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	Project 3958: CTR Candeias Landfill Gas Project
Scale of the project activity	☒ Large-scale ☐ Small-scale
Version number of the PDD	23
Completion date of the PDD	16/12/2020
Project participants	**Brazil:** Haztec Tecnologia e Planejamento 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	**482,464 tCO2e**

SECTION A. Description of project activity

A.1. Purpose and general description of project activity

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The objective of the CTR Candeias Landfill Gas Project is to capture and burn the landfill gas (LFG)[1] generated by the decay of organic waste from the CTR Candeias Sanitary landfill located in the municipality of Jaboatão dos Guararapes, in the Recife Metropolitan Area. The project also intends to generate electricity from the combustion of LFG and sale it to the national electricity grid and thus reduce CO_2 emissions by displacing electricity generated from fossil fuels.

The landfill of CTR Candeias, built and operated by Haztec Tecnologia e Planejamento Ambiental SA (HAZTEC), is strategically located close to major cities in the Recife Metropolitan Area and is the first sanitary landfill in the State of Pernambuco. The landfill started operations in August 2007 and received all necessary environmental licenses for operations. The landfill was designed to operate over a 21 years-period and will thus be closed by the end of 2027.

The project activity results in greenhouse gas (GHG) emission reduction from the landfill through the ways below:

- Burning LFG in flares and/or group generators;
- The amount of electricity generated in the project activity will be exported 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 municipal landfill covers an area of over 170,000 m^2 and will receive about 24 million tons of solid waste during the period 2007-2027. The landfill is currently disposing about 4,000 tons of municipal solid waste (MSW) per day. Landfill gas (LFG) extraction and flaring begun in 2011, while electricity production is scheduled to begin in 2019 dispatching electricity to the Brazilian interconnected electric system.

The power generation facility will be comprised of LFG engine generator sets of high performance standards. The engine-generator sets will be the primary equipment to combust the collected LFG once they are installed. A fraction of the collected LFG could be diverted to flares, which will be used to combust any gas in excess of the fuel demand for the engines, as well as a contingency backup. The flares will be kept in standby for periods when electricity will not be produced or other operational considerations.

The final installed capacity is expected to reach until 28.520 MW upon project completion. However, the installed capacity may vary depending on the availability of the generator equipment in the market at the time of its actual implementation.

Prior to the implementation of the project activity the landfill gas is being released to atmosphere and electricity is being generated in existing and/or new grid-connected power plants, other than the project activity power plant.

For this crediting period, estimates of GHG emission reductions are:

- Annual average GHG emission reduction: 482,464 tCO_2e
- Total estimated GHG emission reductions: 3,377,249 tCO_2e

The project is helping the Host Country fulfill its goal of promoting sustainable development. Specifically, the project:

- Increases employment opportunities in the area where the project is located;

[1] The major landfill gas contents are methane (CH_4) and carbon dioxide (CO_2).

- Uses clean and efficient technologies;
- Acts as a clean technology demonstration project;
- Optimizes the use of natural resources, avoids uncontrolled waste management.

A.2. Location of project activity

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Host Party:

- Brazil

Region/State/Province:

- Pernambuco

City/Town/Community:

Jaboatão dos Guararapes, in Recife Metropolitan Area

Physical/Geographical location:

The project site is located in the Municipality of Jaboatão dos Guararapes in the Recife Metropolitan Area. Several poor communities are located in the vicinity of the project. The landfill is strategically situated close to three major cities in the state of Pernambuco: Recife, Jaboatão dos Guararapes and Cabo de Santo Agostinho. Due to its central location, the landfill will potentially provide services to a metropolitan area of 3.8 million inhabitants. The site, which is located at coordinates Latitude: -8.164258; Longitude: -34.985286, is shown on figure below.

Figure 1 - Location of the CTR Candeias Landfill Gas Project (Source: IBGE)

Figure 2 – Panoramic view of the CTR Candeias Landfill Gas Project

A.3. Technologies/measures

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Project activity:

The proposed project consists of a LFG collecting system, LFG pre-treatment system, enclosed flaring system, electricity generation system and grid connection system. First, the landfill gas will be collected, then through a network composed of transportation pipes, the landfill gas will reach the pre-treatment system, in which the moisture will be removed. The enclosed flare will be used at the start of the operations (period required to test the volume and quality of the gas prior energy generation) and when the volume of gas exceeds the capacity of the power generation system or when the power generation system is not in operation (e.g., maintenance, breakdown).

Landfill gas collection system:

State-of-the-art gas collection technology includes the items listed below. An example of a transmission line from the gas extraction wells to the power generation / flare complex is shown on Photo 1.

- Vertical wells used to extract gas and leachate;
- Horizontal wells used to extract gas;
- Optimal well spacing for maximum gas collection whilst minimizing costs;
- Wellheads designed for gas measurements;
- Blowers;
- Condensate extraction and storage systems designed at strategic low points throughout the gas system; and
- Pipeline collection system to connect the LFG collected with the electricity generation and flaring systems.

Photo 1 – Manifold in the project activity

The landfill will be covered by clay to prevent the biogas to come out through the landfill surface. The LFG collection efficiency (85%[2]) was considered in the calculations of the emission reductions ex-ante.

Landfill gas pre-treatment system:

Once the landfill gas is collected and transported through pipes, the landfill gas will reach pre-treatment system (demister), in which the moisture of landfill gas will be removed.

Enclosed flaring system:

The enclosed flare selected is designed to operate continuously with automatic temperature control to safely destroy the biogas generated by solid waste.

The flaring system will ensure the combustion of LFG (e.g., maintenance, breakdown or when the volume of gas exceeds the capacity of the power generation system). The flare system includes the items listed below.

- Enclosed flare with controlled combustion system;
- Blower system used to direct gas for flaring;
- Equipment to ensure continuous monitoring of the LFG composition (methane, oxygen, dioxide of carbon and balance), flow and burn temperature; and
- Security restarts system, in cases the system shuts down.

The flare system will achieve destruction efficiency greater than 99% of total organic compounds and greater than 98% of total non-methane volatile organic compounds (NMVOC) throughout the entire flare operating range, without any burner adjustments or flare modification[3]. For the ex-ante estimates of the emission reductions, and for conservative reasons, 89% (applying 10% discount as defined in Tool "Project Emissions from Flaring") flare efficiency has been considered. The average lifetime of the equipments of the system is between 15 to 20 years[4].

[2] Source: Technical literature (Collection efficiency 0.85 & Load Factor 0.95 - USEPA 1996 Handbook EPA-LFG.pdf - Item 2.2.2. page 2-8), only collection efficiency technical literature data was used.

[3] Source: Manufacturer (John Zinc) technical specifications.

[4] Ibid

The landfill gas flaring system will be maintained in accordance with manufacturer's recommended specifications on schedule and procedures in order to ensure the safety and environmental soundness of the operations. The project personnel involved in the operations and monitoring will receive a comprehensive training on equipment, maintenance and monitoring from the equipment supplier.

Photo 2 – Flare Station in the project activity

Electricity generation system and grid connection system

Electricity generation is expected to begin in 2019 until the date when the gas extracted will be too low to justify the operation and maintenance costs).

Electricity generation plant is composed of 20 generators, each having a capacity of 1.426 MW (or a combined total capacity of 28.520 MW), as below:

Year	Installed capacity (MWe)	Number of group generators	Net electricity generated in the plant (MWh)
2018	0.000	0	0
2019	14.260	10	118,672
2020	17.112	12	142,406
2021	22.816	16	189,875
2022	25.668	18	213,609
2023	28.520	20	237,343
2024	28.520	20	237,343
2025	28.520	20	237,343

Note 1: As highlighted in Section A.2, 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 its actual implementation.
Note 2: Electricity Plant Load Factor assumed as 95% appropriate value calculated based on data provided by the electricity plant owner, where:

Load Factor (%) = Electricity generated in the plant (MWh) / Installed capacity (MW) / 8760

The lifetime of the equipment is 20 years and it was based on market standard specifications[5].

Monitoring system:

[5] The document was made available to DOE in validation visit.

The process will be controlled by an electrical control system equipped with a Programmable Logical Controller (PLC). All details related to monitoring of CDM project are provided in section B.7. of this PDD.

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)	Haztec Tecnologia e Planejamento Ambiental S.A.	No

A.5. Public funding of project activity

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There is no Annex I public funding involved in the Project Activity

A.6. History of project activity

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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

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Not applicable.

SECTION B. Application of methodologies and standardized baselines

B.1. References to methodologies and standardized baselines

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- Large-scale Consolidated Methodology ACM0001: “Flaring or use of landfill gas” (Version 19.0)[6];
- TOOL02 Methodological tool: “Combined tool to identify the baseline scenario and demonstrate additionality” (Version 07.0)[7];
- TOOL03 Methodological tool: “Tool to calculate project or leakage CO_2 emissions from fossil fuel combustion” (Version 03.0)[8].
- TOOL04 Methodological tool: “Emissions from solid waste disposal sites” (Version 08.0)[9];
- TOOL05 Methodological tool: “Baseline, project and/or leakage emissions from electricity consumption and monitoring of electricity generation” (Version 03.0)[10];
- TOOL06 Methodological tool: “Project emissions from flaring” (Version 03.0)[11];
- TOOL08 Methodological tool: “Tool to determine the mass flow of a greenhouse gas in a gaseous stream” (Version 03.0)[12];

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6 https://cdm.unfccc.int/methodologies/DB/JPYB4DYQUXQPZLBDVPHA87479EMY9M

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

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

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

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

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

- TOOL09 Methodological tool: "Determining the baseline efficiency of thermal or electric energy generation systems" (Version 02.0)[13];
- TOOL10 Methodological Tool: "Tool to determine the remaining lifetime of equipment" (Version 01)[14];
- TOOL12 Methodological tool: "Project and leakage emissions from transportation of freight" (Version 01.1.0)[15];
- TOOL07 Methodological tool: "Tool to calculate the emission factor for an electricity system" (Version 07.0)[16];
- TOOL11 Methodological Tool: "Assessment of the validity of the original/current baseline and update of the baseline at the renewal of the crediting period" (Version 03.0.1)[17];
- TOOL32 Methodological tool: "Positive lists of technologies" (Version 01.0)[18]

B.2. Applicability of methodologies and standardized baselines

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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);

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

"...

a) *Install a new LFG capture system in a new or existing SWDS where no LFG capture system was 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 can not 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; and/or*
   iii) *Supplying the LFG to consumers through a natural gas distribution network;*
   iv) *Supplying compressed/liquefied LFG to consumers using trucks;*
   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 has been made an investment into an existing LFG capture system to increase the recovery rate (collection efficiency) and change the use of the

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

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

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

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

[17] https://cdm.unfccc.int/methodologies/PAmethodologies/tools/am-tool-11-v3.0.1.pdf

[18] https://cdm.unfccc.int/methodologies/PAmethodologies/tools/am-tool-32-v1.pdf

captured LFG (also electricity generation). The captured LFG was only vented and not used prior to the implementation of the project activity.

In the project activity, the LFG is 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.

“...
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:

- *a) 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;*
- *b) 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 release 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).

Justification: - Part 3
The methodology is applicable since the most recent Urban Solid Waste Diagnosis from Institute for Applied Economic Research (IPEA) has been published in 2012. According to Table 18, 99.5% of the Recife area municipal solid waste is disposed in landfills/open dumps and only 0.5% is managed by other methods. Thus, it is possible to state that recycling percentage in the project activity area is negligible.

<u>The “Combined tool to identify the baseline scenario and demonstrate additionality” is applicable to project activities where:</u>

“…
All potential alternatives scenarios to the proposed project activity available to project participants cannot be implemented in parallel to the proposed project activity.

For example, in the following situations a methodology could refer to this tool:

- *For an energy efficiency CDM project where the identified potential alternative scenarios are: (a) retrofit of an existing equipment, or (b) replacement of the existing equipment by new equipment, or (c) the continued use of the existing equipment without any retrofits;*
- *For a CDM project activity related to the destruction of a greenhouse gas in one site where the identified potential alternative scenarios are: (a) installation of a thermal destruction unit, or (b) installation of a catalytic destruction system, or (c) no abatement of the greenhouse gas.*

…"

The project activity encompasses the destruction of a greenhouse gas in one site where one of the identified potential alternative scenarios is no abatement of the greenhouse gas.

Justification:
The tool is **applicable** because the Step 1 of the "Combined tool to identify the baseline scenario and demonstrate additionality" presented in section B.4, demonstrates that all alternative scenarios identified are realistic and credible to the project activity.

<u>The "Tool to calculate project or leakage CO2 emissions from fossil fuel combustion" </u>is **not applicable** due to the non-consumption of fossil fuel by the project activity (with fossil fuel being used for purposes other than for electricity generation).

<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. Either no captive power plant is installed at the site of electricity consumption or, if any on-site captive power plant exits, it is not operating or it can physically not provide electricity to the source of electricity consumption;
- 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 consumption source and supply the source with electricity. The captive power plant(s) is/are not connected to the electricity grid;
- 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 consumption source. The captive power plant(s) can provide electricity to the electricity consumption source. The captive power plant(s) is/are also connected to the electricity 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 determine 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.

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 "Assessment of the validity of the original/current baseline and update of the baseline at the renewal of the crediting period" is **applicable** to the project activity since it is required to assess the continued validity of the baseline at the renewal of a crediting period.

The "Positive lists of technologies" is **not applicable** to the project activity since the LFG is used to generate electricity in one or several power plants with a total nameplate capacity that is higher than 10 MW.

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

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	Source	GHG	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
	Emissions from heat generation	CO_2	No	No heat generation 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	No use of natural gas 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	No fossil fuel consumption for purposes other than electricity generation or transportation due to the project activity
		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
		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

Source		GHG	Included?	Justification/Explanation
		N_2O	No	Emissions are considered negligible
	Emissions from distribution of LFG using trucks and dedicated pipelines	CO_2	No	No existence of distribution of LFG using trucks and dedicated pipelines
		CH_4	No	No existence of distribution of LFG using trucks and dedicated pipelines
		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; (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:

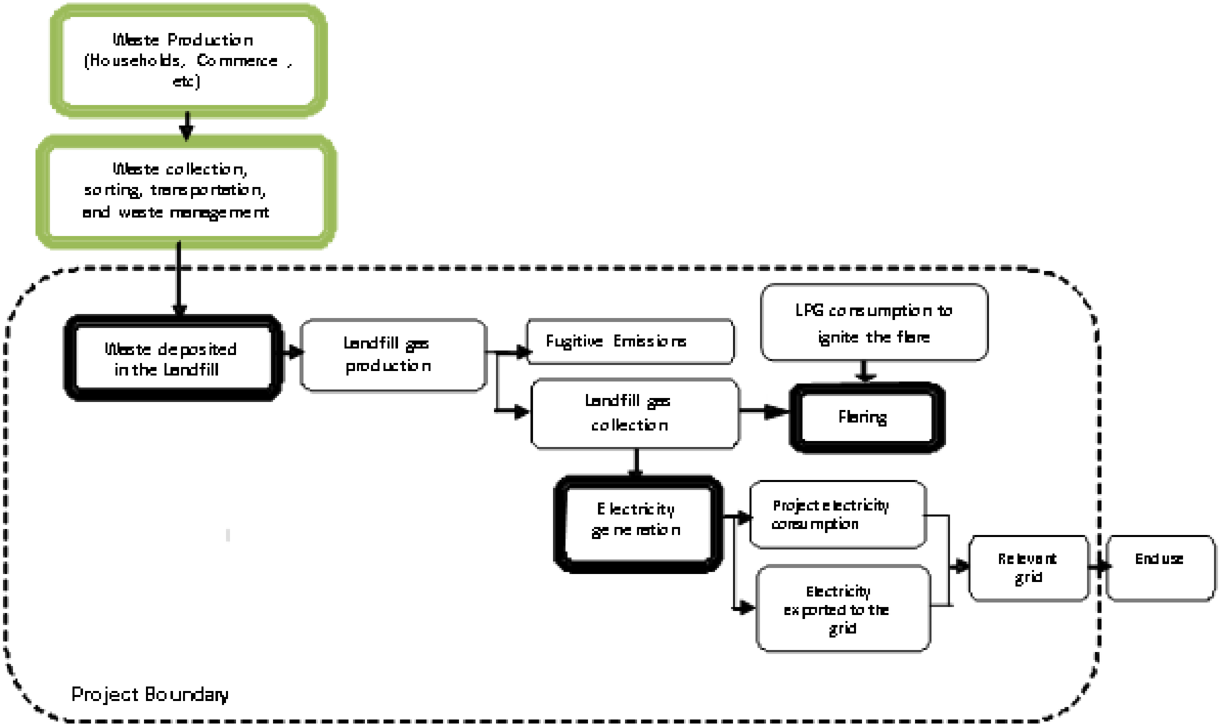

Figure 3 – Flow diagram project boundary

B.4. Establishment and description of baseline scenario

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The methodological tool "Assessment of the validity of the original/current baseline and update of the baseline at the renewal of the crediting period", has been used to assess the continued validity of the baseline considering the renewal of the crediting period.

It is important to clarify that the baseline scenario for LFG defined for the 1st crediting period is maintained valid.

The stepwise procedure of the "Assessment of the validity of the original/current baseline and update of the baseline at the renewal of the crediting period" to assess the continued validity of the baseline and to update the baseline at the renewal of a crediting period are as follows:

Step 1: Assess the validity of the current baseline for the next crediting period

In order to assess the continued validity of the baseline, changes in the relevant national and/or sectorial regulations between the crediting periods have to be examined at the renewal of the crediting period. If at the start of the project activity, the project activity was not mandated by regulations, but at the time of renewal of the crediting period regulations are in place that enforce the practice or norms or technologies that are used by the project activity, the new regulation (formulated after the registration of the project activity) has to be examined to determine if it applies to existing project or not.

The baseline scenario does not have to be updated for the second crediting period as no new regulations requiring capture and combustion or use of LFG are in place.

The “Procedures for the renewal of the crediting period of a registered CDM project activity” approved by the CDM Executive Board require assessing the impact of new relevant national and/or sectorial policies and circumstances on the baseline.

Prior to the implementation of the project activity the landfill gas is being released to atmosphere and electricity is being generated in existing and/or new grid-connected power plants, other than the project activity power plant.

Thus the baseline remains the same as defined in the 1st crediting period and required regulations.

The validity of the current baseline is assessed using the following Sub-steps:

Step 1.1: Assess compliance of the current baseline with relevant mandatory national and/or sectorial policies

At the start of the project activity in 2004, the Brazilian legislation did not require landfills to capture and/or flare and/or use the LFG. After the registration of the project activity in 29/09/2011, the project participant, in order to assess if the current baseline complies with all relevant mandatory national and/or sectorial policies which have come into effect after the submission of the project activity for validation, has verified that the current baseline complies with all applicable laws and regulations.

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”.

Step 1.2: Assess the impact of circumstances

There is no impact of circumstances existing at the time of requesting renewal of the crediting period on the current baseline emissions.

Step 1.3: Assess whether the continuation of use of current baseline equipment(s) or an investment is the most likely scenario for the crediting period for which renewal is requested.

This sub-step is not applicable since the baseline scenario of the project activity is the business as usual (BAU) scenario (passive venting system).
Also, in the baseline scenario, electricity is being generated in existing and/or new grid-connected power plants, other than the project activity power plant.

Step 1.4: Assessment of the validity of the data and parameters

Considering the applied methodology at the project activity registration ACM0001 version 11 has changed to consolidated methodology ACM0001 version 19 and all related applicable tools some ex-ante parameters published by IPCC have been updated accordingly.

According to the “Tool to assess the validity of the original/current baseline and to update the baseline at the renewal of a crediting period”, where any data and parameter used and not monitored during the crediting period are not valid anymore they should be updated following the Step 2 as follows:

Step 2: Update the current baseline and the data and parameters

Step 2.1: Update the current baseline

The baseline emissions for the second crediting period have been updated, without reassessing the baseline scenario, based on the latest approved version of the methodology ACM0001. This update was applied in the context of the sectorial policies and circumstances that are applicable at the time of requesting for renewal of the crediting period, which has not changed as to affect the project.

Step 2.2: Update the data and parameters

All parameters regarding the grid emission factor calculation have been updated for the 2nd crediting period ($EF_{grid,OM,y}$ is ex post monitored, $EF_{grid,BM,y}$ is ex-ante monitored and thus $EF_{grid,CM,y}$ is ex post monitored).

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".

Other parameters have been updated for the 2nd crediting period, according to the list below:

- GWP_{CH4} (From 20 t CO_2e/t CH_4 to 25 t CO_2e/t CH_4);
- TDL_y - Average technical transmission and distribution losses for the electricity (16%).

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.
Even with the Post-Registration Changes related to the increment of electricity generation plant installed capacity (From 4.245 MW to 28.520MW), the baseline remains the same as from the 1st crediting period and not being defined as a new baseline for the 2nd crediting period.

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 (i.e. capture and flaring or 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 and LFG5 should not be considered.

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		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) [19], 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[20].

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.

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

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The additionality of the project activity will be demonstrated and assessed using the “Combined tool to identify the baseline scenario and demonstrate additionality”.

The Step *0*, *1a* and *1b* are described above in section B.4.

Step 2: Barrier analysis

[19] http://www.planalto.gov.br/ccivil_03/_ato2007-2010/2010/lei/l12305.htm

[20] http://www.aneel.gov.br/area.cfm?idArea=43

This step serves to identify barriers and to assess which alternative scenarios are prevented by these barriers as per the latest approved version of the “Guidelines for objective demonstration and assessment of barriers”. The following Sub-steps are applied:

Sub-step 2a: Identify barriers that would prevent the implementation of alternative scenarios

- **Investment barrier:** The implementation of the Scenario 2 (collection and destruction of LFG in enclosed flares + electricity generation in existing and/or new grid-connected power plants) requires a very high amount of investment from such project components:
  - Collection system;
  - Biogas transport pipe system;
  - Blower System;
  - Flare System;
  - LFG Station (edifications).

In Brazil, flaring LFG in enclosed flares does not generate any revenues and has only expenditures. Therefore, the high investment regarding project components described above is not feasible in the economical point of view.

Outcome of Step 2a: the identified barrier (investment barrier) as described above prevents the scenario 2. However, the identified barrier does not prevent the occurrence of the other scenarios (scenarios 1 and 4).

Step 2b: Eliminate alternative scenarios which are prevented by the identified barriers

As the investment in Scenario 2 does not generate any revenues and has only expenditures for the PP, this scenario is not economical/financial attractive.

Outcome of Step 2b: The two realistic and credible alternative scenarios to the project activity are:

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

Step3. Investment analysis

Sub-step3a. Determine appropriate analysis method

As the proposed project activity will generate financial benefits other than CDM related income, the Option III is chosen. This option is appropriated because the baseline does not require investment, as per “Guidelines on the assessment of investment analysis”, paragraph 19.

Sub-step3b. – Option III. Apply benchmark analysis

The alternative LFG1 (equivalent to P1) (proposed project without CDM revenues) is evaluated by applying a benchmark analysis. The likelihood that this project would be developed without CDM revenues, as opposed to the continuation of business as usual activity (LFG2 in combination with P6), is evaluated by comparing its project internal rate of return (IRR) with the benchmark rate of return available to investors in Brazil.

In order to conduct the benchmark analysis, an evaluation of the project’s cash-flow and its internal rate of return (IRR) (without CDM financial incentives) is undertaken. The benchmark analysis is undertaken by comparing the project IRR with the more conservative opportunity cost in the Brazilian economy – SELIC Basic Interest Rate set by the Banco Central do Brasil (Central Bank of Brazil) which represents the expected return of a low-risk investment fund in Brazil. Since the SELIC is a nominal interest rate, the Financial Analysis is developed in nominal terms, excluding income taxes. This is a very conservative benchmark, since it does not include any risk adjustment. The nominal SELIC value selected is among the lowest values in the latest years 10.25%.

All values of financial parameters are reported below[21]:

- Investment analysis is conducted over a period of 21 years (until 2030) based on the expected lifetime of the project[22,23]
- Inflation rate: 4.5%[24]
- Sales taxes[25]. In order to be conservative, it has been included only the Federal sale taxes (PIS and COFINS), excluding other state taxes such as ICMS or municipal taxes:
  - PIS (Profit Participation Contribution): 1.65%
  - COFINS (Social Security Financing Contribution): 7.60%
- Benchmark is equivalent to the SELIC rate: 10.25% (June, 9, 2010)[26].
- Exchange rate used for the investment analysis: 3.97 BRL/EUR[27].
- Generation capacity: maximum generation capacity is 28.520 MW. Units in service will be the following:
- 2019: 10 units X 1.426 MW, total 14.260 MW
- 2020: 12 units X 1.426 MW, total 17.112 MW
- 2021: 16 units X 1.426 MW, total 22.816 MW
- 2022: 18 units X 1.426 MW, total 25.668 MW
- 2023-2030: 20 units X 1.426 MW, total 28.520 MW
- Electricity price: 170.00 R$/MWh[28].
- Generation of electricity in 2019 will be 118,672 MWh/year
- Generation of electricity in 2020 will be 142,406 MWh/year
- Generation of electricity in 2021 will be 189,875 MWh/year
- Generation of electricity in 2022 will be 213,609 MWh/year
- And from 2023 to 2030, the generation of electricity will be 237,343 MWh/year.
- Investment[29]:
  - Pipelines, wellheads and Drill: R$ 4,422,533
  - Biogas plant (blowers, pre-treatment, flare): R$ 3,339,000
  - Group motor including engines, construction of the plant, connection, etc:
    - Year 2018: R$ 8,105,000
    - Year 2019: R$ 25,879,796
    - Year 2020: R$ 4,869,867
    - Year 2021: R$ 9,739,733
    - Year 2022: R$ 4,869,867
    - Year 2023: R$ 4,869,867
- Operation and Maintenance[30]:
  - O&M electricity system: 300,000 R$/year (fixed) and 100 R$/MWh.
  - O&M LFG system costs: 354,240 R$/year.

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[21] All data used in for the financial analysis are the latest available information when preparing the financial analysis in 2010. The targeted start date for the project was then 01/01/2011.

[22] Project defined as biogas capture, generation of electricity and/or gas flaring.

[23] Lifetime of equipment, Source: spec ZTOF JZ.pdf

[24] Source: Target inflation rate for 2010 fixed by the government (COPOM). Page consulted in October 2010. http://www.bcb.gov.br/

[25]Source: Brazilian Tax office (Ministerio da Fazenda)

[26] SELIC Target SELIC rate fixed by the government (COPOM) in the 151 meeting held on June 9,2010. Page consulted in October 2010. http://www.bcb.gov.br/?COPOMJUROS

[27] Bank of Brazil, February 2nd, 2018.

[28] Based on commercial proposal.

[29] Source: Quotations 2010 Candeias (provided at validation and detailed in the Financial analysis Excel spreadsheet).

[30] Source: Quotations 2010 Candeias (provided at validation and detailed in the Financial analysis Excel spreadsheet).

  - Administrative costs: 180,000 R$/year.
  - Insurance costs: 0.177% of investment/y.
- Overhaul (necessary after 60,000 hours of operation) [31]:
  - In 2026, for 10 engines is estimated at: R$ 9,832,771
  - In 2027, for 10 engines is estimated at: R$ 2,055,049
  - In 2028, for 10 engines is estimated at: R$ 4,110,098
  - In 2029, for 10 engines is estimated at: R$ 2,055,049
  - In 2030, for 10 engines is estimated at: R$ 2,055,049

[31] Source: Quotations 2010 Candeias (provided at validation and detailed in the Financial analysis Excel spreadsheet).

Sub-step 3c. Calculation and comparison of financial indicators

<u>Alternative Scenario 1:</u> The scenario 1 is the project activity (capture and flare of LFG and power generation) undertaken without being registered as a CDM project activity.

Economic calculation for Landfill gas extraction project at Candeais landfill With income from electricity production

All economic values are in nominal terms

Taxes																						
Sales taxes																						
PIS	1.65%																					
COFINS	7.60%																					
Inflation rate	4.50%	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**
Cumulative inflation			1.045	1.092	1.141	1.193	1.246	1.302	1.361	1.422	1.486	1.553	1.623	1.696	1.772	1.852	1.935	2.022	2.113	2.208	2.308	2.412
Gas utilisation with electricity production											1.000	1.045	1.092	1.141	1.193	1.246	1.302	1.361	1.422	1.486	1.553	1.623
Selling price of electricity		170.0 R$/MWh																				
		2010	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**
mber of Installed Group generators											**10**	**12**	**16**	**18**	**20**	**20**	**20**	**20**	**20**	**20**	**20**	**20**
Electricity price (R$/MWh)											170.0	177.7	185.6	194.0	202.7	211.9	221.4	231.3	241.8	252.6	264.0	275.9
Electricity produced (MWh)											118,672	142,406	189,875	213,609	237,343	237,343	237,343	237,343	237,343	237,343	237,343	237,343
Income statement (R$)		**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**
Gross Income from electricity production			-	-	-	-	-	-	-	-	20,174,192	25,298,437	35,249,156	41,439,789	48,116,199	50,281,428	52,544,093	54,908,577	57,379,463	59,961,539	62,659,808	65,479,499
Sales taxes			-	-	-	-	-	-	-	-	1,866,113	2,340,105	3,260,547	3,833,180	4,450,748	4,651,032	4,860,329	5,079,043	5,307,600	5,546,442	5,796,032	6,056,854
PIS			-	-	-	-	-	-	-	-	332,874	417,424	581,611	683,757	793,917	829,644	866,978	905,992	946,761	989,365	1,033,887	1,080,412
COFINS			-	-	-	-	-	-	-	-	1,533,239	1,922,681	2,678,936	3,149,424	3,656,831	3,821,389	3,993,351	4,173,052	4,360,839	4,557,077	4,762,145	4,976,442
Net Income			-	-	-	-	-	-	-	-	18,308,080	22,958,332	31,988,609	37,606,608	43,665,451	45,630,396	47,683,764	49,829,533	52,071,862	54,415,096	56,863,776	59,422,645
Costs			1,680,725	1,817,791	1,945,433	2,048,180	2,155,610	1,409,249	1,443,104	1,478,558	15,235,557	24,153,799	32,234,465	38,645,852	44,416,938	45,928,863	42,316,902	52,810,078	44,792,334	47,658,192	47,562,807	49,610,656
Administrative costs			188,100	196,565	205,410	214,653	224,313	234,407	244,955	255,978	267,497	279,534	292,114	305,259	318,995	333,350	348,351	364,027	380,408	397,526	415,415	434,109
O&M electricity costs											12,167,172	15,194,934	21,062,405	24,718,696	28,661,402	29,951,165	31,298,968	32,707,421	34,179,255	35,717,322	37,324,601	39,004,208
Extraordinary maintenance cost for gas engines																		9,832,771	2,055,049	4,110,098	2,055,049	2,055,049
O&M LFG costs			625,994	654,164	683,601	714,363	746,510	780,102	815,207	851,891	2,412,520	3,025,300	4,215,251	4,955,554	5,753,949	6,012,877	6,283,456	6,566,212	6,861,691	7,170,467	7,493,138	7,830,329
Insurance costs			7,941	24,773	26,770	28,617	30,607	32,750	35,061	37,553	40,241	114,279	134,600	171,192	195,591	220,356	230,272	240,634	251,463	262,778	274,603	286,961
Depreciation			858,690	942,290	1,029,652	1,090,547	1,154,181	361,990	347,880	333,136	348,127	5,539,752	6,530,096	8,495,150	9,487,001	9,411,115	4,155,856	3,099,013	1,064,468	-	-	-
EBIT			(1,680,725)	(1,817,791)	(1,945,433)	(2,048,180)	(2,155,610)	(1,409,249)	(1,443,104)	(1,478,558)	3,072,523	(1,195,467)	(245,856)	(1,039,243)	(751,487)	(298,467)	5,366,862	(2,980,544)	7,279,528	6,756,904	9,300,969	9,811,989
Cash Flow Analysis (R$)		**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**
EBIT + Depreciation			(822,035)	(875,501)	(915,781)	(957,634)	(1,001,429)	(1,047,260)	(1,095,223)	(1,145,422)	3,420,650	4,344,286	6,284,240	7,455,907	8,735,513	9,112,648	9,522,718	118,469	8,343,996	6,756,904	9,300,969	9,811,989
Investment		4,293,450	8,523,000	436,810	304,473	318,174	332,492	347,454	363,089	379,428	26,276,298	5,284,212	10,172,724	5,322,342	4,869,867	0	0	0	0	0	0	0
LFG collection system		954,450	418,000	436,810	304,473	318,174	332,492	347,454	363,089	379,428	396,503	414,345	432,991	452,475	-	-	-	-	-	-	-	-
Flare		3,339,000																				
LFG Plant			8,105,000																			
Electricity gerneration plant											25,879,796	4,869,867	9,739,733	4,869,867	4,869,867							
Net cash flow of project		-4,293,450	-9,345,035	-1,312,311	-1,220,253	-1,275,807	-1,333,921	-1,394,713	-1,458,312	-1,524,850	-22,855,648	-939,926	-3,888,484	2,133,565	3,865,647	9,112,648	9,522,718	118,469	8,343,996	6,756,904	9,300,969	9,811,989
IRR for the total project	**1.42%**																					

Alternative Scenario 4

The alternative scenario 4 (atmospheric release of the landfill gas) is the continuation of the current practice, which is in compliance with all applicable regulations and policies; and was deemed the most plausible alternative to the project activity. As explained above, the **alternative scenario 4** does not generate any revenues, but only expenditures.

Therefore, the IRR = 10.25%.

Sub-step 3d. Sensitivity analysis

The sensitivity analysis was performed varying the electricity tariff (revenues), the capital expenses (CapEx) and operational and maintenance costs (O&M) for the alternative scenarios 1 and 4. All parameters ranging from -10% to +10%, as the result presented below:

Item	Variation	IRR - scenario 1	IRR - scenario 4
	%	(%)	(%)
CapEx	-10.00	2.74	10.25
	10.00	0.19	10.25
Revenues	-10.00	-12.53	10.25
	10.00	7.99	10.25
O&M	-10.00	7.26	10.25
	10.00	-9.19	10.25
Base Case	0.00	1.42	10.25

As presented above, the project IRRs in scenario 1 are always less than benchmark (10.25%) in all sensitivity analyses.

Based on the 2nd investment decision:

Breakeven point

To ensure the additionality of this project activity, the project proponents varied the three identified parameters (CapEx, Revenues and O&M) until each of them reached the benchmark (i.e. IRR = benchmark). The results are presented below for alternative scenario 1 and the spreadsheet was provided to the audit team:

Parameter	Breakeven point
	Alternative Scenario 1
Capex variation until reach the benchmark (%)	-53.20%
Revenue until the benchmark (%)	14.74%
O&M variation until the benchmark (%)	-16.91%

Capital Expenditures (CapEx) – To reach the benchmark, the Capital Expenditures should be reduced in the **scenario alternative 1** in 53.20%. This result is unlikely. Consequently, this scenario is unrealistic.

Revenues – Theses values should be increased in the **scenario alternative 1** in 14.74%. This scenario is extremely unlikely to happen in the future based on the average electricity auction price results was 140.29 BRL/MWh (lower than 170 BRL/MWh of the electricity price of the project activity)

according to historical auction data from Brazilian Electricity Regulatory Agency (ANEEL)[32]. Therefore, this scenario is unrealistic.

O&M – Also, to reach the benchmark, the O&M shall be reduced in the scenario alternative 1 in 16.91%. Thus, the PPs deemed this situation to be unlikely to happen in the future since the O&M always increase. Consequently, this scenario is unrealistic.

<u>Outcome of Step 3</u>

A short list raking the alternative scenarios of the project activity is presented below according to the best IRR (financial indicator), taking into account the results of the sensitivity analyses.

Alternatives	Results
Scenario 4	Best scenario
Scenario 1	Worst scenario

As a result, the sensitivity analysis was conclusive, and the most financially attractive alternative is scenario 4.

Therefore, it seems reasonable to conclude that the alternative scenario 1 is unlikely to be the most financially attractive scenario.

Step 4. Common practice analysis

According to “Guidelines on common practice”, the common practice analysis establishes the following items below:

- **Applicable geographical area:** Brazil is the largest country in South America and the world's fifth largest country in the world. Therefore, the entire host country (Brazil) is considered suitable for this analysis;
- **Measure:** The project activity covers methane destruction;
- **Output:** the service delivers by the project is electricity in the grid (MWh);
- **Technology:** the technology used in the project is electricity generation through biogas combustion in group generators.

The common practice analysis consists of the following steps:

Step 1: *Calculate applicable output range as +/-50% of the design output or capacity of the proposed project activity.*

The installed capacity of the project is 28.520 MW. Then, the output range of the project activity is from 14.26 to 42.78 MW.

Step 2: *In the applicable geographical area, identify all plants that deliver the same output or capacity, within the applicable output range calculated in Step 1, as the proposed project activity and have started commercial operation before the start date of the project. Note their number N_{all}. Registered CDM project activities shall not be included in this step.*

The list with all plants is in Annex 3, item 4. The total of the plants is 228. Then, N_{all} = 228.

[32] https://www.aneel.gov.br/resultados-de-leiloes (*Regulated Contracting Market - ACR*)

Step 3: Within plants identified in Step 2, identify those that apply technologies different that the technology applied in the proposed project activity. Note their number N_{diff}.

The technology of the project activity is electricity generation through biogas. All projects in Brazil which generates electricity through biogas are registered CDM Projects and therefore, there is no project with the same technologies as the project activity.

Then, N_{diff} = 228 or $N_{all} = N_{diff}$.

Step 4: Calculate factor F=1-Ndiff/Nall representing the share of plants using technology similar to the technology used in the proposed project activity in all plants that deliver the same output or capacity as the proposed project activity.

$$F = 1 - \left(\frac{N_{diff}}{N_{all}}\right)$$

F = 1 – (228 / 228)

Therefore, F = 0 and $N_{all} - N_{diff} = 0$.

According to Guidelines on common practice: "*the proposed project activity is a "common practice" within a sector in the applicable geographical area if the factor F is greater than 0.2 and Nall-Ndiff is greater than 3".*

<u>Outcome of common practice analysis.</u>

The project activity is not a common practice because the factor F = 0 and the $N_{all} - N_{diff} = 0$.

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)

As the project flares LFG and generate electricity, the $BE_{HG,y} = 0$ and $BE_{NG,y} = 0$.

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

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 (t CH_4/yr)

As the project flares LFG, generate electricity, the $F_{CH4,HG,y} = 0$ and $F_{CH4,NG,y.} = 0$. Thus, the equation is:

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

$F_{CH4,EL,y}$ is determined using the "Tool to determine the mass flow of a greenhouse gas in a gaseous stream" and monitoring the working hours of the power plant(s), 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:

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

operational, paragraph 5 (a) and (b) of the Appendix of the "Tool to determine the mass flow of a greenhouse gas in a gaseous stream" tool shall be followed;

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

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

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

(e) 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[33].

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.

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

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.

[33] 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).

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

According to “Project emissions from flaring”, the flare efficiency will be calculated as follows:

<u>Open flare</u>

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%.

<u>Enclosed flares</u>

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

Option A: Apply a default value for flare efficiency

Option B: Measure the flare efficiency.

The project participant has chosen Option B.

In the present project activity the flare efficiency for minute m (ηflare,m) will be determined by Option B.2 of the methodological tool "Project emissions from flaring", where the flare efficiency is measured in each minute or, if option B.2. measurements are not available, Option A of the methodological tool "Project emissions from flaring" will be used. Both options are described below:

For enclosed flares that are defined as low height flares, which is the case of the project activity, the flare efficiency in the minute m ($n_{flare,m}$) shall be adjusted, as a conservative approach, by subtracting 0.1 from the efficiency as determined in Option A. For example, the default value applied should be 80%, rather than 90%, and if for example the measured value was 99%, then the value to be used shall correspond to 89%.

Option A: Default value

The flare efficiency for the minute m ($n_{\text{flare,m}}$) is 90% when the following two conditions are met to demonstrate that the flare is operating:

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

(2) The flame is detected in minute m ($Flame_{m}$).

Otherwise $n_{flare,m}$ is 0%.

Option B: Measured flare efficiency

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

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

Otherwise $n_{flare,m}$ is 0%.

In applying Option B, the project participants chose to determine $n_{flare,calc,m}$ using Option B.2 where the measurement of flare efficiency are conducted in each minute.

Option B.2: Measurement of flare efficiency in each minute

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

$$\eta_{\text{flare,calc,m}} = 1 - \frac{F_{\text{CH4,EG,m}}}{F_{\text{CH4,RG,m}}}$$

Where:

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

$F_{CH4,RG,m}$	=	Mass flow of methane in the residual gas on a dry basis at reference conditions in the minute m (kg)

$F_{CH4,\ EG,t}$ 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*.

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

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

$$F_{CH4,EG,m} = V_{EG,m} \times fc_{CH4,EG,m} \times 10^{-6}$$

Where:

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

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

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

$$V_{EG,m} = Q_{EG,m} \times M_{RG,m}$$

Where:

$V_{EG,m}$	=	Volumetric flow of the exhaust gas of the flare on a dry basis at reference conditions in minute m (m^3)
$Q_{EG,m}$	=	Volume of the exhaust gas on a dry basis at reference conditions per kilogram of residual gas on a dry basis at reference conditions in minute m (m^3 exhaust gas/kg residual gas)
$M_{RG,m}$	=	Mass flow of the residual gas on a dry basis at reference conditions in the minute m (kg)

Step 2.3: Determine the mass flow of the residual gas ($M_{RG,m}$)

Project participants may select to monitor the mass flow of the residual gas in minute m directly (see monitored parameter $M_{RG,m}$) or, according to the procedure given in this step, calculate $M_{RG,m}$ based on the volumetric flow and the density of the residual gas. The density of the residual gas is determined based on the volumetric fraction of all components in the gas.

$$M_{RG,m} = \rho_{RG,ref,m} \times V_{RG,m}$$

Where:

$M_{RG,m}$	=	Mass flow of the residual gas on a dry basis at reference conditions in the minute m (kg)
$\rho_{RG,ref,m}$	=	Density of the residual gas at reference conditions in minute m (kg/m^3)
$V_{RG,m}$		Volumetric flow of the residual gas on a dry basis at reference conditions in the minute m (m^3)

And

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

$\rho_{RG,ref,m}$	=	Density of the residual gas at reference conditions in minute m (kg/m^3)
P_{ref}	=	Atmospheric pressure at reference conditions (Pa)
R_u	=	Universal ideal gas constant (Pa.m^3/kmol.K)
$MM_{RG,m}$	=	Molecular mass of the residual gas in minute m (kg/kmol)
T_{ref}	=	Temperature at reference conditions (K)

Use the equation below to calculate $MM_{RG,m}$. When applying this equation, project participants may choose to either a) use the measured volumetric fraction of each component i of the residual gas, or b) as a simplification, measure the volumetric fraction of methane and consider the difference to 100% as being nitrogen (N_2). The same equation applies, irrespective of which option is selected.

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

$MM_{RG,m}$	=	Molecular mass of the residual gas in minute m (kg/kmol)
MM_i	=	Molecular mass of residual gas component i (kg/kmol)
$v_{i,RG,m}$	=	Volumetric fraction of component i in the residual gas on a dry basis at reference conditions in the hour h
i	=	Components of the residual gas. If Option (a) is selected to measure the volumetric fraction, then i = CH_4, CO, CO_2, O_2, H_2, H_2S, NH_3, N_2 or if Option (b) is selected then i = CH_4 and N_2

Step 2.4: Determine the volume of the exhaust gas on a dry basis at reference conditions per kilogram of residual gas ($Q_{EG,m}$)

$Q_{ECO2,EG,m}$ shall be determined as follows:

$$Q_{EG,m} = Q_{CO_2,EG,m} + Q_{O_2,EG,m} + Q_{N_2,EG,m}$$

$Q_{EG,m}$	=	Volume of the exhaust gas on a dry basis per kg of residual gas on a dry basis at reference conditions in the minute m (m^3/kg residual gas)
$Q_{CO2,EG,m}$	=	Quantity of CO_2 volume in the exhaust gas per kg of residual gas on a dry basis at reference conditions in the minute m (m^3/kg residual gas)
$Q_{N2,EG,m}$	=	Quantity of N_2 volume in the exhaust gas per kg of residual gas on a dry basis at reference conditions in the minute m (m^3/kg residual gas)
$Q_{O2,EG,m}$	=	Quantity of O_2 volume in the exhaust gas per kg of residual gas on a dry basis at reference conditions in the minute m (m^3/kg residual gas)

With

$$Q_{O_2,EG,m} = n_{O2,EG,m} \times VM_{ref}$$

$Q_{O2,EG,m}$	=	Quantity of O_2 volume in the exhaust gas per kg of residual gas on a dry basis at reference conditions in the minute m (m^3/kg residual gas)
$n_{O2,EG,m}$	=	Quantity of O_2 (moles) in the exhaust gas per kg of residual gas flared on a dry basis at reference conditions in minute m (kmol/kg residual gas)
VM_{ref}	=	Volume of one mole of any ideal gas at reference temperature and pressure (m^3/kmol)

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

$Q_{N2,EG,m}$	=	Quantity of N_2 (volume) in the exhaust gas per kg of residual gas on a dry basis at reference conditions in the minute m (m^3/kg residual gas)
VM_{ref}	=	Volume of one mole of any ideal gas at reference temperature and pressure (m^3/kmol)
$MF_{N,RG,m}$	=	Mass fraction of nitrogen in the residual gas in the minute m
AM_N	=	Atomic mass of nitrogen (kg/kmol)
$v_{O2,ai}$	=	Volumetric fraction of O_2 in air
$F_{O2,RG,m}$	=	Stochiometric quantity of moles of O_2 required for a complete oxidation of one kg residual gas in minute m (kmol/kg residual gas)
$n_{O2,EG,m}$	=	Quantity of O_2 (moles) in the exhaust gas per kg of residual gas flared on a dry basis at reference conditions in minute m (kmol/kg residual gas)

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

$Q_{CO2,EG,m}$	=	Quantity of O_2 (moles) in the exhaust gas per kg of residual gas flared on a dry basis at reference conditions in minute m (kmol/kg residual gas)
$v_{O2,EG,m}$	=	Volumetric fraction of O_2 in the exhaust gas on a dry basis at reference conditions in the minute m
$v_{O2,air}$	=	Volumetric fraction of O_2 in the air
$MF_{C,RG,m}$	=	Mass fraction of carbon in the residual gas in the minute m
AM_C	=	Atomic mass of carbon (kg/kmol)
$MF_{N,RG,m}$	=	Mass fraction of nitrogen in the residual gas in the minute m
AM_N	=	Atomic mass of nitrogen (kg/kmol)
$F_{O2,RG,m}$	=	Stochiometric quantity of moles of O_2 required for a complete oxidation of one kg residual gas in minute m (kmol/kg residual gas)

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

$nO2,EG,m$	=	O2 (moles) in the exhaust gas per kg of residual gas flared on a dry basis at reference conditions in minute m (kmol/kg residual gas)
$vO2,EG,m$	=	Volumetric fraction of O2 in the exhaust gas on a dry basis at reference conditions in the minute m
$vO2,air$	=	Volumetric fraction of O2 in the air
MFC,RG,m	=	Mass fraction of carbon in the residual gas in the minute m
AMC	=	Atomic mass of carbon (kg/kmol)
MFN,RG,m	=	Mass fraction of nitrogen in the residual gas in the minute m
AMN	=	Atomic mass of nitrogen (kg/kmol)
$FO2,RG,m$	=	Stochiometric quantity of moles of O2 required for a complete oxidation of one kg residual gas in minute m (kmol/kg residual gas)

$$F_{O2,RG,m} = \frac{MF_{C,RG,m}}{AM_C} + \frac{MF_{H,RG,m}}{4AM_H} - \frac{MF_{O,RG,m}}{2AM_O}$$

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

Determine the mass fractions of carbon, hydrogen, oxygen and nitrogen in the residual gas, using the volumetric fraction of component *i* in the residual gas and applying the equation below. In applying this equation, the project participants may choose to either a) use the measured volumetric fraction of each component *i* of the residual gas, or (b) as a simplification, measure the volumetric fraction of methane and consider the difference to 100% as being nitrogen (N_2). The same equation applies, irrespective of which option is selected.

$$MF_{j,RG,m} = \frac{\sum_i v_{i,RG,m} \times AM_j \times NA_{j,i}}{MM_{RG,m}}$$

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

i	=	Component of residual gas. If Option (a) is selected to measure the volumetric fraction, then i = CH4, CO, CO2, O2, H2, H2S, NH3, N2 or if Option (b) is selected then i= CH4 and N2

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:

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

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 1 – 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	0.008314472	$Pa.m^3/kmol.K$
T_{ref}	Temperature at reference conditions	273.15	K
GWP_{CH4}	Global warming potential of methane valid for the commitment period	25[34]	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)

[34] Value for the 2nd commitment period updated according to COP/MOP decisions

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

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

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 oxidized in the soil or other material covering the waste)
F	=	Fraction of methane in the SWDS gas (volume fraction)
MCF_y		Methane correction factor for year *y*
DOC_j	=	Fraction of degradable organic carbon in the waste type *j* (weight fraction)
k_j	=	Decay rate for the waste type *j* (1 / yr)
J	=	Type of residual waste or types of waste in the MSW

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 (2010). 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:

In this situation:

$F_{CH4,BL,y} = F_{CH4,BL,sys,y}$

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* (tCO2/yr)
$EC_{BL,k,y} = EG_{PJ,y}$	=	Net amount of electricity generated using LFG in year y (MWh/yr)
$EF_{EL,k,y}$[35]	=	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*.

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.

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.[36]

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.

[35] According to the “*Tool to calculate project or leakage CO2 emissions from fossil fuel combustion*”, $EF_{EL,k,y} = EF_{grid,CM,y}$

[36]According to Brazilian DNA Resolution n.8 published on 26/05/2008.

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 $EF_{grid,OM-DD,y}$.

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 which the project activity is displacing grid electricity

The $EF_{grid,OM,2018}$ is displayed on the Brazilian DNA website, for the year 2018

$EF_{grid,OM,2018}$ = 0.5390 tCO_2/MWh

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 1* 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:

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

Where:

$EF_{grid,BM,y}$	=	Build margin CO_2 emission factor in year y (t CO_2/MWh)
$EG_{m,y}$	=	Net quantity of electricity generated and delivered to the grid by power unit m in year y (MWh)
$EF_{EL,m,y}$	=	CO_2 emission factor of power unit m in year y (t CO_2/MWh)
m	=	Power units included in the build margin
y	=	Most recent historical year for which electricity generation data is available

The $EF_{grid,BM}$ is displayed on the Brazilian DNA website, for the year 2017.

$EF_{grid,BM,}2017$[37] = 0.0028 tCO_2/MWh

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} = 0.25 and w_{BM} = 0.75, fixed for the second crediting period. That gives:

[37] According to STEP 5, option 1 of Tool to calculate the emission factor for an electricity system

$$EF_{2018} = (0.5390 \times 0.25) + (0.0028 \times 0.75) = 0.1369\ tCO_2/MWh$$[38]

The build margin CO_2 emission factors will be ex-ante.

The operating margin CO_2 emission factors 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 CO_2/yr)
$PE_{SP,y}$	=	Emissions from the supply of LFG to consumers through a dedicated pipeline, in year *y* (t CO_2/yr)

The parameter $PE_{DT,y}$ is not used in the calculation of project emissions since there is no distribution of compressed/liquefied LFG using trucks in the project activity.

Since there is no supply of LFG to consumers through a dedicated pipeline, $PE_{SP,y} = 0$

Since there is no consumption of fossil fuels due to the project activity, for purpose other than electricity generation, $PE_{FC,y} = 0$.

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,

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

[38] The source of the data is from Brazilian DNA. The link is http://www.mctic.gov.br/mctic/opencms/ciencia/SEPED/clima/textogeral/emissao_despacho.html, accessed on 23/03/2018.

<u>$PE_{EC1,y}$ - Project emission from electricity consumption from the grid</u>

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 in the latest approved version 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.

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

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 tCO2/MWh for project emission from diesel generator(s).

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

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.

<u>Calculation of $PE_{FC,y}$ – project emission from consumption of heat</u>

There is no project emission from consumption of heat.

Therefore, $PE_{FC,y} = 0$

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);

B.6.2. Data and parameters fixed ex ante

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	0.0028
Choice of data or Measurement methods and procedures	The build margin emission factor has been defined by the Brazilian DNA
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	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 2^{nd} commitment period according to COP/MOP decisions[39]
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	-

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	0.008314472
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	0.00%
B) Pulp, paper and cardboard (other than sludge)	18.70%
C) Food, food waste, beverages and tobacco (other than sludge)	16.80%
D) Textiles	3.80%
E) Garden, yard and park waste	12.90%
F) Glass, plastic, metal, other inert waste	47.90%
TOTAL	**100.00%**

[39] 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 23/03/2018 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 23/03/2018.

Data / Parameter	$SPEC_{flare}$
Unit	Temperature - °C Flow rate - Nm^3/h Maintenance schedule - number of days
Description	Manufacturer's flare specifications for temperature, flow rate and maintenance schedule
Source of data	Flare Manufacturer
Choice of data or Measurement methods and procedures	**Enclosed flare** According to manufacturer manual/recommendation. <table><tr><td>Flare model</td><td>2500 HT</td></tr><tr><td>Minimum flare temperature</td><td>850 ºC</td></tr><tr><td>Maximum flare temperature</td><td>1200 ºC</td></tr><tr><td>Minimum and maximum inlet flow rate</td><td>Minimum flow: 500 Nm^3/h --- Maximum flow: 2,500 Nm^3/h</td></tr><tr><td>Maximum duration in days between maintenance events</td><td>7 days[40]</td></tr></table>
Purpose of data	Calculation of project emissions
Additional comment	-

Data / Parameter	P_{ref}
Unit	Pa
Description	Atmospheric pressure at reference conditions
Source of data	Tool "Project emissions from flaring"
Value(s) applied	101,325
Choice of data or Measurement methods and procedures	Default value extracted from Tool "Project emissions from flaring"
Purpose of data	Calculation of project emissions
Additional comment	-

Data / Parameter	T_{ref}

[40] The maximum duration in days between maintenance events has been chosen considering preventive maintenance program which defines the frequency for checking flare equipment situation every week.

Unit	K
Description	Temperature at reference conditions
Source of data	Tool "Project emissions from flaring"
Value(s) applied	273.15
Choice of data or Measurement methods and procedures	Default value extracted from Tool "Project emissions from flaring"
Purpose of data	Calculation of project emissions
Additional comment	-

Data / Parameter	η_{PJ}
Unit	Dimensionless
Description	Efficiency of the LFG capture system installed in the project activity
Source of data	Collection efficiency 0.85 & Load Factor 0.95 - USEPA 1996 Handbook EPA-LFG.pdf - Item 2.2.2. page 2-8. Only collection efficiency technical literature data was used.
Value(s) applied	85%
Choice of data or Measurement methods and procedures	Based on Collection efficiency 0.85 & Load Factor 0.95 - USEPA 1996 Handbook EPA-LFG.pdf- Item 2.2.2. page 2-8. Only collection efficiency technical literature data was used.
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	see table below
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

<table>
<tr><td>Value(s) applied</td><td>
<table>
<tr><td colspan="2" rowspan="2">Waste type j</td><td>Tropical (MAT > 20 °C)</td></tr>
<tr><td>Wet (MAP > 1,000mm)</td></tr>
<tr><td rowspan="2">Slowly degrading</td><td>Pulp, paper, cardboard (other than sludge), textiles</td><td>0.07</td></tr>
<tr><td>Wood, wood products and straw</td><td>0.035</td></tr>
<tr><td>Moderately degrading</td><td>Other (non-food) organic putrescible garden and park waste</td><td>0.17</td></tr>
<tr><td>Rapidly degrading</td><td>Food, food waste, sewage sludge, beverages and tobacco</td><td>0.4</td></tr>
</table>
</td></tr>
<tr><td>Choice of data or Measurement methods and procedures</td><td>IPCC default value for anaerobic managed solid waste disposal site is applied.</td></tr>
<tr><td>Purpose of data</td><td>Calculation of baseline emissions</td></tr>
<tr><td>Additional comment</td><td>-</td></tr>
</table>

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

<table>
<tr><td>Data / Parameter</td><td>MM_k</td></tr>
<tr><td>Unit</td><td>kg/kmol</td></tr>
<tr><td>Description</td><td>Molecular mass of gas k</td></tr>
<tr><td>Source of data</td><td>Tool to determine the mass flow of a greenhouse gas in a gaseous stream</td></tr>
<tr><td>Value(s) applied</td><td>
<table>
<tr><td>Compound</td><td>Structure</td><td>Molecular mass (kg/kmol)</td></tr>
<tr><td>Nitrogen</td><td>N_2</td><td>28.01</td></tr>
</table>
</td></tr>
</table>

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	-

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

>>

Emission reduction

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 = 85%: (Based on Collection efficiency 0.85 & Load Factor 0.95–- USEPA 1996 Handbook EPA-LFG.pdf–- Item 2.2.2. page 2-8. Only collection efficiency technical literature data was used.);
- 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 85% 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 2 – Ex-ante estimation of $F_{CH4,PJ,y}$

Year	$F_{CH4,PJ,y}$ (tCH_4/yr)
From 29/09/2018	5,786
2019	23,975
2020	24,748
2021	25,465
2022	26,129
2023	26,743
2024	27,312
Until 28/09/2025	20,878

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

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

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

Year	$F_{CH4,BL,y}$ (tCH_4/yr)
From 29/09/2018	1,157
2019	4,795
2020	4,950
2021	5,093
2022	5,226
2023	5,349
2024	5,462
Until 28/09/2025	4,176

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

Year	$BE_{CH4,y}$ (tCO_2/year)
From 29/09/2018	101,260
2019	419,568
2020	433,089
2021	445,636
2022	457,257
2023	468,009
2024	477,952
Until 28/09/2025	365,359

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

The exante calculation is:

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

As explained above, the $EF_{grid,CM,y}$ = 0.1369 tCO_2/MWh

Table 5 – Baseline emissions associated with electricity generation ($BE_{EC,y}$)

Year	$EC_{BL,k,y}$ (MWh/yr)	$BE_{EC,y}$ (tCO_2/yr)
From 29/09/2018	0	0
2019	118,672	18,840
2020	142,406	22,608
2021	189,875	30,144
2022	213,609	33,912
2023	237,343	37,680
2024	237,343	37,680
Until 28/09/2025	178,008	28,260

The equation of the baseline emission calculation is:

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

The result is:

Table 6 – baseline emission calculation

Year	$BE_{CH4,y}$ (tCO_2/year)	$BE_{EC,y}$ (tCO_2/yr)	BE_y (tCO_2/yr)
From 29/09/2018	101,260	0	101,260
2019	419,568	18,840	438,408
2020	433,089	22,608	455,697
2021	445,636	30,144	475,781
2022	457,257	33,912	491,170
2023	468,009	37,680	505,690
2024	477,952	37,680	515,632
Until 28/09/2025	365,359	28,260	393,619

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 (tCO2/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 0.1369 tCO_2/MWh will be used.

Finally the technical transmission and distribution losses ($TDL_{j,y}$) value has been assumed to be 16%, according to World Bank Database – 2014.[41] Table below summarizes the project emissions resulting from electrical consumption in the plant.

Table 7 – Electricity consumption from the grid resulting due to project activity

Year	**Electricity consumption from the grid** (MWh/year)	**$PE_{el,grid}$ (tCO_2/year)**
From 29/09/2018*	38	7
2019	0	0
2020	0	0
2021	0	0
2022	0	0
2023	0	0
2024	0	0
Until 28/09/2025	0	0

*2018 electricity consumption data extracted from monthly data log from 08/2018 and projected for the entire year.

It is important to notice, it is considered that in standard operation the electricity of LFG plant will be supplied by of the LFG electricity power plant. As a result, in principle, there is no electrical consumption from the grid by the LFG plant and if there will be, it will be monitored.

$PE_{EC2,y}$ - Project emission from diesel generator(s)

It is considered no consumption of diesel by the diesel generator since the electricity will be generated through LFG in order to supply the LFG plant internal needs. The emission factor from the diesel generator(s) is 1.3 tCO2/MWh. The following table represents the project emissions from the use of the standby generator over the crediting period. Table below presents the project emissions associated with fossil fuel combustion at the project site.

[41] World Bank Database (15.775% for 2014 is the most recent data. It was adopted 16%). Source: https://data.worldbank.org/indicator/EG.ELC.LOSS.ZS?end=2014&locations=BR&start=1971&view=chart

Table 8 – Project emissions from diesel generator

Year	$PE_{el,diesel}$ (MWh/year)	$PE_{el,diesel}$ (tCO_2/year)
From 29/09/2018	0	0
2019	0	0
2020	0	0
2021	0	0
2022	0	0
2023	0	0
2024	0	0
Until 28/09/2025	0	0

Calculation of $PE_{FC,y}$ – project emission from consumption of heat

For ex-ante calculation, this factor was considered zero because there is no project emission from consumption of heat.

$PE_{FC,y} = 0$

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)
From 29/09/2018	101,260	7	101,253
2019	438,408	0	438,408
2020	455,697	0	455,697
2021	475,781	0	475,781
2022	491,170	0	491,170
2023	505,690	0	505,690
2024	515,632	0	515,632
Until 28/09/2025	393,619	0	393,619

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)
From 29/09/2018	101,260	7	0	101,253
2019	438,408	0	0	438,408
2020	455,697	0	0	455,697
2021	475,781	0	0	475,781
2022	491,170	0	0	491,170
2023	505,690	0	0	505,690
2024	515,632	0	0	515,632
Until 28/09/2025	393,619	0	0	393,619
Total	**3,377,256**	**7**	**0**	**3,377,249**
Total number of crediting years	**7**			
Annual average over the crediting period	**482,465**	**1**	**0**	**482,464**

B.7. Monitoring plan

B.7.1. Data and parameters to be monitored

Baseline, project and/or leakage emission from electricity consumption and monitoring of electricity generation

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	0.1369
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
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	TDL_y
Unit	-
Description	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.
Source of data	World Bank Database
Value(s) applied	16%[42]
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 data was based on World Bank Database – 2014.[43]

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;

[42] World Bank Database (15.775% for 2014 is the most recent data. It was adopted 16%). Source: https://data.worldbank.org/indicator/EG.ELC.LOSS.ZS?end=2014&locations=BR&start=1971&view=chart

[43] World Bank Database (15.775% for 2014 is the most recent data. It was adopted 16%). Source: https://data.worldbank.org/indicator/EG.ELC.LOSS.ZS?end=2014&locations=BR&start=1971&view=chart

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>From 29/09/2018</td><td>38</td></tr><tr><td>2019</td><td>0</td></tr><tr><td>2020</td><td>0</td></tr><tr><td>2021</td><td>0</td></tr><tr><td>2022</td><td>0</td></tr><tr><td>2023</td><td>0</td></tr><tr><td>2024</td><td>0</td></tr><tr><td>Until 28/09/2025</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	$EC_{PJ2,y} = EG_{EC2,y}$
Unit	MWh/y
Description	Quantity of electricity consumed from diesel generator by the project activity during the year y
Source of data	Measurement from Project participants.
Value(s) applied	<table><tr><th>Year</th><th>$PE_{el,diesel}$ (MWh/year)</th></tr><tr><td>From 29/09/2018</td><td>0</td></tr><tr><td>2019</td><td>0</td></tr><tr><td>2020</td><td>0</td></tr><tr><td>2021</td><td>0</td></tr><tr><td>2022</td><td>0</td></tr><tr><td>2023</td><td>0</td></tr><tr><td>2024</td><td>0</td></tr><tr><td>Until 28/09/2025</td><td>0</td></tr></table>
Measurement methods and procedures	Continuously measured by electricity meters for the diesel generators as per “Methodological tool: Baseline, project and/or leakage emissions from electricity consumption and monitoring of electricity generation” and ACM0001 methodology.
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.

ACM0001: Flaring or use of landfill gas

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	237,343 in 2024
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"

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	n/a
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; I 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); I 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	For enclosed flares is possible to analyses the temperature in the exhaust gas.

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 $F_{CH4,flared,y}$, $F_{CH4,EL,y}$

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 $F_{CH4,flared,y}$, $F_{CH4,EL,y}$

Data / Parameter	$v_{i,t,db}$
Unit	m³ gas i/m³ 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	Approximately 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 only in case Option A of the tool “Tool to determine the mass flow of a greenhouse gas in a gaseous stream” is applied for the determination of $F_{CH4,flared,y}$, $F_{CH4,EL,y}$

Data / Parameter	$v_{i,t,wb}$
Unit	m³ gas i/m³ dry 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 analyzer
Value(s) applied	Approximately 50%
Measurement methods and procedures	Calculated based on the dry basis analysis plus water concentration measurement or continuous in-situ analyzers 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 may be monitored only in case Option B of the tool “Tool to determine the mass flow of a greenhouse gas in a gaseous stream” is applied for the determination of $F_{CH4,flared,y}$, $F_{CH4,EL,y}$

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 according manufacturer recommendation. 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[44].
Additional comment	-

Data / Parameter	$Maintenance_y$
Unit	Calendar dates
Description	Maintenance events completed in year y
Source of data	Project participants
Value(s) applied	-
Measurement methods and procedures	Record the date that maintenance events were completed in year y. Records of maintenance logs must include all aspects of the maintenance including the details of the person(s) undertaking the work, parts replaced, or needing to be replaced, source of replacement parts, serial numbers and calibration certificates.
Monitoring frequency	Daily

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

QA/QC procedures	Records must be kept in a maintenance log for two years beyond the life of the flare
Purpose of data	Calculation of baseline and project emissions when the flame is on[45].
Additional comment	Monitoring of this parameter is required for the case of flares. These dates are required so that they can be compared to the maintenance schedule to check that maintenance events were completed within the minimum time between maintenance events specified by the manufacturer ($SPEC_{,flare}$).

Data / Parameter	$T_{EG,m}$
Unit	º C
Description	Temperature in the exhaust gas of the enclosed flare in minute m
Source of data	Measurements by project participants
Value(s) applied	-
Measurement methods and procedures	Measure the temperature of the exhaust gas stream in the flare by a Type N thermocouple. A temperature above 850 ºC indicates that a significant amount of gases are still being burnt and that the flare is operating. Data will be recorded continuously and values will be averaged hourly or at a shorter time interval
Monitoring frequency	Once per minute
QA/QC procedures	According to manufacturer's recommendations.
Purpose of data	(b) Calculation of project emissions or actual net GHG removals by sinks;
Additional comment	This item is only applicable for enclosed flares.

Data / Parameter	$v_{i,RG,m}$
Unit	-
Description	Volumetric fraction of component i in the residual gas on a dry basis in the minute
Source of data	Measurements by project participants using a continuous gas analyser
Value(s) applied	-
Measurement methods and procedures	Measurement may be made on either dry or wet basis. If value is made on a wet basis, then it shall be converted to dry basis for reporting
Monitoring frequency	Continuously. Values to be averaged on a minute basis
QA/QC procedures	Analysers must be periodically calibrated according to the manufacturer's recommendation. A zero check and a typical value check should be performed by comparison with a standard certified gas
Purpose of data	(b) Calculation of project emissions or actual net GHG removals by sinks;
Additional comment	As a simplified approach, project participants may only measure the content CH_4, CO and CO_2 of the residual gas and consider the remaining part as N_2. Monitoring of this parameter is only applicable in case of enclosed flares and continuous monitoring of the flare efficiency

[45] When the maintenance is being carried out, neither baseline nor project emissions occurs since the LFG is not combusted and released to the atmosphere.

Data / Parameter	$V_{RG,m}$
Unit	m³
Description	Volumetric flow of the residual gas on a dry basis at reference conditions in the minute m
Source of data	Measurements by project participants using a flow meter
Value(s) applied	-
Measurement methods and procedures	Instruments with recordable electronic signal (analogical or digital)
Monitoring frequency	Continuously. Values to be averaged on a minute basis
QA/QC procedures	Flow meters are to be periodically calibrated according to the manufacturer's recommendation
Purpose of data	(b) Calculation of project emissions or actual net GHG removals by sinks;
Additional comment	Monitoring of this parameter is applicable in case of enclosed flares and continuous monitoring of the flare efficiency and if project participant selects to calculate VRG,m instead of monitoring directly. Monitoring of this parameter may also be necessary for confirming that the manufacturer's specifications for flow rate/heat flux are met. In this case the flow rate should be measured in a m3 /h basis

Data / Parameter	$M_{RG,m}$
Unit	kg
Description	Mass flow of the residual gas on a dry basis at reference conditions in the minute m
Source of data	-
Value(s) applied	-
Measurement methods and procedures	Instruments with recordable electronic signal (analogical or digital)
Monitoring frequency	Continuous, values to be averaged on a minute basis
QA/QC procedures	Periodic calibration against a primary device provided by an independent accredited laboratory is mandatory. Calibration and frequency of calibration is according to manufacturer's specifications
Purpose of data	(b) Calculation of project emissions or actual net GHG removals by sinks;
Additional comment	Monitoring of this parameter is applicable in case of enclosed flares and continuous monitoring of the flare efficiency and if project participant selects to monitor MRG,m directly, instead of calculating. Monitoring of this parameter may also be necessary for confirming that the manufacturer's specifications for flow rate/heat flux are met. In this case the flow rate should be measured in a kg/h basis

Data / Parameter	$v_{O2,EG,m}$
Unit	-
Description	Volumetric fraction of O2 in the exhaust gas on a dry basis at reference conditions in the minute m

Source of data	Measurements by project participants using a continuous gas analyser
Value(s) applied	-
Measurement methods and procedures	Extractive sampling analysers with water and particulates removal devices or in situ analysers for wet basis determination. The point of measurement (sampling point) shall be in the upper section of the flare (80% of total flare height). Sampling shall be conducted with appropriate sampling probes adequate to high temperatures level (e.g. inconel probes)
Monitoring frequency	Continuously. Values to be averaged on a minute basis
QA/QC procedures	Analysers must be periodically calibrated according to the manufacturer's recommendation. A zero check and a typical value check should be performed by comparison with a standard gas
Purpose of data	(b) Calculation of project emissions or actual net GHG removals by sinks;
Additional comment	Monitoring of this parameter is only applicable in case of enclosed flares and continuous monitoring of the flare efficiency

Data / Parameter	$fc_{CH4,EG,m}$
Unit	mg/m3
Description	Concentration of methane in the exhaust gas of the flare on a dry basis at reference conditions in the minute m
Source of data	Measurements by project participants using a continuous gas analyser
Value(s) applied	-
Measurement methods and procedures	Extractive sampling analysers with water and particulates removal devices or in situ analyser for wet basis determination. The point of measurement (sampling point) shall be in the upper section of the flare in order that the sampling is of the gas after consumption has taken place (80% of total flare height). Sampling shall be conducted with appropriate sampling probes adequate to high temperatures level (e.g. inconel probes)
Monitoring frequency	Continuously. Values to be averaged on a minute basis
QA/QC procedures	Analysers must be periodically calibrated according to manufacturer's recommendation. A zero check and a typical value check should be performed by comparison with a standard gas
Purpose of data	(b) Calculation of project emissions or actual net GHG removals by sinks;
Additional comment	Monitoring of this parameter is only applicable in case of enclosed flares and continuous monitoring of the flare efficiency. Measurement instruments may read ppmv or % values. To convert from ppmv to mg/m3 simply multiply by 0.716. 1% equals 10 000 ppmv.

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 the CDM project standard. Details are available in section B.7.1 above. The monitoring equipment locations are presented in the picture below:

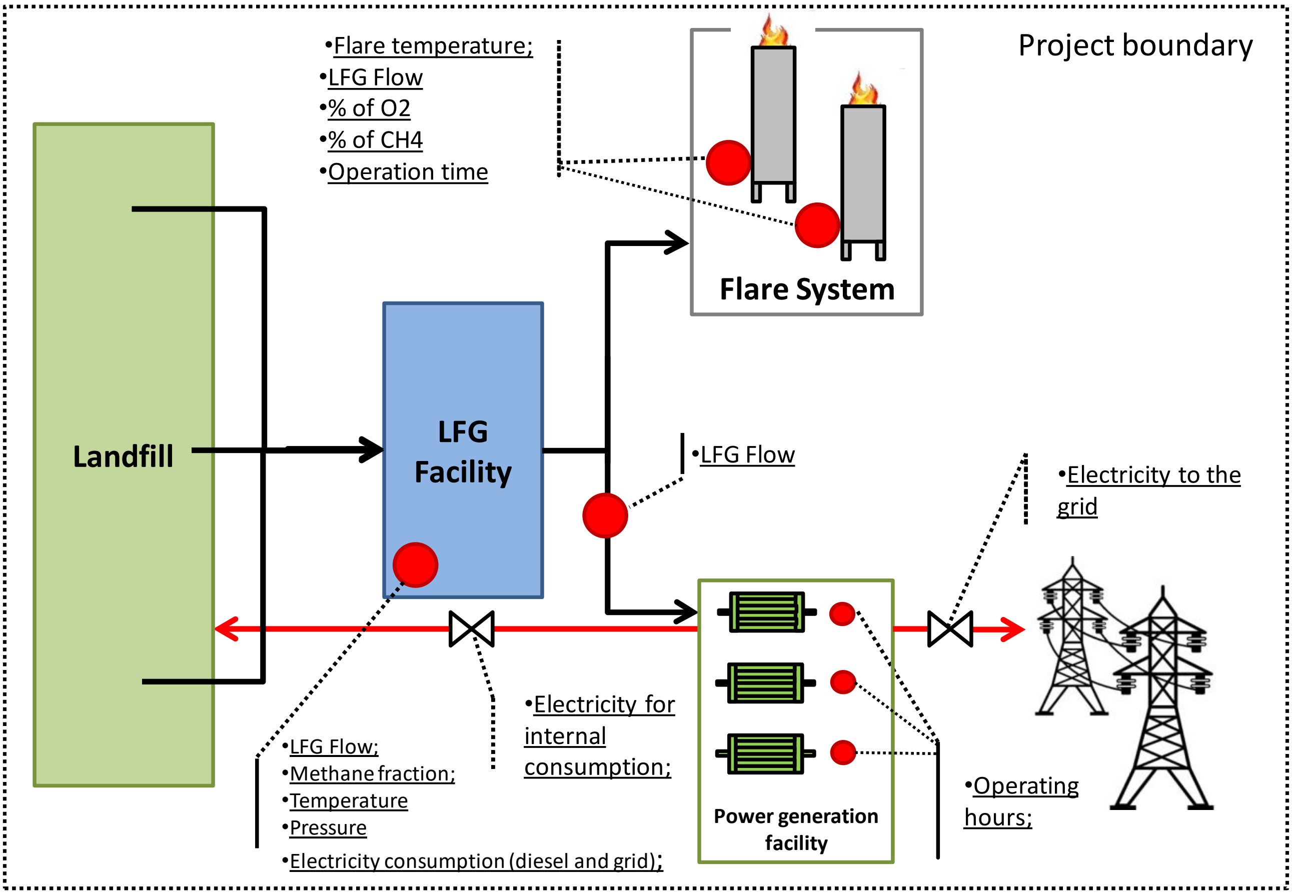

Figure 4 - Monitoring equipment locations

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. This task will be completed by the project owner and reported directly to the DOE. These logs will be available at the request of the DOE in order to prove the operational integrity of the Project.

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 owner 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 operations 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 in case of enclosed flares and flame detection in case of open flares;
- Electrical Consumption;
- Project electricity output;
- Regulatory requirements;
- Data records; and
- Data assessment and reporting.

3.1. Flow Measurement

According to ACM0001, flow meters will be installed during Phase 1 (flaring) on the piping, straight before the flares.

During phase 2 (electricity generation) implementation, in order to follow ACM0001, flow meters will be installed:

- A flow meter will be installed in the piping before the power plant to measure the LFG flow utilized for electricity generation;
- and other flow meter will be either installed in each flare.

The flow of LFG collected by the system and subsequently utilized or flared is measured via individual 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. 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. The equipment selected for the site aggregates gas compositions approximately once every minute.

3.3. Uncombusted Methane

For enclosed flares, the efficiency will be measured per the methodological tool “Project emissions from flaring”.

3.4. Electrical Consumption

The consumed electricity by the project activity will be continuously measured by electricity meters for the grid and/or 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[46] will be continuously measured by an electricity meter and respective data will be electronically recorded.

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.

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

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 frequently, as described above.

Data monitored and required for verification and issuance are kept and archived for at least two years after the end of the final crediting period or the last issuance of CERs, whichever occurs later.

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 enclosed flares 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 enclosed drum 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

The project owner 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.

Also, for calibration, CDM project standard for project activities Version 2, paragraph 79 (d) will be used. Thus the project participants shall apply the following unless the applied methodologies, the applied standardized baselines or the other applied methodological regulatory documents state otherwise:
(d) The calibration of measuring equipment shall be carried out by an accredited person or institution;

8. Date of completion of application of methodology and standardized baseline and contact information of responsible persons/ entities

The date of completion the application of the methodology to the project activity study is 05/07/2019.

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

Beng Engenharia Ltda is not a Project Participant.

SECTION C. Start date, crediting period type and duration

C.1. Start date of project activity

>>
Project starting date: 29/09/2011

C.2. Expected operational lifetime of project activity

>>
21 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 2nd crediting period will start on 29/09/2018.

C.3.3. Duration of crediting period

>>

7 years and 0 months.

SECTION D. Environmental impacts

D.1. Analysis of environmental impacts

>>

According to the National GHG Emissions inventory conducted by CETESB in 1994, at that time Brazil had over 6,000 waste depositing sites, receiving over 60,000 tons of waste per day. Of this amount, 76% of the total waste is deposed in “dumpsites” (Lixões) with no management, gas collection, or water treatment whatsoever, and usually without any license or under no control by the environmental agencies concerned. According to the same study, 84% of Brazil’s methane emissions come from the deposition of waste in uncontrolled dumpsites. The remaining 24% of waste is deposed in ‘controlled’ landfills (as opposed to ‘sanitary’ landfills, as planned by the project), but these are usually highly ineffective in relation to emissions and percolate control. In the few cases where gases are collected, this is done for safety reasons (to avoid explosions), and it is often the case that the amounts effectively collected are very low, due to high levels of percolates (which are often not drained or treated, as well) blocking the drainage pipes.

By collecting and combusting landfill gas, the CTR Candeias Landfill Gas Project will reduce both global and local environmental effects of uncontrolled releases. The major components of landfill gas, methane and carbon dioxide, are colorless and odorless. The main global environmental concern over these compounds is the fact that they are greenhouse gas. Although the majority of landfill gas emissions are quickly diluted in the atmosphere, in confined spaces there is a risk of asphyxiation and/or toxic effects if landfill gas is present in high concentrations. Landfill gas also contains over 150 trace components that can cause other negative local and global environmental effects such as odor nuisances, stratospheric ozone layer depletion, and ground –level ozone creation. Through appropriate management of the Candeias landfill, landfill gas will be captured and combusted, removing the risks of toxic effects on the local community and local environment. The project will not result in trans-boundary environmental impacts.

Landfill gas electricity generators and leachate evaporator systems can also produce nitrogen oxides emissions that vary widely from one site to another, depending on the type of system and the extent to which steps have been taken to minimize such emissions. Combustion of landfill gas can also result in the release of organic compounds and trace amounts of toxic materials, including mercury and dioxins, although such releases are at levels significantly lower than if the landfill gas is flared. These emissions are also viewed as significantly less than the continued uncontrolled release of landfill gas.

Where methane is used for electricity generation, operational practices at the landfill are improved thus contributing to sustainable development. Specifically, for landfills, sustainable means accelerating waste stabilization such that the landfill processes can be said to be largely complete within one generation (30-50 years). This ensures that both leachate and methane are more carefully managed and controlled, and the degradation processes are accelerated.
Groundwater and surface water can be contaminated by untreated leachate from landfill sites. Leachate may cause serious water pollution if not properly managed. Surface water runoff from a landfill site can also cause unacceptable sediment loads in receiving waters, while uncontrolled surface water run-on can lead to excessive generation of leachate and migration of contaminated waters off-site. With the CTR Candeias Landfill Gas Project providing appropriate management installing leachate evaporator system on the site, these potential problems should be avoided. Also few water impacts are associated with landfill gas electricity generation plants.

Other potential hazards and amenity impacts minimized by appropriate management of the CTR Candeias site include the risks of fire or explosions, landfill gas migration, dust, odors, pests, and vermin, each of which may occur on-site or off-site.

The following aspects of the operation of the landfill gas to power energy or flare system have also been addressed:

- Noise – There will be some increase in noise from the site associated with energy or flare systems, although the engines will be housed to reduce noise. The impacts are likely to be marginal given the noise typically associated with operations at landfills.

- Visual amenity – Placement of energy or flare system facilities at the landfill site will increase the visual presence of the site, however the impacts are expected to be marginal given the visual intrusion currently associated with the waste disposal operations.

D.2. Environmental impact assessment

>>

According to Brazilian rules, flaring gas is one activity may cause environmental impacts and Haztec must therefore request an installation license and operational license from state environmental agency.

Haztec has made a request (License for Installation and Operation for the Project Activities) to the State Environmental Agency for an environmental recovery license. The license request was submitted on 29/09/2009. This is the only license required for the landfill gas capture and flare system to be installed and operated.

Most recent Urban Solid Waste Diagnosis from Institute for Applied Economic Research (IPEA) has been published in 2012. According to Table 18, 99.5% of the Recife area municipal solid waste is disposed in landfills/open dumps and only 0.5% is managed by other methods. Thus, it is possible to state that recycling percentage in the project activity area is negligible.

SECTION E. Local stakeholder consultation

E.1. Modalities for local stakeholder consultation

>>

As required by the Interministerial Commission on Global Climate Change (CIMGC), the Designated National Authority (DNA) for Brazil, invitations must be sent for comments to local stakeholders as part of the procedures for analyzing CDM projects and issuing letters of approval. This procedure was followed by CTR Candeias Landfill Gas Project to take its GHG mitigation initiative to the public. Letters and the Executive Summary of the project were sent to the following local stakeholders:

- Prefeitura Municipal de Jaboatão dos Guararapes–-PE / Municipal Administration of Jaboatão dos Guararapes–-PE.
- Secretaria Municipal de Meio Ambiente de Jaboatão dos Guararapes–-PE / Municipal Secretariat of Environment of Jaboatão dos Guararapes–-PE.
- Câmara dos Vereadores de Jaboatão dos Guararapes–-PE / Municipal Legislation Chamber of Jaboatão dos Guararapes–-PE.
- CPRH - Agência Estadual de Meio Ambiente e Recursos Hídricos do Pernambuco / Environmental State Agency of Pernambuco.
- Ministério Público do Estado do Pernambuco / Public Ministry of Pernambuco State.
- Fórum Brasileiro de Moviementos e Organizacoes Sociais (FBMOS) / Brazilian NGO Fórum.

- ABES – Rio – Associação Brasileira de Engenharia Sanitária e Ambiental / Brazilian Association of Sanitary and Environment Engineering.
- Ministerio Público Federal
- CEDECOM – Centro de Estudos e Apoio ao Desenvolvimento de Comunidades

Resolution #7 of the GIMGC has been followed. The PDD in Portuguese as well as Annex III of the resolution were available at the following website until registration http://www.haztec.com.br.

E.2. Summary of comments received

>>
No comments have been received at this time.

E.3. Consideration of comments received

>>
No comments have been received at this time.

SECTION F. Approval and authorization

>>
The letters of approval from Parties for the project activity were available at the time of submitting the PDD to the DOE for validation.

Appendix 1. Contact information of project participants

Organization name	Haztec Tecnologia e Planejamento Ambiental S.A
Country	Brazil
Address	Rua Joaquim Palhares, 40 | 1º andar | Cidade Nova Rio de Janeiro | RJ | Cep 20260-080
Telephone	+55 (21) 3974-7722
Fax	-
E-mail	dalton.canelhas@haztec.com.br
Website	http://www.haztec.com.br
Contact person	Mr. Dalton Canelhas

Appendix 2. Affirmation regarding public funding

There is no Annex I public funding involved in the project activity.

Appendix 3. Applicability of methodologies and standardized baselines

BASELINE INFORMATION

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

Year landfilling operations started operator/historical logs	2007
Projected year for landfill closure - estimated based on current filling rate	2027
GWP for methane (UNFCCC and Kyoto Protocol decisions)	25
Methane concentration in LFG (% by volume) typical assumption for baseline scenario	50
LFG collection efficiency (%)	85
Average electricity consumption from the grid due to the project activity (MWh/year)	0
Electricity consumption from the diesel generator 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.	0.1369
Installed capacity of Power Plant (MW)	28.52
Load factor	95%
Operational lifetime of the project activity (years)	21
Adjustment Factor (AF)	20%

2. Waste disposal

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

Year	Waste disposal (tonnes/yr)
2007	32,508
2008	309,063
2009	457,562
2010	911,018
2011	1,099,453
2012	1,451,683
2013	1,689,270
2014	1,659,935
2015	1,519,002
2016	1,445,630
2017	1,342,466
2018	1,342,466
2019	1,342,466
2020	1,342,466
2021	1,342,466
2022	1,342,466
2023	1,342,466
2024	1,342,466
2025	1,342,466
2026	1,342,466
2027	1,342,466

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[47].

[47] http://www.mctic.gov.br/mctic/opencms/ciencia/SEPED/clima/arquivos/emissoes_co2/Despacho-2017.xlsx, accessed on 05/11/2018

Combined Margin Emission Factor (tCO_2/MWh)		
2nd crediting Period		0.1369
Build Margin - 2017[1]		0.0028
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

1. According to STEP 5, option 1 of Tool to calculate the emission factor for an electricity system

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

Not applicable.

Appendix 5. Further background information on monitoring plan

The monitoring will be made as described in items B.7.1. and B.7.2.

Appendix 6. Summary report of comments received from local stakeholders

No comments have been received.

Appendix 7. Summary of post-registration changes

A summary of the changes/updates related to PDD is presented below:

A) History of Post Registration Changes to the project activity that have been approved by the Board after its registration:

A.1.) Post Registration changes on 07 Feb 2014:

1) Permanent change correction on Transmission and Distribution Losses (TDL) moved to B.6.3 as this variable is not monitored ex-post.
2) Permanent change correction on references to specific technologies of the equipment describe in section B.7.1 have been deleted.

3) Permanent change correction on reference to measurements of gases other than methane and oxygen deleted from baseline calculations, since, as per the simplified approach of the tool, the project developer will only measure the volumetric fraction of methane and consider the difference to 100% as being nitrogen (N2).
4) Permanent change correction on volumetric fraction of methane in the residual gas fvCH4,h defined as measured on wet basis.
5) Permanent changes to the registered monitoring plan, or permanent deviation of monitoring from the applied methodologies: An option has been included to account for project emissions that might occur in case that diesel consumption from an eventual black start diesel generator is required under the scenario of electricity generation from LFG. This diesel generator would be used for the sole purpose of starting the LFG electricity generator and it does not represent a change in the project design.
6) Permanent changes to the registered monitoring plan, or permanent deviation of monitoring from the applied methodologies: use of default values for the flare efficiency in case the continuous monitoring system is unavailable for maintenance, or failure.
7) Permanent changes to the registered monitoring plan, or permanent deviation of monitoring from the applied methodologies: volumetric flow rate of the residual (FVRG), concentration of methane in the exhaust gas (fvCH4,FG,h) and volumetric fraction of O2 in the exhaust gas (tO2,h) measured on wet basis, not dry basis.
8) Permanent changes to the registered monitoring plan, or permanent deviation of monitoring from the applied methodologies: references to specific calibration frequency for the parameters under section B.7.1 have been deleted, as the calibration frequency will be done in according to the methodology and in line with the manufacturer's recommendation.
9) Permanent changes to the registered monitoring plan, or permanent deviation of monitoring from the applied methodologies: inclusion of "Other flare operation parameters" under B.7.1 for the use of default values for the flare efficiency in case the continuous monitoring system is unavailable for maintenance, or failure.

A.2.) Post Registration changes on 18 Apr 2017:

1) Permanent change correction on the sentence: "There will be only one flare" in "Additional comment" under the parameter LFGflare (referring to the parameter under section B.7.1) was deleted to avoid any misinterpretation. Because the project does not specify any number of flares but use of a flare system, as described at section A.3.
2) Permanent change correction regarding update of Project Participants in front page and Section A.4.

B) Post Registration Changes from previous registered PDD (PRC):

1) Typo mistake correction in the first and last days of crediting period from 29/10/2018 to 29/09/2018 and from 28/10/2025 to 28/09/2025 in tables presented Sections B.6.3., B.6.4 and also in table presented for the parameter "$EC_{PJ1,y} = EG_{EC1,y}$" and "$EC_{PJ2,y} = EG_{EC2,y}$" in Section B.7.1. The mistake was made during the renewal of the crediting period process and should be amended in order to be in line with 2nd crediting period dates presented in the project activity on UNFCCC's website.

2) Change to the project design regarding to electricity generation plant installed capacity increase, from 4.245 MW to 28.52 MW. The investments into the electricity generators were not under the PP's control.

3) Change to project design regarding LFG collection efficiency amended from 40% to 85%. The investments into the collection system were not under the PP's control.

4) Change to project design regarding update electricity plant load factor from 91% to 95%, not under PP´s control.

5) Permanent Changes in the cashflow considering amendments of key parameters, not under PP´s control and due to availability of waste disposed in the landfill.
   a. Exchange rate used for the investment analysis: from 1.80 R$/US$ and 2.2 R$/Euro to 3.97 BRL/EUR;
   b. Generation capacity: from 8.49 to 28.520 MW
      i. Energy price: From 148.39 R$/MWh to 170.00 R$/MWh
   c. Generation of electricity amended in:
      i. 2012 to 2018 as 0 MWh/year
      ii. 2019: 10 units X 1.426 MW, total 14.260 MW
      iii. 2020: 12 units X 1.426 MW, total 17.112 MW
      iv. 2021: 16 units X 1.426 MW, total 22.816 MW
      v. 2022: 18 units X 1.426 MW, total 25.668 MW
      vi. 2023-2030: 9 units X 1.426 MW, total 28.520 MW
   d. O&M electricity costs amended: 300,000 R$/year (fixed) and 100 R$/MWh.
   e. Extraordinary maintenance cost for gas engines:
      i. From 1,785,097 R$/year(2019) to 0 R$/year(2019)
      ii. In 2026, for 10 engines is estimated at: R$ 9,832,771
      iii. In 2027, for 10 engines is estimated at: R$ 2,055,049
      iv. In 2028, for 10 engines is estimated at: R$ 4,110,098
      v. In 2029, for 10 engines is estimated at: R$ 2,055,049
      vi. In 2030, for 10 engines is estimated at: R$ 2,055,049
   f. O&M LFG system costs: sum from 2010 to 2030 of 11,613,098 R$ to sum from 2010 to 2030 to 74,452,575 R$
   g. Investment on Electricity generation plant: from 14,299,218 R$ (2011) and 17,819,427 R$ (2016) to 25,879,796 (2019), 4,869,867 (2020), 9,739,733 (2021), 4,869,867 (2022) and 4,869,867 (2023).
   h. “Electricity Schedule” sheet included

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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.

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.
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).
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

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.
01.0	03 August 2002	EB 05, Paragraph 12 Initial adoption.

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