Project design document form for CDM project activities

(Version 08.0)

PROJECT DESIGN DOCUMENT (PDD)	
Title of the project activity	CTR Candeias Landfill Gas Project
Version number of the PDD	Version 11.2
Completion date of the PDD	08/11/2016
Project participant(s)	**Brazil:** Haztec Tecnologia e Planejamento Ambiental SA; **Spain:** International Bank for Reconstruction and Development, as Trustee of the Spanish Carbon Fund (SCF); Kingdom of Spain - Ministry of Agriculture, Food and Environment and Ministry of Economy and Competitiveness; Endesa Generacion S.A.; **Sweden:** Swedish Energy Agency; **Norway:** Norwegian Ministry of Climate and Environment; **Germany:** E.ON Climate & Renewables GmbH.
Host Party	Brazil
Applied methodology(ies) and, where applicable, applied standardized baseline(s)	ACM0001, Version 11: Consolidated baseline and monitoring methodologies for landfill gas project activities.
Sectoral scope(s) linked to the applied methodology(ies)	Sectoral Scopes: 13.-Waste handling and disposal; and 1.-Energy industries (renewable-/ non-renewable sources)
Estimated amount of annual average GHG emission reductions	155,112 tCO_2e

SECTION A. Description of project activity

A.1. Purpose and general description of project activity

The objective of the CTR Candeias Landfill Gas Project is to capture and burn the methane (CH4) emissions generated by the decay of organic waste from the CTR Candeias Sanitary landfill located in the municipality of Jaboatão dos Guararapes, in the Recife Metropolitan Area. The project also intends to generate electricity from the combustion of methane and sale it to the national electricity grid and thus reduce CO2 emissions by displacing electricity generated from fossil fuels.

The landfill of CTR Candeias, built and operated by Haztec Tecnologia e Planejamento Ambiental SA (Haztec)[1], is strategically located close to major cities in the Recife Metropolitan Area and is the first sanitary landfill in the State of Pernambuco. The landfill started operations in August 2007 and received all necessary environmental licenses for operations. The landfill was designed to operate over a 16 years-period and will thus be closed by the end of 2022.

The municipal landfill covers an area of over 170,000 m2 and will receive about 11 million tons of solid waste during the period 2007-2022. Landfill gas (LFG) extraction and flaring will begin in 2011, while electricity production is scheduled to begin in 2012 after testing the LFG quality. Electricity will be delivered to the national grid, displacing electricity from the Brazilian national grid. Installed capacity will go from 4.245 MW in 2012 to 8.490 MW in 2017. The LFG extracted that will not be used to generate electricity will be flared (enclosed system). The scenario existing prior the start of the project activity is the same as the baseline scenario (i.e., atmospheric release of the LFG).

Based on the ex-ante estimates, the annual average emission reduction is estimated to be 155,112 tCO2e per year over the first crediting period.

Social and environmental benefits:
The project will improve local health and the environment. Contaminated leachate and surface run-off from existing dumpsites are affecting ground and surface water quality. The uncontrolled release of landfill gas (LFG) is similarly impacting the environment and leading to risks of explosions in uncontrolled open dumpsites. With the operation of the CTR Candeias sanitary landfill, environmental health risks and the potential for explosions are greatly reduced. The project will also have a limited, but positive impact on local employment through the recruitment of staff for day-to-day operation of the landfill facilities.

A.2. Location of project activity

A.2.1. Host Party

Brazil

[1] Formerly known as NovaGerar. On July 01, 2009 NovaGerar merged with Haztec Tecnologia e Planejamento Ambiental S.A. (Haztec); Haztec is thereby assuming all rights and obligations. Haztec is a private entity.

A.2.2. Region/State/Province etc.

State of Pernambuco

A.2.3. City/Town/Community etc.

Jaboatão dos Guararapes, in Recife Metropolitan Area

A.2.4. Physical/Geographical location

The project site is located in the Municipality of Jaboatão dos Guararapes in the Recife Metropolitan Area. Several poor communities are located in the vicinity of the project. The landfill is strategically situated close to three major cities in the state of Pernambuco: Recife, Jaboatão dos Guararapes, and Cabo de Santo Agostinho. Due to its central location, the landfill will potentially provide services to a metropolitan area of 3.8 million inhabitants. The site, which is located at coordinates Latitude -8.164258; Longitude:-34.985286, is shown on Map 1.

Map 1 – Location of the CTR Candeias Landfill Gas Project (Source: IBGE[2])

A.3. Technologies and/or measures

Candeias landfill site started receiving waste in 2007[3]. The landfill is expected to receive waste for 15 years[4]. Waste received over 16 years will reach about 11 million tons. This estimate is

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[2] Adapted from <http://mapas.ibge.gov.br>

[3] Source: Waste weight control reports (2007).

[4] Source: Project description (Projeto Executivo do Aterro Sanitario de Muribeca). Report No: 832-SAP-PEM-RT-E100 July 2006, page 60.

based on the volume received and monitored between 2007-2009[5] and expected waste to be disposed from 2010 until closure 2022[6].

Based on samplings, the waste composition is: food & food waste 48.3%, paper 12.9%, textile 3.8%, wood & wood product 0.6%, garden waste 0%, and the following inert fractions plastic 15.2%, glass 2.1% metal 1.2%, other inert matter: 15.9% [7].
The scenario that exist prior the project activity is the same as the baseline scenario (atmospheric release of the LFG).

Current situation and baseline scenarios:

- The site has no organized passive vents.
- There is no equipment for flaring landfill gas.

The baseline scenario, as identified later in sections B.4 and B.5, is therefore the continuation of the current operation where waste is being land-filled until the closure of the site without any gas recovery, and gas produced is being emitted into the atmosphere.

Proposed project activity:

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

Landfill gas collection system:

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

- Vertical wells used to extract gas and leachate;
- Horizontal wells used to extract gas;
- Optimal well spacing for maximum gas collection whilst minimizing costs;
- Wellheads designed for gas measurements;
- Blowers;
- Condensate extraction and storage systems designed at strategic low points throughout the gas system; and

[5] Source: Waste weight control reports (2007-2009)

[6] Based on technical capacity of 2,100 tons per day, Source: Project description (Projeto Executivo do Aterro Sanitario de Muribeca). Report No: 832-SAP-PEM-RT-E100 July 2006 page 60.

[7] Source: Waste characterization study, Candeais landfill, 2010 (*Ensaios de caracterização gravimetrica dos residuos dispostos* NA CTR CANDEIAS, Nov. 2010)

- Pipeline collection system to connect the LFG collected with the electricity generation and flaring systems.

Photo 1 – Example of Transmission Pipeline – Adrianópolis Landfill/Brazil

The landfill will be covered by clay to prevent the biogas to come out through the landfill surface. The LFG collection efficiency (40%[8]) was considered in the calculations of the emission reductions ex-ante.

Landfill gas pre-treatment system:

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

Enclosed flaring system:

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

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

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

The flare will be purchased from Annex-I country.

The flare system, with a capacity to process 5,000Nm^3/h of LFG, will achieve destruction efficiency greater than 99% of total organic compounds and greater than 98% of total non-methane volatile organic compounds (NMVOC) throughout the entire flare operating range, without any burner adjustments or flare modification[9]. For the ex-ante estimates of the emission

[8] Source: Feasibility Study (*Relatório Ambiental - Biogás - CANDEIAS - Rv 03, Sept 2009*)

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

reductions, and for conservative reasons, 90% flare efficiency has been considered. The average lifetime of the equipments of the system is between 15 to 20 years[10].

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

Photo 2 – Example of Flare System – Adrianópolis Landfill/Brazil

Electricity generation system and grid connection system

Electricity generation is expected to begin in 2012 and last until 2026 (i.e., the expected date when the gas extracted will be too low to justify the operation and maintenance costs, refer to section B.5).

Modular units have been selected for the site. Each unit will be composed of 3 generators, each having a capacity of 1.415 MW (or a combined total capacity of 4.245 MW). The engines will be imported from Annex 1 country.

Based on the volume of gas extracted, the number of modular units selected for this landfill is: **1 X 3 engines from 2012-2016, 2 X 3 engines units from 2017-2023, and 1 X 3 engines from 2024-2026. From 2024 until 2026 only one unit (1 X 3) will be required given the lower quantity of LFG extracted.**

Table below shows the methane gas generated, captured, flared and used to generated electricity.

[10] Ibid

Parameters	Units	First crediting period (Estimated from 01/08/2011 – 31/07/2018)							
		1 2011[11]	2 2012	3 2013	4 2014	5 2015	6 2016	7 2017	8 2018[12]
CH4 generated from landfill	(m3 * 1000)	**7,406**	**20,846**	**23,234**	**25,076**	**26,535**	**27,724**	**28,716**	**17,172**
CH4 captured	(m3 * 1000)	**2,963**	**8,338**	**9,293**	**10,030**	**10,614**	**11,089**	**11,487**	**6,869**
CH4 to flare	(m3 * 1000)	2,963	238	1,193	1,930	2,514	2,989	0	0
CH4 to electricity generation	(m3 * 1000)	0	8,100	8,100	8,100	8,100	8,100	11,487	6,869

Engine overhaul is required after 60,000 hours of operation[13]. This will extend the life of the engine to another 60,000 hours. Thus the overall lifetime is expected to be about 15 years.

Grid Connection System

Two electricity transformers (3 phases, 60 Hz) will be required to transform the power and deliver it to the grid (voltage input 380 V, output 13.8 KV, capacity: 12,500 KVA).

Monitoring system:

The process will be controlled by an electrical control system equipped with a Programmable Logical Controller (PLC). All details related to monitoring of CDM project are provided in section B.7.1 and B.7.2 of this PDD.

[11] From 01/08/2011 to 31/12/2011

[12] From 01/01//2018 to 31/07/2018

[13] Source: Engine specifications (Overhaull Motores JMS 420.pdf & Email of GE Power.pdf)

A.4. Parties and project participants

Party involved (host) indicates host Party	Private and/or public entity(ies) project participants (as applicable)	Indicate if the Party involved wishes to be considered as project participant (Yes/No)
Brazil (host)	Haztec Tecnologia e Planejamento Ambiental S.A. (private entity)	No
Spain	International Bank for Reconstruction and Development, as Trustee of the Spanish Carbon Fund (SCF) (multilateral); Kingdom of Spain - Ministry of Agriculture, Food and Environment and Ministry of Economy and Competitiveness (public entity); Endesa Generacion S.A. (private entity)	Yes
Sweden	Swedish Energy Agency (public entity)	Yes
Norway	Norwegian Ministry of Climate and Environment (public entity)	Yes
Germany	E.ON Climate & Renewables GmbH (private entity)	No

A.5. Public funding of project activity

There is no public funding involved in this project.

SECTION B. Application of selected approved baseline and monitoring methodology and standardized baseline

B.1. Reference of methodology and standardized baseline

The baseline methodology and tools applied to CTR Candeias Landfill Gas Project are:

- ACM0001 – version 11: *“Consolidated baseline and monitoring methodology for landfill gas project activities.”*
- Version 05.2 – *“Tool for the demonstration and assessment of additonality”*

- *"Tool to determine project emissions from flaring gases containing methane".* EB28, Annex 13
- Version 01- *"Tool to calculate baseline, project and/or leakage emissions from electricity consumption".*
- Version 02- *"Tool to calculate project or leakage CO2 emissions from fossil fuel combustion".*
- Version 05- "*Tool to determine methane emissions avoided from disposal of waste at a solid waste disposal site".*
- Version 02 - *"Tool to calculate the emission factor for an electricity system".*

B.2. Applicability of methodology and standardized baseline

ACM0001-"Consolidated baseline and monitoring methodology for landfill gas project activities - Version 11" is applicable to landfill gas capture project activities, where the baseline scenarios are the partial or total atmospheric release of the gas and the project activities include situations such as:

a) The captured gas is flared; and/or
b) The captured gas is used to produce energy (e.g. electricity/thermal energy). Emission reductions can be claimed for thermal energy generation, only if the LFG displaces use of fossil fuel either in a boiler or in an air heater. For claiming emission reductions for other thermal energy equipment (e.g. kiln), project proponents may submit a revision to this methodology;
c) The captured gas is used to supply consumers through natural gas distribution network.

Thus, the methodology ACM0001 is applicable to the CTR Candeias Landfill Gas Project because the baseline scenario is the atmospheric release of the gas and the project activity is listed as option b) of the methodology.

The *"Tool to determine project emissions from flaring gases containing methane"* EB28, Annex 13 is applicable to projects where residual gas stream to be flared contains no other combustible gases than methane, carbon monoxide and hydrogen and the residual gas to be flared isobtained from decomposition of organic material (through landfills, bio-digesters or anaerobic lagoons, among others). The project activity includes the flaring of the residual gas (not used to generate electricity), obtained from decomposition of municipal organic waste and thus the tool is applicable to the project.

The *"Tool to calculate baseline, project and/or leakage emissions from electricity consumption"* Version 01 applied to situations where electricity is consumed in the project, thus this tool is applicable to the project. Furthermore, the Scenario A applied to the project case (i.e., electricity consumption from the grid).

The *"Tool to determine methane emissions avoided from disposal of waste at a solid waste disposal site"* Version 05 is not applicable to hazardous waste and applicable in cases where the solid waste disposal site where the waste would be dumped can be clearly identified. Under this project activity, e municipal waste (non hazardous) will be deposited in a site that is clearly identified, thus the tool is applicable to the project.

The *"Tool to calculate the emission factor for an electricity system"* version 02 is used to calculate the avoided emissions from grid-connected electricity generation from biogas.

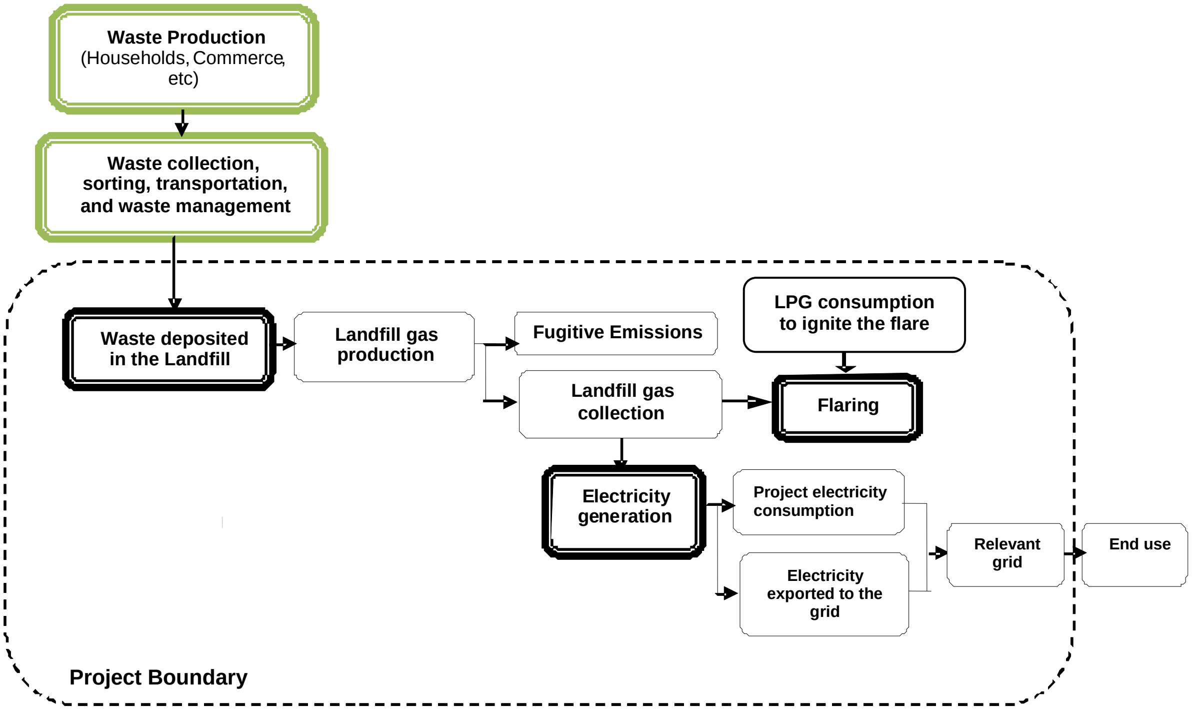
The *"Tool to calculate project or leakage CO2 emissions from fossil fuel combustion"* version 02 is applicable for the purpose of calculating the project CO2 emissions from the combustion of fossil fuels in cases where CO2 emissions from fossil fuel combustion are calculated based on the quantity of fuel combusted and its properties. For the current project activity, since the quantity of fuel combusted and its properties are monitored, then the tool is applicable.

The "Combined tool to identify the baseline scenario and demonstrate additionality" is not necessary since the additionality is demonstrated using the "Tool for the demonstration and assessment of additionality".

B.3. Project boundary

Source		GHGs	Included?	Justification/Explanation
Baseline scenario	Emissions from decomposition of waste at the landfill site	CO_2	No	CO_2 emissions from combustion or decomposition of biomass are not counted as GHG emissions.
		CH4	Yes	Major source of emissions in the baseline.
		N_2O	No	N_2O emissions are small compared to CH4 emissions from landfills. Exclusion of this gas is conservative
	Emissions from electricity consumption	CO_2	Yes	Electricity consumed from the grid in the baseline scenario
		CH4	No	Excluded for simplification. This is conservative.
		N_2O	No	Excluded for simplification. This is conservative.
	Emissions from thermal energy generation	CO_2	No	There is no thermal energy generation included in the baseline scenario
		CH4	No	There is no thermal energy generation included in the baseline scenario
		N_2O	No	There is no thermal energy generation included in the baseline scenario
Project scenario	On-site fossil fuel consumption due to the project activity other than for electricity generation	CO_2	Yes	Minor – only for flare ignition. It has been included
		CH4	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 on-site electricity use	CO_2	Yes	Minor - only during shut down and when the plant starts up after shut down period. It has been included
		CH4	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	CO_2	Yes	Electricity consumed from the grid in the baseline scenario
		CH4	No	Excluded for simplification. This is conservative.
		N_2O	No	Excluded for simplification. This is conservative.

The power plant unit will not consume electricity from the grid. When electricity is not produced in the power plant unit, the landfill gas will be flared; in this situation the project will consume electricity from the grid. This is also indicated in figure below presenting the project boundary.



B.4. Establishment and description of baseline scenario

As per the approved methodology, the procedures to identify the most plausible scenario consist in the following 4 steps.

Step 1. Identification of alternative scenarios
The baseline scenario is defined as the most likely scenario in the absence of the proposed CDM project.

The proposed project involves the capture and utilization of landfill gas that would be released to the atmosphere in absence of the proposed project activity. The alternatives for the disposal/treatment of the waste in the absence of the relevant for estimating baseline methane emissions, to be analyzed should include, inter alia:

LFG1: The project activity (i.e., LFG collection and utilization for power generation) undertaken without being registered as a CDM project activity. It is to be noted that the scenario including strictly flaring is not considered since there is no legislation in Brazil mandating capture and flaring of landfill gas and thus this option involves only costs, no revenues.

LFG2: Atmospheric release of the landfill gas or partial capture of landfill gas and destruction to comply with regulations or contractual requirements, or to address safety and odor. This is the most plausible course of action and is a common practice.

Alternatives LFG1 is not likely to happen without CDM revenues because of the major barriers that still prevent the adoption of LFG capture, flaring and use, including lack of awareness[14] and high investment and operating costs that exceed the revenues generated by the sale of electricity (refer to section B.5, investment analysis). LFG2 (atmospheric release of the landfill gas) is the common practice in Brazil (refer to B.5).

For power generation, the realistic and credible alternatives include, inter alia:

P1. Power generated from landfill gas undertaken without being registered as a CDM Project activity.
P2. Existing or Construction of a new on-site or off-site fossil fuel fired cogeneration plant.
P3. Existing or Construction of a new on-site or off-site renewable based cogeneration plant.
P4. Existing or Construction of a new on-site or off-site fossil fuel fired captive power plant.
P5. Existing or Construction of a new on-site or off-site renewable based captive power plant.
P6. Existing and/or new grid-connected power plants.

Since thermal energy (heat) generation is not contemplated as part of the proposed project activity, cogeneration plant is not considered as baseline alternatives; therefore P2 and P3 are discarded.

Construction of a new on-site or off-site fossil fuel fired captive power plant is not economically practical. Since the only electricity consumption at the landfill site comes from the staff office, lighting, control and monitoring equipment and blowers, a very small amount of electricity is needed at the site. Hence, it is clearly more profitable to obtain electricity from the grid connection that already exists nearby the landfill site. Beside, power production is not a core business of the landfill operator that provides solid waste services. Therefore, it can be concluded that scenarios P4, P5 are neither feasible nor plausible baseline scenarios; hence these scenarios are being discarded from further analysis.

Construction of a new on-site or off-site renewable (P5) based captive power plant is not a suitable alternative. On-site renewable power generation such as a wind farm requiring facility construction on the landfill surface would not be viable due to safety and security concerns. Again, the power production is not a core business of the landfill operator.

Power generated from landfill without being undertaken as a CDM Project activity (P1) is not likely to happened because this activity implies high investment costs and is not financially attractive without being registered as CDM project (refer to the investment analysis).

The remaining options for consideration as plausible baseline alternatives for landfill and power generation are:

LFG1: The project activity (i.e., LFG collection and utilization for power generation) undertaken without being registered as a CDM project activity.

LFG2: Atmospheric release of the landfill gas.

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[14]Barriers to LFG capture and use are further described in IEA, 2009. Turning a Liability into an Asset: the Importance of Policy in Fostering Landfill Gas Use Worldwide.

P1. Power generated from landfill gas undertaken without being registered as a CDM Project activity.

P6. Existing and/or new grid-connected power plants.

Sub-step 1b: Consistency with mandatory laws and regulations:

All remaining alternatives (i.e., LFG1, LFG2, P1 and P6) are consistent with mandatory laws and regulations in Brazil.

Currently in Brazil there are no laws or regulations mandating capture and flaring of landfill gas. The Brazilian legislation establishes that each state is responsible for the environmental license process for landfills. Thus, each state defines the laws, minimum standards, technologies, restrictions and environmental requirements for the landfills. For the case of CTR Candeias, which is located in the Pernambuco State, the environmental agency of the state (CPRH) does not require the landfill to install any landfill gas collection and flare system, including passive flaring. This is the common practice in the state of Pernambuco.

Furthermore, the Ministry of Cities has indicated that the priority for investments should consider the (i) reduction of open dumps by 50% within 5 years; (ii) unification and coordination of existing financing lines and programs; (iii) capacity building with a focus on the elaboration of integrated solid waste management plans for municipalities and states, as well as on research and support to NGOs and other technical assistance programs; and (iv) promotion of programs with socioeconomic objectives linked to waste collection, such as creation and enhancement of solid waste collection cooperatives. That may be done through concessions to private entities either to build and operate sanitary landfills or to be responsible for the whole municipality's waste management. In all cases, however, active collection and flaring of the landfill gas has never been required.

Outcome of sub-step 1b:

All alternatives scenarios described above (i.e., LFG1, LFG2, P1 and P6) are compliant with mandatory legislation and regulations.

Step 2. Identify the fuel for the baseline choice of energy source taking into account the national and/or sectoral policies as applicable

The project activity sale electricity to the Brazilian Grid; therefore, the baseline energy source is the electricity produced by the power plants connected to the Brazilian Grid. The Brazilian Grid is dominated by hydropower, thus there are no fuel supply constraints.

Step 3. Step 2 and/or step 3 of the "Tool for the demonstration and assessment of additionality" shall be used to assess which of these alternatives should be excluded from further consideration (e.g. alternatives facing prohibitive barriers or those clearly economically unattractive).

In this case Step 2. Investment analysis is used (refer to section B.5 for details).

Step 2. Investment analysis

As demonstrated in section B.5 of the PDD, using benchmark analysis, the project activity (LFG1 or P1) is not profitable without CDM revenues. There is only one credible alternative to remaining after this step: LFG2 (atmospheric release of the landfill gas).

Step 4
As shows in the investment analysis (refer to Section B.5) the scenario LFG1 (or P1), without CDM revenues, has an IRR lower than the benchmark and therefore is not a plausible alternative for the baseline scenario. There is thus only one credible alternative as a baseline L LFG2 and step 4 does not apply.

B.5. Demonstration of additionality

<u>Start Date and Implementation Timeline:</u>

Project Timeline	Dates	Supporting Evidences
PIN approval by the World Bank	August 15, 2006	PIN approval, 2006
Signature of the Letter of Intent (LOI) with the World Bank	February 14, 2007	LOI, 2007
ERPA signature	November 19, 2008	ERPA, 2008
Simplified Environmental Report for the biogas capture project	September 2009	Simplified Environmental Report for the biogas capture project (*Relatorio Ambiental Simplificado, Projecto de Captacao e Queima do Biogas*),2009

The equipment for the biogas capture, flaring and electricity generation are not yet purchased at the time of the validation. The starting date is set as: 01 April 2011 (targeted date for the purchase of the flare and extraction system).

Biogas capture is expected to begins in 2011 and electricity generation in 2012[15].

ACM0001 version 11 requires the use of the latest version of the “Tool for the demonstration and assessment of additionality” to prove the project is not the baseline scenario. Version 05.2 of this tool is applied as follows:

Step 1. Identification of alternatives to the project activity consistent with current laws and regulations.

Sub-step 1a: Define alternatives to the project activity

As demonstrated in section B.4, the remaining options for consideration as plausible baseline alternatives for landfill and power generation are:

LFG1: The project activity (i.e., LFG collection and utilization for power generation) undertaken without being registered as a CDM project activity.

LFG2: Atmospheric release of the landfill gas.

[15] Source: Project timeline (Cronograma CTR Candeias - Biogás - RV Setembro 2010.pdf)

P1. Power generated from landfill gas undertaken without being registered as a CDM Project activity.

P6. Existing and/or new grid-connected power plants.

Sub-step 1b: Enforcement of applicable laws and regulations

All remaining alternatives (i.e., LFG1, LFG2, P1 and P6) are consistent with mandatory laws and regulations in Brazil.

Step 2. Investment Analysis

Investment analysis is done in accordance with “Tool for the demonstration and assessment of additionality” version 05.2.

Sub-step 2a. Determine appropriate analysis method

According to the methodology for determination of additionality, option III (Benchmark analysis) is selected because one of the alternatives generates income from energy production (LFG1 or P1). The scenarios LFG2/P6 represent the continuation of the current situation and are not comparable to LFG1/P1 in term of investment. The scenarios LFG2/P6 are thus not further considered in the financial analysis.

Sub-step 2b. – Option III. Benchmark analysis

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

In order to conduct the benchmark analysis, an evaluation of the project’s cash-flow and its internal rate of return (IRR) (without CDM financial incentives) is undertaken. The benchmark analysis is undertaken by comparing the project IRR with the more conservative opportunity cost in the Brazilian economy – SELIC[16] Basic Interest Rate set by the Banco Central do Brasil (Central Bank of Brazil[17]) which represents the expected return of a low-risk investment fund in Brazil. Since the SELIC is a nominal interest rate, the Financial Analysis is developed in nominal terms, excluding income taxes.This is a very conservative benchmark, since it does not include any risk adjustment. The nominal SELIC value selected is among the lowest values in the latest years[18] 10.25%, which in real terms in 2010 represents 5.5%.

All values of financial parameters are reported below[19]:

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[16] SELIC (Sistema Especial de Liquidação e Custódia – Special System of Clearance and Custody) rate is the weighted average of the rates traded in overnight repurchase agreements backed by government bonds registered in SELIC.

[17] Central Bank of Brazil, http://www.bcb.gov.br/

[18] Source: Central Bank of Brazil: historical values of the SELIC rate http://www.bcb.gov.br/?INTEREST

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

- Investment analysis is conducted over a period of 21 years (until 2030) based on the expected lifetime of the project[20,21]
- Inflation rate: 4.5%[22]
- Sales taxes[23]. In order to be conservative it has been included only the Federal sale taxes (PIS and COFINS), excluding other state taxes such as ICMS or municipal taxes:
    - PIS (Profit Participation Contribution): 1.65%
    - COFINS (Social Security Financing Contribution): 7.60%
- Benchmark is equivalent to the SELIC rate: 10.25% (June, 9, 2010)[24].
- Exchange rate used for the investment analysis: 1.80 R$/US$ and 2.2 R$/Euro[25].
- Generation capacity: maximum generation capacity is 8.49 MW. Units in service will be the following:
- 2012-2016: 3 units X 1.06 MW, total 4.245 MW
- 2017-2023: 6 units X 1.06 MW, total 8.490 MW
- 2024-2026: 3 units X 1.06 MW, total 4.245 MW
- Revenues from electricity are calculated using the latest available Renewable Energy Auction (small hydro, bagasse and wind) in Brazil (2010): 148.39 R$/MWh[26] (82.4 US$/MWh).
- Generation of electricity is declining after 2023 and being no longer profitable to continue operations after 2026. Electricity generation is thus stopped in 2027; however, the flaring activity is scheduled to continue until 2030.
- Investment[27]:
    - o Pipelines, wellheads and Drill: R$ 4,422,533 (US$ 2,456,963)
    - o Biogas plant (blowers, pre-treatment, flare): R$ 3,339,000 (US$ 1,855,000)
    - o Group motor including engines, construction of the plant, connection, etc: R$ 13,683,462 (US$ 7,601,923.47)
- Operation and Maintenance[28]:
    - o O&M electricity system: 576,000 R$/y (320,000US$/y) (fixed) and 36 R$/MWh (20US$/MWh).
    - o O&M LFG system costs: 354,240 R$/y (196,800US$/y).
    - o Administrative costs: 180,000 R$/y (100,000 US$/y).
    - o Insurance costs: 0.177% of investment/y.

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

[21] lifetime of equipment, Source: spec ZTOF JZ.pdf

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

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

http://www.receita.fazenda.gov.br/PessoaJuridica/PisPasepCofins/IncidenciaExportServico.htm#Base

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

[25] Bank of Brazil, June 30, 2010.

[26] The reference price for the electricity is based on the second auction for renewable energy sources (August 28, 2010). Available on CCEE website.

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

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

- Overhaul for the first group motor (including 3 engines) is estimated at: R$ 400,400 (US$ 667,333) (necessary after 60,000 hours of operation)[29].
- **Fair value for the group motor operating since 2016 is included.** This group is sold in 2024 because of the declining LFG. This was calculated using depreciation rate of 10%[30] for 7 years.
- **No fair value is considered in 2030 since all remaining equipment will reach the end of their technical lifetime.** By the 2026, this group motor will reach about 120,000 hours of operation and the end of its technical lifetime[31], while the flare and piping will reach the end of the technical by 2030[32].

Sub-step 2c. – Calculation and comparison of financial indicators
Using the assumptions listed in the previous section, the calculated project IRR for alternative LFG1/P1 is **5.20%** which is below the benchmark of **10.25**%.

Sub-step 2d. Sensitivity analysis
A sensitivity analyses was made by altering the following parameters for the alternative LFG1, electricity production (without registration as a CDM Project):

- Increase of the electricity tariff + 10%
- Decrease the investment costs with + 10%
- Increase in the operation and maintenance cost with + 10%

Parameters	Variations	
	+10%	-10%
electricity tariff	9.22%	0.36%
operation and maintenance cost	2.54%	7.54%
investment costs	3.46%	7.21%

The sensitivity analyses show that in spite of the range of realistic and optimistic assumptions made, the project returns remain unfavourable (the project IRR does not reach the benchmark of **10.25**%).

In order to evaluate how reasonable is the +/- 10% sensitivity analysis, it has been made an analysis of the variation needed for each variable to reach the benchmark of 10.25%:

Parameter	Variation needed to reach the benchmark
Electricity tariff	+13%
operation and maintenance cost	-23%
investment costs	-23%

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

[30] Source: (Receita Federal,.pdf – Federal Revenue.pdf))

[31] Source: GE Power.pdf

[32] lifetime of equipment, Source: spec ZTOF JZ.pdf

The analysis of the historical electricity price from Renewable Energy auctions in Brazil[33] shows that the variation is not larger than 7% in nominal terms, which in real terms is a decrease of 8%[34]. Therefore, it is very unlikely that the electricity tariff for the project goes beyond the + 10% of the sensitivity analysis and even less unlikely to surpass +13% calculated to reach the benchmark.

As for the O&M and investment costs, the values were based on recent quotes, therefore it is very unlikely that the final cost exceed the -10% of the sensitivity analysis. Nonetheless, it is even less unlikely that they decrease 23% and 23% to reach the benchmark of 10.25%.

Step 3. Barrier analysis
Since the additionality is demonstrated using financial analysis, the barrier analysis is not undertaken.

Step 4. Common practice analysis

Sub-step 4a: Analyze other activities similar to the proposed project activity

As it was mentioned in section B.4., the Brazilian legislation establishes that each state is responsible for the environmental license process for landfills. Thus, each state defines the laws, minimum standards, technologies, restrictions and environmental requirements for the landfills. In this context, the state should be considered the relevant geographical region to conduct the common practice analysis.

For the case of CTR Candeias, which is located in the Pernambuco State, the environmental agency of the state (CPRH) does not require the landfill to install any landfill gas collection and flare system, including passive flaring. This is the common practice in the state of Pernambuco, as it is reflected in the most recent "Diagnostic of Urban Solid Waste Management-2008 *(Diagnostico do Manejo de Residuos Solidos Urbanos -2008*)"elaborated by the Brazilian Ministry of the Cities and published in November 2010[35]. According to this research, none of the landfills are using/flaring the landfill gas. Therefore there is no activity similar to the proposed project activity (neither flaring of LFG, nor energy generation using LFG). In addition, the report clearly shows that the landfills in the state of Pernambuco have a very poor operational management. The following table[36] shows the characteristics of the landfills surveyed by the mentioned Diagnostic in Pernambuco, showing that there is no similar project to the proposed project activity, as no landfill/dumpsite is collecting the LFG and using it (flaring, electricity generation, etc.). In addition, the table shows that 2 out of 6 surveyed sites have very poor waste management (no impermeabilization, no passive venting, and no leachate collection and treatment).

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[33] Source: Chamber of commercialization of electricity. Auctions (Camara de comercialização de energia electrica. Leilões.)

http://www.ccee.org.br/cceeinterdsm/v/index.jsp?vgnextoid=d3caa5c1de88a010VgnVCM100000aa01a8c0RCRD. Page consulted in October 2010.

[34] The cumulative inflation between the first and second Renewable Energy Auction is 16.2%. Source:Central Bank of Brazil http://www.bcb.gov.br/pec/metas/InflationTargetingTable.pdf

[35]

[36]

	Landfill / Dumpsite characteristics				
Municipality	**Impermeabilization**	**Passive venting**	**LFG collection and utilization**	**Leachate collection and treatment**	**Uncontrolled burning of waste**
Camaragibe	No	No	No	No	No
Caruaru	Yes	Yes	No	Yes	No
Jaboatão dos Guararapes	Yes	Yes	No	Yes	No
Olinda	Yes	Yes	No	Yes	No
Rio Formoso	Yes	Yes	No	Yes	No
Serra Talhada	No	No	No	No	Yes

Outcome of sub-step 4a:

The common practice in the State of Pernambuco is to release of the landfill gas without installing any landfill gas collection and flare system, including passive flaring.

Sub-step 4b. Discuss any similar options that are occurring:

As demonstrated in the previous section this type of technology for gas collection and use is not common practice in the State of Pernambuco and according to the reference provided[37], there are no landfills in Pernambuco that operate this way as there are no regulatory incentives and the sale of electricity alone does not cover the additional costs of a biogas capture, flaring, and electricity generation system. Therefore, this kind of project is only possible with CDM revenues and is not to be considered as a business as usual activity.

B.6. Emission reductions

B.6.1. Explanation of methodological choices

Baseline emissions:

According to the methodology, the following equation should be applied to calculate the baseline emissions:

$$BE_y = \left(MD_{project,y} - MD_{BL,y}\right) * GWP_{CH4} + EL_{LFG,y} \cdot CEF_{elec,BL,y} + ET_{LFG,y} * CEF_{ther,BL,y}$$

Where:

BE_y:	=	Baseline emissions in year y (t CO_2e).
$MD_{project,y}$:	=	The amount of methane that would have been destroyed/combusted during the year, in tonnes of methane (t CH4) in project scenario.
$MD_{BL,y}$:	=	The amount of methane that would have been destroyed/combusted during the year in the absence of the project due to regulatory and/or contractual requirement, in tons of methane (t CH4)
GWP_{CH4}:	=	Global Warming Potential value for methane for the first commitment period is 21 t CO_2e/t CH4.
$EL_{LFG,y}$:	=	Net quantity of electricity produced using LFG, which in the absence of the project activity would have been produced by power plants connected to the

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grid or by an on-site/off-site fossil fuel based captive power generation, during year y, in megawatt hours (MWh).

$CEF_{elecy,BL,y}$: = CO_2 emissions intensity of the baseline source of electricity displaced, in t CO_2e/MWh.

ETLFG,y = The quantity of thermal energy produced utilizing the landfill gas, which in the absence of the project activity would have been produced from onsite/offsite fossil fuel fired boiler/air heater, during the year *y* in TJ.

CEFther,BL,y = CO2 emissions intensity of the fuel used by boiler/air heater to generate thermal energy which is displaced by LFG based thermal energy generation, in tCO2e/TJ.

The baseline emissions in a given year "y" (BE_y) is the difference between the amount of methane actually destroyed/combusted during the year ($MD_{project,y}$) and the amount of methane that would have been destroyed/combusted during the year in the absence of the project activity ($MD_{BL,y}$), times the approved Global Warming Potential value for methane (GWP_{CH4}), plus the net quantity of electricity displaced during the year (EG_y) multiplied by the CO2 emissions intensity of the electricity displaced ($CEF_{electricity,y}$).

The term $MD_{BL,y}$ is calculated using the following equation:

$$MD_{BL,y} = MD_{project,y} * AF$$

In the case of the Candeias landfill, the term $MD_{BL,y}$ is assumed to be zero since there are no regulations or contractual agreements requiring capture and flaring of methane. The Brazilian legislation establishes that each state is responsible for the environmental license process for landfills. Thus, each state defines the laws, minimum standards, technologies, restrictions and environmental requirements for the landfills. For the case of CTR Candeias, which is located in the Pernambuco State, the environmental agency of the state (CPRH) did not require the landfill to install any landfill gas collection and flare system, including passive flaring. This is the common practice in the state of Pernambuco[38].

The last term of the equation *ETLFG,y,* is equal to zero since there is no thermal energy produced by the project activity.

Thus, the previous equation is simplified to:

$$BE_y = MD_{project,y} * GWP_{CH4} + EL_{LFG,y} * CEF_{elec,BL,y}$$

Ex-ante estimation of the amount of methane destroyed during the year, in tones of methane ($MD_{project,y}$)

Ex-ante baseline emissions are estimated as per the **"***Tool to determine methane emissions avoided from disposal of waste at a solid waste disposal site*" version 05, where BECH4,SWDS,y represents the methane emissions generated during the year *y* from the disposal of waste at the solid waste disposal site during the period from the start of the project activity to the end of the year y (tCO_2e).

[38] This common practice was verified by the DOE during the validation visit. In addition, the DOE verified that the environmental licence of CTR Candeias did not require the installation of any flaring system.

As per the tool, we have that:

$MD_{project,y} = BE_{CH4,SWDS,y}/GWP_{CH4}$

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

Where:

$BE_{CH4,SWDS,y}$ =	Methane emissions avoided during the year y from preventing waste disposal at the solid waste disposal site (SWDS) during the period from the start of the project activity to the end of the year y (tCO_2e).
φ =	Model correction factor to account for model uncertainties (0.9).
f =	Fraction of methane captured at the SWDS and flared, combusted or used in another manner (0).
GWP_{CH4} =	Global Warming Potential (GWP) of methane, valid for the relevant commitment period (21).
OX =	Oxidation factor (reflecting the amount of methane from SWDS that is oxidized in the soil or other material covering the waste) (0.1).
F =	Fraction of methane in the SWDS gas (volume fraction) (0.5).
DOC_f =	Fraction of degradable organic carbon (DOC) that can decompose (0.5)
MCF =	Methane correction factor (1).
$W_{j,x}$ =	Amount of organic waste type *j* disposed in the SWDS in the year *x* (tons) (tpd).
DOC_j =	Fraction of degradable organic carbon (by weight) in the waste type *j.*
k_j =	Decay rate for the waste type *j.*
j =	Waste type category (index).
x =	Year during the crediting period: x runs from the first year of the first crediting period (x = 1) to the year y for which avoided emissions are calculated (x = y).
y =	Year for which methane emissions are calculated.

The efficiency of the degassing system (E_{DS} = 40%)[39], as well as the flare efficiency (90%)[40] which will be installed in the project activity have both been taken into account while estimating the *ex ante* emission reductions.

Ex-post estimation of the amount of methane destroyed during the year, in tones of methane ($MD_{project,y}$)

$MD_{project,y}$ will be determined *ex post* by metering the actual quantity of methane captured and destroyed once the project activity is operational. The methane destroyed by the project activity ($MD_{project,y}$) during a year is determined by monitoring the quantity of methane actually flared and gas used to generate electricity and the total quantity of methane captured.

$MD_{project,y} = MD_{electricity,y} + MD_{flared,y} + MD_{thermal,y} + MD_{PL,y}$

Where:

$MD_{electricity,y}$	=	Quantity of methane destroyed by generation of electricity (t CH4).
$MD_{flared,y}$	=	Quantity of methane destroyed by flaring (t CH4).

[39] Source: Feasibility Study (*Relatório Ambiental - Biogás - CANDEIAS - Rv 03, Sept 2009*)

[40] Source: Tool to determine project emissions from flaring gases containing methane. EB 28 Annex 13

$MD_{thermal,y}$ = Quantity of methane destroyed for generation of thermal energy (t CH4).
$MD_{PL,y}$ = Quantity of methane sent to the pipeline for feeding to the natural gas distribution (tCH4).

The sum of the quantities fed to the flare and the power plant will be compared annually with the total quantity of methane captured. The lowest value must be used as $MD_{project,y}$.

There is no thermal energy produced under this project activity and no methane sent to a pipeline and thus the previous equation can be simplified to:

$$MD_{project,\,y} = MD_{electricity,\,y} + MD_{flared,\,y}$$

Where:

$$MD_{electricity,\,y} = LFG_{electricity,y} * w_{CH4,\,y} * D_{CH4}$$

Where:

$LFG_{electricity,y}$ = Quantity of landfill gas fed into electricity generator.
$w_{CH4,y}$ = Average methane fraction of the landfill gas as measured during the year and expressed as a fraction (in m³ CH4 / m³ LFG).
D_{CH4} = Methane density expressed in tons of methane per cubic meter of methane (t $CH4/m^3$ CH4).

The quantity of methane destroyed by flaring (t CH4) is calculated using the following equation:

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

Where:

$LFG_{flare,y}$ = Quantity of landfill gas fed to the flare(s) during the year y measured in cubic meters (m^3).
$PE_{flare,y}$ = Project emissions from flaring of the residual gas stream in year y (t CO_2e) determined following the procedure described in the *"Tool to determine project emissions from flaring gases Containing Methane".* If methane is flared through more than one flare, the $PE_{flare,y}$ shall be determined for each flare using the tool.

When applying the tool, the continuous monitoring of the efficiency is selected for the enclosed flare (option b).

According to the tool, $PE_{flare,y}$ is determined as follows:

STEP 1: Determination of the mass flow rate of the residual gas that is flared
STEP 2: Determination of the mass fraction of carbon, hydrogen, oxygen and nitrogen in the residual gas
STEP 3: Determination of the volumetric flow rate of the exhaust gas on a dry basis
STEP 4: Determination of methane mass flow rate of the exhaust gas on a dry basis
STEP 5: Determination of methane mass flow rate of the residual gas on a dry basis
STEP 6: Determination of the hourly flare efficiency
STEP 7: Calculation of annual project emissions from flaring based on measured hourly values or based on default flare efficiencies.

STEP 1. Determination of the mass flow rate of the residual gas that is flared

As per the tool, using the simplified approach, the project developer will only measure the volumetric fraction of methane and consider the difference to 100% as being nitrogen (N_2).

$$FM_{RG,h} = \rho_{RG,n,h} \times FV_{RG,h}$$

Where

Variable	SI unit	Description
$FM_{RG,h}$	Kg/h	Mass flow of the residual gas in hour h
$\rho_{RG,n,h}$	Kg/m^3	Density of the residual gas at normal conditions in hour h
$FV_{RG,h}$	m^3/h	Volumetric flow rate of the residual gas in dry basis at normal (NTP) conditions[41] in the hour h

and:

$$\rho_{RG,n,h} = \frac{P_n}{\frac{R_u}{MM_{RG,h}} x T_n}$$

Where:

Variable	SI unit	Description
$\rho_{RG,n,h}$	Kg/m^3	Density of the residual gas at normal conditions in hour h
P_n	Pa	Atmospheric pressure at normal conditions (101 325)
R_u	Pa m^3/kmol K	Universal ideal gas constant (8 314)
$MM_{RG,h}$	Kg/kmol	Molecular mass of the residual gas in hour h
T_n	K	Temperature at normal conditions (273,15)

and:

$$MM_{RG,h} = \sum_i fv_{i,h} \times MM_i$$

Where

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

As per the tool, the project participant will only measure the volumetric fraction of methane and consider the difference as 100% nitrogen (N_2). Therefore, only elements C, H, N are included in the calculation of STEP 2.

STEP 2. Determination of the mass fraction of carbon, hydrogen, oxygen and nitrogen in the residual gas

[41] Normal (NTP) conditions are 101.325 kPa and 273.15 K

Determine the mass fractions of carbon, hydrogen, and nitrogen in the residual gas, calculated from the volumetric fraction of each component *i* in the residual gas, as follows:

$$fm_{j,h} = \frac{\sum_i fv_{i,h} \cdot AM_j \cdot NA_{j,i}}{MM_{RG,h}}$$

Where

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

STEP 3. Determination of the volumetric flow rate of the exhaust gas on a dry basis

This step is applicable to the project activity because the methane combustion efficiency of the flare will be continuously monitored.

The average volumetric flow rate of the exhaust gas in each hour *h* is determined based on a stoichiometric calculation of the combustion process, which depends on the chemical composition of the residual gas, the amount of air supplied to combust it and the composition of the exhaust gas, as follows:

$$TV_{n,FG,h} = V_{n,FG,h}\, XFM_{RG,h}$$

Where:

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

$$V_{n,FG,h} = V_{n,CO_2,h} + V_{n,O_2,h} + V_{n,N_2,h}$$

Where:

Variable	SI unit	Description
$V_{n,FG,h}$	m³/ kg residual gas	Volume of the exhaust gas of the flare in dry basis at normal conditions per kg of residual gas in the hour h
$V_{n,CO_2,h}$	m³/ kg residual gas	Quantity of CO_2 volume free in the exhaust gas of the flare at normal conditions per kg of residual gas in the hour h
$V_{n,O_2,h}$	m³/ kg residual gas	Quantity of O_2 volume free in the exhaust gas of the flare at normal conditions per kg of residual gas in the hour h
$V_{n,N_2,h}$	m³/ kg residual gas	Quantity of N_2 volume free in the exhaust gas of the flare at normal conditions per kg of residual gas in the hour h

$$V_{n,O_2,h} = n_{O_2,h} \, x \, MV_n$$

Where:

Variable	SI unit	Description
$V_{n,O_2,h}$	m³/ kg residual gas	Quantity of O_2 volume free in the exhaust gas of the flare at normal conditions per kg of residual gas in the hour h
$n_{O_2,h}$	kmol/kg residual gas	Quantity of moles O_2 in the exhaust gas of the flare per kg residual gas flared in hour h
MV_n	m³/ kmol	Volume of one mole of any ideal gas at normal temperature and pressure (22.4 L/mol)

$$V_{n,N_2,h} = MV_n * \left\{ \frac{fm_{N,h}}{200AM_N} + \left(\frac{1 - MF_{O2}}{MF_{O2}} \right) * \left[F_h + n_{O2,h} \right] \right\}$$

Where:

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

$$V_{n,CO_2,h} = \frac{fm_{C,h}}{AM_C} * MV_n$$

Where:

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

$$n_{O_2,h} = \frac{t_{O_2,h}}{\left[1 - \left({t_{O_2,h}}/{MF_{O_2}}\right)\right]} * \left[\frac{fm_{c,h}}{AM_c} + \frac{fm_{N,h}}{2AM_N} + \left(\frac{1 - MF_{O2}}{MF_{O2}}\right) x\ F_h\right]$$

Where

Variable	SI unit	Description
$n_{O_2,h}$	kmol/kg residual gas	Quantity of moles O_2 in the exhaust gas of the flare per kg residual gas flared in hour h
$t_{O_2,h}$	-	Volumetric fraction of O_2 in the exhaust gas in the hour h
MF_{O_2}	-	Volumetric fraction of O_2 in the air (0.21)
F_h	kmol/kg residual gas	Stochiometric quantity of moles of O_2 required for a complete oxidation of one kg residual gas in hour *h*
$fm_{j,h}$		Mass fraction of element j in the residual gas in

		hour h
AM_j	kg/kmol	Atomic mass of element j
j	-	The elements carbon (index C) and nitrogen (index N)

$$F_h = \frac{fm_{C,h}}{AM_C} + \frac{fm_{H,h}}{4AM_H} - \frac{fm_{O,h}}{2AM_O}$$

Where

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

STEP 4. Determination of methane mass flow rate in the exhaust gas on a dry basis
This step is applicable to this project activity because the combustion efficiency of the flare will be continuously monitored.

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

$$TM_{FG,h} = \frac{TV_{n,FG,h} * fv_{CH4,FG,h}}{1000000}$$

Where

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

STEP 5. Determination of methane mass flow rate in the residual gas on a dry basis

The quantity of methane in the residual gas flowing into the flare is the product of the volumetric flow rate of the residual gas ($FV_{RG,h}$), the volumetric fraction of methane in the residual gas (*fvCH4,RG,h*) and the density of methane (*CH4,n,h*) in the same reference conditions (normal conditions and dry or wet basis).

It is necessary to refer both measurements (flow rate of the residual gas and volumetric fraction of methane in the residual gas) to the same reference condition that may be dry or wet basis. If the residual gas moisture is significant (temperature greater than 60ºC), the measured flow rate of the residual gas that is usually referred to wet basis should be corrected to dry basis due to the fact that the measurement of methane is usually undertaken on a dry basis (i.e. water is removed before sample analysis).

$$TM_{RG,h} = FV_{RG,h} \times fv_{CH4,RG,h} \times \rho_{CH4,n}$$

Where:

Variable	SI unit	Description
$TM_{RG,h}$	Kg/h	Mass flow rate of methane in the residual gas in the hour h
$FV_{RG,h}$	m^3/h	Volumetric flow rate of the residual gas in dry basis at normal conditions in hour h
$fv_{CH4,RG,h}$	-	Volumetric fraction of methane in the residual gas on dry basis in hour h.
$\rho_{CH4,n}$	kg/m^3.	Density of methane at normal conditions (0.716),

STEP 6. Determination of the hourly flare efficiency

The approach used in the project is enclosed flare with continuous monitoring.

In this case the flare efficiency in the hour *h* (□□$_{flare,h}$) is

- 0% if the temperature of the exhaust gas of the flare (T_{flare}) is below 500 °C during more than 20 minutes during the hour *h*.
- determined as follows in cases where the temperature of the exhaust gas of the flare (T_{flare}) is above 500 °C for more than 40 minutes during the hour *h* :

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

Where:

Variable	SI unit	Description
$n_{flare,h}$	-	Flare efficiency in the hour h
$TM_{FG,h}$	Kg/h	Methane mass flow rate in exhaust gas averaged in a period of time t (hour, two months or year)
$TM_{RG,h}$	kg/h.	Mass flow rate of methane in the residual gas in the hour h

In case of the continuous monitoring system is unavailable for maintenance, or failure, the following methods will be used:

- 0% if the temperature in the exhaust gas of the flare (Tflare) is below 500 °C for more than 20 minutes during the hour *h* .

- 50%, if the temperature in the exhaust gas of the flare (Tflare) is above 500 °C for more than 40 minutes during the hour *h,* but the manufacturer's specifications on proper operation of the flare are not met at any point in time during the hour *h*.
- 90%, if the temperature in the exhaust gas of the flare (Tflare) is above 500 °C for more than 40 minutes during the hour *h* and the manufacturer's specifications on proper operation of the flare are met continuously during the hour *h*.

STEP 7. Calculation of annual project emissions from flaring
Project emissions from flaring are calculated as the sum of emissions from each hour *h*, based on the methane flow rate in the residual gas ($TM_{RG,h}$) and the flare efficiency during each hour *h* ($\eta_{flare,h}$), as follows:

$$PE_{flare,y} = \sum_{h=1}^{8760} TM_{RG,h} \; x \left(1 - n_{flare,h}\right) x \frac{GWP_{CH4}}{1000}$$

Where:

Variable	SI unit	Description
$PE_{flare,y}$	tCO_2e	Project emissions from flaring of the residual gas stream in year y
$TM_{RG,h}$	kg/m^3	Mass flow rate of methane in the residual gas in the hour h
$n_{flare,h}$	-	Flare efficiency in the hour h
GWP_{CH4}	tCO_2e/tCH_4	Global Warming Potential of methane valid for the commitment period

Baseline emissions associated with the displacement of energy from the grid

The baseline emission associated with the displacement of electricity from the grid is calculated using the following parameters:

$EL_{LFG,y}$ = Net quantity of electricity produced using LFG, which in the absence of the project activity would have been produced by power plants connected to the grid or by an on-site/off-site fossil fuel based captive power generation, during year y, in megawatt hours (MWh).

$CEF_{elecy,BL,y}$ = CO_2 emissions intensity of the baseline source of electricity displaced, in t CO_2e/MWh, calculated as per the "*Tool to calculate the emission factor for an electricity system".* The grid emission factor will be adjusted ex-post (all details are provided in Annex 3).

Project Emissions

According to the methodology, project emissions are determined by the following:

$PEy = PE_{EC\,y} + PE_{FC\,j\,y}$

Where:
PEEC,y = Emissions from consumption of electricity in the project case.
PEFC,j,y = Project emissions from consumption of heat

Project emissions from electricity consumption ($PE_{EC,y}$) are calculated following the *"Tool to calculate baseline, project and/or leakage emissions from electricity consumption",* version 01.

Scenario A applies to this project activity (i.e., electricity from the grid). Furthermore, the option **A1** has been selected, i.e., the combined margin emission factor will be calcualted, using the procedures of the Tool to calculate the emission factor for an electricity system ($EF_{EL,j/k/l,y}$ = $EF_{grid,CM,y}$).

The generic approach has been selected for this project activity:

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

Where:

$EC_{PJ,,jy}$	Quantity of electricity consumed by the project activity during the year y (MWh/y)
$EF_{EL,j,y}$	Emission factor for the electricity grid ($EF_{EL,j/k/l,y}$ = $EF_{grid,CM,y}$) in year y (tCO2/MWh)
$TDL_{j,y}$	Average technical transmission and distribution losses for providing the electricity source j in year y
j	sources of electricity consumption in the project

Project emissions from fossil fuel combustion ($PE_{FC,j,y}$) are calculated following version 02 of "*Tool to calculate project or leakage CO_2 emissions from fossil fuel combustion*". For this project, LPG (Liquefied Petroleum Gas) is used for the ignition of the flare system, and an option has been included to account for project emissions that might occur in case the back up diesel generator is used, thus these emissions are calculated as follows:

$$PE_{FC,j,y} = FC_{i,j,y} * COEF_{i,y}$$

Where

$FC_{i,j,y}$	is the quantity of fossil fuel *i* (LPG or diesel) combusted in process *j* (flare ignition) during year *y* (m^3)
$COEF_{i,y}$	is the CO_2 emission coefficient of the fuel (tCO_2/ m^3 fuel)

Due to data availability, $COEF_{i,y}$ is calculated following Option B of the tool:

$$COEF_{i,y} = NCV_{i,y} * EF_{CO2i,y}$$

Where

$NCV_{i,y}$	Is the weighted average net calorific value of the fuel type *i* in year *y* (GJ/ m^3)
$EF_{CO2i,y}$	Is the weighted average CO_2 emission factor of fuel type *i* in year *y* (tCO_2/GJ)

Leakages

No leakages effects need to be accounted under this methodology.

Emission Reduction

Emission reductions will be calculated as follows:

$$ER_y = BE_y - PE_y$$

Where:

ERy	=	Emission reductions in year *y* (t CO_2e/yr).
BEy	=	Baseline emissions in year *y* (t CO_2e/yr).
PEy	=	Project emissions in year *y* (t CO_2e/yr).

B.6.2. Data and parameters fixed ex ante

Data / Parameter	Regulatory requirements relating to landfill gas
Unit	Norms
Description	Regulatory requirements relating to landfill gas from ABNT NBR (Associação Brasileira de Normas Tecnicas / Brazilian Association of Technical Norms) and (Norma Brasileira / Brazilian Norm), including:
Source of data	ABNT NBR 8419:1992 Versão Corrigida: 1996. Apresentação de projetos de aterros sanitários de resíduos sólidos urbanos / Introduction of Projects for Sanitary Landfills of Municipal Solid Waste.
Value(s) applied	Publicly available information
Choice of data or Measurement methods and procedures	Will be reflected in the AF. Further information can be found in section B.6.3.
Purpose of data	The information will be recorded, to use it for changes in the adjustment factor (AF) or directly to MDBL, y at renewal of the credit period.
Additional comment	Calculation of baseline emissions

Data / Parameter	GWP_{CH4}
Unit	tCO_2e/tCH_4
Description	Global warming potential of CH4
Source of data	IPCC
Value(s) applied	25
Choice of data or Measurement methods and procedures	Shall be updated accordingly to any future COP/MOP decisions
Purpose of data	Calculation of baseline emissions
Additional comment	N/A

Data / Parameter	D_{CH4}
Unit	tCH_4/m^3CH_4
Description	Methane density
Source of data	IPCC
Value(s) applied	0.0007168
Choice of data or Measurement methods and procedures	At standard T and P (0 degrees C and 1,013 bar)
Purpose of data	Calculation of baseline emissions
Additional comment	N/A

Data / Parameter	$BE_{CH4, SWDS,y}$
Unit	tCO_2e
Description	Methane generation from the landfill in the absence of the project activity at year y
Source of data	Calculated as per the *"Tool to determine methane emissions avoided from disposal of waste at a solid waste disposal site" version 05.*
Value(s) applied	(see table below)
Choice of data or Measurement methods and procedures	As per the "*Tool to determine methane emissions avoided from disposal of waste at a solid waste disposal site" version 05.*
Purpose of data	Calculation of baseline emissions
Additional comment	Used for ex-ante estimation of the amount of methane that would have been destroyed/combusted during the year.

	BECH4,SWDS,y (t CO2e)
01/08/2011-31/12/2011	111,488
01/01/2012 -31/12/2012	313,788
01/01/2013- 31/12/2013	349,732
01/01/2014 -31/12/2014	377,457
01/01/2015- 31/12/2015	399,429
01/01/2016- 31/12/2016	417,320
01/01/2017- 31/12/2017	432,263
01/01/2018 - 31/07/2018	258,486
Total	2,659,964

Data / Parameter	φ
Unit	-
Description	Model correction factor to account for model uncertainties
Source of data	As per the "*Tool to determine methane emissions avoided from disposal of waste at a solid waste disposal site" version 05.*
Value(s) applied	0.9
Choice of data or Measurement methods and procedures	Oonk et el. (1994) have validated several landfill gas models based on 17 realized landfill gas projects. The mean relative error of multi-phase models was assessed to be 18%. Given the uncertainties associated with the model and in order to estimate emission reductions in a conservative manner, a discount of 10% is applied to the model results.
Purpose of data	Calculation of baseline emissions
Additional comment	N/A

Data / Parameter	OX
Unit	-
Description	Oxidation factor (reflecting the amount of methane from SWDS that is oxidized in the soil or other material covering the waste)
Source of data	As per the "*Tool to determine methane emissions avoided from disposal of waste at a solid waste disposal site" version 05.*
Value(s) applied	0.1
Choice of data or Measurement methods and procedures	According to the "*Tool to determine methane emissions avoided from disposal of waste at a solid waste disposal site"* version 05 for managed solid waste disposal sites.
Purpose of data	Calculation of baseline emissions
Additional comment	N/A

Data / Parameter	F
Unit	-
Description	Fraction of methane in the SWDS gas (volume fraction)
Source of data	IPCC 2006 Guidelines for National Greenhouse Gas Inventories
Value(s) applied	0.5
Choice of data or Measurement methods and procedures	According to the "*Tool to determine methane emissions avoided from disposal of waste at a solid waste disposal site".* version 05.
Purpose of data	Calculation of baseline emissions
Additional comment	This factor reflects the fact that some degradable organic carbon does not degrade, or degrades very slowly, under anaerobic conditions in the SWDS. A default value of 0.5 is recommended by IPCC.

Data / Parameter	f
Unit	-
Description	Fraction of methane captured at the SWDS and flared, combusted or used in another manner
Source of data	According to the "*Tool to determine methane emissions avoided from disposal of waste at a solid waste disposal site". – version 05*
Value(s) applied	0
Choice of data or Measurement methods and procedures	All the methane generated was directly vented to the atmosphere prior to the project activity.
Purpose of data	Calculation of baseline emissions
Additional comment	N/A

Data / Parameter	z
Unit	-
Description	Number of samples collected during the year x
Source of data	Sample measurements done by Haztec Tecnologia e Planejamento Ambiental S.A. Source: Waste characterization study, Candeias landfill, 2010 (*Ensaios de caracterização gravimetrica dos residuos dispostos na CTR CANDEIAS*, Nov 2010)
Value(s) applied	3
Choice of data or Measurement methods and procedures	The research was conducted by Haztec Tecnologia e Planejamento Ambiental S.A. in year 2010.
Purpose of data	Calculation of baseline emissions
Additional comment	The waste composition is obtained from previous studies. Parameter z represents the number of sample used in the study according to the "*Tool to determine methane emissions avoided from disposal of waste at a solid waste disposal site". – version 05*

Data / Parameter	DOC_f
Unit	-
Description	Fraction of degradable organic carbon (DOC) that can decompose
Source of data	IPCC 2006 Guidelines for National Greenhouse Gas Inventories
Value(s) applied	0.5
Choice of data or Measurement methods and procedures	According to the "*Tool to determine methane emissions avoided from disposal of waste at a solid waste disposal site". version 05*
Purpose of data	Calculation of baseline emissions
Additional comment	N/A

Data / Parameter	MCF
Unit	-
Description	Methane correction factor
Source of data	IPCC 2006 Guidelines for National Greenhouse Gas Inventories
Value(s) applied	1
Choice of data or Measurement methods and procedures	According to the "*Tool to determine methane emissions avoided from disposal of waste at a solid waste disposal site" version 05* for managed solid waste disposal sites this value is to be applied to the Candeias Landfill as it is an anaerobic managed solid waste disposal site.
Purpose of data	Calculation of baseline emissions
Additional comment	N/A

Data / Parameter	DOC_j
Unit	-
Description	Fraction of degradable organic carbon (by weight) in the waste type *j*.
Source of data	IPCC 2006 Guidelines for National Greenhouse Gas Inventories (adapted from Volume 5, Tables 2.4 and 2.5)
Value(s) applied	The following values for the different waste types *j* are applied: (see table below)
Choice of data or Measurement methods and procedures	In accordance with "*Tool to determine methane emissions avoided from disposal of waste at a solid waste disposal site". version 05.*
Purpose of data	Calculation of baseline emissions
Additional comment	The values applied are for wet waste.

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

<table>
<tr><td>Data / Parameter</td><td>Kj</td></tr>
<tr><td>Unit</td><td>-</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>The following values for the different waste types j are applied:
<table>
<tr><td colspan="2">Waste type j</td><td>Tropical (MAT > 20ºC)
Wet (MAP > 1000 mm)</td></tr>
<tr><td rowspan="2">Slowly Degrading</td><td>Pulp, paper, cardboard (other than sludge), textiles</td><td>0.07</td></tr>
<tr><td>Wood,wood products and straw</td><td>0.035</td></tr>
<tr><td>Moderately Degrading</td><td>Other (non-food) organic putrescible garden and park waste</td><td>0.17</td></tr>
<tr><td>Rapidly Degrading</td><td>Food, food waste, sewage sludge, beverages and tobacco</td><td>0.40</td></tr>
</table>
</td></tr>
<tr><td>Choice of data or Measurement methods and procedures</td><td>In accordance with “Tool to determine methane emissions avoided from disposal of waste at a solid waste disposal site” version 05.</td></tr>
<tr><td>Purpose of data</td><td>Calculation of baseline emissions</td></tr>
<tr><td>Additional comment</td><td>The values applied are for tropical (MAT> 20°C) and wet (MAP > 1000m) conditions. Source: INMET 2007. Refer to annex 3 for details.</td></tr>
</table>

Data / Parameter	E_{DS}
Unit	%
Description	Efficiency of the degassing system which will be installed in the Project Activity
Source of data	Feasibility Study (*Relatório Ambiental - Biogás - CANDEIAS - Rv 03 2010*)
Value(s) applied	40
Choice of data or Measurement methods and procedures	The collection efficiency value considers the physical conditions of this Landfill as well as the capping material (soil cover) used to cover the waste. The 40% is a reasonable conservative factor to differentiate between LFG estimated to be generated (from the pure application of the methodology) and LFG expected to be collected by the Project Developer.
Purpose of data	Calculation of baseline emissions
Additional comment	N/A

Data / Parameter	W_x
Unit	tons
Description	Total amount of organic waste prevented from disposal in year *x* (tons)
Source of data	Project Developer, measured (2007-2009) and estimated data based on design and capacity (2010 -2022)
Value(s) applied	11 million until the closure of the landfill (2022)
Choice of data or Measurement methods and procedures	From 2007 until 2009, the weight per year of waste disposed at the landfill is based on the weighted reports. From 2010 until closure (2022) the waste quantity disposed per year is based on the design capacity of the landfill (2,100 tpd).
Purpose of data	Calculation of baseline emissions
Additional comment	N/A

Data / Parameter	$p_{n,j,x}$
Unit	%
Description	Weight fraction of the waste type *j* in the sample *n* collected during the year *x*
Source of data	Sample measurements done by Haztec Tecnologia e Planejamento Ambiental S.A. (*Ensaios de caraterização gravimetrica dos residuos dispostos na CTR CANDEIAS*, Nov 2010))
Value(s) applied	see Waste Composition table below
Choice of data or Measurement methods and procedures	Based on specific waste composition study
Purpose of data	Calculation of baseline emissions
Additional comment	The waste composition is obtained from previous studies. Parameter $p_{n,j,x}$ represents the weight fraction of the waste type *j* in the sample used in this study according to the "*Tool to determine methane emissions avoided from disposal of waste at a solid waste disposal site". – version 05*

Waste Composition		
Pulp, paper, Cardboard (other than Sludge)	% of Wet MSW	12.9
Textiles	% of Wet MSW	3.8
Food and Food Waste, beverages and tobacco (other than sludge)	% of Wet MSW	48.3
Garden,Yard and Park Waste	% of Wet MSW	0
Wood & Wood Products	% of Wet MSW	0.6

Data / Parameter	MM_{CH4}
Unit	kg/kmol
Description	Molecular mass of methane
Source of data	Constant
Value(s) applied	16.04
Choice of data or Measurement methods and procedures	As per “*Tool to determine project emissions from flaring gases containing methane”* EB 28 Annex 13
Purpose of data	Calculation of baseline emissions
Additional comment	N/A

Data / Parameter	MM_{CO}
Unit	kg/kmol
Description	Molecular mass of carbon monoxide
Source of data	Constant
Value(s) applied	28.01
Choice of data or Measurement methods and procedures	As per “*Tool to determine project emissions from flaring gases containing methane”* EB 28 Annex 13
Purpose of data	Calculation of baseline emissions
Additional comment	N/A

Data / Parameter	MM_{CO2}
Unit	kg/kmol
Description	Molecular mass of carbon dioxide
Source of data	Constant
Value(s) applied	44.01
Choice of data or Measurement methods and procedures	As per “*Tool to determine project emissions from flaring gases containing methane”* EB 28 Annex 13
Purpose of data	Calculation of baseline emissions
Additional comment	N/A

Data / Parameter	MM_{O2}
Unit	kg/kmol
Description	Molecular mass of oxygen
Source of data	Constant
Value(s) applied	32.00
Choice of data or Measurement methods and procedures	As per "*Tool to determine project emissions from flaring gases containing methane"* EB 28 Annex 13
Purpose of data	Calculation of baseline emissions
Additional comment	N/A

Data / Parameter	MM_{H2}
Unit	kg/kmol
Description	Molecular mass of hydrogen
Source of data	Constant
Value(s) applied	2.02
Choice of data or Measurement methods and procedures	As per "*Tool to determine project emissions from flaring gases containing methane"* EB 28 Annex 13.
Purpose of data	Calculation of baseline emissions
Additional comment	N/A

Data / Parameter	MM_{N2}
Unit	kg/kmol
Description	Molecular mass of nitrogen
Source of data	Constant
Value(s) applied	28.02
Choice of data or Measurement methods and procedures	As per "*Tool to determine project emissions from flaring gases containing methane"* EB 28 Annex 13
Purpose of data	Calculation of baseline emissions
Additional comment	N/A

Data / Parameter	AM_c
Unit	kg/kmol
Description	Atomic mass of carbon
Source of data	Constant
Value(s) applied	12.00
Choice of data or Measurement methods and procedures	As per "*Tool to determine project emissions from flaring gases containing methane"* EB 28 Annex 13
Purpose of data	Calculation of baseline emissions
Additional comment	N/A

Data / Parameter	AM_H
Unit	kg/kmol
Description	Atomic mass of hydrogen
Source of data	Constant
Value(s) applied	1.01
Choice of data or Measurement methods and procedures	As per "*Tool to determine project emissions from flaring gases containing methane"* EB 28 Annex 13
Purpose of data	Calculation of baseline emissions
Additional comment	N/A

Data / Parameter	AM_O
Unit	kg/kmol
Description	Atomic mass of oxygen
Source of data	Constant
Value(s) applied	16.00
Choice of data or Measurement methods and procedures	As per "*Tool to determine project emissions from flaring gases containing methane"* EB 28 Annex 13
Purpose of data	Calculation of baseline emissions
Additional comment	N/A

Data / Parameter	AM_N
Unit	kg/kmol
Description	Atomic mass of nitrogen
Source of data	Constant
Value(s) applied	14.01
Choice of data or Measurement methods and procedures	As per "*Tool to determine project emissions from flaring gases containing methane"* EB 28 Annex 13
Purpose of data	Calculation of baseline emissions
Additional comment	N/A

Data / Parameter	P_n
Unit	Pa
Description	Atmospheric pressure at normal conditions
Source of data	Constant
Value(s) applied	101,325
Choice of data or Measurement methods and procedures	As per "*Tool to determine project emissions from flaring gases containing methane"* EB 28 Annex 13
Purpose of data	Calculation of baseline emissions
Additional comment	N/A

Data / Parameter	R_u
Unit	$Pa.m^3/kmol.K$
Description	Universal ideal gas constant
Source of data	Constant
Value(s) applied	8,314.472
Choice of data or Measurement methods and procedures	As per "*Tool to determine project emissions from flaring gases containing methane"* EB 28 Annex 13
Purpose of data	Calculation of baseline emissions
Additional comment	N/A

Data / Parameter	T_n
Unit	K
Description	Temperature at normal conditions
Source of data	Constant
Value(s) applied	273.15
Choice of data or Measurement methods and procedures	As per "*Tool to determine project emissions from flaring gases containing methane"* EB 28 Annex 13
Purpose of data	Calculation of baseline emissions
Additional comment	N/A

Data / Parameter	MF_{O2}
Unit	Dimensionless
Description	O_2 volumetric fraction of air
Source of data	Constant
Value(s) applied	0.21
Choice of data or Measurement methods and procedures	As per "*Tool to determine project emissions from flaring gases containing methane"* EB 28 Annex 13
Purpose of data	Calculation of baseline emissions
Additional comment	N/A

Data / Parameter	MV_n
Unit	m^3/Kmol
Description	Volume of one mole of any ideal gas at normal temperature and pressure
Source of data	Constant
Value(s) applied	22.414
Choice of data or Measurement methods and procedures	As per "*Tool to determine project emissions from flaring gases containing methane"* EB 28 Annex 13
Purpose of data	Calculation of baseline emissions
Additional comment	N/A

Data / Parameter	TDL_y
Unit	%
Description	Average technical transmission and distribution losses in the grid in year y for the voltage level at which electricity is obtained from the grid at the project site.
Source of data	Default value according to the "*Tool to calculate project emissions from electricity consumption" version 01.*
Value(s) applied	20%
Choice of data or Measurement methods and procedures	Default value according to the "*Tool to calculate project emissions from electricity consumption" version 01.*
Purpose of data	Required to calculate project emissions
Additional comment	N/A

B.6.3. Ex ante calculation of emission reductions

Baseline Emissions

The ex ante estimate of baseline emissions was formulated using the ACM0001 –Version 11.

$$BE_y = MD_{project,y} * GWP_{CH4} + EL_{LFG,y} * CEF_{elec,BL,y}$$

Calculation of $MD_{Project,y}$
Ex-ante estimation of the amount of methane generated by the disposal of waste at a solid waste disposal site during the year ($MD_{Project,y}$) is calculated by:

$MD_{project,y} = BE_{CH4,SWDS,y}/GWP_{CH4}$

The efficiency of the degassing system (40%) , as well as the flare efficiency (90%) which will be installed in the project activity have both been taken into account while estimating the ex ante estimation of $MD_{Project,y}$

Years	MDproject,y (t CH4)
01/08/2011-31/12/2011	1,911
01/01/2012 -31/12/2012	5,960
01/01/2013- 31/12/2013	6,576
01/01/2014 -31/12/2014	7,051
01/01/2015- 31/12/2015	7,428
01/01/2016- 31/12/2016	7,735
01/01/2017- 31/12/2017	8,234
01/01/2018 - 31/07/2018	4,924
Total	**49,818**

Calculation of baseline emissions associated with the displacement of the grid electricity
The grid emission factor will be adjusted ex-post (all details are provided in Annex 3).

The ex-ante calculation for the emission reductions associated with the displacement of the grid electricity are the following:

Years	$EL_{LFG,y}$ (MWh)	Grid displacement (t CO_2e)

01/08/2011-31/12/2011	0	0
01/01/2012 -31/12/2012	33,960	5,552
01/01/2013- 31/12/2013	33,960	5,552
01/01/2014 -31/12/2014	33,960	5,552
01/01/2015- 31/12/2015	33,960	5,552
01/01/2016- 31/12/2016	33,960	5,552
01/01/2017- 31/12/2017	48,159	7,874
01/01/2018 - 31/07/2018	28,798	4,708
Total	**246,757**	**40,345**

The resulting baseline emissions (BE_y) are finally obtained using equation mentioned earlier:

$BEy = MD_{project,y} * GWP_{CH4} + EL_{LFG,y} * CEF_{elec,BL,y}$

Thus:

Years	MD project *GWP CH4 (t CO2e)	Grid displacement (t CO2e)	BE,y (t CO_2 e)
01/08/2011- 31/12/2011	40,136	0	40,136
01/01/2012 - 31/12/2012	125,157	5,552	130,709
01/01/2013- 31/12/2013	138,096	5,552	143,649
01/01/2014 - 31/12/2014	148,077	5,552	153,630
01/01/2015- 31/12/2015	155,987	5,552	161,540
01/01/2016- 31/12/2016	162,428	5,552	167,980
01/01/2017- 31/12/2017	172,905	7,874	180,779
01/01/2018 - 31/07/2018	103,395	4,708	108,103
Total	**1,046,181**	**40,345**	**1,086,526**

Project Emissions

$PEy = PE_{EC\ y} + PE_{FC\ j\ y}$

For project emissions from electricity consumption, the guidance from the "*Tool to calculate baseline, project and/or leakage emissions from electricity consumption*" version 01 is followed.

The project emissions are estimated as follow:

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

Where

$EC_{PJ,j,y}$ Is the electricity consumed by the Project Activity (estimated at 541MWh/y)

Project emissions from fossil fuel combustion ($PE_{FC,j,y}$) are calculated as follow:

$PE_{FC,j,y} = FC_{i,j,y} * COEF_{i,y}$

Where

$FC_{i,j,y}$ is the quantity of fossil fuel *i* (LPG or diesel) combusted in process *j* (flare ignition) during year *y* (m^3) (estimated at 2.07E-06 m^3)[42]

$COEF_{i,y}$ is the CO_2 emission coefficient of the fuel (tCO_2/ m^3 fuel)

$COEF_{i,y}$ is calculated following Option B of the tool:

$COEF_{i,y} = NCV_{i,y} * EF_{CO2i,y}$

Where

$NCV_{i,y}$ Is the weighted average net calorific value of the fuel type *i* in year *y* (0.106 GJ/m^3)

$EF_{CO2i,y}$ Is the weighted average CO_2 emission factor of fuel type *i* in year *y* (0.0656 tCO_2e/GJ)

Thus in summary we have that

[42] Based on monitored and verified consumption of LPG by similar equipment installed at a project site run by the same project developer.

Project emissions

Year	PE_{ECy} (tCO_2e)	$PE_{FC,y}$ (tCO2 e)	PE_y (tCO2 e)
01/08/2011-31/12/2011	44	0.0000000060	44
01/01/2012 -31/12/2012	106	0.0000000144	106
01/01/2013- 31/12/2013	106	0.0000000144	106
01/01/2014 -31/12/2014	106	0.0000000144	106
01/01/2015- 31/12/2015	106	0.0000000144	106
01/01/2016- 31/12/2016	106	0.0000000144	106
01/01/2017- 31/12/2017	106	0.0000000144	106
01/01/2018 - 31/07/2018	62	0.0000000083	62
Total	**742**	**0.0000001006**	**742**

Emission Reductions

As per the methodology:

$$ER_y = BE_y - PE_y$$

Thus:

Year	Estimation of baseline emissions (tCO2e)	Estimation of project activity emissions (tCO2e)	Estimation of overall emission reductions (tCO2e)
01/08/2011-31/12/2011	40,136	44	40,091
01/01/2012 -31/12/2012	130,709	106	130,603
01/01/2013- 31/12/2013	143,649	106	143,543
01/01/2014 -31/12/2014	153,630	106	153,524
01/01/2015- 31/12/2015	161,540	106	161,434
01/01/2016- 31/12/2016	167,980	106	167,874
01/01/2017- 31/12/2017	180,779	106	180,673
01/01/2018 - 31/07/2018	108,103	62	108,041
Total (tonnes of CO2e)	**1,086,526**	**742**	**1,085,783**

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

Year	Baseline emissions (t CO_2e)	Project emissions (t CO_2e)	Leakage (t CO_2e)	Emission reductions (t CO_2e)
01/08/2011-31/12/2011	40,136	44	0	40,091
01/01/2012-31/12/2012	130,709	106	0	130,603
01/01/2013-31/12/2013	143,649	106	0	143,543
01/01/2014-31/12/2014	153,630	106	0	153,524
01/01/2015-31/12/2015	161,540	106	0	161,434
01/01/2016-31/12/2016	167,980	106	0	167,874
01/01/2017-31/12/2017	180,779	106	0	180,673
01/01/2018-31/07/2018	108,103	62	0	108,041
Total	**1,086,526**	**742**	**0**	**1,085,783**
Total number of crediting years	**7**			
Annual average over the crediting period	**155,218**	**106**	**0**	**155,112**

B.7. Monitoring plan

B.7.1. Data and parameters to be monitored

Data / Parameter	$LFG_{total,y}$
Unit	Nm^3
Description	Total amount of landfill gas captured at normal temperature and pressure on a wet basis.
Source of data	Measured on site with a flow meter.
Value(s) applied	20.195 million (Annual average over the first crediting period)
Measurement methods and procedures	Flow meter.
Monitoring frequency	Monitored continuously (average value in a time interval not greater than an hour) by the Project Developer. Data to be aggregated monthly and yearly. The flow meter includes automatic measure of the Temperature and Pressure so the measure is expressed in normalized cubic meter.
QA/QC procedures	The flow meter will be calibrated as per manufacturer recommendations. It will be subject to a regular maintenance, testing and calibration regime in accordance with manufacturer specifications and appropriate national/international standards to ensure its accuracy, which is assumed to be above 95%.
Purpose of data	Calculation of baseline emissions
Additional comment	Data will be kept for 2 years after end of crediting period or last issuance of CERs for the project activity

Data / Parameter	LFGflared,y
Unit	Nm^3
Description	Amount of landfill gas flared at normal temperature and pressure on a wet basis.
Source of data	Measured on site with a flow meter.
Value(s) applied	3.379 million (Annual average over the first crediting period)
Measurement methods and procedures	Flow Meter.
Monitoring frequency	Measured with a flow meter continuously (average value in a time interval not greater than an hour), data to be aggregated monthly and yearly. The flow meter includes automatic measure of the Temperature and Pressure so the measure is expressed in normalized cubic meter.
QA/QC procedures	The measurement instrument will be calibrated as per manufacturer recommendations. It will be subject to a regular maintenance, testing and calibration regime in accordance with manufacturer specifications and appropriate national/international standards to ensure its accuracy, which is assumed to be above 95%.
Purpose of data	Calculation of baseline emissions.
Additional comment	$LFG_{flare,y}$ is considered to be equivalent to the variable $FV_{RG,h}$ (volumetric flow rate of the residual gas) as described in the "*Tool to determine Project emissions from flaring gases containing methane*" EB 28 Annex 13 used to determine project emissions from flaring. Data will be kept for 2 years after end of crediting period or last issuance of CERs for the project activity

Data / Parameter	LFGelectricity,y
Unit	Nm3
Description	Amount of LFG sent to power plant at Normal temperature and pressure on a wet basis.
Source of data	Measured on site with a flow meter.
Value(s) applied	16.816 million (Annual average over the first crediting period)
Measurement methods and procedures	Flow Meter.
Monitoring frequency	Measured continuously (average value in a time interval not greater than an hour), data to be aggregated monthly and yearly. The flow meter includes automatic measure of the Temperature and Pressure so the measure is expressed in normalized cubic meter.
QA/QC procedures	The measurement instrument will be calibrated as per manufacturer recommendations. It will be subject to a regular maintenance, testing and calibration regime in accordance with manufacturer specifications and appropriate national/international standards to ensure its accuracy, which is assumed to be above 95%.
Purpose of data	Calculation of baseline emissions.
Additional comment	Data will be kept for 2 years after end of crediting period or last issuance of CERs for the project activity.

Data / Parameter	$w_{CH4,y}$
Unit	m³ CH_4/ m³ LFG
Description	Methane fraction in the landfill gas on a wet basis
Source of data	Gas analyzer.
Value(s) applied	50%
Measurement methods and procedures	Methane content will be measured with a gas analyser by the Project Developer.
Monitoring frequency	Methane content will be measured continuously.
QA/QC procedures	The gas analyzer shall be subject to regular maintenance and calibration, based on the manufacturer's specifications and appropriate national/international standards to ensure accuracy, which is assumed to be above 95%.
Purpose of data	Calculation of baseline emissions.
Additional comment	w_{CH4} is considered to be equivalent to the variable $fv_{CH4,h}$ (volumetric fraction of the component CH_4 in the landfill gas in the hour h) as described in the "*Tool to determine Project emissions from flaring gases containing methane*" EB 28 Annex 13. Data will be kept for 2 years after end of crediting period or last issuance of CERs for the project activity.

Data / Parameter	$PE_{flare,y}$
Unit	tCO_2e
Description	Project emissions from flaring of the residual gas stream in year *y*
Source of data	Project Developer
Value(s) applied	2,544
Measurement methods and procedures	Calculated as per the "*Tool to determine Project emissions from flaring gases containing Methane*". EB 28 Annex 13
Monitoring frequency	N/A
QA/QC procedures	As per the "*Tool to determine Project emissions from flaring gases containing Methane*" EB 28 Annex 13.
Purpose of data	Calculation of baseline emissions.
Additional comment	Data will be kept for 2 years after end of crediting period or last issuance of CERs for the project activity

Data / Parameter	T_{flare}
Unit	°C
Description	Temperature in the exhaust gas of the flare
Source of data	Project Developer
Value(s) applied	> 500ºC
Measurement methods and procedures	The temperature in the exhaust gas will be measured continuously with a thermocouple.
Monitoring frequency	Measured continuously.
QA/QC procedures	Measuring instruments will be subject to regular maintenance and testing regime, based on the manufacturer's recommended schedule and procedures, and in accordance with appropriate national/international standards to ensure its accuracy, which is assumed to be above 95%.
Purpose of data	Calculation of baseline emissions.
Additional comment	Required to determine adequate operation and operating hours of the flare. Data will be kept for 2 years after end of crediting period or last issuance of CERs for the project activity.

Data / Parameter	$t_{O2,h}$
Unit	--
Description	Volumetric fraction of O_2 in the exhaust gas of the flare on wet basis in the hour *h*
Source of data	Project Developer
Value(s) applied	-
Measurement methods and procedures	Monitored as per the "*Tool to determine project emissions from flaring gases containing methane*". EB 28 Annex 13. An in situ LANDTEC Gas analyzer or another similar technology provider will be adopted. The gas analyzer will: 1) sample and analyze the methane, and oxygen content of LFG, 2) provide continuous monitoring of the parameter and 3) transfer data to monitoring system for storage of the information.
Monitoring frequency	Monitored continuously.
QA/QC procedures	Analyzers will be calibrated according to the manufacturer's recommendation and in accordance with appropriate national/international standards to ensure its accuracy, which is assumed to be above 95%. A zero check and a typical value check will be performed by comparison with a standard certified gas.
Purpose of data	Calculation of baseline emissions.
Additional comment	Monitoring of this parameter is due to continuous monitoring of the flare efficiency. Data will be kept for 2 years after end of crediting period or last issuance of CERs for the project activity.

Data / Parameter	$fv_{CH4,h}$
Unit	--
Description	Volumetric fraction of methane in the residual gas on wet basis in the hour h
Source of data	Gas analyzer.
Value(s) applied	-
Measurement methods and procedures	Monitored as per the "*Tool to determine project emissions from flaring gases containing methane*". EB 28 Annex 13. Continuously measured. Ensure that the same basis (dry or wet) is considered for this measurement and the measurement of the volumetric flow rate of the residual gas (FVRG,h) when the residual gas temperature exceeds 60 ºC
Monitoring frequency	Monitored continuously.
QA/QC procedures	Gas analyzer will be periodically calibrated according to the manufacturer's recommendation and in accordance with appropriate national/international standards to ensure its accuracy, which is assumed to be above 95%. A zero check and a typical value check will be performed by comparison with a standard certified gas.
Purpose of data	Calculation of baseline emissions.
Additional comment	$\mathbf{fv}_{CH4,h}$ is considered to be equivalent to the variable w_{CH4} (methane fraction in the landfill gas on a wet basis). Data will be kept for 2 years after end of crediting period or last issuance of CERs for the project activity

Data / Parameter	$FV_{RG,h}$
Unit	m^3/h
Description	Volumetric flow rate of the residual gas on wet basis at normal (NTP) conditions in the hour h
Source of data	Flow meter.
Value(s) applied	-
Measurement methods and procedures	Monitored as per the "*Tool to determine project emissions from flaring gases containing methane*". EB 28 Annex 13. Continuously measured. Ensure that the same basis (dry or wet) is considered for this measurement and the measurement of the volumetric fraction of methane in the residual gas ($\mathbf{fv}_{CH4,h}$) when the residual gas temperature exceeds 60 ºC.
Monitoring frequency	Measured continuously.
QA/QC procedures	Flow meters are to be periodically calibrated according to the manufacturer's recommendations. It will be subject to a regular maintenance, testing and calibration regime in accordance with manufacturer specifications and appropriate national/international standards to ensure its accuracy, which is assumed to be above 95%.
Purpose of data	Calculation of baseline emissions.
Additional comment	$FV_{RG,h}$ is considered the equivalent of the variable LFGflared,y (Amount of landfill gas flared at normal temperature and pressure). Monitoring of this parameter is due to continuous monitoring of the flare efficiency. Data will be kept for 2 years after end of crediting period or last issuance of CERs for the project activity

Data / Parameter	$fv_{CH4,FG,h}$
Unit	Mg/m^3
Description	Concentration of methane in the exhaust gas of the flare on wet basis at normal conditions in the hour h
Source of data	Gas analyzer.
Value(s) applied	-
Measurement methods and procedures	Monitored as per the "*Tool to determine project emissions from flaring gases containing methane*". EB 28 Annex 13. Continuously measured. Values to be averaged hourly or at a shorter time interval.
Monitoring frequency	Measured continuously.
QA/QC procedures	Gas analyzer will be periodically calibrated according to manufacturer's recommendation and in accordance with appropriate national/international standards to ensure its accuracy, which is assumed to be above 95%. Zero check and typical value check will be performed by comparison with a standard gas.
Purpose of data	Calculation of baseline emissions.
Additional comment	Data will be kept for 2 years after end of crediting period or last issuance of CERs for the project activity

Data / Parameter	EL_{LFG}
Unit	MWh
Description	Net amount of electricity generated using LFG.
Source of data	Electricity meter.
Value(s) applied	For the first crediting period values used are: 33,960 MWh per year (2012 – 2016); 48,159 MWh/y (2017) 28,798 MWh (01/01/2018-31/07/2018) (ex-ante estimate).
Measurement methods and procedures	Electricity will be measured continuously using an electricity meter.
Monitoring frequency	Measured continuously.
QA/QC procedures	Electricity meter will be subject to regular maintenance and testing in accordance with stipulation of the meter supplier and in accordance with appropriate national/international standards to ensure its accuracy, which is assumed to be above 95%.
Purpose of data	Calculation of baseline emissions.
Additional comment	Data will be kept for 2 years after end of crediting period or last issuance of CERs for the project activity.

Data / Parameter	Operation of the energy plants
Unit	hours
Description	Operation of the energy plants in a year y
Source of data	Project Developer
Value(s) applied	8,000
Measurement methods and procedures	Data will be recorded by the Project Developer to ensure methane destruction is claimed for methane used in electricity plant when it is operational.
Monitoring frequency	Measured continuously.
QA/QC procedures	Equipment will be maintained in line with manufacturer's recommendations to assure high quality output.
Purpose of data	Calculation of baseline emissions.
Additional comment	Data will be kept for 2 years after end of crediting period or last issuance of CERs for the project activity

Data / Parameter	$PE_{EC,y}$
Unit	tCO2
Description	Project emissions from electricity consumption by the Project activity during the year y.
Source of data	Calculated as per the "*Tool to calculate baseline, project and/or leakage emissions from electricity consumption" version 01.*
Value(s) applied	106
Measurement methods and procedures	As per the "*Tool to calculate baseline, project and/or leakage emissions from electricity consumption*" version 01
Monitoring frequency	
QA/QC procedures	As per the "*Tool to calculate baseline, project and/or leakage emissions from electricity consumption*" version 01
Purpose of data	
Additional comment	Data will be kept for 2 years after end of crediting period or last issuance of CERs for the project activity

Data / Parameter	ECPJ,y
Unit	MWh
Description	Quantity of electricity consumed by the project activity during the year y
Source of data	Electricity meter.
Value(s) applied	541 MWh (ex-ante estimate from Project Developer, based on electricity consumption of equipment to be installed in the landfill and a number of operating hours per day).
Measurement methods and procedures	Electricity will be measured continuously using an electricity meter. Data will be aggregated at least annually as stated in the "*Tool to calculate Project emissions from electricity consumption" version 01.*
Monitoring frequency	Measured continuously.
QA/QC procedures	Electricity meter will be subject to regular maintenance and testing in accordance with stipulation of the meter supplier and in accordance with appropriate national/international standards to ensure accuracy, which is assumed to be above 95%.
Purpose of data	Calculation of project emissions.
Additional comment	Required to calculate project emissions. Data will be kept for 2 years after end of crediting period or last issuance of CERs for the project activity.

Data / Parameter	$EF_{grid, CM,y}$ = CEFelec,BL,y = $EF_{EL,j,y}$
Unit	tCO_2/MWh
Description	Combined margin emission factor
Source of data	Calculated using the Tool to calculate the emission factor for an electricity system
Value(s) applied	0.1635
Measurement methods and procedures	Calculated as per the *"Tool to calculate the emission factor for an electricity system" version 02.*
Monitoring frequency	Annually
QA/QC procedures	For details on the calculations please refer to Annex 3. This value will be monitored ex-post.
Purpose of data	Calculation of project emissions.
Additional comment	Data will be kept for 2 years after end of crediting period or last issuance of CERs for the project activity

Data / Parameter	$PE_{FC,y}$
Unit	tCO_2e
Description	Project emissions from fossil fuel combustion
Source of data	Calculated as per the "Tool to calculate project or leakage CO2 emissions from fossil fuel combustion" *version 02*.
Value(s) applied	1.44E-08
Measurement methods and procedures	Calculated as per the "*Tool to calculate project or leakage CO2 emissions from* *fossil fuel combustion*" *version 02*.
Monitoring frequency	
QA/QC procedures	Meter will be installed, maintained and calibrated in accordance with manufacturer specifications and in line with appropriate national/international standards.
Purpose of data	
Additional comment	Data will be kept for 2 years after end of crediting period or last issuance of CERs for the project activity

Data / Parameter	$FC_{i,j,y}$
Unit	m^3/yr
Description	Onsite combustion of fossil fuels of type *i* (LPG or diesel) in process *j* (flare ignition system) during the year y
Source of data	Project Developer
Value(s) applied	2.07E-06 for LPG 0 for diesel (it is assumed that only LPG will be used) (ex-ante estimate from Project Developer, based on monitored consumption on similar equipment installed at a project site run by the same project developer)
Measurement methods and procedures	Volumetric meter will be employed to measure the fossil fuel consumption continuously as per the "*Tool to calculate project or leakage CO2 emissions from fossil fuel combustion*" *version 02*. There will be a book of control for recording the measurements.
Monitoring frequency	Daily and aggregated monthly
QA/QC procedures	The flow meter will be calibrated in accordance with manufacturer specifications and in accordance with appropriate national/international standards to ensure accuracy, which is assumed to be above 95%. The consistency of metered fuel consumption quantities will with available purchase invoices from the financial records.
Purpose of data	Calculation of project emissions
Additional comment	Required to calculate project emissions from fossil fuel combustion (flare ignition). Data will be kept for 2 years after end of crediting period or last issuance of CERs for the project activity.

Data / Parameter	$NCV_{i,y}$
Unit	GJ/m^3
Description	Weighted average net calorific value of fuel type *i* (LPG or diesel) in year y
Source of data	Values from the fuel supplier will be used.
Value(s) applied	0.1059 for LPG
Measurement methods and procedures	Values provided by the fuel supplier. Undertaken in line with national or international fuel standards. The NCV will be obtained for each fuel delivery, from which weighted average values should be calculated.
Monitoring frequency	Monthly or annual.
QA/QC procedures	Values will be verified to check that they are 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 should have ISO17025 accreditation or justify that they can comply with similar quality standards
Purpose of data	Calculation of project emissions.
Additional comment	Diesel consumption has not been considered for the ex-ante calculations as the assumption is that the backup generator will not be used. Data will be kept for 2 years after end of crediting period or last issuance of CERs for the project activity.

Data / Parameter	$EF_{CO2,i,y}$
Unit	tCO_2/GJ
Description	Weighted average CO_2 emission factor of fuel type *i* (LPG or diesel) in year y
Source of data	There are no value provided by the fuel supplier, therefore the IPCC default values at the upper limit of the uncertainty at a 95% confidence interval as provided in table 1.4 of chapter 1 of Vol 2 (Energy) of the 2006 IPCC Guidelines on National GHG Inventories (there is no available data from the fuel supplier).
Value(s) applied	0.0656 for LPG
Measurement methods and procedures	N/A
Monitoring frequency	N/A
QA/QC procedures	Will be checked against any future revision of IPCC Guidelines
Purpose of data	Calculation of project emissions.
Additional comment	Diesel consumption has not been considered for the ex-ante calculations as the assumption is that the backup generator will not be used. Data will be kept for 2 years after end of crediting period or last issuance of CERs for the project activity.

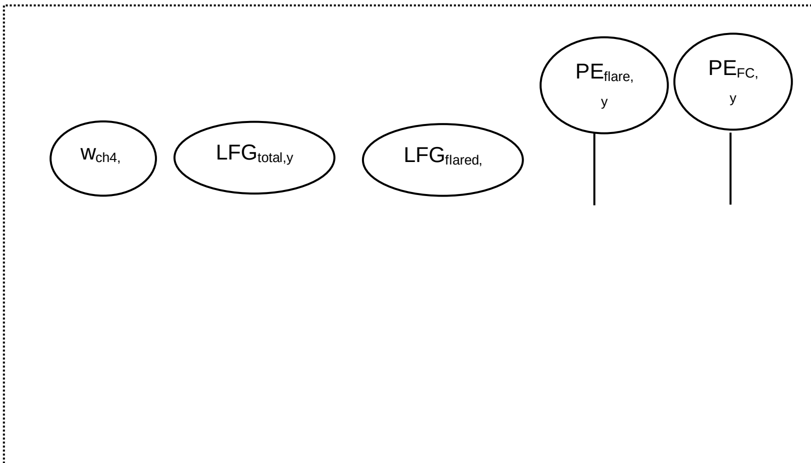
Data / Parameter	**Other flare operation parameters: T_{flare} and $LFG_{flare,y}$**
Unit	-
Description	The range of operating conditions is defined according to the methodology and the manufacturer's specifications based on the flow of LFG to the flare and the temperature of the exhaust gas.
Source of data	Thermocouple and flow meter measurements
Value(s) applied	-
Measurement methods and procedures	Data will be continuously measured to ensure that the flare/s operate within the range specified by the methodology and the manufacturer in terms of the temperature of the exhaust gas and the LFG flow rate, as follows: Minimum temperature: 500°C Maximum temperature: 1,430°C Minimum flow rate: 500 Nm³/h Maximum flow rate: 2,500 Nm³/h The thermocouple and the flow meter will also follow the measurement methods and procedures described for T_{flare} and $LFG_{flare,y}$
Monitoring frequency	Monitored continuously.
QA/QC procedures	As previously defined fo T_{flare} and $LFG_{flare,y}$
Purpose of data	Calculation of baseline emissions.
Additional comment	Only applicable in case of use of a default value.

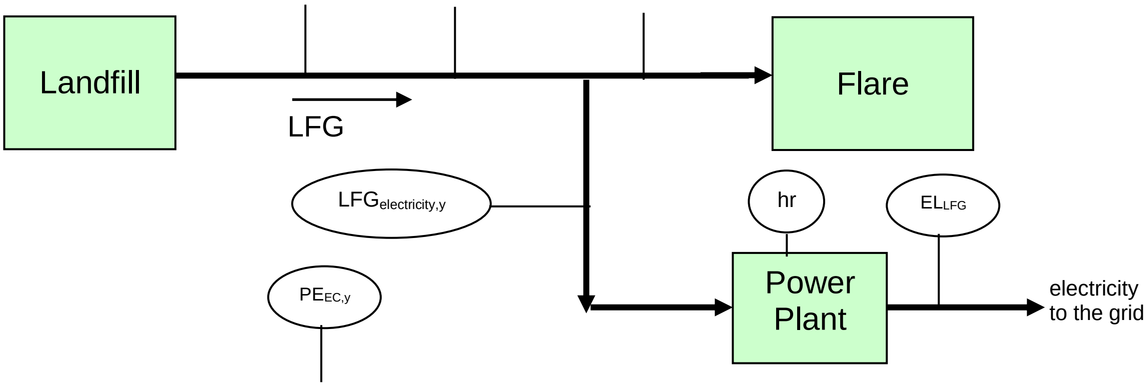
B.7.2. Sampling plan

Since data and parameters monitored in section B.7.1 above are not to be determined by a sampling approach, no description of the sampling plan in accordance with the "Standard for sampling and surveys for CDM project activities and programme of activities" is required.

B.7.3. Other elements of monitoring plan

Simplified monitoring diagram (For complete details on required equipment for the measurement of each parameter, please see section B.7.1 above)





$w_{CH4,y}$ = Fraction of methane in the landfill gas
$LFG_{total,y}$ = Total amount of landfill gas captured
$LFG_{flared,y}$ = Amount of landfill gas flared
$LFG_{electricity,y}$ = Amount of landfill gas used for electricity generation
$PE_{flare,y}$ = Project emissions from flaring of the residual gas stream in year *y*
$PE_{FC,y}$ = Project emissions from fossil fuel combustion
$PE_{EC,y}$ = Project emissions from electricity consumption by the project activity
hr = Operation of the energy plants (hours)
EL_{LFG} = Net amount of electricity generated using LFG

According to ACM0001, the parameters below have to be monitored:

- Amount of landfill gas collected (in Nm³, using flow meters), where the total quantity ($LFG_{total,y}$) as well as the quantities fed to the flare ($LFG_{flare,y}$) and the quantity fed to the electricity generator ($LFG_{electricity,y}$) are measured continuously on a wet basis.
- The fraction of methane in the landfill gas ($w_{CH4,y}$) should be measured with a continuous analyzer. Methane fraction of the landfill gas to be measured on wet basis.
- The temperature of the exhaust gas will be measured continuously with a thermocouple and continuously monitored as required by the methodology to determine adequate operation and operating hours of the flare.
- The volumetric fraction of the components in the exhaust gas will be monitored for the flare efficiency.
- Volumetric flow rate of the residual gas in wet basis at normal (NTP) conditions.
- Methane concentration in the exhaust gas of the flare in dry basis at normal conditions.
- The quantity of electricity generated using LFG will be monitored (EL_{LFG}) and the operating hours of the power plant.
- The quantity of electricity required to operate the landfill gas project will be monitored ($EC_{PJ,y}$) and the average technical transmission and distribution losses in the grid in year *y* (TDL_y).
- The onsite consumption of LPG used for the flare ignition and the diesel used by the back-up electricity generator ($FC_{i,j,y}$), the weighted average net calorific value of each fuel ($NCV_{i,y}$), the weighted average CO_2 emission factor of each fuel.
- Relevant regulations for LFG project activities shall be monitored and updated at renewal of each crediting period. Changes to regulations will be converted to the amount of methane that would have been destroyed/combusted during the year in the absence of the project activity ($MD_{BL,y}$).
- The grid emission factor, as published by the Brazilian DNA.

Project management responsibility. Information on the Monitoring Manager, the project team, and internal inspection of the LFG capture and flare program are addressed below.

- Monitoring Manager. A competent manager will be assigned responsibility for the monitoring plan and supervision on the collected data. The manager will report monthly about project performance and data. Additionally, the manager will report immediately to senior company management if non-conformance in the performance is detected such as flow meters not working. The Monitoring Manager will be the main contact person for the verifiers, Brazilian DNA and any other designated entity, during the crediting period.

- Project Team. The LFG project team will gather, at least monthly, to discuss the performance of the LFG capture and flaring project. Members of the project team will include the Monitoring Manager and the General Manager of the Candeias landfill. Meetings of the project team can be part of regular meetings, but meeting minutes will be recorded as required. In case of non-conformance, each members of the team will be called in for a project team meeting.

- Internal inspection. The monitoring plan including all defined procedures, reports, data, and personnel will be inspected internally to ensure the monitoring activities are in-compliance. Especially in the beginning of the crediting period, these internal inspections should take place, to guarantee the monitoring procedures.

Training. A training program will be developed for all employees involved in the landfill gas capture and flaring project. The program will define the type and frequency of training. The site's General Manager will ensure that only trained and skilled staff will work in the project. The training program's content will depend on the trainees' background and the function to which each will be assigned. Depending on each staff member's assignment, they will receive comprehensive information on the general and technical aspects of the gas capture and flaring project.

The technology suppliers will be requested to provide instructions and training to the project staff on the instalment, operation, maintenance and calibration of monitoring equipment. Over time, as staff members change, new employees will be trained by existing staff on these topics.

Data management - Quality control and quality assurance procedures. The project will establish a quality management system that will ensure the quality and accuracy of the measured data, including corrective measures in case of non-conformity. The quality management system will include:

- Gas field monitoring records
    - Daily readings of all field meters will be filled out on paper worksheets or electronically and filed consecutively. All data collected will also be entered on electronic worksheets and stored on a computer system immediately and on discs periodically.
    - Periodic controls of the LFG field monitoring records will be carried out to check any deviations from the estimated ERs following the guidelines for the LFG flare operation and monitoring for correction or future references.
    - Periodic reports to evaluate performance and assist with performance management will be elaborated.

- Monitoring data evaluation
    - Following the main criteria such as use and strict adherence to standard methods, use of non-standard methods only after approved validation, use of standard reporting forms

    - including process measures as well as emission data, etc. to guarantee the data reliable and accurate.
    - A procedure will be developed to define the responsibility of how critical data parameters and possible adjustments or uncertainties will be evaluated and performed.

- Equipment calibration and maintenance.
    - Flow meters, gas analyzers, other critical CDM project equipment will be subject to regular maintenance and testing according to the technical specifications from the manufactures to ensure accuracy and good performance.
    - Calibration of equipment will be conducted periodically according to manufacturer's technical specifications.

- Corrective actions
    - Actions to correct deviations from the Monitoring Plan and the guidelines for LFG capture and flare operation and monitoring will be implemented as these deviations are observed either by the operator or during internal audits.
    - Corrective actions also will be set down in case of equipment or systems malfunction or breakdown.

- Site audits
    - The company's management team for this project will make regular site audits to ensure that monitoring and operational procedures are being observed in accordance with the monitoring plan and the guideline for LFG capture and flare operation and monitoring activities.

- Documents storage
    - List of monitoring equipment (flow meters, gas analyzers, thermometers, etc.), including their numbers, names, manufacturers, specifications, use requirements, etc.
    - Calibration lists and reports, including equipment or parts calibrated, date, method and procedures of calibration, their precision after these procedures, personnel, devices needed, etc.
    - Maintenance lists and reports, including equipment or parts maintained, date, method and procedures of maintenance, their performance after these procedures, personnel, devices needed, etc.
    - Operational manual of the proposed project
    - Meeting minutes of CDM project team meeting
    - Non-conformance reports
    - Worksheets, monthly and yearly
    - Training plan
    - Internal audit/inspection reports, including personnel, time, findings, corrective actions, follow-up inspections
    - Annual monitoring review

- Emergency preparedness for unintended emissions
    - In case of equipment malfunction or breakdown, the timely corrective actions will be carried out to minimize the unintended consequences.
    - Project staff will be trained to appropriately cope with the emergent situations. They will be able to effectively judge an abnormal situation and make a prompt response such as fixing malfunctioned equipment, recording and reporting to the management team in a timely manner.

- The plant operator will inspect the gas capture and flare system, at least once per week, including all methane-containing parts of the plant (on the surface). All findings will be documented. In case a leakage is found, the leakage will be repaired according to the manufacturer's recommendations.

Verification. Verification is the focal point of a CDM project and all relevant documents will be in place, archived and accumulated in a Monitoring Report or on-site review by the DOE (verifier), who is verifying the project. The project management team will work closely with the verifier and answer all questions raised by the DOE for the emission reduction verification.

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

>> The baseline and monitoring methodology were approved 29.09.2011 (registration date).

Contact information:
Mrs.: Helena Reis (Environmental Engineer)
Ecopesa Ambiental S.A. (CTR candeias)
Address: Estrada Velha da Muribeca 1000, Jaboatão dos Guararapes, Pernambuco
+55 81 997740579
helena@ctrcandeias.com.br

SECTION C. Duration and crediting period

C.1. Duration of project activity

C.1.1. Start date of project activity

01/04/2011 (targeted date for the purchase of the flare and extraction system)

C.1.2. Expected operational lifetime of project activity

20 years and 0 month (based on the expected lifetime of the project).

C.2. Crediting period of project activity

C.2.1. Type of crediting period

Renewable

C.2.2. Start date of crediting period

01/08/2011 or on the date of registration of the project activity, whichever is later.

C.2.3. Length of crediting period

7 years and 0 month. The total expected crediting period is 21 years based on the initial 7-year crediting period and the potential for two 7-year renewals of the crediting period.

SECTION D. Environmental impacts

D.1. Analysis of environmental impacts

According to the National GHG Emissions inventory conducted by CETESB[43] in 1994, at that time Brazil had over 6,000 waste depositing sites, receiving over 60,000 tons of waste per day. Of this amount, 76% of the total waste is deposed in ‘dumpsites’ (Lixões) with no management, gas collection, or water treatment whatsoever, and usually without any license or under no control by the environmental agencies concerned. According to the same study, 84% of Brazil’s methane emissions come from the deposition of waste in uncontrolled dumpsites. The remaining 24% of waste is deposed in ‘controlled’ landfills (as opposed to ‘sanitary’ landfills, as planned by the project), but these are usually highly ineffective in relation to emissions and percolate control. In the few cases where gases are collected, this is done for safety reasons (to avoid explosions), and it is often the case that the amounts effectively collected are very low, due to high levels of percolates (which are often not drained or treated, as well) blocking the drainage pipes.

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

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

Where methane is used for electricity generation, operational practices at the landfill are improved thus contributing to sustainable development. Specifically for landfills, sustainable means accelerating waste stabilization such that the landfill processes can be said to be largely complete within one generation (30-50 years). This ensures that both leachate and methane are more carefully managed and controlled, and the degradation processes are accelerated.

Groundwater and surface water can be contaminated by untreated leachate from landfill sites. Leachate may cause serious water pollution if not properly managed. Surface water runoff from a landfill site can also cause unacceptable sediment loads in receiving waters, while

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[43] Source: Inventario Braileiro de gas metano Gerardo por residues. CETESB. Sao Paulo. September 2001. Web site: http://www.cetesb.sp.gov.br/geesp/docs/docs_cetesb/3.pdf

uncontrolled surface water run-on can lead to excessive generation of leachate and migration of contaminated waters off-site. With the CTR Candeias Landfill Gas Project providing appropriate management installing leachate evaporator system on the site, these potential problems should be avoided. Also few water impacts are associated with landfill gas electricity generation plants.

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

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

- Noise – There will be some increase in noise from the site associated with energy or flare systems, although the engines will be housed to reduce noise. The impacts are likely to be marginal given the noise typically associated with operations at landfills.
- Visual amenity – Placement of energy or flare system facilities at the landfill site will increase the visual presence of the site, however the impacts are expected to be marginal given the visual intrusion currently associated with the waste disposal operations.

D.2. Environmental impact assessment

According to Brazilian rules, flaring gas is one activity may cause environmental impacts and Haztec must therefore request an installation license and operational license from state environmental agency.
Haztec has made a request (License for Installation and Operation for the Project Activities) to the State Environmental Agency for an environmental recovery license. The license request was submitted on 29/09/2009[44]. This is the only license required for the landfill gas capture and flare system to be installed and operated.

SECTION E. Local stakeholder consultation

E.1. Solicitation of comments from local stakeholders

As required by the Interministerial Commission on Global Climate Change (CIMGC), the Designated National Authority (DNA) for Brazil, invitations must be sent for comments to local stakeholders as part of the procedures for analyzing CDM projects and issuing letters of approval. This procedure was followed by CTR Candeias Landfill Gas Project to take its GHG mitigation initiative to the public. Letters and the Executive Summary of the project were sent to the following local stakeholders[45]:

- Prefeitura Municipal de Jaboatão dos Guararapes–-PE / Municipal Administration of Jaboatão dos Guararapes–-PE.

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[44] Ref: *Protocolo de Licenciamento 2009* (Licencing protocol)

[45] Letters sent on 24/07/2009. Copies of the transmissions have been submitted to DOE at validation.

- Secretaria Municipal de Meio Ambiente de Jaboatão dos Guararapes–-PE / Municipal Secretariat of Environment of Jaboatão dos Guararapes–-PE.
- Câmara dos Vereadores de Jaboatão dos Guararapes–-PE / Municipal Legislation Chamber of Jaboatão dos Guararapes–-PE.
- CPRH - Agência Estadual de Meio Ambiente e Recursos Hídricos do Pernambuco / Environmental State Agency of Pernambuco.
- Ministério Público do Estado do Pernambuco / Public Ministry of Pernambuco State.
- Fórum Brasileiro de Moviementos e Organizacoes Sociais (FBMOS) / Brazilian NGO Fórum.
- ABES – Rio – Associação Brasileira de Engenharia Sanitária e Ambiental / Brazilian Association of Sanitary and Environment Engineering.
- Ministerio Público Federal
- CEDECOM – Centro de Estudos e Apoio ao Desenvolvimento de Comunidades

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

E.2. Summary of comments received

No comments have been received at this time.

E.3. Report on consideration of comments received

No comments have been received at this time.

SECTION F. Approval and authorization

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

Appendix 1. Contact information of project participants and responsible persons/ entities

Project participant and/or responsible person/ entity	☒ Project participant ☐ Responsible person/ entity for application of the selected methodology (ies) and, where applicable, the selected standardized baselines to the project activity
Organization name	Haztec Tecnologia e Planejamento Ambiental SA
Street/P.O. Box	Rua Sao Jose, 70; 18º andar; Centro
Building	Sao Jose
City	Rio de Janeiro
State/Region	Rio de Janeiro
Postcode	20010-020
Country	Brazil
Telephone	+55-21-3974-6150
Fax	+55-21-3974-6705
E-mail	Eduardo.gaiotto@haztec.com.br
Website	www.haztec.com.br
Contact person	Eduardo Gaiotto
Title	Project Manager
Salutation	Mr.
Last name	Gaiotto
Middle name	
First name	Eduardo
Department	Waste Management Department
Mobile	+55-21-9611-4412
Direct fax	+55-21-3974-6705
Direct tel.	+55-21-397-9140
Personal e-mail	

Project participant and/or responsible person/ entity	☒ Project participant ☐ Responsible person/ entity for application of the selected methodology (ies) and, where applicable, the selected standardized baselines to the project activity
Organization name	International Bank for Reconstruction and Development (IBRD) as Trustee of the Spanish Carbon Fund (SCF)
Street/P.O. Box	1818H St
Building	Washington, DC
City	District of Columbia
State/Region	20433
Postcode	USA
Country	202-458-1873
Telephone	202-522-7432
Fax	IBRD-carbonfinance@worldbank.org
E-mail	www.carbonfinance.org
Website	Ms. Joelle Chassard
Contact person	Manager
Title	Ms.
Salutation	Chassard
Last name	
Middle name	Joelle
First name	Environment Department
Department	
Mobile	202-522-7432
Direct fax	202-458-1873
Direct tel.	International Bank for Reconstruction and Development (IBRD) as Trustee of the Spanish Carbon Fund (SCF)
Personal e-mail	International Bank for Reconstruction and Development (IBRD) as Trustee of the Spanish Carbon Fund (SCF)

Project participant and/or responsible person/ entity	☒ Project participant ☐ Responsible person/ entity for application of the selected methodology (ies) and, where applicable, the selected standardized baselines to the project activity
Organization name	Kingdom of Spain - Ministry of Environment and Rural and Marine Affairs
Street/P.O. Box	C/Alcalá 92, 28009
Building	
City	Madrid
State/Region	
Postcode	28009
Country	Spain
Telephone	+34 91-4361549
Fax	+34 91-4361501
E-mail	and@mma.es
Website	
Contact person	
Title	Director General
Salutation	
Last name	MONTALVO
Middle name	
First name	Alicia
Department	Spanish Office of Climate Change (OECC)
Mobile	
Direct fax	
Direct tel.	
Personal e-mail	

Project participant and/or responsible person/ entity	☒ Project participant ☐ Person/entity responsible for completing the CDM-MR-FORM
Organization name	Kingdom of Spain - Ministry of Economy and Finance
Street/P.O. Box	Po de La Castellana, 162
Building	
City	Madrid
State/region	
Postcode	28046
Country	Spain
Telephone	+34 91 583 76 59
Fax	+34 91 583 52 11
E-mail	dgfint@meh.es
Website	
Contact person	
Title	Director General for International Finance
Salutation	
Last name	FERNANDEZ GARCIA
Middle name	
First name	Maria Jesus
Department	Directorate-General of International Financing
Mobile	
Direct fax	
Direct tel.	
Personal e-mail	

Project participant and/or responsible person/ entity	☒ Project participant ☐ Person/entity responsible for completing the CDM-MR-FORM
Organization name	Swedish Energy Agency
Street/P.O. Box	P.O. Box 310, SE-631 04 Eskilstuna, Sweden, Visiting address Kungsgatan 43
Building	
City	Eskilstuna
State/region	
Postcode	
Country	Sweden
Telephone	+46 16-544 20 00
Fax	+46 16-544 20 99
E-mail	registrator@swedishenergyagency.se
Website	www.swedishenergyagency.se
Contact person	
Title	Acting Director Gerneral
Salutation	
Last name	Eriksson
Middle name	
First name	Erik
Department	
Mobile	
Direct fax	
Direct tel.	
Personal e-mail	

Project participant and/or responsible person/ entity	☒ Project participant ☐ Person/entity responsible for completing the CDM-MR-FORM
Organization name	E.ON Climate & Renewables GmbH
Street/P.O. Box	45131 Essen, Brüsseler Platz 1, Germany
Building	
City	
State/region	
Postcode	
Country	
Telephone	
Fax	
E-mail	
Website	
Contact person	
Title	
Salutation	
Last name	Wolke
Middle name	
First name	Frank
Department	
Mobile	
Direct fax	
Direct tel.	
Personal e-mail	

Project participant and/or responsible person/ entity	☒ Project participant ☐ Person/entity responsible for completing the CDM-MR-FORM
Organization name	Norwegian Ministry of Climate and Environment
Street/P.O. Box	Stromsveien 96, N-0663, Oslo
Building	
City	Oslo
State/region	
Postcode	
Country	Norway
Telephone	+47 73 58 05 00
Fax	+47 73 58 05 01
E-mail	post@miljodir.no
Website	www.environmentagency.no
Contact person	
Title	Director of the Climate Department
Salutation	
Last name	Rosland
Middle name	
First name	Audun
Department	
Mobile	
Direct fax	
Direct tel.	
Personal e-mail	

Project participant and/or responsible person/ entity	☒ Project participant ☐ Person/entity responsible for completing the CDM-MR-FORM
Organization name	Norwegian Ministry of Climate and Environment
Street/P.O. Box	Stromsveien 96, N-0663, Oslo
Building	
City	Oslo
State/region	
Postcode	
Country	Norway
Telephone	+47 73 58 05 00
Fax	+47 73 58 05 01
E-mail	post@miljodir.no
Website	www.environmentagency.no
Contact person	
Title	Acting Head of Section for Emission Trading
Salutation	
Last name	Berntzen
Middle name	
First name	Trine
Department	
Mobile	
Direct fax	
Direct tel.	
Personal e-mail	

Project participant and/or responsible person/ entity	☐ Project participant ☒ Responsible person/ entity for application of the selected methodology (ies) and, where applicable, the selected standardized baselines to the project activity
Organization name	Ecopesa Ambiental S.A. (CTR candeias)
Street/P.O. Box	Estrada Velha da Muribeca 1000
Building	
City	Jaboatão dos Guararapes
State/Region	Pernambuco
Postcode	54325-042
Country	Brazil
Telephone	+55 81 34763634
Fax	+55 81 34763558
E-mail	
Website	www.ctrcandeias.com.br
Contact person	Helena Reis
Title	Environmental Engineer
Salutation	Mrs.
Last name	Reis
Middle name	Vasconcelos Martins
First name	Helena
Department	Unidade de Tratamento de Biogás
Mobile	+55 81 997740579
Direct fax	
Direct tel.	
Personal e-mail	helena@ctrcandeias.com.br

Appendix 2. Affirmation regarding public funding

There is no public funding involved in the CTR Candeias Landfill Gas Project.

Appendix 3. Applicability of methodology and standardized baseline

Please refer to section B.2.

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

BASELINE INFORMATION

Table A4-1: - Baseline determination information

DATA	VALUE	UNIT	SOURCE
Year of opening	2007		
Year of closure	2022		
Disposal	Refer to Table A3- 4	tons	
Waste composition Paper/cardboard Textile Food waste Garden waste Wood	 12.9% 3.8% 48.3% 0% 0.6%	Percentage of total waste	
MCF	1.0		IPCC 2006
K- decay rate Pulp, paper, Cardboard Textiles Food and Food Waste Garden, Yard and Park Waste Wood **DOCf** **DOCj** Wood and Wood Products Pulp, paper and Cardboard Food, Food Waste Textiles Garden, Yard and Park Waste	 0.07 0.07 0.40 0.17 0.35 0.5 40% 24% 15% 20% 43%	(% Wet Waste)	IPCC 2006 For tropical wet climate (lowered to adjust for Recife's slightly dryer climate) IPCC 2006 IPCC 2006

Table A4-2: - Monthly precipitation (2007)[46]

Month	Mean precipitation in mm
Jan	103.4
Feb	144.2
Mar	264.9
Apr	326.4
May	328.9
Jun	389.6
Jul	385.6
Aug	213.5
Sep	122.5
Oct	66.1
Nov	47.8
Dec	65.0
Mean annual	**2457.9**

Table A4- 3: - Mean monthly temperature[47]

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Máx	29°C	30°C	29°C	28°C	27°C	25°C	26°C	26°C	25°C	26°C	27°C	29°C
Mín	23°C	23°C	23°C	22°C	21°C	19°C	18°C	19°C	19°C	20°C	22°C	22°C
Méan	26°C	27°C	26°C	24°C	23°C	22°C	21°C	22°C	22°C	23°C	24°C	25°

Table A4- 4: - Annual waste to landfill

Year	Tons/Year
2007	32,501
2008	309,003
2009	457,303
2010	766,500
2011	766,500
2012	766,500
2013	766,500
2014	766,500
2015	766,500
2016	766,500
2017	766,500
2018	766,500
2019	766,500
2020	766,500
2021	766,500
2022	766,500

46 SOURCE INMET. http://www.inmet.gov.br/

47 SOURCE INMET. http://www.inmet.gov.br/

Brazilian Grid Emission Factor, $EF_{grid,CM,y}$

According to the "*Tool to calculate the emission factor for an electricity system*" version 02 the following steps have been followed:

STEP 1. Identify the relevant electricity systems.
STEP 2. Choose whether to include off-grid power plants in the project electricity system (optional).
STEP 3. Select a method to determine the operating margin (OM).
STEP 4. Calculate the operating margin emission factor according to the selected method.
STEP 5. Identify the group of power units to be included in the build margin (BM).
STEP 6. Calculate the build margin emission factor.
STEP 7. Calculate the combined margin (CM) emissions factor.

The official calculation was developed by the Brazilian DNA (Inter-ministerial Commission on Climate Change) and was used. The methodology and calculations are detailed below, as well as the source data published by the DNA.

Version 02 of the "*Tool to calculate the emission factor for an electricity system*" considers the determination of the emissions factor for the grid to which the project activity is connected as the core data to be determined in the baseline scenario. In the meeting of the April 29, 2008 the Brazilian DNA decided, by the information note (http://www.mct.gov.br/upd_blob/0024/24562.pdf), to use a unique national system (SIN) for entire Brazilian grid.

According to the tool, we have that:

The grid emission factor is calculated as the weighted average of the operating margin emission factor and the build margin emission factor and is expressed in tCO_2/MWh.

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

Where
$EF_{grid,OM,y}$ = Operating margin CO2 emission factor in year *y* (tCO2/MWh)
$EF_{grid,BM,y}$ = Build margin CO2 emission factor in year *y* (tCO2/MWh)
w_{OM} = Weighting for operating margin emission factor (%)
w_{BM} = Weighting for build margin emission factor (%)

In this case, for weighting these two factors, the default value of 50% will be considered for both the operating margin and the build margin emission factors (i.e., $w_{OM} = w_{BM} = 0.5$).

For both Operating and Build margins, the Brazilian DNA has decided to suppress the informational barrier by making the calculations available on a daily and monthly basis.

For the calculation of the Operation Margin, $EF_{grid,OM,y}$, the dispatch data analysis was used, option (C) of the "*Tool to calculate the emission factor for an electricity system*". According to the tool we have that:

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

Where:
$EF_{grid,OM-DD,y}$ = Dispatch data analysis operating margin CO2 emission factor in year *y* (tCO2/MWh)
$EG_{PJ,h}$ = Electricity displaced by the project activity in hour *h* of year *y* (MWh)

$EF_{EL,DD,h}$ = CO2 emission factor for grid power units in the top of the dispatch order in hour *h* in year *y* (tCO2/MWh)
$EG_{PJ,y}$ = Total electricity displaced by the project activity in year *y* (MWh)
h = Hours in year *y* in which the project activity is displacing grid electricity
y = Year in which the project activity is displacing grid electricity

The hourly emissions factor is calculated based on the energy efficiency of the power unit and the fuel type used, as follows:

$$EF_{EL,DD,h} = \frac{\sum_n EG_{n,h} \cdot EF_{EL,ny}}{\sum_n EG_{n,h}}$$

Where:
$EF_{EL,n,y}$ CO_2 emission factor of power unit n in year y (tCO_2/MWh);
$EG_{n,h}$ Net quantity of electricity generated and delivered to the grid by power unit n in hour h (MWh);
n Power units in the top of the dispatch.

For the *ex-ante* calculation of the Operation Margin (OM) Emission Factor, the arithmetic average of the OM Emission Factor published by the DNA was used (latest available data at the time the project was submitted for validation). (http://www.mct.gov.br/index.php/content/view/307492.html)

OPERATING MARGIN											
Emission Factor (tCO2/MWh) - Monthly											
2009											
January	February	March	April	May	June	July	August	September	October	November	December
0,2813	0,2531	0,2639	0,2451	0,4051	0,3664	0,2407	0,1988	0,1622	0,1792	0,181	0,194
										Mean	**0.2476**

Thus, $EF_{grid,OM-DD,y}$ = 0.2476

For the calculation of the Build Margin, the latest published information by the Brazilian DNA is that for the year 2009; thus we have that:

BUILDING MARGIN
Emission Factor (tCO2/MWh) - Annual
2009
0.0794

$EF_{grid,BM,y}$ = 0.0794

We are using the values divulged for 2009.

Finally, using the formula for the combined grid emission factor we have that:

$$EF_{grid,CM,y,} = 0.5 \times 0.0794 + 0.5 \times 0.2476 = 0.1635 \text{ tCO}_2\text{/MWh}$$

Appendix 5. Further background information on monitoring plan

All monitoring information is provided in Section B.7.1 and B.7.2 of this PDD.

Appendix 6. Summary of post registration changes

Corrections:

- The sentence: “There will be only one flare” in “Additional comment” under the parameter LFGflare (referring to the parameter under section B.7.1) was deleted to avoid any misinterpretation. Because the project does not specify any number of flares but use of a flare system, as described at section A.3.
- Update of Project Participants in front page and Section A.4.

Current version the form:

- Update to version 08.0 of the PDD template.

- - - - -

Document information

Version	Date	Description
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	Revisions 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; Editorial improvement.
05.0	25 June 2014	Revisions 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;* • 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.

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