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	Oeste de Caucaia Landfill Project Activity
Scale of the project activity	☒ Large-scale ☐ Small-scale
Version number of the PDD	5
Completion date of the PDD	15/02/2021
Project participants	GNR Fortaleza Valorização de Biogás Ltda.
Host Party	Brazil
Applied methodologies and standardized baselines	ACM0001 – “Flaring or use of landfill gas”
Sectoral scopes	13: Waste handling and disposal
Estimated amount of annual average GHG emission reductions	498,097 tCO_2e/year

SECTION A. Description of project activity

A.1. Purpose and general description of project activity

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The primary objective of the Oeste de Caucaia Landfill Project Activity is to avoid greenhouse gases emission by the Oeste de Caucaia Landfill through landfill gas capture, purification and injection in a distribution grid, while contributing to the environmental, social and economic sustainability by minimizing global climate changes and local air pollution.

The Oeste de Caucaia - Ecofor is a municipal solid waste (MSW) landfill located in Caucaia, Brazil. The landfill is owned by the municipality of Caucaia and operated since 2003 by ECOFOR, under a 20 year concession. The site property covers 116 hectares (ha), of which 84.1ha have been designated for waste disposal and is divided in 6 different disposal areas: SL1-SL2, SHA, S1-S5, S6-S7, S8-S10 and S11-S14. Areas SL1-SL2, SHA and S8-S10 have the oldest waste, but they did not present sufficient biogas production to justify the implementation of the forced LFG extraction system. The active disposal area is located in Area S6-S7.

In addition to these areas, in 2019 ECOFOR was granted a license to expand the landfill area, which adds approximately 73 hectares to the existing landfill[1].

The Landfill operates Monday through Sunday, 24 hours a day, and receives a daily average of approximately 5,200 metric tons of MSW and is intended to be operational until 2031 (expected closure date). As of today, a passive LFG capture system is operational. The forced LFG capture system as well as the upgrading facility is under implementation. The flare is expected to be installed up to November 2015 and the proposed CDM Project Activity is forecasted to be fully operational in July 2016.

The proposed CDM project activity is not a CPA that has been excluded from a registered CDM PoA as a result of erroneous inclusion of CPAs. Previously to the implementation of the proposed CDM Project Activity no active collection of LFG took place in the project site. On the contrary, only a small portion of the gas was destructed using a passive venting system[2]. The wells that were used in the passive venting system were shallow and very inefficient even for just venting. Therefore LFG flow could not be controlled to avoid free emission to the atmosphere.

The proposed CDM Project Activity consists of capturing the landfill gas (LFG) generated by the landfill using an active LFG capture system and injecting it into a natural gas distribution network (after a purification process), displacing the use of natural gas. Any LFG excess will be flared. GNR Fortaleza Valorização de Biogás Ltda., which is the project activity implementer, understands that flaring shall be always the very last option of any CDM project related to LFG destruction.

Applying the state-of-the-art on LFG capture technology, a collecting system will be installed to avoid the free emission of methane to the atmosphere. The LFG captured will be sent to the upgrading facility before being injected to the natural gas distribution grid of CEGÁS – Companhia de Gás do Ceará (local natural gas supplier).

CEGÁS will receive the upgraded gas from Oeste de Caucaia Landfill Project through a natural gas distribution grid, therefore mixing with natural gas. This type of project, i.e., upgrading of landfill gas to natural gas and injection into a natural gas distribution grid is not usual in Brazil.

The project activity is expected to have 7,500Nm^3/h processing capacity. Depending on the project performance up to 2017, a second and third phase may be implemented. Then, 12,500Nm^3/h processing capacity may be achieved from 2018 to 2028 (phase II) and 15,000 Nm^3/h in 2029 onwards (phase III). Then, the estimated emission reductions considered this expansion scenario, resulting in an annual average 498,097 tCO_2e/yr. By the end of the first crediting period, the project is expected to reduce on total 3,486,678 tCO_2e.

The Oeste de Caucaia Landfill Project Activity will have a substantial positive impact in terms of sustainable development as it will be one of the first projects that purify the LFG and injects it to a network distribution grid being developed in Brazil that, as consequence, directly displaces natural gas.

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[1] LICENÇA DE INSTALAÇÃO PARA AMPLIAÇÃO Nº 122/2019 – DICOP, issued on 22/07/2019 valid until 21/07/2023.

[2] Case 3 of ACM0001, i.e. no requirement to destroy methane and a LFG capture system exists.

An environmental benefit with the implementation of the Oeste de Caucaia Landfill Project is the destruction of methane that otherwise would be emitted to the atmosphere, increasing the impact on global warming. Despite of being possibly flared if necessary, the landfill gas collected will be primarily injected (after the upgrading process) into the natural gas distribution grid, therefore avoiding the consumption of natural gas.

As mentioned earlier, the proposed CDM Project Activity is one of the first projects in Brazil that purify the LFG and injects it into a natural gas distribution network. Hence, there are not qualified people in the market, principally related to the LFG upgrading plant. Given that, each new project must invest on training engineers and operators to the qualification level required by these new activities. Oeste de Caucaia will make use of the experience of its own shareholders as well as its international consultants to train and qualify the human resources necessary for the implementation and operation of the magnitude of the Oeste de Caucaia Landfill Project.

A.2. Location of project activity

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The Oeste de Caucaia Landfill is located is located in the municipality of Caucaia, Ceará state, north-eastern region of Brazil (
Figure **1**). The geographic coordinates of the site (
Figure **2**) where the project has been implemented are:

Latitude: 3°47'20.29"South[3]
Longitude: 38°40'24.99"West

Figure 1 - Caucaia location (Source: http://pt.wikipedia.org)

[3] SCS Draft Assessment Report – Oeste de Caucaia Landfill, Fortaleza, Brazil dated May 2013.

Figure 2 - Oeste de Caucaia Landfill location (Source: adapted from Google Earth)

A.3. Technologies/measures

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The technology to be employed will be the improvement of landfill gas collection and flaring, through the installation of an active recovery system composed by:

- Gas extraction wells with wellhead flow control and monitoring;
- A wellfield gas conveyance system ("laterals" and "header");
- A Gas Station and an upgrading gas facility;
- A flaring system; and,
- A pipeline to inject the upgraded gas into the natural gas distribution grid.

Collecting System

The Oeste de Caucaia Landfill Project will involve the perforation of new vertical wells as well as the installation of wellheads on top of them to collect the LFG emitted directly to the atmosphere in the baseline. An example of wellhead and the detail of its construction are shown in Figure 3.

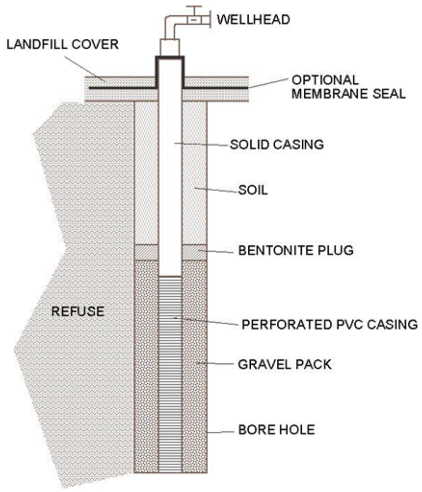

Figure 3 - Internal detail of a well and wellhead (source: USEPA, 1996[4])

The use of the few existing wells is not recommended as they are quite shallow and not properly placed across the landfill surface. New wells are to be drilled in order to guarantee the efficiency of the controlled drainage of the landfill as well as of the LFG collection. The exact number of wells will be determined in the Executive Project and will be subject to adjustment based on conditions at the landfill observed during well installation and preliminary operation. It is expected that there will be more than 60 gas vertical extraction wells and 20 horizontal extraction wells.
Flow-control and monitoring wellheads will be employed at every gas extraction well, to allow precise regulation/adjustment of the gas flow at each well. Gas quality monitoring and flow adjustment is important to ensure that the system is "balanced" (i.e. gas extraction matches gas production so that atmospheric air is not introduced into the landfill).
A network of LFG header piping will be designed to connect the horizontal collectors and vertical extraction wells, and direct the LFG to the LFG processing plant or (if the plant is down or there is excess LFG) the blower and flaring station for methane destruction.

Gas Station and Upgrading gas facility

The Gas Station is the facility where the gas is suctioned from the landfill and where the gas receives the proper treatment, depending on the final use of the gas. Usually, the Gas Station is composed by blowers and condensate knock-outs. The project is expected to have 2 blowers, with a capacity of 5,000Nm³/hour each. In the project expansion scenario, one more blower maybe installed at the project site.
As a source of methane, LFG can be used to replace the consumption of Natural Gas. However, in order to accomplish with the requirements from ANP – Agência Nacional do Petróleo (National Petroleum Agency) to be considered as natural gas, the concentration of methane must be higher than 86%[5]. Prior to the introduction of the biogas to the natural gas distribution grid, it will be treated in an upgrading facility, where most of the non-methane gases will be removed from the stream. It is forecasted that the upgraded gas will contain at least 94.7% of methane[6], therefore meeting the national standards for natural gas.
The project activity is expected to have 7,500Nm^3/h processing capacity. Depending on the project performance up to 2017, a second and third phase may be implemented. Then, 12,500Nm^3/h processing capacity may be achieved from 2018 to 2028 (phase II) and 15,000 Nm^3/h in 2029 onwards (phase III).

Flare System

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[4] USEPA – United States Environmental Agency; *Turning a Liability into an Asset: a Landfill Gas-to-Energy Project Development Handbook;* LMOP – Landfill Methane Outreach Program, 1996
[5] Resolução ANP Nº 16, from 17/06/2008.
[6] In accordance with the LFG Upgrading Process Diagram.

Whenever LFG exceeds the processing capacity of the purification plant or it is not operational the gas will be sent to the flaring system. In accordance with ACM0001 methodology, a default value for monitoring the flare efficiency is to be adopted. Please refer to details, below in Section B.6.1.
The project is expected to have one open flare, with a capacity of 8,200 Nm³/hour. In order to ensure safety and, depending on the project performance, two more flares may be installed at the project site.

Upgraded gas pipeline
The upgraded gas will be transported to the injection point through a pipeline. Within the landfill area the gas will be collected using a Flex Steel pipeline. From the landfill border until CEGÁS pipeline (consumer), a Carbon Steel pipeline is to be used. This technology will reduce the environmental impacts produced in a conventional mechanical construction, as it requires the use of fewer machines during its construction.
Despite the fact that LFG projects can be of great potential in Brazil, the local market does not have yet technology for LFG flaring and upgrading. Technology will have to come from abroad and mainly from the United States and Europe. Hence, technology transfer will occur from countries with strict environmental legislative requirements and environmentally sound technologies.

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 Party)	Private entity – GNR Fortaleza Valorização de Biogás Ltda.	No

A.5. Public funding of project activity

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There is no public funding from Parties included in Annex I involved in this 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 or previously included as a component project activity (CPA) in a registered CDM program 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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Oeste de Caucaia Landfill Project Activity applies the ACM0001 methodology – "*Flaring or use of landfill gas*" (version 15.0.0) and the following methodological tools:

- "*Project emissions from flaring"* (version 02.0.0)[7];
- "*Tool to calculate baseline, project and/or leakage emissions from electricity consumption"* (version 01)[8];
- *"Tool to calculate the emission factor for an electricity system"* (version 4.0)[9]*;*
- "*Tool to calculate project or leakage CO_2 emissions from fossil fuel combustion"* (version 02)[10]*;*
- "*Emissions from solid waste disposal sites"* (version 07.0)[11];

[7] https://cdm.unfccc.int/methodologies/PAmethodologies/tools/am-tool-06-v2.0.pdf
[8] https://cdm.unfccc.int/methodologies/PAmethodologies/tools/am-tool-05-v1.pdf
[9] https://cdm.unfccc.int/methodologies/PAmethodologies/tools/am-tool-07-v4.0.pdf
[10] https://cdm.unfccc.int/methodologies/PAmethodologies/tools/am-tool-03-v2.pdf

- "*Combined tool to identify the baseline scenario and demonstrate additionality"* (version 05.0.0)[12];
- *"Tool to determine the mass flow of a greenhouse gas in a gaseous stream"* (version 02.0.0)[13];
- *"Tool to determine the baseline efficiency of thermal or electric energy generation systems"* (version 01)[14];
- *"Tool to determine the remaining lifetime of equipment"* (version 01)[15];
- *"Project and leakage emissions from transportation of freight"* (version 01.1.0)[16];
- *"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].

Please note that *"Tool to determine the baseline efficiency of thermal or electric energy generation systems",* the *"Tool to determine the remaining lifetime of equipment"* and the methodological tool *"Project and leakage emissions from transportation of freight"* are not applicable to the project activity, and therefore are not used. Similarly, the methodological tool *"Assessment of the validity of the original/current baseline and update of the baseline at the renewal of the crediting period"* since this PDD corresponds to the first crediting period of the proposed CDM Project Activity.

B.2. Applicability of methodologies and standardized baselines

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The project complies with the applicability conditions described in the methodology ACM0001 as further detailed below.

This methodology is applicable to project activities which:

(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 cannot be collected separately from the project system after the implementation of the project activity and its efficiency is not impacted on by the project system: historical data on the amount of LFG capture and flared is available.

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

   (i) Generating electricity;

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

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

   (iv) Supplying compressed/liquefied LFG to consumers using trucks.

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

The project activity will capture the landfill gas which was previously vented prior to the implementation of the project activity in an existing SDWS. LFG flow cannot be currently controlled to avoid free emission to the atmosphere as the existent wells are shallow with less than 4 meters depth and very inefficient even for just venting.

The project activity consists of using the captured gas for flaring (as emergency) and upgrading for injection in a natural gas distribution grid. The proposed project activity will process and upgrade biogas from the Oeste de Caucaia landfill to the quality of natural gas, which will be distributed through the natural gas distribution grid of CEGÁS (i.e., consumer). The project activity will install the flare system for emergency purposes.

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[11] https://cdm.unfccc.int/methodologies/PAmethodologies/tools/am-tool-04-v7.pdf
[12] https://cdm.unfccc.int/methodologies/PAmethodologies/tools/am-tool-02-v5.0.0.pdf
[13] https://cdm.unfccc.int/methodologies/PAmethodologies/tools/am-tool-08-v2.0.0.pdf
[14] https://cdm.unfccc.int/methodologies/PAmethodologies/tools/am-tool-09-v1.pdf
[15] https://cdm.unfccc.int/methodologies/PAmethodologies/tools/am-tool-10-v1.pdf
[16] https://cdm.unfccc.int/methodologies/PAmethodologies/tools/am-tool-12-v1.1.0.pdf
[17] https://cdm.unfccc.int/methodologies/PAmethodologies/tools/am-tool-11-v3.0.1.pdf

Further, the implementation of the proposed CDM project activity does not reduce the amount of organic waste that would be recycled in the absence of the project activity. There is no recycling system in the region. All the solid waste is disposed in the Oeste de Caucaia landfill.

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 on-site equipment.*

The baseline scenario is the partial or total atmospheric release of the gas (usual practice of the Oeste de Caucaia Landfill Project Activity management). Please refer to Section B.4 for details.

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 the 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.*

The ACM0001 is applicable to the proposed CDM Project Activity since the Oeste de Caucaia Landfill Project does not use other CDM approved methodology. In addition, the management of the Oeste de Caucaia landfill in the project activity is not changed in order to increase methane generation compared to the situation prior to the implementation of the project activity (e.g. other to meet a technical or regulatory requirement). There is neither the addition of liquids to the SWDS and pre-treating waste to seed it with bacteria for the purpose of increasing the anaerobic degradation environment of the SWDS nor changing the shape of the SWDS to increase the Methane Correction Factor.

Besides the ACM0001 methodology applicability conditions, the ones listed in the tools applied must also be assessed. Regarding the *"Tool to determine the mass flow of a greenhouse gas in a gaseous stream"*, the flow and composition of residual or flared gases or exhaust gases are measured for the determination of baseline or project emissions. Therefore, this tool is applicable.

The methodological tool *¨Emissions from solid waste disposal sites"* is applicable as it is used under Application A: *¨The CDM project activity mitigates methane emissions from a specific existing SWDS. Methane emissions are mitigated by capturing and flaring or combusting the methane. The methane is generated from waste disposed in the past, including prior to the start of the CDM project activity. In these cases, the tool is only applied for an ex- ante estimation of emissions in the CDM-PDD. The emissions will then be monitored during the crediting period (e.g. measuring the amount of methane captured from the SWDS).*

The *"Tool to calculate baseline, project and/or leakage emissions from electricity consumption"* is applicable since the project activity consumes electricity from the grid (a source of project emissions). Further, the *"Tool to calculate the emission factor for an electricity system"* is applicable since, as further described below in section B.6.1., off-grid power plants are not considered. Hence, the requirements of Annex 2 of the tool, referring to the applicability conditions that shall be met when this kind of plants are considered, are not applicable. Besides, the Brazilian Electric System is neither partially nor totally located in any Annex-I country.

The methodological tool *"Project emissions from flaring"* is applicable to the flaring of flammable greenhouse gases where:

- *Methane is the component with the highest concentration in the flammable residual gas;*
- *The source of the residual gas is coal mine or gas from biogenic source (e.g. biogas, landfill gas or wastewater treatment gas).*

The flammable residual gas is LFG (gas from biogenic source), which is composed by CH_4, H_2S, CO_2 and N_2, among other components. By default, the methodology adopts that the default fraction

of methane in the LFG is 50%. Therefore, it can be assumed that methane is the component with the highest concentration in the LFG. In this sense, both applicability conditions of the tool are met. The *"Tool to calculate project or leakage CO_2 emissions from fossil fuel"* combustion is applicable for calculating the project CO_2 emissions from the combustion of fossil fuels - *i.e.* LPG use for flare ignition - which are determined based on the quantity of fuel used. Finally, in addition to the tools mentioned above, as required by the methodology ACM0001, the "*Combined tool to identify the baseline scenario and demonstrate additionality"* is used.

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

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Source		GHGs	Included?	Justification/Explanation
Baseline scenario	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	No	Excluded. Power generation is not 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	Excluded. Heat generation is not included in the project activity
		CH_4	No	Excluded for simplification. This is conservative
		N_2O	No	Excluded for simplification. This is conservative
	Emissions from the use of natural gas	CO_2	No	Excluded for simplification. This is conservative
		CH_4	Yes	Major emission source if supply of LFG through a natural gas distribution network or using trucks is included in the project activity
		N_2O	No	Excluded for simplification. This is conservative
Project scenario	Emissions from fossil fuel consumption for purposes other than electricity generation or transportation 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 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	Corresponds to an important source of emission whenever the flare is used.
		N_2O	No	Emissions are considered negligible
	Emissions from distribution of LFG using trucks	CO_2	No	Not applicable to the proposed CDM project activity
		CH_4	No	Not applicable to the proposed CDM project activity
		N_2O	No	Not applicable to the proposed CDM project activity

According to the ACM0001 methodology the project boundary includes *the site where the LFG is captured* (Oeste de Caucaia Landfill) *and*:

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

In the case of the proposed CDM Project Activity, the sites where the LFG is flared/used consists of the collection system, biogas upgrading facility, pipeline, gas station facilities (including flaring);

- *Captive power plant(s) (including emergency diesel generators) or power generation sources connected to the grid, which are supplying electricity to the project activity;*

All the power generation sources connected to the Brazilian National Grid are included in the project boundary once electricity from the grid will be consumed both by the blowers and by the LFG purification plant. On May 26th, 2008, the Brazilian Designated Authority published Resolution #8[18] defining the Brazilian Interconnected Grid as a single system covering all five geographical regions of the country (North, Northeast, South, Southeast and Midwest). Hence, this is the configuration of the national grid that is to be considered.

The figure below is a representation of the project boundary.

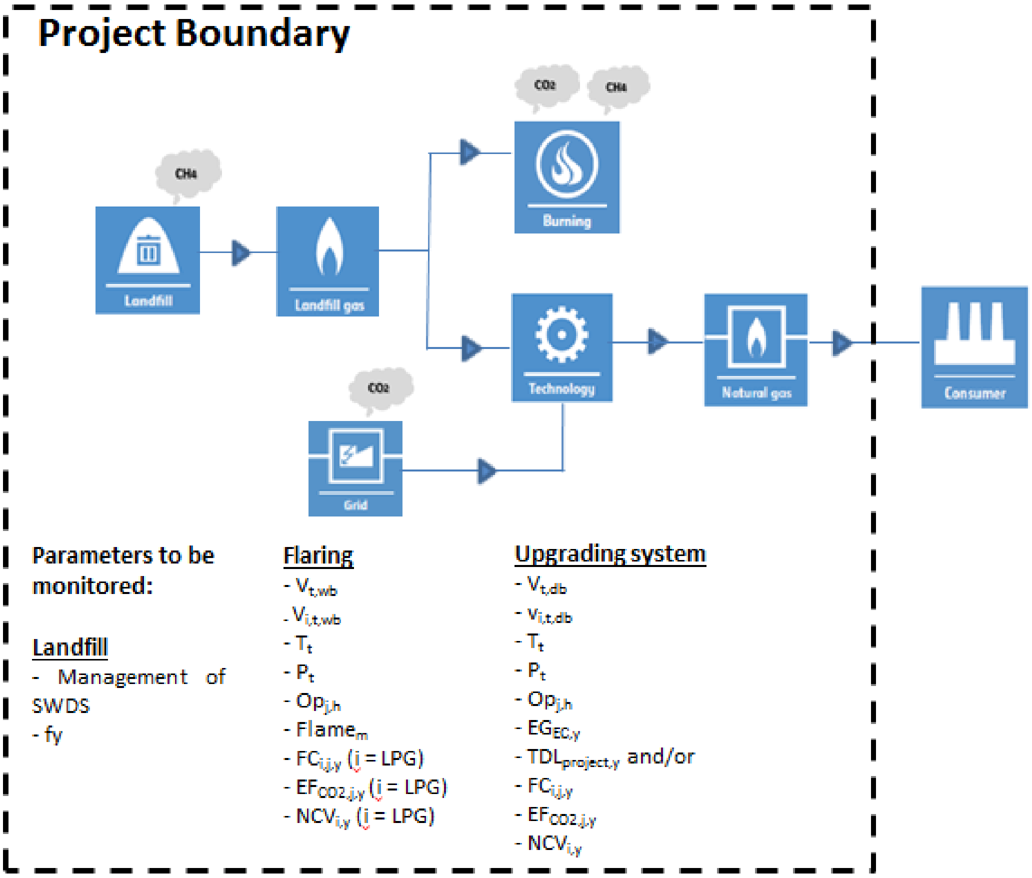

Figure 4 - Simplified diagram of the Project Boundary[19]

B.4. Establishment and description of baseline scenario

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According with ACM0001 the procedures of the latest version of the "*Combined tool to identify the baseline scenario and demonstrate additionality"* is to be applied when selecting the most plausible baseline scenario.

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

Not applicable to the proposed CDM Project Activity.

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[18] Comissão Interministerial de Mudança Global do Clima (CIMGC). Available at: <http://www.mct.gov.br/upd_blob/0024/24719.pdf>.

[19] Some of the icons used to illustrate the project boundary were adapted from the CDM Methodology Booklet available at http://cdm.unfccc.int/methodologies/documentation/meth_booklet.pdf

STEP 1: Identification of alternative scenarios

The realistic and credible alternatives scenarios to the proposed CDM Project Activity were identified following the recommendations of the "*Combined Tool for the demonstration and assessment of additionality"* and ACM0001 methodology.

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

According with this Sub-step, it's necessary to identify realistic and credible alternatives to the project participants that provide outputs or services comparable with the proposed CDM project activity. Considering that the project consists of capture the LFG and supplying it to consumers, the following alternatives are identified for the destruction of the LFG in the absence of the project activity:

- *LFG1*: Project Activity undertaken without being registered as a CDM Project Activity (capture, flare and use of LFG),
- *LFG2*: Continuation of the landfill operation, continuation of atmospheric release of the landfill gas (Business as Usual – BAU scenario) or partial capture of landfill gas and destruction trough flaring to comply with regulations or contractual requirements, or to address safety and odour concerns. Continuation of the fossil NG supply to the distribution network[20];
- *LFG3*: LFG is partially not generated because part of the organic fraction of the solid waste is recycled and not disposed in the SWDS;
- *LFG4*: LFG is partially not generated because part of the organic fraction of the solid waste is treated aerobically and not disposed in the SWDS;
- *LFG5*: LFG is partially not generated because part of the organic fraction of the solid waste is incinerated and not disposed in the SWDS.

In addition to the scenarios presented above, for the supply of LFG to a natural gas distribution network, the baseline is assumed to be the supply with natural gas, as indicated in the methodology.

Once the proposed CDM Project Activity does not foresee either the production of heat or electricity, no Scenarios for those components are applicable.

Step 1b: Consistency with mandatory laws and regulations

In Brazil, there are no policies regarding mandatory LFG capture or destruction requirements neither local environmental regulations nor policies which promote the productive use of LFG such as those for the production of renewable energy and processing of organic waste.

In the beginning of 2010, the *Política Nacional de Resíduos Sólidos* (National Solid Waste Policy), under discussion since 2000, was approved. One of the scopes of this policy is to enforce the adequate environmental final destination of the solid waste. However, the Policy does not foreseen either the obligation of landfill gas destruction or the promotion of the landfill gas use such as those for the production of renewable energy and processing of organic waste[21].

Concerning energetic use of the landfill gas, the *PROINFA – Programa de Incentivo a Fontes Alternativas* was created in 2002, in order to incentive the use of renewable sources to generate electricity. The goal of the program was to generate 3,300 MW of renewable energy, divided in three groups: wind-energy (1,100 MW), small-hydro power plants (1,100 MW) and biomass (1,100 MW, including bagasse, wood, solid waste, rice husk, etc.). Despite of achieving the goals, no landfill-gas-to-energy project was implemented. The calls for PROINFA were closed in 2003, before the beginning of the Oeste de Caucaia Landfill Project Activity's operation and investment decision.

The following table presents an analysis of the compliance of the alternatives listed previously with the local/national regulation.

[20] In the case of LFG supply to a natural gas distribution network or distribution of compressed/liquefied using trucks, the baseline is assumed to be the supply with fossil natural gas, as indicated in the methodology.

21 PROJETO DE LEI - Institui a Política Nacional de Resíduos Sólidos e dá outras providências; Available at http://www.camara.gov.br/sileg/integras/501911.pdf, accessed on 10/04/2010.

Alternative	Compliance with Local / National Policies	Observations
LFG1: Project Activity undertaken without being registered as a CDM Project Activity	Yes	---
LFG2: Continuation of the landfill operation, continuation of atmospheric release of the landfill gas (Business as Usual – BAU scenario) or partial capture of landfill gas and destruction trough flaring to comply with regulations or contractual requirements, or to address safety and odour concerns. Continuation of the fossil NG supply to the distribution network;	Yes	▪ As stated before, there is no current law or contractual requirements to capture/destroy/use the LFG.
LFG3: LFG is partially not generated because part of the organic fraction of the solid waste is recycled and not disposed in the SWDS	Yes	▪ There is no law which restricts the use of the organic fraction of the waste to be recycled and not disposed in the SWDS
LFG4: LFG is partially not generated because part of the organic fraction of the solid waste is treated aerobically and not disposed in the SWDS;	Yes	▪ There is no law which restricts the use of the organic fraction of the waste to be treated aerobically and not disposed in the SWDS
LFG5: LFG is partially not generated because part of the organic fraction of the solid waste is incinerated and not disposed in the SWDS.	Yes	▪ There is no law which restricts the incineration of organic wastes in Brazil

Concerning the supply of LFG to a natural gas distribution network, as explained above, the baseline scenario is assumed to be the supply of natural gas. In the same as mentioned above for the LFG related scenarios, there are no mandatory policies and/or regulations in the country enforcing the supply of natural gas.

Outcome of Sub-Step 1b: all alternatives comply with local laws/regulations and none of them are mandatory.

STEP 2: Barrier analysis

Step 2a. Identify barriers that would prevent the implementation of alternative scenarios

The proposed use of LFG from the Oeste de Caucaia Landfill Project is a pioneer initiative in Brazil. The majority of projects of LFG capture in the country have been undertaken considering only the CDM revenues and none of them has been developed so far considering the upgrading of the LFG and its injection into a natural gas distribution grid.

- *Barriers due to prevailing practice:*

According to the ABRELPE, a reputed association of the municipal solid waste sector in Brazil – *Panorama dos Resíduos Sólidos no Brasil, 2013*[22] – the country produces 209,280 tons of waste per day. And though there is a worldwide trend towards reducing, reusing and recycling (therefore reducing the amount of urban solid waste to be disposed in landfills), the situation in Brazil is peculiar. Most of the waste produced in the country is sent towards open dumps or controlled

[22] Publicly available in local language at <http://www.abrelpe.org.br/Panorama/panorama2013.pdf>. Assessed on 10/09/2014.

landfills which are, in most of the cases, areas without any sort of proper infrastructure to avoid environmental hazards.

Table 1 shows the final destination of the waste per municipality, according to 2008 National Sanitation Diagnosis - "PNSB 2008" (from the Portuguese *Pesquisa Nacional de Saneamento Básico 2008*) which is the most recent information available from the Brazilian Institute of Geography and Statistics (IBGE).

Table 1 - Daily amount of urban solid waste collected/received, by final destination unit and according with the size and population of the Districts - 2008

Districts according to size (population)	Daily amount of urban solid waste collected/received in t/day								
	Total	Units of collected waste final destination							
		Open Dump	Open dumps in Flooded Areas	Controlled Landfill	Sanitary Landfill	Composting	Recycling	Incineration	Other
Brazil	*259,547*	*45,710 (17.6%)*	*46 (0.02%)*	*40,695 (15.7%)*	*167,636 (64.6%)*	*1,635 (0.63%)*	*3,122 (1.2%)*	*67 (0.03%)*	*636 (0.25%)*

Source: IBGE, Diretoria de Pesquisas, Departamento de População e Indicadores Sociais, Pesquisa Nacional de Saneamento Básico 2008.
Note: This table was adapted from the original table from PNSB2008

Only few of the existing Brazilian landfills have installed a collecting and flaring LFG system. The majority of landfills operate with natural emission of LFG to the atmosphere, usually through concrete built wells. According to the "Brazilian Atlas of Greenhouse Gas Emissions and Energetic Potential in the Residues Destination"[23] published by ABRELPE in 2013, there are 22 (twenty-two) LFG projects comprising electricity generation and only 1 (one) upgrading the biogas to then inject it into the NG distribution system. As far as project developers are concerned, the identified project, which is similar to Ecofor is Gramacho landfill, which is also a CDM project activity (ref. 9087)[24]. All the 23 projects identified in the ABRELPE study are CDM projects. Detailed information regarding operational landfills in the country with a forced LFG collection system is presented below in the Common Practice analysis section.

The existing landfills operate with passive emission of methane to the atmosphere, as controlled landfill gas collection and destruction is neither mandated by laws/regulations nor by local environmental regulations and GHG emission reduction policies. The most relevant law of the sector is Brazil's new National Solid Waste Policy (http://www.planalto.gov.br/ccivil_03/_ato2007-2010/2010/lei/l12305.htm), ratified by the President on 02/08/2010 after 19 years under discussion, which does not requires the LFG to be captured and/or flared.

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

Alternative	Barriers due to prevailing practice
LFG1: Project Activity undertaken without being registered as a CDM Project Activity	This alternative is not realistic as no LFG project in Brazil was implemented without the CDM revenues.
LFG2: Continuation of the landfill operation, continuation of atmospheric release of the landfill gas or partial capture of landfill gas and destruction trough flaring to comply with regulations or contractual requirements, or to address safety and odour concerns. Continuation of the fossil NG supply to the distribution network;	This barrier does not prevent the implementation of this alternative, as it is the business as usual scenario (please refer to Sub-Step 2 a).
LFG3 is partially not generated because part of the organic fraction of the solid waste is	Considering the actual situation of waste disposal in Brazil this barrier prevents the implementation of this alternative;

[23] ABRELPE (2013). Atlas Brasileiro de Emissões de GEE e Potencial Energético na Destinação de Resíduos Sólidos. Report supported by US Environmental Protection Agency (EPA) and the Global Methane Initiative. Associação Brasileira de Empresas de Limpeza Pública e Resíduos Especiais – ABRELPE. ABRELPE is an association founded in 1976 and is the representative International Solid Waste Association (ISWA) in Brazil.

[24] Gramacho Landfill Gas Project <https://cdm.unfccc.int/Projects/DB/DNV-CUK1356155404.95/view>.

recycled and not disposed in the SWDS	only 1.2% of the waste generated in Brazil is recycled. Thus, this alternative would face a prevailing practice barrier.
LFG4 LFG is partially not generated because part of the organic fraction of the solid waste is treated aerobically and not disposed in the SWDS	Considering the actual situation of waste disposal in Brazil this barrier prevents the implementation of this alternative; only 0.62% of the waste generated in Brazil is sent to composting. Thus, this alternative would face a prevailing practice barrier.
LFG5 LFG is partially not generated because part of the organic fraction of the solid waste is incinerated and not disposed in the SWDS.	Considering the actual situation of waste disposal in Brazil this barrier prevents the implementation of this alternative; only 0.02% of the waste generated in Brazil is incinerated. Thus, this alternative would face a prevailing practice barrier.

As presented in the table above, the prevailing practice barrier would prevent the implementation of all alternatives, except for the release of the methane generated to the atmosphere, BAU scenario. Therefore LFG2 is considered as the baseline scenario.

CDM incentives will help alleviate the barriers identified for the proposed project above and also the investment barrier (Please refer to Step 3 below).

STEP 3: Investment analysis

On 25/10/2013, the capital contribution for the implementation of the project activity was approved. This event was decisive for the project developer's decision to implement the project. Before this date, no major expenses could be done for the project implementation, but few preliminary studies only. Therefore, this date demonstrates the timing of the investment decision and is considered as the project "starting date", since it is the first real action that demonstrates that the project would be implemented. Detailed description of the project timeline is presented in section C.1.1.

The financial indicator identified for the project activity is the Project's Net Present Value (NPV). The NPV of the project without CDM revenues was determined considering the appropriate benchmark of the sector, which is the Weighted Average Cost of Capital (WACC).

Weighted Average Cost of Capital (WACC)

The weighted-average cost of capital (WACC) is a rate used to discount business cash flows and takes into consideration the cost of debt and the cost of equity of a typical investor in the sector of the project activity. The benchmark can be applied to the cash flow of the project as a discount rate when calculating the net present value (NPV) of the same, or simply by comparing its value to the internal rate of return (IRR) of the project (in accordance with paragraph 12, Annex 5, EB 62). The WACC considers that shareholders expect compensation towards the projected risk of investing resources in a specific sector or industry in a particular country.

The WACC calculation is based on parameters that are standard in the market, considers the specific characteristics of the project type, and is not linked to the subjective profitability expectation or risk profile of this particular project developer. This is due the fact that any corporate entity would be able to obtain the public concession to implement that project. Therefore, the use a sectoral benchmark is applicable as per the guidance provided in paragraph 13, Annex 5, EB62.

The WACC of the sector considered is the one calculated for the first semester of 2013 and is equal to 9.97%. This value is calculated through the formula below:

$$WACC = Wd \times Kd + We \times Ke$$

We and **Wd** are, respectively, the weights of equity and debt typically observed at the sector. Nevertheless, this information is not readily available for similar project being developed in Brazil. Then, in accordance with the "*Guidelines on the assessment of investment analysis*" (paragraph 18, Annex 5, EB62), 50% debt (**Wd**) and 50% (**We**) equity are assumed as a default value.

Kd is the cost of debt, which is observed in the market related to the project activity, and which already accounts for the tax benefits of contracting debts. Unlike markets where most commercial players and companies approach private lenders for loans, most Brazilian companies investing in the infrastructure sector expect to get funds from the Brazilian Development Bank ("BNDES" from the Portuguese Banco Nacional de Desenvolvimento Econômico e Social). BNDES, a governmentally backed entity, is the major provider of long-term loans in the country, which are scarcely provided by commercial banks, and in general, these entities do not have competitive rates compared to the BNDES. BNDES provides several type of financing lines available to

companies. The most suitable financial line to the proposed project activity is the "BNDES FINEM" and then, interests rates of the **Kd** calculation are based on this financing line.
In the **Kd** calculation, the marginal tax rate (**t**) is multiplied by the Cost of debt and then by the debt to total cost of capital ratio to ascertain the debt portion of the WACC formula. In the case of Brazil, this tax factor could either be 34% (actual profit) or 0% (presumed profit). This is decided by the specific type of project and tax regime under which it sits. For the Presumed Profit eligibility, corporate entities revenues must be under Forty eight million Reais per year (Article #13, Law #9.718/1998)[25]. In the case of the proposed project activity, the 0% tax factor applies.
The nominal rate achieved for debt is used to calculate nominal WACC, which is used to discount nominal cash flow projections. In order to achieve the nominal cash flow rate in *Reais* (BRL), the inflation targeting figure (d) for Brazil is reduced from the nominal figure achieved. The (d) is obtained from the Brazilian Central Bank (www.bcb.gov.br) and has experienced very little variance in the past 5 years.
Kd is calculated through the following equation:

$$Kd = [1 + (a+b+c) \times (1-t)]/(1+d) - 1$$

Values used in the cost of debt calculation are presented in Table 2 below.

Table 2 – Cost of debt (Kd) calculation

Cost of Debt (Kd)	
(a) Financial cost[26]	5.88%
(b) BNDES Spread[27]	1.50%
(c) Credit Risk Rate[28]	4.18%
(a+b+c) Pre-Cost of Debt	11.56%
(t) Marginal tax rate[29]	0%
(d) Inflation forecast[30]	4.50%
After tax Cost of Debt	6.75%p.a.

According to the table above, **Kd** is of 6.75% in the first semester of 2013.
Ke is the cost of equity. As per option b) provided in the paragraph 15 of Annex5, EB62, it was estimated using the best financial practices through the Capital Asset Pricing Model - CAPM (mentioned as an appropriate method to determine benchmarks in guidance 14, Annex 5, EB62). This method considers the risk associated in investing in the Brazil.
The following equation is used to calculate the **Ke**:

$$Ke = [(1+ Rf) /(1+ \pi')-1] + \beta \times (Rm-Rf) + Rc$$

Rf stands for the risk free rate. The risk-free rate used for **Ke** calculation was a long term bond rate. This bond was issued by the US government. In order to adjust the risk-free rate (**Rf**) to the inflation adjusted rate, the expected inflation rate (for the United States) (**π'**) is reduced. The inflation is calculated based on the treasury through spot TIPS (Treasury Inflation Protected Securities) which are readily quoted in the market.

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25 Publicly available in Portuguese at http://www.receita.fazenda.gov.br/legislacao/leis/Ant2001/lei971898.htm.

26 http://www.bndes.gov.br/SiteBNDES/bndes/bndes_pt/Institucional/Apoio_Financeiro/Custos_Financeiros/Taxa_de_Juros_de_Longo_Prazo_TJLP/index.html

27 http://www.bndes.gov.br/SiteBNDES/bndes/bndes_pt/Institucional/Apoio_Financeiro/Produtos/FINEM/petroleo_gas_transporte.html

28 http://www.bndes.gov.br/SiteBNDES/bndes/bndes_pt/Institucional/Apoio_Financeiro/Produtos/FINEM/petroleo_gas_transporte.html

29 http://www.receita.fazenda.gov.br/Aliquotas/ContribCsll/Aliquotas.htm http://www.receita.fazenda.gov.br/Aliquotas/ContribPj.htm

30 http://www.bcb.gov.br/pec/metas/InflationTargetingTable.pdf

Beta, or **β,** stands for the average sensitivity of comparable companies in that industry to movements in the underlying market. **β** derives from the correlation between returns of US companies from the sector and the performance of the returns of the US market. **β** has been adjusted to the leverage of Brazilian companies in the sector, reflecting both structural and financial risks. **β** adjusts the market premium to the sector.
(Rm–Rf) represents the market premium, or higher return, expected by market participants in light of historical spreads attained from investing in equities versus risk free assets such as government bond rates, investors require a higher return when investing in private companies. The market premium is estimated based on the historical difference between the S&P 500 returns and the long term US bonds returns. The spread over the risk-free rate is the average of the difference between those returns.
Note that in the formula above there is the factor EMBI+ (Emerging Markets Bond Index Plus), considers as the country risk premium, **Rc**. This factor accounts for the country or sovereign risk embedded in the debt of a country. Assuming that relative to the US risk-free debt market EMBI+ is 0, then Brazil's EMBI+ would calculate for the added or reduced risk relative of Brazils debt markets to the US.
Justification for the EMBI+ addition to the risk-free rate lies in the vast differences between the United States in such factors as credit risk, inflation history, politics, debt markets, and more. Ignoring these differences would result in the incorrect application of relevant environmental factors in the decision-making process of an investor in Brazil.
Values used in the cost of equity calculation are presented in Table 3 below.

Table 3 – Cost of equity (Ke) calculation

Cost of Equity (Ke) – CAPM	
(Rf) Risk-free rate[31]	3.26%
(Rm) Equity risk premium[32]	5.49%
(Rc) Estimated country risk premium[33]	2.32%
(β) Adjusted industry beta[34]	1.71%
(π') US expected inflation[35]	1.76%
Cost of Equity with Brazilian Country Risk (p.a.)	13.18%

According to the table above, Ke is of 13.18%. Plugging these numbers into WACC formulae we obtain:

$$WACC_{2012} = 50\% \times 6.75\% + 50\% \times 13.18\% = 9.97\%$$

Each assumption made and all data used to estimate the benchmark has been presented to the DOE. The spreadsheet used for calculation of the WACC is available with the Project Participants and has also been provided to the DOE. For complete reference of the data used to estimate the benchmark please refer to this spreadsheet, which is also attached to this PDD.

Financial Indicator, Net Present Value (NPV)

The financial indicator calculation was made considering a 20-year period (considering the forecasted lifetime of the equipment to be used in the proposed project activity). This term is in line with the guidance of paragraph 3, Annex 5, EB62.
On the starting date of the proposed project activity the project sponsors were aware of all of these costs and revenues and thus, their consideration in the investment analyses are reasonable and are in accordance with Guidance 6 from Annex 5, EB62 where it is recommended that "*input values used in all investment analysis should be valid and applicable at the time of the investment decision taken by the project participant*".
The table presented below provides a list of the main input values considered for the NPV calculation as well as the source of the information used. This result for the NPV was achieved

[31] http://www.federalreserve.gov/
[32] http://pages.stern.nyu.edu/~adamodar/
[33] www.ipeadata.gov.br
[34] http://pages.stern.nyu.edu/~adamodar/
[35] http://www.federalreserve.gov/

considering the input values listed in the table when considering the WACC determined above as the discount rate.

Table 4 - Parameters considered for the project NPV calculation

Parameter	*Value*	Justification/source of information used
RNG generation (Nm^3/yr)	34,155,000	Values based on the minimum value between LFG generation in the landfill as presented in the LANDTEC_Feasibility Report-ASMOC – Caucaia/Fortaleza and the purification plant capacity of 7,500Nm^3/h. It was conservatively assumed that the upgrading system will have 95% upgrading efficiency (20 days maintenance during the year) and 0% of LFG will be flared.
RNG price (US$/$m^3$)	0.38 (including taxes)	RNG price based on Monthly Reports from the Mines and Energy Ministry (“MME” from the Portuguese Ministério de Minas e Energia) / Natural Gas Department. Since gas price presented in these reports are in US$/MMBTU, conversion to m^3 was made considering 26.81m^3/MMBTU as presented in these reports. Also, the final energy price took into account taxes (described below) and calorific value of NG presented in the MME reports and the upgraded gas. The calorific value of the upgraded gas was made following ASTM D3588-98 (Standard Practice for Calculating Heat Value, Compressibility Factor, and Relative Density of Gaseous Fuels).
Operational costs (US$/yr)	6,932,500	SCS Assessment Report nr. 06212012.00. Operation costs considered in the project cash flow are based on a third-party entity contracted by the project developer in order to assess technical and investment feasibility for LFG upgrading. This report presents detailed values of annual Opex for biogas upgrading. These costs were proportionally applied to the proposed project activity. Opex cost is composed by the following expenses: • Power cost; • Operation and maintenance (O&M); • Property tax and insurance; • General and administrative expenses.
Investment (US$)	34,053,260	LANDTEC_Feasibility Report – ASMOC – Caucaia/Fortaleza.
CSLL and IR taxes	CSLL: 12% x social taxes 9% = 1.08% IR: 8% x 25% = 2%	Assumed income for social/income tax is based on the Brazilian regulations, which is public available information: • CSLL is the social tax (from the Portuguese Contribuição Social sobre Lucro Líquido): Law # 8,981, January 20th, 1995 • IR is the income tax (from the Portuguese Imposto de Renda): Law # 9,430, December 27th, 1996
PIS and COFINS taxes	PIS: 0.65% COFINS: 3.00%	Revenues tax is based on the Brazilian regulations, which is public available information: • PIS is tax of the Employees' Profit Participation Program (from the Portuguese Programa de Integração Social): at http://www.portaltributario.com.br/tributos/pis.htm • COFINS is the tax for social security financing (from the Portuguese Contribuição para o Financiamento da Seguridade Social): at http://www.receita.fazenda.gov.br/legislacao/leis/2003/lei10833.htm
ICMS tax	17%	Sales revenues tax is based on the Brazilian regulations, which is public available information: ICMS is the tax on the circulation of goods and services (from the Portuguese Imposto sobre Circulação de Mercadorias e Serviços): http://www.fiscontex.com.br/legislacao/ICMS/aliquotainternaicms.htm
Lifetime (years)	20 years	20-year assessment period was considered in the project cash flow based on information from the manufacturer of the upgrading system.

As mentioned above, the financial indicator identified for Oeste de Caucaia Landfill Project is the Net Present Value (NPV). Oeste de Caucaia cash flow over its lifetime shows that the NPV is – US$8,873,913. The resulted negative value of NPV clearly shows that the proposed project needs the CDM revenues in order to overcome its financial unattractiveness. The project cash flow is available with the Project Participants and was presented to the DOE.

Sensitivity analysis:

A sensitivity analysis was conducted by altering in 10% the following parameters, as indicated in §21, Annex 5, EB62:

- Increase in project revenues:
  - the price of the upgraded gas;
  - the amount of upgraded gas generation and commercialization
- Reduction in project costs:
  - The project Capex;
  - The project Opex.

The results of the sensitivity analysis the impact on project's NPV are presented in the below table.

Table 5 - The following table summarizes the NPVs resulting from the application of 10% variation in costs and revenues

Parameters	Variation	Initial value	Variation value	Units	NPV
LFG price	+10%	0.38	0.42	US$/Nm^3	-1,528,323
LFG generation	+10%	34,155,000	37,570,500	Nm^3/year	-1,528,323
Capex	-10%	34,053,260	30,647,934	US$	-5,777,178
Opex	-10%	6,932,500	6,239,250	US$/year	-3,737,667

As shown in the Table above the project the project NPV remains negative when the above parameters fluctuated within the range of -10% to +10%. According to the sensitivity analysis, even with ± 10% variations of the financial key parameters, the project NPV is still negative considering the benchmark of 9.97%.

According to the "Guidelines on the assessment of investment analysis", whenever a scenario results in an IRR higher than the benchmark, an assessment on the probability of the respective occurrence shall be presented. Although none of the scenarios presented above the IRR reaches or surpasses the benchmark, the Project Participants also conducted the sensitivity analysis by altering each parameter until the IRR reaches the benchmark and analyzed the probability of the occurrence of these scenarios[36], as required by DOE. Results of this sensitivity analysis are presented in the table below:

Table 6 – The following table summarizes the NPVs resulting from the application of variation in costs and revenues until NPV is zero

Parameters	Initial value	Variation value	Units	Variation (%)
LFG price	0.38	0.42	US$/Nm^3	12.1
LFG generation	34,155,000	38,281,129	Nm^3/year	12.1
Capex	32,586,593	24,295,057	US$	28.7
Opex	6,932,500	5,734,769	US$/year	17.3

The probability of the occurrence of these scenarios is presented below:

(a) *Increase in the gas price*

The upgraded gas price considered in the project cash flow is US$0.38/m^3 (equivalent to US$8.82/MMBTU) including Brazilian taxes. The considered value is based on historical data of the natural gas (NG) price available in the Monthly Reports of the Mines and Energy Ministry ("MME" from the Portuguese Ministério de Minas e Energia) / Natural Gas Department. Therefore, values are based on official data source.

Considering an increase in the NG price of 12.1% to NPV zero, the NG price would be US$0.42/m^3 (equivalent to US$9.75/MMBTU). However, there is a tendency of reduction in the NG price considering the *shale gas* offer. The *shale gas* has introduced new parameters for the NG price by

[36] Variation required during the CDM validation of the Project. Please refer to the PPs response in CAR 4 of the Validation Protocol.

reducing it and unlinking it with the petroleum price (GOMES, 2011)[37]. The unexpected shale gas offer in the US market has surprised international markets, including Brazil, which had intention of exporting gas to US after pre-salt consolidation.

The Economic Research Institute Foundation ("FIPE" from the Portuguese Fundação Instituto de Pesquisas Econômicas) presented the "NG Strategic Project – NG Economical Potential in Brazil based on International Experience", Oct 2012[38]. The methodology of the study considered tendencies of natural gas in Brazil and worldwide regarding offer and demand and industrial policies, sensitivity in the natural consumption in relation to other sources of energy (as electric and fuel oil) and its influence in costs, critical levels of natural gas prices and their impact on taxes, income and employment, etc. The study presented a natural gas price scenario considering US$7/MMBtu up to 2025 year.

Another study that it is worth mention is the one published in June 2012 by the National Forum of State Secretaries for Energy Matters (from the Portuguese Fórum Nacional de Secretários de Estado para Assuntos de Energia)[39]. This study considered a competitive price of natural gas for 2020 year scenario in a range of US$5.50-7.50MBtu ("MBtu" as one million Btu).

Considering the increase of gas offer with the shale gas and pre-salt basins discovered in Brazil, it is expected an increase in the NG offer and, consequently, the NG price was not expected to increase in a short-medium term period. Therefore, an increase in the NG price of 12.1% to NPV equals to zero would not be reasonable in the project making context and it is not expected to occur.

(b) Increase in the upgrade gas generation

The estimated upgrade gas generation considered in the project cash flow is based on Landtec Assessment Study, a third-party engineering company contracted by the project developer in order to perform technical and financial analysis of the project activity implementation.

Considering an increase of 12.1% in the gas generation to NPV equals to zero, the average of upgraded gas generation would be 38,281,129Nm^3/yr. In fact, as presented in the Landtec Assessment Report, the LFG generation could increase considering the increase in the waste deposited in Oeste de Caucaia landfill. Therefore, depending on the project performance, the project activity may pass from 7,500Nm^3/h to 12,500 Nm^3/h (phase II) and 15,000Nm^3/h (phase III). This scenario includes an increase in the project revenues with upgraded gas sale, but it also requires an increase of costs with investment and maintenance.

In order to demonstrate additionality in the possible expansion scenario, another investment assessment was made. Since the project expansion was not predicted to the project developers at the time of the investment decision, Landtec conducted an assessment of the first phase of the project only. Then, values considered at the time of the investment decision were proportionally applied to the possible expansion capacity of the project[40].

	Phase I	**Phase II**	**Phase III**
Operation start	from 2016 onwards	from 2018 onwards	from 2028 onwards
Upgrade capacity (Nm^3/h)	7,500	12,500	15,000
Capex (US$)	34,053,260	Plus 16,835,507	Plus 8,417,753
Opex (US$/yr)	6,932,500	11,554,167	13,865,000
Annual average of LFG commercialization (Nm^3/yr)	34,155,000	49,506,079	57,078,318

The assessment period of the project cash flow is based on the 20-year lifetime of Phase I equipment as informed by the upgrading manufacturer. Then, fair value of Phase II and III were included in the final year of the project cash in accordance with §4, Annex 5, EB62.

[37] Brazilian Market Study of Natural Gas in the Contexto f Shale Gas (in a free translation from the Portuguese Estudo do Mercado Brasileiro de Gás Natural Contextualizado ao Shale Gas). Rio Grande do Sul University, 2011.

[38] http://www.estadao.com.br/brasilcompetitivo/Apresentacoes/20121017/fernando.pdf

[39] http://www.forumdeenergia.com.br/nukleo/pub/cepe_ago2012.pdf

[40] There are some values that do change in the project expansion as NG price and NG pipeline costs in Capex, and therefore they were not revised. For this reason, this assessment is very conservative.

Considering information above, the NPV of the project is –US$24,631,652, demonstrating that the project is not a feasible, even when parameters change 10% in favor of the project[41]:

Parameters	Variation	NPV
LFG price	+10%	-14,159,767
LFG generation	+10%	-14,159,767
Capex	-10%	-20,091,679
Opex	-10%	-16,236,574

Considering explanations above, the upgraded gas generation and commercialization was based on the Landtec Feasibility study and a 12.1% increase to NPV equals to zero was not taken into consideration at the time of the investment decision. Even in the expansion scenario of the project, the project remains additional even with the sensitivity analysis. Therefore, an increase of 12.1% was not expected to occur and if it occurs, the project remains additional.

(c) Reduction in investment cost

Investment considered in the project cash flow is based on the Landtec Assessment Report. A 28.7% reduction in the project investment to NPV equals to zero would result in approximately US$ 24.3 MM. However, the proposed project activity is not common practice in the country, as discussed in Step 2 and Step 4. Therefore, it faces several barriers due to the lack of manufacturers, and consequently equipment, experienced personnel, know-how, regulations regarding licensing and renewable natural gas, and others, which reflects in the increase of project Capex.

Furthermore, according to Bacon and Besant-Jones (1998) study, real investments in developing countries are usually higher than the original estimative[42]. The study indicates that although the ratio of actual to estimated cost can be smaller than one (indicating actual investment smaller than estimated), less than 10% of the analyzed projects had investments lower than those forecasted. One of the conclusions is that "*the estimated values were significantly biased below actual values*".

In conclusion, the investment considered in the project cash flow is based on a reliable documented evidence (a third-party contracted by the project developer) and very conservative in spite of the innovative solution to renewable energy generation in the country, where several sources available are less costly. For this reason, a 28.7% reduction in project investment is not reasonable in the project context, which in fact it is not expected to occur.

(d) Reduction in operational costs

Operational costs presented in the project cash flow are composed of power cost, O&M, property tax and insurance, general and administrative costs. Total operational costs result in around US$ 6.9 MM/year as presented in the SCS Assessment Report nr. 06212012.00. SCS is a third-party entity contracted by the project developer in order to assess technical and investment feasibility for LFG upgrading. A reduction in the project costs until the NPV equals to zero would result in 17.3% reduction from the estimated operational costs, *i.e.* US$ 5.7 MM/year.

As mentioned in item (c), there are no similar projects to Ecofor in Brazil and, therefore, reference for costs involved in the project is based on specific technical studies contracted by the project sponsor. Since the project is not operational yet and reference of costs that composted the annual Opex – as property tax, insurance, power cost, general, administrative – were not found in literature. However, the PPs stress that data considered in project cash flow was made available by a third-party company contracted by the project developer in order to assess the technical and financial feasibility of the proposed project activity. Therefore, a reduction of 17.3% is not a reasonable scenario in the context of the project activity and is not expected to occur given the innovative technology employed by the project in the Host Country.

Thus without CDM revenues, the proposed CDM Project Activity is not financially attractive.

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[41] In acordance with the default value presented in §21 of Annex 5, EB 62.

[42] R. W. Bacon and J. E. Besant Jones (1998). Estimating construction costs and schedules – Experience with power generation projects in developing countries. Energy Policy, vol. 26, no 4, pp 317-333.

STEP 4. Common practice analysis

The Combined tool establishes that for those CDM project activities consisting of one of the measures that are listed in the definitions section of the tool, the approach presented in *Step 4a* shall be used. The measures listed in the tool are:

(a) Fuel and feedstock switch;
(b) Switch of technology with or without change of energy source (including energy efficiency improvement as well as use of renewable energies);
(c) Methane destruction;
(d) Methane formation avoidance.

The proposed CDM Project Activity matches option (c) since it consists of destructing the methane contained in the landfill[43]. Therefore, the approach provided in the *Step 4a* is to be used.

Step 4a: The proposed CDM project activity(s) applies measure(s) that are listed in the definitions section above

In accordance with the combined tool, the stepwise approach presented below shall be applied since the proposed CDM Project Activity consists of one of the measures listed in its definitions section.

Sub-step 4a(1): *Calculate the applicable output range as +/-50% of the design output or capacity of the proposed project activity.*

Output is defined by the "*Combined tool to identify the baseline scenario and demonstrate additionality*" as *goods or services with comparable quality, properties and application areas (e.g. clinker, lighting, residential cooking)*.

The proposed CDM Project Activity aims at supplying methane from the LFG displacing the use of natural gas. Therefore, the output is the total LFG collected and sent to the distribution network implemented as a result of the project.

The installed capacity of the biogas upgrading plant considered in the proposed CDM Project Activity is 7,500Nm^3/h equivalent to 65,700,000Nm^3/year of LFG at full capacity. Therefore, the applicable range is 32,850,000Nm^3/year and 98,550,000Nm^3/year. If the capacity expansion is considered (15,000Nm^3/h), 131,400,000 Nm^3 LFG is resulted in the year at full capacity. Then, the range is 65,700,000-197,100,000Nm^3/year.

Sub-step 4a(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 and projects activities undergoing validation shall not be included in this step.*

The "*Guidelines on common practice*" states that the *"applicable geographical area covers the entire Host Country as a default"*. Therefore, Brazil is identified as the applicable geographical area for the purpose of conducting the common practice analysis.

The starting date of the proposed CDM Project Activity is October 25th, 2013. Therefore, all landfills that have started supplying upgraded LFG to a natural gas distribution network before this date have to be assessed.

According to "2012 Municipal Solid Waste Management Diagnosis" (from the Portuguese "*Diagnóstico do Manejo do Resíduos Sólidos Urbanos 2012*") prepared by the Brazilian Ministry of the Cities, there are 765 solid waste disposal sites in the country classified as open dumps, composting projects, recycling sites, sanitary and controlled landfills. However, it was not identified any landfill which collects LFG and upgrades it to natural gas quality.

According to the "Brazilian Atlas of Greenhouse Gas Emissions and Energetic Potential in the Residues Destination"[44] published by ABRELPE in 2013, there are 22 (twenty-two) LFG projects

[43] Analogously to the example provided in the Annex 8 of the EB 62.

[44] ABRELPE (2013). Atlas Brasileiro de Emissões de GEE e Potencial Energético na Destinação de Resíduos Sólidos. Report supported by US Environmental Protection Agency (EPA) and the Global Methane Initiative. Associação Brasileira de Empresas de Limpeza Pública e Resíduos Especiais – ABRELPE. ABRELPE is an association founded in 1976 and is the representative International Solid Waste Association (ISWA) in Brazil.

encompassing electricity generation projects and only 1 (one) considering the biogas upgrading and injection into the NG distribution system. Therefore, N_{all} = 1.
However, as far as project developer is concerned, the identified project, which is similar to Ecofor, is Gramacho landfill, which is also a CDM project activity (ref. 9087)[45]. Therefore, according to the most recent information available from ABRELPE, the 23 identified projects are also CDM projects.
In conclusion, $\boldsymbol{N_{all}}$ **=** 0, since there are no similar projects to the proposed project activity and, all projects involving LFG for energetic use purposes are related to electricity generation and also CDM project activities.

Sub-step 4a(3): *Within the plants identified in Step 2, identify those that apply technologies different to the technology applied in the proposed project activity. Note their number* N_{diff}.
From the list of SWDS mentioned above in *Sub-step 4a(2)*, there are no similar projects to the proposed CDM Project activities (N_{all} = 0). Therefore, $\boldsymbol{N_{diff}}$ **= 0**.

Sub-step 4a(4): *Calculate factor* $F=1-N_{diff}/N_{all}$*, representing the share of plants using a 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. The proposed project activity is regarded as common practice within a sector in the applicable geographical area if both the following conditions are fulfilled:*

(a) The factor F is greater than 0.2; and

(b) $N_{all}-N_{diff}$ *is greater than 3.*

From the above, neither of these two conditions applies to the proposed CDM Project Activity. Hence, the conditions of *sub-step4a(4)* are met and the project is additional.

Outcome of Step 4: the proposed project activity is not regarded as common practice. Therefore, it is additional.

B.5. Demonstration of additionality

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The additionality of the proposed project activity has been demonstrated using the *"Combined Tool to identify the baseline scenario and demonstrate additionality"*, in line with the requirements of ACM0001. Please refer to section B.4. above for details.

CDM Prior Consideration and continuing and real actions to secure the CDM status

According to the "*Glossary of CDM Terms*" (EB66, Annex 63) the start date of the CDM Project Activity corresponds to "*the earliest date at which either the implementation or construction or real action of a CDM project activity or PoA begins*".
The identified starting date of the proposed project activity is 25/10/2013, which corresponds to the date when the first capital increase for the implementation of the Ecofor Project was agreed by the board of the directors. For details on how the project starting date was identified please refer to Section C.1.1.
With regards to the demonstration of the prior consideration of the CDM, the "*Clean Development Mechanism Project Standard*", requires that the CDM consideration must be demonstrated by those projects for which the identified start date *is prior to the date of publication of the PDD for the global stakeholder consultation*.
In addition, paragraph 7 of the "Project Cycle Procedure establishes that "*For project activities with a start date on or after 2 August 2008, the project participants shall notify the designated national authority(ies) (DNAs) of the host Party(ies) of the project activity and the secretariat in writing of the commencement of the project activity and their intention to seek the CDM status within 180 days of the start date of the project activity as defined in the "Glossary of CDM terms", by using the "Prior consideration of the CDM form" (F-CDM-PC). Such notification is not necessary if:*

(a) *A PDD regarding the project activity has been published for global stakeholder consultation in accordance with paragraph 16 below; or (…)".*

[45] Gramacho Landfill Gas Project <https://cdm.unfccc.int/Projects/DB/DNV-CUK1356155404.95/view>.

The proposed CDM Project Activity notified both the CDM EB and the Brazilian DNA of its intention to seek the registration on 19/06/2013. The confirmation of receipt from those entities is available with Project Participants and was sent to the DOE.

B.6. Estimation of emission reductions

B.6.1. Explanation of methodological choices

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Baseline Emissions

Baseline emissions for the proposed project activity are determined according to the following equation:

$$BE_y = BE_{CH4,y} + BE_{EC,y} + BE_{HG,y} + BE_{NG,y}$$ **Equation 1**

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)
$BE_{HG4,y}$	=	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)

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

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

Baseline emissions of methane from the SWDS are determined, based on the amount of methane that is captured under the project activity and the amount that would be captured and destroyed in the baseline (such as due to regulations). In addition, the effect of methane oxidation that is present in the baseline and absent in the project is taken into account[46].

$$BE_{CH4,y} = \left(\left(1 - OX_{top\_layer}\right) \times F_{CH4,PJ,y} - F_{CH4,BL,y}\right) \quad GWP_{CH4}$$ **Equation 2**

Where,

$BE_{CH4,y}$	=	Baseline emissions of methane from the SWDS in year y (t CO_2e/yr)
OX_{top_layer}	=	Fraction of methane in the LFG that would be oxidized in the top layer of the SWDS in the baseline (dimensionless)
$F_{CH4,PJ,y}$	=	Amount of methane in the LFG which is flared and/or used in the project activity in year y (t CH_4/yr)
$F_{CH4,BL,y}$	=	Amount of methane in the LFG that would be flared in the baseline in year y (t CH_4/yr)
GWP_{CH4}	=	Global warming potential of CH_4 (t CO_2e/t CH_4)

Ex post determination of $F_{CH4,PJ,y}$

During the crediting period, $F_{CH4,PJ,y}$ is to be determined as the sum of the quantities of methane flared and forwarded to the natural gas distribution network, considering the following equation:

$$F_{CH4,PJ,y} = F_{CH4,flared,y} + F_{CH4,EL,y} + F_{CH4,HG,y} + F_{CH4,NG,y}$$ **Equation 3**

46 $OX_{top\text{-}layer}$ is the fraction of the methane in the LFG that would oxidize in the top layer of the SWDS in the absence of the project activity. Under the project activity, this effect is reduced as a part of the LFG is captured and does not pass through the top layer of the SWDS. This oxidation effect is also accounted for in the methodological tool "Emissions from solid waste disposal sites". In addition to this effect, the installation of a LFG capture system under the project activity may result in the suction of additional air into the SWDS. In some cases, such as with a high suction pressure, the air may decrease the amount of methane that is generated under the project activity. However, in most circumstances where the LFG is captured and used this effect was considered to be very small, as the operators of the SWDS have in most cases an incentive to main a high methane concentration in the LFG. For this reason, this effect is neglected as a conservative assumption.

Where,

$F_{CH4,PJ,y}$	=	Amount of methane in the LFG which is flared and/or used in the project activity in year *y* (tCH_4/yr)
$F_{CH4,flared,y}$	=	Amount of methane in the LFG which is destroyed by flaring in year *y* (tCH_4/yr)
$F_{CH4,EL,y}$	=	Amount of methane in the LFG which is used for electricity generation in year *y* (tCH_4/yr)
$F_{CH4,HG,y}$	=	Amount of methane in the LFG which is used for heat generation in year *y* (tCH_4/yr)
$F_{CH4,NG,y}$	=	Amount of methane in the LFG which is sent to the natural gas distribution network and/or to the trucks in year *y* (tCH_4/yr)

In the case of the project activity, $F_{CH4,HG,y}$ and $F_{CH4,EL,y}$ are zero since neither heat nor electricity will be generated using the biogas.

The *ex-post* determination of $F_{CH4,NG,y}$ is done using the *"Tool to determine the mass flow of a greenhouse gas in a gaseous stream"*. Since the proposed project activity is under conception, the PDD presents the most likely options for biogas and methane monitoring. In spite of the options chosen at the time of the project verification, monitoring will be followed according to ACM0001 and the "Tool to determine the mass flow of a greenhouse gas in a gaseous stream".

Following the requirements of the "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 60°C (333.15 K) at the flow measurement point, *AND*;
- **Option B** (Volume flow in wet basis and volumetric fraction in dry basis) *OR* **Option C** (Volume flow in wet basis and volumetric fraction in wet basis) when the temperature of the gaseous stream is higher than 60°C (333.15 K) at the flow measurement point.

Option A of the Tool applies when the biogas mass flow and volumetric fraction of methane measured in dry basis. While considering this option, it is necessary to demonstrate that the gaseous stream is dry by:

(a) Measuring the moisture content of the gaseous stream ($C_{H2O,t,db,n}$) and demonstrate that this is less or equal to 0.05 kg H_2O/m^3 dry gas; or

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

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 corresponding option available in the tool should be applied instead.

Under this option, $F_{CH4,NG,y} = F_{i,t}$.

$$F_{i,t} = V_{t,db} \times v_{i,t,db} \times \rho_{i,t}$$ **Equation 4**

And:

$$\rho_{i,t} = \frac{P_t \times MM_i}{R_u \times T_t}$$ **Equation 5**

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 wet gas/h);
$v_{i,t,db}$	=	Volumetric fraction of greenhouse gas *i* in the gaseous stream in 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);

Ru = Universal ideal gases constant ($Pa.m^3/kmol.K$);
T_t = Temperature of the gaseous stream in time interval *t* (K).

Option B is applicable when the volume flow in wet basis and volumetric fraction in dry basis, following the demonstration criteria presented under Option A.

The mass flow of greenhouse gas *i* ($F_{i,t}$) is determined using Equation 4 and Equation 5 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:

$$V_{t,tb} = V_{t,wb}/(1 + v_{H2O,t,db})$$ **Equation 6**

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.

$$v_{H2O,t,db} = \frac{m_{H2O,t,db} * MM_{t,db}}{MM_{H2O}}$$ **Equation 7**

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 ($m_{H2O,t,db}$) 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[47].

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.

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

$$m_{H2O,t,db,Sat} = \frac{p_{H2O,t,Sat} * MM_{H2O}}{(P_t - p_{H2O,t,Sat}) * MM_{t,db}}$$ **Equation 8**

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.

$$MM_{t,db} = \sum_k (v_{k,t,db} * MM_k)$$ **Equation 9**

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,).

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.

Option C is the used when LFG and volumetric fraction of methane are measured in wet basis. Then, $F_{CH4,NG,y} = F_{i,t}$ and is determined following the below equations:

$$F_{i,t} = V_{t,wb,n} \times v_{i,t,wb} \times \rho_{i,n}$$ **Equation 10**

And:

$$\rho_{i,n} = \frac{P_n \times MM_i}{R_u \times T_n}$$ **Equation 11**

Where:

Fi,t	=	Mass flow of greenhouse gas *i* in the gaseous stream in time interval *t* (kg gas/h);
Vt,wb,n	=	Volumetric flow of the gaseous stream in time interval *t* on a wet basis at normal conditions (m^3 wet gas/h);
vi,t,wb	=	Volumetric fraction of greenhouse gas *i* in the gaseous stream in time interval *t* on a wet basis (m^3 gas *i* /m^3 wet gas);
ρi,n	=	Density of greenhouse gas *i* in the gaseous stream at normal conditions (kg gas *i*/m^3 wet gas *i*);
Pn	=	Absolute pressure at normal conditions (Pa);
Tn	=	Temperature at normal conditions (K);

MMi = Molecular mass of greenhouse gas *i* (kg/kmol);
Ru = Universal ideal gases constant (Pa.m3/kmol.K).

The following equation should be used to convert the volumetric flow of the gaseous stream from actual conditions to normal conditions of temperature and pressure:

$$V_{t,wb,n} = V_{t,wb} \times [(T_n / T_t) \times (P_t / P_n)]$$ **Equation 12**

Where:
Vt,wb,n = Volumetric flow of the gaseous stream in a time interval *t* on a wet basis at normal conditions (m3 wet gas/h);
Vt,wb = Volumetric flow of the gaseous stream in time interval *t* on a wet basis (m^3 wet gas/h);
Pt = Pressure of the gaseous stream in time interval *t* (Pa);
Tt = Temperature of the gaseous stream in time interval *t* (K);
Pn = Absolute pressure at normal conditions (Pa);
T_n = Temperature at normal conditions (K).

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

$$F_{CH4,flared,y} = F_{CH4,sent\_flare,y} \quad \frac{PE_{flare,y}}{GWP_{CH4}}$$ **Equation 13**

Where,
$F_{CH4,flared,y}$ = Amount of methane in the LFG which is destroyed by flaring in year *y* (t CH_4/yr)
$F_{CH4,sent\_flare,y}$ = Amount of methane in the LFG which is sent to the flare in year *y* (t CH_4/yr)
$PE_{flare,y}$ = Project emissions from flaring of the residual gas stream in year *y* (t CO_2e/yr)
GWP_{CH4} = Global warming potential of CH_4 (t CO_2e/t CH_4)

$F_{CH4,sent\_flare,y}$ is determined directly using the *“Tool to determine the mass flow of a greenhouse gas in a gaseous stream”*, applying the requirements of one of the options listed above to determine $F_{CH4,NG,y}$, but considering that the gaseous stream the tool shall be applied to is the LFG delivery pipeline to the flare ($F_{CH4,sent\_flare,y} = F_{i,t}$).
It is important to mention that the upgraded gas that does not reach specifications to be delivered in the NG pipeline will be flared. Also, for the determination of biogas resulted from the upgrade system return that will be flared, one of those options and its respective requirements shall be applied.
Considering the possibility of installation of two more flares in the project expansion scenario, $PE_{flare,y}$ will be determined as the sum of the emissions for each flare determined separately following ACM001.

Project Emissions from flaring:
Project emissions are related to the amount of methane not destroyed in the flare and will be calculated following the procedures of the methodological tool “*Project emissions from flaring*”. The project will install an open flare and Oeste de Caucaia Landfill Project will adopt the default flare efficiency. The calculation of flare efficiency will be made by the following steps:

<u>STEP 1</u>: Determination of the methane mass flow of the residual gas;
The mass flow of methane in the residual gaseous stream in the minute *m* ($F_{CH4,m}$) will be determined using the procedures set out by the “*Tool to determine the mass flow of a greenhouse gas in a gaseous stream*” and the following requirements apply:

- The gaseous stream tool shall be applied to the residual gas;
- The flow of the gaseous stream shall be measured continuously;

- CH_4 is the greenhouse gas *i* for which the mass flow should be determined;
- The simplification 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* ($F_{CH4,RG,m}$). This parameter corresponds to $F_{CH4,sent\_flare,y}$. Therefore, the same methodological approaches apply to both parameters (Option C of the tool described above).

However, the upgraded gas, which does not reach quality specifications to be delivered into the NG pipeline, will be flared. In this case, Option A of the tool will be applied as explained above. Please refer to methodological explanations for the ex-post determination of $F_{CH4,sent\_flare,y}$ and monitoring equipment in section B.7.3.

<u>STEP 2</u>: Determination of flare efficiency

The Oeste de Caucaia Landfill Project will install an open flare. Therefore, in accordance with the methodological tool, the flare efficiency in the minute *m* ($\eta_{flare,m}$) is 50% when the flame is detected in minute *m* ($Flame_m$), otherwise $\eta_{flare,m}$ is 0%.

<u>STEP 3</u>: Calculation of project emissions from flaring

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

$$PE_{flare,y} = GWP_{CH_4} \times \sum_{m=1}^{525600} F_{CH4,RG,m} \cdot (1 - \eta_{flare,m}) \times 10^{-3}$$ **Equation 14**

Where,

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

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

It is determined as follows:

$$F_{CH4,PJ,y} = \eta_{PJ} \cdot BE_{CH4,SWDS,y} / GWP_{CH4}$$ **Equation 15**

Where,

$F_{CH4,PJ,y}$	=	Amount of methane in the LFG which is flared and/or used in the project activity in year *y* ($t\ CH_4/yr$)
$BE_{CH4,SWDS,y}$	=	Amount of methane in the LFG that is generated from the SWDS in the baseline scenario in year *y* ($t\ CO_2e/yr$)
η_{PJ}	=	Efficiency of the LFG capture system that will be installed in the project activity, this is considered as 50% considering the default value provide in the methodology.
GWP_{CH4}	=	Global warming potential of CH_4 ($t\ CO_2e/t\ CH_4$)

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

- f_y in the tool shall be assigned a value of 0 because the amount of LFG that would have been captured and destroyed is already accounted for in $\boldsymbol{F_{CH4,BL,y}}$;
- In the tool, x begins with the year that the SWDS started receiving wastes (e.g. the first year of SWDS operation); and
- Sampling to determine the fractions of different waste types is not necessary because the waste composition can be obtained from previous studies (obtained from ECOFOR, as discussed in the LANDTEC Report).

Application A of the Tool is used (*i.e.*, the project activity mitigates methane emissions from a specific existing SWDS-solid waste disposal site). A yearly selection has been chosen as the Oeste de Caucaia landfill started receiving wastes in January 1998.
The amount of methane that would in the absence of the project activity be generated from disposal of waste at the solid waste disposal site ($BE_{CH4,SWDS,y}$) is calculated with a multi-phase model. The calculation is based on a first order decay (FOD) model.

$$BE_{CH_\$,SWDS,y} = \varphi y \times (1-f_y) * GWP_{CH_4} * (1-OX) * \frac{16}{12} * F * DOC_{f,y} * MCFy * \sum_{x=1}^{y} \sum_{j} W_{j,x} * DOC_j \times e^{-k_j(y-x)} * \left(1-e^{-k_j}\right) \quad \textbf{Equation 16}$$

Where,

$BE_{CH4,SWDS,y}$	=	Baseline methane emissions occurring in year y generated from waste disposal at the solid waste disposal site (SWDS) during a period ending in year y (tCO_2e/y)
Φ	=	Model correction factor to account for model uncertainties (default value of 0.75), Option 1 in the Tool has been selected, value as per Table 3 of the Tool (Application A and humid wet conditions).
F	=	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. As this is already accounted for in $\boldsymbol{F_{CH4,BL,y}}$, "*f*" in the Tool shall be assigned a value of 0.
GWP_{CH4}	=	Global Warming Potential (GWP) of methane, valid for the relevant commitment period
OX	=	Oxidation factor (reflecting the amount of methane from SWDS that is oxidized in the soil or other material covering the waste) (value 0, as per the guidance of AM_CLA_259)
F	=	Fraction of methane in the SWDS gas (volume fraction) (0.5)
$DOC_{f,y}$	=	Fraction of degradable organic carbon (DOC) that decomposes under the specific conditions occurring in the SWDS for year y (weight fraction). Default value of 0.5 used as per page 65 of the Tool.
MCF_y	=	Methane correction factor for year y (1.0)
$W_{j,x}$	=	Amount of solid waste type j disposed or prevented from disposal in the SWDS in the year *x* (t)
DOC	=	Fraction of degradable organic carbon (by weight fraction) in the waste type *j*
k_j	=	Decay rate for the waste type *j (1/yr)*
j	=	Type of residual waste or types of waste in the MSW
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 (x = y)
y	=	Year for which methane emissions are calculated (considering a consecutive period of 12 months)

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

NBR 13896/97, consisting of the technical standard published by ABNT (Brazilian Association of Technical Standards - *Associação Brasileira de Normas Técnicas*), sets out the requirements for the development of the design, implementation and operation of landfills aiming at minimizing gaseous emissions and promoting its capture and correct management. However, its use is not mandatory and the norm neither specifies the amount of methane to be destroyed nor the system that shall be put in place. In addition, there is no federal/state/local law requiring the destruction of the methane.
Previously to the implementation of the proposed CMD Project Activity there was a passive system and methane was burned in an uncontrolled manner (Figure 5). Hence, to the understanding of the project participants, *Case 1* is applicable to Oeste de Caucaia Landfill Project (*i.e.*, there is no technical requirement to destroy methane and no existing LFG capture and destruction system).

However, based on the MP clarifications received[48], Case 3 is applicable in this case, *i.e* no requirement to destroy methane exists and a LFG capture system exists.

Figure 5 – Existing wells at the project site previously to the implementation of the CMD Project Activity (Source: SCS Report)

In accordance with the ACM0001 methodology, under *Case 3*, $F_{CH4,BL,y}$ = $F_{CH4,BL,sys,y}$ and, since 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 (option C), the following equation applies:

$$F_{CH4,BL,sys,y} = 0.2 \times F_{CH4,PJ,y}$$ **Equation 17**

Baseline emissions associated with natural gas use ($BE_{NG,y}$)

$BE_{NG,y}$ is estimated as follows:

$$BE_{NG,y} = 0.0504 \times F_{CH4,NG,y} \times EF_{CO2,NG,y}$$ **Equation 18**

Where,

$BE_{NG,y}$ = Baseline emissions associated with natural gas use in year *y* (t CO_2/yr)

$EF_{CO2,NG,y}$ = Average CO_2 emission factor of natural gas in the natural gas network or in trucks in year *y* (tCO_2/TJ)

$F_{CH4,NG,y}$ = Amount of methane in the LFG which is sent to the natural gas distribution network or in trucks in year *y* (tCH_4/yr)

$EF_{CO2,NG,y}$ is determined using the *"Tool to calculate project or leakage CO_2 emissions from fossil fuel combustion".*

Project Emissions

Sources of project emissions are electricity and fossil fuel consumption, as presented in the equation below:

$$PE_y = PE_{EC,y} + PE_{FC,y} + PE_{DT,y}$$ **Equation 19**

Where,

$PE_{EC,y}$ = 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).

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[48] AM_CLA_0265 - Procedure to determine the amount of methane that would have been captured and destroyed (by flaring) in the baseline ($F_{CH4,BL,y}$). Available at: https://cdm.unfccc.int/methodologies/PAmethodologies/clarifications/90436

The proposed project activity will not make use of trucks to distribute compressed/liquefied LFG. On the contrary, it will inject the purified LFG directly into the natural gas distribution grid. Therefore, there are no project emissions associated with the distribution of compressed/liquefied LFG using trucks and $PE_{DT,y}$ is **zero.**

The project emissions from electricity consumption ($PE_{EC.y}$) will be calculated following the procedures set out by the *"Tool to estimate the baseline, project and/or leakage emissions from electricity consumption"*. During the crediting period, electricity is expected to be purchased from the grid will be consumed for the operation of the active LFG collection system and LFG upgrading facility.

The project will consume electricity from the grid. Therefore, Option **A.1** of the "*Tool to calculate baseline, project and/or leakage emissions from electricity consumption"* is used. Under this option, project emissions from consumption of electricity from the grid are calculated based on the power consumed by the project activity and the emission factor of the grid, adjusted for transmission losses, using the following formula:

$$PE_{EC,grid,y} = \sum_j EC_{PJ,j,y} \times EF_{EL,j,y} \times (1 + TDL_{j,y})$$ **Equation 20**

Where,

$PE_{EC,grid,y}$	=	Project emissions from electricity consumption from the grid by the project activity during the year *y* (tCO_2/year);
$EC_{PJ,y}$	=	Quantity of electricity consumed by the project electricity consumption source *j* in year *y* (MWh)
$EF_{EL,j,,y}$	=	Emission factor for electricity generation for source *j* in year (tCO_2/MWh)
$TDL_{j,y}$	=	Average technical transmission and distribution losses for providing electricity to source *j* in year *y*
j	=	Sources of electricity consumption in the project

Electricity sources *j* corresponds to all the sources of electricity consumed for the operation of the LFG capture system, for the processing and upgrading of the LFG, for transportation of the LFG to the flare, for the compression of the LFG into the natural gas network, etc. For the *ex-ante* estimation of electricity consumed, the installed power of the active LFG collection system and LFG upgrading facility equipment was used.

For Scenario A, the Emission Factor will be calculated according with the *"Tool for calculation of emission factor for electricity systems".* The Tool considers the determination of the emission factor for the grid to which the project activity is connected as the core data to be determined in the baseline scenario. Thus $EF_{EL,y} = EF_{grid,CM,y}$.

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

The "*Tool for calculation of emission factor for electricity systems"* presents the following steps to calculate the Emission Factor:

- **STEP 1** - Identify the relevant electricity systems

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

Brazilian DNA published Resolution #8, issued on 26th May, 2008, defines the Brazilian Interconnected Grid as a single system that covers all the five macro-geographical regions of the country (North, Northeast, South, Southeast and Midwest). Hence this figure will be used to calculate the baseline emission factor of the grid.

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

Option I of the tool is chosen, which is to include only grid power plants in the calculation.

- **STEP 3 -** Select a method to determine the operating margin (OM).

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

(a) Simple OM, or
(b) Simple adjusted OM, or
(c) Dispatch data analysis OM, or
(d) Average OM.

The simple operating margin can only be used where low-cost/must-run resources[49] constitute less than 50% of total grid generation in: 1) average of 5 most recent years, or 2) based on long-term normalities for hydroelectricity production. Table 7 shows the share of hydroelectricity in the total electricity production for the Brazilian interconnected system. The results show the non-applicability of the simple operating margin to the proposed CDM Project Activity.

Table 7 - Share of hydroelectricity generation in the Brazilian interconnected system, 2009 to 2013

Year	Share of hydroelectricity (%)
2009	93.27%
2010	88.77%
2011	91.18%
2012	85.86%
2013	78.77%

Source: *ONS: Histórico de Geração. Available at <http://www.ons.org.br/historico/geracao_energia.aspx>.*

The fourth alternative, an average operating margin, is an oversimplification and does not reflect in any way the impact of the project activity on the operating margin. The use of the dispatch data analysis method is only applicable to the *ex-post* vintage for determining the emission factor, which is not the vintage chosen by the project participants. Therefore, the simple adjusted operating margin will be used to determine the grid emission factor.

Further, the *ex-ante* data vintage is the chosen to estimate the operating margin. Hence, in accordance with the methodology, *the emission factor is determined once at the validation stage, thus no monitoring and recalculation of the emissions factor during the crediting period is required. For grid power plants, use a 3-year generation-weighted average, based on the most recent data available at the time of submission of the CDM-PDD to the DOE for validation.*

The PDD was submitted to the DOE for validation in the first quarter of 2014. Therefore, data from 2011, 2012 and 2013 are to be used to determine this parameter. In accordance with the explanation provided above in STEP 2, off-grid power plants are not considered in the grid emission factor calculation.

- **STEP 4** - Calculate the operating margin emission factor according to the selected method

According to the tool "*the simple adjusted OM emission factor ($EF_{grid,OM-adj,y}$) is a variation of the simple OM, where the power plants / units (including imports) are separated in low-cost/must-run power sources (k) and other power sources (m).*"

The simple adjusted OM was calculated based on the net electricity generation and a CO_2 emission factor for each power unit – i.e. similarly to **Option A** of the simple OM method – as follows:

$$EF_{grid,OM-adj,y} = (1-\lambda_y) \cdot \frac{\sum_m EG_{m.y} \times EF_{EL,m,y}}{\sum_m EG_{m.y}} + \lambda_y \cdot \frac{\sum_k EG_{k,y} \times EF_{EL,k,y}}{\sum_k EG_{k,y}}$$ **Equation 21**

Where,

$EF_{grid,OM-adj,y}$ = Simple adjusted operating margin CO_2 emission factor in year *y* (tCO_2/MWh)

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

λ_y	=	Factor expressing the percentage of time when low-cost/must-run power units are on the margin in year *y*
$EG_{m,y}$	=	Net quantity of electricity generated and delivered to the grid by power unit *m* in year *y* (MWh)
$EG_{k,y}$	=	Net quantity of electricity generated and delivered to the grid by power unit *k* in year *y* (MWh)
$EF_{EL,m,y}$	=	CO_2 emission factor of power unit *m* in year *y* (tCO_2/MWh)
$EF_{EL,k,y}$	=	CO_2 emission factor of power unit *k* in year *y* (tCO_2/MWh)
m	=	All grid power units serving the grid in year *y* except low-cost/must-run power units
k	=	All low-cost/must run grid power units serving the grid in year *y*
y	=	The relevant year as per the data vintage chosen in Step 3

Determination of $EF_{EL,m,y}$

Considering that only data on electricity generation and the fuel types used in each of the power units was available, the emission factor was be determined based on the CO_2 emission factor of the fuel type used and the efficiency of the power unit, as per **Option A2** of the simple OM method. The following formula was used:

$$EF_{EL,m,y} = \cdot \frac{EF_{CO2,m,i,y} \cdot 3.6}{\eta_{m,y}}$$ **Equation 22**

Where,

$EF_{EL,m,y}$	=	CO_2 emission factor of power unit *m* in year *y* (tCO_2/MWh)
$EF_{CO2,m,i,y}$	=	Average CO_2 emission factor of fuel type *i* used in power unit *m* in year *y* (tCO_2/GJ)
$\eta_{m,y}$	=	Average net energy conversion efficiency of power unit *m* in year *y* (ratio)
m	=	All power units serving the grid in year *y* except low-cost/must-run power units
y	=	The relevant year as per the data vintage chosen in Step 3

Determination of $EG_{m,y}$

Information used to determine this parameter was supplied by ONS, which is an official source, as recommended by the tool. ONS is a non-profit corporate entity, founded on 26 August 1998, and is responsible for coordinating and controlling the operation of generation and transmission facilities in the Brazilian Interconnected System (SIN) under supervision and regulation of the ANEEL[50].

- **STEP 5** - Calculate the build margin (BM)emission factor

In terms of vintage, **option 1** was chosen. In this sense, the build margin was calculated using the most recent information available on units already built for sample group *m* at the time of PDD submission to the DOE, *i.e.* 2013.

The sample group of power units *m* used to calculate the build margin was determined following the guidance provided by the tool as further discussed in section B.6.3. below. The build margin was calculated following the same approach described above in step 4.

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

The combined margin calculation is based on method ***a)*** provided by the tool, as follows:

$$EF_{grid,CM,y} = EF_{grid,OM,y} \cdot w_{OM} + EF_{grid,BM,y} \cdot w_{BM}$$ **Equation 23**

Where,

$EF_{grid,BM,y}$	=	Build margin CO_2 emission factor in year y (tCO_2/MWh);
$EF_{grid,OM,y}$	=	Operating margin CO_2 emission factor in year y (tCO_2/MWh);
w_{OM}	=	Weighting of operating margin emissions factor (%);

[50] http://www.ons.org.br/institucional/modelo_setorial.aspx?lang=en

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

According with the Tool, values adopted for w_{OM} and w_{BM} were equal to 0.5 for each one during the 1st crediting period. As mentioned above, the *ex-ante* approach is used.

In the future, it may be possible that a generator could be installed at the plant site considering the high variation of electricity supply where the project is located. In this case, project emissions from the use of fuel to produce electricity will be considered in the $PE_{FC,y}$ calculation following the "Tool to calculate baseline, project and/or leakage emissions from electricity consumption".

Emissions from consumption of fossil fuels ($PE_{FC,y}$)

In order to calculate project emissions resulting from combustion of fossil fuels (LPG used for flare ignition), the *"Tool to calculate project or leakage emissions from fossil fuel combustion"* will be used. Project emissions related to this source are estimated using the following formulae:

$$PE_{FC,j,y} = SUM(FC_{i,j,y} * COEF_{i,y})$$ **Equation 24**

Where,

$PE_{FC,j,y}$ = Are the CO_2 emissions from fossil fuel combustion in process *j* during the year *y* (tCO_2/yr);

$FC_{i,j,y}$ = Is the quantity of fuel type *i* combusted in process *j* during the year *y* (mass or volume unit/yr);

$COEF_{i,y}$ = Is the CO_2 emission coefficient of fuel type *i* in year *y* (tCO_2/mass or volume unit)

i = Are the fuel types combusted in process *j* during the year *y*

The proposed project activity will consume LPG for flare ignition. The CO_2 emission coefficient $COEF_{i,y}$ will be calculated using Option B of the Tool since the necessary data for Option A is not available. As per Option B, the CO_2 emission coefficient $COEF_{i,y}$ is calculated based on net calorific value and CO_2 emission factor of the fuel type *i*, as follows:

$$COEF_{i,y} = NCV_{i,y} * EF_{CO2,i,y}$$ **Equation 25**

Where,

$COEF_{i,y}$ = Is the CO_2 emission coefficient of fuel type *i* in year *y* (tCO_2/mass or volume unit)

$NCV_{i,y}$ = Is the weighted average net calorific value of the fuel type *i* in year *y* (GJ/mass or volume unit)

$EF_{CO2,i,y}$ = Is the weighted average CO_2 emission factor of fuel type *i* in year *y* (tCO_2/GJ)

i = Are the fuel types combusted in process j during the year *y*

If a fossil fuel generator is installed at the project site for electricity generation, fuel consumption will be also monitored following equations above.

Leakage

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

Emission reductions

Emission reductions will be calculated using the formula below:

$$ER_y = BE_y – PE_y$$ **Equation 26**

Where,

ER_y = Emission reductions during the year *y* (tCO_2e)

BE_y = Baseline emissions in year *y* (tCO_2e)

PE_y = Project emissions in year *y* (tCO_2e)

B.6.2. Data and parameters fixed ex ante

“ACM0001 Methodology”

Data / Parameter	***OX_{top_layer}***
Data 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	As per the applicable tool
Purpose of data	Calculation of baseline emissions
Additional comment	Applicable to section 5.4.1. (baseline emissions of methane from the SWDS, $BE_{CH4,y}$)

Data / Parameter	***GWP_{CH4}***
Data unit	tCO_2e/tCH_4
Description	Global Warming Potential of CH_4
Source of data	IPCC
Value(s) applied	25 for the second commitment period. Shall be updated according to any future COP/MOP decisions.
Choice of data or measurement methods and procedures	As per the applicable methodology
Purpose of data	Calculation of baseline emissions
Additional comment	-

Data / Parameter	***NCV_{CH4}***
Data unit	TJ/t CH_4
Description	Net calorific value of methane at reference conditions
Source of data	Technical literature
Value(s) applied	0.0504
Choice of data or measurement methods and procedures	As per the applicable methodology
Purpose of data	Calculation of baseline emissions
Additional comment	-

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

“Tool Emissions from solid waste disposal sites”

Data / Parameter	***$\varphi_{default}$***
Data unit	-
Description	Default value for the model correction factor to account for model uncertainties
Source of data	-
Value(s) applied	0.75
Choice of data or measurement methods and procedures	As per the applicable methodological tool *"Emissions from solid waste disposal sites"*. This parameter is used to determine the baseline emissions following the procedures related to *Application A*. Further, the project is located at Caucaia municipality (next to Fortaleza), Ceará state (northeast region of Brazil) which possesses humid/wet weather conditions[51]: MAT = 26.6ºC MAP = 1.643mm. Therefore, the value correspondent to this condition as presented in Table 3 of the methodology is chosen.
Purpose of data	Calculation of baseline emissions
Additional comment	As per Table 3 since the project participants have chosen to apply Option 1 to determine this parameter.

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

Data / Parameter	***OX***
Data 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
Choice of data or measurement methods and procedures	As per the applicable methodological tool *"Emissions from solid waste disposal sites"*
Purpose of data	Calculation of baseline emissions
Additional comment	As per the AM_CLA_0259 clarification request final response, it was opted not to account for this effect while determining the ex-ante estimative of baseline emissions.

[51] The climatic conditions are based on long-term averages from 1973 to 1990 and were taken from EMBRAPA - Brazilian Agricultural Research Company, available at http://www.bdclima.cnpm.embrapa.br/resultados/balanco.php?UF=&COD=43.

Data / Parameter	***F***
Data unit	-
Description	Fraction of methane in the SWDS gas (volume fraction)
Source of data	IPCC 2006 Guidelines for National Greenhouse Gas Inventories
Value(s) applied	0.5
Choice of data or measurement methods and procedures	As per the applicable methodological tool *“Emissions from solid waste disposal sites”*
Purpose of data	Calculation of baseline emissions
Additional comment	Upon biodegradation, organic material is converted to a mixture of methane and carbon dioxide.

Data / Parameter	$DOC_{f,default}$
Data unit	Weight fraction
Description	Default value for the fraction of degradable organic carbon (DOC) in MSW that decomposes in the SWDS
Source of data	IPCC 2006 Guidelines for National Greenhouse Gas Inventories”
Value(s) applied	0.5
Choice of data or measurement methods and procedures	The proposed project activity corresponds to *Application A* described in the applicable methodological tool *“Emissions from solid waste disposal sites”*. Therefore, in accordance with the requirements set out by tool, the default value was chosen.
Purpose of data	Calculation of baseline emissions
Additional comment	This factor reflects the fact that some of the degradable organic carbon does not degrade, or degrades very slowly, in the SWDS.

Data / Parameter	$MCF_{default}$
Data 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 proposed project activity matches *Application A* described in the tool *“Emissions from solid waste disposal sites”*. The Oeste de Caucaia Lanfill meets the criteria of managed SWDS. Hence, the value corresponding to anaerobic **managed solid waste disposal sites** is chosen.
Purpose of data	Calculation of baseline emissions
Additional comment	-

<table>
<tr><td>Data / Parameter</td><td>DOC_j</td></tr>
<tr><td>Data unit</td><td>-</td></tr>
<tr><td>Description</td><td>Fraction of degradable organic carbon in the waste type j (weight fraction)</td></tr>
<tr><td>Source of data</td><td>IPCC 2006 Guidelines for National Greenhouse Gas Inventories (adapted from Volume 5, Tables 2.4 and 2.5)</td></tr>
<tr><td>Value(s) applied</td><td>
<table>
<tr><th>DOC_j
(% wet waste)</th><th>Waste type j</th></tr>
<tr><td>43%</td><td>Wood and wood products</td></tr>
<tr><td>40%</td><td>Pulp, paper and cardboard</td></tr>
<tr><td>15%</td><td>Food, food waste, beverages and tobacco</td></tr>
<tr><td>24%</td><td>Textiles</td></tr>
<tr><td>20%</td><td>Garden, yard and park waste</td></tr>
<tr><td>0%</td><td>Glass, plastic, metal, other inert waste</td></tr>
</table>
</td></tr>
<tr><td>Choice of data or measurement methods and procedures</td><td>Values for MSW, as per Table 6 of the methodological tool “Emissions from solid waste disposal sites”.</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>k_j</td></tr>
<tr><td>Data unit</td><td>1/yr</td></tr>
<tr><td>Description</td><td>Decay rate for the waste type j</td></tr>
<tr><td>Source of data</td><td>IPCC 2006 Guidelines for National Greenhouse Gas Inventories (adapted from Volume 5, Table 3.3)</td></tr>
<tr><td>Value(s) applied</td><td>
<table>
<tr><th colspan="2">Waste type j</th><th>k_j</th></tr>
<tr><td rowspan="2">Slowly degrading</td><td>Pulp, paper, 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>0.40</td></tr>
</table>
</td></tr>
<tr><td>Choice of data or measurement methods and procedures</td><td>As per Table 7 of the methodological tool “Emissions from solid waste disposal sites”.</td></tr>
<tr><td>Purpose of data</td><td>Calculation of baseline emissions</td></tr>
<tr><td>Additional comment</td><td>The project is located at Caucaia municipality (next to Fortaleza), Ceará state (northeast region of Brazil) which possesses humid/wet weather conditions[51]:
MAT = 26.6ºC
MAP = 1.643mm</td></tr>
</table>

<table>
<tr><td>Data / Parameter</td><td>W_x</td></tr>
<tr><td>Data unit</td><td>T</td></tr>
<tr><td>Description</td><td>Total amount of waste disposed in a SWDS in year x</td></tr>
<tr><td>Source of data</td><td>Data from ECOFOR, which manages the landfill</td></tr>
<tr><td>Value(s) applied</td><td>Large amount of data. Please refer to the CERs calculation spreadsheet</td></tr>
<tr><td>Choice of data or measurement methods and procedures</td><td>ECOFOR is the institution responsible for waste management of the landfill.</td></tr>
<tr><td>Purpose of data</td><td>Calculation of baseline emissions</td></tr>
<tr><td>Additional comment</td><td>This parameter does not need to be monitored during the crediting period since is corresponds to Application A of the methodological tool “Emissions from solid waste disposal sites”.</td></tr>
</table>

Data / Parameter	***R_u***
Data unit	$Pa.m^3/kmol.K$
Description	Universal ideal gases constant
Source of data	As per the applicable tool
Value(s) applied	8,314
Choice of data or measurement methods and procedures	-
Purpose of data	Calculation of baseline emissions
Additional comment	-

Data / Parameter	***MM_i***
Data unit	kg/kmol
Description	Molecular mass of greenhouse gas *i*
Source of data	Tool
Value(s) applied	16.04 (for methane)
Choice of data or measurement methods and procedures	-
Purpose of data	Calculation of baseline emissions
Additional comment	-

Data / Parameter	***MM_k***
Data unit	kg/kmol
Description	Molecular mass of gas *k* *(k = N_2)*
Source of data	As per the tool
Value(s) applied	28.01
Choice of data or measurement methods and procedures	According to ACM0001, the simplification offered in the tool for calculating the molecular mass of the gaseous stream ($MM_{t,db}$) is valid. Thus, the volumetric fraction of the greenhouse gas (CH_4) is considered and the difference to 100% is considered as pure nitrogen.
Purpose of data	Calculation of baseline emissions
Additional comment	-

Data / Parameter	***MM_{H2O}***
Data unit	kg/kmol
Description	Molecular mass of water
Source of data	As per the tool
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	-

Data / Parameter	P_n
Data unit	Pa
Description	Total pressure at normal conditions
Source of data	As per the tool
Value(s) applied	101,325
Choice of data or measurement methods and procedures	-
Purpose of data	Calculation of baseline and project emissions
Additional comment	-

Data / Parameter	T_n
Data unit	K
Description	Temperature at normal conditions
Source of data	As per the tool
Value(s) applied	273.15
Choice of data or measurement methods and procedures	-
Purpose of data	Calculation of baseline and project emissions
Additional comment	-

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

Data / Parameter	$FC_{i,m,y}$, $FC_{i,y}$, $FC_{i,k,y}$, $FC_{i,n,y}$ and $FC_{i,n,h}$
Data unit	mass or volume unit
Description	Amount of fuel type i consumed by power plant/unit m, k or n (or in the project electricity system in case of FCi,y) in year y or hour h
Source of data	Official publications (data from ONS), IPCC default values and default values provided by the *"Tool to calculate the emission factor for an electricity system"*
Value(s) applied	Large amount of data. Please refer to the emission factor calculation spreadsheet which is attached to the PDD.
Choice of data or Measurement methods and procedures	The *ex-ante* calculation vintage of this parameter was chosen as per the procedures of the *"Tool to calculate the emission factor for an electricity system"*.
Purpose of data	Calculation of the project emissions due to electricity consumption
Additional comment	For methodological choices details, please refer to section E.6.1.

Data / Parameter	$EF_{CO2,i,y}$ and $EF_{CO2,m,i,y}$
Data unit	tCO_2/GJ
Description	CO_2 emission factor of fossil fuel type *i* used in power unit *m* in year *y*
Source of data	IPCC default values at the lower limit of the uncertainty at a 95% confidence interval as provided in table 1.4 of Chapter1 of Vol. 2 (Energy) of the 2006 IPCC Guidelines on National GHG Inventories
Value(s) applied	Large amount of data. Please refer to the emission factor calculation spreadsheet which is attached to the PDD.
Choice of data or measurement methods and procedures	As per the recommendation of the *"Tool to calculate the emission factor for an electricity system"*. IPCC default values are being used since this information is neither provided by fuel suppliers nor regional and/or local default values are publicly available.
Purpose of data	Calculation of the project emissions due to electricity consumption
Additional comment	-

Data / Parameter	***$EG_{m,y}$ and $EG_{k,y}$***
Data unit	MWh
Description	Net electricity generated by power plant/unit *m* or *k* in year *y*
Source of data	Official publications. Data from the Electric System National Operator was used.
Value(s) applied	Large amount of data. Please refer to the emission factor calculation spreadsheet which is attached to the PDD.
Choice of data or measurement methods and procedures	Once for each crediting period using the most recent three historical years for which data is available at the time of submission of the PDD to the DOE for validation (*ex-ante* option).
Purpose of data	Calculation of the project emissions due to electricity consumption
Additional comment	For methodological choices details, please refer to section E.6.1.

Data / Parameter	***$\eta_{m,y}$***
Data unit	-
Description	Average net energy conversion efficiency of power unit *m* in year *y*
Source of data	Default values provided in Annex 1 of the *"Tool to calculate the emission factor for an electricity system"*
Value(s) applied	Large amount of data. Please refer to the emission factor calculation spreadsheet which is attached to the PDD.
Choice of data or measurement methods and procedures	As per the recommendation of the *"Tool to calculate the emission factor for an electricity system"*.
Purpose of data	Calculation of the project emissions due to electricity consumption
Additional comment	For methodological choices details, please refer to section E.6.1.

Data / Parameter	***$EF_{grid,OM-adj,y}$***
Data unit	tCO_2/MWh
Description	Simple adjusted operating margin CO_2 emission factor in year *y*
Source of data	Official publications (data from ONS), IPCC default values and default values provided by the *"Tool to calculate the emission factor for an electricity system"*
Value(s) applied	0.3612
Choice of data or measurement methods and procedures	The *ex-ante* calculation vintage of this parameter was chosen as per the procedures of the *"Tool to calculate the emission factor for an electricity system"*.
Purpose of data	Calculation of the project emissions due to electricity consumption
Additional comment	For methodological choices details, please refer to section E.6.1.

Data / Parameter	***$EF_{BM,2013}$***
Data unit	tCO_2/MWh
Description	Build Margin CO_2 emission factor in year *y*
Source of data	Official publications (data from ONS), IPCC default values and default values provided by the *"Tool to calculate the emission factor for an electricity system"*
Value(s) applied	0.2850
Choice of data or measurement methods and procedures	The *ex-ante* calculation vintage of this parameter was chosen as per the procedures of the *"Tool to calculate the emission factor for an electricity system"*.
Purpose of data	Calculation of the project emissions due to electricity consumption
Additional comment	For methodological choices details, please refer to section E.6.1.

The methodological tool "Project emissions from flaring"

No additional parameters are required to be fixed *ex-ante* in the case of the proposed project activity, since the project applies an open flare (50% default efficiency).

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

No additional parameters are required to be fixed *ex-ante* in the case of the proposed project activity, since electricity to be used in the project is from the grid. *Ex-ante* parameters for the CO_2 emission factor of the grid is presented in section "Tool to calculate the emission factor for an electricity system" above.
Possibly, electricity may be generated from a captive plant installed at the project site considering the high variation of electricity supply which the project has been facing at the time of commissioning.

"Tool to calculate project or leakage CO_2 emissions from fossil fuel combustion"
No additional parameters are required to be fixed *ex-ante* in the case of the proposed project activity. All parameters required for the project emissions calculation regarding fossil fuel combustion will be monitored. Please refer to the section B.7.1.

B.6.3. Ex ante calculation of emission reductions

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

Year	$BE_{CH4,SWDS,y}$ ($t_{CO2}e$)	$F_{CH4,PJ,y}$ (t CH_4/yr)	$F_{CH4,BL,y}$ (t CH_4/yr)	$BE_{CH4,y}$ (tCO_2,y)
2016	1,283,757	25,675	5,135	462,152
2017	1,276,317	25,526	5,105	459,474
2018	1,279,980	25,600	5,120	460,793
2019	1,301,807	26,036	5,207	468,650
2020	1,332,237	26,645	5,329	479,605
2021	1,369,326	27,387	5,477	492,957
2022	1,411,329	28,227	5,645	508,078

The following data was used to calculate the *ex-ante* methane estimative (as per the Tool *"Emissions from solid waste disposal sites"*:

- *MFC (Methane Conversion Factor):* MCF value is adopted according with the type of SWDS. The Oeste de Caucaia Landfill is a managed SWDS; thus, the MCF adopted is equal to 1.0;
- Oxidation factor, reflecting the amount of methane from SWDS that is oxidised in the soil or other material covering the waste: 0 (as per the guidance of AM_CLA_0259)
- Model correction factor to account for model uncertainties: 0.75 (default value as per the Tool Application A and humid/wet conditions)
- W_x (Total amount of organic waste prevented disposed in year x, in tons):
- The amount of the solid waste entering in the Oeste de Caucaia Landfill has been monitored by ECOFOR (the owner and operator of the landfill). The future waste deposition is presented in the table below:

Table 8 – Historical and forecasted deposited solid waste at the site.

Year	Deposited waste (tons)
2005	944,083
2006	1,062,288
2007	1,188,830
2008	1,249,739
2009	1,398,065
2010	1,597,026
2011	1,829,511
2012	1,910,383
2013	2,118,587
2014	2,207,977
2015	1,935,318
2016	1,718,071
2017	1,641,774

Year	Deposited waste (tons)
2019	1,728,751
2020	1,781,537
2021	1,838,940
2022	1,898,289
2023	1,959,656
2024	2,023,117
2025	2,088,752
2026	2,156,643
2027	2,226,876
2028	2,226,876
2029	2,226,876
2030	2,226,876
2031	2,226,876

2018	1,654,471		**-**	-

The estimated amount of waste to be received is based on the Environmental Impact Assessment related to the landfill expansion. The characterization of the municipal solid waste is based on the study performed by the Federal Institute of Education, Science and Technology of Ceará in 2009:

Table 9 – Waste types historically disposed at the project site.

Category	% (wet basis)
Wood and wood products	5.20
Pulp, paper and cardboard	14.00
Food, food waste, beverages and tobacco	47.50
Textiles	3.20
Garden, yard and park waste	0.00
Glass, plastic, metal, other inert waste	30.10

b) Baseline emissions associated with natural gas use

ACM0001 does not provide a guide for the *ex-ante* calculation of these baseline emissions. Therefore, it has been estimated that 95% of the collected gas ($F_{CH4,PJ,y}$) will be derived to the gas purification process. The balance of LFG collected is considered to be burned in an open flare while the upgrading facility stops (e.g. during maintenance or emergencies) or when there is an excess of LFG.
The IPCC emission factor for the natural gas[52] is equal to 58.3tCO_2e/TJ. Applying these figures to Equation 18, we obtain the results presented in the below table.

Table 10 – Baseline emissions associated with natural gas use

Year	$F_{CH4,NG,y}$ (tCH_4/yr)	$BE_{NG,y}$ (tCO_2/yr)
2016	11,760	34,556
2017	23,521	69,111
2018	24,320	71,459
2019	24,734	72,677
2020	25,312	74,376
2021	26,017	76,447
2022	26,815	78,792

c) Grid Emission Factor Calculation.

The calculation of the combined margin CO_2 emission factor for grid connected power generation ($EF_{grid,CM,y}$) follows the steps established in the "*Tool to calculate the emission factor for an electricity system*". The results are presented below.

- **STEP 1** - Identify the relevant electricity systems

Following Resolution #8, issued by the Brazilian DNA on 26th May, 2008, the Brazilian Interconnected Grid corresponds to the system to be considered. It covers all the five macro-geographical regions of the country (North, Northeast, South, Southeast and Midwest) as presented in the figure below.

52 Value at the upper limit of the uncertainty at a 95% confidence interval as per the "*Tool to calculate project or leakage CO2 emissions from fossil fuel combustion*"..

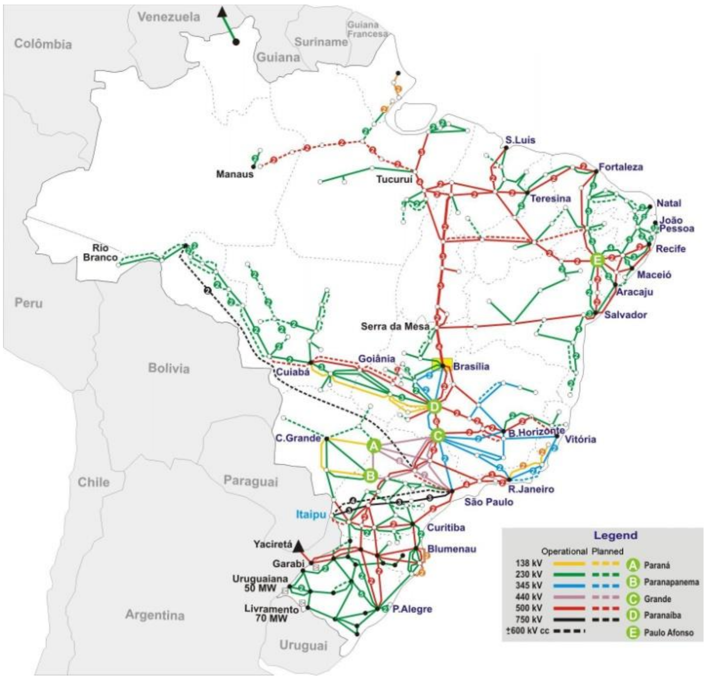

Figure 6 - Brazilian Interconnected System. (*Source:* Electric System National Operator)

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

Option I was chosen and only grid connected power plants are considered.

- **STEP 3** - *Select a method to determine the operating margin (OM)*

The simple adjusted operating margin and *ex-ante* data vintage were chosen for the calculation of this parameter. Data from 2011, 2012 and 2013 were used in the calculation. Please refer to section E.6.1. for proper justification.

- **STEP 4** - Calculate the operating margin emission factor according to the selected method

A spreadsheet containing all data used to determine the operation margin was supplied to the DOE. The result is presented below.

$$EF_{grid,OM\text{-}adj,y} = 0.3612tCO_2e/MWh$$

- **STEP 5** - Calculate the build margin (BM) emission factor

As described above in section E.6.1., the *ex-ante* vintage was the option chosen to determine the build margin (option 1).

The sample group of power units *m* used to calculate the build margin was identified following the procedure provided by the tool. The result is discussed below and is presented in detail in the spreadsheet supplied to the DOE which is also attached to the PDD.

(a) *Identify the set of five power units, excluding power units registered as CDM project activities, that started to supply electricity to the grid most recently ($SET_{5\text{-}units}$) and determine their annual electricity generation ($AEG_{SET\text{-}5\text{-}units}$, in MWh);*

From the most recent consolidated information the SET5-units are: Termopernambuco, UHE Jirau, UTE Tambaqui, T. Ponta Negra and UTE Aparecida. The electricity generated by these set of plants ($AEG_{SET\text{-}5\text{-}units}$) in 2013 was 1,440,999MWh.

(b) *Determine the annual electricity generation of the project electricity system, excluding power units registered as CDM project activities (AEG_{total}, in MWh). Identify the set of power units, excluding power units registered as CDM project activities, that started to supply electricity to the grid most recently and that comprise 20% of AEG_{total} (if 20% falls on part of the generation of a unit, the generation of that unit is fully included in the calculation) ($SET_{\geq 20\%}$) and determine their annual electricity generation ($AEG_{SET\text{-}\geq 20\%}$, in MWh);*

Not considering the CDM project activities, in 2013, the Brazilian electricity System generated (AEG_{total}) 487,520,106MWh. A large number of plants comprise 20% of AEG_{total}. This information ($SET_{\geq 20\%}$) can be checked in the calculation spreadsheet attached to this PDD. The annual electricity generation of $SET_{\geq 20\%}$, corresponding to the parameter $AEG_{SET-\geq 20\%}$, is 97,504,021MWh.

(c) From $SET_{5\text{-}units}$ and $SET_{\geq 20\%}$ select the set of power units that comprises the larger annual electricity generation (SET_{sample}); Identify the date when the power units in SET_{sample} started to supply electricity to the grid. If none of the power units in SET_{sample} started to supply electricity to the grid more than 10 years ago, then use SET_{sample} to calculate the build margin. Ignore steps (d), (e) and (f).

From data presented in items (a) and (b), it can be observed that $SET_{\geq 20\%}$ is greater than $SET_{5\text{-}units}$. Therefore, SET_{sample} corresponds to $SET_{\geq 20\%}$. The oldest plant comprised in SET_{sample} started to supply electricity to the grid in May 2002. Hence, steps *(d), (e)* and *(f)* of the tool are applicable.

(d) Exclude from SET_{sample} the power units which started to supply electricity to the grid more than 10 years ago. Include in that set the power units registered as CDM project activity, starting with power units that started to supply electricity to the grid most recently, until the electricity generation of the new set comprises 20% of the annual electricity generation of the project electricity system (if 20% falls on part of the generation of a unit, the generation of that unit is fully included in the calculation) to the extent is possible. Determine for the resulting set ($SET_{sample\text{-}CDM}$) the annual electricity generation ($AEG_{SET\text{-}sample\text{-}CDM}$, in MWh);

Plants which have started to supply electricity to the grid more than 10 years ago were excluded. Six registered CDM Projects were included in the SET_{smaple}. The electricity generation by resultant set of plants, corresponds to the parameter $AEG_{SET\text{-}sample\text{-}CDM}$, is 7,756,515MWh.

If the annual electricity generation of that set is comprises at least 20% of the annual electricity generation of the project electricity system (i.e. $AEG_{SET\text{-}sample\text{-}CDM} \geq 0.2 \times AEG_{total}$), then use the sample group $SET_{sample\text{-}CDM}$ to calculate the build margin. Ignore steps (e) and (f).

From the results presented above, $AEG_{SET\text{-}sample\text{-}CDM}$ is lower than AEG_{total}. Then, steps (e) and (f) were applied.

(a) Include in the sample group $SET_{sample\text{-}CDM}$ the power units that started to supply electricity to the grid more than 10 years ago until the electricity generation of the new set comprises 20% of the annual electricity generation of the project electricity system (if 20% falls on part of the generation of a unit, the generation of that unit is fully included in the calculation);

(b) The sample group of power units m used to calculate the build margin is the resulting set ($SET_{sample\text{-}CDM\text{-}>10yrs}$).

Power plants that started to supply electricity to the grid more than 10 years ago were included. The resultant set $SET_{sample\text{-}CDM\text{-}>10yrs}$ is identified in the grid emission factor calculation spreadsheet. The build margin was calculated following the same approach described above in Step 4, and considered the set of plants identified above. As mentioned previously, this parameter will be validated since the *ex-ante* option was chosen.
The result for the build margin emission factor is presented below.

$$EF_{grid,BM,2013} = 0.2850tCO_2e/MWh$$

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

Applying the results presented above in STEPS 4 and 5 above to Equation 23 presented in section E.6.1. and considering the weights w_{OM} = 0.5 and w_{BM} = 0.5 (as per method ***a)*** of the tool) we obtain,

$$EF_{grid,CM,y} = 0.5 \times 0.3612 + 0.5 \times 0.2850 = 0.3231tCO_2e/MWh$$

d) Project emissions due to electricity consumption from the grid

The electricity consumed by the LFG capture system and LFG upgrading facility was *ex-ante* estimated from the PP. For the purpose of *ex-ante* estimative, it was assumed that equipment will

operate at full capacity during 8,760hours/year. The result is that the estimated electricity consumption from the grid by the project activity is equal to 16,673MWh/year. As presented above, the combined margin grid emission factor of 0.3231tCO_2/MWh. TDL_y is based on local electricity distribution company (COELCE) published by ANEEL (9.36%).
Plugging this number into Equation 20, we obtain the total project emissions related to the consumption of electricity from the grid, as follows:

$$PE_{EC,grid,y} = 16{,}072 MWh/yr \times 0.3231 tCO_2/MWh \times (1+9.36\%) = 5{,}679\ tCO_2e/yr$$

e) Project emissions due to fossil fuel consumption

Based on monitored values of similar project 266.95 kg/yr of LPG for the parameter $FC_{i,j,y}$ has been used[53]. While applying 0.0465GJ/kg $NCV_{i,y}$ from the 2014 National Energetic Balance and 0.0656tCO_2/GJ EF_{CO2} as per 2006 IPCC in equation 21, we have:

$$COEF_{i,y} \text{ is } 0.0465 GJ/kg \times 0{,}0656 tCO_2/GJ = 0.00305\ tCO_2/kg$$

Thus, following equation 20 project emissions due to fuel consumption are:

$$PE_{FC,j,y} = 266.95\ kg/yr \times 0.00305\ tCO_2/kg = 0.81\ tCO_2/yr$$

f) Project emission due to flaring

The calculation of the *ex-ante* methane emissions from flaring of vent gas has been estimated using the balance of methane in the LFG collected by the proposed project activity system and the methane in the LFG sent to the upgrading process. It is assumed that all the methane not injected to the natural gas distribution grid due to inefficiencies of the process will be flared in the open flare.
As per the tool, for open flares a default value of 50% shall be used when the flame is detected in minute *m* (please refer to Section B.6.1 above). It was assumed that 95% the biogas collected will enter the upgrading facility. Then, the project emissions due to flaring gases have been estimated following equation 10:

Year	***$PE_{flare,y}$ (tCO_2e/year)***
2016	173,935
2017	25,072
2018	16,000
2019	16,273
2020	16,653
2021	17,117
2022	17,642

Project emissions from flaring are higher in 2016, since flare is expected to be fully operational since the beginning of 2016 and the upgrading system is expected to be operational in the middle of 2016 only.

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

B.7. Monitoring plan

Year	Baseline emissions (t CO_2e)	Project emissions (t CO_2e)	Leakage (t CO_2e)	Emission reductions (t CO_2e)

[53] Value from Project Participants, based on estimated consumption of a similar project.

2016	496,708	179,615	0	317,093
2017	528,585	30,752	0	497,834
2018	532,252	21,680	0	510,572
2019	541,328	21,952	0	519,375
2020	553,981	22,333	0	531,649
2021	569,404	22,796	0	546,608
2022	586,870	23,321	0	563,549
Total	3,809,128	322,449	0	3,486,678
Total number of crediting years	7			
Annual average over the crediting period	544,161	46,064	0	498,097

B.7.1. Data and parameters to be monitored

ACM0001 Methodology

Data / Parameter	**Management of SWDS**
Data unit	-
Description	Management of SWDS
Source of data	Environmental Impact Assessment and valid environmental permits: - *Operation Permit Nº081/2016 and its renewal request, Nº 76/2020;* - *Operation Permit Nº76/2020, issued on 15/09/2020*
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	Calculation of baseline emissions
Additional comment	-

Data / Parameter	***$Op_{j,h}$***
Data unit	-
Description	Operation of the equipment that consumes the LFG
Source of data	Project participants
Value(s) applied	Not used for *ex-ante* calculations.
Measurement methods and procedures	In the context of the proposed project activity, equipment unit *j* using *the LFG* consists of the LFG upgrading facility and a flare. Hence, the following parameters are to be used to ensure that the plant is operating in hour *h*: *For the LFG upgrading facility* • Products generated. Monitor the generation of upgraded LFG which is sold to the consumer. This information can be cross-checked with invoices; *For the flaring system* • Flame. Flame detection system is used to ensure that the equipment is in operation; $Op_{j,h}$=0 when: • No products are generated in the hour *h* • Flame is not detected continuously in hour *h* (instantaneous measurements are made at least every minute); Otherwise, $Op_{j,h}$=1
Monitoring frequency	Hourly
QA/QC procedures	Flow meters and flame detectors shall be subject to a regular maintenance and testing regime to ensure accuracy. Calibration shall be according to manufacturers' specifications. Accuracy of the flow meters and flame detectors is described in the monitoring tables of parameters $V_{t,db}$ and $Flame_m$, respectively.
Purpose of data	Calculation of baseline emissions
Additional comment	This is monitored to ensure methane destruction is claimed for methane used in the upgrading LFG facility when it is operational

Data / Parameter	***$EG_{EC,y}$***
Data unit	MWh
Description	Amount of electricity consumed by the project activity in year *y*
Source of data	Electricity meters
Value(s) applied	16,072
Measurement methods and procedures	Sources of consumption shall include, where applicable, electricity consumed for the operation of the LFG capture system, for any processing and upgrading of the LFG, for transportation of the LFG to the flare, for the compression of the LFG into the natural gas network, etc. Electricity meters will measure the electricity consumed by the LFG capture system and LFG upgrading facility.
Monitoring frequency	Continuously, aggregated at least annually.
QA/QC procedures	Electricity meter will be subject to regular maintenance and testing to ensure accuracy. The calibration periodicity will be in accordance with the manufacturer recommendation. The accuracy of the equipment, as per the manufacturer specification is 1% (Accuracy class 1%).
Purpose of data	Calculation of Project Emissions
Additional comment	This parameter is required for calculating project emissions from electricity consumption due to an alternative waste treatment process *t* ($PE_{EC,y}$) using the "*Tool to calculate baseline, project and/or leakage emissions from electricity consumption*". In accordance with ACM0001, this parameter is equivalent to $EC_{PJ,k,y}$ in the tool.

Note: the depth and height of the water table in the SWDS is not monitored as the MCF has been selected as a default value as per Application A of the methodological tool *"Emissions from solid waste disposal sites"*.

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

Data / Parameter	$V_{t,wb}$
Data unit	m³ wet gas/h
Description	Volumetric flow of the gaseous stream in time interval *t* on a wet basis
Source of data	Onsite measurements
Value(s) applied	Not used for *ex-ante* calculations.
Measurement methods and procedures	Volumetric flow measurement should always refer to the actual pressure and temperature. Instruments with recordable electronic signal (analogical or digital) are required.
Monitoring frequency	Continuous, aggregated at least hourly.
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 specification.
Purpose of data	Calculation of baseline and project emissions
Additional comment	This parameter will be monitored when Option B and C is used.

Data / Parameter	$V_{t,db}$
Data unit	m³ dry gas/h
Description	Volumetric flow of the gaseous stream in time interval *t* on a dry basis
Source of data	Onsite measurements
Value(s) applied	Not used for *ex-ante* calculations.
Measurement methods and procedures	Volumetric flow measurement should always refer to the actual pressure and temperature. Calculated based on the wet basis flow measurement plus water concentration measurement.
Monitoring frequency	Continuous, aggregated at least hourly.
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 specification.
Purpose of data	Calculation of baseline and project emissions
Additional comment	This parameter will be monitored when Option A is used.

Data / Parameter	$v_{i,t,db}$
Data unit	m³ gas *i*/m³ dry gas
Description	Volumetric fraction of greenhouse gas *i* in time interval *t* on a dry basis
Source of data	Onsite measurements
Value(s) applied	Not used for *ex-ante* calculations.
Measurement methods and procedures	Continuous gas analyzer operating in dry basis. Volumetric flow measurement should always refer to the actual pressure and temperature.
Monitoring frequency	Continuous, aggregated at least hourly.
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	Calculation of baseline and project emissions
Additional comment	This parameter will be monitored when Option A and B is used.

Data / Parameter	$v_{i,t,wb}$
Data unit	m³ gas *i*/m³ wet gas
Description	Volumetric fraction of greenhouse gas *i* in a time interval *t* on a wet basis
Source of data	Onsite measurements
Value(s) applied	Not used for *ex-ante* calculations.
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, aggregated at least hourly.
QA/QC procedures	Calibration should include zero verification with an inert gas (e.g. N2) 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	Calculation of baseline emissions
Additional comment	This parameter will be monitored in Options C and may be monitored in Option A.

Data / Parameter	T_t
Data unit	K
Description	Temperature of the gaseous stream in time interval *t*
Source of data	Onsite measurements
Value(s) applied	Not used for *ex-ante* calculations.
Measurement methods and procedures	Instruments with recordable electronic signal (analogical or digital) are required. The temperature will be measured by the flow meters turbines which possesses temperature sensors.
Monitoring frequency	Continuous, aggregated at least hourly.
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	Calculation of baseline and project emissions
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. Applicable to Options A and C of the tool.

Data / Parameter	***P_t***
Data unit	Pa
Description	Pressure of the gaseous stream in time interval *t*
Source of data	Onsite measurements
Value(s) applied	Not used for *ex-ante* calculation.
Measurement methods and procedures	Instruments with recordable electronic signal (analogical or digital) are required. Examples include pressure transducers, etc.
Monitoring frequency	Continuous, aggregated at least hourly.
QA/QC procedures	Periodic calibration against a primary device must be performed periodically and records of calibration procedures must be kept available as well as the primary device and its calibration certificate. Pressure transducers (either capacitive or resistive) must be calibrated monthly.
Purpose of data	Calculation of baseline emissions
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). Applicable to Option A and C of the tool

Data / Parameter	$P_{H2O,t,Sat}$
Data unit	Pa
Description	Saturation pressure of H_2O at temperature T_t 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	Calculation of baseline emissions
Additional comment	[1] Fundamentals of Classical Thermodynamics; Gordon J. Van Wylen, Richard E. Sonntag and Borgnakke; 4º Edition 1994, John Wiley & Sons, Inc.

"Project emissions from flaring"

Data / Parameter	***$Flame_m$***
Data unit	Flame on or Flame off
Description	Flame detection of flare in the minute *m*
Source of data	Project Participants
Value(s) applied	Not used for *ex-ante* calculations.
Measurement methods and procedures	Measure using a fixed installation optical flame detector type Ultra Violet detector
Monitoring frequency	Once per minute. Detection of flame recorder as a minute that the flame was on, otherwise recorded as a minute that the flame was off
QA/QC procedures	Equipment shall be maintained and calibrated in accordance with manufacturer's recommendations. It will be replaced after 10,000 operating hours. The spectral range of the equipment is 190 – 270nm and its maximum sensitivity is 210 ± 10nm.
Purpose of data	Calculation of project emissions
Additional comment	-

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

Data / Parameter	$TDL_{project, y}$
Data unit	%
Description	Average technical transmission and distribution losses for providing electricity to source *j* in year *y*
Source of data	Technical Note #80/2012-SRE/ANEEL, dated April 4th, 2012.
Value(s) applied	9.36
Measurement methods and procedures	Data from the local electricity distribution company (*Companhia Energética do Ceará* - COELCE) published by the Brazilian Electricity Regulatory Agency – ANEEL, is to be used.
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	Calculation of project emissions
Additional comment	-

Tool to determine project emissions from fossil fuel combustion

Data / Parameter	$FC_{i,j,y}$
Data unit	kg/yr
Description	Quantity of fuel type *i* combusted in process *j* during the year y (*i* = LPG)
Source of data	Sales of receipt
Value(s) applied	266.95
Measurement methods and procedures	Conservatively, it shall be considered that all LPG purchase will be used.
Monitoring frequency	At every purchase of LPG
QA/QC procedures	The consistency of metered fuel consumption quantities is to be cross-checked by an annual energy balance that is based on purchased quantities and stock changes. Where the purchased fuel invoices can be identified specifically for the CDM project, the metered fuel consumption quantities should also be cross-checked with available purchase invoices from the financial records.
Purpose of data	Calculation of project emissions from fossil fuel consumption for the flare ignition.
Additional comment	-

Data / Parameter	$NCV_{,i,y}$
Data unit	GJ/kg
Description	Weighted average net calorific value of fuel type *i* in year *y* (*i* = LPG)
Source of data	c) Regional or national default values
Value(s) applied	0.0465
Measurement methods and procedures	-
Monitoring frequency	Review appropriateness of values annually
QA/QC procedures	Verify if the value is within the uncertainty range of the IPCC default values as provided in Table 1.2, Vol. 2 of the 2006 IPCC Guidelines. If the values fall below this range collect additional information from the testing laboratory to justify the outcome or conduct additional measurements. The laboratories in a), b) or c) should have ISO17025 accreditation or justify that they can comply with similar quality standards.
Purpose of data	Calculation of project emissions from fossil fuel consumption for the flare ignition.
Additional comment	Option c) is used since a liquid fuel is considered and is based on well documented reliable sources (*i.e.* Brazilian Energy Balance). Information used with the purpose of calculating expected emission reductions is in accordance with the values provided in 2006 IPCC Guidelines.

Data / Parameter	***$EF_{CO2,i,y}$***
Data unit	tCO_2/GJ
Description	Weighted average CO_2 emission factor of fuel type *i* in year *y* (*i* = LPG)
Source of data	d) IPCC default values at the upper limit of the uncertainty at 95% confidence interval as provided in Table 1.2 of Chapter 1 of Vol.2 (Energy) of the 2006 IPCC Guidelines on National GHG Inventories
Value(s) applied	0.0656
Measurement methods and procedures	Not applicable since IPCC default value is used.
Monitoring frequency	Any future revisions of the IPCC Guidelines should be taken into account.
QA/QC procedures	Not applicable since IPCC default value is used.
Purpose of data	Calculation of project emissions from fossil fuel consumption for the flare ignition.
Additional comment	-

Data / Parameter	***$EF_{CO2,i,y}$***
Data unit	tCO_2/TJ
Description	Weighted average CO_2 emission factor of fuel type *i* in year *y* (*i* = natural gas)
Source of data	IPCC default values at the upper limit of the uncertainty at 95% confidence interval as provided In Table 1.2 of Chapter 1 of Vol.2 (Energy) of the 2006 IPCC Guidelines on National GHG Inventories
Value(s) applied	58.3
Measurement methods and procedures	Not applicable since IPCC default value is used.
Monitoring frequency	Any future revisions of the IPCC Guidelines should be taken into account.
QA/QC procedures	Not applicable since IPCC default value is used.
Purpose of data	Calculation of baseline emissions
Additional comment	Option d) is used since the source mentioned in option a) is not available. Further the fuel considered – *i.e.* natural gas - is not liquid. Therefore, option c) could not be used. This parameter is used to determine $EF_{CO2,NG,y}$ from ACM0001. Following the procedures of the methodology, it is to be determined using the "*Tool to determine project emissions from fossil fuel combustion*".

Data / Parameter	***$FC_{i,j,y}$***
Data unit	kg/yr
Description	Quantity of fuel type *i* combusted in process *j* during the year y
Source of data	Sales of receipt
Value(s) applied	Not used for *ex-ante* calculation
Measurement methods and procedures	Conservatively, it shall be considered that all fossil fuel purchase will be used.
Monitoring frequency	At every purchase of fossil fuel.
QA/QC procedures	The consistency of metered fuel consumption quantities should be cross-checked by an annual energy balance that is based on purchased quantities and stock changes. Where the purchased fuel invoices can be identified specifically for the CDM project, the metered fuel consumption quantities should also be cross-checked with available purchase invoices from the financial records.
Purpose of data	Calculation of project emissions due to fossil fuel consumption for electricity generation
Additional comment	The installation of a fossil fuel generator is possible considering intermittences of electricity supply at the project site. If this type of generator is installed at the project site, fossil fuel shall be monitored in order to calculation project emissions.

Data / Parameter	***$NCV_{,i,y}$***
Data unit	GJ/m^3
Description	Weighted average net calorific value of fuel type *i* in year *y*
Source of data	c) Regional or national default values
Value(s) applied	Not used for *ex-ante* calculation
Measurement methods and procedures	Measurements should be undertaken in line with national or international fuel standards
Monitoring frequency	Review appropriateness of the values annually
QA/QC procedures	Verify if the value is within the uncertainty range of the IPCC default values as provided in Table 1.2, Vol. 2 of the 2006 IPCC Guidelines. If the values fall below this range collect additional information from the testing laboratory to justify the outcome or conduct additional measurements. The laboratories in a), b) or c) should have ISO17025 accreditation or justify that they can comply with similar quality standards.
Purpose of data	Calculation of project emissions due to fossil fuel consumption for electricity generation
Additional comment	Applicable where Option B is used.

Data / Parameter	***$EF_{CO2,i,y}$***
Data unit	tCO_2/GJ
Description	Weighted average CO_2 emission factor of fuel type *i* in year *y*
Source of data	2006 IPCC Guidelines on National GHG Inventories
Value(s) applied	Not used for *ex-ante* calculation
Measurement methods and procedures	IPCC default values at the upper limit of the uncertainty at a 95% confidence interval as provided in table 1.4 of Chapter1 of Vol. 2 (Energy) of the 2006 IPCC Guidelines on National GHG Inventories following the tool.
Monitoring frequency	Any future revision of the IPCC Guidelines shall be taken into account.
QA/QC procedures	Official source of data.
Purpose of data	Calculation of project emissions due to fossil fuel consumption for electricity generation
Additional comment	Option (c) of the “Tool to calculate project or leakage CO_2 emissions from fossil fuel combustion”

B.7.2. Sampling plan

>>

Not applicable. This section is intentionally left blank.

B.7.3. Other elements of monitoring plan

>>

The monitoring of project activity will follow the requirements established in ACM0001 and referred tools. All data monitored will be available at the time of the verification and will be archived electronically for two years after the end of the crediting period or the last issuance of CERs, whichever occurs later.

Monitoring equipment/system

The plant is expected to have meters which measures: (i) the landfill gas (LFG) sent to flare, (ii) the LFG sent to the upgrading system, (iii) the biomethane resulted from upgrading, (iv) the biomethane sent to the NG distribution system, (iv) the biomethane which does not reach the required parameters to be delivered to the NG distribution system and, for this reason, is flared.

Maintenance and calibration of the monitoring equipment and system will be made in accordance with manufacturer’s recommendations and following national/international standards. Calibrations of measuring equipment will be carried out by an accredited person or institution.

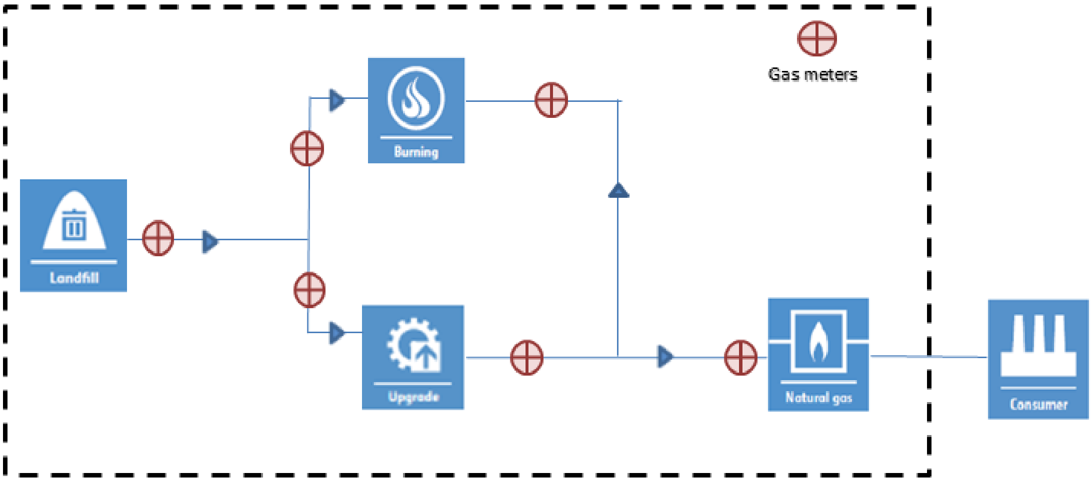

Figure 7 – Diagram of gas meters and expected location

Data transmission, processing and storage
The variables described in item B.7.1 will be automatically registered in a supervisory computer system. There will be a responsible person in charge of data checking in order to keep the process functioning. If the automatic transmission fails, the responsible person will contact an operator to register data manually. If data can be retrieved subsequently, they will be reintegrated on the server. All information will be stored physically on the disk of the server machine and a backup copy is to be done periodically. Copies of the files will be stored up to two years after the end of the crediting period or the last issuance of CERs for this project activity whichever occurs later.

Responsibilities
The CDM aspects of the project are managed by the administrators of the biogas and purification plant, who is in charge of monitoring activities. It is the ultimate responsibility of the Director to ensure the content of the monitoring report is correct at the time of requesting issuance. The CDM Project Managers supervises the calibration and maintenance procedures. Maintenance programs are carried out on site by the Field Technician, who also makes sure the monitoring tools are operating correctly.

Training
Employees involved in the monitoring will be periodically trained internally and/or externally. Training will include: Review of equipment, Calibration requirements, Configuration of monitoring equipment, maintenance requirements.

SECTION C. Start date, crediting period type and duration

C.1. Start date of project activity

>>

25/10/2013

In accordance with the "*Glossary of CDM Terms*" (EB66, Annex 63) the start date of the CDM Project Activity corresponds to "*the earliest date at which either the implementation or construction or real action of a CDM project activity or PoA begins*".
The following timeline shows relevant dates connected to the implementation of the Oeste de Caucaia Landfill Project as a CDM project activity.

Table 11 – Project's implementation timeline.

Date	Milestone
21/12/2012	Agreement between Ecometano x Ecofor
19/06/2013	Prior Consideration Form submitted to the CDM EB and Brazilian DNA
13/05/2013	Issuance of the environmental permit to conduct preliminary tests

25/10/2013	First capital increase
24/04/2014	Blower and flare contract
02/07/2014	Construction Permit
22/08/2014	Supply Agreement of the upgrading system
24/02/2015	Biogas Compressor Unit contract

The identified starting date of the proposed project activity represents the date the first capital increase for the project implementation occurred. All other tasks towards the implementation of the proposed CDM Project Activity do not require significant expenditures and, therefore, do not demonstrate that the project would in fact be implemented. The capital increase represented around 80% of total expected investment for the project implementation and, therefore, it shall be considered as the first relevant action for the project implementation.

C.2. Expected operational lifetime of project activity

>>
20 years

C.3. Crediting period of project activity

C.3.1. Type of crediting period

>>
Renewable

C.3.2. Start date of crediting period

>>
01/01/2016

C.3.3. Duration of crediting period

>>
7 years – 0 months

SECTION D. Environmental impacts

D.1. Analysis of environmental impacts

>>
In Brazil, the sponsor of any project that involves construction, installation, expansion or operation of any polluting or potentially polluting activity or any other capable to cause environmental degradation is obliged to secure a several permits from the relevant environmental agency (federal and/or local, depending on the project).
Licenses required by the Brazilian environmental regulation (National Environmental Council – from the Portuguese CONAMA - *Conselho Nacional do Meio Ambiente* nr. 237/97[54]) are:

- The preliminary license (*Licença Prévia* or LP);
- The construction license (*Licença de Instalação* or LI); and
- The operating license (*Licenca de Operação* or LO).

No transboundary impacts additional to those already observed before the implementation of the project are expected. Additionally, it is expected that the impacts due to the implementation of the project are to be positive once it involves civil works to improve the environmental quality of the Oeste de Caucaia Landfill, including the LFG collection system, leachate treatment improvement, final closure and capping of the landfill and monitoring of environmental parameters (ground-water quality leachate treatment facility monitoring).
Environmental impacts related to the construction and operation of Oeste de Caucaia - Ecofor landfill were raised at the Environmental Study Assessment prepared to the Landfill Process of Environmental Licensing, and submitted to *Superintendência Estadual do Meio Ambiente*

[54] Available at: http://www.mma.gov.br/port/ conama/res/res97/res23797.html.

(SEMACE). Oeste de Caucaia - Ecofor Operating License for sanitary landfill activities LO #352/2014 – DICOP – GECON was issued on May 8th, 2014 and is valid up to May 8th, 2015. Currently, operation license (LO) for landfilling activities is under renewing period and waiting the environmental agency analysis.

Regarding the LFG capture and upgrading for delivering it to the NG distribution network, the Environmental Impact Study ("EIA", from the Portuguese Estudo de Impacto Ambiental), Environmental Impact Report ("RIMA", from the Portuguese Relatório de Impacto Ambiental) and the Risk Analysis Study ("EAR", from the Portuguese Estudo de Análise de Risco) were prepared for the licensing process.

EIA/RIMA presents 104 impacts regarding the project construction and operation, which 54% are positive, 45% are negative and 1% is classified as undefined. For the impacts identified, mitigating measures were planned for the construction site implementation, soil erosion control, recuperation of degraded areas, water quality control (superficial and underground), gases, sound, vectors and air quality control, accident prevention and safety work, indemnification measures, environmental and social education with employees and local community, and others..

Regarding EAR, it concludes that fatalities due to the project implementation reach 1% and, therefore, this result demonstrates that local population is not exposed to inacceptable risks and the project implementation is accepted under the Technical Instruction for Studies Presentation of Risk Analysis and Technical Norm "P4.261 – Accident Risk of Technological Nature – Methods for Decision and Reference Terms".

Since no major impacts were identified given the project implementation, the construction license (LI) for the LFG capture and destruction/use LI #172/2014 was issued on July 2nd, 2014 and is valid up to July 1st, 2016.

D.2. Environmental impact assessment

>>

As previously explained the environmental negative impacts of the project's implementation are not considered significant and all impacts raised were properly described in the Environmental Study and analysed by SEMACE.

SECTION E. Local stakeholder consultation

E.1. Modalities for local stakeholder consultation

>>

According to Resolution nr. 7, issued on March 5th 2008[55], Brazilian Designated National Authority (*Comissão Interministerial de Mudanças Globais do Clima – CIMGC)*, requests, among other documents, comments from local stakeholders in order to provide the Letter of Approval for a project.

The Resolution determines that the project proponent has to send invite for comments, at least, the following agents involved in and affected by project activity:

- Municipal governments and City Councils;
- State and Municipal Environmental Agencies;
- Brazilian Forum of NGOs and Social Movements for Environment and Development;
- Community associations;
- State Attorney for the Public Interest (state and federal);

The same resolution also requires that at the time these letters are sent, a version of the PDD in the local language and a declaration stating how the project contributes to the sustainable development of the country must be made available to these stakeholders at least 15 days previous to the starting of the Global Stakeholder Process (GSP).

The Portuguese version of the PDD was published at the internet website <http://sites.google.com/site/dcpconsulta/> on 25/06/2014 which is also the date when the invitation letters were sent to the following agents:

- Caucaia City Hall/Prefeitura Municipal de Caucaia

[55] Available at: <http://www.mct.gov.br/>.

- Caucaia Municipal Assembly/Câmara Municipal de Caucaia;
- Caucaia Environmental Agency/Instituto do Meio Ambiente Municipal de Caucaia
- Ceará State Attorney for the Public Interest/Ministério Público do Estado do Ceará
- Brazilian Forum of NGOs and Social Movements for the Development and Environment/FBOMS - Fórum Brasileiro de ONGs e Movimentos Sociais para o Meio Ambiente e o Desenvolvimento
- Federal Attorney for the Public Interest/Ministério Público Federal
- Brazilian Association of Sanitary and Environment Engineering/ABES – Ceará – Associação Brasileira de Engenharia Sanitária e Ambiental
- Ceará State Environmental Agency/SEMACE - Superintendência Estadual do Meio Ambiente

Copies of the letters and post office confirmation of receipt are available upon request and will be submitted to the DOE during the validation of the Project Activity.

E.2. Summary of comments received

>>
No comments have been received yet.

E.3. Consideration of comments received

>>
No comments have been received yet.

SECTION F. Approval and authorization

>>
Not applicable. The Letter of Approval from the Brazilian DNA is to be requested and will be available only after the conclusion of the validation.

Appendix 1. Contact information of project participants

Organization name	GNR Fortaleza Valorização de Biogás Ltda.
Country	Brazil
Address	R Joaci Sampaio Pontes, 1696-A, sala 04
Telephone	+55 (21) 3177-5900
Fax	-
E-mail	-
Website	http://www.mdcpar.com.br/
Contact person	Mr. Marcio S. Pinto

Appendix 2. Affirmation regarding public funding

No public funding for this project has been obtained.

Appendix 3. Applicability of methodologies and standardized baselines

Not applicable. This section is intentionally left blank. Please refer to sections B.6.1 and B.6.3. for details regarding the emission factor of the Brazilian Interconnected Grid calculation.

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

Not applicable. This section is intentionally left blank.

Appendix 5. Further background information on monitoring plan

This section is intentionally left blank. For details, please, refer to B.7.1. and B.7.2.

Appendix 6. Summary report of comments received from local stakeholders

Not applicable. This section is intentionally left blank.

Appendix 7. Summary of post-registration changes

Two post-registration change are being proposed in the current version of the PDD. The first one is a change to project design and consists of an update of the existent landfill area from what was described in the registered PDD. This amendment is foreseen in paragraph 1 (d) of the CDM Project Standard Appendix:

> *"(d) Changes to the project design of a registered CDM project activity that do not adversely impact any of the following:*
>
> > *(i) The applicability and application of the applied methodologies, the applied standardized baselines and the other applied methodological regulatory documents with which the project activity has been registered;*

(ii) The additionality of the project activity;
(iii) The scale of the project activity."

The amount of waste deposited at the project site was also updated according to the most recent data monitored by the project proponent, which were not available during the validation of the Project Activity. No significant difference can be observed with respect to the information provided in the first registered version of the PDD, but emission reductions were revised accordingly. Nonetheless, this update resulted in a more conservative ex-ante estimative, since there will be no increase in the LFG generation capacity.

In addition, a second post registration change in the registered monitoring plan is submitted aiming at revising Section B.6.1 in order to include additional options to determine the mass flow of gases containing methane depending on the properties (e.g. temperature, humidity, among others) of the monitored gas flow (i.e. LFG or biomethane).

The inclusion of other options provided by the tool that were not considered in the registered version of the PDD, mainly Option B, sought to increase consistency between the PDD and the operational reality of the project.

This second modification corresponds to option c), paragraph 1 of the Project Standard Appendix:

> *"(c) Changes to the monitoring of a registered CDM project activity that have no material impact on the applicability of the applied methodologies or the other applied methodological regulatory documents, or the accuracy and completeness of the monitoring;"*

As a consequence, Sections B.6.2. and B.7.1 were updated following the requirements of the tool *"Tool to determine the mass flow of a greenhouse gas in a gaseous stream"* as detailed below:

For fixed parameters (Section B.6.2.)

- R_u and MM_i: exclusion of the mention of the use of the parameter for the calculation of project emissions and "additional comments", as per the tool;
- MM_k: exclusion of "additional comments" since this parameter may be applicable to monitored data;
- MM_{H2O}: inclusion of the parameter that may be applicable for circumstances when additional options used to determine the mass flow of gases containing methane, listed in the revised version of the PDD, are used;
- P_n *and* T_n*:* exclusion of "additional comments", as per the tool

For monitored parameters (Section B.7.1.)

- Vt,wb: revision of additional comments to include option B;
- Vt,db, and $V_{i,}$t,db: revision of additional comments to increase consistency with the provisions of the tool;
- $v_{i,t,wb}$: revised additional comments to increase consistency between the tool and the applicable options listed in the revised version of the PDD
- $P_{H2O,t,Sat}$: inclusion of the parameter , as per the applicable tool;
- Tt and Pt: revision of additional comments aiming at excluding specific mention to the gas flow monitored.

It should be noted that there is no increase in capacity of the LFG capture system or addition of new equipment that increases its capacity to upgrade the captured landfill gas. Hence, these revisions neither influences the applicability of the methodology nor the additionality and scale of the project, as determined in the provisions of the applicable paragraph of the Project Standard.

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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.

Version	*Date*	*Description*
10.0	7 June 2017	Revision to: • Improve consistency with the “CDM project standard for project activities” and with the PoA-DD and CPA-DD forms; • Make editorial improvement.
09.0	24 May 2017	Revision to: • Ensure consistency with the “CDM project standard for project activities” (CDM-EB93-A04-STAN) (version 01.0); • Incorporate the “Project design document form for small-scale CDM project activities” (CDM-SSC-PDD-FORM); • Make editorial improvement.
08.0	22 July 2016	EB 90, Annex 1 Revision to include provisions related to automatically additional project activities.
07.0	15 April 2016	Revision to ensure consistency with the “Standard: Applicability of sectoral scopes” (CDM-EB88-A04-STAN) (version 01.0).
06.0	9 March 2015	Revision to: • Include provisions related to statement on erroneous inclusion of a CPA; • Include provisions related to delayed submission of a monitoring plan; • Provisions related to local stakeholder consultation; • Provisions related to the Host Party; • Make editorial improvement.
05.0	25 June 2014	Revision to: • Include the Attachment: Instructions for filling out the project design document form for CDM project activities (these instructions supersede the "Guidelines for completing the project design document form" (Version 01.0)); • Include provisions related to standardized baselines; • Add contact information on a responsible person(s)/ entity(ies) for the application of the methodology (ies) to the project activity in B.7.4 and Appendix 1; • Change the reference number from F-CDM-PDD to CDM-PDD-FORM; • Make editorial improvement.
04.1	11 April 2012	Editorial revision to change version 02 line in history box from Annex 06 to Annex 06b.
04.0	13 March 2012	Revision required to ensure consistency with the “Guidelines for completing the project design document form for CDM project activities” (EB 66, Annex 8).
03.0	26 July 2006	EB 25, Annex 15
02.0	14 June 2004	EB 14, Annex 06b
01.0	03 August 2002	EB 05, Paragraph 12 Initial adoption.

Version	*Date*	*Description*

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