source of data	IPCC
Value(s) applied	25. Updated for the 2nd commitment period according to COP/MOP decisions[28]
Choice of data or Measurement methods and procedures	Default value used, according to IPCC Fourth Assessment Report: Climate Change 2007, item 2.10.2: Direct Global Warming Potentials, Table 2.14
Purpose of data	Calculation of baseline emission
Additional comment	In opposite of the PDD registered on 26 Feb 13 using GWP of 21, it has been updated to 25.

Data / Parameter	R_u
Unit	$Pa.m^3/kmol.K$
Description	Universal ideal gas constant
Source of data	Methodological tool "Project emissions from flaring"
Value(s) applied	8,314
Choice of data or Measurement methods and procedures	Default value used, according to Methodological tool "Project emissions from flaring", table 1: Constants used in equations
Purpose of data	Calculation of baseline emission
Additional comment	-

Data / Parameter	Waste composition
Unit	%
Description	Waste composition
Source of data	landfill internal studies
Value(s) applied	(see table below)
Choice of data or Measurement methods and procedures	Internal Report
Purpose of data	Calculation of baseline emission
Additional comment	Used for projection of methane avoidance

Composition of waste	
A) Wood and wood products	29.40%
B) Pulp, paper and cardboard (other than sludge)	6.40%
C) Food, food waste, beverages and tobacco (other than sludge)	29.40%
D) Textiles	0.00%
E) Garden, yard and park waste	0.00%
F) Glass, plastic, metal, other inert waste	34.80%
TOTAL	**100.00%**

[28] IPCC Fourth Assessment Report: Climate Change 2007, item 2.10.2: Direct Global Warming Potentials, Table 2.14, available at: http://www.ipcc.ch/publications_and_data/ar4/wg1/en/ch2s2-10-2.html , accessed on 11/01/2018 and in accordance with EB69, Annex 3 and decision 4/CMP.7, available at: http://cdm.unfccc.int/Reference/Standards/meth/reg_stan02.pdf , accessed on 11/01/2018.

Data / Parameter	η_{PJ}
Unit	Dimensionless
Description	Efficiency of the LFG capture system installed in the project activity
Source of data	Equipments manufacturer of biogas capture system
Value(s) applied	65%
Choice of data or Measurement methods and procedures	Based on the active LFG capture system installed, according to technical specifications from the equipments provider
Purpose of data	Calculation of baseline emission
Additional comment	-

Data / Parameter	$\varphi_{default}$
Unit	-
Description	Default value for the model correction factor to account for model uncertainties
Source of data	Tool “Emissions from solid waste disposal sites”
Value(s) applied	0.75
Choice of data or Measurement methods and procedures	According to “Emissions from solid waste disposal sites”, the *Application A* was used because the landfill is an existing solid waste disposal site and in the project activity the methane emissions are being mitigated by capturing and flaring the methane (ACM0001).
Purpose of data	Calculation of baseline emission
Additional comment	-

Data / Parameter	OX
Unit	-
Description	Oxidation factor (reflecting the amount of methane from SWDS that is oxidized in the soil or other material covering the waste)
Source of data	Based on an extensive review of published literature on this subject, including the IPCC 2006 Guidelines for National Greenhouse Gas Inventories
Value(s) applied	0.1
Choice of data or Measurement methods and procedures	Default value used according to “Emissions from solid waste disposal sites”
Purpose of data	Calculation of baseline emission
Additional comment	When methane passes through the top-layer, part of it is oxidized by methanotrophic bacteria to produce CO_2. The oxidation factor represents the proportion of methane that is oxidized to CO_2.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.

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	Default value used according to “Emissions from solid waste disposal sites”
Purpose of data	Calculation of baseline emission
Additional comment	Upon biodegradation, organic material is converted to a mixture of methane and carbon dioxide

Data / Parameter	$DOC_{f,default}$
Unit	Weight fraction
Description	Default value for the fraction of degradable organic carbon (DOC) in MSW that decomposes in the SWDS
Source of data	IPCC 2006 Guidelines for National Greenhouse Gas Inventories
Value(s) applied	0.5
Choice of data or Measurement methods and procedures	The default value was used for type Application A). according to “Emissions from solid waste disposal sites”
Purpose of data	Calculation of baseline emission
Additional comment	This factor reflects the fact that some degradable organic carbon does not degrade, or degrades very slowly, in the SWDS. This default value can be used for Application A.

Data / Parameter	$MCF_{default}$
Unit	-
Description	Methane correction factor
Source of data	IPCC 2006 Guidelines for National Greenhouse Gas Inventories
Value(s) applied	1.0
Choice of data or Measurement methods and procedures	The project activity is an anaerobic managed solid waste disposal site with controlled placement of waste (i.e. waste directed to specific deposition areas, a degree of control of scavenging and a degree of control of fires) and is include: (i) cover material; (ii) mechanical compacting and (iii) leveling of the waste;
Purpose of data	Calculation of baseline emission
Additional comment	-

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

Value(s) applied	**Waste type j** / **DOCj (% wet waste)**: Wood and wood products: 43% Pulp, paper and cardboard (other than sludge): 40% Food, food waste, beverages and tobacco (other than sludge): 15% Textiles: 24% Garden, yard and park waste: 20% Glass, plastic, metal, other inert waste: 0%
Choice of data or Measurement methods and procedures	IPCC default value for municipal solid waste (MSW) disposal site is applied.
Purpose of data	Calculation of baseline emission
Additional comment	-

Waste type j	DOCj (% wet waste)
Wood and wood products	43%
Pulp, paper and cardboard (other than sludge)	40%
Food, food waste, beverages and tobacco (other than sludge)	15%
Textiles	24%
Garden, yard and park waste	20%
Glass, plastic, metal, other inert waste	0%

Data / Parameter	k_j
Unit	-
Description	Decay rate for waste type j
Source of data	2006 IPCC Guidelines for National Greenhouse Gas Inventories
Value(s) applied	See table below
Choice of data or Measurement methods and procedures	IPCC default value for anaerobic managed solid waste disposal site is applied.
Purpose of data	Calculation of baseline emissions
Additional comment	• The mean annual temperature (MAT) is 26.3ºC and the mean annual precipitation (MAP) 2,326 mm. Source: INMET - Instituto Nacional de Meteorologia[29]

Waste type j		Tropical (MAT > 20 °C)
		Wet (MAP>1000mm)
Slowly degrading	Pulp, paper, cardboard (other than sludge), textiles	0.07
	Wood, wood products and straw	0.035
Moderately degrading	Other (non-food) organic putrescible garden and park waste	0.17
Rapidly degrading	Food, food waste, sewage sludge, beverages and tobacco	0.4

[29] https://www.cnpm.embrapa.br/projetos/bdclima/balanco/resultados/ma/72/balanco.html, accessed on 16/07/2019.

Data / Parameter	MM_i
Unit	kg/kmol
Description	Molecular mass of greenhouse gas i
Source of data	Tool to determine the mass flow of a greenhouse gas in a gaseous stream
Value(s) applied	Compound: Methane; Structure: CH_4; Molecular mass (kg/kmol): 16.04
Choice of data or Measurement methods and procedures	According to "Tool to determine the mass flow of a greenhouse gas in a gaseous stream"
Purpose of data	Calculation of baseline emissions
Additional comment	-

Compound	Structure	Molecular mass (kg/kmol)
Methane	CH_4	16.04

Data / Parameter	MM_k
Unit	kg/kmol
Description	Molecular mass of gas *k*
Source of data	Tool to determine the mass flow of a greenhouse gas in a gaseous stream
Value(s) applied	Compound: Nitrogen; Structure: N_2; Molecular mass (kg/kmol): 28.01
Choice of data or Measurement methods and procedures	According to "Tool to determine the mass flow of a greenhouse gas in a gaseous stream"
Purpose of data	Calculation of baseline emissions
Additional comment	-

Compound	Structure	Molecular mass (kg/kmol)
Nitrogen	N_2	28.01

Data / Parameter	MM_{H2O}
Unit	kg/kmol
Description	Molecular mass of water
Source of data	Tool to determine the mass flow of a greenhouse gas in a gaseous stream
Value(s) applied	18.0152
Choice of data or Measurement methods and procedures	According to "Tool to determine the mass flow of a greenhouse gas in a gaseous stream"
Purpose of data	Calculation of baseline emissions
Additional comment	-

B.6.3. Ex-ante calculation of emission reductions

>>

<u>**Emission reduction**</u>

Baseline emission calculation

The total of methane generation at the site has been estimated based on the waste tonnage of the landfill using the first order decay model presented in the *"Emissions from solid waste disposal sites"* and considering the following equation as mentioned previously.

Ex-ante estimation of $F_{CH4,PJ,y}$

The assumptions used to calculate $\mathbf{F_{CH4,PJ,y}}$ are:

- Methane content in LFG = 50% (default value);
- LFG collection efficiency = 65%
- Density of methane = 0.716 kg/m^3 (as per tool "Project emissions from flaring*").*

The landfill gas collection and utilization system will capture only a portion of the generated landfill gas. Thus, an estimate of 65% LFG collection was applied to the estimate of LFG produced, under assumption that generated LFG is composed of 50% methane.

The ex ante estimation of the $F_{CH4,PJ,y}$ is presented below:

$$F_{CH4,PJ,y} = \eta_{PJ} \times \frac{BE_{CH4,SWDS,y}}{GWP_{CH4}}$$

Where:

$F_{CH4,PJ,y}$	=	Amount of methane in the LFG which is flared and/or used in the project activity in year y (tCH_4/yr)
$BE_{CH4,SWDS,y}$	=	Amount of methane in the LFG that is generated from the SWDS in the baseline scenario in year y (tCO_2e/yr)
η_{PJ}	=	Efficiency of the LFG capture system that will be installed in the project activity
GWP_{CH4}	=	Global warming potential of CH_4 (tCO_2e/tCH_4)

The table below illustrates the ex-ante estimation of $F_{CH4,PJ,y}$ by the project activity during the crediting period.

Table 3 - Ex-ante estimation of $F_{CH4,PJ,y}$

Year	$F_{CH4,PJ,y}$ (tCH_4/yr)
2014	2,311
2015	3,083
2016	3,703
2017	4,215
2018	4,652
2019	5,034
2020	5,376

Determination of $F_{CH4,BL,y}$

$F_{CH4,BL,y} = 20\% \times F_{CH4,PJ,y}$

Table 4 - Ex-ante estimation of $F_{CH4,BL,y}$

Year	$F_{CH4,BL,y}$ (tCH_4/yr)
2014	462
2015	617
2016	741
2017	843
2018	930
2019	1,007
2020	1,075

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

The equation of the $BE_{CH4,y}$ is:

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

Where the OX_{top_layer} = 0.1 (default value) and $F_{CH4,PJ,y}$ and $F_{CH4,BL,y}$ are calculated above. The results are presented below:

Table 5 - Baseline emissions of methane from the SWDS ($BE_{CH4,y}$)

Year	$BE_{CH4,y}$ (tCO_2/year)
2014	40,442
2015	53,959
2016	64,800
2017	73,769
2018	81,413
2019	88,099
2020	94,077

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

The ex-ante calculation is:

$$BE_{EC,y} = EC_{BL,k,y} \times EF_{grid,CM,y} \times (1+TDL_y)$$

$EF_{grid,CM,y}$ = 0.3380 tCO_2/MWh

Table 6 - Baseline emissions associated with electricity generation ($BE_{EC,y}$)

Year	$EC_{BL,k,y}$ (MWh/yr)	$BE_{EC,y}$ (tCO_2/yr)
2014	0	0
2015	0	0
2016	0	0
2017	0	0
2018	0	0
2019	15,768	6,396
2020	23,652	9,594

The forecast installed capacity and electricity generated ($EC_{BL,k,y}$) by the project activity are present below:

Year	Number of engines	Installed capacity (MWe)	Electricity generated in the plant (MWh)
2014	0	0.000	0
2015	0	0.000	0
2016	0	0.000	0
2017	0	0.000	0
2018	0	0.000	0
2019	2	2.000	15,768
2020	3	3.000	23,652

[1] The plant load factor is 90%.

The equation of the baseline emission calculation is:

$$BE_y = BE_{CH4,y} + BE_{EC,y}$$

The result is:

Table 7 - Baseline emission calculation

Year	$BE_{CH4,y}$ (tCO_2/year)	$BE_{EC,y}$ (tCO_2/yr)	BE_y (tCO_2/yr)
2014	40,442	0	40,442
2015	53,959	0	53,959
2016	64,800	0	64,800
2017	73,769	0	73,769
2018	81,413	0	81,413
2019	88,099	6,396	94,495
2020	94,077	9,594	103,671

Therefore, the combined margin CO_2 emission factor will be ex-ante.

1. Project emission

$$PE_y = PE_{EC,y} + PE_{FC,y}$$

Where:

PE_y	=	Project emissions in year y (tCO_2/yr)
$PE_{EC,y}$	=	Emissions from consumption of electricity due to the project activity in year y (tCO_2/yr)
$PE_{FC,y}$	=	Emissions from consumption of fossil fuels due to the project activity, for purpose other than electricity generation, in year y (tCO_2/yr)

There is no consumption of fossil fuels due to the project activity for purpose other than electricity generation, in year y (tCO_2/yr), therefore $PE_{FC,y} = 0$

Thus,

$$PEy = PE_{EC,y}$$

Calculation of $PE_{EC,y}$ – project emission from consumption of electricity

The project emission from consumption of electricity is:

$$PE_{EC,y} = PE_{EC1,y} + PE_{EC2,y}$$

Where:

$PE_{EC1,y}$ - Project emission from the grid

In the option A1 of the "Methodological tool: Baseline, project and/or leakage emissions from electricity consumption and monitoring of electricity generation", states that a value of the combined margin emission factor ($EF_{grid,CM,y}$) may be used as the emission factor ($EF_{ELj/k/l,y}$). Therefore a value of 0.3380 tCO_2/MWh will be used.

Finally, the technical transmission and distribution losses ($TDL_{j,y}$) value has been assumed to be 20%, according to Option 2: default value from TOOL05 - Baseline, project and/or leakage emissions from electricity consumption and monitoring of electricity generation. Table below summarizes the project emissions resulting from electrical consumption in the plant.

Table 8 - Electricity consumption from the grid resulting due to project activity

Year	Electricity consumption from the grid (MWh/year)	$PE_{el,grid}$ (tCO_2/year)
2014	0	0
2015	0	0
2016	0	0
2017	0	0
2018	0	0
2019	0	0
2020	0	0

Calculation of $PE_{FC,y}$ – Emissions from consumption of fossil fuels due to the project activity, for purpose other than electricity generation

For ex-ante calculation, this factor was considered zero because there is no estimation from LPG consumption in pilot flames of flares.

$PE_{FC,y} = 0$

2. Leakage:

No leakage effects need to be accounted under methodology ACM0001.

3. Emission reduction

Emission reductions are calculated as follows:

$$ER_y = BE_y - PE_y$$

Where:

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

Year	BEy (tCO_2)	PEy (tCO_2)	ERy (tCO_2)
2014	40,442	0	40,442
2015	53,959	0	53,959
2016	64,800	0	64,800
2017	73,769	0	73,769
2018	81,413	0	81,413
2019	94,495	0	94,495
2020	103,671	0	103,671

It is important to notice that, even with a lower electricity plant installed capacity proposed in this Post-Registration Changes, the ex-ante estimates of emission reductions are higher than in the PDD prior to the changes. This is due to the update of parameter GWP_{CH4} “Global warming potential of methane valid for the commitment period” to 25 tCO_2e/t CH_4 and update of paramenter $EF_{grid,CM,y}$ from 2011 to 2018 values.

B.6.4. Summary of ex ante estimates of emission reductions

Year	Baseline emissions (t CO_2e)	Project emissions (t CO_2e)	Leakage (t CO_2e)	Emission reductions (t CO_2e)
2014	40,442	0	0	40,442
2015	53,959	0	0	53,959
2016	64,800	0	0	64,800
2017	73,769	0	0	73,769
2018	81,413	0	0	81,413

2019	94,495	0	0	94,495
2020	103,671	0	0	103,671
Total	**512,549**	**0**	**0**	**512,549**
Total number of crediting years	**7**			
Annual average over the crediting period	**73,221**	**0**	**0**	**73,221**

B.7. Monitoring plan

B.7.1. Data and parameters to be monitored

The following ex ante parameters, listed in the registered project activity, will not be used in this project activity and thus not presented in the tables below since have been not used in the calculation of emission reductions:

- Quantity of LPG combusted in pilot flames of flares during year y ($FC_{i,j,y}$)
- Weighted average CO2 emission factor of LPG in year y ($EF_{CO2,LPG,y}$)
- Weighted average net calorific value of fossil fuel i in year y ($NCV_{fuel,y}$)
- Mass flow of methane in the exhaust gas of the flare on a dry basis at reference conditions in the time period t ($F_{CH4,EG,t}$)
- Maintenance events completed in year y ($Maintenance_y$)
- Temperature in the exhaust gas of the flare in minute m ($T_{EG,m}$)

Data / Parameter	$EF_{grid,CM,y}$
Unit	tCO_2 /MWh
Description	CO_2 emission factor of the Brazilian grid electricity during the year y
Source of data	Calculations based on parameters described above.
Value(s) applied	0.3380 (year 2018)
Measurement methods and procedures	The emission factor is calculated ex-post, as the weighted average of the dispatch data analysis OM (Operating Margin) and the BM (Build margin), as described in B.6.3.
Monitoring frequency	Annual
QA/QC procedures	Apply procedures in the “Tool to calculate the emission factor for an electricity system”.
Purpose of data	(b) Calculation of project emissions or actual net GHG removals by sinks;
Additional comment	All data and parameters to determine the grid electricity emission factor, as required by the “Tool to calculate the emission factor for an electricity system”, were included in the monitoring plan. For more details, see Annex 3.

Data / Parameter	$EF_{grid,OM,y}$
Unit	tCO_2 /MWh
Description	Operating margin emission factor of the Brazilian grid
Source of data	Calculations based on parameters described above.
Value(s) applied	0.5390 (year 2018)
Measurement methods and procedures	The operating margin emission factor is calculated ex-post, as described in B.6.3.

Monitoring frequency	Annual
QA/QC procedures	Apply procedures in the “Tool to calculate the emission factor for an electricity system”.
Purpose of data	(b) Calculation of project emissions or actual net GHG removals by sinks;
Additional comment	All data and parameters to determine the grid electricity emission factor, as required by the “Tool to calculate the emission factor for an electricity system”, were included in the monitoring plan. For more details, see Annex 3.

Data / Parameter	$EF_{grid,BM,y}$
Unit	tCO_2 /MWh
Description	Build margin emission factor of the Brazilian grid
Source of data	Calculations based on parameters described above.
Value(s) applied	0.1370 (year 2018)
Measurement methods and procedures	The emission factor is calculated ex-ante, as described in B.6.3.
Monitoring frequency	Annual
QA/QC procedures	Apply procedures in the “Tool to calculate the emission factor for an electricity system”
Purpose of data	(b) Calculation of project emissions or actual net GHG removals by sinks;
Additional comment	All data and parameters to determine the grid electricity emission factor, as required by the “Tool to calculate the emission factor for an electricity system”, were included in the monitoring plan. For more details, see Annex 3.

Data / Parameter	$TDL_{j,y}$
Unit	-
Description	Average technical transmission and distribution losses for providing electricity to source j, in year y
Source of data	Default value from TOOL05
Value(s) applied	20%
Measurement methods and procedures	For (a): *TDLj/k/l,y* should be estimated for the distribution and transmission networks of the electricity grid of the same voltage as the connection where the proposed CDM project activity is connected to. The technical distribution losses should not contain other types of grid losses (e.g. commercial losses/theft). The distribution losses can either be calculated by the project participants or be based on references from utilities, network operators or other official documentation
Monitoring frequency	Annually. In the absence of data from the relevant year, most recent figures should be used, but not older than 5 years
QA/QC procedures	-
Purpose of data	(b) Calculation of project emissions or actual net GHG removals by sinks;
Additional comment	The technical transmission and distribution losses (TDLj,y) value has been assumed to be 20%, default value from TOOL05.

Data / Parameter	$EC_{PJ1,y} = EG_{EC1,y}$

Unit	MWh/y
Description	Quantity of electricity consumed from the grid by the project activity during the year y;
Source of data	Measurement from Project participants.
Value(s) applied	<table><tr><th>Year</th><th>$EC_{PJ1,y}$ (MWh/year)</th></tr><tr><td>2014</td><td>0</td></tr><tr><td>2015</td><td>0</td></tr><tr><td>2016</td><td>0</td></tr><tr><td>2017</td><td>0</td></tr><tr><td>2018</td><td>0</td></tr><tr><td>2019</td><td>0</td></tr><tr><td>2020</td><td>0</td></tr></table>
Measurement methods and procedures	Continuously measured by electricity meters for the grid electricity consumption as per the “Methodological tool: Baseline, project and/or leakage emissions from electricity consumption and monitoring of electricity generation” and methodology ACM0001.
Monitoring frequency	Continuously
QA/QC procedures	As per the “Methodological tool: Baseline, project and/or leakage emissions from electricity consumption and monitoring of electricity generation”
Purpose of data	(b) Calculation of project emissions or actual net GHG removals by sinks;
Additional comment	The data will be archived throughout the crediting period and two years thereafter.

Data / Parameter	Management of SWDS
Unit	-
Description	Management of SWDS
Source of data	Use different sources of data: - Original design of the landfill; - Technical specifications for the management of the SWDS; - Local or national regulations
Value(s) applied	-
Measurement methods and procedures	Project participants should refer to the original design of the landfill to ensure that any practice to increase methane generation have been occurring prior to the implementation of the project activity Any change in the management of the SWDS after the implementation of the project activity should be justified by referring to technical or regulatory specifications.
Monitoring frequency	Annually
QA/QC procedures	-
Purpose of data	(a) Calculation of baseline emissions or baseline net GHG removals by sinks;
Additional comment	-

Data / Parameter	$EG_{PJ,y} = EC_{BL,k,y}$
Unit	MWh
Description	Amount of electricity generated using LFG by the project activity in year y
Source of data	Electricity meter
Value(s) applied	(see table below)
Measurement methods and procedures	Monitor net electricity generation by the project activity using LFG
Monitoring frequency	Continuous
QA/QC procedures	Electricity meter will be subject to regular (in accordance with stipulation of the meter supplier) maintenance and testing to ensure accuracy. The readings will be double checked by the electricity distribution company.
Purpose of data	(b) Calculation of project emissions or actual net GHG removals by sinks;
Additional comment	This parameter is required for calculating baseline emissions associated with electricity generation (*$BE_{EC,y}$*) using the “Methodological tool: Baseline, project and/or leakage emissions from electricity consumption and monitoring of electricity generation”

Value(s) applied:

Year	$EG_{PJ,y}$ (MWh/year)
2014	0
2015	0
2016	0
2017	0
2018	0
2019	15,768
2020	23,652

Data / Parameter	$O_{pj,h}$
Unit	-
Description	Operation of the equipment that consumes the LFG
Source of data	Measurements by Project participant using a device integrated with the operational software at the landfill gas plant.
Value(s) applied	1 or 0
Measurement methods and procedures	For each equipment unit j using the LFG monitor that the plant is operating in hour h by the monitoring any one or more of the following three parameters: (a) Temperature. Determine the location for temperature measurements and minimum operational temperature based on manufacturer's specifications of the burning equipment. Document and justify the location and minimum threshold in the PDD; (b) Flame. Flame detection system is used to ensure that the equipment is in operation; (c) Products generated. Monitor the generation of steam for the case of boilers and air-heaters and glass for the case of glass melting furnances. This option is not applicable to brick kilns. Opj,h=0 when: (a) One of more temperature measurements are missing or below the minimum threshold in hour h (instantaneous measurements are made at least every minute); (b) Flame is not detected continuously in hour h (instantaneous measurements are made at least every minute); (c) No products are generated in the hour h. Otherwise, Opj,h=1
Monitoring frequency	Once per minute
QA/QC procedures	The calibration of this equipment is not applicable since it is a device integrated with the operational software at the landfill gas plant.
Purpose of data	(a) Calculation of baseline emissions or baseline net GHG removals by sinks;
Additional comment	-

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

Data / Parameter	$V_{t,db}$
Unit	m³ /h
Description	Volumetric flow of the gaseous stream in time interval t on a dry basis
Source of data	Measurements by Project participants using a flow meter(s)
Value(s) applied	n/a
Measurement methods and procedures	The volumetric flow rate of the residual gas which is sent to each individual flare, LFG engines in the hour h will be measured by the installed flow meters with digital recordable electronic signal, according to the “Tool to determine the mass flow of a greenhouse gas in a gaseous stream”, the measurement option in the project activity will be: • Option (A) dry basis: when the temperature of gaseous stream is lower than 60ºC (333.15 K) at the flow measurement point; • Option (B) wet basis: when the temperature of gaseous stream is higher than 60o C (333.15 K) at the flow measurement point;
Monitoring frequency	Continuous recorded and hourly aggregated
QA/QC procedures	Periodic calibration against a primary device provided by an independent accredited laboratory is mandatory. The calibration frequency of this monitoring equipment should be in accordance with manufacturer’s specifications.
Purpose of data	(a) Calculation of baseline emissions or baseline net GHG removals by sinks;
Additional comment	This parameter will be monitored only in case Option A of the “Tool to determine the mass flow of a greenhouse gas in a gaseous stream” is applied for the determination of $F_{CH4,flared,y}$, $F_{CH4,EL,y}$ and $F_{CH4,NG,y}$

Data / Parameter	$V_{t,wb}$
Unit	m³ /h
Description	Volumetric flow of the gaseous stream in time interval t on a wet basis
Source of data	Measurements by Project participants using a flow meter
Value(s) applied	n/a
Measurement methods and procedures	The volumetric flow rate of the residual gas which is sent to each individual flare, LFG engines in the hour h will be measured by the installed flow meters with digital recordable electronic signal, according to the “Tool to determine the mass flow of a greenhouse gas in a gaseous stream”, the measurement option in the project activity will be: • Option (A) dry basis: when the temperature of gaseous stream is lower than 60ºC (333.15 K) at the flow measurement point; • Option (B) wet basis: when the temperature of gaseous stream is higher than 60o C (333.15 K) at the flow measurement point;
Monitoring frequency	Continuous recorded and hourly aggregated
QA/QC procedures	Periodic calibration against a primary device provided by an independent accredited laboratory is mandatory. The calibration frequency of this monitoring equipment should be in accordance with manufacturer’s specifications.
Purpose of data	(a) Calculation of baseline emissions or baseline net GHG removals by sinks;
Additional comment	This parameter will be monitored only in case Options B or C of the “Tool to determine the mass flow of a greenhouse gas in a gaseous stream” is applied for the determination of $F_{CH4,flared,y}$, $F_{CH4,EL,y}$ and $F_{CH4,NG,y}$

Data / Parameter	$v_{i,t,db}$
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
Source of data	Measurements by Project participants using gas analyser
Value(s) applied	50%
Measurement methods and procedures	Continuous gas analyser operating in dry basis. Volumetric flow measurement should always refer to the actual pressure and temperature.
Monitoring frequency	Continuous recorded and hourly aggregated
QA/QC procedures	Calibration should include zero verification with an inert gas (e.g. N_2) and at least one reading verification with a standard gas (single calibration gas or mixture calibration gas). All calibration gases must have a certificate provided by the manufacturer and must be under their validity period.
Purpose of data	(a) Calculation of baseline emissions or baseline net GHG removals by sinks;
Additional comment	This parameter will be monitored in Options B and E and may be monitored in Options A and D of the tool "Tool to determine the mass flow of a greenhouse gas in a gaseous stream" is applied for the determination of $F_{CH4,flared,y}$, $F_{CH4,EL,y}$ and $F_{CH4,NG,y}$

Data / Parameter	$v_{i,t,wb}$
Unit	m^3 gas i/m^3 wet gas
Description	Volumetric fraction of greenhouse gas i in a time interval t on a wet basis
Source of data	Measurements by Project participants using gas analyser
Value(s) applied	50%
Measurement methods and procedures	Calculated based on the dry basis analysis plus water concentration measurement or continuous in-situ analysers if not specified in the underlying methodology
Monitoring frequency	Continuous recorded and hourly aggregated
QA/QC procedures	Calibration should include zero verification with an inert gas (e.g. N_2) and at least one reading verification with a standard gas (single calibration gas or mixture calibration gas). All calibration gases must have a certificate provided by the manufacturer and must be under their validity period.
Purpose of data	(a) Calculation of baseline emissions or baseline net GHG removals by sinks;
Additional comment	This parameter will be monitored in Options B and E and may be monitored in Options A and D of the tool "Tool to determine the mass flow of a greenhouse gas in a gaseous stream" is applied for the determination of $F_{CH4,flared,y}$, $F_{CH4,EL,y}$ and $F_{CH4,NG,y}$

Data / Parameter	T_t
Unit	K
Description	Temperature of the gaseous stream in time interval t
Source of data	Measurements by Project participant using a temperature meter
Value(s) applied	n/a
Measurement methods and procedures	Thermoresistance with digital recordable electronic signal will be used. The accuracy and uncertainty of the monitoring instrument will be in accordance with manufacturer specifications.
Monitoring frequency	Continuous
QA/QC procedures	Periodic calibration against a primary device provided by an independent accredited laboratory is mandatory. The calibration frequency of this monitoring equipment should be according to the manufacturer's specifications
Purpose of data	(a) Calculation of baseline emissions or baseline net GHG removals by sinks;
Additional comment	Provided all parameters are converted to normal conditions during the monitoring process, this parameter may not be needed except for moisture content determination and therefore it should be metered only when performing such measurements (with same frequency). However, if the applicability condition related to the gaseous stream flow temperature being below 60ºC is adopted, this parameter must be monitored continuously to assure the applicability condition is met.

Data / Parameter	P_t
Unit	Pa
Description	Pressure of the gaseous stream in time interval t
Source of data	Measurements by Project participant using a pressure meter
Value(s) applied	n/a
Measurement methods and procedures	Instruments with recordable electronic signal (analogical or digital) will be used. Examples include pressure transducers, etc. The accuracy and uncertainty of the monitoring instrument will be in accordance with manufacturer specifications.
Monitoring frequency	Continuous
QA/QC procedures	Periodic calibration against a primary device must be performed periodically and records of calibration procedures must be kept available as well as the primary device and its calibration certificate. Pressure transducers (either capacitive or resistive) must be calibrated monthly. In case the pressure meter is not a capacitive or resistive pressure transducer, the calibration frequency of this monitoring equipment should be according to the manufacturer's specifications.
Purpose of data	(a) Calculation of baseline emissions or baseline net GHG removals by sinks;
Additional comment	Provided all parameters are converted to normal conditions during the monitoring process, this parameter may not be needed except for moisture content determination and therefore it should be metered only when performing such measurements (with same frequency)

Data / Parameter	Status of biogas destruction device
Unit	-
Description	Operational status of biogas destruction devices
Source of data	Provided by project participants
Value(s) applied	n/a
Measurement methods and procedures	Monitoring and documenting may be undertaken by recording the energy production from methane captured or the operation of the flare by means of a flame detector to demonstrate the actual destruction of methane, unless a different method is specified in the underlying methodology/tool. Emission reductions will not accrue for periods in which the destruction device is not operational.
Monitoring frequency	Continuous
QA/QC procedures	-
Purpose of data	(a) Calculation of baseline emissions or baseline net GHG removals by sinks;
Additional comment	For Flame detector devices refer to the methodological tool “Project emissions from flaring”

Data / Parameter	$P_{H2O,t,Sat}$
Unit	Pa
Description	Saturation pressure of H_2O at temperature Tt in time interval t
Source of data	Provided by project participants
Value(s) applied	n/a
Measurement methods and procedures	This parameter is solely a function of the gaseous stream temperature Tt and can be found at reference [1] for a total pressure equal to 101,325 Pa
Monitoring frequency	-
QA/QC procedures	-
Purpose of data	(a) Calculation of baseline emissions or baseline net GHG removals by sinks;
Additional comment	[1] Fundamentals of Classical Thermodynamics; Gordon J. Van Wylen, Richard E. Sonntag and Borgnakke; 4º Edition 1994, John Wiley & Sons, Inc.

Methodological tool “Project emissions from flaring”

Data / Parameter	$Flame_m$
Unit	Flame on or Flame off
Description	Flame detection of flare in the minute m
Source of data	Project Participant
Value(s) applied	-
Measurement methods and procedures	Measurements by project participants using a continuous Ultra Violet flame detector
Monitoring frequency	Once per minute. Detection of flame recorded as a minute that the flame was on, otherwise recorded as a minute that the flame was off
QA/QC procedures	Equipment shall be maintained and calibrated in accordance with manufacturer’s recommendations

Purpose of data	Calculation of baseline and project emissions when the flame is on[30].
Additional comment	-

B.7.2. Sampling plan

>>

Not applicable

B.7.3. Other elements of monitoring plan

>>

The monitoring plan will be done according to the methodology ACM0001, the applicable tools, as well as per CDM project standard. Details are available in section B.7.1 above. The monitoring equipment locations are presented in the picture below:

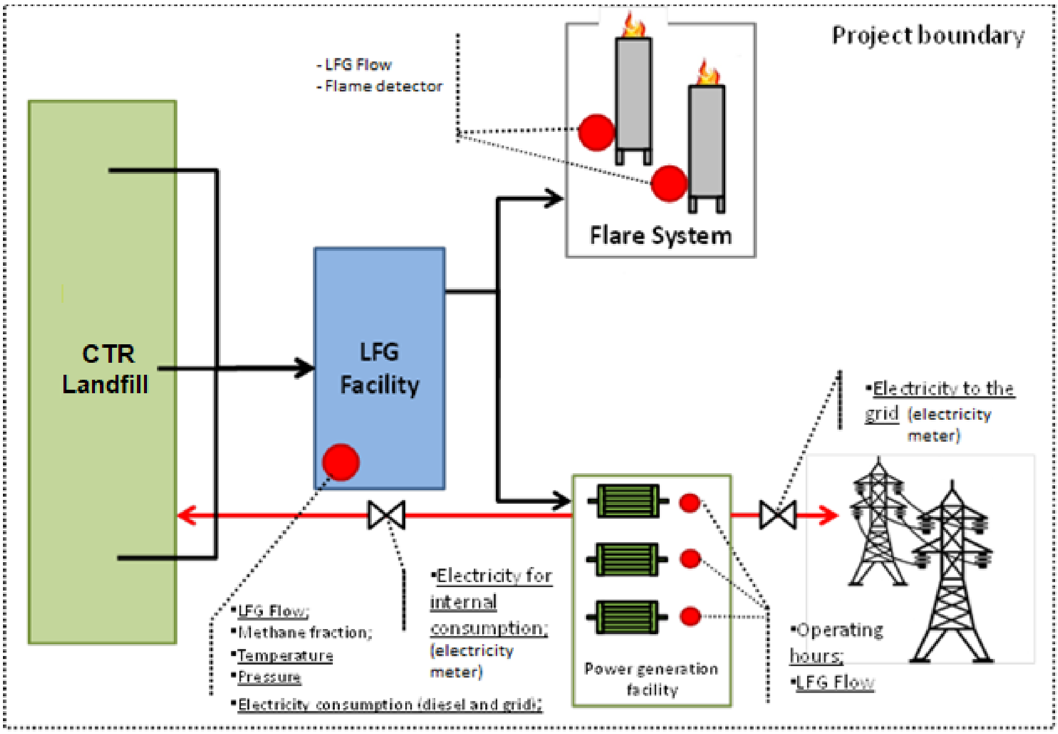

Figure 13 - Monitoring equipment locations

All continuously measured parameters (LFG flow, CH_4 concentration, flare temperature, flare operating hours, engine operating hours, and engine electrical output) will be recorded electronically via a datalogger, located within the Site boundary which will have the capability to aggregate and print the collected data at the frequencies as specified above. It will be the responsibility of the Site Operator to provide all requested data logs which will be stored over the duration of the reporting period at the Site office. The data logs will be summarized into emission reduction calculations prior to each verification.

[30] When the flame is off, neither baseline nor project emissions occurs since the LFG is not combusted and instead released to the atmosphere.

1. Introduction and Objectives

The two primary purposes of the monitoring plan are:

- To collect the necessary system data required for the determination of emissions reductions; and
- To demonstrate successful compliance with established operating and performance criteria to verify the emission reductions and generate the respective CERs.

The operational data that is collected will be used to support the periodic verification report that will be required for CER auditing. The monitoring plan discussed herein is designed to meet or exceed the UNFCCC requirements (approved monitoring methodology ACM0001).

The routine system monitoring program required for the determination of the emission reductions is discussed in section 2 below, while the additional system data that is collected to ensure the safe, correct, and efficient operation of the LFG management system is discussed in section 3.

2. Training of monitoring personnel

Before commencement of the O&M phase, project activity will conduct a training and quality control program to ensure that good management practices are carried out and implemented by all project operating personnel in terms of record-keeping, equipment calibration, overall maintenance, and procedures for corrective action. An operation manual will be developed for the operating personnel. The procedures for filing data and calculations to be performed by the LFG utilization operator will be included in a daily log to be placed in the main control room.

3. Monitoring Work Program

The LFG monitoring program is a relatively simple, straight forward program designed to collect system operating data required to safely operate the system and for the verification of CERs. This data will be collected in real time and will provide a continuous record that is easy to monitor, review, and validate.

The following sections will outline and discuss the following key elements of the monitoring program:

- Flow measurement;
- Gas quality measurements;
- Uncombusted methane;
- Electrical Consumption;
- Project electricity output;
- Regulatory requirements;
- Data records; and
- Data assessment and reporting.

3.1. Flow Measurement

According to ACM0001, depending on necessity, flow meters will be installed on the piping, straight before the flares.

In order to follow ACM0001, depending on necessity, flow meters will also be installed:

- In the main piping straight after the blowers to measure the total LFG flow extracted from the landfill;
- In the piping before the energy use to measure the LFG flow utilized for energy use.

In case of LFG is sent to consumer through dedicated pipeline, in order to follow ACM0001, flow meter will also be installed in the piping leading to a consumer through dedicated pipeline.

The flow of LFG collected by the system and subsequently utilized, flared or sent to consumer through dedicated pipeline are measured via individual flow measuring devices suitable for measuring the velocity and volumetric flow of a gas. One common example is an annubar. The flow measurements are taken within the piping itself, and the flow sensors are connected to transmitters that are capable of collecting and sending continuous data to a recording device such as a datalogger.

The flow sensors are calibrated according to a specified temperature and composition of the gas, thus the flow actually measured must be corrected to according to actual temperature, pressure, and composition, thus density, of the gas measured. The equipment selected will allow dynamic compensation for these parameters, normalized to a standard temperature, pressure, and gas composition. For reporting purposes, the flows are generally required to be normalized to 0°C and 1.01325 bar at standard gas composition of 50% methane and carbon dioxide each by volume.

The accuracy of a flow meter is dependent on the design of the equipment, and the specific type of sensor used, however equipment is available that will provide a minimum accuracy of +/- 2% by volume. The equipment selected for the site utilizes a continuous monitoring system as defined in ACM0001, which measures and aggregates flow data approximately once every minute.

3.2. Gas Quality

The two parameters that are most pertinent to the validation of CERs, as well as the safe and efficient operation of the system are the concentration of methane and oxygen in the gas stream delivered for utilization or diverted to flaring. These two parameters are measured via a common sample line that is ran to the main collection system piping, and measured in real time by two separate sensors, one for methane and the other for oxygen, installed as per ACM0001.

Regular calibration of the equipment is especially important, as the accuracy of the methane and oxygen sensors is greatest within the expected range of the gas stream to be measured. Equipment is readily available that will provide an accuracy of at least +/- 1% by volume. The equipment selected for the site aggregates gas compositions approximately once every 1 minute as per the definition of a continuous monitoring system in ACM0001.

3.3. Uncombusted Methane

The efficiency of the open flares will be measured per the methodological “Project emissions from flaring”.

3.4. Electrical Consumption

The consumed electricity from the grid by the project activity will be continuously measured by electricity meters for the grid and diesel generators. The respective data will be electronically recorded.

Monthly electrical bills charged to the project will be monitored and considered as the actual energy consumption for the project.

3.5. Project Electricity Output

The generated electricity used for the landfill internal consumption (i.e. administration offices, truck garage, recycling plant, leachate pumps), excluding the LFG facility electricity consumption by the project activity[31] will be continuously measured by an electricity meter and respective data will be electronically recorded.

[31] There will not be claimed CERs for LFG Facility electricity consumption because the electricity consumption is a consequence of the CDM Project.

The electricity output crosscheck will be made using monthly electricity invoices. The substation is located into the project activity area. The distance between point of electricity generation and electricity distribution is negligible.

3.6. Regulatory Requirements

Regulatory requirements relating to LFG projects will be evaluated annually by investigating municipal, state and national regulations pertaining to LFG. This will be done through consultation with the appropriate regulatory bodies, ongoing discussion with regulators, and monitoring of publications delineating upcoming legislative changes governing landfills and LFG.

4. Data records and storage

Data collected from each of the parameter sensors is transmitted directly to an electronic database from which the CER volume calculations may be carried out, as described in section 2.1 above. A hard copy backup or reports of the data may be printed as required or recorded in Portable Document Format (PDF). Backup of the electronic data is conducted every minute, as described above.

4.1. Data Assessment and Reporting

Assessment of the flow and composition data described above coupled with the operating hours of the engines/flare and engines/flare destruction efficiencies are used to determine the quantity of CERs to be generated. For electricity generation offsets, the appropriate emission factors will be applied.

The destruction efficiency of the flare is a function of the internal combustion temperature and resident holding time, which are generally measured by the flare system controller and recorded for auditing purposes. Extensive technical documentation is available that documents the destructive efficiency of the open flares that will be used, subject to the flow rate and combustion temperature verification. Destruction efficiency will also be assessed periodically through measurement of uncombusted methane emissions.

As discussed in Section 2.1, flow data is normalized to standard temperature, pressure, and composition for reporting purposes. The data will be compiled and assessed to produce the required quantification and validation. The periodic monitoring report will contain the data required for the verification of the CERs, and additionally may contain operational data from the collection system and flaring system described below to illustrate that the system is well maintained and operating at peak efficiency. Records of regular maintenance performed will also be a component of the annual report.

5. Related monitoring and project performance review

Project activity will conduct an additional operational monitoring of the LFG collection system to check the project performance and ensure that the system is being operated both correctly and efficiently. Periodic adjustments to the horizontal trenches and to the extraction wells/drains will be required to optimize the capture and collection systems effectiveness. LFG collection field adjustments will be made based upon a review of the trench and well performance history considered within the context of the overall LFG collection field operation in order to maximize the collection of methane balanced against minimization of any oxygen in the system that could introduce unsafe operating conditions. Monitoring at each trench and extraction well will consist of the following parameters: valve position, individual well/trench flow, individual well/trench vacuum, and composition of the gas collected, i.e., methane, carbon dioxide, and oxygen, using a portable measuring device.

6. Emergency procedures

As a precautionary measure, system is plugged to a battery-based uninterruptible power supply (UPS) to avoid data loss due to power failures. As a backup is produced and stored off-site from the main recording system, no more than 2 to 3 minutes of data at a time would ever be lost due to a system malfunction.

All data are collected and registered in data log in supervisory system. In addition, there will be developed an Emergency Plan including other types of emergencies such as fire and *work accidents.*

7. Calibration

All the measurement instruments will be subject to regular calibration as per manufacturer's specifications. The regular check and calibration will be made to the operators. The plant Manager will be responsible for checking the equipment's proper working order, as well as checking and storing up the calibration certificates and records. Calibration certificates will be kept for all the equipment during the crediting period and two years after.

The person/entity determining the baseline is as follows:
Beng Engenharia Ltda, São Paulo, Brazil
Contact person: Mr. João Sprovieri
Mr. Francisco Santo
Email: joao.sprovieri@beng.eng.br
francisco.santo@beng.eng.br

SECTION C. Start date, crediting period type and duration

C.1. Start date of project activity

>>
01/09/2013.

The starting date of the project activity will be the forecast date of purchasing the main equipment (flare) for capture and flare of LFG.

C.2. Expected operational lifetime of project activity

>>
25 years and 0 months

C.3. Crediting period of project activity

C.3.1. Type of crediting period

>>
Renewable (3 x 7 years)

C.3.2. Start date of crediting period

>>
The crediting period will start on 01/01/2014 or on the date of the registration of the CDM project activity (whichever is later).

C.3.3. Duration of crediting period

>>
7 years and 0 months.

SECTION D. Environmental impacts

D.1. Analysis of environmental impacts

>>

An analysis of the environmental impacts was done for the landfill project aiming:

1. Prevent the pollution of water sources, considering the use of surface and groundwater in region.
2. Provide soil conservation.
3. Minimize air pollution.
4. Ensure welfare of entrepreneurs and neighbourhood.
5. Minimize impacts to flora and fauna of the region.

For the construction and operation of the landfill gas project, the applicable laws were followed:

- Law 6.938/1991 (National Environmental Policy)
- Law 9.605/1998 (Environmental Crimes).
- Law 4.771/1965 (Forestry Code)
- Law 9.985/2000 (National System of Nature Conservation Units - SNUC, criteria and standards for creation, implantation and management of conservation areas, including those ones related to Environmental Protection Areas – EPA, Areas of Ecologic Interests (*Áreas de Relevante Interesse Ecológico -ARIEs*), Private Reserves of Nature Heritage (*Reservas Particulares de Patrimônio Natural - RPPN*).
- CONAMA Resolution 302 and 303/2002 (Permanent Protection Areas – APP).
- CONAMA Resolution 001/86 (Environmental Impact Assessment)
- CONAMA Resolution 396/2008 (Groundwater legislation)

According to Brazilian legislation mentioned above is required an environmental impact assessment to the landfill implementation. As the project boundary includes the landfill, an environmental impact assessment (EIA) of the landfill implementation was carried out and the possible environmental impacts were analysed by the *Secretaria de Estado do Meio Ambiente e Recursos Naturais – SEMA* (responsible agency to issue environmental licences in Maranhão State). The landfill implementation has satisfied all the requirements and the CTR Rosario landfill received from SEMA the Operation License nº 1049272/2018 process number nº 171800/2017 - dated of 06/04/2018 valid up to 06/04/2022. A summary of the environmental impacts and mitigation measures are explained in the section D.2.

There will be no transboundary impacts resulting from this project activity. All the relevant impacts will occur within Brazilian borders and have been mitigated to comply with the environmental requirements for project's implementation.

D.2. Environmental impact assessment

>>

As mentioned previously an environmental impact assessment was developed by the project participant and analysed by SEMA, thus CTR Rosario landfill has obtained Operation License.

A summary of the environmental impacts and mitigation measures are explained in the Table 9 and in the Table 10 are showed the positive impacts due to the implementation of the landfill.

Table 9 - Environmental Impacts and mitigation measures

IMPACT	POTENCIAL FACTOR	MITIGATION MEASURES
Atmospheric Pollution	• Dust emission from civil works. • Gas emissions from fossil combustion of vehicles and equipments. • Odour and biogas emissions from landfill.	• Wetting, calculated explosions for lower emissions of dust and vegetation surround. • Maintenance of vehicles and equipments. • Vegetation surround, drainage of leachate, daily coverage of waste, deodorizer, maintenance of wastewater treatment plant (WWTP) and biogas drainage and flare using passive capture system.
Superficial and ground water pollution.	• Leachate generation. • Wastewater emissions containing oil and grease. • Ground leachate generation. • Runoff water with particulate material.	• Subsurface drainage and treatment at the WWTP. • Oil/water separator - API and treatment at the WWTP. • Waterproofing with geomembrane and drainage • Sand separator before discharged into the rivers or natural drainage.
Erosion Soil destabilization. Siltation of water bodies Soil impermeabilization.	• Installation of construction site and access roads • Cut and filling of soil. • Leaching of soils. • Pile formation	• Rainwater drainage • Pluvial drainage, reutilization of soil and revegetation. • Preservation of coverage, dike and reutilization of soils. • Specific criteria for operation and infiltration basins.
Noise Pollution	• Noise emissions from civil works, vehicular traffic and equipments.	• Vegetation surround and calculated explosions for lower noise emissions, signalization and planning schedules. • Maintenance of vehicles and equipments.
Sanitary risks	• Vectors (insects, rats) proliferation	• Daily coverage of waste
Traffic alteration and risk of accidents.	• Increase of vehicular traffic. • Waste transport.	• Improvement of access via, signalization and paving. • Construction of alternatives via, maintenance of vehicles and training of drivers.
Suppression of vegetation and loss of natural habitat of fauna Landscape reconfiguration and landscape alteration	• Installation of construction site and access roads •	• Specific criteria in deforestation operations and programs of reforestation and fauna conservation • Planning of vegetation removal, replanting of forest and heterogeneous reforestation
Global environmental collapse	• Destabilization of landfill with rupture.	• Proper design project, rigorous execution and geotechnical monitoring

Table 10 - Positive Impacts

IMPACT	POTENCIAL FACTOR	MITIGATION MEASURES
Traffic of vehicles improvement	• Implantation and improvement of access via	• Positive impact
Increase of per capita income and stimulation of economy in the region. Increase of tax revenues	• Generation of direct and indirect jobs using local labor. • Purchase of materials and services in the region.	• Positive impact
Organization of use and occupation of land.	• Regular use and occupation of land, avoiding situations of invasion and disordered occupation.	• Positive impact

Moreover, it was developed a global plan of environmental management to verify and monitor in the proper frequency, the effective implantation of mitigation measures proposed.

The global plan consists of the following specifics monitoring programs:

- Program of environmental control of works.
- Program of environmental management of construction site
- Program of manpower training
- Program of communication and social participation
- Program of environmental education
- Archeological monitoring program
- Program of rescue and preservation of cultural heritage
- Program of environmental compensation
- Program of degraded areas recuperation
- Program of signalization, control and prevention of accidents
- Monitoring program of noise
- Monitoring program of landfill stability (Geotechnical)
- Monitoring program of flora and fauna
- Monitoring program of environmental-society conditions.
- Drainage and erosion control systems
- Emergency plan of CTR Rosario
- Closure plan for the CTR Rosario

SECTION E. Local stakeholder consultation

E.1. Modalities for local stakeholder consultation

>>

According to the Resolutions Number 1[32], 4[33] and 7[34] of the Brazilian Designed National Authority (CIMGC – Comissão Interministerial de Mudança Global do Clima / *Interministerial Commission on Global Climate Change*), project participants shall send letters to local stakeholders 15 days before the start of the validation period, in order to receive comments. It includes:

- Name and type of the activity project;
- PDD (translated to Portuguese), made available through a website;
- Description of the project's contribution to the sustainable development, also made available through a website.

The link for PDD translated to Portuguese and project contributions to the sustainable development is http://www.econergy.com.br/Vital/RosarioDCPLSP.pdf

Letters were sent on 18/05/2012 to the following stakeholders involved and affected by the project activity:

- *Prefeitura municipal de Rosario* / Municipal Administration of *Rosario*;
- *Câmara dos vereadores de Rosario* / Legislation Chamber of *Rosario*;
- *Secretaria Municipal de Meio Ambiente de Rosario* / Municipal Secretary Environmental of *Rosario* City;
- Secretaria Estadual do Meio Ambiente do Maranhão / Secretary of Environmental of Maranhão State;

[32] http://www.mct.gov.br/upd_blob/0002/2736.pdf (Art. 3º, II)

[33] http://www.mct.gov.br/upd_blob/0011/11780.pdf (Artº 5°, unique paragraph)

[34] http://www.mct.gov.br/upd_blob/0023/23744.pdf, accessed on July 21st, 2008.

- *Fórum Brasileiro das Organizações Não Governamentais e Movimentos Sociais para o Meio Ambiente e o Desenvolvimento - FBOMS* / Brazilian Forum of Non-Governmental Organizations and Social Movements for Environment and Development;
- *Ministério Público do Estado do Maranhão* / *Maranhão* Pr*osecutor's Office;*
- *Ministério Público Federal* / Federal Prosecutor's Office.
- Local associations;
    - ONG LIBERTAS
    - SOMADENA – Sociedade Maranhense de Defesa a Natureza
    - Sindicato dos Trabalhadores e Trabalhadoras Rurais Rosario – MA

E.2. Summary of comments received

>>
No comments were received.

E.3. Consideration of comments received

>>
Not applicable

SECTION F. Approval and authorization

>>
In the proposed project, the project participant is presented below:

Thus, the Party involved is Brazil.

In accordance with the CDM project cycle procedure for project activities", the project participant has already obtained a letter of approval from the host parties DNAs.

During the 1st CP validation, the registered CDM project activity has been granted with Letter of Acceptance (LoA) by the Designated National Authority (DNA) of the host party Brazil (dated 09/11/2012). Copy of such LoA and related assessment details are made available at the project's page at UNFCCC's CDM website.

Appendix 1. Contact information of project participants

Organization name	Vital Engenharia Ambiental S.A.
Country	Brazil
Address	Rua Santa Luzia, 651, 21º andar – Centro – Rio de Janeiro
Telephone	+55 (21) 2131-7204
Fax	-
E-mail	neiber.silva@vitalambiental.com.br
Website	http://www.vitalambiental.com.br/
Contact person	Mr. Neiber Rodrigues Da Silva

Appendix 2. Affirmation regarding public funding

Not applicable. There is no public funding involved in the project activity.

Appendix 3. Applicability of methodologies and standardized baselines

All the information about the applicability of selected methodology is described in Section B.2. above.

Appendix 4. Further background information on ex ante calculation of emission reductions

The baseline scenario for the project activity is the uncontrolled release of landfill gas to the atmosphere and also the generation of electricity from other sources.

The table below shows the key elements used for estimate the emissions of the baseline scenario.

1. Key Parameters

Landfill operations start	2013
Projected year for landfill closure - estimated based on current filling rate	2033
GWP for methane (UNFCCC and Kyoto Protocol decisions)[35]	25
Methane concentration in LFG (% by volume) typical assumption for baseline scenario	50
LFG collection efficiency (%)	65
Flare efficiencies (%) operational data from flare manufacturer	50%
Electricity consumption from the grid due to the project activity (MWh/year)	0
Combined margin emission factor for electricity displacement (tCO_2/MWh) calculated based on the Tool to calculate the emission factor for an electricity system.	0.3380
Installed capacity of Power Plant (MW) – End of 1st CP	3.000
Load factor	90.00
Operational lifetime of the project activity (years)	25
Adjustment Factor (AF)	20%

[35] In opposite of the PDD registered on 26 Feb 13 using GWP of 21, it has been updated to 25

2. Waste disposal

The forecast amount of waste disposal in landfill is presented below:

Year	Waste disposal (tonnes/yr)
2013	436,800
2014	436,800
2015	436,800
2016	436,800
2017	436,800
2018	436,800
2019	436,800
2020	436,800
2021	436,800
2022	436,800
2023	436,800
2024	436,800
2025	436,800
2026	436,800
2027	436,800
2028	436,800
2029	436,800
2030	436,800
2031	436,800
2032	436,800
2033	436,800

3. Emission factors

The table below shows the Brazilian emission factors according to determination of the Brazilian DNA. More information is available at the Brazilian DNA website[36].

Combined Margin Emission Factor 2018 (tCO_2/MWh) [8]		
1st crediting Period		**0.3380**
Build Margin - 2018		0.1370
Operating Margin 2018	January	0.5652
	February	0.5559
	March	0.5750
	April	0.5058
	May	0.5461
	June	0.6691
	July	0.5989
	August	0.5948
	September	0.5718
	October	0.5782
	November	0.3654
	December	0.3423
	2018	0.5390

Source: Brazilian DNA

Appendix 5. Further background information on monitoring plan

All the information about the monitoring plan were described in section B.7.1 and B.7.3

Appendix 6. Summary report of comments received from local stakeholders

Presented in section E.2.

Appendix 7. Summary of post-registration changes

A summary of the Permanent Changes of the post registration changes is presented below:

All Post Registration Changes are applicable to the applied methodologies, in compliance with the monitoring plan. The level of accuracy and completeness in the monitoring of the project activity is in line with the requirements contained in the registered monitoring plan. Changes did not affected the project activity additionality or scale.

Permanent changes to project design:

36 https://www.mctic.gov.br/mctic/opencms/ciencia/SEPED/clima/textogeral/emissao_despacho.html, accessed on 30/10/2019.

a. By voluntary update of the applied methodology version, ACM0001 v19.0. All applicable tools, emission reductions calculations and parameters inclusion related to the applied methodology have been updated accordingly.
b. Change in the electricity generation plant installed capacity estimation from 5.7 MW to 3 MW. The investments into the electricity generators were not under the PP's control. Emission reductions calculations were updated according to the new installed capacity.
c. Change in the electricity generation plant installed capacity currently installed from 4.3 MW to 2 MW. The investments into the electricity generators were not under the PP's control.
d. Change in flare design from enclosed flare to open flare.
e. Change in the value of technical transmission and distribution losses ($TDL_{k,y}$) from 16% to 20%, as being the default value from TOOL05.

- - - - -

Document information

Version	*Date*	*Description*
11.0	31 May 2019	Revision to: • Ensure consistency with version 02.0 of the "CDM project standard for project activities" (CDM-EB93-A04-STAN); • Make editorial improvements.
10.1	28 June 2017	Revision to make editorial improvement.
10.0	7 June 2017	Revision to: • Improve consistency with the "CDM project standard for project activities" and with the PoA-DD and CPA-DD forms; • Make editorial improvement.
09.0	24 May 2017	Revision to: • Ensure consistency with the "CDM project standard for project activities" (CDM-EB93-A04-STAN) (version 01.0); • Incorporate the "Project design document form for small-scale CDM project activities" (CDM-SSC-PDD-FORM); • Make editorial improvement.
08.0	22 July 2016	EB 90, Annex 1 Revision to include provisions related to automatically additional project activities.
07.0	15 April 2016	Revision to ensure consistency with the "Standard: Applicability of sectoral scopes" (CDM-EB88-A04-STAN) (version 01.0).

Version	*Date*	*Description*
06.0	9 March 2015	Revision to: • Include provisions related to statement on erroneous inclusion of a CPA; • Include provisions related to delayed submission of a monitoring plan; • Provisions related to local stakeholder consultation; • Provisions related to the Host Party; • Make editorial improvement.
05.0	25 June 2014	Revision to: • Include the Attachment: Instructions for filling out the project design document form for CDM project activities (these instructions supersede the "Guidelines for completing the project design document form" (Version 01.0)); • Include provisions related to standardized baselines; • Add contact information on a responsible person(s)/ entity(ies) for the application of the methodology (ies) to the project activity in B.7.4 and Appendix 1; • Change the reference number from F-CDM-PDD to CDM-PDD-FORM; • Make editorial improvement.
04.1	11 April 2012	Editorial revision to change version 02 line in history box from Annex 06 to Annex 06b.
04.0	13 March 2012	Revision required to ensure consistency with the “Guidelines for completing the project design document form for CDM project activities” (EB 66, Annex 8).
03.0	26 July 2006	EB 25, Annex 15
02.0	14 June 2004	EB 14, Annex 06b
01.0	03 August 2002	EB 05, Paragraph 12 Initial adoption.

Decision Class: Regulatory
Document Type: Form
Business Function: Registration
Keywords: project activities, project design document