



**PROJECT DESIGN DOCUMENT FORM  
FOR CDM PROJECT ACTIVITIES (F-CDM-PDD)  
Version 04.1**

**PROJECT DESIGN DOCUMENT (PDD)**

<b>Title of the project activity</b>	CTR Maceio Landfill Gas Project
<b>Version number of the PDD</b>	Version 05
<b>Completion date of the PDD</b>	26/11/2012
<b>Project participant(s)</b>	Estre Ambiental S.A.
<b>Host Party(ies)</b>	Brazil
<b>Sectoral scope and selected methodology(ies)</b>	Sectorial Scope: 13 Methodology: ACM0001 - Version 13.0.0
<b>Estimated amount of annual average GHG emission reductions</b>	116,336 tCO <sub>2</sub> e



## SECTION A. Description of project activity

### A.1. Purpose and general description of project activity

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The proposed project activity has the objective to capture, flare and generate electricity through the use of landfill gas (LFG)<sup>1</sup> produced in anaerobic conditions into the landfill called “Centro de Tratamento de Resíduos Maceio” (hereinafter referred to as *CTR Maceio*) located in the municipality of Maceió in the state of Alagoas, Brazil.

CTR Maceió belongs to Estre Ambiental S.A. a company specialized in waste treatment and disposal which will be the biogas plant operator.

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

- Burning CH<sub>4</sub> in flares and/or group generators;
- The amount of electricity generated in the project activity will be dispatched to the Brazilian national grid, avoiding the dispatch of an equal amount of energy produced by fossil-fuelled thermal plants to that grid. The initiative avoids CO<sub>2</sub> emissions and contributes to the regional and national sustainable development.

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

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

The estimate of:

- Annual average is 116,336 tCO<sub>2</sub>e;
- Total GHG emission reduction is 814,349 tCO<sub>2</sub>e.

The project activity will be to capture and to flare the LFG and to generate electricity through the implementation of a power generation plant using LFG. The installed generation capacity will be expected to change during the lifetime of the project, totalizing at the end 10.5 MW.

The project will be to construct an efficient capture, collection and flaring system to burn CH<sub>4</sub> (a greenhouse gas), and this will reduce odours and adverse environmental impacts. Moreover, it will install generators that will combust the LFG to produce electricity, using part of the electricity for self-consumption and the other part will be exported to the grid. The flares will be kept in operation due to LFG excess, periods when electricity will not be produced or other operational considerations. The LFG power plant will be expected to install approximately 10.5 MW upon project completion. However, the final equipments that will be chosen (as well as the final installed capacity) may vary depending on the availability of the generation equipments on the market at the time of actual implementation.<sup>2</sup>

The LFG capture and collection systems and flaring station will consist on a LFG pipeline grid and a flaring station, equipped with flares, centrifugal blowers, and all other supporting mechanical and electrical subsystems and appurtenances necessary to run the system. The power generation facility will

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

<sup>2</sup> The installed capacity by generator group may vary between 1.4 to 1.5 MW. This range has been considered based on technical specifications of main manufacturers in the market. The project activity considered 1.5 MW the installed capacity per generator group.



be comprised of LFG engine generator sets of high performance standards. The engine-generator sets will be the primary equipment to combust the collected LFG once they are installed. A fraction of the collected LFG will be diverted to flares, which will be used to combust any gas in excess of the fuel demand for the engines, as well as a contingency backup.

The landfill began its operation in 2010, receiving solid waste (type Class II-A Inert and Class II-B Non-inert)<sup>3</sup>, according to License of Operation nº 163/2012 valid up to 23/04/2014.

### **Contribution of the Project Activity to Sustainable Development:**

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

#### **a) Contribution to the environment:**

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

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

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

#### **c) Contribution to income generation:**

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

#### **A.2. Location of project activity**

##### **A.2.1. Host Party(ies)**

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Brazil

##### **A.2.2. Region/State/Province etc.**

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Alagoas

##### **A.2.3. City/Town/Community etc.**

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Maceió

##### **A.2.4. Physical/Geographical location**

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CTR Maceio is located in Guaxuma, without number – district of Benedito Bentes, Municipality of Maceió, Alagoas State, Brazil.

<sup>3</sup> According to definition of the Brazilian Association of Technical Norms (ABNT NBR 10004) <http://www.aslaa.com.br/legislacoes/NBR%20n%2010004-2004.pdf>

Geographical Coordinates: Latitude: -9.561214° (09°33'40.37"S) and Longitude: -35.697483° (35°41'50.94" W)



Figure 1 - Geographical position of Maceió city, inside of Alagoas State in Brazil  
(Source: <http://www.ibge.gov.br/cidadesat/topwindow.htm?1>)



Figure 2 – CTR Maceio

### A.3. Technologies and/or measures

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The landfill is operated under anaerobic conditions adopting the following conditions:

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

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

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

### **Collection system**

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



**Figure 3 – Example of control system (manifolds)**

Source: Cenbio, 2006

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

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



**Figure 4 - Example of collection system (well head)**

Source: Landfill Methane Outreach Program - EPA

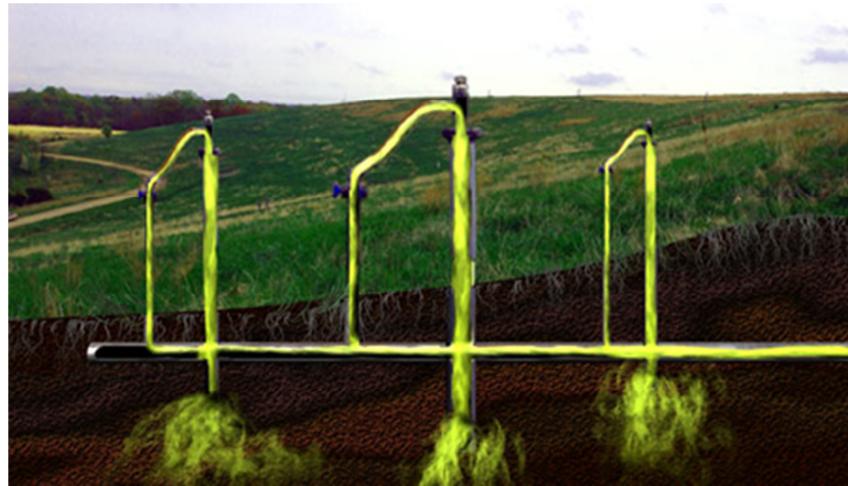
The collection pipe will be built using HDPE or similar. The sizing of the piping was done considering the maximum production of landfill gas that can reach. Activities will be intense welding tubing to connect each station of the adjustment. The pipe will be covered with materials that do not pose any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

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

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

### **Transport System**

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



**Figure 5 - Illustrative of transport system**  
Source: Landfill Methane Outreach Program - EPA

### Blowering System

The blowering system is responsible to give negative pressure to the landfill, blowing the gas to the pipeline. The dimensioning of the blowers will depend on flow of the landfill gas which may range between 500 to 5,000 Nm<sup>3</sup>/h per each blower and the installed capacity around 50 kW for each equipment.

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



**Figure 6 - Example of blower system**  
Source: John Zink

### Flare System

The destruction of the methane content in the LFG collected will be made via enclosed flares, in order to assure higher methane destruction (enclosed flare).

The flare operational flow may range between 500 to 5,000 Nm<sup>3</sup>/h depending on the manufacturer and design that will be chosen in the purchasing moment. The standard combustion temperature is around 850° C.

Basically, the flare is constructed using refractory material, a gas inlet, dampers to control the air inlet, an ignition spark, flame viewer and points to sample collection, as presented in the pictures below:



**Figure 7 - Detail of Enclosed Flare**  
Source: Landfill Methane Outreach Program - EPA

### **Biogas Station**

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



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



Figure 8 - Example of a flare system

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

### **Power generation**

The power generation system will be comprised of around 10.5 MW. The electricity generated by the project will be to the internal consumption and the surplus energy supplied to the grid, this energy will be measured using a bi-directional electricity meter.

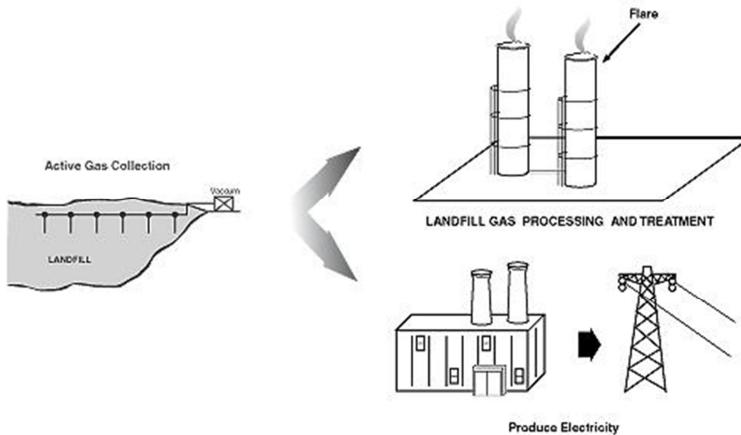
A diesel generator will be installed in case of downtimes of the power plant.

This kind of technology is still not widely applied in Brazil, additionally the PP carried out a survey in order to verify the existence of any landfill with LFG collection and destruction active system generating electricity and that has been not registered as a CDM Project. The information sources that demonstrate that there are not landfills with power generation in Brazil other than CDM projects are the database with all energy plants published by ANEEL (Brazilian Electricity Regulatory Agency) crosschecked with database of UNFCCC.

The result of this survey concludes that there is no similar project activities developed without CDM benefits.

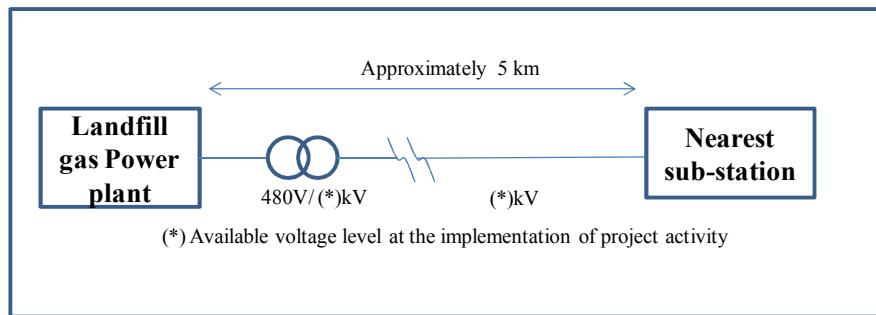
Very few landfills have already installed equipment for flaring and combustion LFG. Therefore, the company will need engineers and other specialists with experience in this area to advise the company while implementing the project. These professionals will also train local operators and engineers on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

The installed capacity by generator group may vary between 1.4 to 1.5 MW. This range has been considered based on technical specifications of main manufacturers in the market. The project activity considered 1.5 MW the installed capacity per generator group.



**Figure 9 – Power generation diagram**

It is important to clarify that the authorization to generate electricity to Brazilian Electricity Regulatory Agency (ANEEL) has not been request yet. The point of connection to the electrical grid will be the closest substation to the project activity available at the moment of the project implementation considering the available voltage level conditions. The length of transmission line will be approximately 5 km as stated in the feasibility study. A single line diagram has been provided in Figure 10.



**Figure 10 - Single line of electricity connection**

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

**Table 1 - Electricity generation**

Year	Number of engines installed (unit)	Installed capacity (MW)*	Net electricity generated in the plant (MWh)
2013	0	0.0	0
2014	4	6.0	24,703
2015	4	6.0	32,938
2016	4	6.0	32,938
2017	4	6.0	32,938
2018	4	6.0	41,172
2019	4	6.0	41,172
2020	4	6.0	20,586**

\*The total installed capacity will be expected since 2032 with 10.5 MW and 7 installed



group-generators.

\*\* The first crediting period is until 31/06/2020.

The lifetime of the equipments is 25 years and it was based on "Tool to determine the remaining lifetime of equipment Version 01 – Option (c) Default Values" (Electric Generators, air cooled)<sup>4</sup>. The equipments that will be installed in the project site will be all new.

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

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

The load factor is 94% based on manufacturer's specification<sup>5</sup>.

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

The technology for biogas collection, flaring and power generation can be considered state of art in the Brazilian sanitation context.

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

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<sup>4</sup> The lifetime of the equipments is also supported by the International Energy Agency (IEA) World energy model – Methodology and assumptions, page 13.

<sup>5</sup> Manufacturer specifications: Apresentação Custos de O&M.pdf.

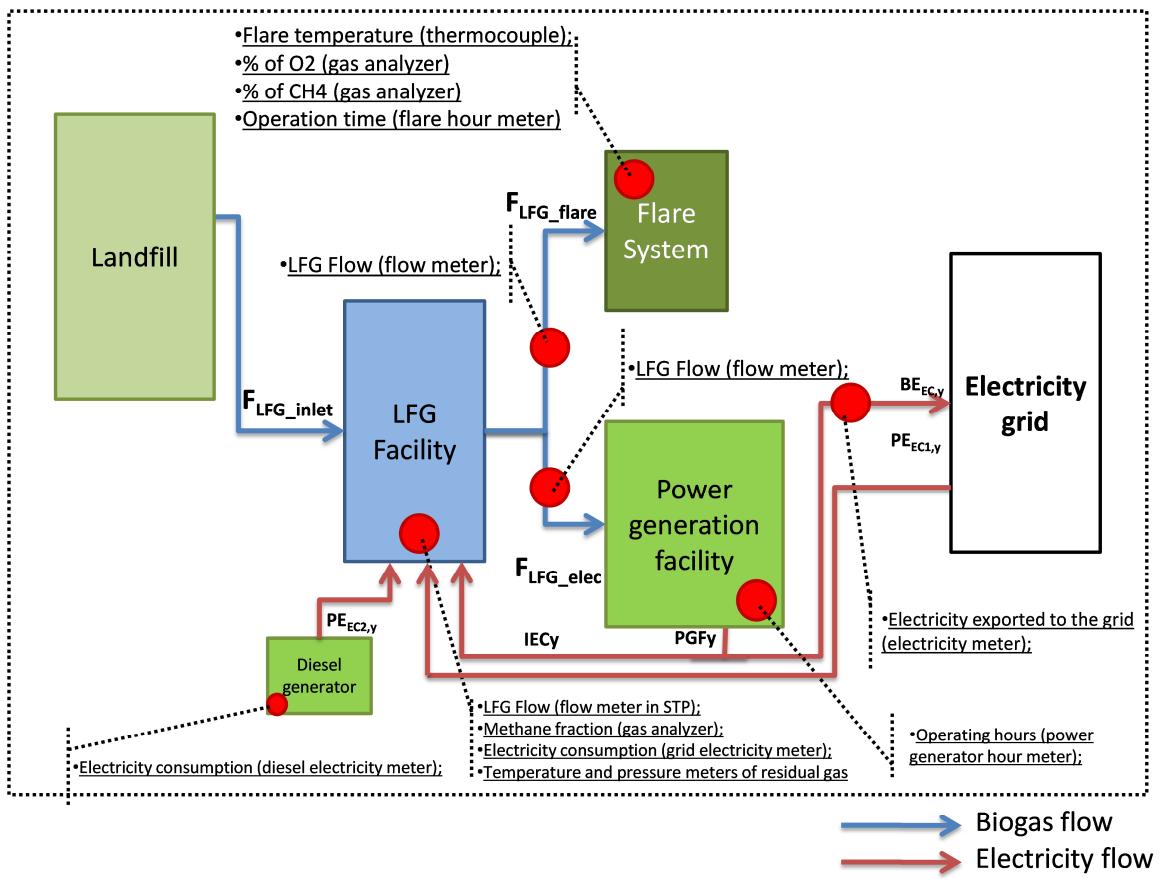


Figure 11 - Technologies and measures of the project activity

#### A.4. Parties and project participants

Party involved (host) indicates a host Party	Private and/or public entity(ies) project participants (as applicable)	Indicate if the Party involved wishes to be considered as project participant (Yes/No)
Brazil (host)	Estre Ambiental S.A. (private entity)	No

CTR Maceió belongs to Estre Ambiental S.A. a company specialized in waste treatment and disposal.

#### A.5. Public funding of project activity

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There is no public funding involved in the project activity.

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

#### B.1. Reference of methodology

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- ACM0001: “Flaring or use of landfill gas” (Version 13.0.0);
- Combined tool to identify the baseline scenario and demonstrate additionality (Version 04.0.0);
- Tool to calculate project or leakage CO<sub>2</sub> emissions from fossil fuel combustion (Version 02);



- Emissions from solid waste disposal sites (Version 06.0.1);
- Tool to calculate baseline, project and/or leakage emissions from electricity consumption (Version 01);
- Tool to determine project emissions from flaring gases containing methane (Version 01), EB 28, Annex 13;
- Tool to determine the mass flow of a greenhouse gas in a gaseous stream (Version 02.0.0);
- Tool to determine the baseline efficiency of thermal or electric energy generation systems (Version 01);
- Tool to determine the remaining lifetime of equipment (Version 01).

## B.2. Applicability of methodology

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The methodology ACM0001 is applicable to project activities which:

“...”

- a) *Install a new LFG capture system in a new or existing SWDS; or*
- b) *Make an investment into an existing LFG capture system to increase the recovery rate or change the use of the captured LFG, provided that:*
  - i) *The captured LFG was vented or flared and not used prior to the implementation of the project activity; and*
  - ii) *In the case of an existing active LFG capture system for which the amount of LFG can not be collected separately from the project system after the implementation of the project activity and its efficiency is not impacted on by the project system: historical data on the amount of LFG capture and flared is available.*
- c) *Flare the LFG and/or use the captured LFG in any (combination) of the following ways:*
  - i) *Generating electricity;*
  - ii) *Generating heat in a boiler, air heater or kiln (brick firing only) or glass melting furnace; and/or*
  - iii) *Supplying the LFG to consumers through a natural gas distribution network.*
- d) *Do not reduce the amount of organic waste that would be recycled in the absence of the project activity.*

...”

### Justification: - Part 1

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

The project activity will burn LFG in enclosed flares and will generate electricity through LFG.

Moreover, the amount of organic waste will be the same in the project activity as well as in the absence of the project activity.

“...”

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

- a) *Release of the LFG from the SWDS; and*
- b) *In the case that the LFG is used in the project activity for generating electricity and/or generating heat in a boiler, air heater, glass melting furnace or kiln;*



- i) For electricity generation: that electricity would be generated in the grid or in captive fossil fuel fired power plants; and/or
- ii) For heat generation: that heat would be generated using fossil fuels in on-site equipment.

*This methodology is not applicable:*

- a) In combination with other approved methodologies. For instance, ACM0001 cannot be used to claim emission reductions for the displacement of fossil fuels in a kiln or glass melting furnace, where the purpose of the CDM project activity is to implement energy efficiency measures at the kiln;
  - b) If the management of the SWDS in the project activity is deliberately changed in order to increase methane generation compared to the situation prior to the implementation of the project activity.
- ... ”

### **Justification: - Part 2**

According to Section B.4 and B.5, the methodology is applicable because:

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

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



### B.3. Project boundary

	<b>Source</b>	<b>GHGs</b>	<b>Included?</b>	<b>Justification/Explanation</b>
Baseline scenario	Emissions from decomposition of waste at the SWDS site	CH <sub>4</sub>	Yes	The major source of emissions in the baseline.
		N <sub>2</sub> O	No	N <sub>2</sub> O emissions are small compared to CH <sub>4</sub> emissions from SWDS. This is conservative.
		CO <sub>2</sub>	No	CO <sub>2</sub> emissions from decomposition of organic waste are not accounted since the CO <sub>2</sub> is also released under the project activity.
	Emissions from electricity generation	CO <sub>2</sub>	Yes	Major emission source because power generation is included in the project activity.
		CH <sub>4</sub>	No	Excluded for simplification. This is conservative.
		N <sub>2</sub> O	No	Excluded for simplification. This is conservative.
	Emissions from heat generation	CO <sub>2</sub>	No	There is no heat generation.
		CH <sub>4</sub>	No	There is no heat generation.
		N <sub>2</sub> O	No	There is no heat generation.
	Emissions from the use of natural gas	CO <sub>2</sub>	No	There is no use of natural gas.
		CH <sub>4</sub>	No	There is no use of natural gas.
		N <sub>2</sub> O	No	There is no use of natural gas.
Project scenario	Emissions from fossil fuel consumption for purposes other than electricity generation or transportation due to the project activity	CO <sub>2</sub>	No	There is no fossil fuel consumption for purposes other than electricity generation or transportation due to the project activity
		CH <sub>4</sub>	No	There is no fossil fuel consumption for purposes other than electricity generation or transportation due to the project activity
		N <sub>2</sub> O	No	There is no fossil fuel consumption for purposes other than electricity generation or transportation due to the project activity
	Emissions from electricity consumption due to the project activity	CO <sub>2</sub>	Yes	May be an important emission source by use of emergency diesel generator.
		CH <sub>4</sub>	No	Excluded for simplification. This emission source is assumed to be very small.
		N <sub>2</sub> O	No	Excluded for simplification. This emission source is assumed to be very small.

The flow diagram is presented below:

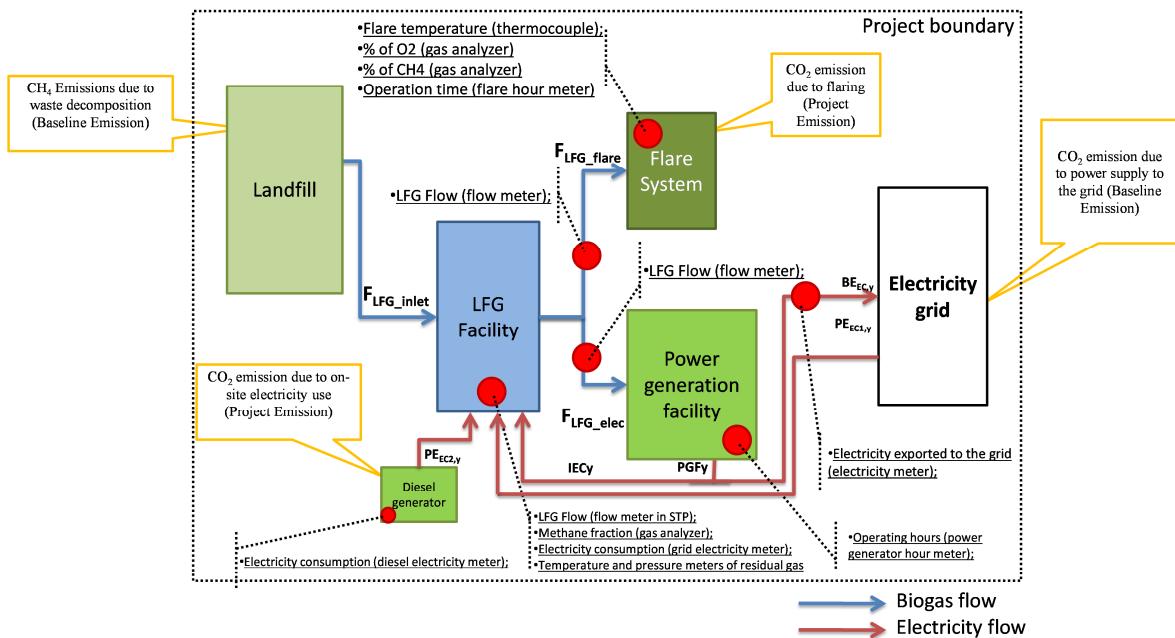


Figure 12 – Flow diagram project boundary

#### B.4. Establishment and description of baseline scenario

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

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

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

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

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

##### **Step 1: Identification of alternative scenarios**

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

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

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

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

<b>LFG1</b>	The project activity implemented without being registered as a CDM project activity (capture, flaring and use of LFG);
<b>LFG2</b>	Release of the LFG to atmosphere



As the EIA (Environmental Impact Assessment) and landfill design project do not cover recycling, treatment or incineration of waste, alternatives LFG3, LFG4 and LFG5 should not be considered.

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

For electricity generation, the realistic and credible alternatives are:

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

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

The project activity does not aim heat generation. Therefore, all alternative scenarios (from H1 to H7) considering heat generation should not be considered.

Thus, the remaining real alternatives for electricity generation are E1 and E3.

The combinations of the project activity compose the following scenarios:

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

**Outcome of Step 1a:** Three realistic and credible alternative scenarios to the project activity were identified:

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

#### ***Step 1b: Consistency with mandatory applicable laws and regulations***

All alternative scenarios identified in Step 1a comply with all applicable laws and regulations. Brazil's New National Solid Waste Policy (NSWP),<sup>6</sup> ratified by the President on 02/08/2010 after 19 years under discussion. The NSWP does not request the LFG capture and/or flare and there is not forecast to approve any regulation or policy in the next years with this requirement.

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

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

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

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

<sup>6</sup> [http://www.planalto.gov.br/ccivil\\_03/\\_ato2007-2010/14/lei/l12305.htm](http://www.planalto.gov.br/ccivil_03/_ato2007-2010/14/lei/l12305.htm)



- Scenario 4 (LFG2 + E3).

### B.5. Demonstration of additionality

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The following table shows the timeline of the project activity showing that the CDM benefits were taken into account to implement it.

**Table 2 - Implementation timeline of the Project**

Key Events	Date
Prior Consideration of the CDM to UNFCCC and Brazilian DNA	15/06/2012
Submit the PDD for Global Stakeholder Consultation (GSC)	13/07/2012
The starting date of the project activity will be the purchase of the main equipment.*	01/01/2013
Initial operation of the project activity *	01/07/2013

\*Estimated

The project participants notified on 15/06/2012 the Brazilian DNA and UNFCCC of their intention to seek CDM status, according to “Clean development mechanism project cycle procedure” version 02.0.

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

The Step 0, 1a and 1b are described above.

### **Step 2: Barrier analysis**

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

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

*It was made an assessment to identify barriers that would prevent the implementation of alternative scenarios and only one barrier has been identified:*

#### **Investment barrier:**

This barrier would prevent the implementation of scenario 2 (collection and destruction of LFG in enclosed flare + electricity generation in existing and/or new grid-connected power plants), because, this scenario would have lack of access to capital to be developed due to this scenario does not meet the requirements of the main financial entity in Brazil BNDES (Brazilian Development Bank) to obtain a loan.

BNDES requires to finance any project: “Item b -The expected cash flows of the project should be sufficient to pay off loans”<sup>7</sup>

**Outcome of Step 2a:** the identified barrier (investment barrier) as described above may prevent one of the alternatives to occur.

<sup>7</sup>[http://www.bnDES.gov.br/SiteBNDES/bnDES\\_pt/Institucional/Apoio\\_Financeiro/Produtos/Project\\_Finance/index.html](http://www.bnDES.gov.br/SiteBNDES/bnDES_pt/Institucional/Apoio_Financeiro/Produtos/Project_Finance/index.html)



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

As the investment in Scenario 2 does not generate any revenues for the PP and there is not a mandatory requirement legislation and/or regulations to collection and destruction of LFG in enclosed flare (active system), this scenario is not plausible.

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

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

**Step 3: Investment analysis**

For the purpose of assessing the financial/economic attractiveness, the indicator used was the Net Present Value (NPV).

The discount rate used for this analysis was the value pointed out in Appendix A (Group 1 - Brazil) of the “Guidelines on the assessment of investment analysis” - version 05. The value was 11.75%.

The following assumptions were taken for the purpose of the calculation of the financial indicator in all alternatives:

**Table 3 - Financial parameters of the cash flow**

Parameter	Value	Unit	Reference
Discount rate	11.75%	%	Guidelines on the assessment of investment analysis - version 05, Group 1 (Brazil).
Asset's Life time	25	Years	The option c of the "Tool to determine the remaining lifetime of equipment" - version 1 (Electric Generators, air cooled) and; International Energy Agency (IEA) World energy model – Methodology and assumptions, page 13.
Installed capacity for each engine	1.50	MW	Based on the manufacturer proposal
Number of generators groups	7	unit	Based on the feasibility study
Total installed capacity	10.5	MW	Based on the feasibility study
Price per MW installed	2,391,687.73	R\$/MWe	Based on the manufacturer proposal dated
Investment in biogas plant	4,673.62	kRS	Calculated in cash flow
Investment in power electricity plant	27,612.72	kRS	Calculated in cash flow
Total investment in the CDM project	32,286.34	kRS	Calculated in cash flow
Load factor	94.00%	%	Based on information from the manufacturer specification
O&M costs	33.29	R\$/MWh	Calculated as the average from the whole period.
Electricity price	102.18	R\$/MWh	The highest value from the last auctions held in Brazil 3 years prior to the starting date of the project activity. (Source: Electric Power Commercialization Chamber - CCEE)
Tax - IRPJ (income tax)	25%	%	Income tax ( <a href="http://www.receita.fazenda.gov.br/legislacao/ins/Art2001/Art1997/1995/insr05195.htm">http://www.receita.fazenda.gov.br/legislacao/ins/Art2001/Art1997/1995/insr05195.htm</a> ), accessed on 25/06/2012
Tax - CSLL (social contribution)	9%	%	Social contribution ( <a href="http://www.planalto.gov.br/civil/03/LEIS/L7689.htm">http://www.planalto.gov.br/civil/03/LEIS/L7689.htm</a> ), accessed on 25/06/2012
Tax (PIS)	1.65%	%	Contribution to the Social Integration Program and Civil Service Asset Formation Program – PIS/PASEP ( <a href="http://www.receita.fazenda.gov.br/principal/Ingles/SistemaTributarioBR/Taxes.htm">http://www.receita.fazenda.gov.br/principal/Ingles/SistemaTributarioBR/Taxes.htm</a> ), accessed on 25/06/2012.
Tax (Cofins)	7.60%	%	COFINS - Contribution to Social Security Financing ( <a href="http://www.receita.fazenda.gov.br/principal/Ingles/SistemaTributarioBR/Taxes.htm">http://www.receita.fazenda.gov.br/principal/Ingles/SistemaTributarioBR/Taxes.htm</a> ), accessed on 25/06/2012.
Depreciation	5	years	Secretary of the Federal Revenue of Brazil. Available on <a href="http://www.receita.fazenda.gov.br/legislacao/ins/ant2001/1998/in16298ane1.htm">http://www.receita.fazenda.gov.br/legislacao/ins/ant2001/1998/in16298ane1.htm</a> , accessed on 02/03/2012, item: R\$01. As the group generators will work in 3 shift of operation, a coefficient of 2 was considered for accelerated depreciation, according to Federal Revenue of Brazil (RIR/99, art. 313). Available on <a href="http://www.receita.fazenda.gov.br/pessoajuridica/dpj/2002/ptgresp2002/pr371a375.htm">http://www.receita.fazenda.gov.br/pessoajuridica/dpj/2002/ptgresp2002/pr371a375.htm</a> , accessed on 25/06/2012.
Commercial Lending rate	10.97%	%	Available on <a href="http://www.bnDES.gov.br/SiteBNDES/bnDES_pt/Institucional/Apoio_Financeiro/Produtos/FINEM/energias_alternativas.html">http://www.bnDES.gov.br/SiteBNDES/bnDES_pt/Institucional/Apoio_Financeiro/Produtos/FINEM/energias_alternativas.html</a> , accessed on 25/06/2012.
Debt term	16	years	Available on <a href="http://www.bnDES.gov.br/SiteBNDES/bnDES_pt/Institucional/Apoio_Financeiro/Produtos/FINEM/energias_alternativas.html">http://www.bnDES.gov.br/SiteBNDES/bnDES_pt/Institucional/Apoio_Financeiro/Produtos/FINEM/energias_alternativas.html</a> , accessed on 25/06/2012.
Salvage value	0	RS	Cash flow spreadsheet



### Scenario 1 (LFG1 + E1)

The scenario 1 is the project activity (capture and flare of LFG and power generation) undertaken without being registered as a CDM project activity, the estimated project cash flow has been made available to DOE in the validation visit.

**Table 4 - Scenario 1**

Year											
	0	1	2	3	4	5	6	7	8	9	10
<b>Biogas flaring and Electricity generation</b>											
2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	
<b>INCOME x COSTS ANALYSIS</b>											
Dispatched electricity (MWh/year)	-609	24,703	32,938	32,938	41,172	41,172	41,172	49,406	49,406	49,406	
Electricity Price (R\$/MWh)	102	102	102	102	102	102	102	102	102	102	
Electricity revenues (kRS)	-63	2,524	3,366	3,366	4,207	4,207	4,207	5,048	5,048	5,048	
Gross Revenue (kRS)	-62	2,524	3,366	3,366	4,207	4,207	4,207	5,048	5,048	5,048	
Tax (PIS/Cofins)	9,25%	0	-233	-311	-311	-389	-389	-389	-467	-467	
Net revenues	-62	2,291	3,054	3,054	3,818	3,818	3,818	4,581	4,581	4,581	
Op&M Total Costs	-657	-2,612	-2,780	-2,780	-2,948	-1,497	-1,497	-2,028	-2,028	-2,028	
Operational Results - EBITDA	-719	-321	275	275	870	2,321	2,321	2,554	2,554	2,554	
Depreciation	-4,305	-4,305	-4,305	-4,305	0	0	-718	-718	-718	-718	
EBIT	-5,024	-4,626	-4,030	-4,030	-4,030	870	2,321	1,603	1,836	1,836	
Interest	-1,181	-1,107	-1,033	-959	-885	-812	-738	-664	-590	-517	-443
EBT	-6,205	-5,732	-5,063	-4,989	-4,916	59	1,583	939	1,246	1,320	1,393
IRPJ/CSL taxes (Real Profit Regime)	34%	0	0	0	0	-20	-58	-319	-424	-449	-474
Depreciation	4,305	4,305	4,305	4,305	4,305	0	0	718	718	718	718
Net operational profit	-1,900	-1,428	-758	-685	-611	39	1,045	1,337	1,540	1,588	1,637
<b>CapEx</b>											
CapEx - Biogas plant	-4,674	0	0	0	0	0	0	0	0	0	
CapEx - Electricity Generation	-16,850	0	0	0	0	0	0	-3,588	0	0	0
Drawdown of debt	10,762	0	0	0	0	0	0	1,794	0	0	0
Debt Repayment	0	-673	-673	-673	-673	-673	-673	-673	-673	-673	-673
Net Cash Flow Equity	-12,662	-2,100	-1,431	-1,357	-1,283	-634	372	-1,129	867	916	965

Note: All numbers are in Brazilian Real (k BRL)

Benchmark	11.75%
NPV (25 years)	-13,701.54

11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038
49,406	57,641	57,641	57,641	57,641	65,875	65,875	74,110	74,110	74,110	57,641	41,172	32,938	24,703	
102	102	102	102	102	102	102	102	102	102	102	102	102	102	
5,048	5,890	5,890	5,890	6,731	6,731	6,731	7,573	7,573	7,573	5,890	4,207	3,366	2,524	
5,048	5,890	5,890	5,890	6,731	6,731	6,731	7,573	7,573	7,573	5,890	4,207	3,366	2,524	
-467	-545	-545	-545	-623	-623	-623	-700	-700	-700	-545	-389	-311	-233	
4,581	5,345	5,345	5,345	6,108	6,108	6,108	6,872	6,872	6,872	5,345	3,818	3,054	2,291	
-2,028	-2,558	-2,196	-2,196	-2,364	-2,001	-2,001	-2,532	-2,532	-2,532	-2,196	-1,860	-1,329	-1,161	
2,554	2,787	3,149	3,149	3,745	4,107	4,107	4,340	4,340	4,340	3,149	1,958	1,725	1,130	
-1,435	-718	-718	-718	0	0	-718	-718	-718	-718	0	0	0	0	
1,119	2,069	2,432	2,432	2,432	3,745	4,107	3,390	3,623	3,623	2,432	1,958	1,725	1,130	
-369	-295	-221	-148	-74	0	0	0	0	0	0	0	0	0	
750	1,774	2,210	2,284	2,358	3,745	4,107	3,390	3,623	3,623	2,432	1,958	1,725	1,130	
-255	-603	-752	-777	-802	-1,273	-1,397	-1,153	-1,232	-1,232	-827	-666	-587	-384	
1,435	718	718	718	0	0	718	718	718	718	0	0	0	0	
1,930	1,888	2,176	2,225	2,274	2,472	2,711	2,955	3,109	3,109	2,322	1,292	1,139	746	
0	0	0	0	0	0	0	0	0	0	0	0	0	0	
-3,588	0	0	0	0	0	-3,588	0	0	0	0	0	0	0	
0	0	0	0	0	0	0	1,794	0	0	0	0	0	0	
-673	-673	-673	-673	-673	0	0	0	0	0	0	0	0	0	
-537	1,216	1,504	1,552	1,601	1,799	2,711	1,161	3,109	3,109	2,322	1,292	1,139	746	

According to the cash flow, the NPV of scenario 1 is kRS **-13,701.54**. Consequently, this scenario is not deemed attractive by the project participants.



#### Scenario 4 (LFG2 + E3)

The scenario is the continuation of the current practice, which is in compliance with all applicable regulations and policies.

According to “Combined tool to identify the baseline scenario and demonstrate additionality”, if the alternative scenario does not involve any investment costs, operational costs or revenues for the Project Participant, the NPV will be equal to zero.

Therefore, NPV = 0.

A short list showing the alternatives of the project activity is presented below according to the NPV (financial indicator).

**Table 5 - Financial indicator comparison**

Scenarios	NPV @ 11.75% (k R\$)
Scenario 1	-13,701.54
Scenario 4	0

#### Sensitivity analysis

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

**Table 6 - Sensitivity analysis**

	Variation	NPV (k R\$)	
		Scenario 1	Scenario 4
<b>CapEx</b>	-10%	-11,431.98	0
	10%	-15,975.44	0
<b>Revenues</b>	-10%	-16,165.60	0
	10%	-11,300.47	0
<b>O&amp;M</b>	-10%	-12,118.11	0
	10%	-15,330.98	0

As presented above, the project Net Present Values are always below zero in all sensitivity analyses.

The figures below show the sensitivity analysis for scenarios 1 and 4, respectively.

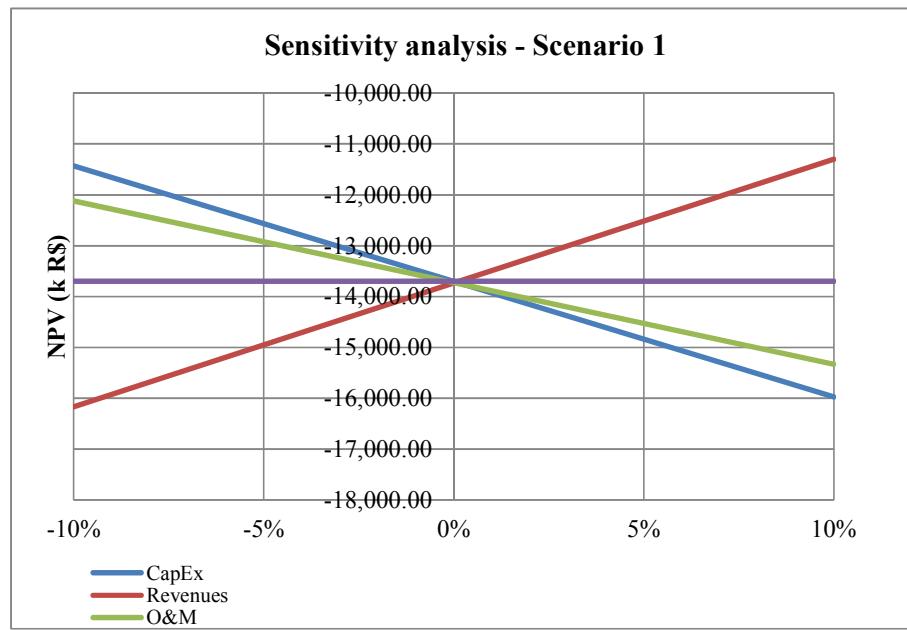


Figure 13 - Sensitivity analysis – Scenario 1 (in Brazilian Reais - k R\$)

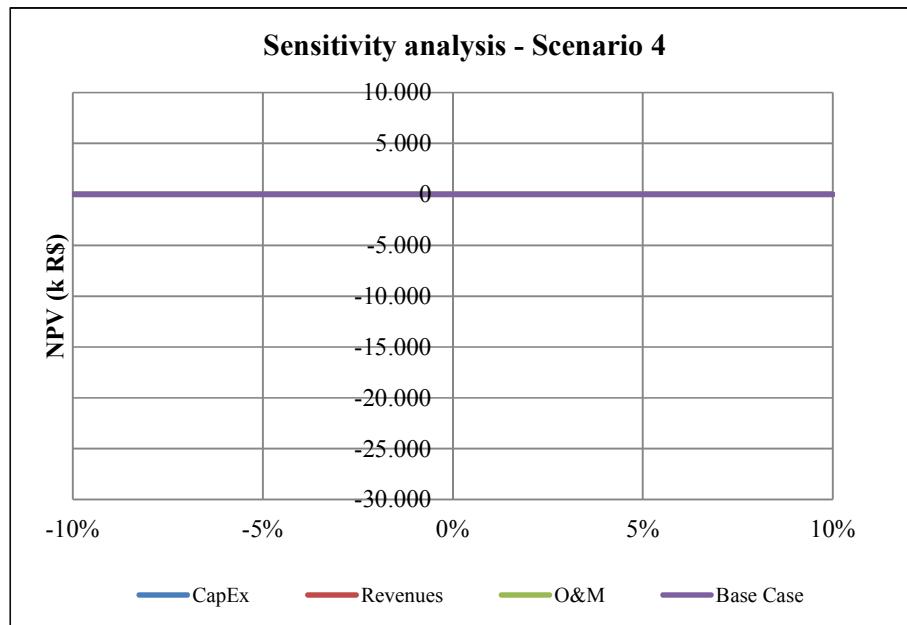


Figure 14 - Sensitivity analysis – Scenario 4 (in Brazilian Reais - k R\$)

### Break-even point

To ensure the additionality of this project activity, the project proponents varied the three identified parameters (CapEx, Revenues and O&M) until each of them reached the benchmark (i.e. NPV=0). The results are presented below for each scenario (1 and 4) and the spreadsheet will be provided to the audit team:

- Scenario 1 (LFG1 + E1)



**Capital Expenditures (CapEx)** – To reach the benchmark, the Capital Expenditures should be reduced in 60.4%. This result is extremely unlikely to happen in the future, as this reduction is too large for any kind of project which has a reliable investment estimate and as usually the CapEx increases during the project implementation.

**Revenues** – This value should be increased in 57.1% to reach the benchmark. This means that the electricity tariff should reach R\$ 160.49 or the maximum annual electricity generated reaches 103,467 MWh<sup>8</sup>, deemed unrealistic as this value is far superior to the average values from the latest electricity sale auctions in Brazil.

The table below shows the electricity price for the alternatives auctions held in Brazil 3 years prior to the starting date of the project activity. The maximum electricity price in auctions was 102.18 R\$/MWh. In addition, in Brazil the energy auctions are reverse auctions, therefore power is acquired at the lowest prices.

**Table 7 - Results of the alternatives sources auctions held in Brazil**

Date	Name of the Auction	Electricity price (R\$/MWh)
17/08/2011	12 <sup>th</sup> New Energy Auction	102.07
20/12/2011	13 <sup>th</sup> New Energy Auction	102.18 <sup>9</sup>

Source: Electric Power Commercialization Chamber – CCEE (<http://www.ccee.org.br>), accessed on 02/04/2012.

**O&M** – Also, to reach the benchmark, the O&M shall be reduced in 86.5%. This means that PPs should reduce all O&M costs, practically. Consequently, this scenario is unreal. Thus, the PPs deemed this situation to be unlikely to happen in the future.

- **Scenario 4 (LFG2 + E3)**

As in this alternative there are no revenues or expenditures, the NPV is zero. Thus, it is not possible to carry out the breakeven point.

### **Outcome of Step 3**

A short list raking the alternatives of the project activity is presented below according to the best NPV (financial indicator), taking into account the results of the sensitivity analysis.

**Table 8 – Rank of the alternatives scenarios**

Alternatives	NPV @ 11.75% (k R\$)	Rank
Scenario 1	-13,701.54	Worst scenario
Scenario 4	0	Best scenario

<sup>8</sup> Note: It is important to notice that for the revenues to increase 57.1%, the LFG production should increase 76.1%, since the collection efficiency of the biogas plant is 75%.

<sup>9</sup> This value was considered in the financial analysis for the electricity tariff.



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

Therefore, it seems reasonable to conclude that the project activity (Scenario 1) is unlikely to be the most financially attractive scenario.

#### Step 4. Common practice analysis

According to “Combined tool to identify the baseline scenario and demonstrate additionality”, the common practice analysis establishes the following items below:

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

As the project activity applies measure that are listed in the definitions section of the “Combined tool to identify the baseline scenario and demonstrate additionality”, the Step 4 a was applied.

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

The common practice analysis consists of the following steps:

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

The installed capacity of the project is 10.5 MW. Then, the output range of the project activity is from 5.25 to 15.75 MW.

**Sub-step 4a (2): In the applicable geographical area, identify all plants that deliver the same output or capacity within the applicable output range, calculated in Step 1, as the proposed project activity and have started commercial operation before the start date of the project. Note their number  $N_{all}$ . Registered CDM project activities and projects activities undergoing validation shall not be included in this step.**

It was carried out a survey through ANEEL website and the list with all plants was given to the DOE<sup>10</sup>. The total of the plants is 146. Then,  $N_{all} = 146$ .

**Sub-step 4a (3):** Within plants identified in Step 2, identify those that apply technologies different than the technology applied in the proposed project activity. Note their number  $N_{diff}$ .

The technology of the project activity is electricity generation through biogas. All projects in Brazil which generates electricity through biogas are registered CDM project activities or projects activities undergoing validation. Therefore, there is no project with the same technologies as the project activity.

Then,  $N_{diff} = 146$  or  $N_{all} = N_{diff}$ .

<sup>10</sup> The website at ANEEL was accessed on 03/04/2012

(<http://www.aneel.gov.br/aplicacoes/capacidadebrasil/capacidadebrasil.asp>) and the name of the electronic spreadsheet is “10.5 MW CTR Maceio common practice.xlsx”



**Sub-step 4a (4):** Calculate factor  $F=1 - \frac{N_{diff}}{N_{all}}$  representing the share of plants using technology similar to the technology used in the proposed project activity in all plants that deliver the same output or capacity as the proposed project activity.

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

$$F = 1 - \left( \frac{146}{146} \right)$$

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

The “Combined tool to identify the baseline scenario and demonstrate additionality” states:

*The proposed project activity is regarded as “common practice” within a sector in the applicable geographical area if both the following conditions are fulfilled:*

- (a) The factor  $F$  is greater than 0.2; and
- (b)  $N_{all} - N_{diff}$  is greater than 3.

#### **Outcome of common practice analysis.**

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

### **B.6. Emission reductions**

#### **B.6.1. Explanation of methodological choices**

>>

#### **Baseline emission calculation**

The baseline emission was calculated according to the following formulas from the methodology ACM0001:

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

Where:

$BE_y$	= Baseline emissions in year $y$ (t CO <sub>2</sub> e/yr)
$BE_{CH4,y}$	= Baseline emissions of methane from the SWDS in year $y$ (t CO <sub>2</sub> e/yr)
$BE_{EC,y}$	= Baseline emissions associated with electricity generation in year $y$ (t CO <sub>2</sub> /yr)
$BE_{HG,y}$	= Baseline emissions associated with heat generation in year $y$ (t CO <sub>2</sub> /yr)
$BE_{NG,y}$	= Baseline emissions associated with natural gas use in year $y$ (t CO <sub>2</sub> /yr)

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

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

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

The formula below was extracted from the methodology ACM0001:

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

Where:



$BE_{CH4,y}$	= Baseline emissions of LFG from the SWDS in year $y$ (t CO <sub>2</sub> e/yr)
$OX_{top\_layer}$	= Fraction of methane in the LFG that would be oxidized in the top layer of the SWDS in the baseline (dimensionless)
$F_{CH4,PJ,y}$	= Amount of methane in the LFG which is flared and/or used in the project activity in year $y$ (t CH <sub>4</sub> /yr)
$F_{CH4,BL,y}$	= Amount of methane in the LFG that would be flared in the baseline in year $y$ (t CH <sub>4</sub> /yr)
$GWP_{CH4}$	= Global warming potential of CH <sub>4</sub> (t CO <sub>2</sub> e/t CH <sub>4</sub> )

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

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

The formulas below was extracted from the methodology ACM0001:

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

Where:

$F_{CH4,PJ,y}$	= Amount of methane in the LFG which is flared and/or used in the project activity in year $y$ (tCH <sub>4</sub> /yr)
$F_{CH4,flared,y}$	= Amount of methane in the LFG which is destroyed by flaring in year $y$ (t CH <sub>4</sub> /yr)
$F_{CH4,EL,y}$	= Amount of methane in the LFG which is used for electricity generation in year $y$ (t CH <sub>4</sub> /yr)
$F_{CH4,HG,y}$	= Amount of methane in the LFG which is used for heat generation in year $y$ (t CH <sub>4</sub> /yr)
$F_{CH4,NG,y}$	= Amount of methane in the LFG which is sent to the natural gas distribution network in year $y$ (t CH <sub>4</sub> /yr)

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

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

$F_{CH4,EL,y}$  is determined using the “Tool to determine the mass flow of a greenhouse gas in a gaseous stream”. The following requirements apply:

- The gaseous stream the tool shall be applied to is the LFG delivery pipeline to each item of electricity generation.
- $F_{CH4,EL,y}$  is then calculated as the sum of mass flows to each item of electricity generation;
- C<sub>H4</sub> is the greenhouse gases for which the mass flow should be determined;
- The simplification offered for calculating the molecular mass of the gaseous stream is valid (equations 3 or 17 in the tool); and
- The mass flow should be calculated on an hourly basis for each hour  $h$  in year  $y$ ;
- The mass flow calculated for hour  $h$  is 0 if the equipment is not working in hour  $h$  ( $O_{pj,h}=\text{not working}$ ), the hourly values are then summed to a yearly unit basis.

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

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

Where:

$$F_{CH4,flared,y} = \text{Amount of methane in the LFG which is destroyed by flaring in year } y \text{ (t CH}_4\text{/yr)}$$



$F_{CH_4, sent, flare, y}$	= Amount of methane in the LFG which is sent to the flare in year y (t CH <sub>4</sub> /yr)
$PE_{flare, y}$	= Project emissions from flaring of the residual gas stream in year y (t CO <sub>2</sub> e/yr)
$GWP_{CH_4}$	= Global warming potential of CH <sub>4</sub> (t CO <sub>2</sub> e/t CH <sub>4</sub> )

$F_{CH_4, sent, flare, y}$  will be determined directly using the “Tool to determine the mass flow of a greenhouse gas in a gaseous stream”, applying the requirements described above where the gaseous stream the tool shall be applied to is the LFG delivery pipeline to the flare(s).

According to “Tool to determine the mass flow of a greenhouse gas in a gaseous stream” for the determination of the absolute humidity of the gaseous stream will be used the option 2: simplified calculation without measurement of the moisture content and the measurement option in Table 1 will be Option B (Volume flow in wet basis and volumetric fraction in dry basis) when the temperature of the gaseous stream is higher than 60°C (333.15 K) at the flow measurement point.

When the temperature of the gaseous stream is less than 60°C (333.15 K) at the flow measurement point the Option A will be considered.  $PE_{flare, y}$  shall be determined using the “Tool to determine project emissions from flaring gases containing methane”. If LFG is flared through more than one flare, then  $PE_{flare, y}$  is the sum of the emissions for each flare determined separately.

Enclosed flare(s) will be installed in the project activity to increase the destruction efficiency. Those flares reach 99% (minimum)<sup>11</sup> of methane destruction efficiency.

To determine the project emissions from flaring gases was used the “Tool to determine project emissions from flaring gases containing methane”. According to this tool, the project emissions should be calculated in 7 steps.

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

The density of the residual gas is determined based on the volumetric fraction of all components in the gas.

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

$FM_{RG,h}$	= Mass flow rate of the residual gas in hour h (kg/h);
$\rho_{RG,n,h}$	= Density of the residual gas at normal conditions in hour h (kg/m <sup>3</sup> );
$FV_{RG,h}$	= Volumetric flow rate of the residual gas in dry basis at normal conditions in the hour h;

And

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

$P_n$	= Atmospheric pressure at normal conditions (101,325Pa);
$R_u$	= Universal ideal gas constant (8.314 Pa.m <sup>3</sup> /kmol.K);
$MM_{RG,h}$	= Molecular mass of the residual gas in hour h (kg/kmol);
$T_n$	= Temperature at normal conditions (273.15K);

And,

<sup>11</sup> The document about the specification of the flare efficiencies will provide to DOE (*flare efficiency.pdf*).



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

$fv_{i,h}$  = Volumetric fraction of component  $i$  in the residual gas in the hour  $h$ ;

$MM_i$  = Molecular mass of residual gas component  $i$  (kg/kmol);

$i$  = Gas components;

As permitted by the tool, the project participants will only measure the volumetric fraction of methane and consider the difference to 100% as being nitrogen ( $N_2$ ).

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

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

$fm_{j,h}$  = Mass fraction of element  $j$  in the residual gas in hour  $h$ ;

$AM_j$  = Atomic mass of element  $j$  (kg/kmol);

$NA_{j,i}$  = Number of atoms of element  $j$  in component  $i$ ;

$MM_{RG,h}$  = Molecular mass of the residual gas in hour  $h$  (kg/kmol);

$j$  = The elements carbon, hydrogen, oxygen and nitrogen;

$i$  = The components  $CH_4$  and  $N_2$  (according to the simplification used);

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

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

Where:

$TV_{n,FG,h}$  = Volumetric flow rate of the exhaust gas in dry basis at normal conditions in hour  $h$  ( $m^3/h$ );

$V_{n,FG,h}$  = Volume of the exhaust gas of the flare in dry basis at normal conditions per kg of residual gas in hour  $h$  ( $m^3/kg$  residual gas);

$FM_{RG,h}$  = Mass flow rate of the residual gas in the hour  $h$  (kg residual gas/h);

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

Where:

$V_{n,N_2,h}$  = Quantity of  $N_2$  volume free in the exhaust gas of the flare at normal conditions per kg of residual gas in the hour  $h$  ( $m^3/kg$  residual gas);

$V_{n,O_2,h}$  = Quantity of  $O_2$  volume free in the exhaust gas of the flare at normal conditions per kg of residual gas in the hour  $h$  ( $m^3/kg$  residual gas);

$V_{n,CO_2,h}$  = Quantity of  $CO_2$  volume free in the exhaust gas of the flare at normal conditions per kg of residual gas in the hour  $h$  ( $m^3/kg$  residual gas);

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

$n_{O_2,h}$  = Quantity of moles  $O_2$  in the exhaust gas of the flare per kg residual gas flared in hour  $h$  (kmol/kg<sub>residual\_gas</sub>);

$MV_n$  = Volume of one mole of any ideal gas at normal temperature and pressure (22.4 L/mol) (in  $m^3/kmol$ );



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

$fm_{C,h}$  = Mass fraction of carbon in the residual gas in the hour h;

$AM_C$  = Atomic mass of carbon (kg/kmol);

$MV_n$  = Volume of one mole of any ideal gas at normal temperature and pressure (22.4 L/mol) (in  $m^3/kmol$ );

And

$$V_{n,N2,h} = MV_n \cdot \left\{ \frac{fm_{N,h}}{200.4M_n} + \left( \frac{1 - MF_{O_2}}{MF_{O_2}} \right) \cdot (F_h + n_{O_2,h}) \right\}$$

Where:

$fm_{N,h}$  = Mass fraction of nitrogen in the residual gas in the hour h

$AM_n$  = Atomic mass of nitrogen (kg/kmol);

$MF_{O_2}$  =  $O_2$  volumetric fraction of air (0.21);

$F_h$  = Stoichiometric quantity of moles of  $O_2$  required for a complete oxidation of one kg residual gas flared in hour h (kmol/kg residual gas);

$n_{O_2,h}$  = Quantity of moles  $O_2$  in the exhaust gas of the flare per kg residual gas flared in hour h (kmol/kg residual gas);

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

$t_{O_2,h}$  = Volumetric fraction of  $O_2$  in the exhaust gas in the hour h;

$MF_{O_2}$  =  $O_2$  volumetric fraction of air (0.21);

$F_h$  = Stoichiometric quantity of moles of  $O_2$  required for a complete oxidation of one kg residual gas in hour h (kmol/kg residual gas);

$AM_j$  = Atomic mass of element  $j$  (kg/kmol);

$j$  = The elements carbon, hydrogen, oxygen and nitrogen;

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

Where:

$fm_{j,h}$  = Mass fraction of element  $j$  in the residual gas in hour h;

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

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:

$$TM_{FG,h} = \frac{TV_{n,FG,h} \cdot fV_{CH4,FG,h}}{1000000}$$

Where:



- $TV_{n,FG,h}$  = Volumetric flow rate of the exhaust gas in dry basis at normal conditions in hour  $h$  ( $m^3/h$  exhaust gas);  
 $f_{vCH_4,FG,h}$  = Concentration of methane in the exhaust gas of the flare in dry basis at normal conditions in hour  $h$  ( $mg/m^3$ ).

#### 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 ( $f_{vCH_4,RG,h}$ ) and the density of methane ( $\rho_{CH_4,n,h}$ ) in the same reference conditions (normal conditions and dry or wet basis).

$$TM_{RG,h} = FV_{RG,h} \times f_{vCH_4,RG,h} \times \rho_{CH_4,n,h}$$

- $FV_{RG,h}$  = Volume flow rate of the residual gas in dry basis at normal conditions in hour  $h$  ( $m^3/h$ );  
 $f_{vCH_4,RG,h}$  = Volumetric fraction of methane in the residual gas on dry basis in hour  $h$  (NB: this corresponds to  $f_{v,i,RG,h}$  where  $i$  refers to methane).  
 $\rho_{CH_4,n}$  = Density of methane at normal conditions ( $0.716 \text{ kg/m}^3$ );

#### STEP 6. Determination of the hourly flare efficiency

The determination of the hourly flare efficiency depends on the operation of flare (through temperature), the type of flare used (enclosed) and the approach selected (continuous).

For the project activity, the case of enclosed flares and continuous monitoring of the flare efficiency, the flare efficiency in the hour  $h$  is:

- 0% if the temperature of the exhaust gas of the flare ( $T_{flare}$ ) is below  $500^\circ\text{C}$  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  $500^\circ\text{C}$  for more than 40 minutes during the hour  $h$ ;

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

Where:

$TM_{FG,h}$  = Methane mass flow rate in exhaust gas averaged in a period of time  $t$  ( $kg/h$ );  
 $TM_{RG,h}$  = Mass flow rate of methane in the residual gas in the hour  $h$  ( $kg/h$ );

#### STEP 7. Calculation of annual project emissions from flaring

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

$$PE_{flare,y} = \sum_{h=1}^{8760} TM_{RG,h} \times (1 - \eta_{flare,h}) \times \frac{GWP_{CH_4}}{1000}$$

$TM_{RG,h}$  = Mass flow rate of methane in the residual gas in the hour  $h$  ( $kg/h$ );  
 $\eta_{flare,h}$  = Flare efficiency in hour  $h$ ;



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

An *ex ante* estimate of  $F_{CH4,PJ,y}$  is required to estimate baseline emission of methane from the SWDS in order to estimate the emission reductions of the proposed project activity in the CDM-PDD. The formula below was extracted from the methodology ACM0001:

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

Where:

$F_{CH4,PJ,y}$	= Amount of methane in the LFG which is flared and/or used in the project activity in year $y$ (tCH <sub>4</sub> /yr)
$BE_{CH4,SWDS,y}$	= Amount of methane in the LFG that is generated from the SWDS in the baseline scenario in year $y$ (tCO <sub>2</sub> e/yr)
$\eta_{PJ}$	= Efficiency of the LFG capture system that will be installed in the project activity
$GWP_{CH4}$	= Global warming potential of CH <sub>4</sub> (tCO <sub>2</sub> e/tCH <sub>4</sub> )

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

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

Where:

$BE_{CH4,SWDS,y}$	= Baseline, project or leakage methane emissions occurring in year $y$ generated from waste disposal at a SWDS during a time period ending in year $y$ (t CO <sub>2</sub> e / yr)
$X$	= Years in the time period in which waste is disposed at the SWDS, extending from the first year in the time period ( $x = 1$ ) to year $y$ ( $x = y$ ).
$Y$	= Year of the crediting period for which methane emissions are calculated ( $y$ is a consecutive period of 12 months)
$DOC_{f,y}$	= Fraction of degradable organic carbon (DOC) that decomposes under the specific conditions occurring in the SWDS for year $y$ (weight fraction)
$W_{j,x}$	= Amount of solid waste type $j$ disposed or prevented from disposal in the SWDS in the year $x$ (t)
$\varphi_y$	= Model correction factor to account for model uncertainties for year $y$
$f_y$	= Fraction of methane captured at the SWDS and flared, combusted or used in another manner that prevents the emissions of methane to the atmosphere in year $y$
$GWP_{CH4}$	= Global Warming Potential of methane
$OX$	= Oxidation factor (reflecting the amount of methane from SWDS that is oxidised in the soil or other material covering the waste)
$F$	= Fraction of methane in the SWDS gas (volume fraction)
$MCF_y$	= Methane correction factor for year $y$
$DOC_j$	= Fraction of degradable organic carbon in the waste type $j$ (weight fraction)
$k_j$	= Decay rate for the waste type $j$ (1 / yr)
$J$	= Type of residual waste or types of waste in the MSW

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

In the baseline there are no regulatory or contractual requirements, or to address safety and odour concerns to capture and destroy LFG. Thus, the case of the project activity for determining methane



captured and destroyed in the baseline is ***Case 3: No requirement to destroy methane exists and LFG capture system exists*** according to methodology ACM0001, because there is existing LFG capture system (passive system), however there is no requirement to destroy methane. In this case:

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

Where:

$F_{CH4,BL,sys,y}$  = Amount of methane in the LFG that would be flared in the baseline in year y for the case of an existing LFG capture system (t CH<sub>4</sub>/yr)

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

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

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

The 20% is a default factor according to methodology ACM0001<sup>12</sup>.

#### Step (B): Baseline emissions associated with electricity generation (BE<sub>EC,y</sub>)

It was used the “Tool to calculate baseline, project and/or leakage emissions from electricity consumption”, Scenario A, Option A.1 to calculate the baseline emissions associated with electricity generation.

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

Where:

$BE_{EC,y}$   
 $EC_{BL,k,y} = EG_{PJ,y}$  Baseline emissions associated with electricity generation in year y (tCO<sub>2</sub>/yr)  
Amount of electricity generated using LFG by the project activity in year (MWh)

$EF_{EL,k,y} = EF_{grid,CM,y}$  Emission factor for electricity generation for source k in year y (tCO<sub>2</sub>/MWh)  
 $TDL_y$  Average technical transmission and distribution losses in the grid in year y for the voltage level at which electricity is obtained from the grid at the project site (dimensionless).

To ex-ante calculations the parameter TDL<sub>y</sub> is not being considered because is not applicable to baseline emissions calculations.

#### Project emissions

The formula below was extracted from the methodology ACM0001:

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

---

<sup>12</sup> This default value of 20% is based on assuming a situation in which: the efficiency of the LFG capture system in the project is 50%; the efficiency of the LFG capture system in the baseline is 20%; and, the amount captured in the baseline is flared using an open flare with a destruction efficiency of 50% (consistent with the default value provided in the “Tool to determine project emissions from flaring gases containing methane”). Project participants may propose and justify an alternative default value as a request for revision to this methodology



Where:

- |             |   |
|-------------|---|
| $PE_y$      | = Project emissions in year $y$ (tCO <sub>2</sub> /yr)  |
| $PE_{EC,y}$ | = Emissions from consumption of electricity due to the project activity in year $y$ (tCO <sub>2</sub> /yr)  |
| $PE_{FC,y}$ | = Emissions from consumption of fossil fuels due to the project activity, for purpose other than electricity generation, in year $y$ (tCO <sub>2</sub> /yr) |

There is no consumption of fossil fuels due to the project activity for purpose other than electricity generation, in year  $y$  (tCO<sub>2</sub>/yr), therefore  $PE_{FC,y} = 0$

Thus,

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

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

According to “*Tool to calculate baseline, project and/or leakage emissions from electricity consumption*”, the project emission from consumption of electricity will be from two sources:

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

Thus,

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

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

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

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

Thus, the project emission is calculated as following:

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

Where:

- |                           |  |
|---------------------------|--|
| $EC_{PJ1,y} = EG_{EC1,y}$ | Quantity of electricity consumed from the grid by the project activity during the year $y$ (MWh);  |
| $EF_{grid,CM,y}$          | The emission factor for the grid in year $y$ (tCO <sub>2</sub> /MWh);  |
| $TDL_y$                   | Average technical transmission and distribution losses in the grid in year $y$ for the voltage level at which electricity is obtained from the grid at the project site. |

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

As electricity will be consumed from diesel generators (off-grid captive power plant), a conservative approach was adopted and the option B2 of the scenario B was chosen because: “The electricity consumption source is a project or leakage electricity consumption source”. Therefore, the value used will be 1.3 tCO<sub>2</sub>/MWh for project emission from diesel generator(s).



$$PE_{EC\ 2,y} = EC_{PJ\ 2,y} \times EF_{diesel\_generator,\ y}$$

Where:

- $EC_{PJ\ 2,y} = EG_{EC\ 2,y}$       Quantity of electricity consumed from diesel generator by the project activity during the year  $y$  (MWh);  
 $EF_{diesel\_generator,y}$       The emission factor for the diesel generator in year  $y$  (tCO<sub>2</sub>/MWh);

#### **Calculation of PE<sub>FC,y</sub> – project emission from consumption of heat**

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

#### **Leakage:**

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

#### **Emission Reduction**

Emission reductions are calculated according the formula below extracted from methodology ACM0001 as follows:

$$ER_y = BE_y - PE_y,$$

Where:

- $ER_y$       = Emission reductions in year  $y$  (tCO<sub>2</sub>e/yr);  
 $BE_y$       = Baseline emissions in year  $y$  (tCO<sub>2</sub>e/yr);  
 $PE_y$       = Project emissions in year  $y$  (tCO<sub>2</sub>e/yr);

#### **B.6.2. Data and parameters fixed ex ante**

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



<b>Data / Parameter</b>	GWP <sub>CH4</sub>
<b>Unit</b>	t CO <sub>2</sub> e/t CH <sub>4</sub>
<b>Description</b>	Global warming potential of CH <sub>4</sub>
<b>Source of data</b>	IPCC
<b>Value(s) applied</b>	21 for the first commitment period. Shall be updated according to any future COP/MOP decisions
<b>Choice of data or Measurement methods and procedures</b>	Default value used, according to ACM0001
<b>Purpose of data</b>	Calculation of baseline emission
<b>Additional comment</b>	-

<b>Data / Parameter</b>	NCV <sub>CH4</sub>
<b>Unit</b>	TJ/t CH4
<b>Description</b>	Net calorific value of methane at reference conditions
<b>Source of data</b>	Technical literature
<b>Value(s) applied</b>	0.0504
<b>Choice of data or Measurement methods and procedures</b>	Default value used, according to ACM0001
<b>Purpose of data</b>	Calculation of baseline emission
<b>Additional comment</b>	-

<b>Data / Parameter</b>	$\eta_{PJ}$
<b>Unit</b>	Dimensionless
<b>Description</b>	Efficiency of the LFG capture system that will be installed in the project activity
<b>Source of data</b>	Feasibility study
<b>Value(s) applied</b>	75%
<b>Choice of data or Measurement methods and procedures</b>	Based on the active LFG capture system to be installed, according to technical specifications from the equipments provider.
<b>Purpose of data</b>	Calculation of baseline emission
<b>Additional comment</b>	-



<b>Data / Parameter</b>	$\phi_{\text{default}}$
<b>Unit</b>	-
<b>Description</b>	Default value for the model correction factor to account for model uncertainties
<b>Source of data</b>	Tool “Emissions from solid waste disposal sites”
<b>Value(s) applied</b>	0.75
<b>Choice of data or Measurement methods and procedures</b>	According to “Emissions from solid waste disposal sites”, the <i>Application A</i> was used because the project activity mitigates methane emissions from the landfill and the default value was applied for the wet climatic condition.
<b>Purpose of data</b>	Calculation of baseline emission
<b>Additional comment</b>	The mean annual precipitation (MAP) is higher than 2,223 mm (wet climatic condition).

<b>Data / Parameter</b>	OX
<b>Unit</b>	-
<b>Description</b>	Oxidation factor (reflecting the amount of methane from SWDS that is oxidized in the soil or other material covering the waste)
<b>Source of data</b>	Based on an extensive review of published literature on this subject, including the IPCC 2006 Guidelines for National Greenhouse Gas Inventories
<b>Value(s) applied</b>	0.1
<b>Choice of data or Measurement methods and procedures</b>	Default value used according to “Emissions from solid waste disposal sites”
<b>Purpose of data</b>	Calculation of baseline emission
<b>Additional comment</b>	When methane passes through the top-layer, part of it is oxidized by methanotrophic bacteria to produce CO <sub>2</sub> . The oxidation factor represents the proportion of methane that is oxidized to CO <sub>2</sub> . This should be distinguished from the methane correction factor (MCF) which is to account for the situation that ambient air might intrude into the SWDS and prevent methane from being formed in the upper layer of SWDS.



<b>Data / Parameter</b>	F
<b>Unit</b>	-
<b>Description</b>	Fraction of methane in the SWDS gas (volume fraction)
<b>Source of data</b>	IPCC 2006 Guidelines for National Greenhouse Gas Inventories
<b>Value(s) applied</b>	0.5
<b>Choice of data or Measurement methods and procedures</b>	Default value used according to "Emissions from solid waste disposal sites"
<b>Purpose of data</b>	Calculation of baseline emission
<b>Additional comment</b>	Upon biodegradation, organic material is converted to a mixture of methane and carbon dioxide

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

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



<b>Data / Parameter</b>	DOC <sub>j</sub>														
<b>Unit</b>	-														
<b>Description</b>	Fraction of degradable organic carbon in the waste type j (weight fraction)														
<b>Source of data</b>	IPCC 2006 Guidelines for National Greenhouse Gas Inventories (adapted from Volume 5, Tables 2.4 and 2.5)														
<b>Value(s) applied</b>	<table border="1"><thead><tr><th>Waste type j</th><th>DOCj (% wet waste)</th></tr></thead><tbody><tr><td>Wood and wood products</td><td>43</td></tr><tr><td>Pulp, paper and cardboard (other than sludge)</td><td>40</td></tr><tr><td>Food, food waste, beverages and tobacco (other than sludge)</td><td>15</td></tr><tr><td>Textiles</td><td>24</td></tr><tr><td>Garden, yard and park waste</td><td>20</td></tr><tr><td>Glass, plastic, metal, other inert waste</td><td>0%</td></tr></tbody></table>	Waste type j	DOCj (% wet waste)	Wood and wood products	43	Pulp, paper and cardboard (other than sludge)	40	Food, food waste, beverages and tobacco (other than sludge)	15	Textiles	24	Garden, yard and park waste	20	Glass, plastic, metal, other inert waste	0%
Waste type j	DOCj (% wet waste)														
Wood and wood products	43														
Pulp, paper and cardboard (other than sludge)	40														
Food, food waste, beverages and tobacco (other than sludge)	15														
Textiles	24														
Garden, yard and park waste	20														
Glass, plastic, metal, other inert waste	0%														
<b>Choice of data or Measurement methods and procedures</b>	IPCC default value for anaerobic managed solid waste disposal site is applied.														
<b>Purpose of data</b>	Calculation of baseline emission														
<b>Additional comment</b>	-														



<b>Data / Parameter</b>	k		
<b>Unit</b>	1/yr		
<b>Description</b>	Decay rate for the waste type j		
<b>Source of data</b>	IPCC 2006 Guidelines for National Greenhouse Gas Inventories (adapted from Volume 5, Table 3.3)		
<b>Value(s) applied</b>	<b>Waste type j</b>		<b>Tropical (MAT &gt; 20 °C)</b>
	<b>Slowly degrading</b>		<b>Wet (MAP &gt; 1,000 mm)</b>
	Slowly degrading	Pulp, paper, cardboard (other than sludge), textiles	0.07
		Wood, wood products and straw	0.035
	Moderately degrading	Other (non-food) organic putrescible garden and park waste	0.17
		Food, food waste, sewage sludge, beverages and tobacco	0.40
<b>Choice of data or Measurement methods and procedures</b>	IPCC default value for anaerobic managed solid waste disposal site is applied.		
<b>Purpose of data</b>	Calculation of baseline emission		
<b>Additional comment</b>	The mean annual temperature (MAT) is 25.7°C and the mean annual precipitation (MAP) 2,223 mm. Source: Agritempo – Sistema de Monitoramento Agrometeorológico. ( <a href="http://www.agritempo.gov.br/agroclima/sumario?uf=AL">http://www.agritempo.gov.br/agroclima/sumario?uf=AL</a> )		

<b>Data / Parameter</b>	EF <sub>diesel_generator</sub>
<b>Unit</b>	tCO <sub>2</sub> /MWh
<b>Description</b>	Emission factor for the diesel generator
<b>Source of data</b>	Tool to calculate baseline, project and/or leakage emissions from electricity consumption
<b>Value(s) applied</b>	1.3
<b>Choice of data or Measurement methods and procedures</b>	The diesel generator is an off-grid fossil fuel fired captive power plant. Thus, the default value of the Scenario B2 was applied.
<b>Purpose of data</b>	Calculation of project emission
<b>Additional comment</b>	-



<b>Data / Parameter</b>	MM <sub>i</sub>		
<b>Unit</b>	kg/kmol		
<b>Description</b>	Molecular mass of greenhouse gas i		
<b>Source of data</b>	Tool to determine the mass flow of a greenhouse gas in a gaseous stream		
<b>Value(s) applied</b>	Compound	Structure	Molecular mass (kg/kmol)
	Carbon dioxide	CO <sub>2</sub>	44.01
	Methane	CH <sub>4</sub>	16.04
	Nitrous oxide	N <sub>2</sub> O	44.02
	Sulfur hexafluoride	SF <sub>6</sub>	146.06
	Perfluoromethane	CF <sub>4</sub>	88.00
	Perfluoroethane	C <sub>2</sub> F <sub>6</sub>	138.01
	Perfluoropropane	C <sub>3</sub> F <sub>8</sub>	188.02
	Perfluorobutane	C <sub>4</sub> F <sub>10</sub>	238.03
	Perfluorocyclobutane	c-C <sub>4</sub> F <sub>8</sub>	200.03
<b>Choice of data or Measurement methods and procedures</b>	According to "Tool to determine the mass flow of a greenhouse gas in a gaseous stream"		
<b>Purpose of data</b>	Calculation of baseline emissions		
<b>Additional comment</b>	-		



<b>Data / Parameter</b>	MM <sub>k</sub>		
<b>Unit</b>	kg/kmol		
<b>Description</b>	Molecular mass of gas <i>k</i>		
<b>Source of data</b>	Tool to determine the mass flow of a greenhouse gas in a gaseous stream		
<b>Value(s) applied</b>	Compound	Structure	Molecular mass (kg/kmol)
	Nitrogen	N <sub>2</sub>	28.01
	Oxygen	O <sub>2</sub>	32.00
	Carbon monoxide	CO	28.01
	Hydrogen	H <sub>2</sub>	2.02
	Nitric oxide	NO	30.01
	Nitrogen dioxide	NO <sub>2</sub>	46.01
	Sulfur dioxide	SO <sub>2</sub>	64.06
<b>Choice of data or Measurement methods and procedures</b>	According to "Tool to determine the mass flow of a greenhouse gas in a gaseous stream"		
<b>Purpose of data</b>	Calculation of baseline emissions		
<b>Additional comment</b>	-		

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



<b>Data / Parameter</b>	Constants used in equations of tool to determine project emissions from flaring gases containing methane		
<b>Unit</b>	-		
<b>Description</b>	Constants used in equations of Tool to determine project emissions from flaring gases containing methane		
<b>Source of data</b>	Tool to determine project emissions from flaring gases containing methane		
<b>Value(s) applied</b>	<b>Parameter</b>	<b>SI Unit</b>	<b>Description</b>
	MM <sub>CH4</sub>	kg/kmol	Molecular mass of methane
	MM <sub>CO</sub>	kg/kmol	Molecular mass of carbon monoxide
	MM <sub>CO2</sub>	kg/kmol	Molecular mass of carbon dioxide
	MM <sub>O2</sub>	kg/kmol	Molecular mass of oxygen
	MM <sub>H2</sub>	kg/kmol	Molecular mass of hydrogen
	MM <sub>N2</sub>	kg/kmol	Molecular mass of nitrogen
	AM <sub>c</sub>	kg/kmol (g/mol)	Atomic mass of carbon
	AM <sub>h</sub>	kg/kmol (g/mol)	Atomic mass of hydrogen
	AM <sub>o</sub>	kg/kmol (g/mol)	Atomic mass of oxygen
	AM <sub>n</sub>	kg/kmol (g/mol)	Atomic mass of nitrogen
	P <sub>n</sub>	Pa	Atmospheric pressure at normal conditions
	R <sub>u</sub>	Pa.m <sup>3</sup> /kmol.K	Universal ideal gas constant
	T <sub>n</sub>	K	Temperature at normal conditions
	MF <sub>O2</sub>	Dimensionless	O <sub>2</sub> volumetric fraction of air
<b>Choice of data or Measurement methods and procedures</b>	GW <sub>P</sub> <sub>CH4</sub>	tCO <sub>2</sub> /tCH <sub>4</sub>	Global warming potential of methane
	MV <sub>n</sub>	m <sup>3</sup> /Kmol	Volume of one mole of any ideal gas at normal temperature and pressure
	ρ <sub>CH4, n</sub>	kg/m <sup>3</sup>	Density of methane gas at normal conditions
	NA <sub>i,j</sub>	Dimensionless	Number of atoms of element j in component i, depending on molecular structure
	According to “Tool to determine project emissions from flaring gases containing methane”		



Purpose of data	Calculation of baseline emissions
Additional comment	-

### B.6.3. Ex ante calculation of emission reductions

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The emission reductions derived from the displacement of fossil fuels used for electricity generation from other sources are estimated for the Brazilian Interconnected System and guided by “Tool to calculate baseline, project and/or leakage emissions from electricity consumption. The combined margin emission factor” was calculated by the “Tool to calculate the emission factor for an electricity system” – version 02.2.1, as follows:

#### ***Step 1. Identify the relevant electric power system***

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

The Brazilian DNA published an official delineation of the project electricity system in Brazil, considering a national interconnected system.<sup>13</sup>

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

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

#### ***Step 3. Select a method to determine the operating margin (OM)***

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

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

The Brazilian DNA is responsible for calculating the OM emission factor in Brazil. It uses the method c) Dispatch data analysis OM.

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

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

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

The emission factor is calculated as follows:

<sup>13</sup> DNA Resolution n.8 was published on 26/05/2008 on <http://www.mct.gov.br/index.php/content/view/14797.html>, accessed on 04/04/2012.



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

Where:

- $EF_{grid,OM-DD,y}$  = Dispatch data analysis operating margin CO<sub>2</sub> emission factor in year y (tCO<sub>2</sub>/MWh)
- $EG_{PJ,h}$  = Electricity displaced by the project activity in hour h m of year y (MWh)
- $EF_{EL,DD,h}$  = CO<sub>2</sub> emission factor for power units in the top of the dispatch order in hour h in year y (tCO<sub>2</sub>/MWh)
- $EG_{PJ,y}$  = Total electricity displaced by the project activity in year y (MWh)
- h = hours in year y in which the project activity is displacing grid electricity
- y = Year in which the project activity is displacing grid electricity

The  $EF_{EL,DD,h}$ ,  $EF_{EL,DD,d}$  and  $EF_{EL,DD,m}$  are displayed on the Brazilian DNA website<sup>14</sup>, for the year 2011. However only the  $EF_{EL,DD,m}$  will be used in order to calculate the emission reductions.

In order to estimate the emission reductions for the first crediting period the  $EF_{EL,DD,2011}$  was calculated as a mean average of the  $EF_{EL,DD,m}$ . Then,

$$EF_{grid,OM-DD,2011} = 0.2920 \text{ tCO}_2/\text{MWh}.$$

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

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

In terms of vintage of data, project participants can choose between one of the following two options:

*Option 1:* For the first crediting period, calculate the build margin emission factor *ex-ante* based on the most recent information available on units already built for sample group m at the time of CDM-PDD submission to the DOE for validation. For the second crediting period, the build margin emission factor should be updated based on the most recent information available on units already built at the time of submission of the request for renewal of the crediting period to the DOE. For the third crediting period, the build margin emission factor calculated for the second crediting period should be used. This option does not require monitoring the emission factor during the crediting period.

*Option 2:* For the first crediting period, the build margin emission factor should be updated annually, *ex-post*, including those units built up to the year of registration of the project activity or, if information up to the year of registration is not yet available, including those units built up to the latest year for which information is available. For the second crediting period, the build margin factor shall be calculated *ex-ante*, as described in option 1 above. For the third crediting period, the build margin emission factor calculated for the second crediting period should be used.

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

The build margin emissions factor is the generation-weighted average emission factor (tCO<sub>2</sub>/MWh) of all power units m during the most recent year y for which power generation data is available, calculated as follows:

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<sup>14</sup> Source: <http://www.mct.gov.br/index.php/content/view/333605.html#ancora>, accessed on 08/08/2012.



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

$$EF_{grid,BM,2011} = 0.1056 \text{ tCO}_2/\text{MWh}$$

#### **Step 6. Calculate the combined margin emissions factor**

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

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

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

$$EF_{2011} = 0.2920 \times 0.5 + 0.1056 \times 0.5 = 0.1988 \text{ tCO}_2/\text{MWh}$$

The build margin CO<sub>2</sub> emission factor and operating margin CO<sub>2</sub> emission factor will be ex-post.

Therefore, the combined margin CO<sub>2</sub> emission factor will be ex-post.

#### **Emission reduction**

##### **Baseline emission calculation**

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

##### **Ex-ante estimation of F<sub>CH4,PJ,y</sub>**

The assumptions used to calculate F<sub>CH4,PJ,y</sub> are:

- Methane content in LFG = 50% (default value);
- LFG collection efficiency = 75%: (Based on technical specifications from the equipments provider for the active LFG capture system);
- Density of methane = 0.716 kg/m<sup>3</sup> (as per “*Tool to determine project emissions from flaring gases containing methane*”).

The landfill gas collection and utilization system will capture only a portion of the generated landfill gas. Thus, an estimate of 75% LFG collection was applied to the estimate of LFG produced, under assumption that generated LFG is composed of 50% methane.

The ex ante estimation of the F<sub>CH4,PJ,y</sub> is presented below:

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

Where:

F<sub>CH4,PJ,y</sub> = Amount of methane in the LFG which is flared and/or used in the project activity in year y (tCH<sub>4</sub>/yr)



- $BE_{CH4,SWDS,y}$  = Amount of methane in the LFG that is generated from the SWDS in the baseline scenario in year y (tCO<sub>2</sub>e/yr)  
 $\eta_{PJ}$  = Efficiency of the LFG capture system that will be installed in the project activity  
 $GWP_{CH4}$  = Global warming potential of CH<sub>4</sub> (tCO<sub>2</sub>e/tCH<sub>4</sub>)

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

**Table 9 - Ex-ante estimation of  $F_{CH4,PJ,y}$**

Year	$F_{CH4,PJ,y}$ (tCH <sub>4</sub> /yr)
2013	2,486
2014	5,813
2015	6,515
2016	7,123
2017	7,662
2018	8,155
2019	8,613
2020	4,524

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

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

**Table 10 - Ex-ante estimation of  $F_{CH4,BL,y}$**

Year	$F_{CH4,BL,y}$ (tCH <sub>4</sub> /yr)
2013	497
2014	1,163
2015	1,303
2016	1,425
2017	1,532
2018	1,631
2019	1,723
2020	905

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

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

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

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



**Table 11 - Baseline emissions of methane from the SWDS ( $BE_{CH4,y}$ )**

Year	$BE_{CH4,y}$ (tCO <sub>2</sub> /year)
2013	37,595
2014	87,887
2015	98,514
2016	107,693
2017	115,854
2018	123,297
2019	130,232
2020	68,404

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

The ex-ante calculation is:

$$BE_{EC,y} = EC_{BL,k,y} \times EF_{grid,CM,y}$$

As explained above, the  $EF_{grid,CM,y} = 0.1988$  tCO<sub>2</sub>/MWh

**Table 12 - Baseline emissions associated with electricity generation ( $BE_{EC,y}$ )**

Year	$EC_{BL,k,y}$ (MWh/yr)	$BE_{EC,y}$ (tCO <sub>2</sub> /yr)
2013	-	-
2014	24,703	4,910
2015	32,938	6,547
2016	32,938	6,547
2017	32,938	6,547
2018	41,172	8,184
2019	41,172	8,184
2020	20,586	4,092

The equation of the baseline emission calculation is:

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

The result is:



Table 13 - baseline emission calculation

Year	$BE_{CH4,y}$ (tCO <sub>2</sub> /year)	$BE_{EC,y}$ (tCO <sub>2</sub> /yr)	$BE_y$ (tCO <sub>2</sub> /yr)
2013	37,595	-	37,595
2014	87,887	4,910	92,798
2015	98,514	6,547	105,061
2016	107,693	6,547	114,240
2017	115,854	6,547	122,401
2018	123,297	8,184	131,481
2019	130,232	8,184	138,416
2020	68,404	4,092	72,496

### Project emissions

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

Where:

- $PE_y$  = Project emissions in year y (tCO<sub>2</sub>/yr)
- $PE_{EC,y}$  = Emissions from consumption of electricity due to the project activity in year y (tCO<sub>2</sub>/yr)
- $PE_{FC,y}$  = Emissions from consumption of fossil fuels due to the project activity, for purpose other than electricity generation, in year y (tCO<sub>2</sub>/yr)

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

There are two emission project sources:

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

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

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

In the project activity, the electricity consumption from the grid is estimated around 609 MWh/year. it was assumed for ex-ante calculations that the internal consumption of diesel generator is 0% and all internal consumption will be from the Brazilian grid.

The option A1 of the “*Tool to calculate baseline, project and/or leakage emissions from electricity consumption*”, states that a value of the combined margin emission factor ( $EF_{grid,CM,y}$ ) may be used as the emission factor ( $EF_{ELj/k/l,y}$ ). Therefore a value of 0.1988 tCO<sub>2</sub>/MWh will be used.

Finally the technical transmission and distribution losses ( $TDL_{j,y}$ ) value has been assumed to be 15.4%, according to publication from Brazil's Energy Research Agency (EPE)<sup>15</sup>. Table below summarizes the project emissions resulting from electrical consumption in the plant.

<sup>15</sup> Source: Brazil's Energy Research Agency - “Balanço energético nacional 2012.pdf”



**Table 14 – Electricity consumption from the grid resulting due to project activity**

Year	Electricity consumption from the grid – EC <sub>PJ1,y</sub> (MWh/yr)	PE <sub>EC1,y</sub> (tCO <sub>2</sub> /year)
2013	609	140
2014	0	0
2015	0	0
2016	0	0
2017	0	0
2018	0	0
2019	0	0
2020	0	0

#### PE<sub>EC2,y</sub> - Project emission from diesel generator(s)

It was assumed for ex-ante calculations that the internal consumption of diesel generator is 0%. However, this parameter will be monitored ex-post and emission factor from the diesel generator(s) is 1.3 tCO<sub>2</sub>/MWh. The following table represents the project emissions from the use of the standby generator over the crediting period. Table below presents the project emissions associated with fossil fuel combustion at the project site.

**Table 15 – Project emissions from diesel generator**

Year	PE <sub>el,diesel</sub> – EC <sub>PJ2</sub> , (MWh/year)	PE <sub>EC2,y</sub> (tCO <sub>2</sub> /year)
2013	0	0
2014	0	0
2015	0	0
2016	0	0
2017	0	0
2018	0	0
2019	0	0
2020	0	0

#### **Leakage:**

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

#### **Emission Reduction**

Emission reductions are calculated as follows:

$$ER_y = BE_y - PE_y,$$

Where:

- ER<sub>y</sub> = Emission reductions in year y (tCO<sub>2</sub>e/yr);
- BE<sub>y</sub> = Baseline emissions in year y (tCO<sub>2</sub>e/yr);
- PE<sub>y</sub> = Project emissions in year y (tCO<sub>2</sub>e/yr);



Year	$BE_y$ (tCO <sub>2</sub> /year)	$PE_y$ (tCO <sub>2</sub> /year)	$ER_y$ (tCO <sub>2</sub> /year)
2013	37,595	140	37,525
2014	92,798	-	92,798
2015	105,061	-	105,061
2016	114,240	-	114,240
2017	122,401	-	122,401
2018	131,481	-	131,481
2019	138,416	-	138,416
2020	72,496	-	72,496

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

Year	Baseline emissions (t CO <sub>2</sub> e)	Project emissions (t CO <sub>2</sub> e)	Leakage (t CO <sub>2</sub> e)	Emission reductions (t CO <sub>2</sub> e)
2013	37,595	140	0	37,456
2014	92,798	0	0	92,798
2015	105,061	0	0	105,061
2016	114,240	0	0	114,240
2017	122,401	0	0	122,401
2018	131,481	0	0	131,481
2019	138,416	0	0	138,416
2020	72,496	0	0	72,496
<b>Total</b>	<b>814,489</b>	<b>140</b>	<b>0</b>	<b>814,349</b>
<b>Total number of crediting years</b>	7			
<b>Annual average over the crediting period</b>	<b>116,356</b>	<b>20</b>	<b>0</b>	<b>116,336</b>

#### B.7. Monitoring plan

##### B.7.1. Data and parameters to be monitored

Flaring or use of landfill gas



<b>Data / Parameter</b>	Management of SWDS
<b>Unit</b>	-
<b>Description</b>	Management of SWDS
<b>Source of data</b>	Use different sources of data: <ul style="list-style-type: none"><li>• Original design of the landfill;</li><li>• Technical specifications for the management of the SWDS;</li><li>• Local or national regulations</li></ul>
<b>Value(s) applied</b>	-
<b>Measurement methods and procedures</b>	Project participants should refer to the original design of the CTR Maceió to ensure that any practice to increase methane generation have been occurring prior to the implementation of the project activity.  Any change in the management of the SWDS after the implementation of the project activity should be justified by referring to technical or regulatory specifications
<b>Monitoring frequency</b>	Annually
<b>QA/QC procedures</b>	-
<b>Purpose of data</b>	Calculation of baseline emissions
<b>Additional comment</b>	-



<b>Data / Parameter</b>	$O_{pj,h}$
<b>Unit</b>	
<b>Description</b>	Operation of the equipment that consumes the LFG
<b>Source of data</b>	Measurements by Project participant
<b>Value(s) applied</b>	n/a
<b>Measurement methods and procedures</b>	<p>For each equipment unit j (enclosed flare and group generator) using the LFG monitor that the plant is operating in hour h by the monitoring of the following parameters:</p> <p>1. Enclosed flare:</p> <ul style="list-style-type: none"><li>Temperature on the exhaust gas of the flare. The location for temperature measurements and minimum operational temperature will be based on manufacturer's specifications of the burning equipment.</li></ul> <p><math>O_{pj,h}=0</math> when:</p> <ul style="list-style-type: none"><li>One or more temperature measurements are missing or below the minimum threshold in hour h (instantaneous measurements are made at least every minute);</li></ul> <p>Otherwise, <math>O_{pj,h}=1</math></p> <p>2. Group generator</p> <ul style="list-style-type: none"><li>Products generated. Monitor the generation of electricity for the case of group generators</li></ul> <p><math>O_{pj,h}=0</math> when:</p> <ul style="list-style-type: none"><li>No electricity is generated in the hour h</li></ul>
<b>Monitoring frequency</b>	Hourly
<b>QA/QC procedures</b>	-
<b>Purpose of data</b>	Calculation of baseline emissions
<b>Additional comment</b>	-

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



<b>Data / Parameter</b>	V <sub>t,wb</sub>
<b>Unit</b>	m <sup>3</sup> wet gas/h
<b>Description</b>	Volumetric flow of the gaseous stream in time interval t on a wet basis
<b>Source of data</b>	Measurements by Project participant
<b>Value(s) applied</b>	n/a
<b>Measurement methods and procedures</b>	Volumetric flow measurement should always refer to the actual pressure and temperature. Instruments with recordable electronic signal (analogical or digital) are required
<b>Monitoring frequency</b>	Continuous
<b>QA/QC procedures</b>	Periodic calibration against a primary device provided by an independent accredited laboratory is mandatory. Calibration and frequency of calibration is according to manufacturer's specifications
<b>Purpose of data</b>	Calculation of baseline emissions
<b>Additional comment</b>	According to the Table 1 of the "Tool to determine the mass flow of a greenhouse gas in a gaseous stream", the measurement option in the project activity will be Option B

<b>Data / Parameter</b>	V <sub>t,db</sub>
<b>Unit</b>	m <sup>3</sup> dry gas/h
<b>Description</b>	Volumetric flow of the gaseous stream in time interval t on a dry basis
<b>Source of data</b>	Measurements by Project participants
<b>Value(s) applied</b>	n/a
<b>Measurement methods and procedures</b>	Volumetric flow measurement should always refer to the actual pressure and temperature. Calculated based on the wet basis flow measurement plus water concentration measurement
<b>Monitoring frequency</b>	Continuous
<b>QA/QC procedures</b>	Periodic calibration against a primary device provided by an independent accredited laboratory is mandatory. Calibration and frequency of calibration is according to manufacturer's specifications
<b>Purpose of data</b>	Calculation of baseline emissions
<b>Additional comment</b>	According to the "Tool to determine the mass flow of a greenhouse gas in a gaseous stream", the measurement option in the project activity will be Option A when the temperature of gaseous stream is lower than 60°C (333.15 K) at the flow measurement point



<b>Data / Parameter</b>	$v_{i,t,db} = f v_{i,h}$
<b>Unit</b>	-
<b>Description</b>	Volumetric fraction of greenhouse gas $i$ in a time interval $t$ on a dry basis
<b>Source of data</b>	Measurements by project participants
<b>Value(s) applied</b>	n/a
<b>Measurement methods and procedures</b>	Continuous gas analyzer operating in dry-basis. Volumetric flow measurement should always refer to the actual pressure and temperature Data will be monitored continuously and values will be averaged hourly or a shorter time interval.
<b>Monitoring frequency</b>	Continuously
<b>QA/QC procedures</b>	Calibration should include zero verification with an inert gas (e.g. N <sub>2</sub> ) and at least one reading verification with a standard gas (single calibration gas or mixture calibration gas). All calibration gases must have a certificate provided by the manufacturer and must be under their validity period
<b>Purpose of data</b>	Calculation of baseline emissions
<b>Additional comment</b>	As a simplified approach, project participants may only measure the methane content of the gaseous stream and consider the remaining part as N <sub>2</sub> , therefore $i = CH_4$ and N <sub>2</sub> This parameter will be monitored to option A e B

<b>Data / Parameter</b>	$T_t$
<b>Unit</b>	K
<b>Description</b>	Temperature of the gaseous stream in time interval $t$
<b>Source of data</b>	Measurements by Project participant
<b>Value(s) applied</b>	n/a
<b>Measurement methods and procedures</b>	Instruments with recordable electronic signal (analogical or digital) are required. Examples include thermocouples, thermo resistance, etc.
<b>Monitoring frequency</b>	Continuous unless differently specified in the underlying methodology
<b>QA/QC procedures</b>	Periodic calibration against a primary device provided by an independent accredited laboratory is mandatory. Calibration and frequency of calibration is according to manufacturer's specifications
<b>Purpose of data</b>	Calculation of baseline emissions.
<b>Additional comment</b>	Provided all parameters are converted to normal conditions during the monitoring process, this parameter may not be needed except for moisture content determination and therefore it should be metered only when performing such measurements (with same frequency). However, if the applicability condition related to the gaseous stream flow temperature being below 60°C is adopted, this parameter must be monitored continuously to assure the applicability condition is met



<b>Data / Parameter</b>	$P_t$
<b>Unit</b>	Pa
<b>Description</b>	Pressure of the gaseous stream in time interval t
<b>Source of data</b>	Measurements by Project participant
<b>Value(s) applied</b>	n/a
<b>Measurement methods and procedures</b>	Instruments with recordable electronic signal (analogical or digital) are required. Examples include pressure transducers, etc.
<b>Monitoring frequency</b>	Continuous unless differently specified in the underlying methodology
<b>QA/QC procedures</b>	Periodic calibration against a primary device must be performed periodically and records of calibration procedures must be kept available as well as the primary device and its calibration certificate. Pressure transducers (either capacitive or resistive) must be calibrated monthly
<b>Purpose of data</b>	Calculation of baseline emissions.
<b>Additional comment</b>	Provided all parameters are converted to normal conditions during the monitoring process, this parameter may not be needed except for moisture content determination and therefore it should be metered only when performing such measurements (with same frequency)

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

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



<b>Data / Parameter</b>	EF <sub>grid,CM,y</sub>
<b>Unit</b>	tCO <sub>2</sub> /MWh
<b>Description</b>	CO <sub>2</sub> emission factor of the Brazilian grid electricity during the year y
<b>Source of data</b>	Brazilian DNA
<b>Value(s) applied</b>	0.1988
<b>Measurement methods and procedures</b>	The emission factor is calculated ex-post, as the weighted average of the dispatch data analysis OM (Operating Margin) and the BM (Build margin), as described in B.6.3. According to the “Tool to calculate the emission factor for an electricity system”, the chosen monitoring option is <i>ex-post</i> .
<b>Monitoring frequency</b>	Annual
<b>QA/QC procedures</b>	Apply procedures in the “Tool to calculate the emission factor for an electricity system”.
<b>Purpose of data</b>	Calculation of baseline emissions and; Calculation of project emissions.
<b>Additional comment</b>	All data and parameters to determine the grid electricity emission factor, as required by the “Tool to calculate the emission factor for an electricity system”, were included in the monitoring plan.  For more details, see appendix 4.

<b>Data / Parameter</b>	EF <sub>grid,BM,y</sub>
<b>Unit</b>	tCO <sub>2</sub> /MWh
<b>Description</b>	Build margin emission factor of the Brazilian grid
<b>Source of data</b>	Brazilian DNA
<b>Value(s) applied</b>	0.1056
<b>Measurement methods and procedures</b>	According to the “Tool to calculate the emission factor for an electricity system”, the chosen monitoring option is <i>ex-post</i> .
<b>Monitoring frequency</b>	Annual
<b>QA/QC procedures</b>	Apply procedures in the “Tool to calculate the emission factor for an electricity system”.
<b>Purpose of data</b>	Calculation of baseline emissions and; Calculation of project emissions.
<b>Additional comment</b>	All data and parameters to determine the grid electricity emission factor, as required by the “Tool to calculate the emission factor for an electricity system”, were included in the monitoring plan.  For more details, see appendix 4.



<b>Data / Parameter</b>	EF <sub>grid,OM,y</sub>
<b>Unit</b>	tCO <sub>2</sub> /MWh
<b>Description</b>	Operating margin emission factor of the Brazilian grid
<b>Source of data</b>	Brazilian DNA
<b>Value(s) applied</b>	0.2920
<b>Measurement methods and procedures</b>	According to the “Tool to calculate the emission factor for an electricity system”, the chosen monitoring option is <i>ex-post</i> .
<b>Monitoring frequency</b>	Annual
<b>QA/QC procedures</b>	Apply procedures in the “Tool to calculate the emission factor for an electricity system”.
<b>Purpose of data</b>	Calculation of baseline emissions and; Calculation of project emissions.
<b>Additional comment</b>	All data and parameters to determine the grid electricity emission factor, as required by the “Tool to calculate the emission factor for an electricity system”, were included in the monitoring plan.  For more details, see appendix 4.

<b>Data / Parameter</b>	TDL <sub>y</sub>
<b>Unit</b>	-
<b>Description</b>	Average technical transmission and distribution losses in the grid in year y for the voltage level at which electricity is obtained from the grid at the project site.
<b>Source of data</b>	Regional or national technical literature
<b>Value(s) applied</b>	15.4%
<b>Measurement methods and procedures</b>	The technical distribution losses do not contain grid losses other than technical transmission and distribution.
<b>Monitoring frequency</b>	Annually. In the absence of data from the relevant year, most recent figures should be used, but not older than 5 years.
<b>QA/QC procedures</b>	-
<b>Purpose of data</b>	Calculation of project emissions.
<b>Additional comment</b>	The data was based on National Energy Balance 20012



<b>Data / Parameter</b>	$EG_{PJ,y} = EC_{BL,k,y}$
<b>Unit</b>	MWh
<b>Description</b>	Amount of electricity generated using LFG by the project activity in year y
<b>Source of data</b>	Measured by the project participant using electricity meter
<b>Value(s) applied</b>	-
<b>Measurement methods and procedures</b>	<p>Monitor net electricity generation by the project activity using LFG</p> <p>The data will be collected continuously using an electricity meter. The net amount of electricity will be directly measured. The data will be archived throughout the crediting period and two years thereafter.</p> <p>The point of connection to the electrical grid will be the closest substation to the project activity available at the moment of the project implementation.</p>
<b>Monitoring frequency</b>	Continuously
<b>QA/QC procedures</b>	Electricity meter will be subject to regular (in accordance with stipulation of the meter supplier) maintenance and testing to ensure accuracy. Periodical calibration as per manufacturer specifications to ensure validity of data measured. The readings will be double checked by the electricity distribution company.
<b>Purpose of data</b>	Calculation of baseline emissions.
<b>Additional comment</b>	This parameter is required for calculating baseline emissions associated with electricity generation ( $BE_{EC,y}$ ) using the “Tool to calculate baseline, project and/or leakage emissions from electricity consumption”.

<b>Data / Parameter</b>	$EG_{EC1,y} = EC_{PJ1,y}$
<b>Unit</b>	MWh/y
<b>Description</b>	Quantity of electricity consumed from the grid by the project activity during the year y
<b>Source of data</b>	Measured by the project participant using electricity meter
<b>Value(s) applied</b>	-
<b>Measurement methods and procedures</b>	The data will be collected continuously using an electricity meter. The data will be archived throughout the crediting period and two years thereafter.
<b>Monitoring frequency</b>	Continuously
<b>QA/QC procedures</b>	Electricity meter will be subject to regular (in accordance with stipulation of the meter supplier) maintenance and testing to ensure accuracy. Periodical calibration as per manufacturer specifications to ensure validity of data measured. The readings will be double checked by the electricity distribution company.
<b>Purpose of data</b>	Calculation of project emissions.
<b>Additional comment</b>	This parameter is required for calculating project emissions from electricity consumption due to an alternative waste treatment process t ( $PE_{EC1,y}$ ) using the “Tool to calculate baseline, project and/or leakage emissions from electricity consumption”.



<b>Data / Parameter</b>	$EG_{EC2,y} = EC_{PJ2,y}$
<b>Unit</b>	MWh/y
<b>Description</b>	Quantity of electricity consumed from diesel generator by the project activity during the year y
<b>Source of data</b>	Measured by project participants using electricity meter
<b>Value(s) applied</b>	-
<b>Measurement methods and procedures</b>	The data will be collected continuously using an electricity meter. The data will be archived throughout the crediting period and two years thereafter.
<b>Monitoring frequency</b>	Continuously
<b>QA/QC procedures</b>	Electricity meter will be subject to regular (in accordance with stipulation of the meter supplier) maintenance and testing to ensure accuracy. Calibration of equipment as per manufacturer specifications to ensure validity of data measured. Periodical calibration.
<b>Purpose of data</b>	Calculation of project emissions.
<b>Additional comment</b>	This parameter is required for calculating project emissions from electricity consumption due to an alternative waste treatment process t ( $PE_{EC2,y}$ ) using the “Tool to calculate baseline, project and/or leakage emissions from electricity consumption”.

#### Tool to determine project emissions from flaring gases containing methane

<b>Data / Parameter</b>	$t_{O2,h}$
<b>Unit</b>	-
<b>Description</b>	Volumetric fraction of O <sub>2</sub> in the exhaust gas of the flare in the hour h
<b>Source of data</b>	Measurements by project participants using a continuous gas analyzer
<b>Value(s) applied</b>	-
<b>Measurement methods and procedures</b>	Extractive sampling analyzers with water and particulates removal devices or <i>in situ</i> analyzers for wet basis determination. The point of measurement (sampling point) shall be in the upper section of the flares (80% of total flare height). Sampling shall be conducted with appropriate sampling probes adequate to high temperature level. An excessively high temperature at the sampling point (above 700 °C) may be an indication that the flare is not being adequately operated or that its capacity is not adequate to the actual flow.
<b>Monitoring frequency</b>	Continuously
<b>QA/QC procedures</b>	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. Periodical calibration.
<b>Purpose of data</b>	Calculation of baseline emissions.
<b>Additional comment</b>	The enclosed flares that will be installed in the project activity have a standard temperature higher than 850°C, according to manufacturer specification <sup>16</sup> .

<sup>16</sup> The documentation regarding technical specifications of the flare was made available to DOE in the validation visit.



<b>Data / Parameter</b>	fV <sub>CH4,FG,h</sub>
<b>Unit</b>	mg/m <sup>3</sup>
<b>Description</b>	Concentration of methane in the exhaust gas of the flare in dry basis at normal conditions in the hour h
<b>Source of data</b>	Measurements by project participants using a continuous gas analyzer
<b>Value(s) applied</b>	n/a
<b>Measurement methods and procedures</b>	Extractive sampling analyzers with water and particulates removal devices or <i>in situ</i> analyzers for wet basis determination. The point of measurement (sampling point) shall be in the upper section of the flares (80% of total flare height). Sampling shall be conducted with appropriate sampling probes adequate to high temperature level. An excessively high temperature at the sampling point (above 700 °C) may be an indication that the flare is not being adequately operated or that its capacity is not adequate to the actual flow. Data will be recorded continuously and values will be averaged hourly or at a shorter time interval
<b>Monitoring frequency</b>	Continuously. Values to be averaged hourly or at a shorter time interval
<b>QA/QC procedures</b>	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. Periodical calibration.
<b>Purpose of data</b>	Calculation of baseline emissions.
<b>Additional comment</b>	The enclosed flares that will be installed in the project activity have a standard temperature higher than 850°C, according to manufacturer specification.  Monitoring of this parameter is only applicable in case of enclosed flares and continuous monitoring of the flare efficiency. Measurement instruments will be read ppmv values or % values. To convert from ppmv to mg/m <sup>3</sup> simply multiply by 0.716. 1% equals 10,000 ppmv.



<b>Data / Parameter</b>	T <sub>flare</sub>
<b>Unit</b>	° C
<b>Description</b>	Temperature on the exhaust gas of the flare
<b>Source of data</b>	Measurements by project participants
<b>Value(s) applied</b>	n/a
<b>Measurement methods and procedures</b>	Measure the temperature of the exhaust gas stream in the flare by a Type S thermocouple. A temperature above 500 °C indicates that a significant amount of gases are still being burnt and that the flare is operating. Data will be recorded continuously and values will be averaged hourly or at a shorter time interval
<b>Monitoring frequency</b>	Continuously
<b>QA/QC procedures</b>	Thermocouples will be replaced or calibrated every year
<b>Purpose of data</b>	Calculation of baseline emissions.
<b>Additional comment</b>	The enclosed flares that will be installed in the project activity have a standard temperature higher than 850°C, according to manufacturer specification. A thermocouple type S has been considered in accordance to manufacturer specifications <sup>17</sup>

<b>Data / Parameter</b>	FV <sub>RG,h</sub>
<b>Unit</b>	m <sup>3</sup> /h
<b>Description</b>	Volumetric flow rate of the residual gas in dry basis at normal conditions in the hour h
<b>Source of data</b>	Measurements by project participants using a flow meter
<b>Value(s) applied</b>	n/a
<b>Measurement methods and procedures</b>	Ensure that the same basis (wet or dry) is considered for this measurement and the measurement of volumetric fraction of all components in the residual gas ( $f_{vi,h}$ ) when the residual gas temperature exceeds 60°C. Data will be monitored continuously and values will be averaged hourly or a shorter time interval.
<b>Monitoring frequency</b>	Continuously
<b>QA/QC procedures</b>	Flow meters must be periodically calibrated according to the manufacturer's recommendation. Periodical calibration.
<b>Purpose of data</b>	Calculation of baseline emissions.
<b>Additional comment</b>	-

### B.7.2. Sampling plan

&gt;&gt;

Not applicable.

### B.7.3. Other elements of monitoring plan

&gt;&gt;

The monitoring plan will be done according to the methodology ACM0001 and the applicable tools. The monitoring equipments locations are presented in the picture below:

<sup>17</sup> The documentation regarding technical specifications of the type of thermocouple was made available to DOE in the validation visit.

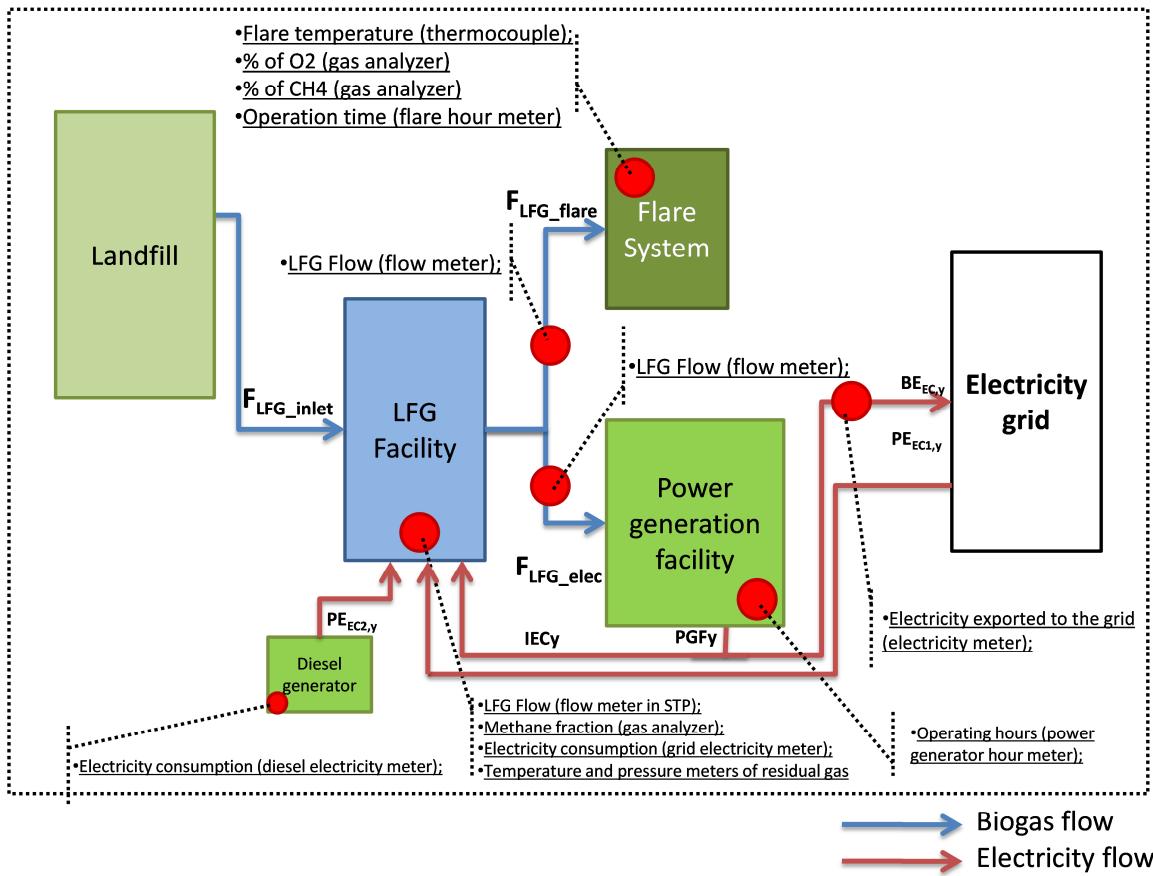


Figure 15 - Monitoring equipments locations

All continuously measured parameters (LFG flow, LFG CH<sub>4</sub> concentration, flare temperature, flare operating hours, engine operating hours, and engine electrical output) will be recorded electronically via a datalogger, located inside the site boundary which will have the capability to aggregate and print the collected data in the frequencies range specified above. It will be the Site Operator responsibility to provide all requested data logs which will be stored during the reporting period at the Site office. The data logs will be summarized into emission reduction calculations prior to each verification. This task will be completed by Project Participant and reported directly to the DOE. These logs will be available to the DOE when requested in order to prove the operational integrity of the Project.

## 1. Management Structure

The collected operational data will be used to support the periodic verification report requiring CER auditing. The herein discussed monitoring plan has been designed to meet or conservatively exceed the UNFCCC requirements (approved monitoring methodology ACM0001 version 13).

The monitoring program routine system required to determine emission reductions and the additional system data collected to ensure the safe, correct, and efficient operation of the LFG management system are discussed in sections 2 and 3 below.

### 1.1. Responsibility of the personnel involved

The personnel involved in the monitoring will be responsible for carrying out the following tasks:



- Supervise and verify metering and recording: The staff will internally coordinate with other departments the adequate verification of data metering and recording.
- Collection of sales/billing receipts and additional data: The staff will collect sales receipts and additional data such as daily operational reports of project.
- Calibration: The staff will internally coordinate to ensure that calibration of the metering instruments will be carried out in accordance with the equipment manufacturers' specifications.
- Preparation of monitoring report: The staff will prepare the monitoring report for verification.
  - Data Archives: The staff will be responsible for keeping all monitoring data, and making it available to the DOE for the verification of the emission reductions.

## 1.2. Installation of meters

All meters will be installed in order to fulfill the proposed monitoring plan.

## 2. Monitoring Work Program

The LFG monitoring program is designed to collect system operating data required for the safe system operation and for the verification of CERs. This data is collected in real time, and will provide continuous recording which can be easily monitored, reviewed, and validated.

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

- LFG Flow;
- LFG quality;
- Uncombusted methane;
- Electricity consumption;
- Project electricity output;
- Regulatory requirements;
- Data records;
- Data assessment and reporting.

### 2.1. LFG Flow

During flaring phase the data will be collected continuously using 1 vortex flow meter located in the piping leading to the flare. Upon completion of electricity generation phase additional vortex flow meters will be installed, being one of them in the piping leading to the engine and the other on the main piping measuring the total collected landfill gas. The data will be aggregated at least every hour and recorded in a database for each flare. The data will be archived for a minimum of two years after the end of the crediting period or the last issuance of CERs for this project activity, whichever occurs later.

The vortex meter will be provided with a normalizer unit which normalizes the flow rate at standard temperature and pressure.

The equipment selected for the project activity will utilize a continuous monitoring system as defined in ACM0001, which measures and aggregates flow data.

### 2.2. LFG Quality

The concentration of methane will be measured via common sample line that runs to the main collection system piping and is measured in real time. The equipment selected for the site aggregates gas composition as per the definition of a continuous monitoring system in ACM0001.

Regular calibrations will be made according to manufacturer specification.

### 2.3. Uncombusted Methane

The efficiency of the enclosed flare will be measured per the methodological “Tool to determine project emissions from flaring gases containing methane”.

### 2.4. Electricity

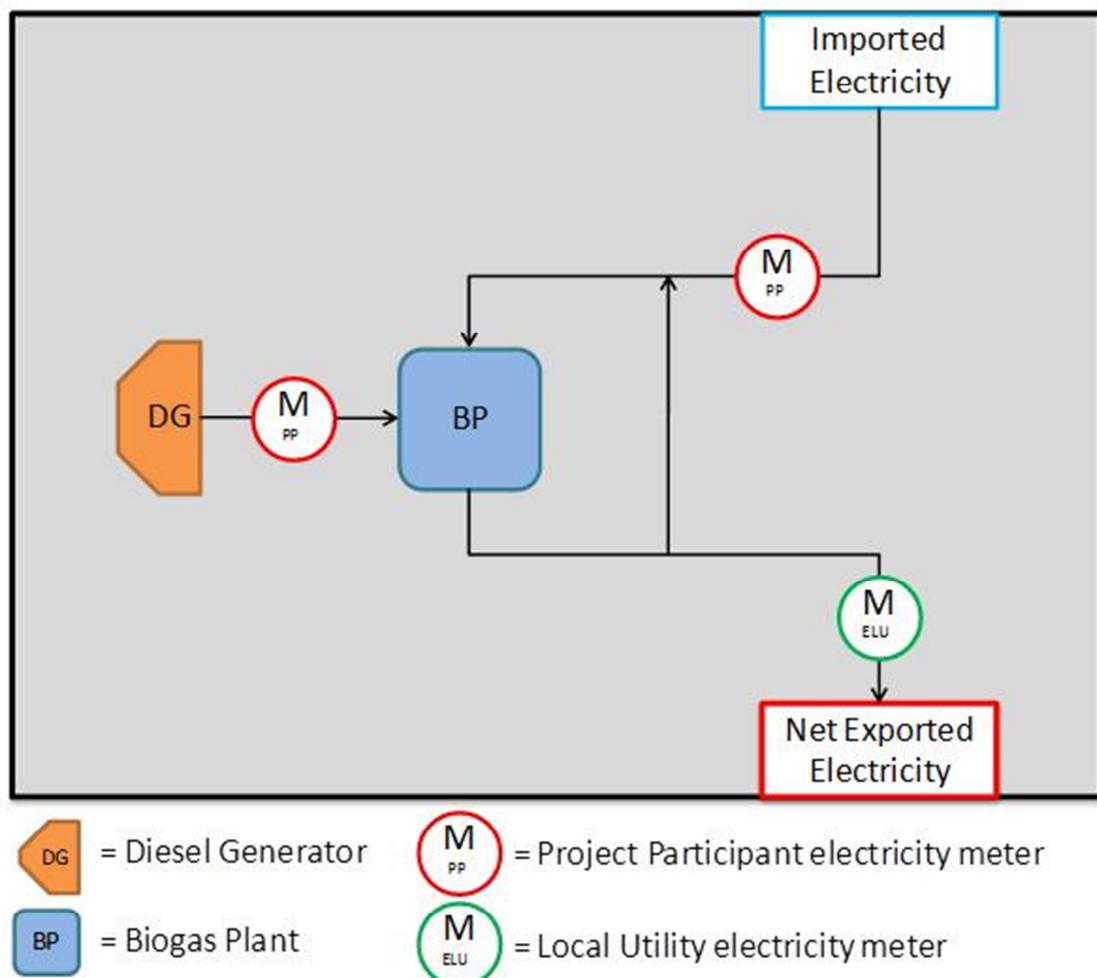


Figure 16 – Electricity Monitoring

#### 2.4.1 Electricity for self consumption

The electricity supplied by the grid and diesel generators to LFG Plant will be continuously measured by electricity meters located in the LFG plant to define energy for self-consumption due to project activity.

#### 2.4.2 Project Electricity Output

The net generated electricity supplied to the grid by the project activity will be continuously measured by a Local Electricity Utility (LEU) meter and the respective data will be electronically recorded.



## 2.5 Regulatory Requirements

Regulatory requirements relating to LFG projects will be evaluated annually by investigating municipal, state and national regulations regarding the LFG. This will be done through consultation with the appropriate regulatory agencies, on-going discussions with regulators and monitoring of publications delineating upcoming legislative changes governing landfills and LFG.

## 2.6 Data Records

Data collected from each of the parameter sensors is transmitted directly to an electronic database. Backup of the electronic data will be carried out frequently. Calibration records will be kept for all instrumentation during 2 years after the end of the crediting period.

## 2.7 Data Assessment and Reporting

The record data will be daily analysed by the LFG Plant Supervisor. If detected any inconsistency regarding monitoring parameter data, it will be reported in a log-book and the LFG Plant Supervisor along with the LFG Plant Manager will provide corrective actions, according to internal operational procedures.

Daily consolidated data will be sent by the LFG Plant Supervisor to the LFG Plant Manager through electronic reports. The data of the monitored parameters will be storage using internal system network.

The data will be compiled and assessed to produce the required quantification and validation. The periodic monitoring report will contain the data required for the verification of the CERs. The records of regular maintenance performed will also be a component of the verification reports.

## 3 Corrective actions

The staff will log all corrective actions and will report these in the monitoring report. In case when the corrective actions are considered necessary, these actions will be implemented according to internal procedures.

## 4 Procedures for monitoring personnel training

The PP will conduct a training and quality control program to ensure that the good management practices are carried out and implemented by all project operating personnel in terms of record-keeping, equipment calibration, overall maintenance, and procedures for corrective action.

## 5 Emergency procedures

As a precautionary measure, it will be made regularly backups to avoid data loss due to power outages. The LFG Plant Manager will check daily the records. In addition, an emergency plan will be developed including other types of emergencies such as fire and work accidents.

## 6 Calibration

All the measurement instruments will be subject to regular calibration as per manufacturer's specifications or, when applicable, the calibration frequency will be defined by the PP. The regular check and calibration will be made by the operators. The LFG Plant Manager will be responsible for checking the equipment's proper working conditions, as well as checking and storing up the calibration certificates



and records. Calibration certificates will be kept for all the equipments during the crediting period and two years after.

## **SECTION C. Duration and crediting period**

### **C.1. Duration of project activity**

#### **C.1.1. Start date of project activity**

>>

Project starting date: 01/01/2013.

The starting date of the project activity will be the forecast date of purchasing the main equipment (enclosed flare).

#### **C.1.2. Expected operational lifetime of project activity**

>>

25 years and 0 months

### **C.2. Crediting period of project activity**

#### **C.2.1. Type of crediting period**

>>

Renewable (first)

#### **C.2.2. Start date of crediting period**

>>

The crediting period will start on 01/07/2013 or on the date of the registration of the CDM project activity (whichever is later).

#### **C.2.3. Length of crediting period**

>>

7 years (renewable for two times) and 0 months

## **SECTION D. Environmental impacts**

### **D.1. Analysis of environmental impacts**

>>

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

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

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

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



- CONAMA Resolution 001/86 (Environmental Impact Assessment)
- CONAMA Resolution 396/2008 (Groundwater legislation)

According to Brazilian legislation mentioned above is required an environmental impact assessment to the landfill project and the possible environmental impacts were analyzed by the *Secretaria Municipal de Proteção ao Meio Ambiente (SEMPMA) (responsible agency to issue environmental licences in Alagoas State)*. The project activity has satisfied all the requirements for implementation of the landfill gas project and the CTR Maceio received from SEMPMA the Environmental Operational License nº.163/2012. A summary of the environmental impacts and mitigation measures are explained in the section D.2.

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

## D.2. Environmental impact assessment

>>

For the project activity, which has the objective to capture, flare and generates electricity through the use of LFG produced in the landfill, it is not necessary to develop an EIA (Environmental Impact Assessment). However, as the project boundary includes the project landfill, an environmental impact assessment (EIA) analysed by *SEMPMA* has been carried out considering the landfill characteristics. Thus, CTR Maceio has obtained all pertinent Licenses before its operation.

A summary of the environmental impacts and mitigation measures are explained in the Table 16 and in the Table 17 are showed the positive impacts due to the implementation of landfill project.

**Table 16 - Environmental Impacts and mitigation measures**

IMPACT	POTENCIAL FACTOR	MITIGATION MEASURES
Atmospheric Pollution	<ul style="list-style-type: none"><li>• Dust emission from civil works.</li><li>• Gas emissions from fossil combustion of vehicles and equipments.</li><li>• Odour and biogas emissions from landfill.</li></ul>	<ul style="list-style-type: none"><li>• Wetting, calculated explosions for lower emissions of dust and vegetation surround.</li><li>• Maintenance of vehicles and equipments.</li><li>• Vegetation surround, drainage of leachate, daily coverage of waste, deodorizer, maintenance of waste water treatment plant (WWTP) and biogas drainage and flare using passive capture system.</li></ul>
Superficial and ground water pollution.	<ul style="list-style-type: none"><li>• Leachate generation.</li><li>• Wastewater emissions containing oil and grease.</li><li>• Ground leachate generation.</li><li>• Runoff water with particulate material.</li></ul>	<ul style="list-style-type: none"><li>• Subsurface drainage and treatment at the WWTP.</li><li>• Oil/water separator - API and treatment at the WWTP.</li><li>• Waterproofing with geomembrane and drainage</li><li>• Sand separator before discharged into the rivers or natural drainage.</li></ul>
Soil destabilization. Siltation	<ul style="list-style-type: none"><li>• Cut and filling of soil.</li><li>• Leaching of soils.</li></ul>	<ul style="list-style-type: none"><li>• Pluvial drainage, reutilization of soil and revegetation.</li><li>• Preservation of coverage, dike and reutilization of soils.</li></ul>
Noise Pollution	<ul style="list-style-type: none"><li>• Noise emissions from civil works, vehicular traffic and equipments.</li></ul>	<ul style="list-style-type: none"><li>• Vegetation surround and calculated explosions for lower noise emissions, signalization and planning schedules.</li><li>• Maintenance of vehicles and equipments.</li></ul>
Sanitary risks	<ul style="list-style-type: none"><li>• Vectors (insects, rats)</li></ul>	<ul style="list-style-type: none"><li>• Daily coverage of waste</li></ul>



	proliferation	
Traffic alteration and risk of accidents.	<ul style="list-style-type: none"> <li>• Increase of vehicular traffic.</li> <li>• Waste transport.</li> </ul>	<ul style="list-style-type: none"> <li>• Improvement of access via, signalization and paving.</li> <li>• Construction of alternatives via, maintenance of vehicles and training of drivers.</li> </ul>
Landscape reconfiguration and landscape alteration	• Suppression of vegetation	• Planning of vegetation removal, replanting of forest and heterogeneous reforestation
Global environmental collapse	• Destabilization of landfill with rupture.	• Proper design project, rigorous execution and geotechnical monitoring ,

**Table 17 - Positive Impacts**

IMPACT	POTENCIAL FACTOR	MITIGATION MEASURES
Traffic of vehicles improvement	• Implantation and improvement of access via	• Positive impact
Increase of per capita income and stimulation of economy in the region.  Increase of tax revenues	<ul style="list-style-type: none"> <li>• Generation of direct and indirect jobs using local labor.</li> <li>• Purchase of materials and services in the region.</li> </ul>	• Positive impact
Organization of use and occupation of land.	• Regular use and occupation of land, avoiding situations of invasion and disordered occupation.	• Positive impact

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

The monitoring plan consists of the following specifics monitoring plans:

- Monitoring plan of air quality
- Monitoring plan of superficial waters
- Monitoring plan of ground waters
- Monitoring plan of noise
- Monitoring plan of landfill stability
- Monitoring plan of flora and fauna
- Monitoring plan of unit operations
- Monitoring plan of environmental-society conditions.

## SECTION E. Local stakeholder consultation

### E.1. Solicitation of comments from local stakeholders

>>

According to the Resolutions Number 1<sup>18</sup>, 4<sup>19</sup> and 7<sup>20</sup> of the Brazilian Designed National Authority (CIMGC – Comissão Interministerial de Mudança Global do Clima / *Interministerial Commission on Global Climate Change*), project participants shall send letters to local stakeholders 15 days before the start of the validation period, in order to receive comments. It includes:

- Name and type of the activity project;

<sup>18</sup> [http://www.mct.gov.br/upd\\_blob/0002/2736.pdf](http://www.mct.gov.br/upd_blob/0002/2736.pdf) (Art. 3º, II)

<sup>19</sup> [http://www.mct.gov.br/upd\\_blob/0011/11780.pdf](http://www.mct.gov.br/upd_blob/0011/11780.pdf) (Artº 5º, unique paragraph)

<sup>20</sup> [http://www.mct.gov.br/upd\\_blob/0023/23744.pdf](http://www.mct.gov.br/upd_blob/0023/23744.pdf), accessed on July 21<sup>st</sup>, 2008.



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

Letters were sent on 16/06/2012 to the following stakeholders involved and affected by the project activity:

- Prefeitura municipal de Maceió / Municipal Administration of Maceio;
- Câmara dos vereadores de Maceió/ Legislation Chamber of Maceio;
- Secretaria Municipal de Meio Ambiente de Maceió / Municipal Secretary Environmental of Maceio City;
- Secretaria do Meio Ambiente e Recursos Hídricos do Estado de Alagoas/ Environmental and Water Resources Secretary of Alagoas State;
- Fórum Brasileiro das Organizações Não Governamentais e Movimentos Sociais para o Meio Ambiente e o Desenvolvimento - FBOMS / Brazilian Forum of Non-Governmental Organizations and Social Movements for Environment and Development;
- Ministério Público do Estado de Alagoas / Alagoas Prosecutor's Office;
- Local associations.
  - o Cooperativa de Recicladores de Lixo Urbano de Maceió (COOPLUM);
  - o Cooperativa dos Catadores da Vila Emater (Coopvila);
  - o ONG Bioética.
- Ministério Público Federal / Federal Prosecutor's Office<sup>21</sup>.

During the 71º Ordinary Meeting of CIMGC that took place on 08/11/2012 (Letter nº MDL 736/2012/CIMGC) the PP has been exhorted to develop a new *in situ* local stakeholder consultation, due to the letter sent to Federal Prosecutor's Office had not met the standards of Art. 3º of Resolutions Nº 7 of CIMGC.

The new invitations letters were submitted to entities mentioned above and others, in accordance to CIMGC regulations and the onsite local stakeholder consultation took place on 23/11/2012 (Figure 17). It was presented to the attendees about landfill gas project, explaining the positive and negatives impacts due to the implementation of CMD Project.



Figure 17 - *In situ* local stakeholder consultation

<sup>21</sup> This letter did not reach the destination due to error in address and was resubmitted on 02/07/2012 successfully.



During this presentation the attendees received complete and clear information about the landfill gas project by CTR Maceió employees which answered all the stakeholder's doubts or inquires.

### E.2. Summary of comments received

>>

During the process of *in situ* local stakeholder consultation, PP were asked by the following stakeholders:

- COOPVILA

*Question:* What will be the benefits of the project to the local associations?

*Answer:* It was explained that the project will contribute positively to the developing of local environmental sustainability, net generations of direct and indirect jobs, improvement of road infrastructure, improvement of local commerce among others benefits that will impact positively in the local associations of the region.

- Secretaria Municipal de Meio Ambiente de Maceió

*Question:* What will be the use of landfill gas?

*Answer:* It was explained that the biogas will be combusting in group generators to produce electricity, using part of the electricity for self-consumption and the other part will be exported to the grid.

- SLUM – Superintendência Municipal de Limpeza Urbana de Maceió

*Question:* What is the impact on landfill stability due to implantation of active collection system of biogas?

*Answer:* It was explained that landfill operation has been a rigorous execution of design project with periodic geotechnical monitoring to avoid the destabilization of landfill.

No other questions or criticism was received, but recognition of the work being done by the PP and have emphasized the environmental benefits that the project will bring to the region.

### E.3. Report on consideration of comments received

>>

The PP considered every comment as welcome and was open to any criticism or suggestion to improve the project quality and its relationship with the local community and region. After the local stakeholder event, the PP concluded that until the moment no additional action was needed and decided to proceed with the project as initially planned.

## SECTION F. Approval and authorization

>>

The Letter of Approval (LoA) from the Party is not available.

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**Appendix 1: Contact information of project participants**

<b>Organization name</b>	ESTRE AMBIENTAL S/A.
<b>Street/P.O. Box</b>	Av. Juscelino Kubitschek, 1.830 – Torre 1 - 2º e 3º andar
<b>Building</b>	São Luiz
<b>City</b>	São Paulo
<b>State/Region</b>	SP
<b>Postcode</b>	-
<b>Country</b>	Brazil
<b>Telephone</b>	+55 (11) 3709-2300
<b>Fax</b>	-
<b>E-mail</b>	<a href="mailto:demetrios.christofidis@estre.com.br">demetrios.christofidis@estre.com.br</a>
<b>Website</b>	<a href="http://www.estre.com.br">www.estre.com.br</a>
<b>Contact person</b>	Demetrios Christofidis Jr
<b>Title</b>	Superintendent
<b>Salutation</b>	Mr
<b>Last name</b>	Christofidis
<b>Middle name</b>	
<b>First name</b>	Demetrios
<b>Department</b>	New business and Strategy
<b>Mobile</b>	-
<b>Direct fax</b>	-
<b>Direct tel.</b>	-
<b>Personal e-mail</b>	<a href="mailto:demetrios.christofidis@estre.com.br">demetrios.christofidis@estre.com.br</a>

**Appendix 2: Affirmation regarding public funding**

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

**Appendix 3: Applicability of selected methodology**

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

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

The baseline study and monitoring methodology was developed by:

Econergy Brasil Ltda, São Paulo, Brazil

Telephone: +55 (11) 3555-5700

Contact person: Mr. Francisco do Espírito Santo Filho

Mr. Javier Montalvo Andia

Mr. João Sprovieri

Mr. Gustavo Dorregaray

Email:



[francisco.santo@econergy.com.br;](mailto:francisco.santo@econergy.com.br;)  
[javier.montalvo@econergy.com.br;](mailto:javier.montalvo@econergy.com.br;)  
[joao.sprovieri@econergy.com.br](mailto:joao.sprovieri@econergy.com.br;)  
[gustavo.dorregaray@econergy.com.br](mailto:gustavo.dorregaray@econergy.com.br;)

Econergy Brasil Ltda is not a Project Participant.

The table below shows the key elements used for estimate the emissions of the emission reductions.

### 1. Key Parameters

Year landfilling operations started	Apr/2010
Projected year for landfill closure - estimated based on current filling rate	2034
GWP for methane (UNFCCC and Kyoto Protocol decisions)	21
Methane concentration in LFG (% by volume) typical assumption for baseline scenario	50
LFG collection efficiency (%)	75
Electricity consumption from the grid due to the project activity (MWh/year)	609
Electricity consumption from the diesel generator due to the project activity (MWh/year)	0
Unit price of electricity sold to the grid (R\$/MWh)	102.18
Combined margin emission factor for electricity displacement (tCO <sub>2</sub> /MWh) calculated based on the “Tool to calculate the emission factor for an electricity system”.	0.1988
Installed capacity of Power Plant (MW)	10.5
Load factor (%)	94.00
Price per MW installed (R\$/MWe)	2,391,687.73
O&M average costs (R\$/MWh) (R\$/MWh)	33.29
Operational lifetime of the project activity (years)	25
LFG destruction rate	20%

### 2. Waste disposal

The forecast amount of waste disposal in project activity is presented below:

**Table 18 - Forecast amount of waste disposal in project activity**

<b>Year</b>	<b>Waste disposal (tonnes/yr)</b>
2010	184,011.32
2011	299,314.81
2012	335,311.75
2013	344,331.63
2014	353,594.16
2015	363,105.84
2016	372,873.39
2017	382,903.68
2018	393,203.79
2019	403,780.97
2020	414,642.68
2021	425,796.57
2022	437,250.49
2023	449,012.53
2024	461,090.97
2025	473,494.32
2026	486,231.31
2027	499,310.94
2028	512,742.40
2029	526,535.17
2030	540,698.97
2031	555,243.77
2032	570,179.83
2033	585,517.66
2034	601,268.09

**Table 19- Composition of the waste<sup>22</sup>**

A) Wood and wood products	0.60%
B) Pulp, paper and carboard (other than sludge)	11.20%
C) Food, food waste, beverages and tobacco (other than sludge)	52.60%
D) Textiles	3.30%
E) Garden, yard and park waste	19.60%
F) Glass, plastic, metal, other inert waste	12.70%
<b>TOTAL</b>	<b>100.0%</b>

<sup>22</sup> Source: GALVÃO, L. E. - Caracterização dos resíduos sólidos urbanos de Maceió, Universidade Federal de Alagoas



### 3. Emission factors

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

Combined Margin Emission Factor 2011 (tCO <sub>2</sub> /MWh)	
1 <sup>st</sup> crediting Period	0.1988
Build Margin - 2011	0.1056
Operating Margin 2011	January 0.2621
	February 0.2876
	March 0.2076
	April 0.1977
	May 0.2698
	June 0.341
	July 0.3076
	August 0.3009
	September 0.2734
	October 0.3498
	November 0.3565
	December 0.3495
	2011 0.2920

Source: Brazilian DNA<sup>23</sup>

### Appendix 5: Further background information on monitoring plan

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

### Appendix 6: Summary of post registration changes

It was left blank intentionally.

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<sup>23</sup> Emission factor from Brazilian DNA: <http://www.mct.gov.br/index.php/content/view/333605.html#ancora> accessed on 08/08/2012

**History of the document**

<b>Version</b>	<b>Date</b>	<b>Nature of revision</b>
04.1	11 April 2012	Editorial revision to change version 02 line in history box from Annex 06 to Annex 06b.
04.0	EB 66 13 March 2012	Revision required to ensure consistency with the “Guidelines for completing the project design document form for CDM project activities” (EB 66, Annex 8).
03	EB 25, Annex 15 26 July 2006	
02	EB 14, Annex 06b 14 June 2004	
01	EB 05, Paragraph 12 03 August 2002	Initial adoption.

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