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

CONTENTS

Annexes

SECTION A. General description of project activity

A.1 Title of the project activity:

Feira de Santana Landfill Gas Project.
Version 2.
10 September 2007.

A.2. Description of the project activity:

The objective of Feira de Santana Landfill Gas Project is to capture and use landfill gas (LFG) generated through the decomposition of the organic waste disposed at Feira de Santana landfill site. This will involve investing in a landfill gas collection system, a flare station and equipment for the generation of electricity and/or thermal energy. The principal components of landfill gas are methane (CH_4) and carbon dioxide (CO_2), both of which are greenhouse gases (GHG) covered by the Kyoto Protocol. Flaring or burning landfill gas for energy involves methane destruction leading to GHG emissions reductions. The landfill gas that is put to energy use at the landfill site will generate additional GHG emissions reductions, as CO_2 that would be emitted if the energy were generated from fossil fuels.

Qualix Serviços Ambientais Ltda (Qualix) is a private company focused on environmental quality for urban centres, specialized on urban solid waste cleaning, collecting, transferring and disposal. The landfill is owned and operated by Qualix. Thus, Qualix is the CDM project sponsor.

The landfill site occupies an area of 36 ha, planned for municipal waste treatment and disposal. The area around the landfill may be considered humid, with an average annual precipitation of 870 mm and an average temperature of 28°C. The climate is classified as “tropical with winter rains”.

The landfill began accepting waste in 2002. By the end of July 2006, more than 500,000 tonnes of waste have been filled over 4 of the landfill’s present phase of 10 hectares. Upon completion, maximum waste thickness is expected to be about 45 meters; current maximum landfill height is about 25 meters. This first phase lifetime is expected to be 14 years, ending in 2013. Currently, the landfill is filling at an average rate of 365 tonnes per day, or greater than 130,000 tonnes per year. In the coming years, the disposal rate is expected to increase by 3% per year.

Currently, there are 8 landfill gas vents (or passive gas wells) installed over the 10-hectare area, venting the gas from inside the waste mass to the top of each vent. During first site visits in 2006, six of the eight vents were burning gas sporadically and two did not have any flame.

Following the implementation of the proposed CDM project, the predicted LFG recovery rate for the landfill in 2008 is 600 m^3/h (assuming 65% capture of LFG generated), increasing to 930 m^3/h (65% capture) in 2012. At the end of the first crediting period (7 years) of the proposed CDM project, the predicted LFG recovery would reach 1,080 m^3/h (65% capture).

Possible uses LFG for energy include electricity and thermal generation for use at the landfill site. It is estimated that Qualix would need a 30 kW installed capacity for satisfying demand of the LFG plant (blower) during the first crediting period, and 1.53 TJ (425 MWh/yr) for a medical waste treatment plant equipped with a thermal plant (treatment by autoclave) that is installed next to the flare station.

Besides climate change mitigation, the project would have important local environmental benefits. Almost all the landfill gas is currently released to the atmosphere without any treatment. This implies a potential fire and explosion risk as well as bad odours. Moreover, landfill gas contains trace amounts of volatile organic compounds, which are air pollutants. The capture and flaring of landfill gas would greatly reduce all these risks and thereby contribute to sustainable development.

A.3. Project participants:

Name of Party involved (*). ((host) indicates a host Party)	Private and/or public entity(ies) project participants (*) (as applicable)	Kindly indicates if the Party involved wishes to be considered as project participant (Yes/No)
Brazil (host)	Qualix Serviços Ambientais Ltda. Private entity. Project Sponsor.	No
(*) In accordance with the CDM modalities and procedures, at the time of making the CDM-PDD public at the stage of validation, a Party involved may or may not have provided its approval. At the time of requesting registration, the approval by the Party(ies) involved is required.		

A.4. Technical description of the project activity:

A.4.1. Location of the project activity:

A.4.1.1. Host Party(ies):

Brazil.

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

State of Bahia.

A.4.1.3. City/Town/Community etc:

Feira de Santana city.

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

The landfill Feira de Santana is located in the Municipality of Feira de Santana, about seven kilometres from the centre of the city. The address is Rua Ponte do Rio Branco, 200, Bairro da Nova Esperança. Feira de Santana City.

Figure 1. *Location of Feira de Santana City*

Feira de Santana City is located in Bahia State, about 95 kilometres to the northwest of the city of Salvador, the capital of Bahia State. It is 1,500 kilometres to the northeast of the city of São Paulo and 1,000 kilometres northeast of Brasilia, capital of Brazil.

The landfill has the Geographic Coordinates: S 12°14'49"; W 38°59'51"

The Feira de Santana Landfill began operation in February 2002 receiving municipal waste from Feira de Santana City, which has a population over 500,000 habitants.

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

According to the "Sectoral Scope" classification, the project categories are:
- "13. Waste handling and disposal";
- "1. Energy industries (renewable / non-renewable sources)".

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

In order to maximize LFG recovery rates, and thus GHG emission reductions, an active LFG collection system will need to be installed. The system will consist of a series of vertical extraction wells interconnected by header piping. The LFG will be extracted from the landfill by a blower and conducted to a single point for flaring. Some LFG may be burnt to produce electricity and thermal energy. The essential characteristics of the LFG collection and flaring system are listed below:

- Construction of deep and shallow vertical wells in intermediate or closed areas, trying to not interfere with the landfill operation. Depending on future development plans, some horizontal wells might be installed, to capture the gas in areas that continue to be filled;
- Installation of a piping network to include connection to extraction wells, serving the blower/flare station with a specific diameter piping, suitable for the anticipated flow rates. In general, connection should be made to those extraction wells that have been constructed to final or intermediate grade, and to which the piping connection will have a minimal impact on current filling operations;
- Installation of a leachate pumping system (if needed);
- Installation of a condensate management system. The LFG collection piping will be designed to include self-draining condensate traps and condensate manholes with pumps where necessary;
- Installation of the blower and flaring station;
- Confirm the reliability of electrical service to the blower and flaring station, if necessary, installing backup power capacity (e.g., diesel generator). Installation of a LFG-fuelled power generator is being considered.

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

Table 1. *Annual estimation of emission reduction for Feira de Santana landfill*

Year	Annual estimation of emission reduction in tonnes of CO_2e
2008 (as from February)	25,536
2009	33,920
2010	37,826
2011	43,614

2012	47,331
2013	50,963
2014	54,512
2015 (up to January)	4,302
Total estimated reductions for the first crediting period (tonnes of CO_2e)	**298,004**
Total number of crediting years	**21 (7x3)**
Annual average over the first crediting period of estimated reductions (tonnes of CO_2e)	**42,572**

A.4.5. Public funding of the project activity:

The project sponsors will not receive any international public funding whatsoever for the development of this project.

SECTION B. Application of a baseline and monitoring methodology

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

The baseline and monitoring methodology to be applied for the proposed project activity is the approved consolidated baseline methodology ACM0001, version 6, from CDM Executive Board 32nd meeting: ***"Consolidated baseline methodology for landfill gas project activities"***.

For project emissions calculation or emissions reduction associated with electricity generation using landfill gas, ACM0001 also incorporates ACM0002 version 6, May 19, 2006: ***"Consolidated Baseline Methodology for Grid-Connected Power Generation from Renewable Sources"*** and, for power generation below 15 MW, small-scale CDM methodology: AMS I.D. For this PDD, we use ACM0002, version 6.

For additionality assessement, it was used the tool recommended by the CDM Executive Board (as Annex 1 of their 16th Meeting Report) ***"Tool for the demonstration and assessment of additionality, version 3"***.

In order to determine the flare efficiency and/or to monitor the flare exhaust gases, it was applied the ***"Tool to determine project emissions from flaring gases containing methane"*** recommended by the CDM Executive Board 28th Meeting Report, Annex 13.

In order to estimate the potential LFG recovery rate for the landfill, it was used a first-order decay equation, identical to the algorithm in the U.S. Environmental Protection Agency (EPA) landfill gas emissions model (LandGEM). The k-parameters needed as input in this model, were based on IPCC recommendations (**2006 IPCC Guidelines for National Greenhouse Gas Inventories, Vol. 5**).

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

The methodology chosen is applicable to landfill gas capture project activities, where the baseline scenario is the partial or total atmospheric release of the gas and the project activities include situations such as:

a) *The captured gas is flared; or*
b) *The captured gas is used to produce energy (e.g. electricity/thermal energy);*
c) *The captured gas is used to supply consumers through natural gas distribution network. If emissions reductions are claimed for displacing natural gas, project activities may use approved methodologies AM0053, but no emission reductions are claimed for displacing or avoiding energy from other sources.*

The proposed project activity corresponds to alternatives a) and b). The collected landfill gas will generally be flared or would be used to generate electricity to meet power requirements of the project itself or for other applications at the landfill site, such as energy requirements of medical waste treatment plant, and for sale to the power grid. Emissions reductions would also be claimed for displacing or avoiding energy from other sources.

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

According to ACM0001 baseline methodology, the project boundary is the site of the project activity where the gas will be captured and destroyed/used. The project boundary should encompass the physical, geographical site of the renewable generation source.

Also, any electricity sources for the project activity operation (from grid or captive) shall be included in the project boundary.

The following project activities and emission sources are considered within the project boundaries:

Table 2*. Sources and gases included in the project boundary*

	Source	Gas	Included?	Justification/Explanation
Baseline	Passive LFG venting and no flaring	CO_2	No	It is not considered because it is part of the natural carbon cycle.
		CH_4	Yes	Included as main component of LFG.
		N_2O	No	Not applicable
Project Activity	Active LFG capture and flaring	CO_2	No	It is not considered because it is part of the natural carbon cycle.
		CH_4	Yes	Included as main component of LFG.
		N_2O	No	Not applicable
	LFG combustion for power generation	CO_2	No	It is not considered because it is part of the natural carbon cycle.
		CH_4	Yes	Included as main component of LFG.
		N_2O	No	Not applicable
	LFG combustion for thermal	CO_2	No	It is not considered because it is part of the natural carbon cycle.

	energy generation	CH_4	Yes	Included as main component of LFG.
		N_2O	No	Not applicable

For the determination of baseline emissions of the possible electricity generation component of the project, the project boundary will account for the CO_2 emissions from electricity generation in fossil fuel power stations operating in the grid system, which will be displaced by electricity generated in the project activity. For the electricity generation component, according to ACM0002, ver. 6, *"the spatial extent of the project boundary includes the project site and all power plants connected physically to the electricity system that the CDM project power plant is connected to."*

Note that there is a treatment plant for medical waste near the project site. This plant currently uses LPG (Liquefied Petroleum Gas) as fuel to generate thermal energy in a thermal plant, and would continue to do so in the baseline scenario. Since the treatment plant is unrelated to the project activity, we place it outside the project boundary. However, following project implementation, LFG would displace LPG used by this thermal plant. Thus, for the purpose of accounting for baseline and project emissions correctly, we include the fuel consumption by the treatment plant as within the project boundary. Thus, in the baseline scenario there would be CO_2 emissions from LPG use, while in the project scenario these emissions would be absent, since LFG would fuel the plant.

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

ACM0001, version 6, establishes procedures for the selection of the most plausible scenario. According to them, there are two steps to be followed:

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

The methodology states:

> *"Project participants should use step 1 of the latest version of the "Tool for the demonstration and assessment of additionality", to identify all realistic and credible baseline alternatives. In doing so, relevant policies and regulations related to the management of landfill sites should be taken into account. Such policies or regulations may include mandatory landfill gas capture or destruction requirements because of safety issues or local environmental regulations. Other policies could include local policies promoting productive use of landfill gas such as those for the production of renewable energy, or those that promote the processing of organic waste. In addition, the assessment of alternative scenarios should take into account local economic and technological circumstances."*

Step 1 of the tool (Identification of alternatives to the project activity consistent with current laws and regulations) comprises a number of sub-steps:

"Sub-step 1a. Define alternatives to the project activity."

ACM0001, version 6, indicates the separate determination of applicable baselines for landfill capture, for electricity generation and for thermal use of LFG. The possible alternatives for each part are considered below, using the codes defined in ACM0001, ver. 6.

ACM0001, ver. 6 states:
"Alternatives for the disposal/treatment of the waste in the absence of the project activity, i.e. the scenario relevant for estimating baseline methane emissions, to be analyzed should include, inter alia:

- *LFG1. The project activity (i.e. capture of landfill gas and its flaring and/or its use) undertaken without being registered as a CDM project activity;*
- *LFG2. Atmospheric release of the landfill gas or partial capture of landfill gas and destruction to comply with regulations or contractual requirements,, or to address safety and odour concerns."*

In principle, solid waste could be disposed off in other ways besides landfills, e.g. incineration, composting, conversion to Refuse-derived fuel (RDF), thermochemical gasification, and biomethanation. None of these are realistic alternatives for the project proponents, who have an obligation to the government to dispose solid waste at the specific landfill, and there is enough space and capacity to use the landfill for many years in the future. Moreover, these alternatives all involve advanced processes for treatment of solid waste; they all require very large investments and high operating costs compared to landfilling[1]. Finally, there is only limited experience with these alternative processes in Annex 1 countries, and almost none in non-Annex 1 countries, except for a handful of projects being submitted through the CDM.

Therefore, options LFG1 and LFG2 are the only realistic alternatives.

The project proposes to generate a certain amount of electricity. ACM0001 states:
"If energy is exported to a grid and/or to a nearby industry, or used on-site realistic and credible alternatives should also be separately determined for power generation in the absence of the project activity.

For power generation, the realistic and credible alternative(s) may include, inter alia:
P1. Power generated from landfill gas undertaken without being registered as CDM project activity;
P2. Existing or Construction of a new on-site or off-site fossil fuel fired cogeneration plant;
P3. Existing or Construction of a new on-site or off-site renewable based cogeneration plant;
P4. Existing or Construction of a new on-site or off-site fossil fuel fired captive power plant;
P5. Existing or Construction of a new on-site or off-site renewable based captive power plant;
P6. Existing and/or new grid-connected power plants."

Other renewable sources are not applicable to the project site, so that options P3 and P5 may be discarded. Similarly fossil-fuel based captive power plants or cogeneration plants would not be economically competitive with purchasing power from the grid, so that P2 and P4 may also be discarded.

The only remaining options for plausible baselines are then:
P1. Power generated from landfill gas undertaken without being registered as CDM project activity, and

[1] For instance, even the least expensive of these alternatives, composting, to be economically viable, the waste management company must receive USD 20 - 40 per tonne of waste. Source: *International Source Book on Environmentally Sound Technologies (ESTs) for Municipal Solid Waste Management (MSWM)*, Report of the United Nations Environment Programme, Division of Technology, Industry, and Economics. http://www.unep.or.jp/ietc/ESTdir/Pub/MSW/sp/sp4/sp4_1.asp

P6. Power plants connected to the grid.

The project also proposes to generate some thermal energy for on-site use. ACM0001 states:

"*For heat generation, the realistic and credible alternative(s) may include, inter alia:*
H1. Heat generated from landfill gas undertaken without being registered as CDM project activity;
H2. Existing or Construction of a new on-site or off-site fossil fuel fired cogeneration plant;
H3. Existing or Construction of a new on-site or off-site renewable based cogeneration plant;
H4. Existing or new construction of on-site or off-site fossil fuel based boilers;
H5. Existing or new construction of on-site or off-site renewable energy based boilers;
H6. Any other source such as district heat; and
H7. Other heat generation technologies (e.g. heat pumps or solar energy)."

Credits will be claimed for emissions displaced by LFG used for heat in this project. This is because, in the absence of LFG becoming available, the existing thermal plant would continue working with LPG (fossil fuel).

As stated above, other renewable sources are not applicable to the project site, so that options H3 and H5 may be discarded. Fossil-fuel fired cogeneration plants, other heat sources and other heat generation technologies would not be economically competitive with the existing LPG fired thermal plant, so that H2, H6 and H7 may also be discarded.

Therefore, the most appropriate baselines are:
H1. Heat generated from landfill gas undertaken without being registered as CDM project activity; and
H4. Existing thermal plant on-site fossil fuel based.

Thus the options listed above (LFG1 and LFG2; P1 and P6; H1 and H4) are the only realistic alternatives to be considered as possible alternative baselines. These alternatives will be considered below and further analyzed, in Section B.5.

ACM0001, ver. 6 states how national and sectoral policies must be taken into account using Sub-step 1b of the additionality tool and the adjustment factor *AF*.

"Sub-step 1b. Consistency with mandatory laws and regulations".

This sub-step requires that:

> *"The alternative(s) shall be in compliance with all mandatory applicable legal and regulatory requirements, even if these laws and regulations have objectives other than GHG reductions, e.g. to mitigate local air pollution.."*

There are no legal and regulatory requirements that would require capture or use of landfill gas. Therefore all possible scenarios described above would comply with national and local regulations.

The only document, with no legal force in Brazil, is a Technical Norm NBR 13896, from the Brazilian Technical Norms Association (ABNT), which advises on how to design and operate a landfill. In the topic of landfill gas, this standard states that gas must be removed and treated in order to avoid risk of fire and presence of odours.

When a landfill obtains an environmental permit, the local environmental agency usually requires compliance with the ABNT standard. It is common practice for licensed landfills to have passive venting wells that burn the gas at the top of the vent. Most of the landfills do not have enough wells for efficiently remove the LFG and the uncontrolled burning is not enough for complete destruction of the methane. Sometimes there is no presence of flame at the passive vents.

Bahia State environmental Agency (CRA) does not demand any kind of control in the permit conditions for Feira de Santana landfill regarding the LFG management. However, following the established common practice mentioned, Qualix constructed passive vents with an uncontrolled burning of LFG.

The common practice established in Brazil comprises passive venting with limited flaring. For this situation, an Adjustment Factor of 20% is applied for possible destruction of LFG in baseline scenario taking into account the percentage of LFG vented through wells, wells available for flaring, and percentage of time wells were actually lit and combustion efficiency of open flame combustion. This value of the Adjustment Factor is believed to be conservative.

Thus we can modify Scenarios LFG1 and LFG2 as follows:

LFG1: Disposal of the waste at the landfill with ***active*** extraction of landfill gas and centralized flaring or use of gas captured.

LFG2: Disposal of the waste at the landfill with ***limited*** burning of gas passively vented from the landfill, so that baseline destruction of LFG is 20% of the value with an active extraction system with centralized flaring.

Therefore both LFG1 and LFG2 would comply with local regulations.

The current situation at the Feira de Santana landfill corresponds to LFG2 above and this situation meets all applicable legal requirements and has all its necessary permits up to date.

ACM0001, ver. 6 further declares:

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

For power generation we have considered two plausible baselines:
P1. Power generated from landfill gas undertaken without being registered as CDM project activity, and
P6. Power plants connected to the grid.

There is no specific fuel choice to be made. The fuels in the power plants connected to the grid are what they are, with their emissions factor determined by ACM0002 or AMS I.D, depending on the power generated using LFG, that would be generated in the grid in the baseline.

As for LFG used for heat, some of the LFG collected following project implementation would replace a fossil fuel that would otherwise be used for a thermal plant at the project site. The fossil fuel would be LPG. LPG is a convenient, transportable gaseous fuel, suitable to locations where natural gas is not available. The thermal plant in question is designed to operate on gaseous fuels, so diesel or coal are not viable alternatives. Moreover, the CO_2 emissions factor of LPG is only slightly above that of natural gas, and substantially below those for diesel or coal. Thus the choice of LPG is also the most conservative. This is also consistent with ACM0001, ver. 6 which suggests the use of lowest carbon intensive fuel as a conservative approach.

In principle, the thermal power could also be generated using electricity. However, this is not a reasonable baseline fuel, for economic reasons. The thermal plant operates between 60 and 90 hours per month, therefore monthly LPG consumption would be between 1,800 kg and 2,700 kg. Each kilogram of LPG costs about USD 1,06, so monthly costs will range between USD 1,900 and USD 2,850[2]. If Qualix decided to operate this plant with electricity from the grid, besides the fact that daily operation costs of the equipment increase in about 30%, the electric equipment would consume 447kWh/year, or 37.3MWh/month, costing USD 5,600[3].

Hence, LPG is the most appropriate and conservative choice of fuel in the baseline scenario.

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

A CDM project activity is additional if anthropogenic emissions of greenhouse gases by sources are reduced below those that would occur in the absence of the registered CDM project activity, i.e. in the baseline scenario.

As evidence of when the CDM context was seriously considered for the project, the consulting contract celebrated between Qualix Serviços Ambientais Ltda and MGM International was submited.

Following a review of how individual baseline methodologies deal with the issue of additionality, the CDM Executive Board published, as Annex 1 of their 16th Meeting Report, a “Tool for the demonstration and assessment of additionality.” Note that version 6 of *Approved consolidated baseline methodology ACM0001* “Consolidated baseline methodology for landfill gas project activities” makes the following comment regarding additionality:

> *“Step 2 and/or step 3 of the latest approved version of the “Tool for demonstration and assessment of additionality” shall be used to assess which of these alternatives should be excluded from further consideration.”*

Thus, in keeping with ACM0001, we apply the mentioned “Tool for the demonstration and assessment of additionality, version 3”.

After applying Step 1 of the Additionality Tool in section B.4 above, the additionality tool then offers two options: Step 2 (Investment Analysis) or Step 3 (Barrier Analysis), with a third option of applying both Steps.

ACM0001, ver. 6 requires that the additionality test “*shall be applied for each component of the baseline, i.e. baseline for waste treatment, electricity generation and heat generation*”.

---

[2] The price of LPG taken from purchase invoices at Qualix (USD 1.06 / kg).

[3] Based on the gas supplier, the LPG net calorific value is 47.3 MJ/kg. Assuming that the thermal plant will work an average of 1,080 hours per year (3 hours per day) and a consumption of 30 kg of LPG per hour, the annual energy demand is 1.53 TJ or 425 MWh (1 kWh corresponds to 3.6 MJ). The thermal plant efficiency with electricity would be 95%.The energy cost at Feira de Santana landfill is 0.15 USD/kWh (www.coelba.com.br)

With this in mind, the alternative LFG1 may be further subdivided as follows:
LFG1.1 Disposal of the waste at the landfill with ***active*** extraction of landfill gas and centralized flaring;
LFG1.2 Disposal of the waste at the landfill with ***active*** extraction of landfill gas and use of landfill gas for electricity generation;
LFG1.3 Disposal of the waste at the landfill with ***active*** extraction of landfill gas and use of landfill gas for heat generation; and
LFG1.4 Disposal of the waste at the landfill with ***active*** extraction of landfill gas and use of landfill gas for electricity and heat generation.

First we consider LFG1.1, and we apply ***Step 2 (Investment Analysis)*** of the Additionality Tool.

Here it can be seen that LFG1.1 (active landfill gas collection and centralized flaring) involves substantial investments and no revenues, in the absence of the CDM. Hence, on the basis of a Simple Cost Analysis (Investment Analysis, Option 1), we can discard this option as a possible baseline scenario.

For electricity generation (LFG1.2), there are substantial investments as well as revenues from electricity sales.

In the spirit of ACM0001, ver. 6, we consider the following two possible baselines for evaluating the additionality of power generation:

1. LFG2. Disposal of the waste at the landfill with ***limited*** burning of gas passively vented from the landfill, so that baseline destruction of LFG is 20% of the value with an active extraction system with centralized flaring.
2. LFG1.1 Disposal of the waste at the landfill with ***active*** extraction of landfill gas and centralized flaring.

The two situations differ in the following way. In the first case, the economic benefits from electricity generation need to be more than the investments and operating costs of LFG collection and electricity generation, with no CDM revenues. In the second case, CDM revenues are sufficient to pay for LFG collection and flaring, and we need to determine if the marginal investments and operating costs for power generation is adequately compensated by the benefits from electricity sales.

Case 1: LFG collection and electricity generation without the CDM

For electricity generation, there are substantial investments as well as revenues from electricity sales. We determine the cost effectiveness for LFG capture and power generation in the absence of the CDM. Our analysis is based on the following assumptions[4]:

- Substantial investments are required to capture LFG. These include the construction of active extraction wells, a well field and blowers, etc. to collect the LFG and take it to the location where the power plant would be located. For this project, this involves about USD 0.9 million in 2008, and about USD 25,000 yearly thereafter for well field expansion as the landfill expands;
- Operating costs for landfill gas collection are expected to be USD 150,000 in 2008 and increase slowly as the landfill expands;
- Two 500 kW LFG power generators would be purchased, for a total investment including auxiliary equipment, such as power conditioning and connections, of 0.98 million USD.

[4] Note that the size and timing of generators to be installed will depend on equipment availability at the time specific decisions are made. The size and dates shown here are representative assumptions.

According to LFG estimated quantity available yearly, 500 kW would be operational in 2009 and the other 500kW in 2011;

- Operation and maintenance cost: USD 0.023 per kWh. Small, internal combustion engines have high operation and maintenance costs. Equipment would be imported from Europe or from North America;
- Equipment life: 10 years;
- Electricity sale price (levelized) for biomass and waste sources: USD 0.072 per kWh, for sale to the grid, including estimated wheeling charges. There are no official projections for electricity prices in the future;
- Corporate tax rate: 34%;
- Discount rate: 10%. Note that in July 2007, the Banco Central do Brasil Rate called Selic was around 11.5% (http://www.bcb.gov.br/). Considering the risks of this new technology as well as the risks in effective biodegradation of waste and effective methane capture, another 2% may be added. Thus an appropriate benchmark rate for this type of investment would be 13%. The chosen benchmark discount rate of 12% was chosen here. However, considering that a supposed inflation of 2% is taken to zero, we can bring the discount rate to 10% (considering that the same inflation is applied to different types of costs).

The detailed economic analysis is shown in the electronic workbook:
Economic analysis LFG capture and power generation_FdS_10Sep07.pdf.

For the assumptions stated above, the NPV for LFG capture and electricity generation is so negative (about USD -1.22 million), in the absence of the CDM, that no meaningful IRR can be determined. (This means that even if the discount rate were zero, the revenues are less than expenses.) The electronic workbook also includes a sensitivity analysis with respect to the key assumptions, electricity sale price, O&M costs and investment requirements, in each case considering values ± 20% with respect to the assumptions above. The results of the sensitivity analysis are shown in the table below. Over the range considered, the NPV remains negative (and the IRR remains meaningless), which means that the project is not profitable without CER revenues.

Table 3.A *Sensitivity Analysis for LFG collection and electricity generation*

	Electricity Sale Price				
	-20%	-10%	0%	10%	20%
NPV	(1,788,224)	(1,485,889)	(1,217,184)	(978,967)	(756,712)
IRR	N.A.	N.A.	N.A.	N.A.	N.A.

	O&M Costs				
	-20%	-10%	0%	10%	20%
NPV	(1,788,224)	(1,485,889)	(1,217,184)	(978,967)	(756,712)
IRR	N.A.	N.A.	N.A.	N.A.	N.A.

	Investment				
	-20%	-10%	0%	10%	20%
NPV	(860,017)	(1,038,600)	(1,217,184)	(1,395,767)	(1,574,350)
IRR	N.A.	N.A.	N.A.	N.A.	N.A.

With CER revenues, assuming a CER price of USD 12 per tCO_2e, the NPV would be USD 1.30 million and the IRR would be 24%, and the project would be profitable.

Thus, for this case, the proposed project meets the condition of economic additionality.

Case 2: LFG collection and flaring through CDM and electricity generation without the CDM

The assumptions are similar to those above, the only difference being that investments and operating costs for LFG collection are not considered, since these are justified on the basis of CDM revenues. In other words, we determine if the electricity generation component is additional.

The detailed economic analysis for this case is shown in the electronic workbook:
Economic analysis LFG capture and power generation_marginal_FdS_10Sep07.pdf.

In the absence of CDM revenues, the NPV would be about USD 700,000. The IRR would be 39%. The electronic workbook also includes a sensitivity analysis with respect to the key assumptions, electricity sale price, O&M costs and investment requirements, in each case considering values ± 20% with respect to the assumptions above. The results of the sensitivity analysis are shown in the table below. For lower electricity prices, and higher O&M costs or higher investment requirements, the project cannot be cost effective without CER revenues. Note, that it is unlikely that all factors would lead to this worse situation, however, even considering the particular nature of the sensitivity analysis, we also consider a barrier analysis for Case 2 below.

Table 3.B. *Sensitivity Analysis for electricity generation only*

	Electricity Sale Price				
	-20%	-10%	0%	10%	20%
NPV	292,280	496,715	701,150	905,586	1,110,021
IRR	22.57%	30.92%	39.52%	48.66%	58.60%

	O&M Costs				
	-20%	-10%	0%	10%	20%
NPV	831,943	766,547	701,150	635,754	570,357
IRR	45.29%	42.37%	39.52%	36.72%	33.97%

	Investment				
	-20%	-10%	0%	10%	20%
NPV	874,884	788,017	701,150	614,284	527,417
IRR	57.77%	47.28%	39.52%	33.48%	28.58%

The economic additionality for Case 1 was clearly established above. Therefore, a barrier analysis is not needed to demonstrate additionality.

However, the results were financially positive for Case 2: the project was cost effective for the base-case assumption. Therefore, we will also apply ***Step 3 (Barrier Analysis)*** of the Additionality Tool, with special reference to electricity generation using LFG.

Regarding the thermal generation scenario (LFG1.3), there are investments as well as savings for displacing the LPG consumption.

In the spirit of ACM0001, ver. 6, we consider the following two possible baselines for evaluating the additionality of thermal generation:

1. LFG2. Disposal of the waste at the landfill with ***limited*** burning of gas passively vented from the landfill, so that baseline destruction of LFG is 20% of the value with an active extraction system with centralized flaring.
2. LFG1.1 Disposal of the waste at the landfill with ***active*** extraction of landfill gas and centralized flaring.

The two situations differ in the following way. In the first case, the economic benefits from thermal generation need to be more than the investments and operating costs of LFG collection and thermal generation, with no CDM revenues. In the second case, CDM revenues are sufficient to pay for LFG collection and flaring, and we need to determine if the marginal investments and operating costs for thermal generation by the use of landfill gas is adequately compensated by the benefits from fossil fuel purchase savings.

Case 3: LFG collection and thermal generation without the CDM

For thermal generation, there are no substantial investments to be made. There is also the savings from LPG purchase. We determine the cost effectiveness for LFG capture and thermal generation in the absence of the CDM. Our analysis is based on the following assumptions[5]:

- Investments are required to capture LFG. These include the construction of active extraction wells, a well field and blowers, etc. to collect the LFG and take it to the location where the flare and thermal plant would be located. For this project, this involves about USD 0.9 million in 2008, and about USD 25,000 yearly thereafter for well field expansion as the landfill expands;
- Operating costs for landfill gas collection are expected to be USD 150,000 in 2008 and increase slowly as the landfill expands;
- Adaptation of the burners of the thermal plant for LFG, gas pressure regulators and pipes to connect the thermal plant to the LFG pumping station. An investment of about USD 70,000 is estimated for 2008;
- Operation and maintenance cost: it is inserted in the LFG collection system. The operation and maintenance cost of the thermal plant would exist anyway in the absence of the project, so it is not considered here;
- Operation and maintenance costs for the new system, pipes and burners cleaning: 10% of the investment per year;
- Equipment life: 10 years;
- LPG price: USD 1.06 per kg of fuel;
- Corporate tax rate: 34%;
- Discount rate: 10%. Note that in July 2007, the Banco Central do Brasil Rate called Selic was around 11.5% (http://www.bcb.gov.br/). Considering the risks of this new technology as well as the risks in effective biodegradation of waste and effective methane capture, another 2% may be added. Thus an appropriate benchmark rate for this type of investment would be 13.5%. The chosen benchmark discount rate of 12% was chosen here. However, considering that a supposed inflation of 2% is taken to zero, we can bring the discount rate to 10% (considering that the same inflation is applied to different types of costs).

The detailed economic analysis is shown in the electronic workbook:
Economic analysis LFG capture and thermal generation_FdS_13Aug07.pdf.

[5] Note that the size and timing of equipment to be installed will depend on equipment availability at the time specific decisions are made. The size and dates shown here are representative assumptions.

For the assumptions stated above, the NPV for LFG capture and thermal generation is so negative (about USD -2.2 million), in the absence of the CDM, that again no meaningful IRR can be determined. The electronic workbook also includes a sensitivity analysis with respect to the key assumptions, LPG purchase price, O&M costs and investment requirements, in each case considering values ± 20% with respect to the assumptions above. The results of the sensitivity analysis are shown in the table below. Over the range considered, the NPV remains negative (and the IRR remains meaningless), which means that the project is not profitable without CER revenues.

Table 3.C *Sensitivity Analysis for LFG collection and thermal generation*

LPG Purchase Price

	-20%	-10%	0%	10%	20%
NPV	(2,316,276)	(2,286,276)	(2,256,276)	(2,226,277)	(2,196,277)
IRR	N.A.	N.A.	N.A.	N.A.	N.A.

O&M Costs

	-20%	-10%	0%	10%	20%
NPV	(1,946,089)	(2,101,183)	(2,256,276)	(2,411,370)	(2,566,464)
IRR	N.A.	N.A.	N.A.	N.A.	N.A.

Investment

	-20%	-10%	0%	10%	20%
NPV	(2,055,209)	(2,155,743)	(2,256,276)	(2,356,810)	(2,457,344)
IRR	N.A.	N.A.	N.A.	N.A.	N.A.

With CER revenues, assuming a CER price of USD 12 per tCO_2e, the NPV would be USD 0.32 million and the IRR would be about 20%, and the project would be profitable.

Thus, for this case, the proposed project meets the condition of economic additionality.

Case 4: LFG collection and flaring through CDM and thermal generation without the CDM

The assumptions are similar to those above, the only difference being that investments and operating costs for LFG collection are not considered, since these are justified on the basis of CDM revenues. In other words, we determine if the thermal generation component is additional.

The detailed economic analysis for this case is shown in the electronic workbook:
Economic analysis LFG capture and thermal generation_marginal_FdS_13Aug07.pdf.

In the absence of CDM revenues, the NPV would be about USD 89,565. The IRR would be about 39%. The electronic workbook also includes a sensitivity analysis with respect to the key assumptions, LPG purchase price, O&M costs and investment requirements, in each case considering values ± 20% with respect to the assumptions above. The results of the sensitivity analysis are shown in the table below. Even with a marginal analysis profitable, the project could face other barriers, so we also consider a barrier analysis for Case 4 below.

Table 3.D. *Sensitivity Analysis for thermal generation only*

LPG Purchase Price

	-20%	-10%	0%	10%	20%

NPV	49,966	69,765	89,565	109,365	129,165
IRR	25.53%	32.01%	38.83%	46.09%	53.90%

	O&M Costs				
	-20%	-10%	0%	10%	20%
NPV	97,670	93,618	89,565	85,513	81,460
IRR	41.75%	40.28%	38.83%	37.41%	36.00%

	Investment				
	-20%	-10%	0%	10%	20%
NPV	107,199	98,382	89,565	80,748	71,931
IRR	55.97%	46.10%	38.83%	33.22%	28.73%

The economic additionality for Case 3 was clearly established above. Therefore, a barrier analysis is not needed to demonstrate additionality.

However, the results were financially positive for Case 4: the project was cost effective for the base-case assumption. Therefore, we will also apply ***Step 3 (Barrier Analysis)*** of the Additionality Tool, with special reference to thermal energy generation using LFG.

Finally, we need to analyse the scenario LFG1.4 (landfill gas and use of landfill gas for electricity and heat generation). As it is a mix of scenarios LFG1.2 (electricity generation) and LFG1.3 (heat generation) already analyzed, we can conclude the following: it was demonstrated that each alternative is not economically attractive without CDM revenues, thus the mix of both will not be economically attractive without CDM revenues neither. It was also demonstrated that the marginal analysis for each of the two scenarios was attractive without CDM revenues thus the application of both alternatives together would be attractive too.

Next we apply ***Step 3 (Barrier Analysis).***

In order to apply barrier analysis to the proposed project activity, we are required to show that the project activity faces barriers that:

(a) Prevent a wide spread implementation of this activity and thus preventing the baseline scenarios from occurring; and
(b) Do not prevent a wide spread implementation of at least one of the alternatives.

The demonstration involves two sub-steps:

"Sub-step 3a. Identify barriers that would prevent the implementation of the proposed CDM project activity".

The tool states:

"It is necessary to establish that there are realistic and credible barriers that would prevent the proposed project activity from being carried out if the project were not registered as a CDM activity. Such realistic and credible barriers may include, among others:

1) *Investment barriers, other than the economic/financial barriers in Step 2 above,* inter alia*:*
    - *For alternatives undertaken and operated by private entities: Similar activities have only been implemented with grants or other non-commercial finance terms. Similar activities are*

defined as activities that rely on a broadly similar technology or practices, are of a similar scale, take place in a comparable environment with respect to regulatory framework.
   - *No private capital is available from domestic or international capital markets due to real or perceived risks associated with investment in the country where the proposed CDM project activity is to be implemented, as demonstrated by the credit rating of the country or other country investments reports of reputed origin.*
2) *Technological barriers,* inter alia*:*
   - *Skilled and/or properly trained labour to operate and maintain the technology is not available, which leads to an unacceptably high risk of equipment disrepair and malfunctioning or other underperformance;*
   - *Lack of infrastructure for implementation and logistics for maintenance of the technology (e.g. natural gas can not be used because of the lack of a gas transmission and distribution network).*
   - *Risk of technological failure: the process/technology failure risk in the local circumstances is significantly greater than for other technologies that provide services or outputs comparable to those of the proposed CDM project activity, as demonstrated by relevant scientific literature or technology manufacturer information.*
   - *The particular technology used in the proposed project activity is not available in the relevant region.*
3) *Barriers due to prevailing practice,* inter alia*:*
   - *The project activity is the "first of its kind".*
4) *Other barriers, preferably specified in the underlying methodology as examples."*

According to our interpretation of ACM001, ver. 6, the proposed project activity for which we need to demonstrate additionality needs to be divided into three parts:

- LFG collection and flaring;
- LFG collection for electricity generation using LFG (Case 2);
- LFG collection for thermal use (Case 4).

Below, we show that all three parts face technological barriers as well as barriers due to prevailing practice. Each are analyzed below:

Investment barriers

In most developing countries waste management sector is not given priority within the economy, so that project developers often face difficulties in obtaining investments funds for solid waste management projects. Moreover, the tipping fees (price for waste disposal) are very low compared to values in industrialized countries[6], so that even when investment has been secured, these revenues may not be enough to cover expenses for the proper operation and maintenance of the project activity.

Technological barriers

Skilled and/or properly trained labour to operate and maintain the technologies mentioned in this project, more precisely, LFG energy use. Skilled and trained people are scarce in Brazil and no education/training institution in Brazil provides the needed skill, leading to equipment disrepair and malfunctioning.

---

[6] The average tipping fee Qualix receives from municipalities is USD10.20 per tonne disposed at the landfills. On the other hand, for example, according to California State website, the average tipping fee for municipal waste in California State, in year 2000, was about USD 40.00 (http://www.ciwmb.ca.gov/Landfills/TipFees/TFSums.htm).

There is also a lack of infrastructure for implementation of electricity generation from LFG. Since there is only one operational landfill gas recovery to energy project in Brazil, financed through electricity selling and CDM structure, there is no Brazilian provider of equipment and services for work related electricity generation with landfill gas. If the proposed project is registered under the CDM, it is likely that it will be a company outside Brazil that would have to provide technical expertise in order to conduct detailed engineering studies and support project implementation.

In the case of thermal energy generation, although Feira de Santana project would generate small quantity of thermal energy using LFG, the company cannot predict what could happen in terms of gas availability and in terms of how much maintenance will be required in the thermal plant (LFG contains traces of gases that can be corrosive to equipments).

It is possible that the successful implementation of the proposed project and a few others in Brazil would be the key to breaking the technological barriers to this type of project.

Barriers due to prevailing practice

The proposed project activity (landfill gas capture and energy use) would be one of the first of its kind in Brazil. Although, in recent months, other projects to capture landfill gas in Brazil have been proposed (all within the CDM context), they are mostly for simple flaring of LFG. There is only one project in operation of landfill gas to energy in Brazil, and it will be some years before LFG collection with power generation or thermal energy generation is a well established technology in Brazil.

The additionality tool also provides a Sub-step 3.b.

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

The barriers identified above apply to scenarios LFG1.1 to LFG1.4, considered early in this document. These four scenarios are variants to the proposed project activity, and all face barriers. The barriers identified do not prevent the continuation of the current situation at the landfill (scenario LFG2), which does not require additional investments neither additional training nor skilled workers.

The tool now states: "*If both Sub-steps 3a – 3b are satisfied, proceed to Step 4 (Common practice analysis).*"

"Step 4. Common practice analysis".

Which states:

> *"The above generic additionality tests shall be complemented with an analysis of the extent to which the proposed project type (e.g. technology or practice) has already diffused in the relevant sector and region. This test is a credibility check to complement the investment analysis (Step 2) or barrier analysis (Step 3)."*

Step 4 comprises two Sub-Steps, which are discussed below.

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

> *"Provide an analysis of any other activities implemented previously or currently underway that are similar to the proposed project activity. Projects are considered similar if they are in the same country/region and/or rely on a broadly similar technology, are of a similar scale, and take place in a comparable environment with respect to regulatory framework, investment climate,*

> *access to technology, access to financing, etc. Other CDM project activities are not to be included in this analysis. Provide documented evidence and, where relevant, quantitative information. On the basis of that analysis, describe whether and to which extent similar activities have already diffused in the relevant region"*

As it has been stated in the context of Step 3 above, there are some other activities currently operating in Brazil that are similar to the proposed project activity but without the energy component due to strong barriers presented at national level.

"Sub-step 4b: Discuss any similar options that are occurring", does not apply since no similar activities exist. There are no other similar projects of gas collection and energy generation in Brazil, with exception of projects under CDM structure which are happening due to carbon credits revenues.

Further the tool states that:
"If sub-steps 4a and 4b are satisfied, i.e. (i) similar activities cannot be observed or (ii) similar activities are observed, but essential distinctions between the project activity and similar activities can be reasonably be explained, then the proposed project activity is additional"

Thus, we can assert that the proposed project activity is additional.

B.6. Emission reductions:

B.6.1. Explanation of methodological choices:

According to ACM0001, version 6:
The greenhouse gas emission reduction achieved by the project activity during a given year *"y" (ER_y)* is given by:

$$ER_y = \left(MD_{project,y} - MD_{reg,y}\right) * GWP_{CH_4} + EL_{LFG,y} * CEF_{elec,BL,y} - EL_{PR,y} * CEF_{elec,PR,y} + ET_{LFG,y} * CEF_{ther,BL,y} - ET_{PR,y} * EF_{fuel,PR,y} \quad \textbf{(1)}$$

Where:

ER_y	=	Emissions reduction in tonnes of CO_2 equivalent (tCO_2e).
$MD_{project,y}$	=	Amount of methane that would be destroyed/combusted during the year as a result of project implementation, in tonnes of methane (tCH_4).
$MD_{reg,y}$	=	Amount of methane that would have been destroyed/combusted during the year in the absence of the project, in tonnes of methane (tCH_4).
GWP_{CH4}	=	Global Warming Potential for methane for the first commitment period is 21 tCO_2e/tCH_4.
$EL_{LFG,y}$	=	Net quantity of electricity produced using landfill gas, which in the absence of the project activity would have been produced by power plants connected to the grid or by an on-site/off-site fossil fuel based captive power generation, during year *y*, in megawatt hours (MWh).
$CEF_{elec,BL,y}$	=	CO_2 emissions intensity of the baseline source of electricity displaced, in tCO_2e/MWh.
$ET_{LFG,y}$	=	Quantity of thermal energy produced utilizing the landfill gas, which in the absence

		of the project activity would have been produced from on-site/off-site fossil fuel fired boiler, during the year *y*, in TJ.
$CEF_{ther,BL,y}$	=	CO_2 emissions intensity of the fuel used by boiler to generate thermal energy which is displaced by landfill gas based thermal energy generation, in tCO_2e/TJ.
$EL_{PR,y}$	=	Amount of electricity generated in an on-site fossil fuel fired power plant or imported from the grid as a result of the project activity, measured using an electricity meter (MWh)[7].
$CEF_{elec,PR,y}$	=	Carbon dioxide emissions factor for electricity generation in the project activity (tCO_2/MWh).
$ET_{PR,y}$	=	Fossil fuel consumption on-site during project activity in year *y* (tonne)[8].
$EF_{fuel,PR,y}$	=	CO_2 emissions factor of the fossil fuel used by boiler to generate thermal energy in the project activity during year *y*.

ACM0001, version 6 offers several ways for determining MD_{reg}.
One option is *"In the case where the $MD_{reg,y}$ is given/defined as a quantity that quantity will be used"*. This is not the case here.

Another option is *"In cases where regulatory or contractual requirements do not specify $MD_{reg,y}$ an "Adjustment Factor", (AF) shall be used and justified, taking into account the project context."*

$$MD_{reg,y} = MD_{project,y} * AF \qquad \textbf{(2)}$$

This is the approach taken in this PDD.

In order to calculate $MD_{project,y}$, the methodology states:
"The methane destroyed by the project activity ($MD_{project,y}$) during a year is determined by monitoring the quantity of methane actually flared and gas used to generate electricity and/or produce thermal energy, if applicable, and the total quantity of methane captured."

And,
"The sum of the quantities fed to the flare(s), to the power plant(s) and to the boiler(s)[9], estimated using equation (3), must be compared annually with the total quantity of methane captured[10]. The lowest value of the two must be adopted as $MD_{project,y}$".

This is meant to be conservative, claiming the lower amount of methane destroyed. In case the total methane collection is the highest, $MD_{project,y}$ is given by:

---

7 If in the baseline a part of LFG was captured then the electricity quantity used in calculation is electricity used in project activity net of that consumed in the baseline.
8 If in the baseline part of a LFG was captured then the heat quantity used in calculation is fossil fuel used in project activity net of that consumed in the baseline.

9 In the general case, this can be any heat producing equipment. For this project, it is a medical waste treatment plant by steam.

10 ACM0001 version 6 (and earlier versions) refers to the total quantity of methane generated, but this is believed to be an error, because it is not possible to monitor methane generation. Moreover, the quantities of methane captured will be fed to the flare(s), power plant(s) and thermal plant(s), thus methane destroyed in project will be related to methane *captured*.

$$MD_{project,y} = MD_{flared,y} + MD_{electricity,y} + MD_{thermal,y} \quad \textbf{(3)}$$

Thus we need to determine methane destroyed by flaring, electricity and thermal energy generation.

Calculation of $MD_{flared,\,y}$:

$$MD_{flared,y} = \left(LFG_{flare,y} * w_{CH4,y} * D_{CH4}\right) - \left(\frac{PE_{flare,y}}{GWP_{CH4}}\right) \quad \textbf{(4)}$$

Where, according to ACM0001, *"$MD_{flared,y}$ is the quantity of methane destroyed by flaring, $LFG_{flare,y}$ is the quantity of landfill gas fed to the flare during the year measured in cubic meters (m^3), $w_{CH4,y}$ is the average methane fraction of the landfill gas as measured[11] during the year and expressed as a fraction (in m^3CH_4/m^3LFG), D_{CH4} is the methane density expressed in tonnes of methane per cubic meter of methane (tCH_4/m^3CH_4)[12] and $PE_{flare,y}$ are the project emissions from flaring of the residual gas stream in year y (tCO_2e) determined following the procedure described in the "Tool to determine project emissions from flaring gases containing methane. If methane is flared through more than one flare, the $PE_{flare,y}$ shall be determined for each flare using the tool."*

In order to determine the amount of methane sent to the flare in a year, we need to sum the mass of methane over the year. Since the methane fraction of landfill gas and gas density are, in general, changing with time, a more precise formula for methane destroyed by flaring is:

$$MD_{flared,y} = \left(\sum_{h=1}^{8760} (LFG_{flare,h} * w_{CH4,h} * D_{CH4,h})\right) - \left(\frac{PE_{flare,y}}{GWP_{CH4}}\right) \quad \textbf{(4a)}$$

Here the mass of methane sent to the flare is determined hourly, with hourly values added over the year.

The gas density depends on temperature and pressure, and flow meter likely to be used for monitoring in LFG capture projects automatically compensate for gas density in flow measurement, so that in Eq (4a), $LFG_{flare,h}$ is already expressed in terms of standard temperature and pressure, so that $D_{CH4,h}$ (methane density) is in fact a constant, 0.0007168 tonne/m³, at standard temperature and pressure conditions (0°C, 1.013 bar). Thus, in practice, there is no difference between equations (4) and (4a).

Not all the methane that reaches the flare is destroyed, and the *"Tool to determine project emissions from flaring gases containing methane"* is meant to take this into account.

The tool differentiates between open and enclosed flares. The project proposed here will use enclosed flares, since these are more effective in destroying methane.

For enclosed flares, the Tool proposes two options to determine the flare efficiency*:*
For enclosed flares, either of the following two options can be used to determine the flare efficiency:

---

[11] Methane fraction of the landfill gas to be measured on wet basis.

[12] At standard temperature and pressure (0 degree Celsius and 1,013 bar) the density of methane is 0.0007168 tCH_4/m^3CH_4.

(a) To use a 90% default value. Continuous monitoring of compliance with manufacturer's specification of flare (temperature, flow rate of residual gas at the inlet of the flare) must be performed. If in a specific hour any of the parameters are out of the limit of manufacturer's specifications, a 50% default value for the flare efficiency should be used for the calculations for this specific hour.
(b) Continuous monitoring of the methane destruction efficiency of the flare (flare efficiency).

The Tool further requires that the temperature in the exhaust gas of the flare to be measured in order to determine whether the flare is operating or not. *"In both cases, if there is no record of the temperature of the exhaust gas of the flare or if the recorded temperature is less than 500 °C for any particular hour, it shall be assumed that during that hour the flare efficiency is zero."*

The project is likely to use the 90% default value. However, if project operator decides to monitor emissions continuously, then the Tool procedures for continuous monitoring will be applied. When continuous monitoring is not in place, the default value will be applied. In case of using the 90% default value (enclosed flares), Steps 3 and 4 of the Tool should not be included here.

Step 1: Determination of the mass flow rate of the residual gas that is flared

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

$$FM_{RG,h} = \rho_{RG,n,h} * FV_{RG,h} \qquad \textbf{(T.1)}^{13}$$

Where:

$FM_{RG,h}$	kg/h	Mass flow rate of the residual gas in hour *h*
$\rho_{RG,n,h}$	kg/m^3	Density of the residual gas at normal conditions in hour *h*
$FV_{RG,h}$	m^3/h	Volumetric flow rate of the residual gas in dry basis at normal conditions in hour *h*

And:

$$\rho_{RG,n,h} = \frac{P_n}{\frac{R_u}{MM_{RG,h}} \times T_n} \qquad \textbf{(T.2)}$$

Where:

$\rho_{RG,n,h}$	kg/m^3	Density of the residual gas at normal conditions in hour *h*
P_n	Pa	Atmospheric pressure at normal conditions (101,325)
R_u	Pa.m^3/kmol.K	Universal ideal gas constant (8,314)
$MM_{RG,h}$	kg/kmol	Molecular mass of the residual gas in hour *h*
T_n	K	Temperature at normal conditions (273.15)

And:

[13] Equation numbers from the Tool are prefixed with the letter "T" to distinguish them from equations from the methodology.

$$MM_{RG,h} = \sum_i \left(fv_{i,h} * MM_i \right) \tag{T.3}$$

Where:

$MM_{RG,h}$	kg/kmol	Molecular mass of the residual gas in hour *h*
$fv_{i,h}$	-	Volumetric fraction of component *i* in the residual gas in the hour *h*
MM_i	kg/kmol	Molecular mass of residual gas component *i*
I		The components CH_4, CO, CO_2, O_2, H_2, N_2

The Tool states that "*As a simplified approach, project participants may only measure the volumetric fraction of methane and consider the difference to 100% as being nitrogen (N_2)".*

Note that the Tool is applicable to a wide variety of residual gases to be flared, while landfill gas is the product of anaerobic decomposition, which does not produce hydrogen or carbon monoxide, so these two gases can be eliminated from the calculations, without any assumptions. The simplification proposed in the tool involves considering CO_2 and O_2 as N_2. While this leads to minor errors, we use this simplified approach, since it greatly simplifies measurements, and does not significantly affect the estimate of flare efficiency.

With this simplification, Eq. (T.3) becomes:

$$MM_{RG,h} = \sum_i \left(fv_{i,h} * MM_i \right) \tag{T.3a}$$

Where:

$MM_{RG,h}$	kg/kmol	Molecular mass of the residual gas in hour *h*
$fv_{i,h}$	-	Volumetric fraction of component *i* in the residual gas in the hour *h*
MM_i	kg/kmol	Molecular mass of residual gas component *i*
I		The components CH_4, N_2 (Note that only CH_4 would be measured and N_2 determined as the balance)

Note that elemental hydrogen is a part of methane and therefore the hydrogen content of the residual gas affects its stoichiometry.

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

Step 2 states:

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

$$fm_{j,h} = \frac{\sum_i fv_{i,h} * AM_j * NA_{j,i}}{MM_{RG,h}} \tag{T.4}$$

Where:

$fm_{i,h}$	-	Mass fraction of element *j* in the residual gas in hour *h*
$fv_{i,h}$	-	Volumetric fraction of component *i* in the residual gas in the hour *h*
AM_j	kg/kmol	Atomic mass of element *j*
$NA_{j,i}$	-	Number of atoms of element *j* in component *i*
$MM_{RG,h}$	kg/kmol	Molecular mass of the residual gas in hour *h*
J		The elements carbon, hydrogen, oxygen and nitrogen. Note that the simplified approach, involving measurement of methane and assuming the balance to be nitrogen, implies that there is no elemental oxygen in the gas, and that all the carbon is in the form of methane. The only hydrogen is also in methane, but this does not involve any simplification, since there is no H_2 in the other components that might be present in landfill gas: CO_2 and O_2.
I		The components CH_4 and N_2 (Note that with the simplified approach, the concentrations of other gases would not be determined)

Step 3: Determination of the volumetric flow rate of the exhaust gas on a dry basis

Since the methane combustion efficiency is to be continuously measured in the proposed project, this step is applicable.

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

$$TV_{n,FG,h} = V_{n,FG,h} * FM_{RG,h} \quad \textbf{(T.5)}$$

Where:

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

$$V_{n,FG,h} = V_{n,CO_2,h} + V_{n,O_2,h} + V_{n,N_2,h} \quad \textbf{(T.6)}$$

Where:

$V_{n,FG,h}$	m^3/kg residual gas	Volume of the exhaust gas of the flare in dry basis at normal conditions per kg of residual gas in the hour *h*
$V_{n,CO2,h}$	m^3/kg residual gas	Quantity of CO_2 volume free in the exhaust gas of the flare at normal conditions per kg of residual gas in the hour *h*
$V_{n,N2,h}$	m^3/kg residual gas	Quantity of N_2 volume free in the exhaust gas of the flare at normal conditions per kg of residual gas in the hour *h*
$V_{n,O2,h}$	m^3/kg residual gas	Quantity of O_2 volume free in the exhaust gas of the flare at normal conditions per kg of residual gas in the hour *h*

$$V_{n,O_2,h} = n_{O_2,h} \times MV_n \quad \textbf{(T.7)}$$

Where:

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

The Tool states:

$$V_{n,N_2,h} = MV_n \times \left\{ \frac{fm_{N,h}}{200AM_N} + \left(\frac{1-MF_{O_2}}{MF_{O_2}} \right) \times \left[F_h + n_{O_2,h} \right] \right\} \quad \textbf{(T.8)}$$

Where:

$V_{n, N2, h}$	m^3/kg residual gas	Quantity of N_2 volume free in the exhaust gas of the flare at normal conditions per kg of residual gas in hour *h*
$fm_{N, h}$	-	Mass fraction of nitrogen in the residual gas in the hour *h*
AM_N	kg/kmol	Atomic mass of nitrogen
MF_{O2}	-	O_2 volumetric fraction of air (0.21)
F_h	kmol/kg residual gas	Stoichiometric quantity of moles of O_2 required for a complete oxidation of one kg residual gas in hour *h*

and other variables are as defined earlier.

Note that if the mass fraction is expressed as a fraction, as the definition above implies, and not as a %, the number in the first denominator of Eq. T.8 should be 2 and not 200, so that the correct equation would be:

$$V_{n,N_2,h} = MV_n \times \left\{ \frac{fm_{N,h}}{2AM_N} + \left(\frac{1-MF_{O_2}}{MF_{O_2}} \right) \times \left[F_h + n_{O_2,h} \right] \right\} \quad \textbf{(T.8a)}$$

Next we have:

$$V_{n,CO_2,h} = \frac{fm_{C,h}}{AM_C} \times MV_n \quad \textbf{(T.9)}$$

Where:

$V_{n, CO2, h}$	m^3/kg residual gas	Quantity of CO_2 volume free in the flare exhaust gas at normal conditions per kg of residual gas in the hour *h*
$fm_{C, h}$	-	Mass fraction of carbon in the residual gas in the hour *h*
AM_C	kg/kmol	Atomic mass of carbon

and other variables are as defined earlier.

$$n_{O_2,h} = \frac{t_{O_2,h}}{\left(1-\left(t_{O_2,h}/MF_{O_2}\right)\right)} \times \left[\frac{fm_{C,h}}{AM_C} + \frac{fm_{N,h}}{2AM_N} + \left(\frac{1-MF_{O_2}}{MF_{O_2}} \right) \times F_h \right] \quad \textbf{(T.10)}$$

Where:
$t_{O2,h}$ - Volumetric fraction of O_2 in the exhaust gas in hour *h*
and other variables are as defined earlier.

Note that the second term in the large brackets $[..]$ is $\frac{fm_{N,h}}{2AM_N}$, with 2 in the denominator, not 200, confirming our observation of Eq. (8) above.

$$F_h = \frac{fm_{C,h}}{AM_C} + \frac{fm_{H,h}}{4AM_H} - \frac{fm_{O,h}}{2AM_O} \qquad \textbf{(T.11)}$$

Where:

F_h	kmol O_2 / kg residual gas	Stoichiometric quantity of moles of O_2 required for a complete oxidation of one kg residual gas in hour *h*
$fm_{H,h}$	-	Mass fraction of hydrogen in the residual gas in hour *h*
$fm_{O,h}$	-	Mass fraction of oxygen in the residual gas in hour *h*
AM_H	kg/kmol	Atomic mass of hydrogen
AM_O	kg/kmol	Atomic mass of oxygen

and other variables are as defined earlier.

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:

$$TM_{FG,h} = \frac{TV_{n,FG,h} * fv_{CH_4,FG,h}}{1{,}000{,}000} \qquad \textbf{(T.12)}$$

Where:

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

Step 5: Determination of methane mass flow rate in the residual gas on a dry basis
The Tool states:
"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)."

Note that this is identical to the first part of our reformulation Eq. (4a) of Eq. (4) of ACM0001.

The Tool further elaborates:
"It is necessary to refer both measurements (flow rate of the residual gas and volumetric fraction of methane in the residual gas) to the same reference condition that may be dry or wet basis. If the residual

gas moisture is significant (temperature greater than 60ºC), the measured flow rate of the residual gas that is usually referred to wet basis should be corrected to dry basis due to the fact that the measurement of methane is usually undertaken on a dry basis (i.e. water is removed before sample analysis)."

$$TM_{RG,h} = FV_{RG,h} * fv_{CH_4,RG,h} * \rho_{CH_4,n} \qquad \textbf{(T.13)}$$

Where:

$TM_{RG,h}$	kg/h	Mass flow rate of methane in the residual gas in the hour h
$FV_{RG,h}$	m^3/h	Volumetric flow rate of the residual gas in dry basis at normal conditions in hour h
$fv_{CH4,RG,h}$	-	Volumetric fraction of methane in the residual gas on dry basis in hour h (NB: this corresponds to $fv_{i,RG,h}$ where i refers to methane).
$\rho_{CH_4,n}$	kg/m^3	Density of methane at normal conditions (0.716)

Note that the Tool uses terms of the type $fv_{CH4,FG,h}$ in Eq. (T.12) expressed as mg/m^3 and similar terms $fv_{CH4,RG,h}$ in Eq. (T.13) expressed as a dimensionless quantity. While it would have been better if Equation (T.12) had used a different letter (other than "fv") to designate concentration, the equations are correct as long they are applied noting that there are two types of "fv".

Note also that the Tool denominates density by the traditional Greek letter (ρ), while ACM0001 uses the letter D. Moreover, density is expressed in kg/m^3 in the tool and $tonne/m^3$ in ACM0001. Care should be taken with the units to avoid errors.

Step 6: Determination of the hourly flare efficiency

The Tool states:

"The determination of the hourly flare efficiency depends on the operation of flare (e.g. temperature), the type of flare used (open or enclosed) and, in case of enclosed flares, the approach selected by project participants to determine the flare efficiency (default value or continuous monitoring)."

"In case of enclosed flares and continuous monitoring of the flare efficiency, the flare efficiency in the hour h ($\eta_{flare,h}$) is:

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

$$\eta_{flare,h} = 1 - \frac{TM_{FG,h}}{TM_{RG,h}} \qquad \textbf{(T.14)}$$

Where:

$\eta_{flare,h}$	-	Flare efficiency in hour h
$TM_{FG,h}$	kg/h	Methane mass flow rate in exhaust gas averaged in hour h[14]
$TM_{RG,h}$	kg/h	Mass flow rate of methane in the residual gas in the hour h

[14] Note that the first version of the Tool (EB28 Annex 13) defines $TM_{FG,\,h}$ as "Methane mass flow rate in exhaust gas averaged over a period of time t (hour, two months or year)". We believe this is a misprint. For hourly flare efficiency to be meaningfully determined, the definition should be as stated here in the PDD.

STEP 7. Calculation of annual project emissions from flaring

The Tool states:

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

$$PE_{flare,y} = \sum_{h=1}^{8760} TM_{RG,h} \times \left(1 - \eta_{flare,h}\right) \times \frac{GWP_{CH_4}}{1000} \qquad \textbf{(T.15)}$$

Where:

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

In case of use of the default value for the methane destruction efficiency, the manufacturer's specifications for the operation of the flare and the required data and procedures to monitor these specifications should be documented in the CDM PDD.

Once project emissions $PE_{flare,y}$ has been calculated, the next formula from the methodology ACM0001 ver. 6 is:

$$MD_{electricity,y} = LFG_{electricity,y} \times w_{CH_4,y} \times D_{CH_4} \qquad \textbf{(5)}$$

Where:

$MD_{electricity,y}$	=	quantity of methane destroyed by generation of electricity (tCH_4/yr)
$LFG_{electricity,y}$	=	quantity of landfill gas fed into electricity generator (m^3/yr)
$w_{CH4,y}$	=	average methane fraction of the landfill gas as measured during the year ($m^3\ CH_4/m^3$ LFG)
D_{CH4}	=	methane density at normal conditions ($tCH_4/m^3\ CH_4$)

Considering hourly variations in methane density and methane concentration in LFG, a more precise form of Eq. (5) is:

$$MD_{electricity,y} = \sum_{h=1}^{8760} (LFG_{electricity,h} \times w_{CH_4,h} \times D_{CH_4}) \qquad \textbf{(5.1)}$$

Following the same logic of $MD_{electricity,y}$, the formula for thermal energy is given by the following:

$$MD_{thermal,y} = \sum_{h=1}^{8760} (LFG_{thermal,h} \times w_{CH_4,h} \times D_{CH_4}) \qquad \textbf{(5.2[15])}$$

Where:

[15] The ACM0001 version 6 does not provide formula for $MD_{thermal,y}$. This formula will be numbered as (5.2).

$MD_{thermal,y}$ = quantity of methane destroyed for generation of thermal energy
$LFG_{thermal,h}$ = quantity of landfill gas fed into the thermal plant

Finally, and considering hourly variations in density and methane concentration in LFG, $MC_{total,y}$[16] would be:

$$MC_{total,y} = \sum_{h=1}^{8760} (LFG_{total,h} \times w_{CH_4,h} \times D_{CH_4}) \quad \textbf{(5.3}^{17}\textbf{)}$$

Where:
$MC_{total,y}$ = total quantity of methane captured
$LFG_{total,h}$ = total quantity of landfill gas captured

Determination of $CEF_{elec,BL,y}$

The methodology states: "*In case the baseline is electricity generated by plants connected to the grid the emission factor should be calculated according to the methodology ACM0002 ('Consolidated baseline methodology for grid-connected electricity generation from renewable sources')*".

The value and source of information for $CEF_{elec,BL,y}$ are given in section B.6.2.

Determination of $CEF_{ther,BL,y}$

The formula provided by the methodology is as follows:

$$CEF_{therm,BL,y} = \frac{EF_{fuel,BL}}{\varepsilon_{boiler} \cdot NCV_{fuel,BL}} \quad \textbf{(7)}$$

Where:
ε_{boiler} = The energy efficiency of the thermal plant[18] used in the absence of the project activity to generate the thermal energy
$NCV_{fuel,BL}$ = Net calorific value of fuel, as identified through the baseline identification procedure, used in the [thermal plant] to generate the thermal energy in the absence of the project activity in TJ per unit of volume or mass
$EF_{fuel,BL}$ = Emission factor of the fuel, as identified through the baseline identification procedure, used in the [thermal plant] to generate the thermal energy in the absence of the project

[16] ACM0001 version 6 (and earlier versions) refers to the total quantity of methane generated, using the variable MD_{total}, but this is believed to be an error because it is not possible to monitor methane generation. This should be "methane captured". Then, as the symbol "MD" (methane destroyed) would be misleading, we renamed the variable as MC_{total}.

[17] The ACM0001 version 6 does not provide formula for $MD_{total.y}$. This formula will be numbered as (5.3).

[18] Note that ACM0001 refers to "boiler" but we believe it can be any thermal power plant. In this case it is a medical waste treatment plant equipped with a thermal plant (treatment by autoclave).

activity in tCO_2 / unit of volume or mass of the fuel

According to the methodology, the [thermal plant] efficiency can be assessed by two options:

"Option A: Use the highest value among the following three values as a conservative approach:

1. *Measured efficiency prior to project implementation;*
2. *Measured efficiency during monitoring;*
3. *Manufacturer's information on the [thermal plant] efficiency*

Option B: Assume a [thermal plant] efficiency of 100% based on the net calorific values as a conservative approach."

Here we choose *Option B* above in order to be conservative.

For EF_{fuel} the methodology states: "*In determining the CO_2 emission factors (EF_{fuel}) of fuels, reliable local or national data should be used if available. Where such data is not available, IPCC default emission factors should be chosen in a conservative manner*".

Determination of $CEF_{elect,PR,y}$:

The methodology states: "*In cases where electricity is purchased from the grid, the emission factor shall be calculated according to the methodology ACM0002 ('Consolidated baseline methodology for grid-connected electricity generation from renewable sources'). If electricity consumption is less than small scale threshold (60 GWh per annum), AMS-I.D may be used*".

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

Some of the parameters and data used in equations that are not monitored are constants, as listed in the table below. Most of the table is taken directly from the Flaring Tool. The remaining parameters and data that are available at the time of validation, and are not monitored are listed in individual data tables further below.

Parameter	SI Unit	Description	Value
MM_{CH4}	kg/kmol	Molecular mass of methane	16.04
MM_{CO}	kg/kmol	Molecular mass of carbon monoxide	28.01
MM_{CO2}	kg/kmol	Molecular mass of carbon dioxide	44.01
MM_{O2}	kg/kmol	Molecular mass of oxygen	32.00
MM_{H2}	kg/kmol	Molecular mass of hydrogen	2.02
MM_{N2}	kg/kmol	Molecular mass of nitrogen	28.02
AM_C	kg/kmol (g/mol)	Atomic mass of carbon	12.00
AM_H	kg/kmol (g/mol)	Atomic mass of hydrogen	1.01
AM_O	kg/kmol (g/mol)	Atomic mass of oxygen	16.00
AM_N	kg/kmol (g/mol)	Atomic mass of nitrogen	14.01
P_n	Pa	Atmospheric pressure at normal conditions	101,325
R_u	Pa m^3/kmol K	Universal ideal gas constant	8,314.472
T_n	K	Temperature at normal conditions	273.15
MF_{O2}	Dimensionless	O_2 volumetric fraction of air	0.21
GWP_{CH4}	tCO_2/tCH_4	Global warming potential of methane	21

MV_n	m^3/Kmol	Volume of one mole of any ideal gas at normal temperature and pressure	22.414
$\rho_{CH4,n}$ / D_{CH4}	kg/m^3	Density of methane gas at normal conditions	0.7168
$NA_{i,j}$	Dimensionless	Number of atoms of element *j* in component *i*, depending on molecular structure	

Data / Parameter:	**AF**
Data unit:	Dimensionless
Description:	Adjustment factor (for methane destruction in the baseline)
Source of data used:	Estimate (see justification below)
Value applied:	20%
Justification of the choice of data or description of measurement methods and procedures actually applied:	In the absence of the proposed project, almost all the landfill gas will be released to the atmosphere. As explained in B.4, the current configuration of passive venting and limited burning at Feira de Santana landfill, undertaken to meet safety requirements and common practices, would destroy no more than 20% of the gas that would be collected by an active extraction system.
Any comment:	Value may change at the end of each crediting period in case of changes in regulatory requirements, which will be monitored, see table for variable 25 in B.7.1 below.

Data / Parameter:	**$CEF_{elec,BL,y}$**
Data unit:	tCO_2e/MWh
Description:	CO_2 emissions intensity of the baseline source of electricity displaced.
Source of data used:	Data for power plants in the North-Northeast interconnected grid provided by the National Dispatch Authority or other official data source.
Value applied:	0.0767 (Combined Margin)
Justification of the choice of data or description of measurement methods and procedures actually applied:	For power generation below 15 MW, the emissions factor may be calculated using small-scale CDM methodology: AMS I.D. Otherwise, the more general methodology ACM0002 should be used.
Any comment:	A single, fixed value is used for each crediting period. More calculation details are provided in Annex 3.

Data / Parameter:	**$CEF_{elec,PR,y}$**
Data unit:	tCO_2e/MWh
Description:	Carbon emission factor for electricity generation in the project activity.
Source of data used:	Data for power plants in the North-Northeast interconnected grid provided by the National Dispatch Authority or other official data source.
Value applied:	0.0767 (Combined Margin)
Justification of the choice of data or description of measurement methods and procedures actually applied:	For power generation below 15 MW, the emissions factor may be calculated using small-scale CDM methodology: AMS I.D. Otherwise, the more general methodology ACM0002 should be used.
Any comment:	A single, fixed value is used for each crediting period. More calculation details are provided in Annex 3.

Data / Parameter:	$CEF_{ther,BL,y}$
Data unit:	tCO_2e/TJ
Description:	CO_2 emission intensity of fuel used by the thermal plant to generate thermal energy which is displaced by LFG based thermal energy generation.
Source of data used:	IPCC data tables or other reliable source
Value applied:	63.1 tCO_2e/TJ. (IPCC standard value)
Justification of the choice of data or description of measurement methods and procedures actually applied:	As there is no reliable local or national data available, the IPCC default emission factor for LPG (Liquefied Petroleum Gas) was used.
Any comment:	

Data / Parameter:	$EF_{fuel,BL,y}$
Data unit:	tCO_2e/Gg
Description:	CO_2 emission factor of fossil fuel that would have been used in the baseline captive thermal energy generation.
Source of data used:	IPCC data tables or other reliable source
Value applied:	2,984.6 tCO_2e/Gg.
Justification of the choice of data or description of measurement methods and procedures actually applied:	As there is no reliable local or national data available, the IPCC default emission factor for LPG (Liquefied Petroleum Gas) was used.
Any comment:	This value is calculated using IPCC emission factor and net calorific value of LPG.

Data / Parameter:	ε_{boiler}
Data unit:	%
Description:	Efficiency of the thermal plant
Source of data used:	Conservative approach taken from ACM0001 version 6.
Value applied:	100%
Justification of the choice of data or description of measurement methods and procedures actually applied:	To estimate thermal plant efficiency, project participants will use the highest value between measurement prior project implementation or during monitoring, or information from manufacturer, or at last a default efficiency of 100% should be considered. IPCC default emission factor for LPG (Liquefied Petroleum Gas) was used.
Any comment:	A default of 100% is used for ex-ante calculation purposes as a conservative approach.

B.6.3 Ex-ante calculation of emission reductions:

An ex-ante emission reduction calculation requires an estimation of landfill gas production from the waste at the site. This estimation is made using a First Order Decay Model, developed by the USEPA, and widely used. For more information on this model and the parameters used, please refer to Annex 3.

The LFG collection efficiency for ex-ante estimations is assumed to be 65%, which is a conservative value compared to typical values considered in Brazilian Landfills. The amount of landfill gas collected would represent LFG_{total}.

As discussed in section B.4, in the absence of the proposed project activity, the configuration of passive venting and limited burning at Feira de Santana landfill would destroy no more than 20% of the gas that would be collected by an active extraction system. Thus an appropriate value of AF is 20%.

During the first year of operation of the project, it is expected that the thermal plant installed at the landfill site will be functional, displacing an average of 1,800 kg of LPG (fossil fuel) per year. Hence part of the landfill gas collected will be sent to the thermal generation unit, accordingly to the equipment demand. Based on manufacturer's information, the thermal unit would need a flow of about 71 m^3/h of landfill gas (@50% methane) to bring a thermal generation potential of about 339,000 kcal/h (0.39 thermal-MW capacity). Thus part of the methane destruction will normally take place at this unit.

Project sponsor also intends to generate electricity, hence, once the electricity generator becomes operational, part of the landfill gas collected would be sent to electricity generation unit. This is envisioned to start in 2009. The maximum electricity generation potential (MW) can be estimated from the flow rate of landfill gas collected (m^3/h). We estimated that a dedicated LFG engine-generator will need a flow of 688 m^3/h of landfill gas (@50% methane) to generate 1 MWe (one electric megawatt). This assumption was based on information sent by a LFG engine manufacturer (Waukesha Motors). This allows us to calculate the maximum power generation potential if all the LFG were converted to electricity. While LFG generation may vary continuously over time, power generation equipment is only available at specific power output capacities. Based on the amount of landfill gas available after satisfying the thermal plant demand, we assume that initial power generation in 2009 would be 0.5 MW, reaching up to 1 MW in 2011. While the LFG model indicates that gas may be available to generate almost 1.6 MW during the whole crediting period, given that no firm decision on power generation has yet been made, the present estimate limits power generation to a maximum of 1.0 MW. All these calculations are presented in the tables on the next page.

All the remnant gas will be combusted in an enclosed flare. For conservativeness, the ex-ante estimations assume a default flare efficiency of 90%, as recommended in the Methodological "Tool to determine project emissions from flaring gases containing methane" (Version: EB28, Annex 13).

The project activity involves LFG recovery, which requires a blower for gas pumping, and electricity is needed for this purpose. If the project does not generate electricity, or until the power plant is operational, this electricity will be purchased from the grid and will constitute $EL_{PR,y}$ in Eq. (1). In case of electricity generation using the methane collected in the project, emissions reductions would be determined by the sum of the amount of electricity exported from the project site to the grid and the amount of electricity used on-site unrelated to the project activity –as it would have been imported in the absence of the project activity–. This will constitute $EL_{LFG,y}$.

Other assumptions made for the ex-ante estimations, are as follows:

- **Operation of the thermal plant:** It is expected that the thermal generation facility will operate 1,080 h/yr (or 3 h/day, 12.3% of the year).
- **Operation of the power plant:** It is expected that the electricity generation facility will operate 8,000 h/yr (91.3% of the year).

- **Operation of the flare station:** It was assumed that the flare station will operate 8,600 h/yr (98.2% of the year).
- **Blower electricity consumption:** Based on manufacturer's information, it is assumed that a blower will use 75 HP or about 56 kW to pump 5,000 m^3/h of LFG (@ 50% methane).

Emissions from this power consumption from the grid in the project activity will also depend on the emissions factor for electricity generation, $CEF_{elec,PR,y}$, which is estimated in Annex 3. A value of 0.0767 tCO_2/MWh (combined margin) was used in this project for imported electricity. This CO_2 emissions factor for power generation was determined using a procedure indicated in ACM0002 that allows for $CEF_{elec,BL,y}$ and $CEF_{elec,PR,y}$ to remain fixed for each crediting period.

For ex-ante emission calculation, the baseline fossil fuel consumption is given by the LPG demand of the existing thermal plant ($ET_{LFG,y}$), which is 1,800 kg of LPG, during 3 hours a day, equivalent to 1.53 TJ of energy per year. The formula to estimate $CEF_{ther,BL,y}$ is provided in B.6.2, assuming a thermal plant efficiency (ε_{boiler}) of 100% and the IPCC default values for LPG emissions factor ($EF_{fuel,BL,y}$) and its net calorific value ($NCV_{fuel,BL}$), given in section B.7.1 and in the tables below.

For ex-ante calculation purposes, there will be no fossil fuel consumption at project scenario ($ET_{PR,y}$), but any eventual fossil fuel consumption will be accounted. $EF_{fuel,PR}$ will depend on the fossil fuel consumed and its value will be take from IPCC default emission factors, in case no other data is available.

Because ACM0001 covers a broad spectrum of methane utilization options, there are several calculation details and assumptions which can be better expressed in a spreadsheet. All the equations and main assumptions were presented above and are used to estimate project emissions reductions. The results are shown in the next page.

$ER_y = (MD_{project,y} - MD_{reg,y}) * GWP_{CH4} + EL_{LFG,y} * CEF_{elec,BL,y} - EL_{PR,y} * CEF_{elec,PR,y} + ET_{LFG,y} * CEF_{ther,BL,y} - ET_{PR,y} * EF_{fuel,PR,y}$ (1)		**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**
ER_y	*Emissions reduction (tCO_2e).*	25,536	33,920	37,826	43,614	47,331	50,963	54,512	4,302
$MD_{project,y}$	*Amount of methane that would have been destroyed/combusted during the year y (tCH_4)*	1,515	1,995	2,228	2,554	2,775	2,991	3,203	252
$MD_{reg,y}$	*Amount of methane that would have been destroyed/combusted during the year y in the absence of the project (tCH_4)*	303	399	446	511	555	598	641	50
GWP_{CH4}	*Global Warming Potential value for methane for the first commitment period (tCO_2e/tCH_4)*	21	21	21	21	21	21	21	21
$EL_{LFG,y}$	*Net quantity of electricity produced using LFG, which in the absence of the project activity would have been produced by power plants connected to the grid or by an on-site/off-site fossil fuel based captive power generation, during year y (MWh)*	0	4,000	4,000	8,000	8,000	8,000	8,000	679
$CEF_{elec,BL}$	*CO_2 emissions intensity of the baseline source of electricity displaced (tCO_2e/MWh)*	0.0767	0.0767	0.0767	0.0767	0.0767	0.0767	0.0767	0.0767
$EL_{PR,y}$	*Amount of electricity generated in an on-site fossil fuel fired power plant or imported from the grid as a result of the project activity, measured using electricity meter (MWh)*	52.4	4.6	5.1	5.7	6.2	6.8	7.3	0.6
$CEF_{elec,PR,y}$	*Carbon emission factor for electricity generation in the project activity (tCO_2e/MWh)*	0.0767	0.0767	0.0767	0.0767	0.0767	0.0767	0.0767	0.0767
$ET_{LFG,y}$	*Quantity of thermal energy produced utilizing LFG, which in the absence of the project activity would have been produced from on-site/off-site fossil fuel fired in thermal plant, during the year y (TJ)*	1.40	1.53	1.53	1.53	1.53	1.53	1.53	0.13
$CEF_{ther,BL}$	*CO_2 emissions intensity of the fuel used by thermal plant to generate thermal energy, which is displaced by LFG based thermal energy generation (tCO_2e/TJ)*	63.1	63.1	63.1	63.1	63.1	63.1	63.1	63.1
$ET_{PR,y}$	*Fossil fuel consumption on-site during project activity in year y (tonnes or m^3)*	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
$EF_{fuel,PR,y}$	*CO_2 emission factor of fossil fuel used by thermal plant to generate thermal energy in the project activity during year y (tCO_2/mass or volume)*	63.1	63.1	63.1	63.1	63.1	63.1	63.1	63.1

$MD_{reg,y} = MD_{project,y} * AF$ (2)		2008	2009	2010	2011	2012	2013	2014	2015
$MD_{reg,y}$	*Amount of methane that World have been destroyed/combusted during the year y in the absence of the Project (tCH_4)*	303	399	446	511	555	598	641	50
$MD_{project,y}$	*Amount of methane that would have been destroyed/combusted during the year y (tCH_4)*	1,515	1,995	2,228	2,554	2,775	2,991	3,203	252
AF	*Adjustment factor*	20%	20%	20%	20%	20%	20%	20%	20%

$MD_{project,y} = MD_{flared,y} + MD_{electricity,y} + MD_{thermal,y}$ (3)		2008	2009	2010	2011	2012	2013	2014	2015
$MD_{project,y}$	*Amount of methane that would have been destroyed/combusted during the year y (tCH_4)*	1,515	1,995	2,228	2,554	2,775	2,991	3,203	252
$MD_{flared,y}$	*Methane destroyed by flaring (tCH_4)*	1,489	981	1,214	554	775	991	1,203	83
$MD_{electricity,y}$	*Methane destroyed by electricity generation (tCH_4)*	0	986	986	1,973	1,973	1,973	1,973	168
$MD_{thermal,y}$	*Methane destroyed by thermal generation (tCH_4)*	25	28	28	28	28	28	28	2

$MD_{flared,y} = (LFG_{flare,y} * w_{CH4,y} * D_{CH4}) - (PE_{flare,y}/GWP_{CH4})$ (4)		2008	2009	2010	2011	2012	2013	2014	2015
$LFG_{flare,y}$	*Quantity of landfill gas fed to the flare during the year (m^3)*	4,617,005	3,040,685	3,764,626	1,716,165	2,401,927	3,072,369	3,729,791	255,979
$w_{CH4,y}$	*Average methane fraction of the landfill gas as measured during the year y and expressed as a fraction (m^3 CH_4 / m^3 LFG)*	50%	50%	50%	50%	50%	50%	50%	50%
D_{CH4}	*Methane density (tCH_4/m^3CH_4)*	0.0007168	0.0007168	0.0007168	0.0007168	0.0007168	0.0007168	0.0007168	0.0007168
$PE_{flare,y}$	*Project emissions from flaring of the residual gas stream (tCO_2e) determined following the procedure described in the "Tool to determine project emissions from flaring gases containing methane"*	3,475	2,289	2,833	1,292	1,808	2,312	2,807	193
GWP_{CH4}	*Global Warming Potential value for methane for the first commitment period (tCO_2e/tCH_4)*	21	21	21	21	21	21	21	21

$MD_{electricity,y} = LFG_{electricity,y} * w_{CH4} * D_{CH4}$ (5)		2008	2009	2010	2011	2012	2013	2014	2015
$MD_{electricity,y}$	*Quantity of methane destroyed by generation of electricity (tCH_4)*	0	986	986	1,973	1,973	1,973	1,973	168
$LFG_{electricity,y}$	*Quantity of landfill gas fed into the electricity generator (m^3)*	0	2,752,000	2,752,000	5,504,000	5,504,000	5,504,000	5,504,000	467,463
$w_{CH4,y}$	*Average methane fraction of the landfill gas as measured during the year y and expressed as a fraction (m^3 CH_4 / m^3 LFG)*	50%	50%	50%	50%	50%	50%	50%	50%
D_{CH4}	*Methane density (tCH_4/m^3CH_4)*	0.0007168	0.0007168	0.0007168	0.0007168	0.0007168	0.0007168	0.0007168	0.0007168

$MD_{thermal,y} = LFG_{thermal,y} * w_{CH4} * D_{CH4}$ (5.2)		2008	2009	2010	2011	2012	2013	2014	2015
$MD_{thermal,y}$	*Methane destroyed by thermal generation (tCH_4)*	25	28	28	28	28	28	28	2
$LFG_{thermal,y}$	*Quantity of landfill gas fed into thermal generator (m^3)*	70,438	76,975	76,975	76,975	76,975	76,975	76,975	6,538
$w_{CH4,y}$	*Average methane fraction of the landfill gas as measured during the year y and expressed as a fraction (m^3 CH_4 / m^3 LFG)*	50%	50%	50%	50%	50%	50%	50%	50%
D_{CH4}	*Methane density (tCH_4/m^3CH_4)*	0.0007168	0.0007168	0.0007168	0.0007168	0.0007168	0.0007168	0.0007168	0.0007168

$PE_{flare,y} = \sum TM_{RG,h} * (1 - \eta_{flare,h}) * GWP_{CH4} / 1000$ (T.15)		2008	2009	2010	2011	2012	2013	2014	2015
$PE_{flare,y}$	*Project emissions from flaring of the residual gas stream (tCO_2e) determined following the procedure described in the "Tool to determine project emissions from flaring gases containing methane"*	3,475	2,289	2,833	1,292	1,808	2,312	2,807	193
$\sum TM_{RG,h}$	*Total mass flow rate in the residual gas (kg)*	1,654,735	1,089,782	1,349,242	615,073	860,851	1,101,137	1,336,757	91,743
$\eta_{flare,h}$	*Flare combustion efficiency*	90%	90%	90%	90%	90%	90%	90%	90%
GWP_{CH4}	*Global Warming Potential value for methane for the first commitment period (tCO_2e/tCH_4)*	21	21	21	21	21	21	21	21

$CEF_{elec,BL} = 3.6 * EF_{fuel,BL} / (\varepsilon_{gen,BL} * NCV_{fuel,BL})$ (6)		2008	2009	2010	2011	2012	2013	2014	2015
$CEF_{elec,BL}$	*CO_2 emission intensity of the baseline source of electricity displaced (tCO_2e/MWh)*	0	0	0	0	0	0	0	0
$EF_{fuel,BL}$	*Emission factor of the fuel, as identified through the baseline identification procedure, used in the thermal plant to generate the thermal energy in the absence of the project activity (tCO_2/mass or volume)*	0	0	0	0	0	0	0	0
$NCV_{fuel,BL}$	*Net calorific value of fuel, as identified through the baseline identification procedure (GJ/mass or volume)*	0	0	0	0	0	0	0	0
$\varepsilon_{gen,BL}$	*Efficiency of baseline power generation plant*	0%	0%	0%	0%	0%	0%	0%	0%
3.6	*Equivalent of GJ energy in a MWh of electricity*	3.6	3.6	3.6	3.6	3.6	3.6	3.6	3.6

$CEF_{therm,BL} = EF_{fuel,BL} / (\varepsilon_{boiler,BL} * NCV_{fuel,BL})$ (7)		2008	2009	2010	2011	2012	2013	2014	2015
$CEF_{therm,BL}$	*CO_2 emissions intensity of the fuel used by thermal plant to generate thermal energy, which is displaced by LFG based thermal energy generation (tCO_2e/TJ)*	63.1	63.1	63.1	63.1	63.1	63.1	63.1	63.1
$EF_{fuel,BL}$	*Emission factor of the fuel, as identified through the baseline identification procedure, used in the thermal plant to generate the thermal energy in the absence of the project activity (tCO_2/mass or volume)*	2,984.6	2,984.6	2,984.6	2,984.6	2,984.6	2,984.6	2,984.6	2,984.6
$NCV_{fuel,BL}$	*Net calorific value of fuel, as identified through the baseline identification procedure, used in the thermal plant to generate the thermal energy in the absence of the project activity (TJ/mass or volume)*	47.3	47.3	47.3	47.3	47.3	47.3	47.3	47.3
$\varepsilon_{gen,BL}$	*Energy efficiency of the thermal plant used in the absence of the project activity to generate the thermal energy*	100%	100%	100%	100%	100%	100%	100%	100%

$CEF_{elec,PR} = 3.6 * EF_{fuel,PR} / (\varepsilon_{gen,PR} * NCV_{fuel,PR})$ (8)		2008	2009	2010	2011	2012	2013	2014	2015
$CEF_{elec,PR}$	*Carbon emissions factor for electricity generation in the project activity (tCO_2e/MWh)*	0	0	0	0	0	0	0	0
$EF_{fuel,PR}$	*Emission factor of fossil fuel used in captive power plant (tCO_2/mass or volume)*	0	0	0	0	0	0	0	0
$NCV_{fuel,PR}$	*Net calorific value of the fossil fuel (GJ/mass or volume)*	0	0	0	0	0	0	0	0
$\varepsilon_{gen,PR}$	*Efficiency of captive power generation plant*	0%	0%	0%	0%	0%	0%	0%	0%
3.6	*Equivalent of GJ energy in a MWh of electricity*	3.6	3.6	3.6	3.6	3.6	3.6	3.6	3.6

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

Table 4: Ex-ante estimation of landfill gas collected and flared/used at Feira de Santana Project

Year	$LFG_{total,y}$ m^3LFG /yr	$LFG_{thermal,y}$ m^3LFG /yr	$LFG_{electricity,y}$ m^3LFG /yr	$LFG_{flare,y}$ m^3LFG/yr
2008 (from February)	4,687,443	70,438	0	4,617,005
2009	5,869,660	76,975	2,752,000	3,040,684
2010	6,593,601	76,975	2,752,000	3,764,626
2011	7,297,140	76,975	5,504,000	1,716,165
2012	7,982,902	76,975	5,504,000	2,401,927
2013	8,653,345	76,975	5,504,000	3,072,369
2014	9,310,767	76,975	5,504,000	3,729,791
2015 (up to January)	729,980	6,538	467,463	255,979

Table 5: Ex-ante estimation of net emission reduction by methane destruction at Feira de Santana Project

Year	$MD_{thermal,y}$ tCH_4/yr	$MD_{electricity,y}$ tCH_4/yr	$MD_{flare,y}$ tCH_4/yr	$MD_{project}$ tCH_4/yr	MD_{req} tCH_4/yr	*Net* ER by methane destruction tCO_2e/yr
2008 (from February)	25	0	1,489	1,515	303	25,452
2009	28	986	981	1,995	399	33,516
2010	28	986	1,214	2,228	446	37,422
2011	28	1,973	554	2,554	511	42,903
2012	28	1,973	775	2,775	555	46,620
2013	28	1,973	991	2,991	598	50,253
2014	28	1,973	1,203	3,203	641	53,802
2015 (up to January)	2	168	83	252	50	4,242

Table 6: Ex-ante estimation of net emission reduction by fossil fuels displacement, due to electricity and/or thermal energy generation using landfill gas at Feira de Santana Project

Year	$EL_{LFG,y}$ MWh/yr	$EL_{PR,y}$ MWh/yr	*Net* ER by electricity generation tCO_2e/yr	$ET_{LFG,y}$ TJ/yr	$ET_{PR,y}$ TJ/yr	*Net* ER by thermal generation tCO_2e/yr
2008 (from February)	0	52.4	-4	1.4	0	88
2009	4,000	4.6	307	1.53	0	97
2010	4,000	5.1	307	1.53	0	97
2011	8,000	5.7	614	1.53	0	97
2012	8,000	6.2	614	1.53	0	97
2013	8,000	6.8	613	1.53	0	97
2014	8,000	7.3	613	1.53	0	97
2015 (up to January)	679	0.6	52	0.13	0	8

Table 7: Summary of ex-ante estimation of total emission reduction at Feira de Santana Project

Year	Total ER tCO_2e/yr
2008 (from February)	25,536
2009	33,920

2010	37,826
2011	43,614
2012	47,331
2013	50,963
2014	54,512
2015 (up to January)	4,302
Total	**298,004**

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

B.7.1 Data and parameters monitored:

Note: The "Data /Parameter" includes the variable number as it appears in ACM0001, ver. 6

Data / Parameter:	**1. $LFG_{total,y}$**
Data unit:	m^3
Description:	Total amount of landfill gas captured
Source of data to be used:	Measured by a flow meter
Value of data applied for the purpose of calculating expected emission reductions in section B.6.3	Details of assumptions, calculations and resulting data are presented in sections B.6.3 and B.6.4.
Description of measurement methods and procedures to be applied:	Continuous mass flow meters will be used to measure flow rates. Data will be measured at least once per hour, recorded electronically, and data will be kept during the crediting period and two years after. Data will also be aggregated monthly/yearly.
QA/QC procedures to be applied:	An independent company, accredited by local authorities, will conduct contrasting and data checking in accordance with manufacturer specifications, to ensure accuracy.
Any comment:	Flow meter would adjust volume flow for temperature and pressure.

Data / Parameter:	**2. $LFG_{flare,y}$**
Data unit:	m^3
Description:	Amount of landfill gas flared (fed to flare(s))
Source of data to be used:	Measured by a flow meter
Value of data applied for the purpose of calculating expected emission reductions in section B.6.3	Details of assumptions, calculations and resulting data are presented in sections B.6.3 and B.6.4.
Description of measurement methods and procedures to be applied:	Data will be measured for each flare at least once per hour, recorded electronically, and data will be kept during the crediting period and two years after. Data will also be aggregated monthly/yearly.
QA/QC procedures to be applied:	Continuous mass flow meters will be used to measure flow rates. An independent company, accredited by local authorities, will conduct contrasting and data checking in accordance with manufacturer specifications, to ensure accuracy.

Any comment:	Flow meter would adjust volume flow for temperature and pressure.

Data / Parameter:	**3. $LFG_{electricity,y}$**
Data unit:	m^3
Description:	Amount of landfill gas combusted in power plant (fed into electricity generator(s))
Source of data to be used:	Measured by a flow meter
Value of data applied for the purpose of calculating expected emission reductions in section B.6.3	Details of assumptions, calculations and resulting data are presented in sections B.6.3 and B.6.4
Description of measurement methods and procedures to be applied:	Continuous mass flow meters will be used to measure flow rates. Data will be measured for each power plant at least once per hour, recorded electronically, and data will be kept during the crediting period and two years after. Data will also be aggregated monthly/yearly.
QA/QC procedures to be applied:	An independent company, accredited by local authorities, will conduct contrasting and data checking in accordance with manufacturer specifications, to ensure accuracy.
Any comment:	Flow meter would adjust volume flow for temperature and pressure.

Data / Parameter:	**4. $LFG_{thermal,y}$**
Data unit:	m^3
Description:	Amount of landfill gas combusted in thermal plant(s)
Source of data to be used:	Measured by a flow meter
Value of data applied for the purpose of calculating expected emission reductions in section B.6.3	Details of assumptions, calculations and resulting data are presented in sections B.6.3 and B.6.4
Description of measurement methods and procedures to be applied:	Continuous mass flow meters will be used to measure flow rates. Data will be measured for each thermal plant at least once per hour, recorded electronically, and data will be kept during the crediting period and two years after. Data will also be aggregated monthly/yearly.
QA/QC procedures to be applied:	An independent company, accredited by local authorities, will conduct contrasting and data checking in accordance with manufacturer specifications, to ensure accuracy.
Any comment:	Flow meter would adjust volume flow for temperature and pressure.

Data / Parameter:	**5. $PE_{flare,y}$**
Data unit:	tCO_2e
Description:	Project emissions from flaring of the residual gas stream in year *y*
Source of data to be used:	On-site measurements / calculations
Value of data applied for the purpose of calculating expected emission reductions in section B.6.3	10% of CH_4 in gas stream
Description of measurement methods and procedures to be applied:	The parameters used for determining the project emissions from flaring of the residual gas stream in year *y* (**$PE_{flare,y}$**) will be monitored as per the *"Tool to determine project emissions from flaring gases containing*

	methane". The parameters used for the determination of $PE_{flare,y}$ are $LFG_{flare,y}$, $w_{CH4,y}$, $fv_{i,h}$, $fv_{CH4,FG,h}$ and $t_{O2,h}$.
QA/QC procedures to be applied:	Regular maintenance will ensure optimal operation of the flare. Analysers will be calibrated annually according to manufacturer's recommendations.
Any comment:	Note: A determination of $PE_{flare,y}$ using the flaring tool requires the measurements of a number of additional parameters. These are listed and described following the variables specifically mentioned in ACM0001.

Data / Parameter:	**6. $w_{CH4,y}$**
Data unit:	m^3 CH_4 / m^3 LFG
Description:	Methane fraction in the landfill gas
Source of data to be used:	Measured by a gas analyzer
Value of data applied for the purpose of calculating expected emission reductions in section B.6.3	50%
Description of measurement methods and procedures to be applied:	Methane content will be measured using a continuous gas analyzer. Data will be measured at least once per hour, recorded electronically, and data will be kept during the crediting period and two years after. Data will also be aggregated monthly/yearly.
QA/QC procedures to be applied:	An independent company will contrast instruments with reference instruments, in accordance with manufacturer specifications.
Any comment:	

Data / Parameter:	**7. T**
Data unit:	ºC
Description:	Temperature of the landfill gas
Source of data to be used:	Measured.
Value of data applied for the purpose of calculating expected emission reductions in section B.6.3	0 (At STP conditions)
Description of measurement methods and procedures to be applied:	Data will be measured at least once per hour, recorded electronically. Data will also be aggregated monthly/yearly. Records will be kept during the crediting period and two years after.
QA/QC procedures to be applied:	An independent company will contrast the thermometers used for measurements with certified equipment.
Any comment:	No separate monitoring of temperature is necessary when using flow meters that automatically measure temperature and pressure, expressing LFG volumes in normalized cubic meters (Nm^3).

Data / Parameter:	**8. p**
Data unit:	Pa
Description:	Pressure of the landfill gas
Source of data to be used:	Measured.
Value of data applied for the purpose of calculating expected emission	101,325 (1 atm at STP conditions)

reductions in section B.6.3	
Description of measurement methods and procedures to be applied:	Data will be measured with pressure analyser at least once per hour, recorded electronically. Data will also be aggregated monthly/yearly. Records will be kept during the crediting period and two years after.
QA/QC procedures to be applied:	An independent company will contrast the instruments used for measurements with certified equipment.
Any comment:	No separate monitoring of pressure is necessary when using flow meters that automatically measure temperature and pressure, expressing LFG volumes in normalized cubic meters (Nm^3).

Data / Parameter:	**9. EL_{LFG}**
Data unit:	MWh
Description:	Net amount of electricity generated using LFG.
Source of data to be used:	Measured. Required to estimate the emission reductions from electricity generation from LFG, if credits are claimed.
Value of data applied for the purpose of calculating expected emission reductions in section B.6.3	Details of assumptions, calculations and resulting data are presented in sections B.6.3 and B.6.4
Description of measurement methods and procedures to be applied:	The quantities will be measured with electricity meters installed on the generators units. The readings will be made at least once per hour and electronically stored in a spreadsheet. Data will be recorded during crediting period and two years after.
QA/QC procedures to be applied:	Electric meters are quite accurate. Moreover, the meter will be calibrated periodically according to manufacturer's specification.
Any comment:	

Data / Parameter:	**10. EL_{PR}**
Data unit:	MWh
Description:	Total amount of electricity required to meet project requirement.
Source of data to be used:	Measured. Required to determine CO_2 emissions from use of electricity to operate the project activity.
Value of data applied for the purpose of calculating expected emission reductions in section B.6.3	Details of assumptions, calculations and resulting data are presented in sections B.6.3 and B.6.4
Description of measurement methods and procedures to be applied:	The records of any electricity imported in the baseline too, should be recorded at the start of project. Electric meters will be installed at the entrance of project installations and measurements will be taken at least hourly and values will be stored at a spreadsheet. Data will be recorded during crediting period and two years after.
QA/QC procedures to be applied:	Electric meters are quite accurate. Moreover, the meter will be calibrated periodically, according to manufacturer's specifications.
Any comment:	

Data / Parameter:	**11. ET_{LFG}**
Data unit:	TJ
Description:	Total amount of thermal energy generated using LFG.

Source of data to be used:	Measured. Energy required to estimate the emission reductions from thermal energy generation from LFG, if credits are claimed.
Value of data applied for the purpose of calculating expected emission reductions in section B.6.3	Details of assumptions, calculations and resulting data are presented in sections B.6.3 and B.6.4
Description of measurement methods and procedures to be applied:	The thermal energy generated in the thermal plant is given by the energy supplied by the LFG and the equipment efficiency. Data will be recorded during crediting period and two years after.
QA/QC procedures to be applied:	The thermal plant will have temperature and flow meters which will be calibrated periodically.
Any comment:	

Data / Parameter:	**12. ET_{PR}**
Data unit:	tonne
Description:	Total amount of fossil fuel required to meet project requirement
Source of data to be used:	Measured. Fossil fuel consumption required to determine CO_2 emissions from use of energy carriers to operate the project activity.
Value of data applied for the purpose of calculating expected emission reductions in section B.6.3	0
Description of measurement methods and procedures to be applied:	Monthly records of any fuel used at the project site specifically for the project activity.
QA/QC procedures to be applied:	Check invoices against fuel consumption data where available
Any comment:	If electricity is produced on site using fossil fuel, it is covered under this category. Any propane used for flare(s) ignition or other fossil fuel used in project activity would be included in this item.

Data / Parameter:	**13. $CEF_{elec,BL,y}$**
Data unit:	tCO_2/MWh
Description:	Carbon emission factor of electricity
Source of data to be used:	Data for power plants in the North-Northeast interconnected grid provided by the National Dispatch Authority or other official data source.
Value of data applied for the purpose of calculating expected emission reductions in section B.6.3	0.0767 (Combined Margin)
Description of measurement methods and procedures to be applied:	For power generation below 15 MW, the emissions factor may be calculated using small-scale CDM methodology: AMS I.D. Otherwise, the more general methodology ACM0002 should be used.
QA/QC procedures to be applied:	The calculations will be made according to EB methodology each year or whenever new electric grid information is available to update values.
Any comment:	Based on the approach taken from ACM0002, this value will remain fixed during each crediting period.

Data / Parameter:	**14. $EF_{fuel,BL}$**
Data unit:	tCO_2/mass or volume
Description:	CO_2 emission factor of fossil fuel
Source of data to be used:	Reliable local or national data or IPCC default values. The fossil fuel that would have been used in the baseline captive power plant or thermal energy generation.
Value of data applied for the purpose of calculating expected emission reductions in section B.6.3	2,984.6
Description of measurement methods and procedures to be applied:	None. The value will be taken from credible sources, preferably from IPCC recommended values. Data will be kept during the crediting period and two years after.
QA/QC procedures to be applied:	The value will be confirmed from the source each crediting period.
Any comment:	

Data / Parameter:	**15. $NCV_{fuel,BL}$**
Data unit:	GJ/mass or volume
Description:	Net calorific value of fossil fuel
Source of data to be used:	Reliable local or national data, IPCC default values or reliable literature. Calorific value of the fossil fuel that would have been used in the baseline for thermal energy generation and/or electricity generation.
Value of data applied for the purpose of calculating expected emission reductions in section B.6.3	Details of assumptions, calculations and resulting data are presented in section B.6.3.
Description of measurement methods and procedures to be applied:	None. Values of net calorific value of fossil fuels will be checked each crediting period. Data will be kept during the crediting period and two years after.
QA/QC procedures to be applied:	Values will be checked with supplier’s information every crediting period.
Any comment:	For ex-ante calculation purposes, the net calorific value for LPG at the thermal plant was informed by the gas supplier at Feira Santana and checked with IPCC value.

Data / Parameter:	**17. $CEF_{ther,BL,y}$**
Data unit:	tCO_2/GJ
Description:	Carbon emission factor of thermal energy produced in the baseline.
Source of data to be used:	Calculated.
Value of data applied for the purpose of calculating expected emission reductions in section B.6.3	Details of assumptions, calculations and resulting data are presented in section B.6.3.
Description of measurement methods and procedures to be applied:	None. Calculated as per equation (7) of ACM0001 version 6, and recorded annually. Data will be kept during crediting period and two years after.
QA/QC procedures to be	The value will be recalculated in case of any variable within the formula is

applied:	changed.
Any comment:	

Data / Parameter:	**19. $CEF_{elec,PR,y}$**
Data unit:	tCO_2/MWh
Description:	Carbon emission factor of electricity
Source of data to be used:	Data for power plants in the North-Northeast interconnected grid provided by the National Dispatch Authority or other official data source.
Value of data applied for the purpose of calculating expected emission reductions in section B.6.3	0.0767 (Combined Margin)
Description of measurement methods and procedures to be applied:	For power generation below 15 MW, the emissions factor may be calculated using small-scale CDM methodology: AMS I.D. Otherwise, the more general methodology ACM0002 should be used.
QA/QC procedures to be applied:	The calculations will be made according to EB methodology each year or whenever new electric grid information is available to update values.
Any comment:	Based on the approach taken from ACM0002, this value will remain fixed during each crediting period.

Data / Parameter:	**21. $EF_{fuel,PR}$**
Data unit:	tCO_2/mass or volume
Description:	CO_2 emission factor of fossil fuel
Source of data to be used:	Reliable local or national data or IPCC default values. CO_2 emission factor of fossil fuel that would have been used in the project captive power plant or thermal energy generation.
Value of data applied for the purpose of calculating expected emission reductions in section B.6.3	Details of assumptions, calculations and resulting data are presented in section B.6.3.
Description of measurement methods and procedures to be applied:	None. Data to be recorded annually, as indicated in ACM0001, ver. 6. Data will be kept during the crediting period and two years after.
QA/QC procedures to be applied:	The value will be checked each crediting period.
Any comment:	

Data / Parameter:	**25. Regulatory requirements relating to landfill gas projects**
Data unit:	None
Description:	Regulatory requirements relating to landfill gas projects may affect the value of AF or $MD_{reg,y}$ (see above).
Source of data to be used:	National legislation and mandatory regulations.
Value of data applied for the purpose of calculating expected emission reductions in section B.6.3	AF = 20%
Description of measurement methods and	Although the methodology only requires recording at the renewal of the crediting period, the information related to all relevant policies and

procedures to be applied:	circumstances will be collected and recorded annually. Information will be kept during crediting period and two years after.
QA/QC procedures to be applied:	Legal documents.
Any comment:	The information, though recorded annually, is used for changes in the adjustment factor (AF) or directly $MD_{reg,y}$ at renewal of the crediting period.

Data / Parameter:	**26. Operation of the power plant**
Data unit:	hours
Description:	
Source of data:	Measured with run meter connected to the power plant.
Value of data applied for the purpose of calculating expected emission reductions in section B.6.3	8,000
Description of measurement methods and procedures to be applied:	Records will be kept during the crediting period and two years after.
QA/QC procedures to be applied:	Meters are quite accurate. But it will be calibrated according to manufacturer specifications.
Any comment:	This is monitored to ensure methane destruction is claimed for methane used in electricity plant when it is operational.

Data / Parameter:	**27. Operation of the thermal plant**
Data unit:	hours
Description:	
Source of data:	Measurement with run meter connected to the thermal plant.
Value of data applied for the purpose of calculating expected emission reductions in section B.6.3	1,080
Description of measurement methods and procedures to be applied:	Records will be kept during the crediting period and two years after.
QA/QC procedures to be applied:	Meters are quite accurate. But it will be calibrated according to manufacturer specifications.
Any comment:	The thermal plant works in average 3 hours per day.

Data / Parameter:	**Operation of the flare station**
Data unit:	hours
Description:	
Source of data:	Measurement with run meter connected to the blower
Value of data applied for the purpose of calculating expected emission reductions in section B.6.3	8,600
Description of	Records will be kept during the crediting period and two years after.

measurement methods and procedures to be applied:	
QA/QC procedures to be applied:	Meters are quite accurate. But it will be calibrated according to manufacturer specifications.
Any comment:	It was assumed that the flare station will operate 98% of the year

The following variables are required to determine flare efficiency using the Tool. For ex-ante estimates, a fixed flare efficiency is assumed, so estimates of these data are not needed.

Data / Parameter:	**$FV_{RG,h}$**
Data unit:	m^3/h
Description:	Volumetric flow rate of the residual gas in dry basis at normal conditions in the hour *h*.
Source of data:	On-site measurements.
Value of data applied for the purpose of calculating expected emission reductions in section B.6.3	Not used in ex-ante estimates.
Description of measurement methods and procedures to be applied:	Measured at least one per hour and electronically using a flow meter, and will be kept during the crediting period and two years after.
QA/QC procedures to be applied:	Flow meters will be periodically calibrated according to the manufacturer's recommendation.
Any comment:	The same basis (dry or wet) is considered for this measurement when the residual gas temperature exceeds 60ºC.

Data / Parameter:	**$fv_{i,h}$**
Data unit:	-
Description:	Volumetric fraction of component *i* in the residual gas in the hour *h*
Source of data:	On-site measurements using a continuous gas analyser.
Value of data applied for the purpose of calculating expected emission reductions in section B.6.3	Not used in ex-ante estimates.
Description of measurement methods and procedures to be applied:	As a simplified approach (see Eq. 3a), only methane content of the residual gas will be measured and the remaining part will be considered as N_2. Methane concentration would be measured at least once per hour using a continuous gas analyser, and data records will be kept during the crediting period and two years after.
QA/QC procedures to be applied:	Analysers will be periodically calibrated according to the manufacturer's recommendation. A zero check and typical value check to be performed by comparison with a standard certified gas.
Any comment:	The same basis (dry or wet) is considered for this measurement when the residual gas temperature exceeds 60ºC.

If project operator decides to monitor emissions continuously, the following two variables should be monitored:

Data / Parameter:	**$t_{O2,h}$**
Data unit:	-
Description:	Volumetric fraction of O_2 in the exhaust has of the flare in the hour *h*.
Source of data:	On-site measurements using a continuous gas analyser.
Value of data applied for the purpose of calculating expected emission reductions in section B.6.3	Not used in ex-ante estimates.
Description of measurement methods and procedures to be applied:	Measured at least once per hour and electronically using a continuous gas analyser, and will be kept during the crediting period and two years after. Extractive sampling analysers with water and particulates removal devices or in situ analysers for wet basis determination. The point of measurement (sampling point) will be in the upper section of the flare (80% of total flare height). Sampling will be conducted with appropriate sampling probes adequate to high temperatures level (e.g. inconel probes).
QA/QC procedures to be applied:	Analysers will be periodically calibrated according to the manufacturer's recommendation. A zero check and typical value check to be performed by comparison with a standard certified gas.
Any comment:	

Data / Parameter:	$fv_{CH4,FG,h}$
Data unit:	mg/m^3
Description:	Concentration of methane in the exhaust gas of the flare in dry basis at normal conditions in the hour *h*
Source of data:	Measurements by project participants using a continuous gas analyser
Value of data applied for the purpose of calculating expected emission reductions in section B.6.3	Not used in ex-ante estimates.
Description of measurement methods and procedures to be applied:	Extractive sampling analysers with water and particulates removal devices or in situ analyser for wet basis determination. The point of measurement (sampling point) shall be in the upper section of the flare (80% of total flare height). Sampling shall be conducted with appropriate sampling probes adequate to high temperatures level (e.g. inconel probes). An excessively high temperature at the sampling point (above 700 ºC) may be an indication that the flare is not being adequately operated or that its capacity is not adequate to the actual flow. Monitoring frequency: Continuously. Values to be averaged hourly or at a shorter time interval.
QA/QC procedures to be applied:	Analysers will be periodically calibrated according to manufacturer's recommendation. A zero check and a typical value check will be performed by comparison with a standard gas.
Any comment:	Monitoring of this parameter is only applicable in case of enclosed flares and continuous monitoring of the flare efficiency. Measurement instruments may read ppmv or % values. To convert from ppmv to mg/m^3 simply multiply by 0.716. 1% equals 10 000 ppmv.

If project proponent decides to use the 90% default value for enclosed flares, the following two variables should be monitored:

Data / Parameter:	$\mathbf{T_{flare}}$
Data unit:	ºC
Description:	Temperature in the exhaust gas of the flare.
Source of data:	On-site measurements using a thermocouple.
Value of data applied for the purpose of calculating expected emission reductions in section B.6.3	Not used in ex-ante estimates.
Description of measurement methods and procedures to be applied:	Continuous measurement of the temperature of the exhaust gas stream in the flare by a thermocouple. A temperature above 500 ºC indicates that a significant amount of gases are still being burnt and that the flare is operating.
QA/QC procedures to be applied:	Thermocouples will be replaced or calibrated every year.
Any comment:	An excessively high temperature at the sampling point (above 700 ºC) may be an indication that the flare is not being adequately operated or that its capacity is not adequate to the actual flow.

Data / Parameter:	$\eta_{flare,h}$
Data unit:	Dimensionless
Description:	Flare efficiency in hour h
Source of data:	Values specified in Methane Flaring Tool.
Value of data applied for the purpose of calculating expected emission reductions in section B.6.3	0.9
Description of measurement methods and procedures to be applied:	Calculated as specified in Methane Flaring Tool as follows: ➢ 0%, if the temperature in the exhaust gas of the flare (T_{flare}) is below 500°C for more than 20 minutes during the hour *h*. ➢ 50%, if the temperature in the exhaust gas of the flare (T_{flare}) is above 500°C for more than 40 minutes during the hour *h*, but the manufacturer's specifications on proper operation of the flare are not met at any point in time during the hour *h*. ➢ 90%, if the temperature in the exhaust gas of the flare (T_{flare}) is above 500°C for more than 40 minutes during the hour *h* and the manufacturer's specifications on proper operation of the flare are met continuously during the hour *h*.
QA/QC procedures to be applied:	
Any comment:	

B.7.2 Description of the monitoring plan:

Unlike most methodologies that determine baseline and project emissions separately, and calculate emissions reductions as the difference between the two, the methodology ACM0001 determines emissions reductions directly. ACM0001 version 6 states:

"The monitoring methodology is based on direct measurement of the amount of landfill gas captured and destroyed at the flare platform(s) and the electricity generating/thermal energy unit(s) to determine the quantities as shown in Figure 1 [of ACM0001, ver. 6] *The monitoring plan provides for continuous measurement of the quantity and quality of LFG flared. The main variables that need to be determined are the quantity of methane actually captured* $MD_{project,y}$*, quantity of methane flared (*$MD_{flared,y}$*), the quantity of methane used to generate electricity (*$MD_{electricity,y}$*)/thermal energy (*$MD_{thermal,y}$*), and the quantity of methane captured (*$MC_{total,y}$*).The methodology also measures the energy generated by use of LFG (*$EL_{FLG,y}$*,* $ET_{LFG,y}$*) and energy consumed by the project activity that is produced using fossil fuels".*

Since the proposed project involves flaring and thermal energy generation, the schematic is shown in Figure 2 below, according to ACM0001 ver. 6.

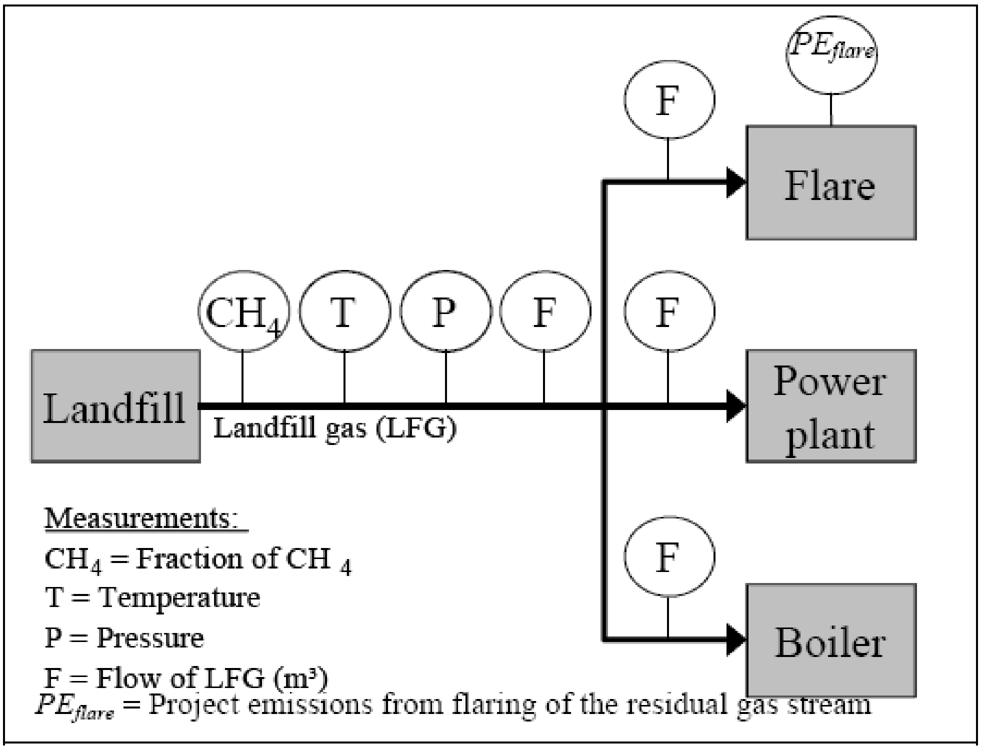

Figure 2. *Schematic of the monitoring system at Feira de Santana Landfill, according to ACM0001 version 6.*

The variables to be monitored were all listed and described in Section B.7.1.

The overall management structure responsible for project monitoring is as follows.

The landfill is owned and operated by Qualix Ltda. (hereinafter Qualix) and also the investor for the proposed CDM project involving investments for gas collection and power generation, as well as additional operation, maintenance and monitoring costs.

The Technical Team of Qualix will be responsible for the day-to-day operation of the landfill gas collection, flaring and use system. This Technical Team would also be responsible for monitoring key variables required for meeting the CDM monitoring requirements.

Data monitoring will be conducted by Landfill Gas Technical Operators supervised by the Landfill Gas Project Engineer, all of them belonging to the Landfill Engineering Department of Qualix. Other staff persons will be assigned by the Landfill Gas Project Engineer to assist in the monitoring tasks, as needed.

Certain activities (calibration of flow meters and electric meters) would be conducted by independent, outside laboratories, with the data archived by the Qualix Landfill Engineering Department.

Qualix will count on supervision from the flare supplier for training, commissioning and start-up. If Qualix decides to generate electricity using landfill gas, they will also acquire either from equipment supplier and/or specialist consultant all the services needed for training related to the operation of the LFG generation system. Qualix staff to be trained will be selected from those with extensive experience at the landfill.

All data recorded would be transferred to and stored as electronic spreadsheets and other electronic files. Calibration certificates would be stored as paper copies, although scanned copies may also be stored electronically. The project proponent and CDM project investor, Qualix, will be responsible for oversight on all aspects involving monitoring and quality control. Qualix will maintain copies of all data collected, including calibration certificates for all instruments.

Following the internal audit, the electronic data would be used in a spreadsheet procedure in order to calculate emissions reductions. The original data, the calculation procedures and the resulting emission reductions will be verified by an independent Designated Operational Entity (DOE). The DOE would issue a Verification Report based on its findings and submit it to the CDM Executive Board for the issuance of CERs.

The operational and management structure for specific monitoring tasks is described in the following table:

***Table 8**. Operational management structure for Feira de Santana Project Monitoring*

#	Task name	Responsible	Frequency	Internal procedures of Quality Control	Documentation
1	Reading of landfill gas capture and gas flared/used	Landfill Engineering Department of Qualix	Weekly. Data will be entered into a spreadsheet on a weekly basis, permitting continuous monitoring.	Yes	The data will be monitoring and filed by the Qualix Landfill Engineering Department.
2	Calibration of the flow meters	External calibration laboratory	Every 2 years.	Yes	Calibration certificate will be issued by the Calibration Laboratory. This certificate will be filed by the Qualix Landfill Engineering Department.
3	Measurements related to the determination of flare efficiency	Landfill Engineering Department of Qualix	Continuous.	Yes	The data will be monitoring and filed by the Qualix Landfill Engineering Department.
4	Measurement of methane fraction in the landfill gas	Landfill Engineering Department of Qualix or external laboratory	Continuous measurement, recording on a weekly basis.	Yes	Measured value will be used, together with corresponding measurements of pressure, temperature and flow rate of landfill gas, and other parameters that are periodically upgraded. Measurement of methane fraction would be recorded in an appropriate computer file, which would indicate start and end time of measurements corresponding to each data file. The data records will be filed by the person responsible for data filing and the Head of Qualix Landfill Engineering Department.
5	Measurement of Pressure and Temperature	Landfill Engineering Department of Qualix	Weekly. Data will be entered into a spreadsheet on a weekly basis, permitting continuous monitoring.	Yes	Daily data on pressure and temperature would be recorded in a spreadsheet file. The data records will be filed by the person responsible for data filing and the Qualix Landfill Engineering Department.
6	Other environmental indicators	Landfill Engineering Department of Qualix	Annual	Yes	This data file will be completed and filed by the person responsible for data filing at Qualix Landfill Engineering Department

7	Monitoring of regulatory requirements relating to landfill gas projects	Landfill Engineering Department of Qualix	Annual	No	Qualix Landfill Engineering Department will prepare the report on the current situation with respect to legal requirements.
8	Electricity generation and consumption from the grid	Landfill Engineering Department of Qualix	Hourly	Yes	Data tables showing date, hour, and meter reading to be recorded in a spreadsheet file, and filed by the person responsible for data filing and the Qualix Landfill Engineering Department.
9	Fossil fuel use (diesel, propane, etc)	Landfill Engineering Department of Qualix	Fossil fuel purchase will be recorded on delivery, with totals recorded monthly	Yes	Data tables showing date and amount of fossil fuel (diesel) purchased (data obtained from invoices) to be recorded in a spreadsheet file by the person responsible and checked by the Head of Qualix Landfill Engineering Department.
10	Operation of the flare(s), the power plant(s) and the thermal plant(s)	Landfill Engineering Department of Qualix	Continuous measurement recording on a annual basis	Yes	The data will the monitored and filed by the Qualix Engineering Department
11	Electric meter calibration	External calibration laboratory	Twice a year	Yes	Calibration certificate will be issued by the Calibration Laboratory. This certificate will be filed by Qualix Landfill Engineering Department.
12	Internal Audit	Landfill Engineering Department of Qualix	Twice a year (July and December)	Yes	The internal auditor will prepare a report to the Manager of the landfill site and the Head of Qualix Landfill Engineering Department on the state of items 1 to 11. In case of non conformity, they will attempt to resolve problems prior to the annual Verification carried out by a Designated Operational Entity. A copy of this report should be filed in the Offices of Qualix Landfill Engineering Department.

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

Detailed baseline information is provided in Annex 3 to this PDD.
Date of completion of the baseline study: 13/08/2007.
Baseline and monitoring analysis prepared by: Gautam Dutt, Ana Luisa Vergara and Juliana Scalon, MGM International (not a project participant).

Contact information:

MGM International
Gautam Dutt, Juliana Scalon, Ana Luisa Vergara
Av. Eng. Luis Carlos Berrini, 1297 conj. 121
04571-000 – São Paulo, SP
Brazil
gdutt@mgminter.com; jscalon@mgminter.com; avergara@mgminter.com

SECTION C. Duration of the project activity / crediting period

C.1 Duration of the project activity:

C.1.1. Starting date of the project activity:

17/07/2006

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

21 years + 6 months

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

C.2.1. Renewable crediting period

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

01/02/08 or the registration date.

C.2.1.2. Length of the first crediting period:

7 years

C.2.2. Fixed crediting period:

C.2.2.1. Starting date:

Not selected

C.2.2.2. Length:

>>

SECTION D. Environmental impacts

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

The combustion of LFG causes both beneficial and adverse impacts on the environment. The net effect is beneficial, which is why flaring or other treatment is required by law in many countries. This section addresses the environmental impacts that are not directly related to the production of CERs and reduction of greenhouse gas emissions. Impacts on air, land, and water resources are discussed.

Impacts on Air

Background information in this sub-section is from the U.S. EPA, Publication AP-42, fifth edition, Supplement E of November 1998.

LFG typically contains less than one percent of various non-methane organic compounds (NMOC). Most of the NMOC in LFG results from the evaporation of materials contained in the landfilled waste. A small fraction of the NMOC might be generated through chemical and biological reactions within the landfill.

The concentration varies substantially from landfill to landfill. The inclusion of commercial and industrial waste in the landfill tends to increase substantially the concentration of NMOC. That is, waste that is not required to be disposed in a hazardous waste disposal site contains small amounts of hazardous material (for example, solvents in rags used to clean metal parts).

NMOC includes several groups of compounds including:

- Volatile organic compounds (VOC);
- Hazardous air pollutants (HAP), and
- Ozone depleting compounds.

Many compounds are included in more than one of these groups. That is, they are not mutually exclusive. Non-organic compounds, such as hydrogen sulphide, are also found in LFG. The effects of each group of compounds and means of destroying them are discussed below.

VOCs are photochemically reactive. That is, they react with oxides of nitrogen (NO_x) in the atmosphere under the influence of sunlight to form photochemical smog, which includes ozone. Ozone is a greenhouse gas that is not regulated under the Kyoto Protocol. Photochemical smog causes major local air pollution problems in many areas. Controlling photochemical smog is the primary motivation for U.S. EPA regulation of LFG emissions in the U.S. Likewise, combustion of LFG at the Feira de Santana Landfill can be expected to improve air quality in the Feira de Santana area.

Typically, VOCs are destroyed in well-operated LFG flares with an efficiency exceeding 90 percent. The destruction efficiencies discussed in this sub-section refer to the fraction of gas entering a combustion device that is destroyed. When an LFG recovery and combustion system is in place, the major source of remaining emissions is from inefficiencies in the collection system rather than from inefficiencies in the combustion system.

HAPs typically occur in concentrations of tens to hundreds of parts per million in LFG. HAPs include compounds that are carcinogenic and toxic. They include benzene, toluene, xylene, methylene chloride, vinyl chloride, ketenes, and others. Typically, HAPs are destroyed in well-operated LFG flares with an efficiency of at least 90 percent.

Hydrogen sulphide (H_2S) and other sulphur-bearing compounds cause much of the objectionable odour associated with decaying waste. As LFG burns, these compounds are oxidized and form SO_x. If left unburned, H_2S reacts slowly in the atmosphere to form SO_x or is dispersed and washed out of the air by rain. Burning LFG generally decreases the odours associated with landfills.

Chlorine-containing compounds in LFG react during combustion to form hydrogen chloride (HCl). The chlorine-containing compounds may be HAPs or they may be ozone-depleting compounds that destroy ozone in the stratosphere, increasing the amount of harmful ultraviolet radiation that reaches the Earth's surface.

The concentrations of VOC, HAP, and H_2S in LFG vary substantially from landfill to landfill. Tests at various U.S. landfills in the U.S. show a range of NMOC concentrations from a few hundred parts per million to more than 4,000 parts per million. Concentrations of various pollutants at the Feira de Santana Landfill may be greater than or less than concentrations in the U.S.

LFG combustion causes the formation of oxides of nitrogen (NO_x), carbon monoxide (CO), sulphur oxides (SO_x), hydrogen chloride (HCl), and particulate matter.

Emissions of NO_x are an unavoidable consequence of high-temperature combustion of fuel with excess air (i.e., a quantity of air exceeding the minimum amount required for complete combustion of the fuel). Low NO_x flares are available that guarantee low emission rates.

Emissions of carbon monoxide are an unavoidable consequence of burning carbon-bearing fuel, such as methane. The carbon monoxide emission rates currently guaranteed by major flare manufacturers are substantially less the rate given in EPA Publication AP-42.

Emissions of SO_x are an unavoidable consequence of burning sulphur-bearing compounds in excess air. Hydrogen chloride is a typical consequence of burning chlorine-bearing compounds.

Emissions of particulate matter of less than 10 microns diameter (PM10) result from particulate matter that enters the flare via the fuel and combustion air and from reactions within the flare. When methane is the fuel, the major source is often the entrainment of particulate matter in the combustion air or in the incoming fuel supply. Some of the entrained particulate matter may be destroyed by combustion.

Currently, in Brazil, emissions from LFG flares are not regulated. That is, emission limits have not been established. However, Centro de Recursos Ambientais (Environmental Resources Center, CRA), the environmental regulatory authority in Bahia State, is currently considering establishing emission limits. Staff of the environmental regulatory authority in Sao Paulo (CETESB) has told that the emission limits in Sao Paulo are likely to be similar to limits in the United States. CRA may follow a similar approach to regulation of flares in Bahia State.

In the United States, LFG flares must destroy at least 98 percent of the VOCs. Limits on NO_x and CO vary depending on local conditions. Enclosed flares are used where NO_x and CO emission limits are strict. Open flares are used where NO_x and CO limits are less strict. Because an enclosed flare would be used at the Feira de Santana Landfill, and because the flare can be specified to meet U.S. standards, it is likely that the flare will comply with future Brazilian emission limits.

Impacts on Land

Landfill operators generally plant grass or shrubs on the surface of finished sections of the landfill. The plants protect the landfill cover soil from erosion and promote the removal of water from the landfill through transpiration. The plants improve the appearance of the landfill. If the finished landfill is used for grazing or is restored to a natural state, plants are an essential feature.

If LFG passes upward through the cover soil, it can displace oxygen in the soil and expose the plants to toxins, thereby hindering the development of healthy roots and eventually killing the plants. The collection of LFG decreases this adverse effect. Consequently, re-vegetation of the landfill surface is promoted and the cover soil is protected.

When pollutants in LFG or in the exhaust from an LFG combustion device reach the atmosphere, they may be deposited on vegetation or onto soil. This may occur in the form of dry deposition, or the pollutant may first be dissolved in rainwater and carried to the ground. The effects of dry and wet deposition have not been determined.

Because effects of the project on land will be positive, regulatory problems are not anticipated.

Impacts on Water

Inadequate design and operation may cause leachate permeation and, therefore, the contamination of surface and underground water. Well-managed landfills have appropriate base liner and leachate drainage system and treatment. Good landfill cover helps minimize rainwater intrusion into the landfill and rainwater runoff from the landfill surface. Therefore, LFG recovery may have an indirect beneficial impact on water by minimizing leachate production and surface runoff.

The landfill already has the permit necessary to operate the landfill and has already entered in the environmental agency for the permit to the project activity specific.
The current landfill operational permit was issued on 5 December 2006 and is due to 5 December 2007.

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

No significant impacts are applicable beyond those discussed in section D.1.

However, according to the process of obtaining the environmental and operational permit from the local environmental agency (CRA), project sponsor must present a description of the project and a brief assessment of possible impacts.

SECTION E. Stakeholders' comments

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

The Brazilian DNA Interministerial Commission on Global Climate Change (Comissão Interministerial em Mudança Global do Clima) regulates the local stakeholder consultation process through four official documents:

- Resolution #1 of1 September 2003;
- Resolution #2 of 2 August 2005;
- Resolution #3 of 24 March 2006 and
- Resolution #4 of 6 December 2006.

All of them establish rules and procedures in order to obtain the letter of approval of the project.

In accordance to these procedures, Qualix performed the stakeholder consultation process in the following manner:

STEP 1: Invitation letters - on 30 May 2007, letters were sent by mail with return receipt in order to invite the following persons to submit comments:

Table 9*. Invitees for local stakeholder consultation process*

Name	Position	Company/Institution
Mr. Luiz da Costa Neto	President	Feira de Santana Industries Centre
Mrs. Marlene Matias de Souza	Head of the Association	Association of Neighborhood Nova Esperança and Surroundings
Mr. Roberto de Almeida Gomes	Environmental District Attorney	Public State Ministry
Mr. Lucílio Souza Flores	Regional Coordinator	Bahia Environmental Agency - (Centro de Recursos Ambientais - CRA)
Mr. Luiz Augusto de Jesus	Town councillor	Feira de Santana Town Council
Mr. José João Monteiro Sobrinho	Coordinator	NGO – Fórum Sócio Ambiental de Feira de Santana – Agenda 21
Mrs. Esther Neuhaus	Executive Manager	NGO - FBOMS – Fórum Brasileiro de ONGS e Movimentos Sociais
Mr. José Ronaldo de Carvalho	Mayor	Feira de Santana Municipality
Mr. José Ferreira Pinheiro	Department Secretary	Feira de Santana Department on Urban Development and Environment
Mr. Luiz Carlos Ferreira de Araújo	Director of the Urban Cleaning Department	Feira de Santana Department on Public Services - SESP
Mr. Sandro Lemos Machado, PhD	Coordinator of the Laboratory on Geotechnics and Environment	Bahia Federal University (UFBA)

This list of entities are pre-established in Resolution #1.

Within the letter, support material was attached, as follows:

- Cover letter with basic explanation and invitation to comments;
- Project summary;

- Questionnaire;
- Envelope with mail paid to return the questionnaire to Qualix;
- Explanation on how the project contributes to sustainable development (document required by Brazil DNA).

In the cover letter, it was said that further documents and online questionnaire would be made available at Qualix website[19]. There, the following documents were available for download:

- Project Design Document;
- Explanation on how the project contributes to sustainable development (document demanded by Brazil DNA);
- Project summary;
- Questionnaire to be printed and sent by e-mail.

In the next page is an example of the questionnaire made available.

[19] www.qualix-sa.com.br

Your opinion is very important to us

Name:

Entity:

Post:

Phone:

E-mail:

Please answer the following questions, including other comments that you consider pertinent.

1. Do you believe that the socio-economic situation of the region will improve due to the implementation of the Feira de Santana Landfill Gas Capture Project?

2. Is the implementation of project able to improve the environmental situation in the region?

3. How does the development of the project affect you (positively or negatively) or your environment?

4. Would you recommend private companies or authorities to develop projects of this nature?

To be continued

5. Do you think the project will contribute to the Brazilian Sustainable Development?

6. Any additional comments you would like to make.

Local:

Date: / /

Signature:

Please send this form to the following address, using the stamped envelope included in the letter, or e-mail, if you wish to (digital version available in www.qualix-sa.com.br). Thank you.

E-mail: *acitvaras@qualix-sa.com.br*
Contact: *Alexandre Citvaras*
Phone/fax: *(11) 2114-1500*
Address: *Rua Antonio Ribeiro Pina, 225*
Jardim Lídia – São Paulo - SP
CEP 05862-150

E.2. Summary of the comments received:

After 30 days of process counted as of 16 June 2007, when the last letter was received by the people invited, two questionnaires were returned filled by:

Name	Position	Company/Institution
Mr. Luiz da Costa Neto	President	Feira de Santana Industries Centre
Mr. Sandro Lemos Machado, PhD	Coordinator of the Laboratory on Geotechnics and Environment	Bahia Federal University (UFBA)

In general, the comments obtained regarding the project were positive. A remarkable aspect was the contribution of this type of projects for improving waste management and the beneficial use of landfill gas as a renewable energy. The project contribution to greenhouse gases mitigations seemed also clearly understood.

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

Neither questions nor doubts were posed.

Annex 1

CONTACT INFORMATION ON PARTICIPANTS IN THE PROJECT ACTIVITY

Organization:	**Qualix Serviços Ambientais Ltda.**
Street/P.O.Box:	Rua Antonio Ribeiro Pina, 225
Building:	
City:	São Paulo
State/Region:	SP
Postfix/ZIP:	05862-150
Country:	Brazil
Telephone:	55 11 2114 1500
FAX:	55 11 2114 1634
E-Mail:	
URL:	www.qualix-sa.com.br
Represented by:	Massimiliano Bellini Trinchi
Title:	CEO
Salutation:	Mr.
Last Name:	Trinchi
Middle Name:	Bellini
First Name:	Massimiliano
Department:	Directory
Mobile:	
Direct FAX:	55 11 2114 1634
Direct tel:	55 11 2114 1500
Personal E-Mail:	mbellini@sidecobrasil.com.br
Represented by:	Alexandre Citvaras
Title:	Operations Control and Planning Manager
Salutation:	Mr.
Last Name:	Citvaras
Middle Name:	
First Name:	Alexandre
Department:	Operation Direction
Mobile:	
Direct FAX:	55 11 2114 1500
Direct tel:	55 11 2114 1567
Personal E-Mail:	acitvaras@qualix-sa.com.br

Annex 2

INFORMATION REGARDING PUBLIC FUNDING

No funds from public national or international sources will be used in any aspect of the proposed project.

Annex 3

BASELINE INFORMATION

Emissions reductions result mainly from methane destruction resulting from the capture and burning of landfill gas. Additional emissions reductions take place when offsetting fossil fuel from thermal plant and if the landfill gas is used to generate electricity, thereby offsetting carbon dioxide emissions at power plants elsewhere in the interconnected grid.

The Annex contains two items:

1. A derivation of the parameters used to estimate landfill gas generation from solid waste; these parameters are only used in the ex-ante estimation of emissions reductions; and
2. A calculation of the emissions factor for power generation in the North-Northeast interconnected power grid in Brazil.

Methane emissions reductions from landfill gas capture

Landfill gas is generated by the anaerobic decomposition of solid waste within a landfill. It is typically composed of approximately 40 to 60 percent methane, with the remainder primarily being carbon dioxide.

The rate at which LFG is generated is largely a function of the type of waste buried and the moisture content and age of the waste. It is widely accepted throughout the industry that the LFG generation rate generally can be described by a first-order decay equation.

To estimate the potential LFG recovery rate for the Landfill, MGM employs a first-order decay equation, identical to the algorithm in the U.S. Environmental Protection Agency (EPA) landfill gas emissions model (LandGEM). The k-parameters needed as input in this model, are based on IPCC recommendations (2006 IPCC Guidelines for National Greenhouse Gas Inventories, Vol. 5). The model is described in detail below.

U.S. EPA Model

The EPA model requires that the site's waste disposal history (or, at a minimum, the amount of waste in place and opening date) be known. The model employs a first-order exponential decay function, which assumes that LFG generation is at its peak following a time lag representing the period prior to methane generation. The EPA model assumes a one-year time lag between placement of waste and LFG generation. After one year, the model assumes that LFG generation decreases exponentially as the organic fraction of waste is consumed.

For sites with known (or estimated) year-to-year solid waste acceptance rates, the model estimates the LFG generation rate in a given year using the following equation, which is published in Title 40 of the U.S. Code of Federal Regulations (CFR) Part 60, Subpart WWW.

$$Q_M = \sum_{i=1}^{n} k\, L_o\, M_i (e^{-k\, t_i})$$

Where

$\sum_{i=1}^{n}$ = sum from opening year+1 (I=1) through year of projection (n);
Q_M = maximum expected methane generation flow rate (m^3/yr);
k = methane generation decay rate constant (1/yr);
L_o = ultimate methane generation potential (m^3/Mg);
M_i = mass of solid waste disposed in the i^{th} year (Mg);
t_i = age of the waste disposed in the i^{th} year (years).

The above equation is used to estimate methane generation for a given year from all waste disposed up through that year. Multi-year projections are developed by varying the projection year and re-applying the equations. The year of maximum LFG generation normally occurs in the closure year or the year following closure (depending on the final year's disposal rate).

It was used the model to estimate the projected LFG recovery rates for the Landfill through 2028 using the following criteria and assumptions:

- **Waste Filling History** - The historical and projected future filling rates were provided by landfill personnel. The landfill is projected to close in 2013, at which time it will have reached a capacity of approximately 1.6 million tonnes.

Table 3.1. *Historical waste filling rate per year in the landfill, historical data and projections up to 2013:*

Year	Waste input (tonnes)
2002	107,702
2003	122,881
2004	123,840
2005	126,761
2006	*130,564*
2007	*134,480*
2008	*138,515*
2009	*142,670*
2010	*146,950*
2011	*151,359*
2012	*155,900*
2013	*160,577*

- **Methane Generation Rate Constant [k]** - The decay rate constant is a function of refuse moisture content, nutrient availability, pH, and temperature. Please see more information on this below.

- **Methane Generation Potential [L_0]** - The methane generation potential is the total amount of methane that a unit mass of refuse will produce given enough time. The L_0 is a function of the organic content of the waste, water content and precipitation data

- **LFG System Coverage or collection efficiency.** Considered as 65%.

Justification of L_0 and k:
The values of L_0 and k can be estimated using procedures described in 2006 IPCC Guidelines for National Greenhouse Gas Inventories.

The amount of methane released from solid waste, L_0, is given by the following formula:
L_0 = MCF x DOC x DOC_f x F x 16/12 **(1)**

This L_0 is dimensionless, e.g. tonnes of methane per tonne of solid waste. Each of the parameters in Eq. (1) is discussed below.

- **MCF: Methane correction factor:**
  IPCC (2006) recommends values of MCF as shown in the table below:

Table 3.2. *Methane Correction Factor*

MCF value	Type of site
1.0	For anaerobic managed solid waste disposal sites. These must have controlled placement of waste (i.e., waste directed to specific deposition areas, a degree of control of scavenging and a degree of control of fires) and will include at least one of the following: (i) cover material; (ii) mechanical compacting; or (iii) levelling of the waste.
0.5	For semi-aerobic managed solid waste disposal sites. These must have controlled placement of waste and will include all of the following structures for introducing air to waste layer: (i) permeable cover material; (ii) leachate drainage system; (iii) regulating poundage; and (iv) gas ventilation system.
0.8	For unmanaged solid waste disposal sites – deep and/or with high water table. This comprises all SWDS not meeting the criteria of managed SWDS and which have depths of greater than or equal to 5 meters and/or high water table at near ground level. Latter situation corresponds to filling inland water, such as pond, river or wetland, by waste.
0.4	For unmanaged-shallow solid waste disposal sites. This comprises all SWDS not meeting the criteria of managed SWDS and which have depths of less than 5 metres.

Source: 2006 IPCC Guidelines for National Greenhouse Gas Inventories

Feira de Santana is a technically managed landfill, which includes impermeabilisation, daily cover and compacting. The depth is more than 5 meters. Therefore, following the 2006 IPCC Guidelines, the selected value of MCF is 1.0.

- **DOC: Degradable organic carbon in waste:**
  IPCC (2006) provides DOC default values for each type of waste *j*, as shown in the table below. Using also the waste composition data from Feira de Santana Landfill, provided by Qualix, the DOC value can be estimated using the following formula:

$$DOC = \sum_j \left(DOC_j * Fraction\ of\ waste\ type\ j \right) = 0.1565 \text{ tonne C/ tonne waste}$$

Table 3.3. *Waste Types and default DOC values*

Waste type j	**DOC_i (% wet waste)**	**Fraction of Waste Type *j*** Waste composition in Feira de Santana Landfill
A. Wood and Wood Products	43%	0.34%
B. Pulp, Paper & Cardboard (other than sludge)	40%	5.76%
C. Food, Food Waste, Beverages & Tobacco (other than sludge)	15%	40.36%
D. Textile	24%	2.00%
E. Garden, Yard & Park Waste	20%	30.00%
F. Leather and Rubber (other than natural rubber)	39%	0.27%
G. Nappies (disposal diapers)	24%	2.10%
H. Sludge	9%	0.65%
TOTAL		**81.48%**

- **DOC_f - Fraction of degradable organic carbon dissimilated:**
  The decomposition of degradable organic carbon does not occur completely and some of the potentially degradable material always remains in the site even over a very long period of time. IPCC recommends that values should vary from 0.5 to 0.77. As stated before, due to the favourable climate conditions and the organic sludge content of the waste, it is expected that a higher percentage of DOC will be dissimilated. Because of this, we used $DOC_f = 0.6$.

- **F - Fraction by volume of methane in landfill gas:**
  Most waste in SWDS generates a gas with approximately 50 percent of CH_4. Only material including substantial amounts of fat or oil can generate gas with substantially more than 50 percent of CH_4. Taking into account the IPCC default value, MGM estimates future methane content in landfill gas to be 50 percent.

Applying these values in Eq. 1, we obtain:
$L_0 = 0.0626$ tonne CH_4/ tonne waste

Or, alternatively,
$L_0 = 87.34$ Nm^3 CH_4/ tonne waste, considering methane density of 0.7168 kg/Nm^3 (P = 1atm, T = 0 °C).

The **methane generation rate constant, k,** that appears in the landfill gas production model is related to the time taken for the DOC in waste to decay to half its initial mass (the 'half life' or $t_{½}$). The rate constant k has dimensions of "per year".
Based on measurements in the USA, the United Kingdom and the Netherlands, IPCC supports values of k in the range of 0.03 per year (dry conditions) to 0.20 per year (high temperature and humidity condition). IPCC provides default values or a range of values for k, depending on the weather conditions.

The precipitation at Feira de Santana landfill is about 870 mm/yr and the average temperature is 28ºC. The IPCC recommended default values for bulk waste disposed under these weather conditions are presented on the table below:

Table 3.4. *Recommended default methane generation rate constant (k) values*

<table>
<tr><th rowspan="2">Type of Waste</th><th colspan="2">Tropical (MAT>20ºC)
Dry (MAP< 1000 mm)</th></tr>
<tr><th>Default Value</th><th>Range</th></tr>
<tr><td>Bulk Waste</td><td>0.065</td><td>0.05 – 0.08</td></tr>
<tr><td colspan="3">Notes: MAT: Mean annual temperature.
MAP: Mean annual precipitation.</td></tr>
</table>

Based on the experience in developed countries, the waste containing organic sludge degrades faster than other types of waste. Considering the 50.3% garden and food content in the waste disposed at Feira de Santana landfill and the relatively humid and temperate conditions in the zone, we have chosen a k value of 0.08 per year.

The parameters L_0 and k derived above, together with the waste filling history and projects at the Feira de Santana landfill are used to estimate LFG production in future years.

Calculation of Brazilian Emission Factor in the North-Northeast Interconnected System

The Brazilian electricity system (Figure 3.1) has been historically divided into four subsystems: North (N), Northeast (NE), South (S) and Southeast-Midwest (SE-CO). This is due mainly to the historical evolution of the physical system, which was naturally developed nearby the biggest consuming centres of the country. Currently, subsystems South and Southeast-Midwest are considered interconnected with minor transmissions constraints. Also subsystems North and Northeast can be considered interconnected with minor transmission constraints.

The natural evolution of both systems is increasingly showing that integration is to happen in the future. In 1998, the Brazilian government was announcing the first leg of the interconnection line between S-SE-CO and N-NE. With investments of around USD 700 million, the connection had the main purpose, in the government's view, at least, to help solve energy imbalances in the country: the S-SE-CO region could supply the N-NE in case it was necessary and vice-versa.

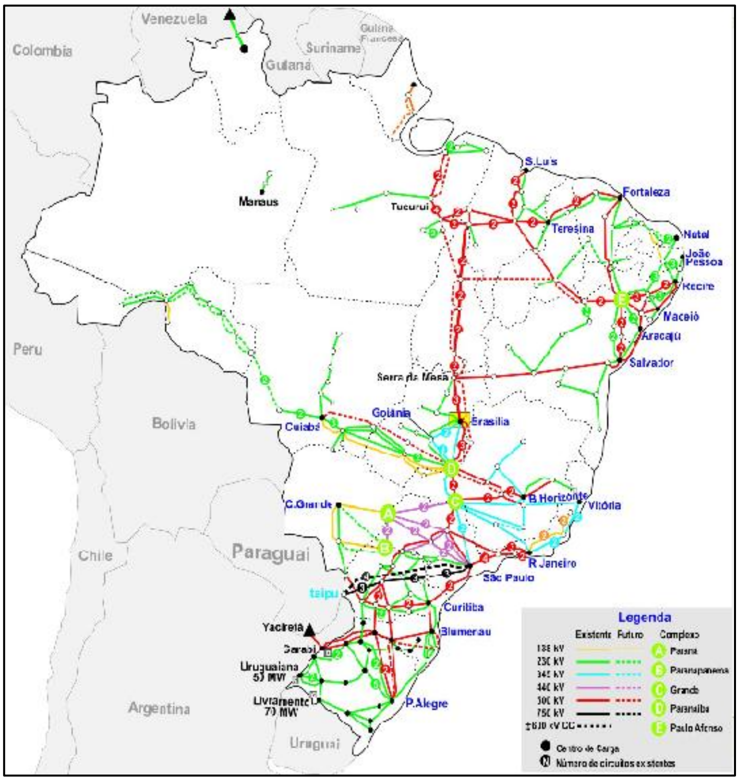

Figure 3.1. *Brazilian Interconnected System (source: ONS)*

Nevertheless, even after the interconnection had been established, technical papers still divided the Brazilian system in three (Bosi, 2000): *"... where the Brazilian Electricity System is divided into three separate subsystems:*

- *The South/Southeast/Midwest Interconnected System;*
- *The North/Northeast Interconnected System; and*

- *The Isolated Systems (which represent 300 locations that are electrically isolated from the interconnected systems)*".

Moreover, Bosi (2000) gives a strong argumentation in favour of having so-called *multi-project baselines*:
"For large countries with different circumstances within their borders and different power grids based in these different regions, multi-project baselines in the electricity sector may need to be disaggregated below the country-level in order to provide a credible representation of 'what would have happened otherwise."

Finally, one has to take into account that even though the systems today are connected, the energy flow between N-NE and S-SE-CO is heavily limited by the transmission lines capacity. Therefore, only a fraction of the total energy generated in both subsystems is sent one way or another. It is natural that this fraction may change its direction and magnitude (up to the transmission line's capacity) depending on the hydrological patterns, climate and other uncontrolled factors. But it is not supposed to represent a significant amount of each subsystem's electricity demand. It has also to be considered that only in 2004 the interconnection between SE and NE was concluded, i.e., if project proponents are to be coherent with the generation database they have available as of the time of the PDD submission for validation, a situation where the electricity flow between the subsystems was even more restricted is to be considered.

The Brazilian electricity system nowadays comprises of around 108 GW of installed capacity, in a total of 1,636 electricity generation enterprises. From those, nearly 70% are hydropower plants, around 10% are natural gas-fired power plants, 4% are diesel and fuel oil plants, 3.6% are biomass sources (sugarcane bagasse, black liquor, wood, rice straw and biogas), 1.86% are nuclear plants, 1.3% are coal plants, and there are also 8.1 GW of installed capacity in neighbouring countries (Argentina, Uruguay, Venezuela and Paraguay) that may dispatch electricity to the Brazilian grid[20]. This latter capacity is in fact comprised by mainly 5.6 GW of the Paraguayan part of *Itaipu Binacional*, a hydropower plant operated by both Brazil and Paraguay, but whose energy almost entirely is sent to the Brazilian grid.

Approved methodology ACM0002 version 6 asks project proponents to account for "all generating sources serving the system". In that way, when applying the methodology, project proponents in Brazil should search for, and research, all power plants serving the Brazilian system. In fact, information on such generating sources is not publicly available in Brazil. The national dispatch centre, ONS – *Operador Nacional do Sistema* – argues that dispatching information is strategic to the power agents and therefore cannot be made available. On the other hand, ANEEL, the electricity agency, provides information on power capacity and other legal matters on the electricity sector, but no dispatch information can be got through this entity.

In that regard, project proponents looked for a plausible solution in order to be able to calculate the emission factor in Brazil in the most accurate way. Since real dispatch data is necessary after all, the ONS was contacted, in order to let participants know until which degree of detail information could be provided. After several months of talks, plants' daily dispatch information was made available for years 2003, 2004 and 2005.

---

[20] http://www.aneel.gov.br/aplicacoes/capacidadebrasil/OperacaoCapacidadeBrasil.asp

Project proponents met with other CDM project developers in Brazil in order to find a solution for the problem. Discussing the feasibility of using such data, it was concluded that this is the most proper information to be considered when determining the emission factor for the Brazilian grid. According to ANEEL, in fact, ONS centralised dispatched plants accounted for 80,603 MW of installed capacity by 31/12/2004[21], out of the total 98,848.5 MW installed in Brazil by the same date[22], which includes capacity available in neighbouring countries to export to Brazil and emergency plants, that are dispatched only during times of electricity constraints in the system. Therefore, even though the emission factor calculation is carried out without considering all generating sources serving the system, about 81.5% of the installed capacity serving Brazil is taken into account, which is a fair amount if we look at the difficulty in getting dispatch information in Brazil. Moreover, the remaining 18.5% are plants that do not have their dispatch coordinated by ONS, since: either they operate based on power purchase agreements which are not under control of the dispatch authority; or they are located in non-interconnected systems to which ONS has no access. In that way, this portion is not likely to be affected by the CDM projects, and this is another reason for not taking them into account when determining the emission factor.

Therefore, considering all the rationale explained above, project developers decided for the database considering ONS information available at the time of validation[23] (at the end of year 2005, ONS supplied raw dispatch data for the whole interconnected grid in the form of daily reports from January 2003 to December 2005).

ACM0002 version 6states: "*The baseline emission factor (EFy) is calculated as a combined margin (CM), consisting of the combination of operating margin (OM) and build margin (BM) factors according to the following three steps. Calculations for this combined margin must be based on data from an official source (where available) and made publicly available*".

STEP 1: Simple Adjusted Operating Margin Emission Factor Calculation

According to ACM0002 version 6, the method chosen to calculate the Operating Margin (OM) for the electricity baseline emission factor is the option (b) *Simple Adjusted OM*, since the preferable choice (c) *Dispatch Data Analysis OM* would face the barrier of data availability in Brazil.

According to the methodology, the project is to determine the *Simple Adjusted OM Emission Factor* ($EF_{OM,simple,adjusted,y}$). Therefore, the following equation is to be solved:

$$EF_{OM,simple adjusted,y} = (1-\lambda_y)\cdot\frac{\sum_{i,j} F_{i,j,y}\cdot COEF_{i,j}}{\sum_{j} GEN_{j,y}} + \lambda\cdot\frac{\sum_{i,k} F_{i,k,y}\cdot COEF_{i,k}}{\sum_{k} GEN_{k,y}} (tCO_2e/GWh)$$

It is assumed here that all the low-cost/must-run plants produce zero net emissions.

[21] Http://www.aneel.gov.br/arquivos/PDF/Resumo_Geral_jun_2007.pdf

[22] http://www.aneel.gov.br/arquivos/PDF/Resumo_Gráficos_mai_2005.pdf

[23] Operador Nacional do Sistema Elétrico, Centro Nacional de Operação do Sistema, Acompanhamento Diário da Operação do SIN,(daily reports from Jan. 1, 2003 to Dec. 31, 2005).

$$\frac{\sum_{i,k} F_{i,k,y} \cdot COEF_{i,k}}{\sum_{k} GEN_{k,y}} = 0 \; (tCO_2e/GWh)$$

Please refer to the methodology text or the explanations on the variables mentioned above.

The ONS data as well as the spreadsheet data with the calculation of emission factors have been provided to the validator.

The aggregated hourly dispatch data got from ONS was used to determine the lambda factor for each of the years with data available (2003, 2004 and 2005). Results are shown in Table 3.5 below.

***Table 3.5**: Lambda factors for the N-NE Interconnected System in Brazil, 2003-2005*

Year	Lambda
2003	0.7192
2004	0.5330
2005	0.5572

The next three figures that follow present the load duration curves for the N-NE subsystem, which calculation was made with aggregated hourly dispatch data received from ONS from years 2003 to 2005.

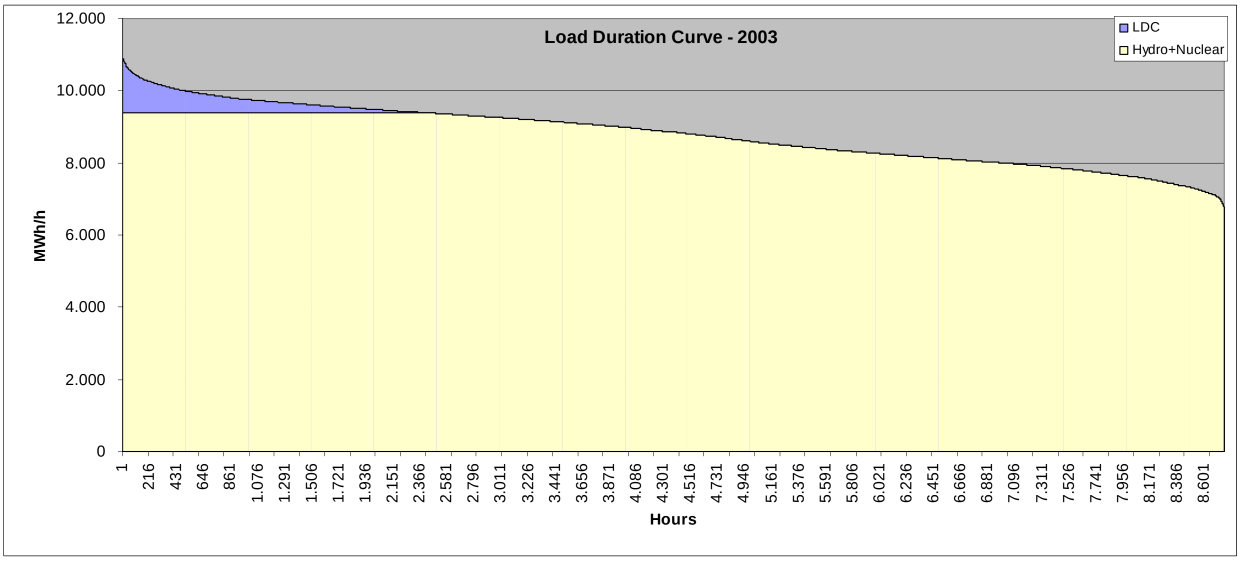

***Figure 3.2.** Load duration curve for the N-NE system, 2003*

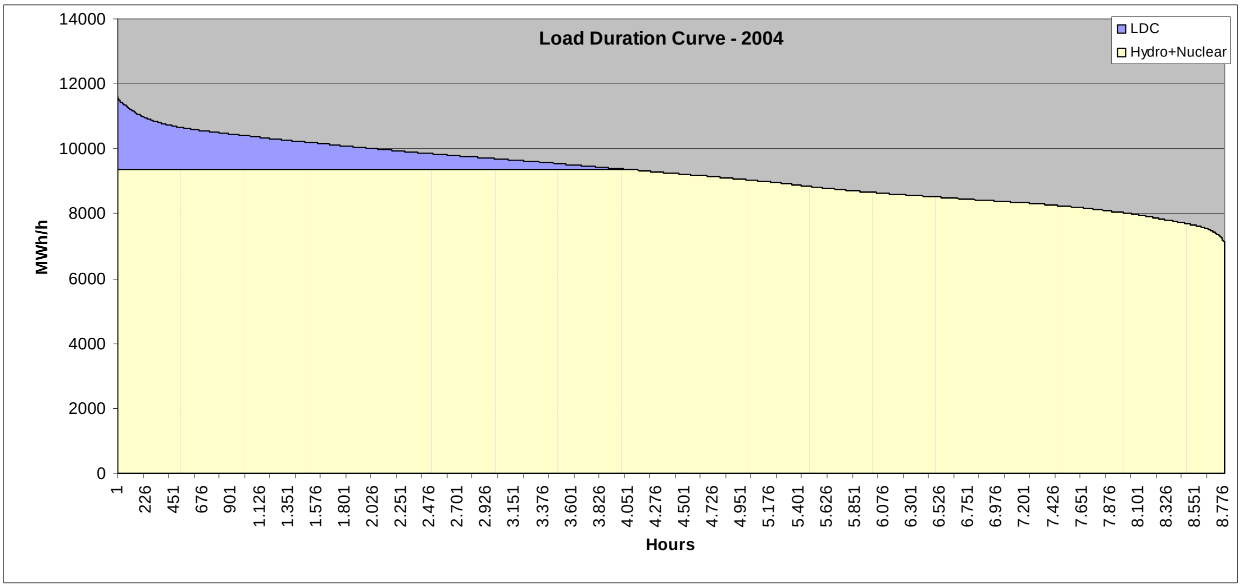

Figure 3.3. *Load duration curve for the N-NE system, 2004*

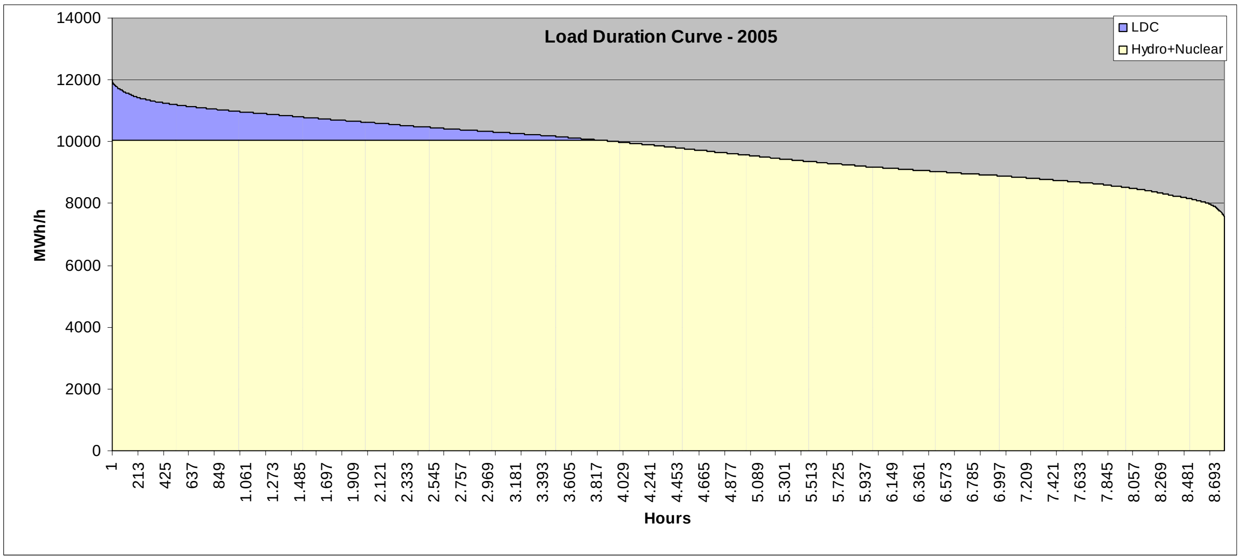

Figure 3.4. *Load duration curve for the N-NE system, 2005*

Electricity generation for each year needs also to be taken into account. This information is provided in the table below.

Table 3.6*: Electricity load in the N-NE Interconnected System in Brazil, 2003-2005*

Year	Electricity Load (MWh)
2003	76,935,819
2004	81,199,780
2005	85,818,478

Using therefore appropriate information for $F_{i,j,y}$ and $COEF_{i,j}$, OM emission factors for each year can determined, as follows:

$$EF_{OM,simple adjusted,2003} = (1-\lambda_{2003}) \cdot \frac{\sum_{i,j} F_{i,j,2003} \cdot COEF_{i,j}}{\sum_{j} GEN_{j,2003}} \therefore EF_{OM,simple adjusted,2003} = 0.0355\ tCO_2e/GWh$$

$$EF_{OM,simple adjusted,2004} = (1-\lambda_{2004}) \cdot \frac{\sum_{i,j} F_{i,j,2004} \cdot COEF_{i,j}}{\sum_{j} GEN_{j,2004}} \therefore EF_{OM,simple adjusted,2004} = 0.1536\ tCO_2e/GWh$$

$$EF_{OM,simple adjusted,2005} = (1-\lambda_{2005}) \cdot \frac{\sum_{i,j} F_{i,j,2005} \cdot COEF_{i,j}}{\sum_{j} GEN_{j,2005}} \therefore EF_{OM,simple adjusted,2005} = 0.1196\ tCO_2e/GWh$$

Finally, to determine the baseline ex-ante, the full generation weighted-average among the three years is calculated, determining the $EF_{OM,simple-adjusted}$

$$EF_{OM,simple adjusted,2003-2005} = \frac{EF_{OM,simple adjusted,2003} * \sum_{j} GEN_{j,2003} + EF_{OM,simple adjusted,2004} * \sum_{j} GEN_{j,2004} + EF_{OM,simple adjusted,2005} * \sum_{j} GEN_{j,2005}}{\sum_{j} GEN_{j,2003} + \sum_{j} GEN_{j,2004} + \sum_{j} GEN_{j,2005}}$$

$$EF_{OM,simple adjusted,2003-2005} = 0.1044\ tCO_2e/GWh$$

STEP 2: Calculation of Building Margin Emission Factor ($EF_{BM,y}$):

According to the methodology used, a Building Margin emission factor also needs to be determined. There are two possible options offered by ACM0002 version 6. The option here chosen is the first one, where it is stated:
"*Calculate the Build Margin emission factor $EF_{BM,y}$ ex-ante based on the most recent information available on plants already built for sample group* m *at the time of PDD submission. The sample group* m *consists of either the five power plants that have been built most recently or the power plant capacity additions in the electricity system that comprise 20% of the system generation (in MWh) and that have been built most recently. Project participants should use from these two options that sample group that comprises the larger annual generation*".

The formula provided is:

$$EF_{BM,y} = \frac{\sum_{i,m} F_{i,m,y} \cdot COEF_{i,m}}{\sum_{m} GEN_{m,y}}$$

Hence, electricity generation in this case means 20% of total generation is the most recent year (2005) as the 5 most recent plants built generate less than such 20%. If 20% falls on part capacity of a plant, that plant is fully included in the calculation. Calculating such factor gives:

$$EF_{BM,2005} = 0.0491\, tCO_2 / MWh$$

STEP 3: Calculation of Baseline Emission Factor (or Combined Margin)

The electricity baseline emission factor is calculated through a weighted-average of the Operating Margin emission factor ($EF_{OM,y}$) and the Build Margin emission factor ($EF_{BM,y}$), as follows:

$$EF_y = w_{OM} \cdot EF_{OM,y} + w_{BM} \cdot EF_{BM,y}$$

Where the weights w_{OM} and w_{BM}, by default, are 50% (i.e., $w_{OM} = w_{BM} = 0.5$), and $EF_{OM,y}$ and $EF_{BM,y}$ are calculated as described in Steps 1 and 2 above and are expressed in tCO_2/MWh.

Hence,

$$EF_{electricity,2003-2005} = 0.5 * 0.1044 + 0.5 * 0.0491 = 0.0767\; tCO_2 / MWh$$

Annex 4

MONITORING INFORMATION

Detailed information is in section B.7.

Annex 5

Economic Analyses

ECONOMIC EVALUATION — No CER Revenues

CAPTURE OF LANDFILL GAS FOR GENERATING ELECTRICITY — Feira de Santana Project — All values in USD 2007

Electric generation starting up date	2009
Landfill gas collection starting up date	2008

Cash Flow in USD

Year	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
	0	1	2	3	4	5	6	7	8	9	10	11
Landfill Gas Investment		(900.000)	(25.000)	(25.000)	(25.000)	(25.000)	(25.000)	(25.000)	-	-	-	-
Electricity Investment		-	(490.000)	-	(490.000)	-	-	-	-	-	-	-
Total Investment	1,0	(900.000)	(515.000)	(25.000)	(515.000)	(25.000)	(25.000)	(25.000)	0	0	0	0
Operation and Maintenance Costs												
Total Operation and Maintenance Costs. Electricity		0	(92.000)	(92.000)	(184.000)	(184.000)	(184.000)	(184.000)	(184.000)	(184.000)	(184.000)	(92.000)
Total Operation Costs Landfill Gas	3%	(150.000)	(154.500)	(159.135)	(163.909)	(168.826)	(173.891)	(179.108)	(179.108)	(179.108)	(179.108)	(179.108)
Total Operation Costs	1,0	(150.000)	(246.500)	(251.135)	(347.909)	(352.826)	(357.891)	(363.108)	(363.108)	(363.108)	(363.108)	(271.108)
Revenues from Sale of Electricity												
Hours of Operation			8.000	8.000	8.000	8.000	8.000	8.000	8.000	8.000	8.000	8.000
Power in kW			500	500	1.000	1.000	1.000	1.000	1.000	1.000	1.000	500
Energy Produced kWh		0	4.000.000	4.000.000	8.000.000	8.000.000	8.000.000	8.000.000	8.000.000	8.000.000	8.000.000	4.000.000
Energy Price USD/kWh	1,0	0,072	0,072	0,072	0,072	0,072	0,072	0,072	0,072	0,072	0,072	0,072
Total Revenues for Sale of Energy		0	287.600	287.600	575.200	575.200	575.200	575.200	575.200	575.200	575.200	287.600
Revenue from Sale of CERs												
Tons CO_2 equivalent from methane destruction less project emissions		25.532	33.920	37.826	43.614	47.331	50.962	54.511	50.647	47.058	43.761	38.750
Emissions factor for electricity generation (tCO_2/MWh)		0,077	0,077	0,077	0,077	0,077	0,077	0,077	0,077	0,077	0,077	0,077
Tons CO_2 offset by electricity generation using LFG		0	307	307	614	614	614	614	614	614	614	307
CER Price [USD/tCO_2e]		0	0	0	0	0	0	0	0	0	0	0
Total Revenue from Sale of CERs [USD]		0	0	0	0	0	0	0	0	0	0	0
Total Revenues		0	287.600	287.600	575.200	575.200	575.200	575.200	575.200	575.200	575.200	287.600
PIS/CONFINS		0	(26.603)	(26.603)	(53.206)	(53.206)	(53.206)	(53.206)	(53.206)	(53.206)	(53.206)	(26.603)
Operational Profit		(150.000)	41.100	36.465	227.291	222.374	217.309	212.092	212.092	212.092	212.092	16.492
Depreciation 1		(90.000)	(90.000)	(90.000)	(90.000)	(90.000)	(90.000)	(90.000)	(90.000)	(90.000)		
Depreciation 2			(49.000)	(49.000)	(49.000)	(49.000)	(49.000)	(49.000)	(49.000)	(49.000)	(49.000)	
Depreciation 3					(49.000)	(49.000)	(49.000)	(49.000)	(49.000)	(49.000)	(49.000)	(49.000)
Depreciation 4												
Depreciation total		(90.000)	(139.000)	(139.000)	(188.000)	(188.000)	(188.000)	(188.000)	(188.000)	(188.000)	(98.000)	(49.000)
Profit Before Taxes		(240.000)	(97.900)	(102.535)	39.291	34.374	29.309	24.092	24.092	24.092	114.092	(32.508)
Corporate Taxes		0	0	0	(13.359)	(11.687)	(9.965)	(8.191)	(8.191)	(8.191)	(38.791)	0
Profit After Taxes		(240.000)	(97.900)	(102.535)	25.932	22.687	19.344	15.901	15.901	15.901	75.301	(32.508)
Depreciation		90.000	139.000	139.000	188.000	188.000	188.000	188.000	188.000	188.000	98.000	49.000
Annual Cash Flow		(1.050.000)	(473.900)	11.465	(301.068)	185.687	182.344	178.901	203.901	203.901	173.301	16.492

Year	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029
	12	13	14	15	16	17	18	19	20	21	22
Landfill Gas Investment	-	-	-	-	-	-	-	-	-	-	-
Electricity Investment	-	-	(490.000)	-	-	-	-	-	-	-	-
Total Investment	0	0	(490.000)	0	0	0	0	0	0	0	0
Operation and Maintenance Costs											
Total Operation and Maintenance Costs. Electricity	(92.000)	(92.000)	(92.000)	(92.000)	(92.000)	(92.000)	0	0	0	0	0
Total Operation Costs Landfill Gas	(179.108)	(179.108)	(179.108)	(179.108)	(179.108)	(179.108)	(179.108)	(179.108)	(179.108)	(179.108)	(179.108)
Total Operation Costs	(271.108)	(271.108)	(271.108)	(271.108)	(271.108)	(271.108)	(179.108)	(179.108)	(179.108)	(179.108)	(179.108)
Revenues from Sale of Electricity											
Hours of Operation	8.000	8.000	8.000	8.000	8.000	8.000	8.000	8.000	8.000	8.000	8.000
Power in kW	500	500	500	500	500	500					
Energy Produced kWh	4.000.000	4.000.000	4.000.000	4.000.000	4.000.000	4.000.000	0	0	0	0	0
Energy Price USD/kWh	0,072	0,072	0,072	0,072	0,072	0,072	0,072	0,072	0,072	0,072	0,072
Total Revenues for Sale of Energy	287.600	287.600	287.600	287.600	287.600	287.600	0	0	0	0	0
Revenue from Sale of CERs											
Tons CO_2 equivalent from methane destruction less project emissions	35.936	33.332	30.938	28.712	26.654	24.785	21.049	19.453	17.962	16.597	1.310
Emissions factor for electricity generation (tCO_2/MWh)	0,077	0,077	0,077	0,077	0,077	0,077	0,077	0,077	0,077	0,077	0,077
Tons CO_2 offset by electricity generation using LFG	307	307	307	307	307	307	0	0	0	0	0
CER Price [USD/tCO_2e]	0	0	0	0	0	0	0	0	0	0	0
Total Revenue from Sale of CERs [USD]	0	0	0	0	0	0	0	0	0	0	0
Total Revenues	287.600	287.600	287.600	287.600	287.600	287.600	0	0	0	0	0
PIS/CONFINS	(26.603)	(26.603)	(26.603)	(26.603)	(26.603)	(26.603)	0	0	0	0	0
Operational Profit	16.492	16.492	16.492	16.492	16.492	16.492	(179.108)	(179.108)	(179.108)	(179.108)	(179.108)
Depreciation 1											
Depreciation 2											
Depreciation 3	(49.000)	(49.000)									
Depreciation 4			(49.000)	(49.000)	(49.000)	(49.000)	(49.000)	(49.000)	(49.000)	(49.000)	(49.000)
Depreciation total	(49.000)	(49.000)	(49.000)	(49.000)	(49.000)	(49.000)	(49.000)	(49.000)	(49.000)	(49.000)	(49.000)
Profit Before Taxes	(32.508)	(32.508)	(32.508)	(32.508)	(32.508)	(32.508)	(228.108)	(228.108)	(228.108)	(228.108)	(228.108)
Corporate Taxes	0	0	0	0	0	0	0	0	0	0	0
Profit After Taxes	(32.508)	(32.508)	(32.508)	(32.508)	(32.508)	(32.508)	(228.108)	(228.108)	(228.108)	(228.108)	(228.108)
Depreciation	49.000	49.000	49.000	49.000	49.000	49.000	49.000	49.000	49.000	49.000	49.000
Annual Cash Flow	16.492	16.492	(473.508)	16.492	16.492	16.492	(179.108)	(179.108)	(179.108)	(179.108)	(179.108)

ECONOMIC EVALUATION PARAMETERS	
Amortization period (years)	10
Discount Rate	10%
Corporate Tax Rate	34%
PIS/COFINS	9,25%
LFG Power plant operating costs [USD/kWh]	0,023

ECONOMIC RESULTS	
NPV	**(1.217.184)**
IRR	**#DIV/0!**

SENSITIVITY ANALYSIS

Electricity Sale Price

	-20%	-10%	—	10%	20%
NPV	(1.788.224)	(1.485.889)	(1.217.184)	(978.967)	(756.712)
IRR	N.A.	N.A.	N.A.	N.A.	N.A.

O&M Costs

	-20%	-10%	—	10%	20%
NPV	(1.788.224)	(1.485.889)	(1.217.184)	(978.967)	(756.712)
IRR	N.A.	N.A.	N.A.	N.A.	N.A.

Investment

	-20%	-10%	—	10%	20%
NPV	(860.017)	(1.038.600)	(1.217.184)	(1.395.767)	(1.574.350)
IRR	N.A.	N.A.	N.A.	N.A.	N.A.

ECONOMIC EVALUATION - Marginal **No CER Revenues**

CAPTURE OF LANDFILL GAS FOR GENERATING ELECTRICITY **Feira de Santana Project** **All values in** **USD 2007**

Electric generation starting up date	2009
Landfill gas collection starting up date	2008

Cash Flow in USD																							
Year	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029
	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
Electricity Investment		-	(490.000)	-	(490.000)	-	-	-	-	-	-	-	-	-	(490.000)	-	-	-	-	-	-	-	-
Total Investment	1,0	0	(490.000)	0	(490.000)	0	0	0	0	0	0	0	0	0	(490.000)	0	0	0	0	0	0	0	0
Operation and Maintenance Costs																							
Total Operation and Maintenance Costs. Electricity		0	(92.000)	(92.000)	(184.000)	(184.000)	(184.000)	(184.000)	(184.000)	(184.000)	(184.000)	(92.000)	(92.000)	(92.000)	(92.000)	(92.000)	(92.000)	(92.000)	0	0	0	0	0
Total Operation Costs	1,0	0	(92.000)	(92.000)	(184.000)	(184.000)	(184.000)	(184.000)	(184.000)	(184.000)	(184.000)	(92.000)	(92.000)	(92.000)	(92.000)	(92.000)	(92.000)	(92.000)	0	0	0	0	0
Revenues from Sale of Electricity																							
Hours of Operation			8.000	8.000	8.000	8.000	8.000	8.000	8.000	8.000	8.000	8.000	8.000	8.000	8.000	8.000	8.000	8.000	8.000	8.000	8.000	8.000	8.000
Power in kW			500	500	1.000	1.000	1.000	1.000	1.000	1.000	1.000	500	500	500	500	500	500	500					
Energy Produced kWh		0	4.000.000	4.000.000	8.000.000	8.000.000	8.000.000	8.000.000	8.000.000	8.000.000	8.000.000	4.000.000	4.000.000	4.000.000	4.000.000	4.000.000	4.000.000	4.000.000	0	0	0	0	0
Energy Price USD/kWh	1,0	0,072	0,072	0,072	0,072	0,072	0,072	0,072	0,072	0,072	0,072	0,072	0,072	0,072	0,072	0,072	0,072	0,072	0,072	0,072	0,072	0,072	0,072
Total Revenues for Sale of Energy		0	287.600	287.600	575.200	575.200	575.200	575.200	575.200	575.200	575.200	287.600	287.600	287.600	287.600	287.600	287.600	287.600	0	0	0	0	0
Revenue from Sale of CERs																							
Emissions factor for electricity generation (tCO_2/MWh)		0,077	0,077	0,077	0,077	0,077	0,077	0,077	0,077	0,077	0,077	0,077	0,077	0,077	0,077	0,077	0,077	0,077	0,077	0,077	0,077	0,077	0,077
Tons CO_2 offset by electricity generation using LFG		0	307	307	614	614	614	614	614	614	614	307	307	307	307	307	307	307	0	0	0	0	0
CER Price [USD/tCO_2e]		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Revenue from Sale of CERs [USD]		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Revenues		0	287.600	287.600	575.200	575.200	575.200	575.200	575.200	575.200	575.200	287.600	287.600	287.600	287.600	287.600	287.600	287.600	0	0	0	0	0
PIS/CONFINS		0	(26.603)	(26.603)	(53.206)	(53.206)	(53.206)	(53.206)	(53.206)	(53.206)	(53.206)	(26.603)	(26.603)	(26.603)	(26.603)	(26.603)	(26.603)	(26.603)	0	0	0	0	0
Operational Profit		0	195.600	195.600	391.200	391.200	391.200	391.200	391.200	391.200	391.200	195.600	195.600	195.600	195.600	195.600	195.600	195.600	0	0	0	0	0
Depreciation 1			(49.000)	(49.000)	(49.000)	(49.000)	(49.000)	(49.000)	(49.000)	(49.000)	(49.000)												
Depreciation 2					(49.000)	(49.000)	(49.000)	(49.000)	(49.000)	(49.000)	(49.000)	(49.000)	(49.000)	(49.000)									
Depreciation 3															(49.000)	(49.000)	(49.000)	(49.000)	(49.000)	(49.000)	(49.000)	(49.000)	(49.000)
Depreciation total		0	(49.000)	(49.000)	(98.000)	(98.000)	(98.000)	(98.000)	(98.000)	(98.000)	(98.000)	(49.000)	(49.000)	(49.000)	(49.000)	(49.000)	(49.000)	(49.000)	(49.000)	(49.000)	(49.000)	(49.000)	(49.000)
Profit Before Taxes		0	146.600	146.600	293.200	293.200	293.200	293.200	293.200	293.200	293.200	146.600	146.600	146.600	146.600	146.600	146.600	146.600	(49.000)	(49.000)	(49.000)	(49.000)	(49.000)
Corporate Taxes		0	(49.844)	(49.844)	(99.688)	(99.688)	(99.688)	(99.688)	(99.688)	(99.688)	(99.688)	(49.844)	(49.844)	(49.844)	(49.844)	(49.844)	(49.844)	(49.844)	0	0	0	0	0
Profit After Taxes		0	96.756	96.756	193.512	193.512	193.512	193.512	193.512	193.512	193.512	96.756	96.756	96.756	96.756	96.756	96.756	96.756	(49.000)	(49.000)	(49.000)	(49.000)	(49.000)
Depreciation		0	49.000	49.000	98.000	98.000	98.000	98.000	98.000	98.000	98.000	49.000	49.000	49.000	49.000	49.000	49.000	49.000	49.000	49.000	49.000	49.000	49.000
Annual Cash Flow		0	(344.244)	145.756	(198.488)	291.512	291.512	291.512	291.512	291.512	291.512	145.756	145.756	145.756	(344.244)	145.756	145.756	145.756	0	0	0	0	0

ECONOMIC EVALUATION PARAMETERS	
Amortization period (years)	10
Discount Rate	10%
Corporate Tax Rate	34%
PIS/COFINS	9,25%
LFG Power plant operating costs [USD/kWh]	0,023

ECONOMIC RESULTS	
NPV	**701.150**
IRR	**39,52%**

SENSITIVITY ANALYSIS

Electricity Sale Price

	-20%	-10%	—	10%	20%
NPV	292.280	496.715	701.150	905.586	1.110.021
IRR	22,57%	30,92%	39,52%	48,66%	58,60%

O&M Costs

	-20%	-10%	—	10%	20%
NPV	831.943	766.547	701.150	635.754	570.357
IRR	45,29%	42,37%	39,52%	36,72%	33,97%

Investment

	-20%	-10%	—	10%	20%
NPV	874.884	788.017	701.150	614.284	527.417
IRR	57,77%	47,28%	39,52%	33,48%	28,58%

ECONOMIC EVALUATION **No CER Revenues**

CAPTURE OF LANDFILL GAS FOR GENERATING THERMAL ENERGY **Feira de Santana Project** **All values in** **USD 2007**

	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
Thermal generation starting up date	2008											
Landfill gas collection starting up date	2008											
Cash Flow in USD												
Year	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
	0	1	2	3	4	5	6	7	8	9	10	11
Landfill Gas Investment		(900.000)	(25.000)	(25.000)	(25.000)	(25.000)	(25.000)	(25.000)	-	-	-	-
Thermal Energy Investment		(70.000)	-	-	-	-	-	-	-	-	-	(70.000)
Total Investment	1,0	(970.000)	(25.000)	(25.000)	(25.000)	(25.000)	(25.000)	(25.000)	0	0	0	(70.000)
Operation and Maintenance Costs												
Total Operation and Maintenance Costs. Thermal Energy		(7.000)	(7.000)	(7.000)	(7.000)	(7.000)	(7.000)	(7.000)	(7.000)	(7.000)	(7.000)	(7.000)
Total Operation Costs Landfill Gas	3%	(150.000)	(154.500)	(159.135)	(163.909)	(168.826)	(173.891)	(179.108)	(179.108)	(179.108)	(179.108)	(179.108)
Total Operation Costs	1,0	(157.000)	(161.500)	(166.135)	(170.909)	(175.826)	(180.891)	(186.108)	(186.108)	(186.108)	(186.108)	(186.108)
Revenues from Sale of Thermal Energy												
Hours of Operation		1.080	1.080	1.080	1.080	1.080	1.080	1.080	1.080	1.080	1.080	1.080
LFG Thermal Plant Capacity in TJ		0,001419	0,001419	0,001419	0,001419	0,001419	0,001419	0,001419	0,001419	0,001419	0,001419	0,001419
LPG Based Energy Consumption Avoidance TJ		1,53	1,53	1,53	1,53	1,53	1,53	1,53	1,53	1,53	1,53	1,53
LPG Cost USD/TJ	1,0	22.317	22.317	22.317	22.317	22.317	22.317	22.317	22.317	22.317	22.317	22.317
Total Savings for Reducing LPG Consumption		34.201	34.201	34.201	34.201	34.201	34.201	34.201	34.201	34.201	34.201	34.201
Revenue from Sale of CERs												
Tons CO_2 equivalent from methane destruction less project		25.532	33.920	37.826	43.614	47.331	50.962	54.511	50.647	47.058	43.761	38.750
Emissions factor for thermal energy generation (tCO_2/MWh)		63,1	63,1	63,1	63,1	63,1	63,1	63,1	63,1	63,1	63,1	63,1
Tons CO_2 offset by thermal energy generation using LFG		88	97	97	97	97	97	97	97	97	97	97
CER Price [USD/tCO_2e]		0	0	0	0	0	0	0	0	0	0	0
Total Revenue from Sale of CERs [USD]		0	0	0	0	0	0	0	0	0	0	0
Total Revenues		34.201	34.201	34.201	34.201	34.201	34.201	34.201	34.201	34.201	34.201	34.201
PIS/CONFINS		(3.164)	(3.164)	(3.164)	(3.164)	(3.164)	(3.164)	(3.164)	(3.164)	(3.164)	(3.164)	(3.164)
Operational Profit		(122.799)	(127.299)	(131.934)	(136.708)	(141.625)	(146.690)	(151.907)	(151.907)	(151.907)	(151.907)	(151.907)
Depreciation 1		(90.000)	(90.000)	(90.000)	(90.000)	(90.000)	(90.000)	(90.000)	(90.000)	(90.000)	(90.000)	
Depreciation 2		(7.000)	(7.000)	(7.000)	(7.000)	(7.000)	(7.000)	(7.000)	(7.000)	(7.000)	(7.000)	
Depreciation 3												(7.000)
Depreciation total		(97.000)	(97.000)	(97.000)	(97.000)	(97.000)	(97.000)	(97.000)	(97.000)	(97.000)	(97.000)	(7.000)
Profit Before Taxes		(219.799)	(224.299)	(228.934)	(233.708)	(238.625)	(243.690)	(248.907)	(248.907)	(248.907)	(248.907)	(158.907)
Corporate Taxes		0	0	0	0	0	0	0	0	0	0	0
Profit After Taxes		(219.799)	(224.299)	(228.934)	(233.708)	(238.625)	(243.690)	(248.907)	(248.907)	(248.907)	(248.907)	(158.907)
Depreciation		97.000	97.000	97.000	97.000	97.000	97.000	97.000	97.000	97.000	97.000	7.000
Annual Cash Flow		(1.092.799)	(152.299)	(156.934)	(161.708)	(166.625)	(171.690)	(176.907)	(151.907)	(151.907)	(151.907)	(221.907)

	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029
Year	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029
	12	13	14	15	16	17	18	19	20	21	22
Landfill Gas Investment	-	-	-	-	-	-	-	-	-	-	-
Thermal Energy Investment	-	-	-	-	-	-	-	-	-	-	-
Total Investment	0	0	0	0	0	0	0	0	0	0	0
Total Operation and Maintenance Costs. Thermal Energy	(7.000)	(7.000)	(7.000)	(7.000)	(7.000)	(7.000)	(7.000)	(7.000)	(7.000)	(7.000)	(7.000)
Total Operation Costs Landfill Gas	(179.108)	(179.108)	(179.108)	(179.108)	(179.108)	(179.108)	(179.108)	(179.108)	(179.108)	(179.108)	(179.108)
Total Operation Costs	(186.108)	(186.108)	(186.108)	(186.108)	(186.108)	(186.108)	(186.108)	(186.108)	(186.108)	(186.108)	(186.108)
Hours of Operation	1.080	1.080	1.080	1.080	1.080	1.080	1.080	1.080	1.080	1.080	1.080
LFG Thermal Plant Capacity in TJ	0,001419	0,001419	0,001419	0,001419	0,001419	0,001419	0,001419	0,001419	0,001419	0,001419	0,001419
LPG Based Energy Consumption Avoidance TJ	1,53	1,53	1,53	1,53	1,53	1,53	1,53	1,53	1,53	1,53	1,53
LPG Cost USD/TJ	22.317	22.317	22.317	22.317	22.317	22.317	22.317	22.317	22.317	22.317	22.317
Total Savings for Reducing LPG Consumption	34.201	34.201	34.201	34.201	34.201	34.201	34.201	34.201	34.201	34.201	34.201
Tons CO_2 equivalent from methane destruction less project	35.936	33.332	30.938	28.712	26.654	24.785	21.049	19.453	17.962	16.597	1.310
Emissions factor for thermal energy generation (tCO_2/MWh)	63,1	63,1	63,1	63,1	63,1	63,1	63,1	63,1	63,1	63,1	63,1
Tons CO_2 offset by thermal energy generation using LFG	97	97	97	97	97	97	97	97	97	97	8
CER Price [USD/tCO_2e]	0	0	0	0	0	0	0	0	0	0	0
Total Revenue from Sale of CERs [USD]	0	0	0	0	0	0	0	0	0	0	0
Total Revenues	34.201	34.201	34.201	34.201	34.201	34.201	34.201	34.201	34.201	34.201	34.201
PIS/CONFINS	(3.164)	(3.164)	(3.164)	(3.164)	(3.164)	(3.164)	(3.164)	(3.164)	(3.164)	(3.164)	(3.164)
Operational Profit	(151.907)	(151.907)	(151.907)	(151.907)	(151.907)	(151.907)	(151.907)	(151.907)	(151.907)	(151.907)	(151.907)
Depreciation 1											
Depreciation 2											
Depreciation 3	(7.000)	(7.000)	(7.000)	(7.000)	(7.000)	(7.000)	(7.000)	(7.000)	(7.000)		
Depreciation total	(7.000)	(7.000)	(7.000)	(7.000)	(7.000)	(7.000)	(7.000)	(7.000)	(7.000)	0	0
Profit Before Taxes	(158.907)	(158.907)	(158.907)	(158.907)	(158.907)	(158.907)	(158.907)	(158.907)	(158.907)	(151.907)	(151.907)
Corporate Taxes	0	0	0	0	0	0	0	0	0	0	0
Profit After Taxes	(158.907)	(158.907)	(158.907)	(158.907)	(158.907)	(158.907)	(158.907)	(158.907)	(158.907)	(151.907)	(151.907)
Depreciation	7.000	7.000	7.000	7.000	7.000	7.000	7.000	7.000	7.000	0	0
Annual Cash Flow	(151.907)	(151.907)	(151.907)	(151.907)	(151.907)	(151.907)	(151.907)	(151.907)	(151.907)	(151.907)	(151.907)

ECONOMIC EVALUATION PARAMETERS	
Amortization period (years)	10
Discount Rate	10%
Corporate Tax Rate	34%
PIS/COFINS	9,25%
LFG Thermal plant operating costs [USD/TJ]	7.000
LPG fuel cost [USD/TJ]	22.317

ECONOMIC RESULTS	
NPV	**(2.256.276)**
IRR	**#DIV/0!**

SENSITIVITY ANALYSIS

LPG Fuel Cost

	-20%	-10%	—	10%	20%
NPV	(2.316.276)	(2.286.276)	(2.256.276)	(2.226.277)	(2.196.277)
IRR	N.A.	N.A.	N.A.	N.A.	N.A.

O&M Costs

	-20%	-10%	—	10%	20%
NPV	(1.946.089)	(2.101.183)	(2.256.276)	(2.411.370)	(2.566.464)
IRR	N.A.	N.A.	N.A.	N.A.	N.A.

Investment

	-20%	-10%	—	10%	20%
NPV	(2.055.209)	(2.155.743)	(2.256.276)	(2.356.810)	(2.457.344)
IRR	N.A.	N.A.	N.A.	N.A.	N.A.