CLEAN DEVELOPMENT MECHANISM
PROJECT DESIGN DOCUMENT FORM (CDM-PDD)
Version 03 - in effect as of: 28 July 2006

CONTENTS

Annexes

SECTION A. General description of project activity

A.1 Title of the project activity:

Natal Landfill Gas Recovery Project. Version 06.

Date: 17/03/2010 (DD/MM/YYYY)

A.2. Description of the project activity:

The city of *Natal*, situated in the Northeast region of Brazil has an estimated population of approximately 766,000 residents, in an area of 170 km^2 with 97% of its waste disposal collected.

The main activity by the project will be the implementation of a Clean Development Mechanism (CDM) on the *Natal Landfill*, using a modular system of suction and flare of biogas with the intention of flaring the methane generated by the landfill biogas, formed by the decomposition of the waste disposed at the landfill site, through an enclosed flare. The biogas has in part of its composition methane and dioxide carbon, among other gases, that cause the greenhouse effect, contributing to global warming. That way, the majority of the greenhouse gases (GHG) emissions by the landfill activity will be mitigated, contributing to the main objective of the UNFCCC – reduce such emissions. This project will also contribute to the sustainable development, demonstrating the potential to better solid waste management practices which became possible by a new financial mechanism (CDM) that can trigger the interest by other localities in the state or in the country and promoting, that way, an environmental consciousness concerning waste management.

The baseline scenario for the project activity is the current situation, where no biogas is collected and the landfill gas is released to the atmosphere, which is the same scenario prior to the start of the implementation of the project activity. With the implementation of the proposed project, this gas will be less hazardous to the global warming problem, decreasing the potential of the greenhouse gas from methane (which Global Warming Potential is 21) when related to CO_2 (which GWP is 1). When the methane is flared, the complete combustion transforms the CH_4 to CO_2.

Moreover, the project activity will present positive effects on health and amenities in the local area, significantly reducing vectors and odors caused by the landfill activities in the baseline scenario as well eliminating the risk of explosions on the landfill surroundings caused by unmanaged biogas emissions.

With the project implementation, there will also be constructive impact on the employment in the area where some temporary positions will be created in the system's assembly process and permanent positions to maintain and manage the LFG capture system operations will also be created.

A.3. Project participants:

Name of the party involved(*) ((host) indicates a host party	Private and/or public entity(ies) project participants (*) (as applicable)	Kindly indicate if the Party involved wishes to be considered as project participant (Yes/No)
Brazil (Host Country)	*Sereco S/A* – Private entity	No

A.4. Technical description of the project activity:

A.4.1. Location of the project activity:

The *Natal* Landfill is situated in the municipality of *Ceará-Mirim*.

A.4.1.1. Host Party(ies):

Brazil.

A.4.1.2. Region/State/Province etc.:

Rio Grande do Norte state, Northeast of Brazil.

A.4.1.3. City/Town/Community etc:

Municipality of *Ceará-Mirim.*

A.4.1.4. Detail of physical location, including information allowing the unique identification of this project activity (maximum one page):

The *Natal* Landfill is located in the municipality of *Ceará-Mirim* in the highway BR-406 in Km 159, 22 km from the city of *Natal* and 7 km from the centre of *Ceará-Mirim*, with an area of 60ha comprising in a waste disposal capacity of 1,028.14 tonnes/day. The landfill location was carefully chosen in order to be distant from the residential area. Therefore the landfill does not cause local negative impacts to the inhabitants of *Ceará-Mirim*. The geographical coordinates are Latitude South: 5°41'30'' and Longitude West: 35°22'53".

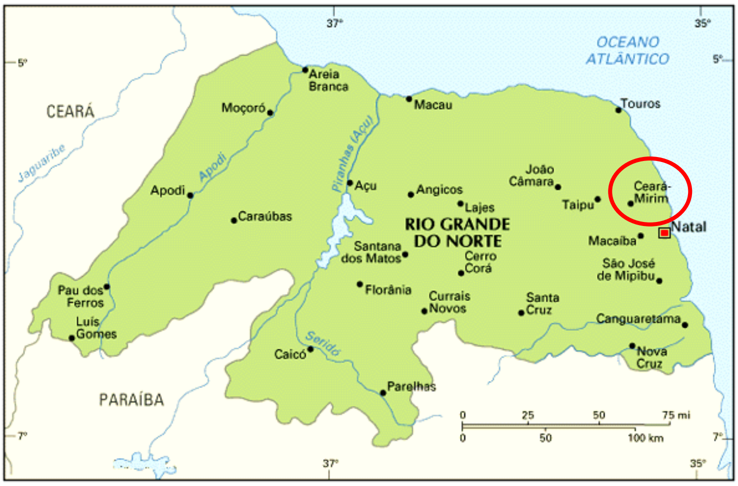

Figure 01: Map of Rio Grande do Norte *State.*

Figure 02: Map of Brazil detailing Rio Grande do Norte *state.*

A.4.2. Category (ies) of project activity:

Sectoral Scope 13: Waste handling and disposal.

A.4.3. Technology to be employed by the project activity:

The technology utilized in the project activity was developed in order to collect and destroy the landfill gases that, in the absence of the project activity, would be released into the atmosphere causing undesirable odors and diseases vectors proliferation. Therefore the technology that will be utilized will drastically improve the safety of the landfill operations. There will be a Modular Aspiration System and Biogas Burning composed, basically, of an extracting unit (or aspiration unit) of the biogas, one confined biogas burning unit (LANDFLARE) and a command and system automation unit. This equipment is projected to have a lifetime of 25 years. The project activity will reduce the GHG emissions that would happen in its absence that is the baseline scenario, where no biogas is collected and the landfill gas is completely released into the atmosphere.

Since the landfill gas extraction and management is not compulsory in Brazil, many landfill components are not present at the Brazilian market, such as control and monitoring equipment, LFG treatment and high efficient flare. However, local technology for the project activity will be used, where possible. The latter applies for the components used on the vertical/horizontal drains, gas network and pumps which are made in Brazil.

Currently, that is the same as the baseline scenario, the landfill presents:

1. Landfill cells coated with an impermeable high-density polyethylene membrane;
2. Equally distributed vertical wells in the landfill to extract LFG through exhaustion with blowers;[1]
3. Collectors pipes;
4. Compressors;
5. Leachate treatment system comprised by 3 pounds that reutilizes all the leachate to moisture the landfill cells.

[1] *LFG – Landfill gas*

In the project activity situation, besides the equipments listed above, it will be installed the flaring system, that includes a modular system of suction and flare of biogas working with the following equipments:

1. Extracting Unit (or aspiration)
2. One enclosed flare unit (LANDFLARE 1600/3000)
3. Unit of management and automation of the system
4. Accessory Unit

The Modular System of suction and flare of the biogas is composed mainly by a biogas Extractor unit (or aspiration unit), Captive Biogas Flare unit (LANDFLARE), Command and Automation System Unit, as described below:

- Extractor Unit (or aspiration)

This part is composed by a mechanical extractor with positive movements, activated through pulleys, chains and a 440 Volt and 30 HP explosion proof electric engines with modulated operation automatically adjusted according to the biogas' volume and composition available.

The extractor unit is based on chassis with acoustic cabinets and anterior and posterior mufflers.

The purpose of this unit is to aspirate the biogas from the condenser / auxiliary filter located before this unit.

- Extraction capacity (via aspiration): 1,600 Nm^3/hour up to 3,000 Nm^3/hour – variable according to the biogas available;

- Maximal depression (aspiration): 200 mBAR;

- Maximal discharge pressure: 100 mBAR;

- Connectors lubricated by oil immersion;

- Natural air refrigeration.

- Captive Flare unit (LANDFLARE 1600/3000)

Modular flare tower for the methane destruction (approximately 1,600 Nm^3/h, having the possibility of expansion up to 3,000 Nm^3/h of 50% methane biogas).

The structure is made of carbon steel with thermal non-corrosive metallic paint, thermal isolation made of a 100 mm ceramic fiber, composed by fixed modules inside the steel structure. The unit's measures are: 9.0 m total height and 2.88 m diameter.

The internal thermal isolation is made of ceramic fiber modules with 100 mm thickness, anchored internally through stainless steel bars. These bars have no contact with the heat to avoid its detachment, as can be commonly observed in fixation systems exposed to heat, like fixation systems made through blades and metal sheets. The aspersion of the refractory cement is made over the modules.

This unit presents also a ladder and a superior runway for sample collection and flare analysis, a thermocouple set is for temperature signaling, a call identifier sensor, and a programmable electric sparkler that guarantees a total automatic unit.

The radial flare installed in venture promotes a better gas mixture, which guarantees a stable flame and also more efficiency to destroy methane.

The LANDFLARES are captive vertical burners designated to destroy the amount of methane gas present in the biogas, with a minimal 35% concentration to avoid the addition of an auxiliary gas for flaring. The minimal destruction rate is between 96% and 98%.

- Command and Automation System Unit

This unit is composed by electronic panels where the flow measurer and biogas qualifying are displayed, as well as the vital signs of the other units, which are organized and translated to coordination reactions trough specially developed software. A 24-hour online data generation is available and data can be transmitted via internet for remote or local operation. The extraction and the automation and command units can be installed in the same container if this option is chosen.

- Auxiliary Unit

This unit is composed by an electric and pneumatic internal nets, safety and flow control valves, connections and accessories, pressure meter and accessories and a vacuum meter and accessories.

A.4.4 Estimated amount of emission reductions over the chosen crediting period:

Years	**Annual estimation of emission reductions (in tonnes of CO2e)**
August to December 2010	32,112
2011	83,386
2012	89,483
2013	95,496
2014	101,521
2015	107,625
2016	113,861
January to August 2017	70,156
Total estimated reductions (tCO2 equ.)	***693,640***
Total number of crediting years	7
Annual average over the crediting period of estimated reductions (tones of CO2 equ.)	**99,091**

A.4.5. Public funding of the project activity:

There will be no public funding on the project.

SECTION B. Application of a baseline and monitoring methodology

B.1. Title and reference of the approved baseline and monitoring methodology applied to the project activity:

The approved baseline methodology ACM-0001 Version 11, EB45: "Consolidated baseline and monitoring methodology for landfill gas project activities". The project activity relates to the sectoral scope 13 "Waste handling and disposal".

The methodology also refers to the latest version to the following tools, which are applicable to the project activity, since it has no electricity neither thermal generation in its scope:

• "Tool for the demonstration and assessment of Additionality"[2], version 5.2;

• "Tool to determine project emissions from flaring gases containing methane"[3], EB28 Annex 13;

• "Tool to calculate baseline, project and/or leakage emissions from electricity consumption"[4], EB39 Annex 7, version 01;

• "Tool to determine methane emissions avoided from disposal of waste at a solid waste disposal site"[5], EB 41 Annex 10, version 04;

• "Tool to calculate the emission factor for an electricity system"[6], EB35 Annex 12, version 01.1.

B.2 Justification of the choice of the methodology and why it is applicable to the project activity:

The applicability of the methodology and the tools are described below:

The methodology ACM0001, version 11, is applicable to Natal Landfill project due to the fact that the captured Landfill biogas is flared destroying methane and the baseline scenario was the partial atmospheric release of the gas. Then, the methodology includes 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. If emissions reductions are claimed for displacing natural gas, project activities may use approved methodology AM0053.

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[2] *Tool available at: http://cdm.unfccc.int/methodologies/PAmethodologies/AdditionalityTools/Additionality_tool.pdf*

[3] *Tool available at: http://cdm.unfccc.int/methodologies/Tools/eb28_repan13.pdf*

[4] *Tool available at: http://cdm.unfccc.int/methodologies/Tools/tool_electricity_consumption_v1.pdf*

[5] *Tool available at: http://cdm.unfccc.int/methodologies/Tools/meth_tool04_v04.pdf*

[6] *Tool available at: http://cdm.unfccc.int/methodologies/PAmethodologies/tools/am-tool-07-v1.1.pdf*

The proposed project activity corresponds to **item a)** of ACM0001, version 11, since it consists in the capture and flare through enclosed flare system of the landfill gases, only.

For the "*Tool to determine project emissions from flaring gases containing methane*", EB28 Annex 13, the applicability conditions are:

• The residual gas stream to be flared contains no other combustible gases than methane, carbon monoxide and hydrogen;

• The residual gas stream to be flared shall be obtained from decomposition of organic material (through landfills, bio-digesters or anaerobic lagoons, among others) or from gases vented in coal mines (coal mine methane and coal bed methane).

Then, the proposed project activity meets with above options, since the landfill comprehends the decomposition of organic material through a landfill and the gas contains no other combustible gas than methane, carbon monoxide and hydrogen. And this tool is, therefore, applicable.

For the "*Tool to calculate baseline, project and/or leakage emissions from electricity consumption*", EB39 Annex 7, version 01, it is necessary to be in line with, at least, one out of the following three scenarios related to the sources of electricity consumption:

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

Then, the proposed project activity meets with **scenario A** of the tool, since the electrical energy consumption is from the grid.

For the "*Tool to determine methane emissions avoided from disposal of waste at a solid waste disposal site*"[7], EB 41 Annex 10, version 04, that calculates baseline emissions of methane from waste that would in the absence of the project activity be disposed at solid waste disposal sites (SWDS), not in stockpiles (as determines the applicability conditions). Emission reductions are calculated with a first order decay model and also the tool is applicable in cases where the solid waste disposal site, where the waste would be dumped, can be clearly identified. The tool is not applicable to hazardous wastes. Since the place where waste (that is not hazardous) is displaced is clearly identified in the project activity, then this tool is applicable.

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[7] *Tool available at: http://cdm.unfccc.int/methodologies/Tools/meth_tool04_v04.pdf*

For the "*Tool to calculate the emission factor for an electricity system*"[8], EB35 Annex 12, version 01.1, the applicability is to estimate the OM, BM and/or CM for the purpose of calculating baseline emissions for a project activity that substitutes electricity from the grid. This tool is used by the Brazilian DNA, that calculates the Brazilian Emission Factor to be used by the CDM projects that generate or consume electrical energy from the grid. However the project activity does not comprise savings of electricity nor supplies energy to the grid, this tool may be referred to "*Tool to calculate baseline, project and/or leakage emissions from electricity consumption*" for the purpose of calculating project and leakage emissions in case where a project activity consumes electricity from the grid or results in increase of consumption of electricity from the grid, that is the case of the project activity.

B.3. Description of the sources and gases included in the project boundary

For *Natal Landfill* there is only one primary source of CO_2 emissions within the boundary of the project activity: the waste decomposition. The project emissions are due to the use of electricity in extracting and pumping the landfill biogas. The emissions of CO_2 in the equipment of extracting and pumping the biogas is based on an electricity based pump system.

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[8] *Tool available at: http://cdm.unfccc.int/methodologies/PAmethodologies/tools/am-tool-07-v1.1.pdf*

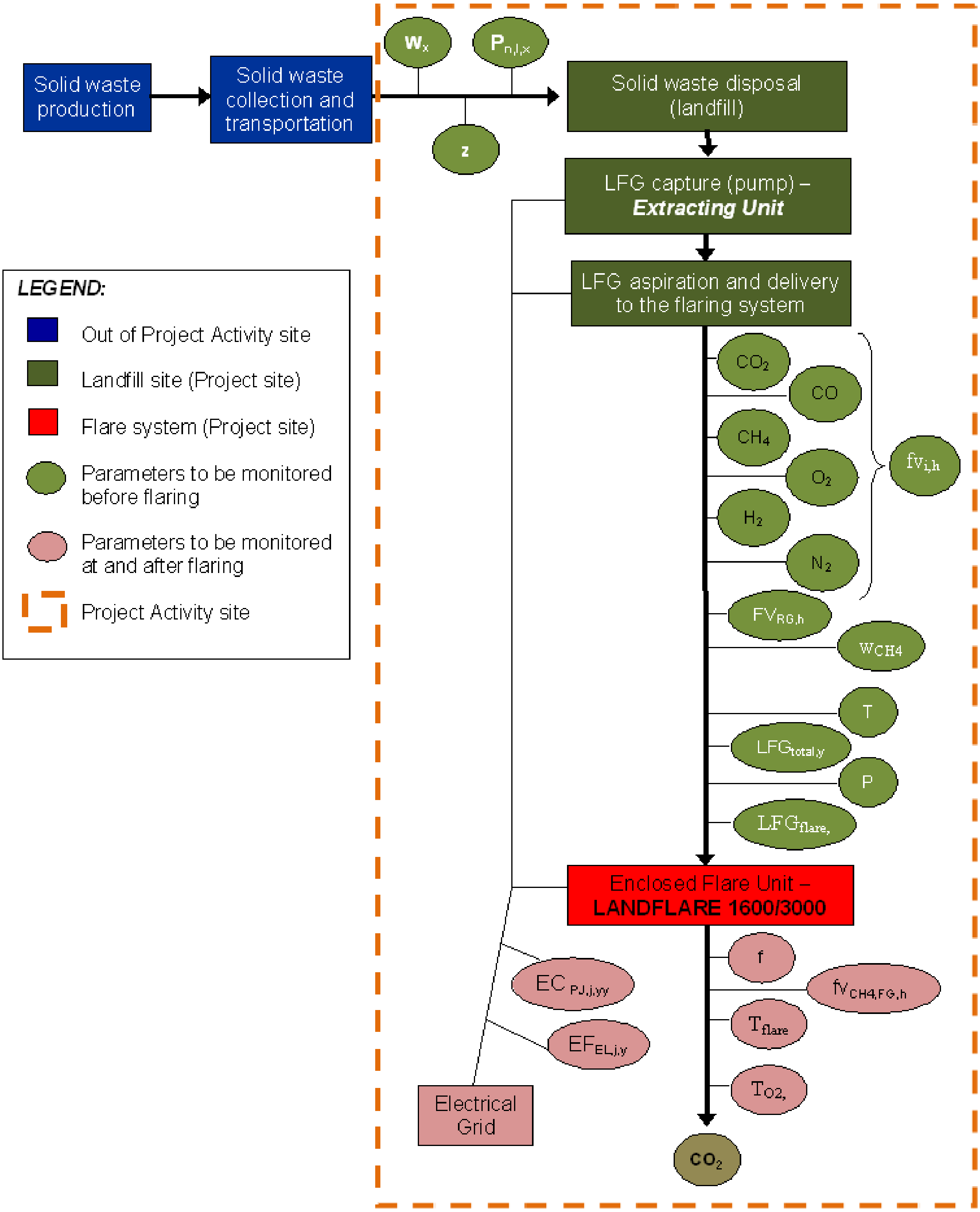

Figure 03. Flow diagram of the project boundary, physically delineating the project activity, based on the descriptions provided in section "A.4.3. Technology to be employed by the project activity".

	Source	Gas	Included?	Justification / Explanation
Baseline	Emissions from decomposition of waste at the landfill site	CH_4	Yes	The major source of emissions in the baseline
		N_2O	No	N_2O emissions are small compared to CH_4 emissions from landfills. Exclusion of this gas is conservative.
		CO_2	No	CO_2 emissions from the decomposition of organic waste are not accounted.
	Emissions from electricity consumption	CO_2	No	Electricity is not consumed from the grid in the baseline scenario.
		CH_4	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 project activity boundary.
		CH_4	No	Excluded for simplification. This is conservative.
		N_2O	No	Excluded for simplification. This is conservative.
Project Activity	On-site fossil fuel consumption due to the project activity other than for electricity generation	CO_2	No	There is no fossil fuel consumption due to the project activity.
		CH_4	No	Excluded for simplification. This emission source is assumed to be very small.
		N_2O	No	Excluded for simplification. This emission source is assumed to be very small.
	Emissions from on-site electricity use	CO_2	Yes	It is an emission source, since there is consumption of electricity from the grid in the project activity boundary.
		CH_4	No	Excluded for simplification. This emission source is assumed to be very small.
		N_2O	No	Excluded for simplification. This emission source is assumed to be very small.

B.4. Description of how the baseline scenario is identified and description of the identified baseline scenario:

The methodology ACM0001, version 11, establishes the procedure for the selection of the most plausible baseline scenario. According to it, four steps should be followed:

Step 1: Identification of alternative scenarios, such as defined by the version 5.2 of the Tool for the demonstration and assessment of additionality. This step has a complementation in section B.5 below.

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

Alternative 1: The proposed project activity undertaken without being registered as a CDM project activity that fits option LFG1 of the referred methodology

This option comprises the installation of an active gas collection and flaring system to burn the landfill gas without considering the CDM revenue. This alternative is unlikely to happen since the system represents a significant investment and no revenue will be generated. The site has no incentive to modify its operational methods since there is no contractual or legal requirement to do so.

Alternative 2: Production and sale of electricity or heat from landfill gas

This alternative consists on the recovery of the landfill gas to produce either thermal energy or electricity and sale this energy to a customer. The alternative scenario consisting of producing electricity from landfill gas is unattractive for reasons linked to the lack of maturity of this technology in Brazil as it is observed in *Atlas de Energia Elétrica do Brasil*[9] – third Edition where it is written in November/2008 there were 3 thermoelectric plants working with biogas (*Bandeirantes* Landfill with an installed capacity of 20 MW, *São João* Landfill - 24,6 MW, and *Energ Biog* Landfill, com 30 kW). Besides those units, there were 7 granted units, totalizing 109 MW of potency in *São Paulo*, *Bahia*, *Rio de Janeiro*, *Pernambuco* and *Santa Catarina*). Then, the project activity does not comprise this kind of activity, due to this technological barrier.

This option foresees the installation of an electric generation system based on LFG. Moreover an electrical transformer of 12.5kVA would be necessary to step up the energy generated for the local transmission lines, specially built for the project.

This specific alternative, then, is not credible for the project activity.

Alternative 3: Continuation of the current situation on site, common practice in Brazil, which fits option LFG2 of the methodology

For this scenario, the landfill gas is released to the atmosphere, with occasional passive flaring, or partial capture of landfill gas and destruction to comply with safety and odour concerns and due to technical standards of operation for safety that is related to the gases draining and flaring[10].Landfill gas is not recovered for energy production onsite, or externally.

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

All alternatives described in sub-step 1a are in compliance with Brazilian legal and regulatory requirements.

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[9] *The third edition of Atlas of Brazilian Electrical Energy is available at: http://www.aneel.gov.br/arquivos/PDF/atlas_par2_cap5.pdf*

[10] *Operating technical standards for landfills given by NBR 8419 from ABNT – Brazilian Association of Technical Norms – in section 5.1.6.5. Gases Draining Systems of this norm.*

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

Since there is no energy generation using the biogas in the project activity, this step is not applicable.

Step 3: Barrier Analysis

Step 3a. Identify barriers that would prevent the implementation of the proposed CDM project activity:

The implementation of a landfill gas collection and utilization system at the *Natal* Landfill site faces a number of investment and technologic barriers in the absence of the CDM incentive. These barriers are briefly discussed below.

Investment Barriers

At the time that the project proponent considered the possibility of undertaking the project activity, the low availability of debt funding or access to international capital markets were relevant to decide about the implementation of the project, since at that time there was a real risk associated with the investment in Brazil yet the international investment grade of Brazil was only available in May, 2008[11]. Besides, the project proponent has no other financial incentives coming from the project activity beyond the carbon credits. Another issue is that, in Brazil, the interest rates are high (due to the monetary policy), which does not incentive the investor to put their money on high level of risk projects, such as biogas collection in landfills, that present several uncertainties due to the amount of methane would be produced related directly to the local climate and humidity. Then, the collectors and monitoring system are very expensive to just flare the biogas, what brings such level of risk to the investor, since only the CERs revenue will be considered.

Technological Barriers

As the technology used in LFG Monitoring, such as the electronic components of monitoring and control like sensors and gas analyzers are not well-known in Brazil, the lack of qualified personal to implement and operate this technology is one of the most relevant barriers. Although the main infrastructure for the implementation of this type of project is readily available, the monitoring components of the LFG management system are neither produced, nor available in Brazil and therefore need to be imported from other countries.

Likewise, the necessary service provider and specialized technical personnel to implement the monitoring and control procedures are not widely available in Brazil. Regarding the fact that there is no national technical school prepared to offer the needed skills, unprepared workers can damage equipments causing disrepair, malfunctioning and as a consequence, financial losses. Therefore, technical expertise from other countries is needed to develop detailed engineering studies and project implementation support in order to supply the monitoring and control information.

"Sub-step 3b. Show that identified barriers would not prevent the implementation of at least one of the alternatives (except the proposed project activity)"

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[11] *http://www.estadao.com.br/economia/not_eco165471,0.htm*

Alternative 1: Implementation of a landfill gas capture and utilization system without registration as a CDM project will require a high investment, but since this activity is not obligated, the project proponent would not invest on it without receiving financial benefits (in this case, CER revenue). Investment barriers, besides the technical ones, prevent the implementation of this alternative.

Alternative 2: Implementation of a landfill gas capture in order to produce energy will not proceed as a result of significant investments required. Besides, in the landfills the biogas production depends on the anaerobic activity being influenced by the temperature, humidity and amount of organic waste, which bring a not exact fuel production in order to commit an amount of energy to be generated. And also energy generation does not comprise the core business of the landfill operator, so a specialized team would be needed to manage this issue. Thus, investment and technical barriers prevent the implementation of this alternative.

Alternative 3: The identified barriers would not affect the current “business-as-usual” scenario of emitting the landfill gas into the atmosphere. The “business-as-usual” scenario does not require any investments or technological improvements and is fully compatible with regulatory requirements.

Then, the third alternative, that comprises the continuation of the current situation, is the unique that would not be prevented by the identified barriers, since nothing in the plant would be built.

Step 4: Baseline scenario

The baseline scenario has been defined as the partial release of the landfill gas to the atmospheric produced by waste in anaerobic conditions and subsequently flared due to safety and odour concerns after reviewing:

• Other alternatives;

• Legal and contractual obligation (existing and forthcoming);

• Current practice of waste management sector in Brazil;

• Current practice on site.

B.5. Description of how the anthropogenic emissions of GHG by sources are reduced below those that would have occurred in the absence of the registered CDM project activity (assessment and demonstration of additionality):

The Additionality is constructed based on the document: “Tool for the demonstration and assessment of Additionality” version 5.2, as defined from the 39th Meeting of the Executive Board.

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

According to the National Inventory of Greenhouse Effect Gas Emission conducted by CETESB[12] (Environmental Sanitation and Technology Company), in 1994, Brazil´s garbage dumping sites receive about 59,000 tons of garbage per day.

[12] *CETESB. 2006. Methane emissions from waste treatment and waste disposal in Brazil. Published by Technology and Science Ministry (Ministério da Ciência e Tecnologia,. Brasilia-DF.* < http://www.mct.gov.br/upd_blob/0008/8856.pdf>

Related to the same study, 76% of the total waste amount produced currently in Brazil is disposed in unmanaged "dumping sites", 22% on controlled landfills (sanitary landfills) and 2% on other disposal ways (see table 1).

Final waste destination	Percentage	Source
Open Dump	76 %	*CETESB*[14]
Controlled landfill	12 %	*CETESB*
Sanitary landfill	10 %	*CETESB*

Table 1: Final waste disposal in Brazil.

The current Brazilian legislation does not require an efficient treatment of the LFG generated besides gas venting (passive ventilation). In spite of the guidelines provided by the Brazilian Association of Technical Norms (*ABNT – Associação Brasileira de Normas Técnicas*[13]), there are no binding regulations for the technical conditions of LFG recovery systems in Brazil.

The baseline scenario shows the atmospheric release of the LFG gas with no regulations and/or contractual requirements governing the landfill gas emissions or treatment. For *Natal Landfill*, the baseline scenario represents a basic LFG ventilation system.

The baseline scenario relates to the waste management activities before the project activity implementation ongoing on *Natal* Landfill operated by the project proponent, *Sereco S.A*, which does not present any capture of the landfill gas releasing it into the atmosphere directly, destructing only a little portion in vertical drains to assure safety and odour concerns, The unique technical specification related to landfills in Brazil is NBR 8419 – from the Brazilian Association of Technical Norms[11] - that states about security in the landfill and odour concerns..

The core business of *Sereco* is the control and management of the waste disposition of municipal and commercial waste in an environmental sustainable way. No hazardous waste material is on place, in compliance with the Brazilian Technical Standard NBR10-0004 for such landfill type.

Under this scenario the company operates a landfill based on a simple landfill gas venting system that releases great portion of LFG generated as a consequence of the anaerobic decomposition of the waste, as the referred methodology has proposed in the procedure for the selection of the most plausible baseline scenario in step 1. This alternative for the disposal/treatment of the waste in the absence of the project activity is in accordance to LFG2, the baseline scenario for the landfill, where there is an atmospheric release of the landfill gas or partial capture of landfill gas and destruction to comply with regulations of contractual requirements, or to address safety and odor concerns.

As it is evident and, since there is no energy and heat generation in the project activity, the unique plausible alternative to the proposed project activity is the continuation of the current situation, where no capture and flare for the landfill gas is foresaw. The other alternative could be, as described in version 11 of ACM0001, LFG1 that the project activity is undertaken without being registered as a CDM project activity. However this alternative is taken out since Brazil does not have any regulation in order to obligate landfill entrepreneurs to capture and flare the gas and the necessary technology to be employed is too expensive and there is no other benefit to the project, besides the CDM revenue. Then, if the landfill operators did not receive any monetary incentive, they would not implement the technology only to not emitting GHG to the atmosphere.

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[13] *www.abnt.org.br/*

In opposition to the business as usual scenario, the project activity will capture and flare the landfill gas through forced gas exhaustion. The proposed project activity is covered and defined under the applicability of the ACM0001 methodology.

On Table 2, project data relating to the baseline scenario.

Variable	Units	Definition	Value	Data Source
$W_{j,y}$	Ton/year	Yearly average waste disposed in the landfill	395,739	*Sereco*
FE	%	Flaring efficiency	96.00	*Brasmetano*
$W_{CH4,y}$	m^3CH_4 / m^3 LFG	Average methane fraction of the landfill gas	0.5	IPCC

Table 2: Key project variables and data used to determine the baseline scenario.

The steps 1 and 3 of the Tool for demonstrating the Additionality are presented in section B.4. The first step has a complementation to the described in B.4 right before this paragraph in section B.5 above. Following are given the subsequent steps.

Step 4. Common practice analysis

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

In Brazil there are no similar activities related to the project activity without considering CDM revenue and the common practice for disposing the urban residues is in sites where there are no capture and flaring systems. According to the latest official statistics on urban solid waste in Brazil – *Pesquisa Nacional de Saneamento Básico 2000* (PNSB 2005) – the country produces 228.413 tons of waste per day, which corresponds to 1.35 kg/inhabitant/day. And though there is a worldwide trend towards reducing, reusing and recycling, therefore reducing the amount of urban solid waste to be disposed in landfills, the situation in Brazil is peculiar. Most of the waste produced in the country is sent to open dumps which are, in most of the cases, areas without any sort of treatment or management to avoid environmental hazards. Besides, in the state of Rio Grande do Norte, there is no other landfill, emphasizing the local practice of disposing the urban waste in open dumps and similar places where no capture and flaring system is installed.

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

Some landfills operate with a forced methane extraction and destruction, using blowers, collection systems and flaring systems: *Bandeirantes* Landfill (2 municipalities) - UNFCC Ref. 0164, *Nova Gerar* Landfill (1 municipality) - UNFCCC Ref. 0008, *Onyx* Landfill (4 municipalities) - UNFCCC Ref. 0027, *Marca* Landfill (8 municipalities) - UNFCCC Ref. 0137, *Sertãozinho* Landfill (8 municipalities), *Salvador da Bahia* Landfill (1 municipality) – UNFCCC Ref. 0052 and *ESTRE Paulínia* Landfill (8 municipalities) – UNFCCC Ref. 0165. This kind of project activity is not widely spread in Brazil and the landfills that operate this type of project represent only a small portion of the total existing landfills. All these landfills are flared gas capturing projects that could only be possible due to the carbon credits incentives.

B.6. Emission reductions:

B.6.1. Explanation of methodological choices:

The consolidated methodology ACM0001 for landfill gas project activity version 11 where the LFG capture project activity where the baseline scenario is the partial or total atmospheric release of the gas. Then, such method is applicable to *Natal Landfill* project activity, since there is currently a partial atmospheric release of the landfill gas. The scenarios for the baseline given by the version 11 of the methodology for this type of project activity are presented below:

1 – *The captured gas is flared*, that is the scope of the project activity; or

2 - *The captured gas is used to produce energy (e.g. electricity/thermal energy)*, this scenario is not for the project activity, since there is no electricity or thermal energy generation; or,

3 - *The captured gas is used to supply consumers through natural gas distribution network*. As the project activity does not comprise the natural gas distribution, this baseline scenario is also not applicable to the project activity.

For the project activity, the **scenario 1** is applicable, therefore, the project activity fulfils the applicability conditions of the methodology ACM0001 (Version 11, EB 47). As no other fuels are used within the project boundary, such emissions have not been taken into account for the proposed project activity. The unique project emission besides the biogas flare is the electrical energy consumption from the grid in order to supply the pumping and extraction system related to the flare equipment.

The internal use of electricity for the operation of the project will be monitored and taken into account for the project emissions in the ER calculation.

In order to estimate the Emission Reductions for a landfill, the systematic stages of calculation must follow the central approach that is, generally, based on this sequence:

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

Equation 1

This first equation gives the Baseline Emissions, which represents the total amount of emissions in the absence of the project activity in a landfill. And after:

$$PE_y = PE_{EC,y} + PE_{FC,j,y} \qquad \textbf{Equation 2}$$

This second equation brings the Project Emissions related to the project activity in a landfill that will be discounted from the total amount of baseline emissions. And, finally:

$$ER_y = BE_y - PE_y \qquad \textbf{Equation 3}$$

The third equation provides the Emission Reductions taking into consideration both equations above mentioned.

These 3 formulas have their variations and other formulas that are directly involved with their result. Then the method is presented in a detailed way below.

Baseline emissions

According to ACM-0001 Methodology version 11, the Baseline Emissions in year "y" (measured in tCO_2e) shall be calculated following the Equation 1, where no fossil fuel consumption exists for the project under the baseline scenario. The baseline emission is the atmospheric release of the gas, although the baseline methodology considers that some of the methane generated by the landfill may be captured and destroyed to comply with regulations or contractual requirements with the intention of addressing safety and odor concerns:

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

Equation 1

Where:

BE_y	is the baseline emissions in year y (tCO_2e);
$MD_{project,y}$	is the amount of methane that is destroyed/combusted during the year, in tonnes of methane (tCH_4) in project scenario;
$MD_{BL,y}$	is 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 tonnes of methane (tCH_4);
GWP_{CH4}	is the Global Warming Potential value for methane for the first commitment period is 21 tCO_2e/tCH_4;
$EL_{LFG,y}$	is the 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 onsite/ off-site fossil fuel based captive power generation, during year y, in MWh (not applicable);
$CEF_{elecy,BL,y}$	is the CO_2 emissions intensity of the baseline source of electricity displaced, in tCO_2e/MWh (not applicable);
$ET_{LFG,y}$	is 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. (not applicable);
$CEF_{ther,BL,y}$	is the CO_2 emissions intensity of the fuel used by boiler/air heater to generate thermal energy which is displaced by LFG based thermal energy generation, in tCO_2e/TJ (not applicable).

Since this project activity does not produce electric and thermal energy using LFG, a simplified equation is assumed:

$$BE_y = (MD_{project,y} - MD_{BL,y}) * GWP_{CH4} \qquad \text{Equation 1.A}$$

EX-ANTE Calculation of $MD_{project}$:

The $MD_{project,y}$ parameter is the amount of methane that is destroyed/combusted during the year y in the project scenario. This value is directly related to the methane emissions avoided during the year y from waste disposal at the landfill site, that is represented by $BE_{CH4,SWDS,y}$ in the version 4 (from EB41 Annex

10) of the "*Tool to determine methane emissions avoided from disposal of waste at a solid waste disposal site*". The ex-ante formula given by the methodology is:

$$MD_{project,y} = BE_{CH4,SWDS,y} / GWP_{CH4} \qquad \text{Equation 4}$$

In order to be conservative in the calculation of $BE_{CH4,SWDS,y}$, it is necessary to consider both the extraction efficiency and the efficiency of the flare, as not all methane generated by the landfill will be destroyed by the flare, as only part of it will be extracted and the not 100% of the extracted methane will be destroyed by the flare, which result in:

$$MD_{project,y,(conservative)} = BE_{CH4,SWDS,y} \text{ *extraction efficiency *flare efficiency} / GWP \qquad \text{Equation 4.A}$$

Where:

$MD_{project,y,\ (conservative)}$	is the amount of methane that is destroyed by the project activity during the year y of the project activity (tCH_4);
$BE_{CH4,SWDS,y}$	is the methane generation from the landfill in the absence of the project activity at year y (tCO_2e), calculated as per the "*Tool to determine methane emissions avoided from disposal of waste at a solid waste disposal site*". The tool estimates methane generation adjusted for, using adjustment factor (f) any landfill gas in the baseline that would have been captured and destroyed to comply with relevant regulations or contractual requirements, or to address safety and odor concerns, as calculated by Equation 5;
GWP_{CH4}	is the Global Warming Potential value for methane for the first commitment period that is 21 tCO_2e/tCH_4;
extraction efficiency	is the extraction efficiency of the proposed system;
flare efficiency	is the flare efficiency of the proposed system;

The $BE_{CH4,SWDS,y}$, as previously described, represents the quantity of methane that would be released to the atmosphere in the absence of the project activity by a solid waste disposal site. In order to estimate it, a First Order Decay model (FOD model) is used, which differentiates the sorts of waste *j* relating them to their own decay rates k_j and fractions of degradable organic carbon (DOC_j). The model takes first the sum of waste per year ($W_{j,x}$) and relates those different types of solid waste to their particular factors. So, the baseline amount of methane produced in the year *y* is given by the formula 8 below:

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

Equation 5

Where:

$BE_{CH4,SWDS,y}$	is the 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 is the model correction factor to account for model uncertainties;

f is the fraction of methane captured at the SWDS and flared, combusted or used in another manner;

GWP_{CH4} is the Global Warming Potential (GWP) of methane, valid for the relevant commitment period;

OX is the oxidation factor (reflecting the amount of methane from SWDS that is oxidized in the soil or other material covering the waste);

F is the fraction of methane in the SWDS gas (volume fraction);

DOC_f is the fraction of degradable organic carbon (DOC) that can decompose;

MCF is the methane correction factor;

$W_{j,x}$ is the amount of organic waste type *j* prevented from disposal in the SWDS in the year *x* (tons);

DOC_j is the fraction of degradable organic carbon (by weight) in the waste type *j*;

k_j is the decay rate for the waste type *j*;

j is the waste type category (index);

x is the 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 is the year for which methane emissions are calculated.

For this formula, there are several defaults, even to differentiate the types of wastes, such as:

Factor	Value	Comments
φ	0.9	Given by the "*Tool to determine methane emissions avoided from disposal of waste at a solid waste disposal site*", version 4.
f	0	The value is null, since there is no percentage of methane that will be flared, combusted or used in another manner.
GWP	21	Given by the IPCC for the first commitment period.
OX	0.1	As the managed solid waste disposal site of the project activity is covered with oxidizing material, such as soil and compost.
F	0.5	This factor reflects 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.
DOC_f	0.5	Given by the IPCC 2006 Guidelines for National Greenhouse Gas Inventories.
MCF	1	It is used 1 for anaerobic managed solid waste disposal sites. These must have controlled placement of waste (i.e., waste directed to specific deposition areas, a degree of control of scavenging and a degree of control of fires) and will include at least one of the following: (i) cover material; (ii) mechanical compacting; or (iii) leveling of the waste. As the Project Activity presents the 3 options, the value must be 1.0.

DOC_j (organic)	0.15	Given by IPCC 2006 Guidelines for National Greenhouse Gas Inventories (adapted from Volume 5, Tables 2.4 and 2.5) specific for food, food waste, beverages and tobacco (other than sludge) in wet waste, between a list of (wood and wood products; pulp, paper and cardboard (other than sludge); food, food waste, beverages and tobacco (other than sludge); textiles; garden, yard and park waste; and glass, plastic, metal, other inert waste.
DOC_j (paper)	0.4	Given by IPCC 2006 Guidelines for National Greenhouse Gas Inventories (adapted from Volume 5, Tables 2.4 and 2.5) specific for pulp, paper and cardboard (other than sludge) in wet waste, between a list of (wood and wood products; pulp, paper and cardboard (other than sludge); food, food waste, beverages and tobacco (other than sludge); textiles; garden, yard and park waste; and glass, plastic, metal, other inert waste.
k_j (organic)	0.4	Given by IPCC 2006 Guidelines for National Greenhouse Gas Inventories (adapted from Volume 5, Table 3.3) specific for Rapidly degrading of food, food waste, sewage sludge, beverages and Tobacco, under a Wet clime (MAP>1000mm).
k_j (paper)	0.07	Given by IPCC 2006 Guidelines for National Greenhouse Gas Inventories (adapted from Volume 5, Table 3.3) specific for slow degrading of Pulp, paper, cardboard (other than sludge), textiles, under a Wet clime (MAP>1000mm).

Table 3: Default values for data and parameters not monitored for Equation 5[14].

And the value for $W_{j,x}$ is given as the following equation:

$$W_{j,x} = W_x \cdot \frac{\sum_{n=1}^{z} p_{n,j,x}}{z}$$

Equation 6

Where:

$W_{j,x}$ is the amount of organic waste type *j* prevented from disposal in the SWDS in the year *x* (tons);

W_x is the total amount of organic waste prevented from disposal in year *x* (tons);

$p_{n,j,x}$ is the weight fraction of the waste type *j* in the sample *n* collected during the year *x;*

z is the number of samples collected during the year *x*.

EX-POST Calculation of $MD_{project,y}$:

Once the project starts operation, the value for the $MD_{project,y}$ will be determined ex-post by metering the actual quantity of methane captured and destroyed. For the ex-post approach, it is necessary to use the following formula to the $MD_{project,y}$:

[14] More information about these values can be found in section B.6.2.

$$MD_{project,y} = MD_{flared,y} + MD_{electricity,y} + MD_{thermal,y} + MD_{PL,y}$$ Equation 7

Where:

$MD_{flared,y}$ is the quantity of methane destroyed by flaring (tCH4);
$MD_{electricity,y}$ is the quantity of methane destroyed by generation of electricity (tCH4);
$MD_{thermal,y}$ is the quantity of methane destroyed for the generation of thermal energy (tCH4);
$MD_{PL,y}$ is the quantity of methane sent to the pipeline for feeding to the natural gas distribution network (tCH4).

As there will be no generation of electricity, neither thermal energy nor natural gas distribution network, then the ex-post:

$MD_{project,y} = MD_{flared,y}$. Equation 7.A

And the $MD_{flared,y}$ can be calculated by:

$MD_{flared,y} = (LFG_{flared,y} * w_{CH\,4,y} * D_{CH\,4}) – (PE_{\,flared,y} / GWP_{CH\,4})$ Equation 8

Where:

$LFG_{flare,y}$ is the quantity of landfill gas fed to the flare(s) during the year measured in cubic meters (m^3);
$w_{CH4,y}$ is the average methane fraction of the landfill gas as measured during the year and expressed as a fraction (in m^3 CH4 / m^3 LFG);
D_{CH4} is the methane density expressed in tones of methane per cubic meter of methane (tCH4/m3CH4);
$PE_{flare,y}$ is the project emissions from flaring of the residual gas stream in year y (tCO2e) determined following the procedure described in the "*Tool to determine project emissions from flaring gases containing Methane*", with a sequence of 7 steps described forwards.

Calculation of $PE_{flare,y}$

The $PE_{flare,y}$ is given by the following equations, as it is determined by the "*Tool to determine project emissions from flaring gases containing methane*", version 1 from EB 28:

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

This step calculates the residual gas mass flow rate in each hour h, based on the volumetric flow rate and the density of the residual gas. The density of the residual gas is determined based on the volumetric fraction of all components in the gas.

$FM_{RG,h} = \rho_{RG,n,h} * FV_{RG,h}$ Equation 9

Where:

Variable	SI Unit	Description _
$FM_{RG,h}$	kg/h	Mass flow rate 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 at

		normal conditions in hour *h*

And after:

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

Equation 10

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:

$$MM_{RG,h} = \sum_i (fv_{i,h} * MM_i)$$

Equation 11

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 residual gas component *i*
I	-	The components CH_4, CO, CO_2, O_2,H_2, N_2

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

In this step, a determination of the mass fractions of carbon, hydrogen, oxygen and nitrogen in the residual gas is made, calculating from the volumetric fraction of each component *i* in the residual gas, as follows:

$$\mathrm{fm}_{j,h} = \frac{\sum_i \mathrm{fv}_{i,h} \cdot \mathrm{AM}_j \cdot \mathrm{NA}_{j,i}}{\mathrm{MM}_{RG,h}}$$

Equation 12

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_i	kg/kmol	Atomic mass of element *j*
$NA_{i,i}$	-	Number of atoms of element *j* in component *i*
$MM_{RG,h}$	kg/kmol	Molecular mass of residual gas in hour *h*
J	-	The elements carbon, hydrogen, oxygen and nitrogen
i	-	The components CH_4, CO, CO_2, O_2,H_2, N_2

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

As, for the project activity the methane combustion efficiency of the flare is continuously monitored, the determination of the average volumetric flow rate of the exhaust gas in each hour *h* is 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:

$$TV_{n,FG,h} = V_{n,FG,h} * FM_{RG,h}$$ Equation 13

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*

After:

$$V_{n,FG,h} = V_{n,CO_2,h} + V_{n,O_2,h} + V_{n,N_2,h}$$ Equation 14

Where:

Variable	SI Unit	Description
$V_{n,FG,h}$	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*
$V_{n,CO2,h}$	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*
$V_{n,N2,h}$	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*
$V_{n,O2,h}$	m^3/ 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*

$$V_{n,O_2,h} = n_{O_2,h} \times MV_n$$ Equation 15

Where:

Variable	SI Unit	Description
$V_{n,O2,h}$	m^3/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*
$n_{O2,h}$	kmol/kg residual gas	Quantity of moles O_2 in the exhaust gas of the flare per kg residual gas flared in hour *h*
MV_n	m^3/ kmol	Volume of one mole of any ideal gas at normal temperature and pressure (22.4 L/mol)

$$V_{n,N_2,h} = MV_n * \left\{ \frac{fm_{N,h}}{200 AM_N} + \left(\frac{1 - MF_{O_2}}{MF_{O_2}} \right) * \left[F_h + n_{O_2,h} \right] \right\}$$

Equation 16

Where:

Variable	SI Unit	Description
$V_{n,N2,h}$	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 L/mol)
$fm_{N,h}$	-	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*

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

Equation 17

Where:

Variable	SI Unit	Description
$V_{n,CO2,h}$	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*
$fm_{C,h}$	-	Mass fraction of carbon in the residual gas in the hour *h*
AM_C	kg/ kmol	Atomic mass of carbon
MV_n	m^3/ kmol	Volume of one mole of any ideal gas at normal temperature and pressure (22.4 m^3/mol)

$$n_{O_2,h} = \frac{t_{O_2,h}}{\left(1-(t_{O_2,h}/MF_{O_2})\right)} \times \left[\frac{fm_{C,h}}{AM_C} + \frac{fm_{N,h}}{2AM_N} + \left(\frac{1-MF_{O_2}}{MF_{O_2}}\right) \times F_h\right]$$

Equation 18

Where:

Variable	SI Unit	Description
$n_{O2,h}$	kmol/ kg residual gas	Quantity of moles O2 in the exhaust gas of the flare per kg of residual gas flared in the hour *h*
$t_{O2,h}$	-	Volumetric fraction of O2 in the exhaust gas in the hour *h*
MF_{O2}	-	Volumetric fraction of O2 in the air (0.21)
F_h	Kmol/ kg residual gas	Stochiometric quantity of moles of O2 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* (from equation 4)
AM_j	kg/kmol	Atomic mass of element *j*
j	-	The elements carbon (index C) and nitrogen (index N)

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

Equation 19

Where:

Variable	SI Unit	Description
F_h	Kmol O2/ kg residual gas	Stoichiometric quantity of moles of O2 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* (from equation 4)
AM_j	kg/kmol	Atomic mass of element *j*
j	-	The elements carbon (index C), hydrogen (index H) and oxigen (index O)
$t_{O2,h}$	-	Volumetric fraction of O2 in the exhaust gas in the hour *h*
MF_{O2}	-	Volumetric fraction of O2 in the air (0.21)
F_h	Kmol/ kg residual gas	Stochiometric quantity of moles of O2 required for a complete oxidation of one kg residual gas in hour *h*
j	-	The elements carbon (index C) and nitrogen (index N)

STEP 4. Determination of methane mass flow rate in the exhaust gas on a dry basis

As the methane combustion efficiency of the flare is 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:

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

Equation 20

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*
$TV_{n,FG,h}$	m3/h exhaust gas	Volumetric flow rate of the exhaust gas in dry basis at normal conditions in hour *h*
$fv_{CH4,FG,h}$	mg/m3	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 ($fv_{CH4,RG,h}$) and the density of methane ($\rho_{CH4,n,h}$) 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).

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

Equation 21

Where:

Variable	SI Unit	Description
$TM_{RG,h}$	kg/h	Mass flow rate of methane in the residual gas in the hour *h*
$FV_{RG,h}$	m3/h	Volumetric flow rate of the residual gas in dry basis at normal
$fv_{CH4,RG,h}$	-	Volumetric fraction of methane in the residual gas on dry basis in hour *h* (NB: this corresponds to fvi,RG,h where i refers to methane).
$\rho_{CH4,n}$	kg/m3	Density of methane at normal conditions (0.716)

STEP 6. Determination of the hourly flare efficiency

For determining the flare efficiency of the enclosed flare LANDFLARE, it will be monitored, continuously the methane destruction of the flare. For this, the flare efficiency in the hour h ($\eta_{flare,h}$) is:

- 0% if the temperature of the exhaust gas of the flare (Tflare) 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*:

$$\eta_{flare,h} = 1 - \frac{TM_{FG,h}}{TM_{RG,h}}$$ Equation 22

Where:

Variable	SI Unit	Description
$\eta_{flare,h}$	-	Flare efficiency in the hour *h*
$TM_{RG,h}$	kg/h	Mass flow rate of methane in the residual gas 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)

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:

$$PE_{flare,y} = \sum_{h=1}^{8760} TM_{RG,h} \times \left(1 - \eta_{flare,h}\right) \times \frac{GWP_{CH4}}{1000}$$ Equation 23

Where:

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

Calculation of $MD_{BL,y}$:

The $MD_{BL,y}$ parameter represents the total of methane that would have been destroyed/combusted during the year in the absence of the project due to regulatory and/or contractual requirements. This value is right allied to the $MD_{project,y}$ value as described in Equation 24. This approach is taken in consideration when no regulatory or contractual requirements specify the $MD_{BL,y}$ and no historical data exists for the LFG captured and destroyed. So the Adjustment Factor is used taking into account the project context. For this estimative, the AF should be used after being calculated by the Equation 25. The steps are presented below:

$$MD_{BL,y} = MD_{project,y} * AF$$ Equation 24

Where:

$MD_{BL,y}$ is 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 tonnes of methane (tCH_4);

$MD_{project,y}$ is the amount of methane destroyed by the project activity during the year y of the project activity (tCH_4);

AF is the Adjustment Factor for year y any landfill gas in the baseline that would have been captured and destroyed to comply with relevant regulations or contractual requirements, or to address safety and odor concerns, calculated by Equation 25.

The adjustment factor (AF) considers the destruction efficiency of the system in the baseline and also the destruction efficiency of the system that will be used in the Project Activity for the whole crediting period. Since in cases where a specific percentage of the "generated" amount of methane to be collected and destroyed is specified in the contract or mandated by regulations, the efficiency of the baseline system (ε_{BL}) is equal to the defined specific percentage. For this type of project activity, the ε_{BL} is considered 20%, which is the value is recommended by the Brazilian DNA. This factor is related to safety and odour concerns and is given by NBR 8419[15] in chapter about gas draining.

$$AF = \varepsilon_{BL} / \varepsilon_{PR,y} \qquad \text{Equation 25}$$

Where:

ε_{BL} is the destruction efficiency of the baseline system (fraction);

$\varepsilon_{PR,y}$ is the destruction efficiency of the system used in the project activity for year *y* (fraction).

The ε_{PR} will be calculated by the next formula in an ex-post approach (after the project operation), the destruction efficiency of the system will be estimated every year (option 2 of ACM0001 version 11).

$$\varepsilon_{PR,y} = MD_{project,y} / MG_{PR,y} \qquad \text{Equation 26}$$

Where:

$MD_{project,y}$ is the amount of methane destroyed by the project activity during the year y of the project activity (tCH_4);

$MG_{PR,y}$ is the amount of methane generated during year y of the project activity estimated using the actual amount of waste disposed in the landfill as per the latest version of the "*Tool to determine methane emissions avoided from disposal of waste at a solid waste disposal site*", see further guidance in Step 1 (tCH_4). This parameter is considered to be the $BE_{CH4,SWDS,y}$ multiplied by GWP_{CH4}, since it represents the quantity of methane that would be released to the atmosphere in the absence of the project activity by a solid waste disposal site. Then:

$$\varepsilon_{PR,y} = MD_{project,\ y} / BE_{CH4,SWDS,y} * GWP_{CH4} \qquad \text{Equation 26.A}$$

applying equations 25, 26 and 26.A in equation 24:

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

[15] *Available at* www.**abnt**.org.br *or to download on* http://rs270.rapidshare.com/files/77279304/8419.rar. *Access date: October/2008.*

$$MD_{BL,y} = MD_{project,y} * \varepsilon_{BL} / \varepsilon_{PR,y}$$

$$MD_{BL,y} = MD_{project,y} * \varepsilon_{BL} / (MD_{project,y} / MG_{PR,y})$$

$$MD_{BL,y} = MD_{project,y} * \varepsilon_{BL} / (MD_{project,y} / BE_{CH4,SWDS,y} * GWP_{CH4})$$

And simplifying:

$$MD_{BL,y} = \varepsilon_{BL} * BE_{CH4,SWDS,y} * GWP_{CH4} \qquad \text{Equation 24.A}$$

<u>Project emissions</u>

The version 11 of the cited methodology predicts the project emissions as the consumption of electricity, following specifications of the current version 1 of the "*Tool to calculate baseline, project and/or leakage emissions from electricity consumption*"; and the consumption of heat in the project case, due to the fossil fuel combustion being guided by the latest version 1 of the "*Tool to calculate project or leakage CO_2 emissions from fossil fuel combustion*". As there is no fossil fuel consumption to generate heat to the project activity, the Equation 2.A is assumed, instead of number 2.

$$PE_y = PE_{EC,y} + PE_{FC,j,y} \qquad \text{Equation 2}$$

Where:

PE_y are the project emissions related directly to the activity of the proposed project;

$PE_{EC,y}$ are the emissions related to the consumption of electricity in the project case. The project emissions from electricity consumption will be calculated following the latest version 1 of "*Tool to calculate baseline, project and/or leakage emissions from electricity consumption*". If in the baseline a part of LFG was captured then the electricity quantity used in calculation is electricity used in project activity net of that consumed in the baseline, as calculated by the Equation 27;

$PE_{FC,j,y}$ are the emissions from the heat consumption in the project case. The project emissions from fossil fuel combustion will be calculated following the latest version 1 of "*Tool to calculate project or leakage CO2 emissions from fossil fuel combustion*". For this purpose, the processes j in the tool corresponds to all fossil fuel combustion in the landfill, as well as any other on-site fuel combustion for the purposes of the project activity. If in the baseline part of a LFG was captured then the heat quantity used in calculation is fossil fuel used in project activity net of that consumed in the baseline. As the project activity does not comprise any fossil fuel consumption, this parameter is not inserted in the proposed project calculation.

Then, the applicable formula for the project activity is the presented below:

$$PE_y = PE_{EC,y} \qquad \text{Equation 2.A}$$

For the $PE_{EC,y}$ calculation it is necessary to follow the guidance of the latest version 1 of the "*Tool to calculate baseline, project and/or leakage emissions from electricity consumption*", which presents three scenarios of applicability. The proposed project complies with **scenario A -** *Electricity consumption from the grid* – where the electricity is purchased from the grid, only. This value, then, gives an estimative for the project emission associated to the consumption of electricity by the proposed project activity. The project emissions are calculated based on the power consumed by the project activity and the emission factor of the grid, adjusted for transmission losses, using the Equation 27 below.

$$PE_{EC,y} = \Sigma_j EC_{PJ,j,y} * EF_{EL,j,y} * (1 + TDL_{j,y}) \qquad \text{Equation 27}$$

Where:

$PE_{EC,y}$ are the project emissions from electricity consumption by the project activity during the year y (tCO_2 / yr);

$EC_{PJ,j,y}$ is the quantity of electricity consumed by the project electricity consumption source j in year y (MWh/yr);

$EF_{EL,j,y}$ is the emission factor for electricity generation for source j in year y (tCO_2/MWh);

$TDL_{j,y}$ are the average technical transmission and distribution losses for providing electricity to source *j* in year *y*.

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

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

STEP 1. Identify the relevant electric power system.

According with the Tool, "*If the DNA of the host country has published a delineation of the project electricity system and connected electricity systems, these delineations should be used*". The Brazilian DNA published Resolution 8, which makes official the use of a single Electric Grid for CDM project activities applying the tool.

STEP 2. Select an operating margin (OM) method

The Brazilian DNA has calculated the Grid Emission Factor applying option *c) Dispatch data analysis OM*.

STEP 3. Calculate the operating margin emission factor according to the selected method

The dispatch data analysis OM emission factor ($EF_{grid,OM,y}$) is determined based on the power units that are actually dispatched at the margin during each hour *h* where the project is displacing electricity. The Brazilian DNA will calculate and publish regularly the emission factor for each year in their web-site.

STEP 4. Identify the cohort of power units to be included in the build margin

The power units will be identified by the Brazilian DNA.

STEP 5. Calculate the build margin emission factor

The Build Margin will be calculated by the Brazilian DNA.

STEP 6. Calculate the combined margin emissions factor

The combined margin emissions factor is calculated as follows:

$$EF_{Grid,CM,y} = EF_{Grid,OM,y} \times w_{OM} + EF_{Grid,BM,y} \times w_{BM}$$ Equation 28

Where:

$EF_{Grid,CM,y}$	is the emission factor for the Brazilian electric grid in year *y* (tCO_2/MWh);
$EF_{Grid,OM,y}$	is the operating margin CO2 emission factor in year *y* (tCO_2/MWh);
$EF_{Grid,BM,y}$	is the build margin CO2 emission factor in year *y* (tCO_2/MWh);
w_{OM}	is the weighting of operating margin emissions factor (%);
w_{BM}	is the weighting of build margin emissions factor (%).

According with the Tool, values adopted for w_{OM} and w_{BM} were equal to 0.5 for each one during the crediting period.

The last parameter $TDL_{j,y}$ is given by the mentioned Tool. Valued in 20%, this rate is applicable since it is described in the "*Tool to calculate baseline, project and/or leakage emissions from electricity consumption*", the project activity comprises the **scenario A** and in the project case, a default given by the methodology is used (20%) for project and leakage electricity consumption.

Leakage

No leakage effects or leakage CO_2 need to be accounted under the version 11 of the methodology ACM0001.

Emission Reduction

As per the project emission relates to the electric power consumption and the project emissions from flaring of the residual gas stream, the following simplified equation will be applied to estimate the Emission Reductions:

$$ER_y = BE_y - PE_y \qquad \text{Equation 3}$$

Where:

ER_y are the emission reductions in year y (tCO_2e/yr);

BE_y are the baseline emission in year y (tCO_2e/yr);

PE_y are the project emissions in year y (tCO_2e/yr).

B.6.2. Data and parameters that are available at validation:

Data / Parameter:	**flare efficiency**
Data unit:	%
Description:	Flare efficiency in hour *h* for the project activity
Source of data used:	Equipment furnisher (ex-ante) *Brasmetano* specifications (*Braseco Proposta_Sistema de queima biogas.pdf*) in ex-ante approach. For ex-post approach it will be calculated.
Value applied:	96.00
Justification of the choice of data or description of measurement methods and procedures actually applied :	This value (ex-ante) is given following specifications of the supplier. Found in Brasmetano Proposal (Braseco Proposta_sistema de queima biogas.pdf) sent to Sereco in 11th June of 2008. The ex-post value will be calculated according to the monitoring methodology stated in the *Tool to determine project emissions from flaring gases containing methane*.
Any comment:	

Data / Parameter:	**φ**
Data unit:	-
Description:	Model correction factor to account for model uncertainties
Source of data used:	Tool to determine methane emissions avoided from dumping waste at a solid waste disposal site default value
Value applied:	0.9
Justification of the choice of data or description of measurement methods and procedures actually applied :	This value (tool) is required in the methodology ACM0001, version 11
Any comment:	

Data / Parameter:	**OX**
Data unit:	-

Description:	Oxidation factor (reflecting the amount of methane from solid waste disposal site (SWDS) that is oxidized in the soil or other material covering the waste.
Source of data used:	IPCC 2006 Guidelines for National Greenhouse Gas Inventories
Value applied:	0.1
Justification of the choice of data or description of measurement methods and procedures actually applied :	Managed solid waste disposal site covered with oxidizing material, such as soil or compost.
Any comment:	

Data / Parameter:	**F**
Data unit:	-
Description:	Fraction of methane in the SWDS gas (volume fraction)
Source of data used:	IPCC 2006 Guidelines for National Greenhouse Gas Inventories
Value applied:	0.5
Justification of the choice of data or description of measurement methods and procedures actually applied :	
Any comment:	This factor reflects the fact that some degradable organic carbon does not degrade, or degrades very slowly, under anaerobic conditions in the SWDS.

Data / Parameter:	**DOC_f**
Data unit:	-
Description:	Fraction of degradable organic carbon (DOC) that can decompose
Source of data used:	IPCC 2006 Guidelines for National Greenhouse Gas Inventories
Value applied:	0.5
Justification of the choice of data or description of measurement methods and procedures actually applied :	
Any comment:	

Data / Parameter:	**MCF**
Data unit:	-
Description:	Methane correction factor

Source of data used:	IPCC 2006 Guidelines for National Greenhouse Gas Inventories
Value applied:	1.0
Justification of the choice of data or description of measurement methods and procedures actually applied :	*Natal Landfill* is an anaerobic managed SWDS, presenting a controlled placement of waste presenting the tree following characteristics specifying the deposition areas, a degree of control of scavenging and a degree of control of fires. And the project includes the presence of the cover material, mechanical compacting and leveling of the waste.
Any comment:	The MCF accounts for the fact that unmanaged SWDS produce less methane from a given amount of waste than managed SWDS, because a larger fraction of waste decomposes aerobically in the top layers of unmanaged SWDS.

Data / Parameter:	**DOC_j**
Data unit:	-
Description:	Fraction of degradable organic carbon (by weight) in the waste type *j*
Source of data used:	IPCC 2006 Guidelines for National Greenhouse Gas Inventories (adapted from Volume 5, Tables 2.4 and 2.5)
Value applied:	(see table below)
Justification of the choice of data or description of measurement methods and procedures actually applied :	These values were considered since represent fractions of degradable organic carbon in wet wastes, as it is applied for this landfill.
Any comment:	

	DOCj
Organic	0,15
Paper	0,4

Data / Parameter:	**k_j**
Data unit:	Number
Description:	Decay rate for the waste type *j*
Source of data used:	IPCC 2006 Guidelines for National Greenhouse Gas Inventories (adapted from Volume 5, Table 3.3) - *(Tool to determine methane emissions avoided from dumping waste at a solid waste disposal site)*
Value applied:	(see table below)

Waste Type	**Kj (Tropical and Wet)**
Pulp, paper and cardboard	0.07
Food, food waste, sewage sludge, beverages and tobacco	0.40
MAT [16]	26 °C
MAP [7]	1380 mm
PET	Not applicable

[16] As it is confirmed by an study of *Natal* Clime made by the Ministry of Science and Technology – National Institute Space Research – INPE-11475-RPQ/776

Justification of the choice of data or description of measurement methods and procedures actually applied :	*Natal Landfill* is an anaerobic and managed SWDS located in tropical regions (Mean Annual Temperature > 20°C) and wet (Mean Annual Precipitation > 1,000 mm).
Any comment:	Long-term averages based on statistical data obtained from the *Instituto Nacional de Pesquisas Especiais – MCT* reported on INPE-11475-RPG/776[17].

Data / Parameter:	**Regulatory requirements relating to landfill gas projects**
Data unit:	--
Description:	Regulatory requirements relating to technical standards of landfill operation and gas draining system (NBR-8419 and ABNT 1984 – section 5.1.6.5)
Source of data used:	*ABNT* – Brazilian Association of Technical Norms
Value applied:	--
Justification of the choice of data or description of measurement methods and procedures actually applied :	--
Any comment:	

Data / Parameter:	**GWP_{CH4}**
Data unit:	tCO_2e/tCH_4
Description:	Global Warming Potential (GWP) of methane, valid for the relevant commitment period
Source of data used:	IPCC
Value applied:	21
Justification of the choice of data or description of measurement methods and procedures actually applied :	This value is applied for the first period of commitment period. Shall be updated according to any future COP/MOP decisions, if any.
Any comment:	

Data / Parameter:	**D_{CH4}**
Data unit:	tCH_4/m^3CH_4
Description:	Methane Density

[17] *Available at: http://mtc-m16.sid.inpe.br/rep/K59XCPPEX3NV42G2CM9BN/N9P5KS?mirror=sid.inpe.br/banon/2003/08.15.17.40.18&metadatarepository=*

Source of data used:	Methodology ACM0001
Value applied:	0.0007168
Justification of the choice of data or description of measurement methods and procedures actually applied :	At standard temperature and pressure (0 degree Celsius and 1,013 bar) the density of methane is 0.0007168 tCH_4/m^3CH_4
Any comment:	

Data / Parameter:	$\mathbf{BE_{CH4,SWDS,y}}$
Data unit:	tCO_2
Description:	Methane generation from the landfill in the absence of the project activity at year *y*
Source of data used:	Calculated as per the “Tool to determine methane emissions avoided from dumping waste at a solid waste disposal site”.
Value applied:	210,216.83 (yearly average for the crediting period). Please see excel file.
Justification of the choice of data or description of measurement methods and procedures actually applied :	As per the “Tool to determine methane emissions avoided from dumping waste at a solid waste disposal site”
Any comment:	Any comment: Used for ex-ante estimation of the amount of methane that would have been destroyed/combusted during the year

Data / Parameter:	ε_{BL}
Data unit:	%
Description:	In cases where regulatory or contractual requirements do not specify $MD_{reg,y}$ an adjustment factor shall be used and justified and taking into account the project context.
Source of data used:	Brazilian DNA letter (Number MDL 0152/2006/CIMGC) dated 22 Sept 2006
Value applied:	20%
Justification of the choice of data or description of measurement methods and procedures actually applied :	Suggested by Brazilian DNA
Any comment:	

Data / Parameter:	Extraction efficiency

Data unit:	%
Description:	Theoretical efficiency of the specific system for collection of biogas
Source of data used:	*Brasmetano* specifications
Value applied:	70%
Justification of the choice of data or description of measurement methods and procedures actually applied :	Suggested by *Brasmetano* as an average value for this type of project in northeast region in Brazil. (Similar project under the same conditions).
Any comment:	

The constants used in the equations of the PE_{flare} calculation systematic will also not be monitored, as given in the respective tool (Annex 13, EB28).

B.6.3 Ex-ante calculation of emission reductions:

Baseline Emissions

According to ACM-0001 version 11, the Baseline Emissions in year "y" (measured in tCO_2e) shall be calculated following the Equation 1, as explained in section B.6.1. And since this project activity does not produce electricity and thermal energy using LFG, the assumed equation is:

$$BE_y = (MD_{project,y} - MD_{BL,y}) * GWP_{CH4} \qquad \text{Equation 1.A}$$

With the intention of estimating the $MD_{project,y}$ from equation 1.A, a conservative ex-ante estimation of the amount of methane that is destroyed/combusted during the year, in tonnes of methane will be done following specifications of ACM0001, version 11, that proposes the use of the amount of methane that would be generated in the landfill converted to carbon dioxide ($BE_{CH4,SWDS,y}$) and also the emission related to the methane flared by the project activity estimation, including then the extraction (70%) and flare efficiency (96%), as it is given by the formula below:

$$MD_{project,y,(conservative)} = BE_{CH4,SWDS,y} * \text{extraction efficiency} * \text{flare efficiency} / GWP_{CH4} \qquad \text{Equation 4.A}$$

The flare efficiency of the project system is referred to *Brasmetano* specifications (*Braseco Proposta_Sistema de queima biogas.pdf*), which values an efficiency of 96%, that is used in Equation 4.A.

In order to value the parameter $BE_{CH4,SWDS,y}$ the latest version 4 of the approved "*Tool to determine methane emissions avoided from disposal of waste at a solid waste disposal site*" must be used. The amount of methane that would, in the absence of the project activity, be generated from disposal of waste at the solid waste disposal site ($BE_{CH4,SWDS,y}$) is calculated with a multi-phase model since the operation starting date of the landfill. This calculation is based on a first order decay (FOD) model, which differentiates the types of waste (named by $\boldsymbol{j}$) with respectively different decay rates, k_j, and different fractions of degradable organic carbon (DOC_j). The FOD model calculates the methane generated based on the actual waste streams $W_{j,x}$ disposed in each year $\boldsymbol{x}$, starting with the first year after the start of the project activity until the end of the year $\boldsymbol{y}$, for which baseline emissions are calculated (years $\boldsymbol{x}$ with $\boldsymbol{x} = 1$ to $\boldsymbol{x} = \boldsymbol{y}$). This sequence is given by the formula below:

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

Equation 5

As it was shown in section B.6.1, the unique value that is not a default given by the methodology is $W_{j,x}$, that represents the amount of waste disposed in the SWDS in that year. The Equation 5 also differentiates the types of waste between a list given for DOC (degradable organic carbon) and k (decay rate), that reference to:

DOC	*k*
Wood and wood products	Pulp, paper, cardboard (other than sludge), textiles
Pulp, paper and cardboard (other than sludge)	Wood, Wood products and straw
Food, food waste, beverages and tobacco (other than sludge)	Other (non-food) organic putrescible garden and park waste
Textiles	Food, food waste, sewage sludge, beverages and tobacco
Garden, yard and park waste	-
Glass, plastic, metal, other inert waste	-

Table 4: List of type of waste for ACM0001, following DOC and k specifications.

And then, the $BE_{CH4,SWDS,y}$ achieves the following values:

Year	$BE_{CH4,SWDS,y}$ **(tCO2)**
August to December 2010	68,150
2011	176,943
2012	189,860
2013	202,600
2014	215,364
2015	228,297
2016	241,508
January to August 2017	148,796

Table 5: $BE_{CH4,SWDS,y}$ *values.*

Then, it is necessary to find the sort of waste following these lists in order to apply the correct factor for each type of waste. Therefore, for the Project Activity, the composition of waste was identified and also their percentages in the total amount, as it is presented in the table below:

Type of Waste	***Composition (P)***
Organic Waste	**53.05%**
Metal	**0.71%**
Plastic	**6.09%**
Glasses	**9.59%**

Paper	**11.50%**
Others	**5.23%**
Non-organic	**16.63%**

Table 6: Composition of each type of waste disposed in Natal Landfill[18].

And, then, for the calculation of Equation 6, the amount of organic and paper waste is:

$$W_{j,x} = W_x \cdot \frac{\sum_{n=1}^{z} p_{n,j,x}}{z} \qquad \text{Equation 6}$$

Year	*Organic Waste*	*Paper Waste*
2010	181,565	39,359
2011	190,121	41,214
2012	199,081	43,156
2013	208,463	45,190
2014	218,287	47,319
2015	228,574	49,549
2016	239,345	51,884
2017	250,625	54,330

Table 7: Amount of Organic and Paper waste applying Equation 6 for the whole years.

Following this systematic, the values for the $MD_{project,y,(conservative)}$ in the defined period are presented:

Year	**MD project,y (tCO2)**
August to December 2010	2,181
2011	5,662
2012	6,076
2013	6,483
2014	6,892
2015	7,306
2016	7,728
January to August 2017	4,761

Table 8: $MD_{project,y}$ values.

For the estimation of $MD_{BL,y}$ factor, $MD_{project,y}$ must be known in cases where regulatory or contractual requirements do not specify $MD_{BL,y}$ or no historic data exists for the captured and destroyed LFG, an "Adjustment Factor" (AF) shall be used and justified, taking into account the project context. So, the formula to achieve the amount of methane that would have been destroyed during the year in the project scenario is given:

[18] *Data provided from* Braseco.

$$MD_{BL,y} = MD_{project,y} * AF \qquad \text{Equation 24}$$

Year	MD bl,y (tCH4)
August to December 2010	702
2011	1,685
2012	1,808
2013	1,930
2014	2,051
2015	2,174
2016	2,300
January to August 2017	1,417

Table 9: $MD_{BL,y}$ values.

In this case, the Adjustment Factor (AF) compiles the value given by a Brazilian DNA letter (Number MDL 0152/2006/CIMGC) dated 22 September 2006, representing 20% of flared methane in the baseline scenario (ε_{BL}), as described in section B.6.2 above, such as the destruction efficiency of the flaring system (ε_{PR}) of 96%, in the project case, as described previously by Equation 25. The adjustment factor formula is presented as follows:

$$AF = \varepsilon_{BL} / \varepsilon_{PR} \qquad \text{Equation 25}$$

Where:

ε_{BL} = Destruction efficiency of the baseline system (fraction);

ε_{PR} = Destruction efficiency of the system used in the project activity that will remain fixed for the whole crediting period (fraction) from Equation 26.A. This value is given from the next assumption:

$$\varepsilon_{PR,y} = MD_{project,y} / MG_{PR,y} \qquad \text{Equation 26}$$

Where $MG_{PR,y}$ reflects the amount of methane generated during the year of the project activity estimated using the actual amount of waste disposed in the landfill as per the latest version of the “Tool to determine methane emissions avoided from disposal of waste at a solid waste disposal site”. In an ex-ante approach, the formula 25 and 26 reach the 24.A:

$$MD_{BL,y} = \varepsilon_{BL} * BE_{CH4,SWDS,y} * GWP_{CH4} \qquad \text{Equation 24.A}$$

After the application of formula 25, the Adjustment Factor achieved 29.76%.

After this systematic of calculation, the baseline emissions, in tCO_2e, are presented in the table below:

Year	BEy (tCO2e)
August to December 2010	32,167

2011	83,517
2012	89,614
2013	95,627
2014	101,652
2015	107,756
2016	113,992
January to August 2017	70,232

Table 10: BE_y values.

Project Emissions

For the Project emissions, the formula below is assumed, as explained in section B.6.1:

$$PE_y = PE_{EC,y} \quad \text{Equation 2.A}$$

Where:

$PE_{EC,y}$ = Emissions from consumption of electricity in the project case. The project emissions from electricity consumption ($PE_{EC,y}$) will be calculated following the latest version of "*Tool to calculate baseline, project and/or leakage emissions from electricity consumption*" from EB39, Annex 7.

The values calculated for the Project Emissions are given below:

Year	PE y = PE_{EC} (tCO2)
August to December 2010	55
2011	131
2012	131
2013	131
2014	131
2015	131
2016	131
January to August 2017	76

Table 11: PE_y values.

In order to estimate the project emissions due to the electricity consumption, it is necessary to follow the applicability given, where the specific project complies with **scenario A**, which description is *Electricity consumption from the grid*, specifying the electricity purchased is from the grid only.

The project emissions are calculated based on the power consumed by the project activity and the emission factor of the grid, adjusted for transmission losses, using the Equation 27 below.

$$PE_{EC,y} = \Sigma_j EC_{PJ,j,y} * EF_{EL,j,y} * (1 + TDL_{j,y}) \qquad \text{Equation 27}$$

For the Equation 27, the table below is assembled:

Parameter	*Value*	*Unit*	*Source*
$EC_{PJ,j,y}$	350.4[19]	MWh/y	*Brasmetano* Proposal

[19] *The value of 350.4 MWh/year is given by* "Braseco Proposta_Sistema de queima biogas.pdf" *archive, since there is foresaw an installation of an energy generator working with biogas of nominal capacity valued in 40kW, which is optional, that represents*

$EF_{EL,j,y}$	0.3112	tCO_2/MWh	Brazilian DNA[20]. Year-base: 2008
$TDL_{j,y}$	0.2	-	Default given in "*Tool to calculate baseline, project and/or leakage emissions from electricity consumption*", as explained in B.6.1.

Table 12: Definition of the parameters for Equation 27.

In the Project Activity, there is an electricity consumption of about 350.4 MWh per year due to the extraction and pumping system.

The CO_2 Emission Factor of the electric power generation verified in the National Interconnected System (*SIN – Sistema Interligado Nacional*) of Brazil is calculated from the generation registers of the dispatched plants consolidated by the National Operator of the Electric System (*ONS – Operador Nacional do Sistema*) and, especially, for the thermoelectric plants (fossil fuel based). The calculation procedure of the CO_2 emission factor was developed jointly between the Ministry of Science and Technology (*MCT – Ministério de Ciência e Tecnologia*) and the Ministry of Mines and Energy (*MME – Minintério de Minas e Energia*), following as base the *Tool to calculate the emission factor for the Electricity System*. This procedure is in accordance with the operative practices of SIN, regulated by the National Agency of Electrical Energy (*ANEEL – Agência Nacional de Energia Elétrica*).

Following that systematic, the CO_2 Emission Factor started to be calculated by ONS for the Interconnected National System and it is available to be consulted online by the interested public and investors. Moreover, the MCT supplies, besides the emission factor, a descriptive manual of the formulas used in the factor calculations. Therefore, the resulting emission factor for 2008 ($EF_{grid,CM,y}$) is 0.3112 tCO_2e/MWh for 2008, since the Operation Margin valued in 0.4766 tCO_2e/MWh and the Build Margin in 0.1458 tCO_2e/MWh. Applying an arithmetic average, it achieve the 0.3112 tCO_2e/MWh for the emission factor of Brazilian Electrical Grid, where was available data for the project activity.

The operating margin for the project boundary is calculated *ex- post* using the full generation-weighted average for the baseline year. The amount of fuel consumption for thermal generation for the project boundary is available for Brazilian DNA. The average $EF_{grid,OM,y}$ for the project activity is 0.4766 (kg CO_2e/kWh) in 2008. At the tables 13 below the values are given.

Emission Factor of Brazilian National Grid 2008												
Month Average Factor (tCO2/MWh)												
Month												
Jan	Febr	March	April	May	June	July	Aug	Sept	Oct	Nov	Dec	***Average***
0.5727	0.6253	0.5794	0.4529	0.4579	0.518	0.4369	0.4258	0.4102	0.4369	0.3343	0.4686	***0.4766***

Table 13. Values of $EF_{grid,OM,y}$ in 2008.

*the project energy consumption from the grid, because this generator will not be installed (40kW * 8760hours/year = 350.4 MWh/year). -*

[20] *All the emission factor calculation and explanation documents can be found at MCT website: http://www.mct.gov.br/index.php/content/view/72764.html*

The build margin approach aims to make a “best guess” on the type of power generation facility that would have otherwise been built, in the absence of the GHG mitigation project. For the project activity the data based on year 2008 are provided through the *ONS*. The values for energy generation are defined through the wholesale electricity market operator (*CCEE*).

The build margin is estimated *ex-post*, based on the most recent built plants, which comprise the larger annual generation compared to the recently built 20%, thus they represent the capacity additions to the system. The $EF_{grid,BM,y}$ for the selected plants is 0.1458 in 2008.

Finally, the baseline emission factor $EF_{grid,CM,y}$ is calculated as the weighted average of the Operating Margin emission factor ($EF_{grid,OM,y}$) and the Build Margin emission factor ($EF_{grid,BM,y}$):

$$EF_{grid,CM,y} = (\omega_{BM} * EF_{grid,BM,y}) + (\omega_{OM} * EF_{grid,OM,y}) \quad \text{Equation 28}$$

Where:

$\omega_{BM} = 0.5$

$\omega_{OM} = 0.5$

Both ω_{BM} and ω_{OM} have a value of 0.5 because the project activity is a Hydro Power Plant.

For the TDL default, the tool gives some options in case of **scenario A** of the “*Tool to calculate baseline, project and/or leakage emissions from electricity consumption*”. And as the baseline scenario does not present any electricity consumption previous to the project activity, the value applied is 20%.

Then, the project emissions are demonstrated as the following table:

Year	PE ec (tCO2e)	Total PE y (tCO2e/y)
August to December 2010	55	55
2011	131	131
2012	131	131
2013	131	131
2014	131	131
2015	131	131
2016	131	131
January to August 2017	76	76
	Total	***916***

Table 14: Total estimated for Project Emissions.

Afterwards, the emission reduction is estimated by the third Equation that:

$$ER_y = BE_y - PE_y \quad \text{Equation 3}$$

And since under methodology ACM0001, no leakage must be accounted, the emission reductions are demonstrated as the following table:

Year	BE y (tCO2)	PE y (tCO2)	Leakage	ER y (tCO2)
August to December 2010	32,167	55	0	32,112
2011	83,517	131	0	83,386
2012	89,614	131	0	89,483
2013	95,627	131	0	95,496
2014	101,652	131	0	101,521
2015	107,756	131	0	107,625
2016	113,992	131	0	113,861
January to August 2017	70,232	76	0	70,156
TOTAL	***694,556***	***916***	***0***	***693,640***

Table 15: Demonstration of Baseline, Project Emissions and Emission Reduction of the project activity.

B.6.4 Summary of the ex-ante estimation of emission reductions:

Year	Estimation of project activity emission (tones of CO_2e)	Estimation of the baseline emission (tones of CO_2e)	Estimation of leakage (tones of CO_2e)	Estimation of emission reductions (tones of CO_2e)
August to December 2010	55	32,167	0	32,112
2011	131	83,517	0	83,386
2012	131	89,614	0	89,483
2013	131	95,627	0	95,496
2014	131	101,652	0	101,521
2015	131	107,756	0	107,625
2016	131	113,992	0	113,861
January to August 2017	76	70,232	0	70,156
TOTAL	**916**	**694,556**	**0**	**693,640**

B.7 Application of the monitoring methodology and description of the monitoring plan:

B.7.1 Data and parameters monitored:

Data / Parameter:	**f**
Data unit:	-
Description:	Fraction of methane captured at the SWDS and flared, combusted or used in another manner
Source of data to be used:	Information from the operator of the solid waste disposal site.
Value of data applied for the purpose of calculating expected emission reductions in section B.5:	0
Description of measurement methods and procedures to be applied:	Annually
QA/QC procedures to be applied:	-
Any comment:	This value is given (ex-ante) by the methodology ACM0001 – “Tool to determine methane emissions avoided from dumping waste at a solid waste disposal site” as a default.

Data / Parameter:	$\mathbf{W_X}$
Data unit:	tons
Description:	Total amount of organic waste prevented from disposal in year *x* (tons)
Source of data to be used:	Measurements made by the project participant.
Value of data applied for the purpose of calculating expected emission reductions in section B.5:	261,008 *Organic (Average ton/year)*: 214,508 *Paper (Average ton/year)*: 46,500
Description of measurement methods and procedures to be applied:	Continuously, aggregated at least annually. It is measured by the weighing scale in the entrance of the landfill. Trucks are weighted in the landfill entrance and exit. The difference of weights gives the amount of waste.
QA/QC procedures to be applied:	This value will be measured by a weighing scale installed in the entrance of the landfill. They are calibrated by *IPEN-RN* (*Instituto de Pesquisas Energéticas e Nucleares* – Institute of Energetical and Nuclear Research) accredited by INMETRO (Brazilian institute for metrology and calibration). This calibration follows the standards and procedures described in *Portaria INMETRO MICT*

	236/94[21].
Any comment:	

Data / Parameter:	$\mathbf{p_{n,i,x}}$
Data unit:	-
Description:	Weight fraction of the waste type *j* in the sample *n* collected during the year *x*
Source of data to be used:	Sample measurements made by the project participant.
Value of data applied for the purpose of calculating expected emission reductions in section B.5:	<table><tr><td></td><td>%</td></tr><tr><td>Organic</td><td>0.5305</td></tr><tr><td>Paper</td><td>0.115</td></tr></table>
Description of measurement methods and procedures to be applied:	Sample the waste prevented from disposal, using the waste categories *j*, as provided in the table for *DOCj* and *kj*, and weigh each waste fraction. The size and frequency of sampling should be statistically significant with a maximum uncertainty range of 20% at a 95% confidence level. As a minimum, sampling should be undertaken four times per year.
QA/QC procedures to be applied:	
Any comment:	This parameter only needs to be monitored if the waste prevented from disposal include several waste categories *j*, as categorized in the tables for *DOCj* and *kj*.

Data / Parameter:	**z**
Data unit:	-
Description:	Number of samples collected during the year x
Source of data to be used:	Project participants
Value of data applied for the purpose of calculating expected emission reductions in section B.5:	12 (for 2004)
Description of measurement methods and procedures to be applied:	Continuously, aggregated annually.
QA/QC procedures to be applied:	This parameter only needs to be monitored if the waste prevented from disposal includes several waste categories *j*, as categorized in the tables for DOC_j and k_j.
Any comment:	

Data / Parameter:	$\mathbf{EF_{grid,CM,y}}$ (= $EF_{EL,j,y}$)
Data unit:	tCO_2/MWh
Description:	Combined margin emission factor for the grid in year y
Source of data to be	Calculated based on data published by Brazilian/DNA, using the procedures in

[21] *This procedure is available at: http://www.smfbalancas.com.br/calibracao/legislacao.htm. Accessed in April, 2009.*

used:	the latest approved version of the "Tool for the calculation of emission factor for an electricity system". This procedure of calculation was made by Brazilian DNA for the National Interconnected System as described in section B.6.3..
Value of data applied for the purpose of calculating expected emission reductions in section B.5:	0.3112 (base year: 2008 for ex-ante estimative)
Description of measurement methods and procedures to be applied:	Follow procedures as described in the "Tool for the calculation of emission factor for an electricity system".
QA/QC procedures to be applied:	In order to present the national emission factor, the National Operator of the System provides to *MCT* the original data to do the calculation procedure.
Any comment:	

Data / Parameter:	**$EF_{grid,OMy}$**
Data unit:	tCO_2equ/MWh
Description:	CO_2 Operating Margin emission factor for the national grid
Source of data to be used:	DNA published data calculated according to *Tool for the calculation of emission factor for an electricity system.*
Value of data applied for the purpose of calculating expected emission reductions in section B.5	0.4766 (base year 2008)
Description of measurement methods and procedures to be applied:	Follow procedures as described in the "Tool for the calculation of emission factor for an electricity system".
QA/QC procedures to be applied:	In order to present the national emission factor, the National Operator of the System provides to *MCT* the original data to do the calculation procedure.
Any comment:	

Data / Parameter:	**$EF_{grid,BMy}$**
Data unit:	tCO_2equ/MWh
Description:	CO_2 Build Margin emission factor for the Brazilian electrical System
Source of data to be used:	Data obtained from ONS (National Operator System) and calculated according to *Tool for the calculation of emission factor for an electricity system.*
Value of data applied for the purpose of calculating expected emission reductions in section B.5	0.1458 (base year: 2008)
Description of measurement methods and procedures to be applied:	Follow procedures as described in the "Tool for the calculation of emission factor for an electricity system".
QA/QC procedures to	In order to present the national emission factor, the National Operator of the

be applied:	System provides to *MCT* the original data to do the calculation procedure.
Any comment:	

Data / Parameter:	**$TDL_{j,y}$**
Data unit:	-
Description:	Average technical transmission and distribution losses for providing electricity to source j in year y
Source of data to be used:	As described in the “Tool to calculate baseline, project and/or leakage emissions from electricity consumption”, the project activity comprises the scenario A and in the project case, a default given by the methodology is used (20%) for project and leakage electricity consumption.
Value of data applied for the purpose of calculating expected emission reductions in section B.5:	0.2
Description of measurement methods and procedures to be applied:	For a): *TDLy* should be estimated for the distribution and transmission networks of the electricity grid of the same voltage as the connection where the proposed CDM project activity is connected to. The technical distribution losses should not contain other types of grid losses (e.g. commercial losses/theft). The distribution losses can either be calculated by the project participants or be based on references from utilities, network operators or other official documentation.
QA/QC procedures to be applied:	Annualy. In the absence of data from the relevant year, most recent figures should be used, but not older than 5 years.
Any comment:	

Data / Parameter:	**$fv_{i,h}$**
Data unit:	-
Description:	Volumetric fraction of component i in the residual gas in the hour *h* where *i* = CH_4, CO, CO_2, O_2, H_2, N_2
Source of data to be used:	Measurements by project participants using a continuous gas analyzer
Value of data applied for the purpose of calculating expected emission reductions in section B.5:	
Description of measurement methods and procedures to be applied:	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 ($FV_{RG,h}$) when the residual gas temperature exceeds 60 ºC. Measured continuously. Values to be averaged hourly or at a shorter time interval. There is an unit of Command unity and system automation that allows the support of all data referred to the biogas, such as Physical-chemical properties and gas flow.
QA/QC procedures to be applied:	Analyzers must be periodically calibrated according to the manufacturer’s recommendation. A zero check and a typical value check should be performed by comparison with a standard certified gas.
Any comment:	

Data / Parameter:	$FV_{RG,h}$
Data unit:	m^3/h
Description:	Volumetric flow rate of the residual gas in dry basis at normal conditions in the hour *h*
Source of data to be used:	Measurements by project participants using a flow meter.
Value of data applied for the purpose of calculating expected emission reductions in section B.5:	
Description of measurement methods and procedures to be applied:	Ensure that the same basis (dry or wet) is considered for this measurement and the measurement of the volumetric fraction of all components in the residual gas ($fv_{i,h}$) when the residual gas temperature exceeds 60 ºC. Measured continuously. Values to be averaged hourly or at a shorter time interval.
QA/QC procedures to be applied:	Flow meters are to be periodically calibrated according to the manufacturer's recommendation.
Any comment:	-

Data / Parameter:	$t_{O2,h}$
Data unit:	-
Description:	Volumetric fraction of O_2 in the exhaust gas of the flare in the hour *h*
Source of data to be used:	Measurements by project participants using a continuous gas analyzer with infrared sensor and flow meter by pipeline (*Pito* pipe).
Value of data applied for the purpose of calculating expected emission reductions in section B.5:	
Description of measurement methods and procedures to be applied:	Extractive sampling analyzers with water and particulates removal devices or in situ analyzers for wet basis determination. The point of measurement (sampling point) shall be in the upper section of the flare (80% of total flare height). Sampling shall be conducted with appropriate sampling probes adequate to high temperatures level (e.g. inconel probes). An excessively high temperature at the sampling point (above 700 ºC) may be an indication that the flare is not being adequately operated or that its capacity is not adequate to the actual flow. Measured continuously. Values to be averaged hourly or at a shorter time interval.
QA/QC procedures to be applied:	Analyzers must be periodically calibrated according to the manufacturer's recommendation. A zero check and a typical value check should be performed by comparison with a standard gas.
Any comment:	Monitoring of this parameter is only applicable in case of enclosed flares and continuous monitoring of the flare efficiency.

Data / Parameter:	$fv_{CH4,FG,h}$
Data unit:	mg/m^3
Description:	Concentration of methane in the exhaust gas of the flare in dry basis at normal

	conditions in the hour *h*
Source of data to be used:	Measurements made by the project participant using a continuous gas analyzer with infrared sensor and flow meter by pipeline (*Pito* pipe).
Value of data applied for the purpose of calculating expected emission reductions in section B.5:	
Description of measurement methods and procedures to be applied:	Extractive sampling analyzers with water and particulates removal devices or in situ analyzers for wet basis determination. The point of measurement (sampling point) shall be in the upper section of the flare (80% of total flare height). Sampling shall be conducted with appropriate sampling probes adequate to high temperatures level (e.g. inconel probes). An excessively high temperature at the sampling point (above 700 ºC) may be an indication that the flare is not being adequately operated or that its capacity is not adequate to the actual flow. Measured continuously. Values to be averaged hourly or at a shorter time interval.
QA/QC procedures to be applied:	Analyzers must be periodically calibrated according to the manufacturer's recommendation. A zero check and a typical value check should be performed by comparison with a standard gas.
Any comment:	Monitoring of this parameter is only applicable in case of enclosed flares and continuous monitoring of the flare efficiency. Measurement instruments may read ppmv or % values. To convert from ppmv to mg/m3 simply multiply by 0.716. 1% equals 10 000 ppmv.

Data / Parameter:	$\mathbf{T_{flare}}$
Data unit:	°C
Description:	Temperature in the exhaust gas of the flare
Source of data to be used:	Measurements made by the project participant.
Value of data applied for the purpose of calculating expected emission reductions in section B.5:	
Description of measurement methods and procedures to be applied:	Measure the temperature of the exhaust gas stream in the flare by a Type N thermocouple. A temperature above 500 ºC indicates that a significant amount of gases are still being burnt and that the flare is operating. Continuously
QA/QC procedures to be applied:	Thermocouples should be replaced or calibrated every year.
Any comment:	An excessively high temperature at the sampling point (above 700 ºC) may be an indication that the flare is not being adequately operated or that its capacity is not adequate to the actual flow.

Data / Parameter:	$\mathbf{LFG_{total,y}}$
Data unit:	m^3/yr
Description:	Total amount of landfill gas captured at Normal Temperature and Pressure in a

	year
Source of data to be used:	Project participants
Value of data applied for the purpose of calculating expected emission reductions in section B.5:	
Description of measurement methods and procedures to be applied:	Measured by a flow meter: LANDIS GYRT-SAGA 1000, model 45N-2X1C. Data to be aggregated continuously (average value in a time interval not greater than an hour will be used in the calculations of emission reductions).
QA/QC procedures to be applied:	Flow meters should be subject to a regular maintenance and testing regime to ensure accuracy.
Any comment:	Measured in Normal Conditions of Temperature and Pression

Data / Parameter:	**$LFG_{flare,y}$**
Data unit:	m^3
Description:	Amount of landfill gas flared at Normal Temperature and Pressure
Source of data to be used:	Project participants
Value of data applied for the purpose of calculating expected emission reductions in section B.5:	
Description of measurement methods and procedures to be applied:	Measured by a flow meter: LANDIS GYRT-SAGA 1000, model 45N-2X1C. Data to be aggregated continuously (average value in a time interval not greater than an hour will be used in the calculations of emission reductions).
QA/QC procedures to be applied:	Flow meters should be subject to a regular maintenance and testing regime to ensure accuracy
Any comment:	-

Data / Parameter:	**$PE_{flare,y}$**
Data unit:	tCO_{2e}
Description:	Project emissions from flaring of the residual gas stream in year y
Source of data to be used:	Calculated as per the “Tool to determine project emissions from flaring gases containing Methane”.
Value of data applied for the purpose of calculating expected emission reductions in section B.5:	
Description of measurement methods and procedures to be	As per the “Tool to determine project emissions from flaring gases containing Methane”.

applied:	
QA/QC procedures to be applied:	As per the “Tool to determine project emissions from flaring gases containing Methane”.
Any comment:	-

Data / Parameter:	$\mathbf{w_{CH4}}$
Data unit:	m^3CH_4 / m^3LFG
Description:	Methane fraction in the landfill gas
Source of data to be used:	To be measured continuously by project participants using an electronic panel.
Value of data applied for the purpose of calculating expected emission reductions in section B.5:	
Description of measurement methods and procedures to be applied:	Methane content will be measured continuously for intervals not greater than an hour with a fixed gas analyzer with infra-red sensor and tubular flow meter: Pito tube, by the project developer. The gas analyzer will be maintained and calibrated regularly in line with the manufacturer’s requirements in order to ensure that factory standards of accuracy are maintained. Data to be aggregated continuously (average value in a time interval not greater than an hour will be used in the calculations of emission reductions).
QA/QC procedures to be applied:	The gas analyzer should be subject to a regular maintenance and testing regime to ensure accuracy.
Any comment:	

Data / Parameter:	**T**
Data unit:	°C
Description:	Temperature of the landfill gas
Source of data to be used:	Project participants
Value of data applied for the purpose of calculating expected emission reductions in section B.5:	
Description of measurement methods and procedures to be applied:	Measured to determine the density of methane D_{CH4}. No separate monitoring of temperature is necessary when using flow meters that automatically measure temperature and pressure, expressing LFG volumes in normalized cubic meters.
QA/QC procedures to be applied:	Measuring instruments should be subject to a regular maintenance and testing regime in accordance to appropriate national/international standards.
Any comment:	-

Data / Parameter:	**P**
Data unit:	Pa

Description:	Pressure of the landfill gas
Source of data to be used:	Project participants
Value of data applied for the purpose of calculating expected emission reductions in section B.5:	
Description of measurement methods and procedures to be applied:	Measured to determine the density of methane D_{CH4}. No separate monitoring of temperature is necessary when using flow meters that automatically measure temperature and pressure, expressing LFG volumes in normalized cubic meters.
QA/QC procedures to be applied:	Measuring instruments should be subject to a regular maintenance and testing regime in accordance to appropriate national/international standards.
Any comment:	-

Data / Parameter:	**$PE_{EC,y}$**
Data unit:	tCO_2
Description:	Project emissions from electricity consumption by the project activity during the year y
Source of data to be used:	Calculated as per the “Tool to calculate project emissions from electricity consumption”.
Value of data applied for the purpose of calculating expected emission reductions in section B.5:	131 (average value/year)
Description of measurement methods and procedures to be applied:	As per the “Tool to calculate project emissions from electricity consumption”
QA/QC procedures to be applied:	As per the “Tool to calculate project emissions from electricity consumption”
Any comment:	-

Data / Parameter:	**$MG_{PR,y}$**
Data unit:	tCH_4
Description:	Amount of methane generated during the year y of the project activity
Source of data to be used:	Project proponents
Value of data applied for the purpose of calculating expected emission reductions in section B.5:	9,959.59(average of methane production per year). Please see calculation spreadsheet
Description of	Estimated using the actual amount of waste disposed in the landfill as per the

measurement methods and procedures to be applied:	latest version of the “*Tool to determine methane emissions avoided from dumping waste at a solid waste disposal site*”. Calculated annually.
QA/QC procedures to be applied:	As per the latest version of the “*Tool to determine methane emissions avoided from dumping waste at a solid waste disposal site*”.
Any comment:	-

Data / Parameter:	$EC_{PJ,y}$
Data unit:	MWh
Description:	Onsite consumption of electricity provided by the grid attributable to the project activity during the year *y*
Source of data to be used:	Onsite measurements
Value of data applied for the purpose of calculating expected emission reductions in section B.5:	350.4
Description of measurement methods and procedures to be applied:	Use electric meters (given by *Cosern*[22] – energy generator, transmissor and distributor in *Natal*) continuously, aggregated at least annually.
QA/QC procedures to be applied:	Cross check measurement results with invoices for purchased electricity if relevant. The energy concessionaire is responsible for the calibration of the electric meter.
Any comment:	Applicable for all cases except where option B4 is used.

B.7.2 Description of the monitoring plan:

According to ACM0001 - version 11, when a landfill project only flares the methane, only one flow-meter must be installed provided that the meter used is calibrated periodically by an officially accredited entity.

All other data need to be monitored continuously, through proper meters or analyzers. The flare efficiency will be monitored by the combustion chamber temperature and the landfill gas flow by the flare system. The monitored data will be kept for, at least, 2 years after the last crediting period by the project proponent.

Considering that *Sereco*'s Landfill facilities will have computer-based equipment and generate continuous data, such equipment will be used for generating data relevant for the annual emission reduction verification report.

The responsible for implementing the monitoring plan will be the technical manager of *Sereco* Landfill and his team. The Operational Area, such as the landfill operators and manager will also be responsible for the day-to-day operation of the landfill gas monitoring, flaring and the party responsible for

[22] Companhia Energética do Rio Grande do Norte - *www.cosern.com.br/*

developing the data and registration forms for further classification. And also an automatic system controlling flare adjustments, blowers speed and alarm system in failure case is under the technical team of the landfill (operators and manager) responsibility.

1. Operational structure.

It will be based on daily monitoring of the LFG flow from the gas extraction stage to the landfill gas flaring. Continuous measurers of gas flow and flared gas meter will be installed along the landfill gas extraction network and data will be continuously acquired from the process (continuous sampling) in order to present an average value in a time interval not greater than an hour. Besides, paired values of the methane fraction of the landfill gas and LFG flow which are averaged for the same time interval will be used in the calculation of emission reductions (i.e. methane fraction of landfill gas averaged at hour x will be used with LFG flow which is averaged at the same hour x).The main purpose is the direct monitoring by the landfill operators, being coordinated by the landfill manager, of any fugitive emissions and the empirical calculation of the landfill gas generated.

2. Monitoring follow-up process.

All data collected following the B.7.1 will be registered and transferred to electronic spreadsheets and/or other suitable electronic files by the landfill operators and their technical manager. The calibration certificates should be stored as paper copies and calibration data would be subject to quality control procedures as described in each description of data to be monitored (Quality control and Quality assurance). The management structure will also ensure that the monitoring equipment is perfectly calibrated based on the INMETRO[23] standards (Brazilian institute for metrology and calibration).

Following an internal audit of the collected data carried out by the Project developer, the electronic data would be verified by an independent Designated Operational Entity (DOE), on an annual basis. The DOE would issue a verification report based on the data sheets to calculate emissions reductions.

3. The management structure.

The landfill operator will be responsible for training of the monitoring and operation staff with the help of the equipment manufactures, developing written work procedures for the local system operation related to the monitoring equipment. This team will create work schedules, periodic maintenance methods and judgment criteria.

The operating personnel will receive training in the operation and maintenance of the system by its provider, in order to allow them to operate it and monitor the operation according to high standards. The equipment provider will give technical support for the system maintenance and operation.

Then, the technical team will manage the monitoring, quality control and the quality assurance procedures carried out at the landfill premises. Further detailed procedures for monitoring shall be developed during the final design of the facilities.

[23] *http://www.inmetro.gov.br/*

B.8 Date of completion of the application of the baseline study and monitoring methodology and the name of the responsible person(s)/entity(ies)

The baseline study for the project activity and monitoring methodology were completed on 06/08/2009 by *CantorCO2e Brazil*, which is not a project participant. Below, the name of person and entity determining the baseline:

Name of person/Organization	Project Participant
Adriana Berti Cantor CO2e Brasil São Paulo, Brazil. Tel: +55 11 5083 3252 Fax: +55 11 5083 8442 e-mail: aberti@cantorco2e.com.br WWW: www.cantorco2e.com	NO

Table 16: Name of person/organization responsible for the baseline study (project developer).

SECTION C. Duration of the project activity / crediting period

C.1 Duration of the project activity:

C.1.1. Starting date of the project activity:

01/08/2010

This date is related to the registration of the project in the UNFCCC, since the project proponent will only proceed with the project activity when the revenue is received. So far, there is no signed proposal and no definitions were taken, financially.

C.1.2. Expected operational lifetime of the project activity:

25 years

C.2 Choice of the crediting period and related information:

C.2.1. Renewable crediting period

C.2.1.1. Starting date of the first crediting period:

01/08/2010 or the date of registry (whichever is later)

C.2.1.2. Length of the first crediting period:

7 years – 0 month.

C.2.2. Fixed crediting period:

C.2.2.1. Starting date:

Not applicable.

C.2.2.2. Length:

Not applicable.

SECTION D. Environmental impacts

D.1. Documentation on the analysis of the environmental impacts, including transboundary impacts:

Natal Landfill was built according with all the specifications of environmental and sanitary engineering, constituting an adequate technological alternative to a final destination of domiciliary solid waste in the metropolitan area of *Natal,* which were indiscriminately disposed in rubbish dump.

The installation and operation of the landfill were submitted to an *EIA/RIMA* (Environmental Impact Assessment) which is mandatory by the law, described in the article 225 of the Brazilian Federal Constitution (*Constituição Federal Brasileira*) and it were approved by the responsible environmental agency IDEMA (*Rio Grande do Norte´s* Institute to Economic Development and Environment).

Based on the results of the Assessment, the environmental licenses were granted to the *Natal Landfill* which is in accordance with federal, state and municipal legislation, the determination of the Environmental Ministry and the resolutions of the Brazilian Environment Advice (CONAMA). After the licensing process, the Operational License Nº 2006 – 006289/TEC/RLO – 0614 (dated of February, 7th 2007) had been renewed and replaced by N° 2007 - 015408/TEC/RLO – 1662 was granted to *SERECO S/A*. permitting *Sereco´s* Landfill activities, dated of 4th August, 2008.

However, the proposed CDM Project will collect and destroy landfill gases produced by the landfill operation. It will reduce both global and local environmental effects of uncontrolled emissions.

Baseline scenario: the main global environmental concern over these compounds is the fact that they are Greenhouse Gases. LFG also contain over 150 trace components that can cause other local and global environmental effects such as odor nuisances, stratospheric ozone layer depletion, and ground-level ozone creation, also related to the project activity

Project activity: Through an appropriate management, the landfill gases will be captured and combusted removing the risk of toxic effects on the local community and environment, including freatic layers, watercourse pollution and odor nuisances. Besides, there will be an improvement of air quality, since the odors related to CH_4 production will be reduced.

Thus, the installation of a set of wells designated for gas collection and consequent flaring will lead into a daily monitoring (as stated at the monitoring plan) and proper landfill operation and no significant adverse impacts are expected due to the project activity implementation.

D.2. If environmental impacts are considered significant by the project participants or the host Party, please provide conclusions and all references to support documentation of an environmental impact assessment undertaken in accordance with the procedures as required by the host Party:

Not applicable for the project activity.

SECTION E. Stakeholders' comments

E.1. Brief description how comments by local stakeholders have been invited and compiled:

According to the Resolution number 1 of the Brazilian Inter-Ministerial Commission on Climate Change[24] (BIMCCC), invitations for comments by local stakeholders are required by the Brazilian Designated National Authority (DNA) as part of the procedures for analyzing CDM projects and issuing letters of approval. Although the Resolution number 7, of March, 5th 2008, was considered in order to invite the stakeholders, since it replaces the Incise II of 3rd Article of Resolution 1 of BIMCCC.

The DNA required project participants to communicate with the public through letters, to be sent inviting for comments to:

- The Brazilian national NGO's forum.
- The local attorneys' and prosecutors' agency.
- The municipality's chamber (mayor and assembly men).
- State's and municipal's environmental authorities.
- Local communities' associations.

As defined by the Designated National Authority (DNA), the project developer sent information letters to the key institutions, describing the major aspects of the implementation and operation of the proposed project. The project participant should leave 30 days opened for comments. The letters were distributed by SERECO S/A by mail to the key institutions.

E.2. Summary of the comments received:

No comments have been received.

E.3. Report on how due account was taken of any comments received:

Not applicable, as no comments were received.

[24] *Issued on December 2nd of the 2003, decree from July 7th 1999.*

Annex 1

CONTACT INFORMATION ON PARTICIPANTS IN THE PROJECT ACTIVITY

Organization:	*Sereco S/A*
Street/P.O.Box:	Romualdo Galvão Street
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Table 17: Project proponent information.

Annex 2

INFORMATION REGARDING PUBLIC FUNDING

There are no public financing for the project.

Annex 3

BASELINE INFORMATION

Below, the parameters and data sources used to determine the baseline for the project activity.

Year	Estimated Total of waste disposed (tons/year)
2004	108,623
2005	272,555
2006	301,815
2007	310,027
2008	312,140
2009	326,850
2010	342,253
2011	358,382
2012	375,271
2013	392,955
2014	411,474
2015	430,865
2016	451,169
2017	472,431

Table 18: Projection of waste disposal in Natal Landfill. Source: Sereco *Landfill*[25].

The waste disposed from 2004 to 2008 comes from historical records of the landfill.
In order to make a projection for the following years, since the PDD was finished in August/2009, the growth rate was calculated between the period 2005 – 2008.
The calculated rate was 4.71% and a spreadsheet demonstrating the calculation was made available to the DOE.
The growth rate of first year (2004 to 2005), was not considered because the number of municipalities which waste has been disposed in Natal landfill has increased in this year, then the rate, considering this period, would not be representative.

[25]*Data available at: http://www.braseco.com.br/2008/navegacao/ver_noticia.php?id_noticia=119. Access: 28/08/2009.*

Annex 4

MONITORING INFORMATION

The monitoring methodology is based on direct measurement of the amount of landfill gas captured and destroyed at the flare platform to determine the quantities as shown in Figure 03.

The monitoring plan provides for continuous measurement of the quantity and quality of LFG flared and the Quality Control (QC) and Quality Assurance (QA) procedures are necessary to ensure consistency on the monitoring equipment and the data collected.

1. Monitoring Process

Below, the monitoring plan defines a set of parameters in order to calculate the main project activity variables.

At the figure 03 in section B.3, the landfill gas flows through the gas network up to the flaring point where the monitoring equipment is placed. Several sensors are placed on-line to the gas pipeline in order to measure continuous gas flows and this gas flow meter must be calibrated by an officially accredited entity.

Monitoring the Project's ER performance requires proper data collection and processing by the Project Operator. *Sereco*'s software will be fed by an Organizational Team that will be responsible for performing it (monthly) and also supervising. The software will report each necessary data to the DOE at Verification Process.

All data required for the Monitoring Plan will come from the Project Operator's information system, and it is the responsibility of the Project Operator to ensure that this data is made available monthly to the software.

It is believed that the monitoring approach presented in this MP will result in an accurate, yet conservative calculation of ERs. However some uncertainties, especially errors in the data monitoring and processing system, may result in a discrepancy on the monitored ERs and, then, the verified ERs. The Project Operator is expected to prevent such errors, and the verification audits are expected to uncover any potential ones. Given that CERs can only be certified after Verification, there is a significant internal incentive for the Project Operator to perform all steps related to data collection and calculations as accurately as possible.

In doing so, *Sereco* will:

- Provide all necessary monitoring information to facilitate the verification work, and cooperate with the DOE in a timely manner on all data requests and questions;
- During the crediting period, always take into account requests by the CDM Executive Board and conduct preparatory work for the verification to obtain high quality and efficient results.

Training is an important element in successful monitoring of ERs. The Monitoring Plan associated to a training program will build the ability for the Operational Team of *Sereco* to replicate - on an ex-post basis – an equivalent process that has been demonstrated in this PDD for an ex-ante emissions calculation. All relevant personnel may be trained at a one- day workshop on a comprehensive set of tools and knowledge required to implement the MP, including: (a) accurate monitoring of the performance and output characteristics of the plant for recording and keeping accurate data; (b) collection and integration of utility data for the current year; (c) incorporation of these data sets into Excel spreadsheets prepared by the project proponent.

Adequate equipment will be defined and obtained during project construction, which will be used for monitoring gas flows, flare temperature and LFG gas combustion. Procedures for maintenance and installation of equipment, as well as calibration, will be performed according to manufacturer's specifications. All measurements, data gathering, record keeping, and procedures for dealing with possible data adjustments will be performed taking into consideration the specific data gathering requirements of the Monitoring Plan, and will also meet the requirements of both ACM0001 and the "Tool to determine project emissions from flaring gases containing methane". *Sereco* Landfill is designed for performing quality control on the data collection, and provides procedures to guarantee the accuracy of the results. The quality control procedures deal with data collection, processing, record keeping and cross-checking. It is therefore, expected that the MP approach presented in this PDD will result in an accurate, yet conservative calculation of ERs.

The following information must be provided by the Project Operator:

- Shall directly measure the CH_4 destroyed by flaring and from generation following ACM0001.

- Shall estimate the project emissions following the "Tool to determine project emissions from flaring gases containing methane".

For those data, the Quality Control and Organizational Structure can be seen below:

Flaring Data:

- LFG flared registered by the flow meter (continuous measurement);
- Volumetric flow rate of the residual gas in dry basis at normal conditions measurement according to the "Tool to determine project emissions from flaring gases containing methane";
- Average methane fraction of the measured LFG by a continuous gas quality analyzer.

Quality of Data Processing:

- Original Data;
- Organized Data;
- Entered Data;
- Processed Data;
- Results;
- All must be recorded and manipulated in an Excel spreadsheet with records of data points;
- Yearly consolidation of monthly calculations.

Quality of Data Storage:

- Prevent Excel version problems by updating Excel software package every year in PCs used for ER calculation;

- Keep all data for 2 years after the end of the crediting period or the last issuance of CERs for this project activity;
- Save document with last date in which an alteration was made so that old versions are kept on disc;
- Keep all written documentation in a folder that will be provided to the DOE together with the data collected in Excel.

2. Emissions reduction calculation process

The monitoring process will establish the effective emission reductions occurred at the landfill. The LFG generated at the cells will flow through the gas network to the gas treatment system under pressure conditions. The monitoring operation will result on tCO_2equ. as the LFG is being flared.

For this purpose, the quantity of LFG (m^3) and the methane content (%) of the LFG are monitored. The equation below outputs the amount of CO_2e (in tons):

The amount of waste displaced on site is defined by the technical equipment and the operational team. The monitoring methodology schedules a continuous screening of the defined values and the further storage on a data-logger (set on place). Finally, the data will be daily download and archived on electronic format. Please refer to the B.7.1 for more information.

3. QA/QC procedures (Data consistency)

The planning procedures are set to ensure consistency on the monitoring equipment and sensors (Quality Control) and the data collected (Quality Assurance). In cases of failure of measurement, failure will be reported to equipment supplier and repairs carried out. If repair is not possible, equipment will be replaced by equivalent item within one month. Failure events will be recorded in the site events log book. In addition, an alarm system in failure case will be adopted.

The procedures are defined and based throughout the following points: process scheduling, operation and maintenance plan, data collecting and data registration, equipment calibration, quality auditing and quality prevention plan. The procedures also include measures to solve non-conformities due to the implementation, operation and maintenance of the project activity.

The data to be included within the QA/QC procedures corresponds to B.7.1 on this PDD. The uncertainty level for the data was set in low. In order to ensure the reliability of the sensors, the following operation steps will be undertaken:

1. On-field sensors.

- LFG flow meter

  The meter will provide two values, the continuous sampling of the amount of LFG (m^3) for intervals not greater than an hour stored by the data-logger and the total value which passed through the flow meter. The valuator will check both for consistency.

- Methane analyzer.

  The most important parameter at the gas analyzer is the normal deviation from the marginal error presented at the electronic device. In order to ensure consistency, the project developer will follow the operation guidelines set up by the fabricant and technical standards provide by the

Brazilian Technical Standard Association (*ABNT*) for the sensor operation. This data will be monitored continuously for intervals not greater than an hour, such as LFG flow.

- Temperature and pressure sensor.

  The temperature and pressure will also suffer time to time deviation outside boundaries of the normal deviation set up by the fabricant. In order to ensure consistency, the project developer will follow recommendations on the operation guidelines defined either by the fabricant and the Brazilian Technical Standard Association (*ABNT*) for the sensor operation.

2. Data logger

Several models for data logger are available at the market. The data logger will be connected directly to the electronic devices (PLC, flow meter, analyzer, temperature sensor). The performance of the data logger will allow hourly registration of the B.7.1 data being daily checked for consistency.

3. Energy meter

The electrical power consumption is measured by means of a kWh-meter.

4. Operation and validation

Currently, the project owner develops its own operation and environmental monitoring at the landfill and landfill premises. The current operation plan monitors the flux of the percolated liquid from landfill to the final treatment, the water quality at the freatic layers, cleaning and pest control activities and finally, the administration of the existing re-forestation activities. The operation routine scheduled for the project activity will be added to the existing operation plan.

Moreover, the project proponent will prepare an operation handbook for the monitoring plan. The manual will define the necessary technical and safety procedures for normal operation and the emergency measures for the project operation.

The project proponent is the only responsible for the operation of the guidelines described at the handbook. Also the project proponent will ensure enough human and material resources for the accomplishment of the activities within the monitoring plan, offering training for the monitoring personal.

5. Regulatory requirements governing landfills in Brazil.

The project developer will be responsible for the analysis and direct monitoring on the governmental rules regarding the landfill gas capture and destruction.

6. Corrective, Preventive and Improvement actions.

Actions and procedures are here defined for treating and correcting non-conformities, deviations from the Monitoring Plan and Operational Manual, observed by the landfill operator or during the periodic monitoring. In case of non-conformities regarding the maintenance and operation, further actions are implemented:

1. Problem analysis: Definition of the origin, causes and further actions to be undertaken.

2. Corrective actions: Administration staff will implement and report to the technical staff the necessary measures.