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

PROJECT DESIGN DOCUMENT (PDD)

Title of the project activity	CGR Catanduva Landfill Gas Project
Version number of the PDD	2
Completion date of the PDD	28/06/2012
Project participant(s)	CGR Catanduva – Centro de Gerenciamento de Resíduos Ltda
Host Party(ies)	Brazil
Sectoral scope and selected methodology(ies)	Sectoral Scope: 13 Methodology: ACM0001 – version 13.0.0
Estimated amount of annual average GHG emission reductions	70,210

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)[1] produced in anaerobic conditions into the landfill called "C*entro de Gerenciamento de Resíduos Catanduva*" (hereinafter referred to as *CGR Catanduva*) located in the municipality of Catanduva in the state of São Paulo, Brazil.

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

- Burning CH_4 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_2 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 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 70,210 tCO_2e;
- Total GHG emission reduction is 491,467 tCO_2e.

The project activity includes two phases: The first phase (from 2013 to 2015) will be to capture and to flare the LFG. The second phase (2016 to 2037) will be the implementation of a power generation plant that will use LFG to generate electricity. The installed generation capacity will be expected to change during the lifetime of the project, totalizing at the end 4.5 MW.

The first phase of the project will be to construct an efficient capture, collection and flaring system to burn CH_4 (a greenhouse gas) in closed flares, and this will reduce odours and adverse environmental impacts.

During the second phase, the project 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 4.5 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 of the second phase[2].

[1] 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.

[2] The installed capacity by generator group may vary between 1.426 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.

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 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 2009, receiving solid waste (type Class II-A Inert and Class II-B Non-inert)[3], according to License of Operation Nº 14004618 valid up to 20/08/2016 issued by the environmental agency CETESB (*Companhia Ambiental do Estado de São Paulo*). Currently, the landfill is requesting an expansion of waste disposal capacity (tons/day) and has already been issued a preliminary environmental license N^{o} 2025 for this expansion.

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 second phase of 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 CGR Catanduva 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)
>>
Brazil

A.2.2. Region/State/Province etc.
>>
São Paulo

A.2.3. City/Town/Community etc.
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[3] According to definition of the Brazilian Association of Technical Norms (ABNT NBR 10004) http://www.aslaa.com.br/legislacoes/NBR%20n%2010004-2004.pdf

Catanduva

A.2.4. Physical/Geographical location

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CGR Catanduva is located at Estrada Municipal CTV 020, S/N, Fazenda Santa Fé, Catanduva (city), São Paulo (State), Brazil.

Geo-coordinates: Latitude: 21°7’23.69” S; Longitude: 48°55’41.65” W.
Decimal coordinates: Latitude: -21.123247° Longitude: -48.928236°

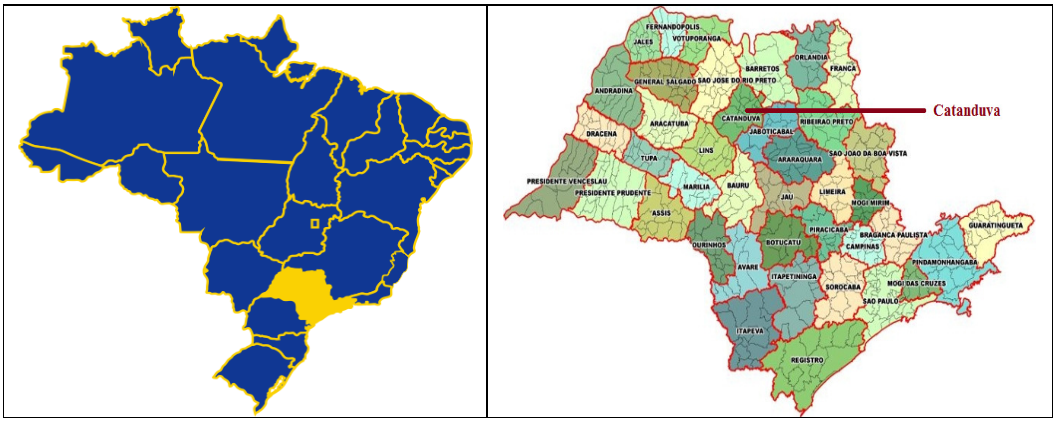

Figure 1 - Geographical position of Catanduva city, inside of São Paulo State in Brazil
(Source: http://www.cati.sp.gov.br/new/enderecos.php)

Figure 2 – CGR Catanduva

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 collection system (manifolds)
Source: Cenbio, 2006

CGR Catanduva 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.

<u>**Transport System**</u>

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.

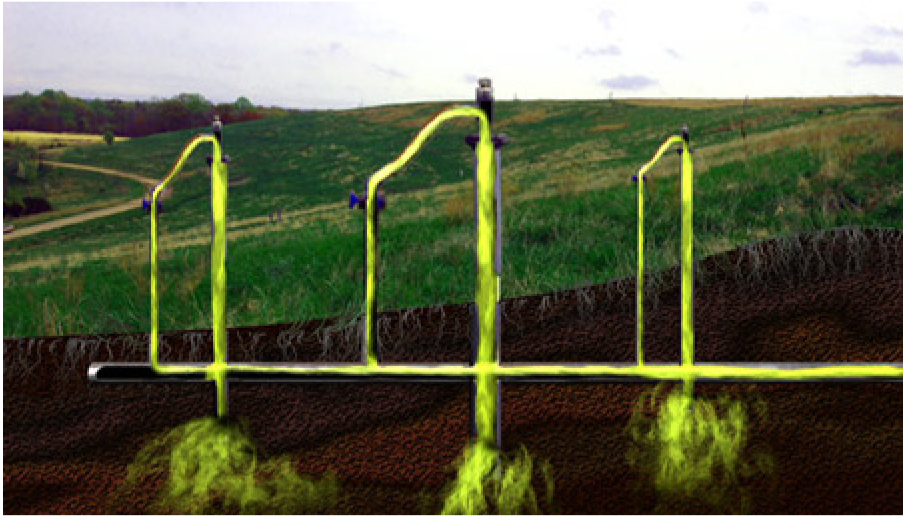

Figure 5 - Illustrative of transport system
Source: Landfill Methane Outreach Program - EPA

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 1,000 to 3,000 Nm³/h per each blower and the installed capacity around 75 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 flares).

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 - Example of a flare system (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.

The biogas station will have, even a system of destruction of methane through flares. This system will be composed initially by 1 enclosure flare with a capacity of 2,000 Nm^3/h and can get others units of 2,000 Nm^3/h each, 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 (around 1,000 º C), controlled by the admission of air, and with a residence time > 0.3 seconds.

Power generation

The power generation system will be comprised of around 4.5 MW. The electricity generated by the project will be supplied to the grid.

This kind of technology is still not widely applied in Brazil. The publication named "Reducing the uncertainty of methane recovered (R) in greenhouse gas inventories from waste sector and of adjustment factor (AF) in landfill gas projects under the Clean Development Mechanism[4]" states that:

> *"…all of Brazilian landfills with collection and destruction system (active system) are implemented projects under the CDM…".*

Additionally, the PP carried out a survey in order to verify the existence of any landfill with LFG collection and destruction active system not register as a CDM Project. 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 advice 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 1.426 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.

[4] Source: MAGALHÃES, G.HC.; ALVES, J.W.S.; SANTO FILHO. F.; COSTA, R.M.; KELSON. M. Reducing the uncertainty of methane recovered (R) in greenhouse gas inventories from waste sector and of adjustment factor (AF) in landfill gas projects under the clean development mechanism (2010). Page 174. (http://ghg.org.ua/fileadmin/user_upload/book/Proceedengs_UncWork.pdf), accessed on 25/06/2012.

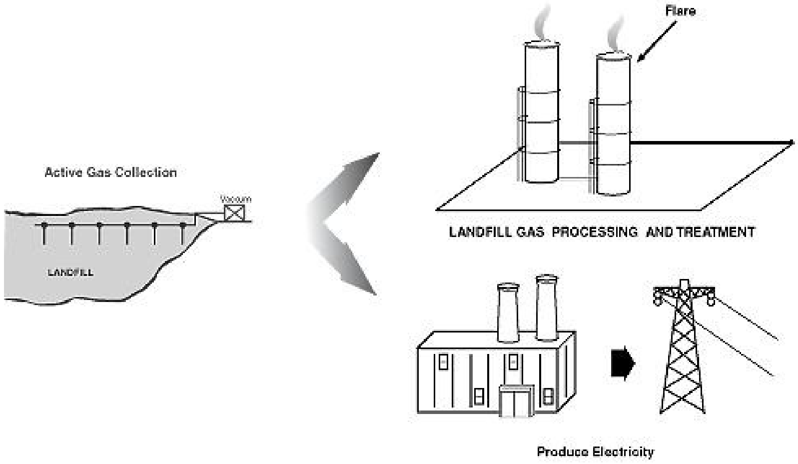

Figure 8 – Power generation diagram

It is important to clarify that the authorization to generate electricity to Brazilian Electricity Regulatory Agency (ANEEL) has not been request yet.

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

Table 1 - Electricity generation

Year	Number of engines installed (unit)	Installed capacity (MW)*	Electricity generated in the plant (MWh)
2013	0	0.0	0
2014	0	0.0	0
2015	0	0.0	0
2016	2	3.0	13,529
2017	2	3.0	15,573
2018	2	3.0	17,365
2019	2	3.0	19,149

*The total installed capacity will be expected since 2021 with 4.5 MW and 3 installed group-generators.

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)[5]. 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.

[5] The lifetime of the equipments is also supported by the International Energy Agency (IEA) World energy model – Methodology and assumptions, page 13.

The load factor is 94.38% and the nominal engine efficiency is 39.8%. Both information it were based on manufacturer's specification[6].

Technology will have to come from 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, because all equipment involved has the highest level of development, and the technology used to combust LFG to produce electricity is not a usual business practice in Brazil, as demonstrated in Section B.5.

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

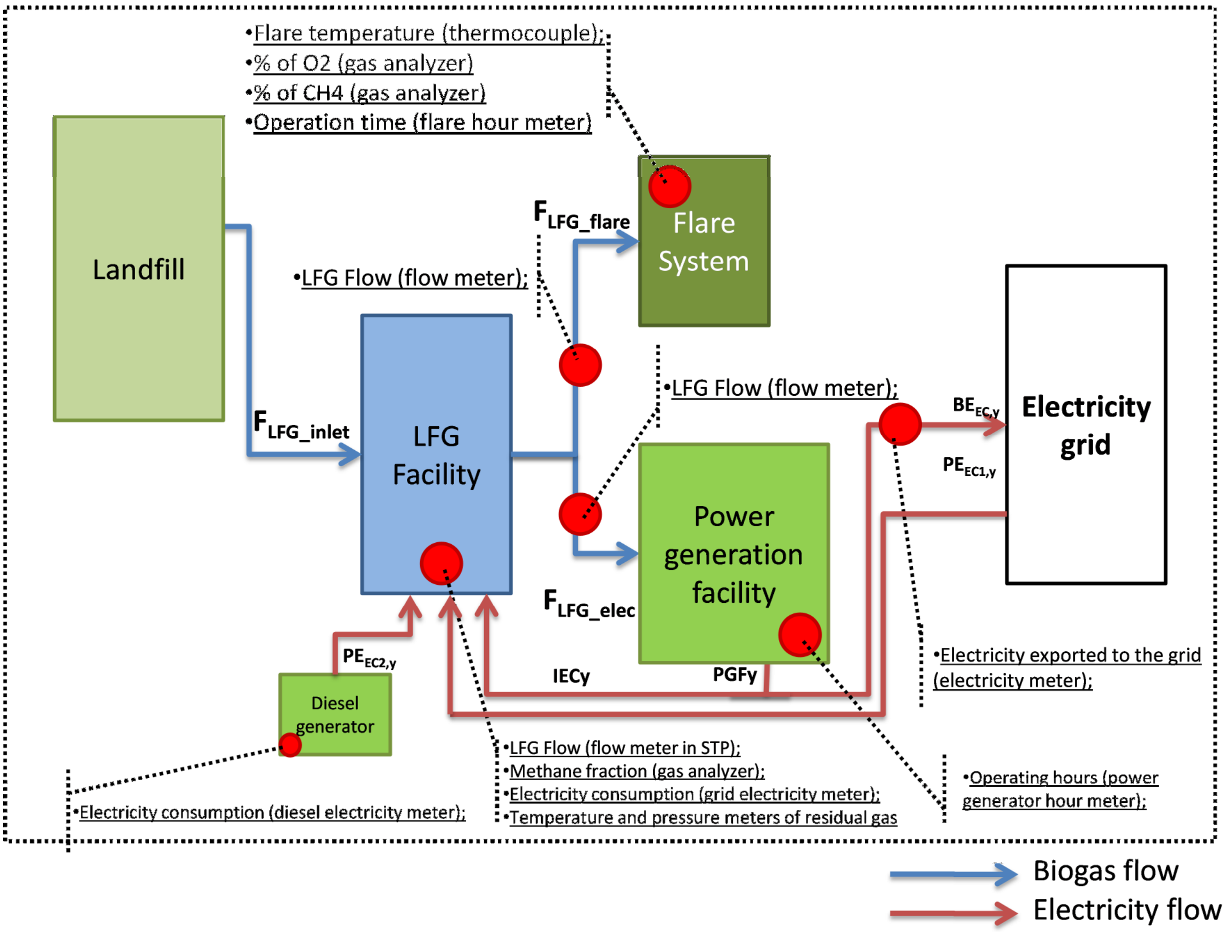

Figure 9 - Technologies and measures of the project activity

Defined as:

F_{LFG_inlet}	Inlet LFG in the project activity
F_{LFG_flare}	LFG which is destroyed by flaring
F_{LFG_elec}	LFG which is used for electricity generation

Where:

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

$$F_{LFG\_inlet} = F_{LFG\_flare} + F_{LFG\_elec}$$

And,

$BE_{EC,y}$	Electricity generation to the grid
$PE_{EC1,y}$	Electricity consumption from the grid
$PE_{EC2,y}$	Electricity consumption from the diesel generator
PGF_y	Electricity generated for internal needs and/or to the grid.
IEC_y	Electricity consumption by the auxiliary equipments generated in the power generation facility.

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

And,

$$PGF_y = BE_{EC,y} + IEC_y$$

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)	CGR Catanduva – Centro de Gerenciamento de Resíduos Ltda (private entity)	No

CGR Catanduva belongs to Geovision S.A.E and Santo Zuliani.

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_2 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.

In the first phase of the project activity the LFG will be only flared and during the second phase will generate electricity.

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

"...

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

a) *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 kiln or glass melting furnace;*

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

	Source	GHGs	Included?	Justification/Explanation
Baseline scenario	Emissions from decomposition of waste at the SWDS site	CH_4	Yes	The major source of emissions in the baseline.
		N_2O	No	N_2O emissions are small compared to CH_4 emissions from SWDS. This is conservative.
		CO_2	No	CO_2 emissions from decomposition of organic waste are not accounted since the CO_2 is also released under the project activity.
	Emissions from electricity generation	CO_2	Yes	Major emission source if power generation is included in the project activity.
		CH_4	No	Excluded for simplification. This is conservative.
		N_2O	No	Excluded for simplification. This is conservative.
	Emissions from heat generation	CO_2	No	There is no heat generation.
		CH_4	No	There is no heat generation.
		N_2O	No	There is no heat generation.
	Emissions from the use of natural gas	CO_2	No	There is no use of natural gas.
		CH_4	No	There is no use of natural gas.
		N_2O	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_2	No	There is no fossil fuel consumption for purposes other than electricity generation or transportation due to the project activity
		CH_4	No	There is no fossil fuel consumption for purposes other than electricity generation or transportation due to the project activity
		N_2O	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_2	Yes	May be an important emission source.
		CH_4	No	Excluded for simplification. This emission source is assumed to be very small.
		N_2O	No	Excluded for simplification. This emission source is assumed to be very small.

The flow diagram is presented below:

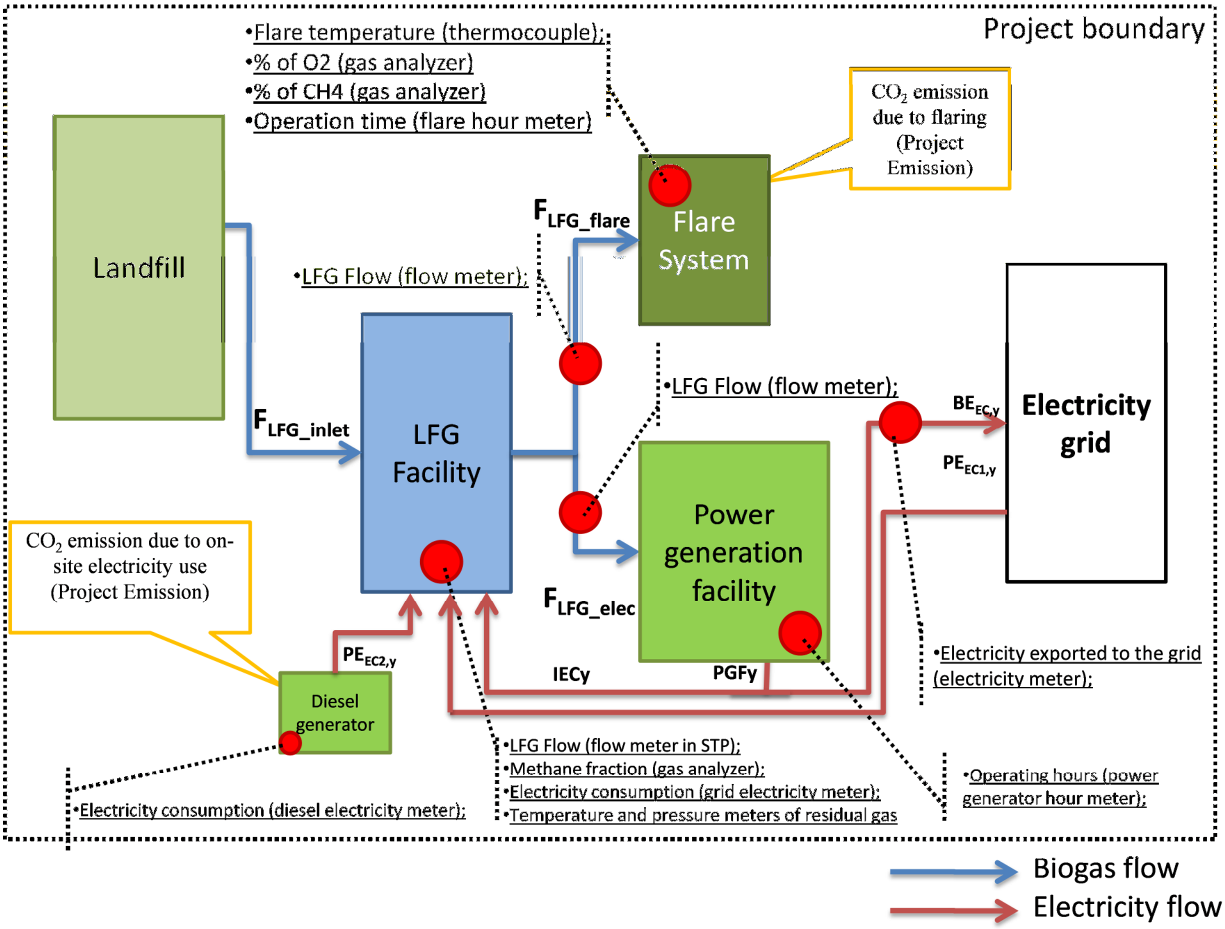

Figure 10 – Flow diagram project boundary

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 participant (PP) will monitor all relevant policies and circumstances at the beginning of each crediting period and adjust the baseline accordingly.

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

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

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

As the EIA (Environmental Impact Assessment) does not cover recycling, treatment or incineration of organic 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:

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

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

The project activity does not aim heat generation organic. 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),[7] ratified by the President on 02/08/2010 after 19 years under

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

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);
- 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
Contract agreement with CDM consultancy to develop the CDM Project.	23/12/2011
Prior Consideration of the CDM to UNFCCC and Brazilian DNA	20/04/2012
Contract between Designed Operational Entity (DOE) and the PP for the validation process.	May/2012
Submit the PDD for Global Stakeholder Consultation (GSC).	May/2012
The starting date of the project activity will be the purchase of the main equipment.*	Nov/2012
Start-up – Phase I*	January/2013
Commercial operation – Phase II*	January/2016

*Estimated

The project participants notified on 20/04/2012 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 in section B.4.

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 met 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"*[8]

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

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 (Report from EB 62 - Group 1 / Brazil) of the "Guidelines on the assessment of investment analysis" - version 05. The value was 11.75%.

[8] http://www.bndes.gov.br/SiteBNDES/bndes/bndes_pt/Institucional/Apoio_Financeiro/Produtos/Project_Finance/index.html

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

Table 3 - key points of the financial analysis

	CGR Catanduva Landfill Gas Project			
	Assumptions			
	Parameter	**Value**	**Unit**	Reference
Assumptions	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	3	unit	Based on the feasibility study
	Total installed capacity	4.5	MW	Based on the feasibility study
	Price per MW installed	2,260,852.89	R$/MWe	Based on the manufacturer proposal
	Investment in biogas plant	3,843.78	kR$	Calculated in cash flow
	Investment in power electricity plant	10,173.84	kR$	Calculated in cash flow
	Total investment in the CDM project	14,017.62	kR$	Calculated in cash flow
	Load factor	94.38%	%	Based on the manufacturer proposal dated
	O&M costs	47.98	R$/MWh	Calculated as the average from the whole period. The range varies between 46.9 and 71.6 R$ /MWh.
	Electricity price	102.18	R$/MWh	The highest value from the last auctions held in Brazil 3 years prior to the starting date of the project activity. (Source: Electric Power Commercialization Chamber - CCEE)
	Tax - IRPJ (income tax)	25%	%	Incomex tax (http://www.receita.fazenda.gov.br/legislacao/ins/Ant2001/Ant1997/1995/insrf05195.htm), accessed on 25/06/2012.
	Tax - CSLL (social contribution)	9%	%	Social contribution (http://www.planalto.gov.br/ccivil_03/LEIS/L7689.htm), accessed on 25/06/2012.
	Tax (PIS)	1.65%	%	Contribution to the Social Integration Program and Civil Service Asset Formation Program – PIS/PASEP (http://www.receita.fazenda.gov.br/principal/Ingles/SistemaTributarioBR/Taxes.htm), accessed on 25/06/2012.
	Tax (Cofins)	7.60%	%	COFINS - Contribution to Social Security Financing (http://www.receita.fazenda.gov.br/principal/Ingles/SistemaTributarioBR/Taxes.htm), accessed on 25/06/2012.
	Depreciation	5	years	Secretary of the Federal Revenue of Brazil. Available on http://www.receita.fazenda.gov.br/legislacao/ins/ant2001/1998/in16298ane1.htm, accessed on 02/03/2012. Item: 8501. As the group generators will work in 3 shift of operation, a coefiecient of 2 was considered for accelerated depreciation, according to Federal Revenue of Brazil (RIR/99, art. 313). Available on http://www.receita.fazenda.gov.br/pessoajuridica/dipj/2002/pergresp2002/pr371a375.htm, accessed on 25/06/2012.
	Commercial Lending rate	10.97%	%	Available on http://www.bndes.gov.br/SiteBNDES/bndes/bndes_pt/Institucional/Apoio_Financeiro/Produtos/FINEM/energias_alternativas.html, accessed on 25/06/2012.
	Debt term	16	years	Available on http://www.bndes.gov.br/SiteBNDES/bndes/bndes_pt/Institucional/Apoio_Financeiro/Produtos/FINEM/energias_alternativas.html, accessed on 25/06/2012.
	Salvage value	0	R$	Cash flow spreadsheet

Note: All numbers are in Brazilian Real (R$).

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
Biogas flaring and Electricity generation		YEARLY INVESTIMENT ANALYSIS										
		2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
INCOME x COSTS ANALYSIS												
Dispatched electricity (MWh/year)			-992	-992	-992	13,529	15,573	17,365	19,149	23,288	26,346	28,660
Electricity Price (R$/MWh)			102	102	102	102	102	102	102	102	102	102
Electricity reveneus (kR$)			-101	-101	-101	1,382	1,591	1,774	1,957	2,380	2,692	2,928
Gross Reveneus (kR$)			-101	-101	-101	1,382	1,591	1,774	1,957	2,380	2,692	2,928
Tax (PIS/Cofins)	9.25%		0	0	0	-128	-147	-164	-181	-220	-249	-271
Net reveneus			-101	-101	-101	1,254	1,444	1,610	1,776	2,159	2,443	2,658
O&M Costs - Biogas plant			-532	-532	-532	-532	-532	-532	-532	-532	-532	-532
O&M Costs - Electricity generation			0	0	0	-969	-730	-814	-897	-1,091	-1,234	-1,343
O&M Total Costs			-532	-532	-532	-1,501	-1,262	-1,346	-1,430	-1,624	-1,767	-1,875
Operational Results - EBITDA			-634	-634	-634	-247	182	264	346	536	676	782
Depreciation			-769	-769	-769	-2,125	-2,125	-1,357	-1,357	-1,357	-678	-678
EBIT			-1,403	-1,403	-1,403	-2,372	-1,943	-1,092	-1,010	-821	-2	104
			-198	-184	-171	-158	-145	-132	-119	-105	-92	-79
						-349	-326	-302	-279	-256	-233	-209
											-174	-163
Interests			-198	-184	-171	-507	-470	-434	-398	-361	-499	-451
EBT			-1,600	-1,587	-1,574	-2,879	-2,414	-1,526	-1,408	-1,182	-501	-347
IRPJ/ CSLL taxes (Real Profit Regime)	34%		0	0	0	0	0	0	0	0	0	0
Depreciation			769	769	769	2,125	2,125	1,357	1,357	1,357	678	678
Net operational profit			-831	-818	-805	-754	-288	-170	-52	175	177	331
CapEx												
CapEx - Biogas plant		-3,844	0	0	0	0	0	0	0	0	0	0
CapEx - Electricity Generation		0	0	0	-6,783	0	0	0	0	-3,391	0	0
Drawdown of debt		1,922	0	0	3,391	0	0	0	0	1,696	0	0
Debt Repayment		0	-120	-120	-120	-332	-332	-332	-332	-332	-438	-438
Net Cash Flow Equity		-1,922	-952	-938	-4,317	-1,086	-621	-502	-384	-1,853	-261	-107

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

Benchmark	11.75%
NPV (25 years)	-8,670.92

11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037
30,456	29,695	29,307	29,162	29,983	30,694	31,271	32,181	32,917	33,529	34,050	34,502	26,788	21,371	17,512
102	102	102	102	102	102	102	102	102	102	102	102	102	102	102
3,112	3,034	2,995	2,980	3,064	3,136	3,195	3,288	3,364	3,426	3,479	3,525	2,737	2,184	1,789
3,112	3,034	2,995	2,980	3,064	3,136	3,195	3,288	3,364	3,426	3,479	3,525	2,737	2,184	1,789
-288	-281	-277	-276	-283	-290	-296	-304	-311	-317	-322	-326	-253	-202	-166
2,824	2,754	2,718	2,704	2,780	2,846	2,900	2,984	3,052	3,109	3,157	3,199	2,484	1,982	1,624
-532	-532	-532	-532	-532	-532	-532	-532	-532	-532	-532	-532	-532	-532	-532
-1,427	-1,391	-1,373	-1,366	-1,405	-1,438	-1,465	-1,508	-1,542	-1,571	-1,595	-1,616	-1,255	-1,001	-820
-1,959	-1,924	-1,905	-1,899	-1,937	-1,970	-1,998	-2,040	-2,075	-2,103	-2,128	-2,149	-1,787	-1,534	-1,353
865	830	812	805	843	876	902	944	978	1,006	1,030	1,050	697	448	271
-678	-678	-678	0	0	0	0	0	0	0	0	0	0	0	0
187	152	134	805	843	876	902	944	978	1,006	1,030	1,050	697	448	271
-66	-53	-40	-26	-13	-0	-0	-0	-0	-0	-0	-0	-0	-0	-0
-186	-163	-140	-116	-93	-70	-47	-23	-0	-0	-0	-0	-0	-0	-0
-151	-140	-128	-116	-105	-93	-81	-70	-58	-47	-35	-23	-12	-0	-0
-403	-355	-307	-259	-211	-163	-128	-93	-58	-47	-35	-23	-12	-0	-0
-216	-203	-173	547	632	713	774	851	920	959	995	1,027	685	448	271
0	0	0	-186	-215	-242	-263	-289	-313	-326	-338	-349	-233	-152	-92
678	678	678	0	0	0	0	0	0	0	0	0	0	0	0
462	475	505	361	417	471	511	562	607	633	657	678	452	296	179
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
-438	-438	-438	-438	-438	-438	-318	-318	-318	-106	-106	-106	-106	-106	0
24	37	67	-77	-21	33	193	244	289	527	551	572	346	190	179

According to the cash flow, the NPV of scenario 1 is kR$ -8,670.92. Consequently, this scenario is not deemed attractive by the project participants.

Scenario 4 (LFG2 + E3)

The scenario 4 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% (kR$)
Scenario 1	-8,670.92
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 (kR$)	
		Scenario 1	Scenario 4
CapEx	-10%	-7,710.13	0
	10%	-9,631.71	0
Revenues	-10%	-9,758.00	0
	10%	-7,604.81	0
O&M	-10%	-7,703.39	0
	10%	-9,639.85	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.

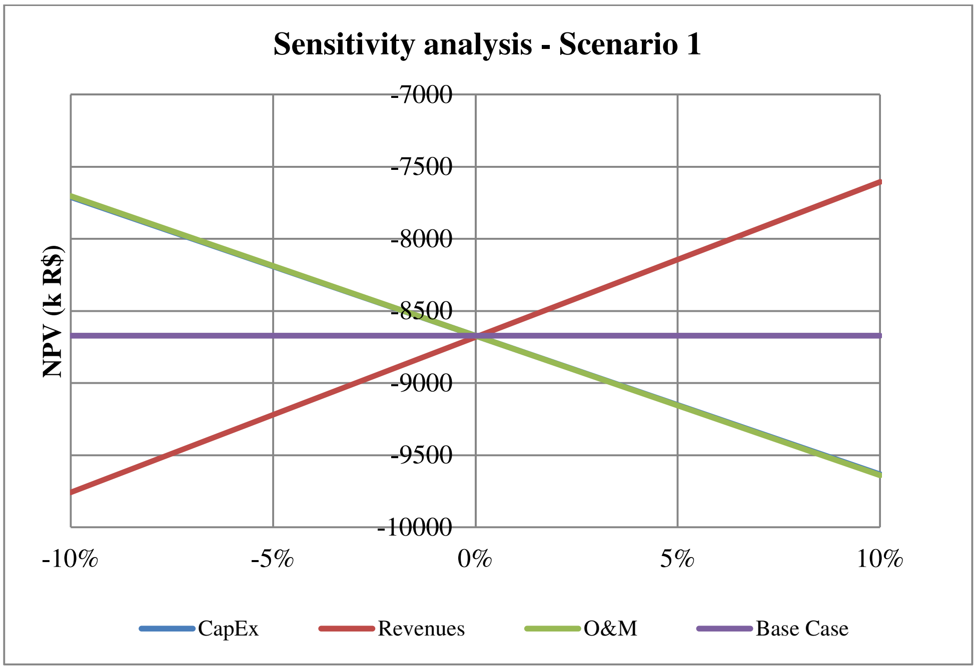

Figure 11 - Sensitivity analysis – Scenario 1 (in Brazilian Reais - kR$)

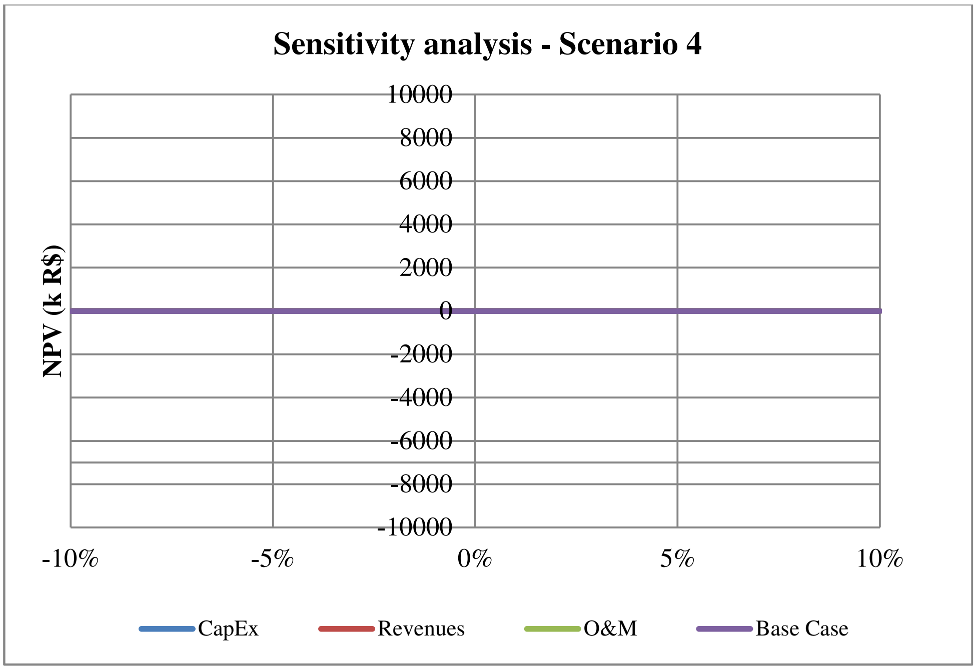

Figure 12 - Sensitivity analysis – Scenario 4 (in Brazilian Reais - kR$)

Breakeven point

To ensure the additionality of this project activity, the project proponents varied the three identified parameters (CapEx, Revenues and O&M) until each of them reached the benchmark (i.e. 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 90.7%. 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 90.7% to reach the benchmark. This means that the electricity tariff should reach R$ 195.10 or the maximum annual electricity generated reaches 65,877 MWh[9], 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	12th New Energy Auction	102.07
20/12/2011	13th New Energy Auction	102.18[10]

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 98.1%. 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% (kR$)	Rank
Scenario 1	-8,670.92	Worst scenario
Scenario 4	0	Best scenario

[9] Note: It is important to notice that for the revenues to increase 90.9% the LFG production should increase 139.9%, since the collection efficiency of the biogas plant is 65%.

[10] 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 measures 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 4.5 MW. Then, the output range of the project activity is from 2.25 to 6.75 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[11]. The total of the plants is 102. Then, $N_{all} = 102$.

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

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

Then, $N_{diff} = 102$ or $N_{all} = N_{diff}$.

[11] 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 "*4.5 MW CGR Catanduva common practice.xlsx*"

Sub-step 4a (4): Calculate factor F=1 - 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.

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

$$F = 1 - \left(\frac{102}{102}\right)$$

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_2e/yr)
$BE_{CH4,y}$	=	Baseline emissions of methane from the SWDS in year *y* (t CO_2e/yr)
$BE_{EC,y}$	=	Baseline emissions associated with electricity generation in year *y* (t CO_2/yr)
$BE_{HG,y}$	=	Baseline emissions associated with heat generation in year *y* (t CO_2/yr)
$BE_{NG,y}$	=	Baseline emissions associated with natural gas use in year *y* (t CO_2/yr)

As the project 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:

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

Where:

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

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

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

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

Where:

$F_{CH4,PJ,y}$	=	Amount of methane in the LFG which is flared and/or used in the project activity in year y (tCH_4/yr)
$F_{CH4,flared,y}$	=	Amount of methane in the LFG which is destroyed by flaring in year y (t CH_4/yr)
$F_{CH4,EL,y}$	=	Amount of methane in the LFG which is used for electricity generation in year y (t CH_4/yr)
$F_{CH4,HG,y}$		Amount of methane in the LFG which is used for heat generation in year y (t CH_4/yr)
$F_{CH4,NG,y}$	=	Amount of methane in the LFG which is sent to the natural gas distribution network in year y (t CH_4/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;
- CH_4 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* ($O_{pj,h}$=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:

$F_{CH4,flared,y}$	=	Amount of methane in the LFG which is destroyed by flaring in year y (t CH_4/yr)
$F_{CH4,sent\_flare,y}$	=	Amount of methane in the LFG which is sent to the flare in year y (t CH_4/yr)

$PE_{flare,y}$ = Project emissions from flaring of the residual gas stream in year y (t CO_2e/yr)
GWP_{CH4} = Global warming potential of CH_4 (t CO_2e/t CH_4)

$F_{CH4,sent\_flare,y}$ will be determined directly using the "Tool to determine the mass flow of a greenhouse gas in a gaseous stream", applying the requirements described 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)[12] 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^3);
$FV_{RG,h}$ = 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^3/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,

[12] 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);

$$V_{n,FG,h} = V_{n,CO2,h} + V_{n,O2,h} + V_{n,N2,h}$$

Where:

$V_{n,N2,h}$ = 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);
$V_{n,O2,h}$ = 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);
$V_{n,CO2,h}$ = 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);

$$V_{n,O2,h} = n_{O2,h} \times MV_n$$

$n_{O2,h}$ = Quantity of moles O_2 in the exhaust gas of the flare per kg residual gas flared in hour *h* ($kmol/kg_{residual\_gas}$);
MV_n = Volume of one mole of any ideal gas at normal temperature and pressure (22.4 L/mol) (in m^3/kmol);

$$V_{n,CO2,h} = \frac{fm_{C,h}}{AM_C} \times MV_n$$

$fm_{C,h}$ = 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

$$V_{n,N2,h} = MV_n \cdot \left\{ \frac{fm_{N,h}}{200AM_n} + \left(\frac{1 - MF_{o_2}}{MF_{O_2}} \right) \cdot \left(F_h + n_{O_2,h} \right) \right\}$$

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_{O2} = O_2 volumetric fraction of air (0.21);
F_h = Stochiometric quantity of moles of O_2 required for a complete oxidation of one kg residual gas flared in hour h (kmol/kg residual gas);
$n_{O2,h}$ = Quantity of moles O_2 in the exhaust gas of the flare per kg residual gas flared in hour h (kmol/kg residual gas);

$$n_{O_2,h} = \frac{t_{O_2,h}}{(1 - (\frac{t_{O_2,h}}{MF_{O_2}}))} \times \left[\frac{fm_{C,h}}{AM_C} + \frac{fm_{N,h}}{2AM_N} + \left(\frac{1 - MF_{O2}}{MF_{O2}} \right) \times F_h \right]$$

$t_{O2,h}$ = Volumetric fraction of O_2 in the exhaust gas in the hour *h*;
MF_{O2} = O_2 volumetric fraction of air (0.21);
F_h = Stochiometric 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);
$fv_{CH4,FG,h}$ = 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 ($fv_{CH4,RG,h}$) and the density of methane ($\rho_{CH4,n,h}$) in the same reference conditions (normal conditions and dry or wet basis).

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

$FV_{RG,h}$ = Volume flow rate of the residual gas in dry basis at normal conditions in hour h (m^3/h);
$fv_{CH4,RG,h}$ = Volumetric fraction of methane in the residual gas on dry basis in hour h (NB: this corresponds to fvi,RG,h where i refers to methane).
$\rho_{CH4,n}$ = Density of methane at normal conditions (0.716 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°C during more than 20 minutes during the hour *h*;
- Determined as follows in cases where the temperature of the exhaust gas of the flare (T_{flare}) is above 500°C for more than 40 minutes during the hour *h*;

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

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:

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

$TM_{RG,h}$ = 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_4/yr)
$BE_{CH4,SWDS,y}$	=	Amount of methane in the LFG that is generated from the SWDS in the baseline scenario in year *y* (tCO_2e/yr)
η_{PJ}	=	Efficiency of the LFG capture system that will be installed in the project activity
GWP_{CH4}	=	Global warming potential of CH_4 (tCO_2e/tCH_4)

$BE_{CH4,SWDS,y}$ 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_2e / yr)
X	=	Years in the time period in which waste is disposed at the SWDS, extending from the first year in the time period (x = 1) to year y (x = y).
Y	=	Year of the crediting period for which methane emissions are calculated (y is a consecutive period of 12 months)
$DOC_{f,y}$	=	Fraction of degradable organic carbon (DOC) that decomposes under the specific conditions occurring in the SWDS for year y (weight fraction)
$W_{j,x}$	=	Amount of solid waste type j disposed or prevented from disposal in the SWDS in the year x (t)
φ_y	=	Model correction factor to account for model uncertainties for year y
f_y	=	Fraction of methane captured at the SWDS and flared, combusted or used in another manner that prevents the emissions of methane to the atmosphere in year y
GWP_{CH4}	=	Global Warming Potential of methane
OX	=	Oxidation factor (reflecting the amount of methane from SWDS that is 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_4/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:

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

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

The 20% is a default factor according to methodology ACM0001[13].

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

It was used the "Tool to calculate baseline, project and/or leakage emissions from electricity consumption" to calculate the baseline emissions associated with electricity generation.

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

Where:

$BE_{EC,y}$	Baseline emissions associated with electricity generation in year y (tCO_2/yr)
$EC_{BL,k,y} = EG_{PJ,y}$	Amount of electricity generated using LFG by the project activity in year (MWh)
$EF_{grid,CM,y}$	Combined margin emission factor of the applicable electricity system (tCO_2/MWh)
TDL_y	Average technical transmission and distribution losses in the grid in year y for the voltage level at which electricity is obtained from the grid at the project site (dimensionless).

Project emissions

The formula below was extracted from the methodology ACM0001:

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

Where:

PE_y	=	Project emissions in year *y* (tCO_2/yr)
$PE_{EC,y}$	=	Emissions from consumption of electricity due to the project activity in year *y* (tCO_2/yr)
$PE_{FC,y}$	=	Emissions from consumption of fossil fuels due to the project activity, for purpose other than electricity generation, in year *y* (tCO_2/yr)

[13] 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

There is no consumption of fossil fuels due to the project activity for purpose other than electricity generation, in year *y* (tCO_2/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_2/MWh);
TDL_y	Average technical transmission and distribution losses in the grid in year y for the voltage level at which electricity is obtained from the grid at the project site.

$PE_{EC2,y}$ - 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_2/MWh for project emissions from diesel generator(s).

$$PE_{EC2,y} = EC_{PJ2,y} \times EF_{diesel\_generator,y}$$

Where:

$EC_{PJ2,y} = EG_{EC2,y}$	Quantity of electricity consumed from diesel generator by the project activity during the year *y* (MWh);

$EF_{diesel\_generator,y}$ The emission factor for the diesel generator in year *y* (tCO_2/MWh);

Calculation of $PE_{FC,y}$ – 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_2e/yr);
BE_y = Baseline emissions in year y (tCO_2e/yr);
PE_y = Project emissions in year y (tCO_2e/yr);

B.6.2. Data and parameters fixed ex ante

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

Data / Parameter	GWP_{CH4}
Unit	t CO_2e/t CH_4
Description	Global warming potential of CH_4
Source of data	IPCC
Value(s) applied	21 for the first commitment period. Shall be updated according to any future COP/MOP decisions
Choice of data or Measurement methods and procedures	Default value used, according to ACM0001
Purpose of data	Calculation of baseline emission
Additional comment	-

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

Data / Parameter	η_{PJ}
Unit	Dimensionless
Description	Efficiency of the LFG capture system that will be installed in the project activity
Source of data	Feasibility study
Value(s) applied	65%
Choice of data or Measurement methods and procedures	Based on the active LFG capture system to be installed, according to technical specifications from the equipments provider.
Purpose of data	Calculation of baseline emission
Additional comment	-

Data / Parameter	$\varphi_{default}$
Unit	-
Description	Default value for the model correction factor to account for model uncertainties
Source of data	Tool "Emissions from solid waste disposal sites"
Value(s) applied	0.75
Choice of data or Measurement methods and procedures	According to "Emissions from solid waste disposal sites", the *Application A* was used because the project activity mitigates methane emissions from the landfill and the default value was applied for the wet climatic condition.
Purpose of data	Calculation of baseline emission
Additional comment	-

Data / Parameter	OX
Unit	-
Description	Oxidation factor (reflecting the amount of methane from SWDS that is oxidized in the soil or other material covering the waste)
Source of data	Based on an extensive review of published literature on this subject, including the IPCC 2006 Guidelines for National Greenhouse Gas Inventories
Value(s) applied	0.1
Choice of data or Measurement methods and procedures	Default value used according to "Emissions from solid waste disposal sites"
Purpose of data	Calculation of baseline emission
Additional comment	When methane passes through the top-layer, part of it is oxidized by methanotrophic bacteria to produce CO_2. The oxidation factor represents the proportion of methane that is oxidized to CO_2.This should be distinguished from the methane correction factor (MCF) which is to account for the situation that ambient air might intrude into the SWDS and prevent methane from being formed in the upper layer of SWDS.

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

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

Data / Parameter	$MCF_{default}$
Unit	-
Description	Methane correction factor
Source of data	IPCC 2006 Guidelines for National Greenhouse Gas Inventories
Value(s) applied	1.0
Choice of data or Measurement methods and procedures	The project activity is an anaerobic managed solid waste disposal 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) levelling of the waste;
Purpose of data	Calculation of baseline emission
Additional comment	-

<table>
<tr><td>Data / Parameter</td><td>DOC_j</td></tr>
<tr><td>Unit</td><td>-</td></tr>
<tr><td>Description</td><td>Fraction of degradable organic carbon in the waste type j (weight fraction)</td></tr>
<tr><td>Source of data</td><td>IPCC 2006 Guidelines for National Greenhouse Gas Inventories (adapted from Volume 5, Tables 2.4 and 2.5)</td></tr>
<tr><td>Value(s) applied</td><td>
<table>
<tr><th>Waste type j</th><th>DOCj
(% wet waste)</th></tr>
<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>
</table>
</td></tr>
<tr><td>Choice of data
or
Measurement methods and procedures</td><td>IPCC default value for anaerobic managed solid waste disposal site is applied.</td></tr>
<tr><td>Purpose of data</td><td>Calculation of baseline emission</td></tr>
<tr><td>Additional comment</td><td>-</td></tr>
</table>

Data / Parameter	kj
Unit	1/yr
Description	Decay rate for the waste type j
Source of data	IPCC 2006 Guidelines for National Greenhouse Gas Inventories (adapted from Volume 5, Table 3.3)
Value(s) applied	(see table below)
Choice of data or Measurement methods and procedures	IPCC default value for anaerobic managed solid waste disposal site is applied.
Purpose of data	Calculation of baseline emission
Additional comment	The information was provided in the Environmental Impact Assessment (EIA) of the project. The mean annual temperature (MAT) is 24.5ºC and the mean annual precipitation (MAP) 1,470 mm.

Waste type j		Tropical (MAT > 20 °C) Wet (MAP > 1,000mm)
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
Rapidly degrading	Food, food waste, sewage sludge, beverages and tobacco	0.40

Data / Parameter	$EF_{diesel\_generator}$
Unit	tCO_2/MWh
Description	Emission factor for the diesel generator
Source of data	Tool to calculate baseline, project and/or leakage emissions from electricity consumption
Value(s) applied	1.3
Choice of data or Measurement methods and procedures	The diesel generator is an off-grid fossil fuel fired captive power plant. Thus, the default value of the Scenario B2 was applied.
Purpose of data	Calculation of project emission
Additional comment	-

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

Compound	Structure	Molecular mass (kg/kmol)
Carbon dioxide	CO_2	44.01
Methane	CH_4	16.04
Nitrous oxide	N_2O	44.02
Sulfur hexafluoride	SF_6	146.06
Perfluoromethane	CF_4	88.00
Perfluoroethane	C_2F_6	138.01
Perfluoropropane	C_3F_8	188.02
Perfluorobutane	C_4F_{10}	238.03
Perfluorocyclobutane	c-$C4F_8$	200.03
Perfluoropentane	C_5F_{12}	288.03
Perfluorohexane	C_6F_{14}	338.04

<table>
<tr><td>Data / Parameter</td><td>MM_k</td></tr>
<tr><td>Unit</td><td>kg/kmol</td></tr>
<tr><td>Description</td><td>Molecular mass of gas k</td></tr>
<tr><td>Source of data</td><td>Tool to determine the mass flow of a greenhouse gas in a gaseous stream</td></tr>
<tr><td>Value(s) applied</td><td>
<table>
<tr><th>Compound</th><th>Structure</th><th>Molecular mass (kg/kmol)</th></tr>
<tr><td>Nitrogen</td><td>N_2</td><td>28.01</td></tr>
<tr><td>Oxygen</td><td>O_2</td><td>32.00</td></tr>
<tr><td>Carbon monoxide</td><td>CO</td><td>28.01</td></tr>
<tr><td>Hydrogen</td><td>H_2</td><td>2.02</td></tr>
<tr><td>Nitric oxide</td><td>NO</td><td>30.01</td></tr>
<tr><td>Nitrogen dioxide</td><td>NO_2</td><td>46.01</td></tr>
<tr><td>Sulfur dioxide</td><td>SO_2</td><td>64.06</td></tr>
</table>
</td></tr>
<tr><td>Choice of data or Measurement methods and procedures</td><td>According to “Tool to determine the mass flow of a greenhouse gas in a gaseous stream”</td></tr>
<tr><td>Purpose of data</td><td>Calculation of baseline emissions</td></tr>
<tr><td>Additional comment</td><td>-</td></tr>
</table>

Data / Parameter	MM_{H2O}
Unit	kg/kmol
Description	Molecular mass of water
Source of data	Tool to determine the mass flow of a greenhouse gas in a gaseous stream
Value(s) applied	18.0152,,
Choice of data or Measurement methods and procedures	According to “Tool to determine the mass flow of a greenhouse gas in a gaseous stream”
Purpose of data	Calculation of baseline emissions
Additional comment	-

B.6.3. Ex ante calculation of emission reductions

>>

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 signification transmission constraints.

The Brazilian DNA published an official delineation of the project electricity system in Brazil, considering a national interconnected system.[14]

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 determined the operating margin (OM)

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

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

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

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

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

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

The emission factor is calculated as follows:

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

Where:

$EF_{grid,OM-DD,y}$	=	Dispatch data analysis operating margin CO_2 emission factor in year *y* (tCO_2/MWh)
$EG_{PJ,h}$	=	Electricity displaced by the project activity in hour *h* m of year *y* (MWh)
$EF_{EL,DD,h}$	=	CO_2 emission factor for power units in the top of the dispatch order in hour *h* in year *y* (tCO_2/MWh)
$EG_{PJ,y}$	=	Total electricity displaced by the project activity in year *y* (MWh)
h	=	hours in year y in which the project activity is displacing grid electricity
y	=	Year in which the project activity is displacing grid electricity

The $EF_{EL,DD,h}$, $EF_{EL,DD,d}$ and $EF_{EL,DD,m}$ are displayed on the Brazilian DNA website[15], for the year 2010. However only the $EF_{EL,DD,m}$ will be used in order to calculate the emission reductions.

[14] DNA Resolution n.8 was published on 26/05/2008 on http://www.mct.gov.br/index.php/content/view/14797.html, accessed on 12/08/2010.
[15] Source: http://www.mct.gov.br/index.php/content/view/327118.html#ancora, accessed on 04/04/2012.

In order to estimate the emission reductions for the first crediting period the $EF_{EL,DD,2010}$ was calculated as a mean average of the $EF_{EL,DD,m}$. Then,

$EF_{grid,OM-DD,2010} = 0.4787$ tCO_2/MWh.

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

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

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

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

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

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

The build margin emissions factor is the generation-weighted average emission factor (tCO_2/MWh) of all power units m during the most recent year y for which power generation data is available, calculated as follows:

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

$EF_{grid,BM,2010} = 0.1404$ tCO_2/MWh

Step 6. Calculate the combined margin emissions factor

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

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

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

$$EF_{2010} = 0.4787 \times 0.5 + 0.1404 \times 0.5 = 0.3095 \text{ tCO}_2\text{/MWh}$$

The build margin CO_2 emission factor and operating margin CO_2 emission factor will be ex-post.

Therefore, the combined margin CO_2 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 $F_{CH4,PJ,y}$

The assumptions used to calculate $\mathbf{F_{CH4,PJ,y}}$ are:

- Methane content in LFG = 50% (default value);
- LFG collection efficiency = 65%: (Based on technical specifications from the equipments provider for the active LFG capture system);
- Density of methane = 0.716 kg/m^3 (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 65% LFG collection was applied to the estimate of LFG produced, under assumption that generated LFG is composed of 50% methane.

The ex ante estimation of the $F_{CH4,PJ,y}$ is presented below:

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

Where:

$F_{CH4,PJ,y}$	=	Amount of methane in the LFG which is flared and/or used in the project activity in year y (tCH_4/yr)
$BE_{CH4,SWDS,y}$	=	Amount of methane in the LFG that is generated from the SWDS in the baseline scenario in year y (tCO_2e/yr)
η_{PJ}	=	Efficiency of the LFG capture system that will be installed in the project activity
GWP_{CH4}	=	Global warming potential of CH_4 (tCO_2e/tCH_4)

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

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

Year	$F_{CH4,PJ,y}$ (tCH_4/yr)
2013	2,168
2014	3,319
2015	4,156
2016	4,779
2017	5,254
2018	5,625
2019	5,924

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_4/yr)
2013	434
2014	664
2015	831
2016	956
2017	1,051
2018	1,125
2019	1,185

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_2/year)
2013	32,786
2014	50,184
2015	62,845
2016	72,261
2017	79,437
2018	85,053
2019	89,568

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 $EF_{grid,CM,y} = 0.3095$ tCO_2/MWh

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

Year	$EC_{BL,k,y}$ (MWh/yr)	$BE_{EC,y}$ (tCO_2/yr)
2013	-	-
2014	-	-
2015	-	-
2016	13,529	4,188
2017	15,573	4,820
2018	17,365	5,375
2019	19,149	5,927

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_2/year)	$BE_{EC,y}$ (tCO_2/yr)	BE_y (tCO_2/yr)
2013	32,786	-	32,786
2014	50,184	-	50,184
2015	62,845	-	62,845
2016	72,261	4,188	76,448
2017	79,437	4,820	84,257
2018	85,053	5,375	90,428
2019	89,568	5,927	95,495

Project emissions

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

Where:

PE_y	=	Project emissions in year y (tCO_2/yr)
$PE_{EC,y}$	=	Emissions from consumption of electricity due to the project activity in year y (tCO_2/yr)
$PE_{FC,y}$	=	Emissions from consumption of fossil fuels due to the project activity, for purpose other than electricity generation, in year y (tCO_2/yr)

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 992 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 0.3095 tCO_2/MWh will be used.

Finally the technical transmission and distribution losses ($TDL_{j,y}$) value has been assumed to be 6%, according to BEN - 2006.[16] Table below summarizes the project emissions resulting from electrical consumption in the plant.

[16] National Energy Balance 2006, page 21.

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

Year	Electricity consumption from the grid - $EC_{PJ1,y}$ (MWh/yr)	$PE_{EC1,y}$ (tCO_2/year)
2013	992	326
2014	992	326
2015	992	326
2016	0	0
2017	0	0
2018	0	0
2019	0	0

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

The annual diesel generator consumption was considered zero as explained above. However, this parameter will be monitored ex-post and emission factor from the diesel generator(s) is 1.3 tCO_2/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	$PE_{el,diesel}$ - $EC_{PJ2,}$ (MWh/year)	$PE_{EC2,y}$ (tCO_2/year)
2013	0	0
2014	0	0
2015	0	0
2016	0	0
2017	0	0
2018	0	0
2019	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_y = Emission reductions in year y (tCO_2e/yr);
BE_y = Baseline emissions in year y (tCO_2e/yr);
PE_y = Project emissions in year y (tCO_2e/yr);

Year	BE_y (tCO_2/year)	PE_y (tCO_2/year)	ER_y (tCO_2/year)
2013	32,786	326	32,461
2014	50,184	326	49,858
2015	62,845	326	62,519
2016	76,448	-	76,448
2017	84,257	-	84,257
2018	90,428	-	90,428
2019	95,495	-	95,495

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

Year	Baseline emissions (t CO_2e)	Project emissions (t CO_2e)	Leakage (t CO_2e)	Emission reductions (t CO_2e)
2013	32,786	326	0	32,461
2014	50,184	326	0	49,858
2015	62,845	326	0	62,519
2016	76,448	0	0	76,448
2017	84,257	0	0	84,257
2018	90,428	0	0	90,428
2019	95,495	0	0	95,495
Total	**492,444**	**977**	**0**	**491,467**
Total number of crediting years	**7**			
Annual average over the crediting period	**70,349**	**140**	**0**	**70,210**

The first crediting period is from 01/01/2013 to 31/12/2019

B.7. Monitoring plan

B.7.1. Data and parameters to be monitored

Flaring or use of landfill gas

Data / Parameter	Management of SWDS
Unit	-
Description	Management of SWDS
Source of data	Use different sources of data: • Original design of the landfill; • Technical specifications for the management of the SWDS; • Local or national regulations
Value(s) applied	-
Measurement methods and procedures	Project participants should refer to the original design of the landfill to ensure that any practice to increase methane generation have been occurring prior to the implementation of the project activity. Any change in the management of the SWDS after the implementation of the project activity should be justified by referring to technical or regulatory specifications
Monitoring frequency	Annually
QA/QC procedures	-
Purpose of data	Calculation of baseline emissions
Additional comment	-

Data / Parameter	$O_{pj,h}$
Unit	
Description	Operation of the equipment that consumes the LFG
Source of data	Measurements by Project participant
Value(s) applied	n/a
Measurement methods and procedures	For each equipment unit j using the LFG monitor that the plant is operating in hour h by the monitoring any one or more of the following three parameters: • Temperature. Determine the location for temperature measurements and minimum operational temperature based on manufacturer's specifications of the burning equipment. Document and justify the location and minimum threshold in the PDD; $O_{pj,h}$=0 when: • One of more temperature measurements are missing or below the minimum threshold in hour h (instantaneous measurements are made at least every minute); Otherwise, Opj,h=1
Monitoring frequency	Hourly
QA/QC procedures	
Purpose of data	Calculation of baseline emissions
Additional comment	-

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

Data / Parameter	$V_{t,wb}$
Unit	m³ wet gas/h
Description	Volumetric flow of the gaseous stream in time interval t on a wet basis
Source of data	Measurements by Project participant
Value(s) applied	n/a
Measurement methods and procedures	Volumetric flow meter
Monitoring frequency	Continuous
QA/QC procedures	Periodic calibration against a primary device provided by an independent accredited laboratory is mandatory. Calibration and frequency of calibration is according to manufacturer's specifications
Purpose of data	Calculation of baseline emissions
Additional comment	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

Data / Parameter	$V_{t,db}$
Unit	m³ dry gas/h
Description	Volumetric flow of the gaseous stream in time interval t on a dry basis
Source of data	Measurements by Project participants
Value(s) applied	n/a
Measurement methods and procedures	Volumetric flow measurement should always refer to the actual pressure and temperature. Calculated based on the wet basis flow measurement plus water concentration measurement
Monitoring frequency	Continuous
QA/QC procedures	Periodic calibration against a primary device provided by an independent accredited laboratory is mandatory. Calibration and frequency of calibration is according to manufacturer's specifications
Purpose of data	Calculation of baseline emissions
Additional comment	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

Data / Parameter	$v_{i,t,db} = fv_{i,,h}$
Unit	-
Description	Volumetric fraction of greenhouse gas *i* in a time interval *t* on a dry basis
Source of data	Measurements by project participants
Value(s) applied	n/a
Measurement methods and procedures	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.
Monitoring frequency	Continuously
QA/QC procedures	Calibration should include zero verification with an inert gas (e.g. N_2) and at least one reading verification with a standard gas (single calibration gas or mixture calibration gas). All calibration gases must have a certificate provided by the manufacturer and must be under their validity period
Purpose of data	Calculation of baseline emissions
Additional comment	As a simplified approach, project participants may only measure the methane content of the gaseous stream and consider the remaining part as N_2, therefore i = CH_4 and N_2 This parameter will be monitored to option A e B

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

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

Data / Parameter	$P_{H2O,t,Sat}$
Unit	Pa
Description	Saturation pressure of H_2O at temperature Tt in time interval *t*
Source of data	Provided by project participants
Value(s) applied	n/a
Measurement methods and procedures	This parameter is solely a function of the gaseous stream temperature Tt and can be found at reference [1] for a total pressure equal to 101,325 Pa
Monitoring frequency	
QA/QC procedures	
Purpose of data	
Additional comment	[1] Fundamentals of Classical Thermodynamics; Gordon J. Van Wylen, Richard E. Sonntag and Borgnakke; 4º Edition 1994, John Wiley & Sons, Inc.

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

Data / Parameter	$EF_{grid,CM,y}$
Unit	tCO_2 /MWh
Description	CO_2 emission factor of the Brazilian grid electricity during the year y
Source of data	Brazilian DNA
Value(s) applied	0.3095
Measurement methods and procedures	The emission factor is calculated ex-post, as the weighted average of the dispatch data analysis OM (Operating Margin) and the BM (Build margin), as described in B.6.3. According to the “Tool to calculate the emission factor for an electricity system”, the chosen monitoring option is *ex-post*.
Monitoring frequency	Annual
QA/QC procedures	Apply procedures in the “Tool to calculate the emission factor for an electricity system”.
Purpose of data	Calculation of baseline emissions and; Calculation of project emissions.
Additional comment	All data and parameters to determine the grid electricity emission factor, as required by the “Tool to calculate the emission factor for an electricity system”, were included in the monitoring plan. For more details, see appendix 4.

Data / Parameter	$EF_{grid,BM,y}$
Unit	tCO_2 /MWh
Description	Build margin emission factor of the Brazilian grid
Source of data	Brazilian DNA
Value(s) applied	0.1404
Measurement methods and procedures	According to the “Tool to calculate the emission factor for an electricity system”, the chosen monitoring option is *ex-post*.
Monitoring frequency	Annual
QA/QC procedures	Apply procedures in the “Tool to calculate the emission factor for an electricity system”.
Purpose of data	Calculation of baseline emissions and; Calculation of project emissions.
Additional comment	All data and parameters to determine the grid electricity emission factor, as required by the “Tool to calculate the emission factor for an electricity system”, were included in the monitoring plan. For more details, see appendix 4.

Data / Parameter	$EF_{grid,OM,y}$
Unit	tCO_2 /MWh
Description	Operating margin emission factor of the Brazilian grid
Source of data	Brazilian DNA
Value(s) applied	0.4787
Measurement methods and procedures	According to the "Tool to calculate the emission factor for an electricity system", the chosen monitoring option is *ex-post*.
Monitoring frequency	Annual
QA/QC procedures	Apply procedures in the "Tool to calculate the emission factor for an electricity system".
Purpose of data	Calculation of baseline emissions and; Calculation of project emissions.
Additional comment	All data and parameters to determine the grid electricity emission factor, as required by the "Tool to calculate the emission factor for an electricity system", were included in the monitoring plan. For more details, see appendix 4.

Data / Parameter	TDL_y
Unit	-
Description	Average technical transmission and distribution losses in the grid in year y for the voltage level at which electricity is obtained from the grid at the project site.
Source of data	Regional or national technical literature
Value(s) applied	6%
Measurement methods and procedures	The technical distribution losses do not contain grid losses other than technical transmission and distribution.
Monitoring frequency	Annually. In the absence of data from the relevant year, most recent figures should be used, but not older than 5 years.
QA/QC procedures	-
Purpose of data	Calculation of project emissions.
Additional comment	The data was based on National Energy Balance.

Data / Parameter	$EG_{PJ,y} = EC_{BL,k,y}$
Unit	MWh
Description	Amount of electricity generated using LFG by the project activity in year y
Source of data	Electricity meter
Value(s) applied	
Measurement methods and procedures	Monitor net electricity generation by the project activity using LFG. 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.
Monitoring frequency	Continuously
QA/QC procedures	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.
Purpose of data	Calculation of baseline emissions.
Additional comment	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"-

Data / Parameter	$EG_{EC1,y} = EC_{PJ1,y}$
Unit	MWh/y
Description	Quantity of electricity consumed from the grid by the project activity during the year y
Source of data	Electricity meter
Value(s) applied	
Measurement methods and procedures	The data will be collected continuously using an electricity meter. The data will be archived throughout the crediting period and two years thereafter.
Monitoring frequency	Continuously
QA/QC procedures	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.
Purpose of data	Calculation of project emissions.
Additional comment	This parameter is required for calculating project emissions from electricity consumption due to an alternative waste treatment process t ($PE_{EC1,y}$) using the "Tool to calculate baseline, project and/or leakage emissions from electricity consumption".

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

Tool to determine project emissions from flaring gases containing methane

Data / Parameter	$t_{O2,h}$
Unit	-
Description	Volumetric fraction of O_2 in the exhaust gas of the flare in the hour h
Source of data	Measurements by project participants using a continuous gas analyzer
Value(s) applied	-
Measurement methods and procedures	Extractive sampling analyzers with water and particulates removal devices or *in situ* analyzers for wet basis determination. The point of measurement (sampling point) shall be in the upper section of the 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 ºC) may be an indication that the flare is not being adequately operated or that its capacity is not adequate to the actual flow.
Monitoring frequency	Continuously
QA/QC procedures	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.
Purpose of data	Calculation of baseline emissions.
Additional comment	The enclosed flares that will be installed in the project activity have a standard temperature higher than 850°C, according to manufacturer specification[17].

[17] The documentation regarding technical specifications of the flare was made available to DOE in the validation visit.

Data / Parameter	$fv_{CH4,FG,h}$
Unit	mg/m^3
Description	Concentration of methane in the exhaust gas of the flare in dry basis at normal conditions in the hour h
Source of data	Measurements by project participants using a continuous gas analyzer
Value(s) applied	n/a
Measurement methods and procedures	Extractive sampling analyzers with water and particulates removal devices or *in situ* analyzers for wet basis determination. The point of measurement (sampling point) shall be in the upper section of the 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 ºC) may be an indication that the flare is not being adequately operated or that its capacity is not adequate to the actual flow. Data will be recorded continuously and values will be averaged hourly or at a shorter time interval
Monitoring frequency	Continuously. Values to be averaged hourly or at a shorter time interval
QA/QC procedures	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.
Purpose of data	Calculation of baseline emissions.
Additional comment	The enclosed flares that will be installed in the project activity have a standard temperature higher than 850ºC, 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/m3 simply multiply by 0.716. 1% equals 10,000 ppmv.

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

Data / Parameter	$FV_{RG,h}$
Unit	m^3/h
Description	Volumetric flow rate of the residual gas in dry basis at normal conditions in the hour h
Source of data	Measurements by project participants using a flow meter
Value(s) applied	n/a
Measurement methods and procedures	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.
Monitoring frequency	Continuously
QA/QC procedures	Flow meters must be periodically calibrated according to the manufacturer's recommendation. Periodical calibration.
Purpose of data	Calculation of baseline emissions.
Additional comment	-

B.7.2. Sampling plan

>>

Not applicable.

B.7.3. Other elements of monitoring plan

>>

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

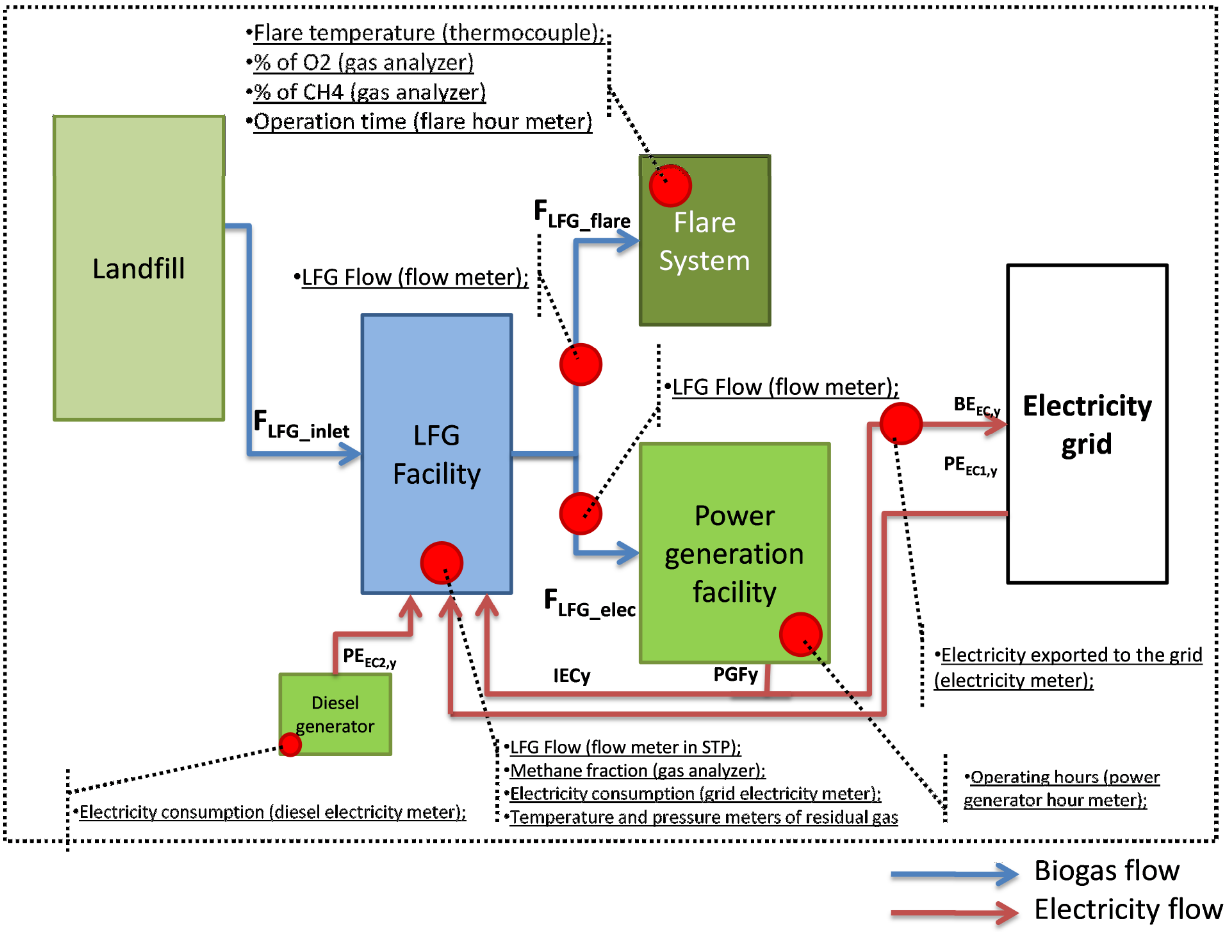

Figure 13 - Monitoring equipments locations

All continuously measured parameters (LFG flow, LFG CH_4 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 is discussed in section 2 below, while the additional system data collected to ensure the safe, correct, and efficient operation of the LFG management system is discussed in section 3.

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 1

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

The data will be collected continuously using 3 vortex flow meters located in the piping leading to the flare, to the electricity generation plant and the other on the main piping measuring the total collected landfill gas. The data will be aggregated monthly and yearly for the 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

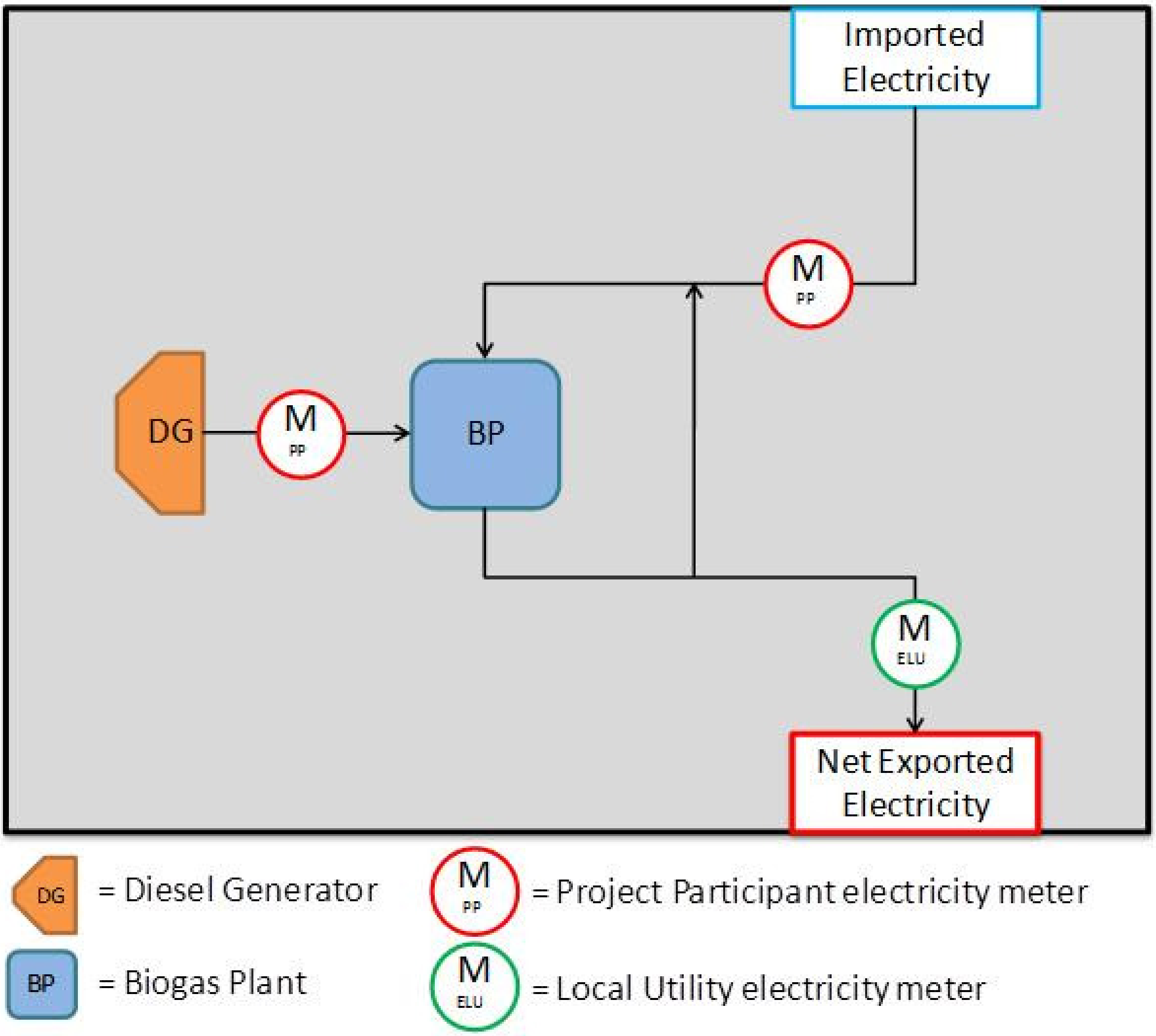

Figure 14 – Electricity Monitoring

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 analyzed 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: 01/11/2012.

The starting date of the project activity will be the forecast date of purchasing the main equipments.

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 01/01/2013 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 gas 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 present project activity and the possible environmental impacts were analyzed by the *Companhia Ambiental do Estado de São Paulo- CETESB* (responsible agency to issue environmental licences in São Paulo state). The project activity has satisfied all the requirements for implementation of the landfill gas project and the CGR Catanduva received from CETESB the Operational License nº 14004618 valid up to 20/08/2016. 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
>>

As mentioned previously an environmental impact assessment was developed by the project participant and analyzed by CETESB, thus CGR Catanduva has obtained all pertinent licenses for the 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 project activity.

Table 16 - Environmental Impacts and mitigation measures

IMPACT	POTENCIAL FACTOR	MITIGATION MEASURES
Atmospheric Pollution	• Dust emission from civil works. • Gas emissions from fossil combustion of vehicles and equipments. • Odour and biogas emissions from landfill.	• Wetting, calculated explosions for lower emissions of dust and vegetation surround. • Maintenance of vehicles and equipments. • 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.
Superficial and ground water pollution.	• Leachate generation. • Wastewater emissions containing oil and grease. • Ground leachate generation. • Runoff water with particulate material.	• Subsurface drainage and treatment at the WWTP. • Treatment at the WWTP. • Waterproofing with geomembrane and drainage • Sand separator before discharged into the rivers or natural drainage.
Soil destabilization. . Siltation	• Cut and filling of soil. • Leaching of soils.	• Pluvial drainage, reutilization of soil and revegetation. • Preservation of coverage, dike and reutilization of soils.
. Noise Pollution	• Noise emissions from civil works, vehicular traffic and equipments.	• Vegetation surround and calculated explosions for lower noise emissions, signalization and planning schedules. • Maintenance of vehicles and equipments.
Sanitary risks	• Vectors (insects, rats) proliferation	• Daily coverage of waste
Traffic alteration and risk of accidents.	• Increase of vehicular traffic. • Waste transport.	• Improvement of access via, signalization and paving. • Construction of alternatives via, maintenance of vehicles and training of drivers.
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	• Generation of direct and indirect jobs using local labor. • Purchase of materials and services in the region.	• 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 and compensation program 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 program of gas emissions
- Monitoring program of superficial waters
- Monitoring program of ground waters
- Monitoring program of landfill geotechnical stability
- Monitoring program of biota
- Social participation and communication program
- Environmental compensation program

SECTION E. Local stakeholder consultation

E.1. Solicitation of comments from local stakeholders

>>

According to the Resolutions Number 1[18], 4[19] and 7[20] 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;
- 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 27/04/2012 to the following stakeholders involved and affected by the project activity:

- *Prefeitura municipal de Catanduva* / Municipal Administration of *Catanduva*;
- *Câmara dos vereadores de Catanduva* / Legislation Chamber of *Catanduva*;
- *Secretaria Municipal de Meio Ambiente de Catanduva* / Municipal Secretariat Environmental of *Catanduva* City;
- Secretaria do Meio Ambiente do Estado de São Paulo / Environmental secretariat of São Paulo State;
- *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* São Paulo / São Paulo Pr*osecutor's Office;*
- *Ministério Público Federal* / Federal Prosecutor's Office.
- Local associations;
    - *Pão Nosso*;
    - *Associação das Empresas Movimentadoras de Resíduos da Construção Civil de Catanduva;*
    - *Associação dos Engenheiros de Catanduva;*
    - *Sindicato dos Empregados em Estabelecimento de Saúde de Catanduva*

[18] http://www.mct.gov.br/upd_blob/0002/2736.pdf (Art. 3º, II)
[19] http://www.mct.gov.br/upd_blob/0011/11780.pdf (Artº 5°, unique paragraph)
[20] http://www.mct.gov.br/upd_blob/0023/23744.pdf, accessed on July 21st, 2008.

E.2. Summary of comments received
>>
No comments were received.

E.3. Report on consideration of comments received
>>
No comments were received.

SECTION F. Approval and authorization
>>
The Letter of Approval (LoA) from the Party is currently not available.

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Appendix 1: Contact information of project participants

Organization name	CGR Catanduva – Centro de Gerenciamento de Resíduos Ltda.
Street/P.O. Box	Avenida Alberto Dotti, 85 – Distrito Industrial Pedro Luis Boso
Building	Sala 3
City	Catanduva
State/Region	São Paulo
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Country	Brazil
Telephone	+55 (17) 3531-2757
Fax	+55 (17) 3531-2757
E-mail	fbonini@cgrcatanduva.com.br
Website	http://www.geovisionsae.com.br
Contact person	Felipe Bonini
Title	Director
Salutation	Sr
Last name	Bonini
Middle name	-
First name	Felipe
Department	Project Management
Mobile	-
Direct fax	+55 (17) 3531-2757
Direct tel.	+55 (17) 3531-2757
Personal e-mail	fbonini@cgrcatanduva.com.br

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 Espirito Santo Filho and Javier Montalvo Andia
Email: francisco.santo@econergy.com.br and javier.montalvo@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	Jul/2009
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 (%)	65
Electricity consumption from the grid due to the project activity (MWh/year)	992
Electricity consumption from the diesel generator due to the project activity (MWh/year)	0
Unit price of electricity sold to the grid (R$/MWh)	102.18
Combined margin emission factor for electricity displacement (tCO_2/MWh) calculated based on the “Tool to calculate the emission factor for an electricity system”.	0.3095
Installed capacity of Power Plant (MW)	4.5
Load factor (%)	94.38
Price per MW installed (R$/MWe)	2,260,852.89
O&M costs (R$/MWh)	47.98
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

Year	Waste disposal (tonnes/yr)
2009	25,140
2010	43,680
2011	46,800
2012	50,000
2013	365,000
2014	365,000
2015	365,000
2016	365,000
2017	365,000
2018	365,000
2019	365,000
2020	365,000
2021	365,000
2022	365,000
2023	365,000
2024	365,000
2025	365,000
2026	365,000
2027	365,000
2028	365,000
2029	365,000
2030	365,000
2031	365,000
2032	365,000
2033	365,000
2034	365,000

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 2010 (tCO_2/MWh)		
1st crediting Period		**0.3095**
Build Margin - 2010		0.1404
Operating Margin 2010	January	0.2111
	February	0.2798
	March	0.2428
	April	0.2379
	May	0.3405
	June	0.4809
	July	0.4347
	August	0.6848
	September	0.7306
	October	0.732
	November	0.7341
	December	0.6348
	2010	0.4787

Source: Brazilian DNA[21]

Appendix 5: Further background information on monitoring plan

All the information about the monitoring plan were described in section B.7.1 and B.7.2

Appendix 6: Summary of post registration changes

It was left blank intentionally.

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[21] Emission factor from Brazilian DNA: http://www.mct.gov.br/index.php/content/view/327118.html#ancora, accessed on 06/04/2012.

History of the document

Version	Date	Nature of revision
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.
Decision Class: Regulatory **Document Type:** Form **Business Function:** Registration		