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:

Laguna Landfill Methane Flaring

Version: 1.0
Date: Friday, October 5, 2007

A.2. Description of the project activity:

The project partners' main goal through this project design document is to reduce Greenhouse gas (GHG) emissions to the atmosphere in the Laguna Landfill, in the south of Brazil in the state of Santa Catarina and it is operated by Serrana Engenharia Ltda. These emissions are generated by the anaerobic decomposition of waste and will be reduced in this project by collecting and burning of these gases. The main purpose of the project activity is to capture and flare the methane, which is the major constituent of landfill gas (LFG) and highly contributes to global warming and climate change. The project's objective is to maximize the capture of LFG from the landfill site and to flare it, in addition to reducing the potential local impacts of odours, explosions and fire hazard associated incidents with landfill gases. The project activity also includes the installation of enhanced landfill gas extraction and flaring equipment for the destruction of the landfill methane that will be collected from the existing and future disposal areas instead of releasing it to the atmosphere.

The project activity involves investing in a gas collection and flaring systems aimed at reducing methane emissions to the atmosphere. Initially, electricity production is not part of the project activity due to the unfavourable pricing and regulations prevailing in Brazil, but it can be considered in a future time, if the Brazilian scenario for electricity generation becomes more favourable. Also, LFG capturing and flaring is not mandatory by Brazilian regulations nor are these common practices in Brazil today. However, Laguna Landfill is already under use and all relevant environmental licenses have already been secured.

Laguna is a 1.98 hectares landfill, opened in 2004 and has a maximum life allowance of 21 years. At present time, the average daily disposal of waste is 153 tones while it is estimated (by the size and demography of the municipalities that originate waste to Laguna landfill) a maximum daily waste disposal of 200 tonnes. Until 2006, the waste tonnage disposed in Laguna Landfill was 162,637 tonnes. As the business-as-usual activity, it is captured and flared about 20% of the LFG generated in Laguna Landfill to avoid risk of explosions. Currently, only a small proportion of the LFG produced in landfills in Brazil are flared to reduce these risks of explosions. Laguna Landfill is designed to receive Class 2 waste only, which includes refuse from the following sources: waste from residential areas, as well as solid waste from non-residential areas such as public buildings, institutions, commercial establishments and industry that falls into Class 2 (up to 200 liters per day), inert residue from constructions, and refuse from markets.

Moreover, the project will actively participate to the sustainable development of Brazil, mainly in Santa Catarina State by providing environmental, social and technological benefits. As for the environmental issues, the use of disposal areas fully lined with a compact clay layer of low permeability under an impermeable geotextile layer for leachate containment and management will consequently reduce emissions of GHG. Also, flaring of the collected LFG will not only destroy methane, but also destroy compounds in the LFG such as volatile organic compounds and ammonia. The implementation of the project will be positive for social improvements in the landfill area since it will generate both direct and indirect jobs (providing at least 20 direct job positions). As for the technological benefits of the project activity, this project will support efforts aimed at facilitating the dissemination of design and operational experience gained at Laguna Landfill for possible use throughout the country and/or region.

Figure 1: View of Laguna Landfill

A.3. Project participants:

.

Name of the Party Involved (host indicates a host party)	Private and/or public entity(ies) project participants	The party involved wishes to be considered as a project participant (Yes/No) *
Brazil (host)	MaxAmbiental S/A	No
Brazil (host)	Bioma Desenvolvimento Sustentável	No
Brazil (host)	Serrana Engenharia Ltda	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.:

Santa Catarina

A.4.1.3. City/Town/Community etc:

Laguna

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

The precise location of the project location is 28º26.006' S from Ecuador and 48º54.105' W from Greenwich. The site is located in the city of Laguna (15 km from the city's city center), which boundaries are the Atlantic Ocean and the cities of Imbituba, Imaruí, Jaguaruna, Capivari de Baixo, Gravatal, and Tubarão. Land occupation around the site is characterized by the predominance of rural activities. The Landfill operation covers an area of approximately 20,000 m².

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

The project activity sectorial scope is nº 13: "Waste Handling and Disposal". The project activity is "Landfill gas capturing and flaring".

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

Fig A.4.3: Laguna landfill Layout.

Landfill gas collection system:

The state-of-the-art gas collection technology proposed in the project activity includes landfill cells coated with an impermeable high-density polyethylene membrane to ensure minimal leakage of LFG to the atmosphere and vertical wells used to extract the gas with optimal well spacing for maximum gas collection and minimal costs. The landfill gas extraction wells will also be drilled into the landfill once areas reach their final elevation and final cover has been applied. The vertical wells consist of a pipe perforated in its lower part, placed in a drilled borehole in the waste, backfilled with gravel and sealed at the surface. Both well types will be equipped with wellheads (designed as a looping system in order to allow for partial or total loss of header function in one direction without losing gas system functionality) that enable monitoring of gas flow and quality. Also, valves are provided to allow adjustment of the available vacuum at each well.

The flaring equipment consists of an enclosed flare; two compressors to require the vacuum in the collection network, an online gas analyzer, valves and tubes that will destroy methane. Condensate extraction and storage systems designed at strategic low points throughout the gas system. Water residues will be channeled and treated in a wastewater treatment plant and condensate extraction and storage systems designed at strategic low points throughout the gas system. All efforts will be made to minimize problems in condensate management.

The flare will be temperature controlled, at high temperature above 700°C, in order to assure methane destruction rate close to 100%.

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

Years	**Annual estimation of emission reductions in tonnes of CO_2 e**
2008*	12,022
2009	29,599
2010	34,624
2011	39,171
2012	43,286
2013	47,009
2014	50,378
2015	26,713
Total estimated reductions (tCO2e)	282,802
Total number of crediting years	7
Annual average over the crediting period of estimated reductions (t CO2e)	35,350

*Note: 1st Crediting period will be from 01/07/2008 to 30/06/2015

A.4.5. Public funding of the project activity:

There is no public funding involved in the project activity.

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 applied for the proposed project activity was the approved consolidated baseline methodology ACM0001, version 6, July 06, 2007: *"Consolidated baseline methodology for landfill gas project activities"* , it's Annex 13 *"Tool to determine project emissions from flaring gases containing methane"* and version 3 of the *"Tool for demonstration and assessment of additionality"*.

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; and/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.

The proposed project activity corresponds to the first of these three alternatives. The collected landfill gas will be flared — option (a) above, so ACM0001 version 6 is perfectly applicable for the project activity proposed.

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

According to the methodology, the project boundary is the site of the project activity where the gas will be captured and destroyed. ACM0001 requires that all CO2 emissions resulting from combustion of fossil fuels and from electricity consumption for the operation of the project activity should be accounted as project emissions.

For the proposed project the following emissions have not been taken into account:

- Emissions from the transport of the waste to the landfill site, as these would occur even in the absence of the proposed project activity;

- Emissions from the vehicles used to compact and cover the waste, as these would also occur in the absence of the project activity.
- There is no additional fossil fuel or electricity consumption for the proposed project activity.

The flow diagram below describes the project boundary:

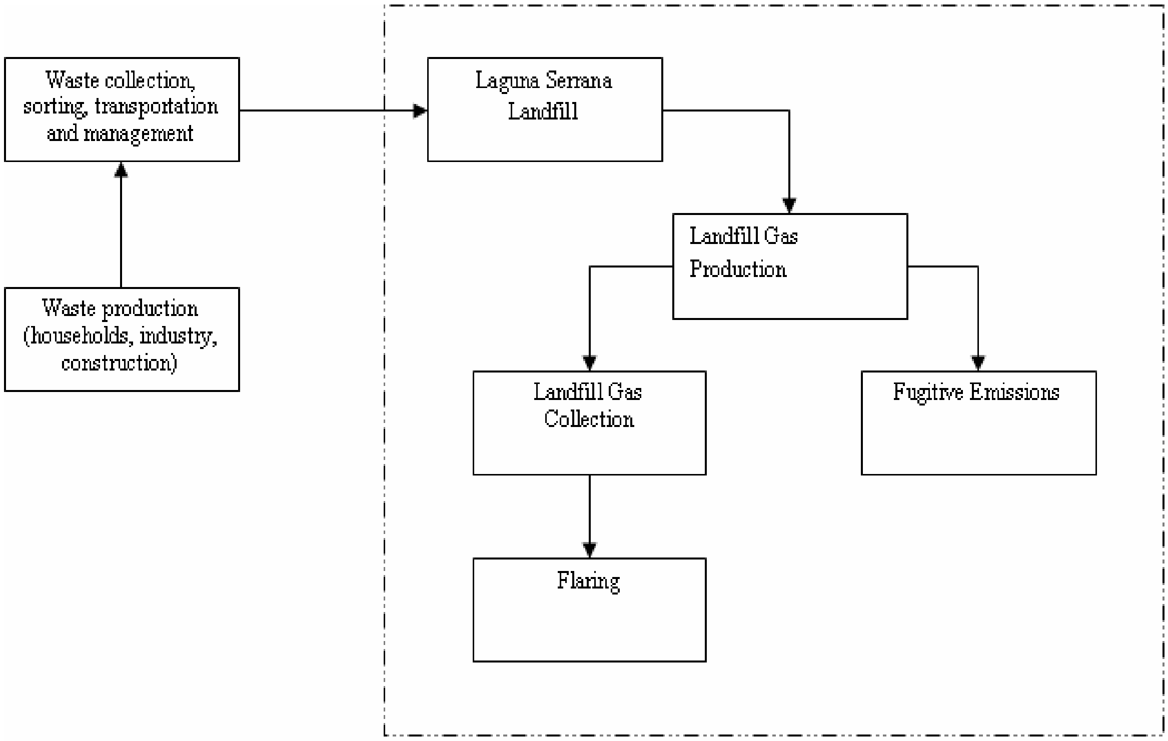


Figure B.3.1: Project Boundary

Emissions	Project Scenario	Baseline Scenario
Direct On-site	Emissions associated with the inefficiency of the LFG capture and flaring process. MaxAmbiental estimates that about 75% of total LFG produced will be collected and then combusted to CO_2. Hence 25% of the total gas production will be released as fugitive emissions.	Uncontrolled release of practically all LFG generated by the landfill.
Direct Off-site	Transportation of equipment to project site – excluded because deemed to be insignificant	None identified
Indirect On-site	Not Applicable	Not Applicable
Indirect Off-site	Transportation of waste to landfill site – excluded because would happen even in absence of project	Transportation of waste to landfill site – excluded because would happen even in absence of project

Table B.3.1: System emissions

Project activities and emission sources considered within the project boundaries:

	Source	Gas	Included?	Justification/Explanation
BASELINE	Passive LFG venting and no flaring	CO_2	No	The emission of CO_2 are neutral per convention since the are coming from degradation of organic waste
		CH_4	Yes	Main source of GHG emission on a landfill
		N_2O	No	Not applicable
PROJECT ACTIVITY	Active LGF capture and flaring	CO_2	No	No active extraction system is in place to data.
		CH_4	Yes	Main source of GHG emission on a landfill
		N_2O	No	Not applicable
	LGF combustion for thermal energy generation	CO_2	No	The emission of CO_2 are neutral per convention since the are coming from the degradation of organic waste
		CH_4	No	Not applicable
		N_2O	No	Not applicable
	LGF combustion for power generation	CO_2	No	Not applicable
		CH_4	No	Not applicable
		N_2O	No	

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 baseline scenario. According to it, there are two steps to be followed:

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

"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."

This step comprises the following sub-steps:

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

The methodology indicates to separate applicable baselines for landfill capture, for electricity generation and for thermal use of LFG.

The possible alternatives for each part were considered below.

"Alternatives for the disposal/treatment of the waste in the absence of the project activity:

- *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. In addition to this, 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, require very large investments and high operating costs compared to landfilling. 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 do not proposes to generate electricity or thermal energy, so the next steps of sub-step 1a are not applicable.

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

According to the official statistics on urban solid waste in Brazil[1] - Pesquisa Nacional de Saneamento Básico 2000 made by IBGE (Instituto Brasileiro de Geografia e Estatística – Statistics and Geographic Brazilian Institute) – the majority of Municipal Solid Waste is disposed at uncontrolled dumps or landfills lacking proper form of control.

[1] IBGE – Instituto brasileiro de Geografia e Estatística.

After reviewing current practice on site, current practice of waste management sector in Brazil and its regulations, it was observed that there are no legislations to enforce active LFG flaring at National or State level, the only requirement is to vent the LFG to avoid the risk of explosion. As a result, active LFG collection and flaring is not implemented at almost any landfill in Santa Catarina. Also, implementation of this type of project is not the most economically attractive course of action due to technological and economic factors. Priority has been given to close uncontrolled landfills within the state of Santa Catarina.

Improvement of the gas collection and combustion conditions is not a priority and it is directly linked to investment for LFG collection, abstractions and flaring systems. The implementation of such project undermines the intention on reducing GHG emissions due to its highly financial costs. Without the revenue from the CERs, the current situation will not change since there is no expected commercial usage of landfill gas nor any forthcoming new laws or policies, so, the situation is unlikely to change in the near future. Consequently, the most probable baseline scenario is the atmospheric release of the LFG produced by waste in anaerobic conditions.

Laguna landfill flares 20% of the actual LFG in a rough type of flare to avoid risks and explosion due to a contractual requirement to address safety and odour concerns. Considering that and the common practice in the region, the most plausible baseline identified for the proposed project activity corresponds to LFG2 above.

Note that According to ACM0001, *" Project participants must take into account that some of the methane generated in the baseline may be captured and destroyed to comply with regulation or contractual requirements… in cases where these are not specified an Adjustment Factor shall be used and justified"*

As Brazilian national/regional regulation do not define the quantity that should be flared, an Adjustment Factor was estimated according to the methodology, as a ratio between specified amount of methane collected and destroyed by requirement (20%) and an assumed efficiency for the collection and destruction system used in the project activity. (75% (collection efficiency) multiplied by 90% (flare efficiency)), see item B.5

Alternatives to project activity	***Probability***
Continuation of the current situation (no LFG recovery and flaring)	*Most Probable: In Brazil there are no regulations requiring capture and destruction of LFG on landfills.*
Project not undertaken as a CDM project activity	*Not probable: The project activity requires funds for construction and to maintain its operation. There is no known available fund to support this kind of project in Brazil.*
Electricity generation from the methane component of the extracted LFG.	*Not Probable: Due to the Brazilian regulations, it is difficult to sell the energy produced. Moreover, electricity price sold in Brazil and the costs for the construction of the power plant make it unfeasible to produce electricity from the methane component*

	of the LFG.

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

As the flare used in the baseline to burn the methane is a rough flare, with no pumping and collection equipments, no fuel need be chosen for this case.

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):

This project foresees the reduction of anthropogenic emissions of GHGs through the capture and flare of biogas generated within the landfill as a result of the anaerobic decomposition of the organic fraction of waste placed therein.

Version 6 of *ACM0001* "Consolidated baseline methodology for landfill gas project activities" instructs additionality as described below:

> *"Step 2 and/or step 3 of the latest approved version of the "Tool for demonstration and assessment of additionality" shall be applied for each component of the baseline ,i.e. baseline for waste treatment, electricity generation and heat generation*".

Since the proposed project activity only capture and flare LFG, steps 2, 3, 4 and 5 from the tool for demonstration and assessment additionality version 3 were applied only for waste treatment.

Step 2: Investment analysis

According to financial analysis conducted, implementation of this type of project is not the most economically attractive course of action due to technological and economic factors, which hinders and limits the project's implementation. It is also taken into account Brazil's lack of legislation for flaring LFG. Therefore, it is concluded that the project is additional because it is clearly not the baseline and without the CDM revenue expected for the project implementation it would most certainly not happen.

Furthermore, the additional value derived from the sale of carbon credits appears to increase the project's financial returns to a level sufficient to justify the inherent risks associated with long-term investment decisions and capital allocation for landfill gas collection systems. This key role that carbon credits could play in the investment decision and financial feasibility of the project, indicates that this investment will lead to emission reductions in relation to the baseline investment scenario.

According to the " Tool for demonstration and assessment of additionality" –, if the CDM project activity generates no financial or economic benefits other than CDM related income, it is necessary to apply a simple cost analysis (Option 1). Hence The cost analysis scenario is applied.

Sub-step 2b – Option 1 – Apply simple cost analysis:

The project activity will require capital expenditures for the construction of the gas collection wells and piping, the instrumentation to monitor LFG composition and the drum flare to the destruction of the methane generated in Laguna landfill. Moreover, capital will be necessary to operate and maintain the system used to destroy the methane generated in Laguna landfill.

The destruction of the methane by the project activity would not result in any income but the incomes generated from the CERs exchange under the CDM. The project activity is not financially feasible under any scenario except through the registration as a CDM project.

Total Investment Flaring Equipment (approx.) (€)	**688.474,56**
Total Annual O&M (€)	**56.268,84**
Share of Proceeds to CDM EB	20%
Validation & Verification Costs (€)	**5.960**
Total Fixed & Variable Costs (excl. Depreciation)(€)	**750.703,40**
Annual Depreciation Rate (Straight line balance)(10%) **(€)**	75.070,34
Total Fixed & Variable Costs (incl. Depreciation)(€)	**825.773,74**

Table 1- Cost Estimative

Step 3: Barrier analysis

For the purpose of demonstration of the additionality, step 2 of the '*Tool for the demonstration and assessment of additionality' version 3* has been used.

Step 4. Common practice analysis

According to the National GHG Emissions Inventory conducted by CETESB in 1994, 84% of Brazil's methane emissions came from the deposition of waste in uncontrolled rubbish dumps (in Portuguese, "lixões"). This source is still responsible for a large part of the methane emitted since not much has changed in the business-as-usual scenario in the country. Besides, the amount of waste produced in Brazil has been increasing and, as estimated in 2000, Brazilians were already producing an average of 0.52 kg of waste per person everyday.[2]

Nowadays 59% of the municipalities in Brazil still dispose their waste in rubbish dumps with no management, gas collection, water and leachate treatment, or regulation by environmental authorities. Among the other 30% that use landfills, only 13% invest in sanitary landfills with sophisticated leachate

[2] CETESB and IGBE Census

collection and treatment systems.

Although, until the present moment there are no regulatory requirements for flaring landfill gas, a number of landfills are collecting a small amount of LFG for safety reasons. To maintain the calculations' conservatism and to assure the environmental integrity of the project, all emission reductions arising from Laguna Landfill will be discounted by 20% in the project. This amount, more than sufficiently covers the volume of gas that would be flared to follow the business-as-usual scenario found in the landfills considered in this analysis.

Step 5: Impact of CDM registration

Once the project activity is registered under CDM, it will be possible to trade the generated CERs in the open market. The sale of CERs will generate a revenue source that will leverage the project IRR (Internal Rate Return) to a point that will make the project economically feasible.

As a consequence, some impact will take place:

- Anthropogenic GHG emission reductions;
- Creation of at least 20 new direct job positions.

B.6. Emission reductions:

B.6.1. Explanation of methodological choices:

According to ACM0001, version 6:

The GHG emission reduction achieved by the project activity during a given year "y" (ERy) is given by:

$$ER_{y} = (MD_{project\ y} - MD_{reg,\ y}) * GWP_{CH4} + EL_{LFG,\ Y} \cdot CEF_{elec,\ BL,\ y} - EL_{PR,y} \cdot CEF_{elec,,PR,,\ y}$$

$$+ ET_{LFG,y} * CEF_{ther,BL,y} - ET_{PR,y} * EF_{fuel,\ PR,\ y} \qquad \textbf{Eq: 1}$$

Where:

ER y	Emission reductions, in tonnes of CO2 equivalents (tCO2e).
MD project,y	the amount of methane that would have been destroyed/combusted during the year, in tonnes of methane (tCH4)
MD reg,y	the amount of methane that would have been destroyed/combusted during the year in the absence of the project, in tonnes of methane (tCH4)

GWP_{CH4}	Global Warming Potential value for methane for the first commitment period is 21 tCO2e/tCH4
$EL_{LFG,Y}$	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 orby an on-site/off-site fossil fuel based captive power generation, during year y, in megawatt hours (MWh)
$CEF_{elec,BL,y}$	CO2 emission intensity of the baseline source of electricity displaced, in tCO2e/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 onsite/offsite fossil fuel fired boiler, during the year y in TJ.
$CEF_{thermal,BL,y}$	CO2 emissions intensity of the fuel used by boiler to generate thermal energy which is displaced by LFG based thermal energy generation, in tCO2e/TJ.
$ET_{PR,y}$	Fossil fuel consumption on site during project activity in year y (tonne)
$EF_{fuel,PR,y}$	CO2 emissions factor of the fossil fuel used by boiler to generate thermal energy in the project activity during year y

For this specific project there will be neither thermal energy production or electricity production, so the followings components of the equation will be nulls:

$EL_{LFG,Y} = 0$; $EL_{PR,y} = 0$ and $ET_{LFG,y} = 0$

According to the methodology, in case regulatory or contractual requirements do not specify *MD reg y*, an "Adjustment Factor" shall be used:

$$MD_{reg,y} = MD_{project\ y} * AF \quad \textbf{Eq: 2}$$

Where:

MD reg,y	the amount of methane that would have been destroyed/combusted during the year in the absence of the project, in tonnes of methane (tCH4)
MD project,y	the amount of methane that would have been destroyed/combusted during the year, in tonnes of methane (tCH4)
AF	Adjustment factor

Even though laguna landfill burns 20% of the LGF due to a requirement, there is no legislation to define the quantity of this methane that should be burned, so *MD reg, y* is calculated based on the "Adjustment Factor", an estimated value considered was 30% (20% total methane flared to avoid risks divided by the 75% from the collection efficiency multiplied by 90% from the flare efficiency), as conservative action.

In order to calculate *MD project,y*, the methodology states:

$$MD_{project,y} = MD_{flared,y} + MD_{electricity,y} + MD_{thermal,y} \qquad \textbf{Eq: 3}$$

The equation (3) above represents the sum of over all the points of methane captured and use: methane flared, methane used for electricity generation source and/or used in thermal energy generator.

As the project won't produce electricity or replace a fossil fuel consumed in the baseline, the methane destroyed by the project activity *MDproject, y* during year *y* is determined by monitoring only the quantity of methane actually flared:

$$MD_{project,y} = MD_{flared,y} \qquad \textbf{Eq: 3a}$$

Thus, as the project won't generate any electricity or thermal energy MD project,y can be calculated as follows:

$$MD_{flared,y} = \{LFG_{flare,y} \times w_{CH4,y} \times D_{CH4} - (PE_{flare,y} / GWP_{CH4})\} \qquad \textbf{Eq: 4}$$

Where:

$MD_{flared,y}$	is the quantity of methane destroyed by flaring
$LFG_{flare,y}$	is the quantity of landfill gas fed to the flare(s) during the year measured in cubic meters (m^3)
$W_{CH4,y}$	is the average methane fraction of the landfill gas as measured during the year and expressed as a fraction (in m^3 CH_4 / m^3 LFG),
D_{CH4}	is the methane density expressed in tonnes of methane per cubic meter of methane (tCH_4/m^3CH_4). According to ACM001 version 6 page 20 D_{CH4} = 0,0007168 tCH4/m3 CH4 at 0ºC and 1,013 bar.
$PE_{flare,y}$	Is 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"*

According to ACM0001, *"MDflared,y is the quantity of methane destroyed by flaring, LFGflare,y is the quantity of landfill gas fed to the flare during the year measured in cubic meters (m3), wCH4,y is the* *average methane fraction of the landfill gas as measured11 during the year and expressed as a fraction (in m³CH4/m³LFG), DCH4 is the methane density expressed in tonnes of methane per cubic meter of methane (tCH4/m3CH4)12 and PEflare,y are the project emissions from flaring of the residual gas stream in year y (tCO2e) determined following the procedure described in the "Tool to determine project emissions from flaring gases containing methane. If methane is flared through more than one flare, the PEflare,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:

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

(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), *LFGflare,h* is already expressed in terms of standard temperature and pressure, so that *DCH4,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).

To calculate residual gas stream and define the flare efficiency depending on type of flare, it is necessary to use the "*Tool to determine project emissions from flaring gases containing methane*" Annex 13 of ACM001 version 6.

This tool differentiates between open and enclosed flares. For this specific proposed project an enclosed flare will be used, since it is more effective in destroying methane.

For enclosed flares, the Tool proposes two options to determine the flare efficiency*:*

> *(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."*

Project participants shall apply the steps below to calculate project emissions from flaring (PEflare,y) based on the measured hourly flare efficiency or based on the default values for the flare efficiency (hflare,h). Note that steps 3 and 4 are only applicable in case of enclosed flares and continuous monitoring of the flare efficiency.

This tool involves the following seven steps:

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

The project would use 90% default value of enclosed flare efficiency (option (a) above), thus steps 3 and 4 of this tool are not applicable.

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."

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

(T.1) [3]

Where:

$FM_{RG,h}$	kg/h	Mass flow rate of the residual gas in hour *h*
$\rho_{RG,n,h}$	kg/m3	Density of the residual gas at normal conditions in hour *h*
$FV_{RG,h}$	m3/h	Volumetric flow rate of the residual gas in dry basis at normal conditions in hour *h*

And:

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

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

(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:

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

(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 (N2)*".

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 implification proposed in the tool involves considering CO2 and O2 as N2. 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:

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

(T.3a)

Where:

MMRG, h kg/kmol Molecular mass of the residual gas in hour ***h***

fvi,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 CH4, N2 (Note that only CH4 would be measured and N2 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:

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

Where:

fm j,h	-	Mass fraction of element *j* in the residual gas in hour *h*
fv i,h	-	Volumetric fraction of component *i* in the residual gas in the hour *h*
AM j	kg/kmol	Atomic mass of element *j*
NA j,i	-	Number of atoms of element *j* in component *i*
$MM_{RG,h}$	kg/kmol	Molecular mass of the residual gas in hour *h*
J	-	The elements carbon, hydrogen, oxygen and nitrogen. 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 H2 in the other components that might be present in landfill gas: CO2 and O2.
I	-	The components CH4 and N2 (Note that with the simplified approach, the concentrations of other gases would not be determined)

Steps 3 and 4 are excluded, because the project would use the 90% default value for enclosed flare efficiency.

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 (FVRG,h), the volumetric fraction of methane in the residual gas (fvCH4,RG,h) and the density of methane (ρCH4,n,h) in the same reference conditions (normal conditions and dry or wet basis)."

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)."

$$TM_{RG,h} = FV_{RG,h} * fv_{CH_4,RG,h} * \rho_{CH_4,n} \quad \textbf{(T.5)}$$

Where:

TMRG,h	kg/h	Mass flow rate of methane in the residual gas in the hour *h*
FVRG,h	m3/h	Volumetric flow rate of the residual gas in dry basis at normal conditions in hour *h*
fvCH4,RG,h	-	Volumetric fraction of methane in the residual gas ondry basis in hour *h* (NB:this corresponds to fvi,RG,h where *i* refers to methane).
$\rho_{CH4,n}$	kg/m3	Density of methane at normal conditions (0.7168)

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/m3 in the tool and tonne/m3 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 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."*

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 (TMRG,h) and the flare efficiency during each hour h (($\eta_{flare,h}$), as follows:"

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

(T.6)

Where:

PE flare y	tCO2e	Project emissions from flaring of the residual gas stream in year
TMRG, 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}	tCO2e/tCH4	Global Warming Potential of methane

Once project emissions *PE flare,y* has been calculated, it is now possible to go back to the methodology and calculate the $MD_{flare,y}$ (Eq. 4 / 4a):

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

(T.7)

The ***LFG flared,y*** quantity of landfill gas fed to the flare and the total methane generation at Laguna landfill has been estimated based on the waste tonnage of the landfill using the United States Environmental Protection Agency (US EPA) first order decay model as below:

$$LFG\ flared,y = CE * FE* \left\{ \frac{k * Rx * L_0 * e\text{-}k * ^{(T-x)}}{w} \right\}$$

Eq: 5

Where:

- CE = collection efficiency (%);
- FE: flare efficiency (%);
- K = decay constant (1/year);
- R x = amount of waste disposed on year x (kg);
- L0 = methane potential generation (m3CH4/Mg waste);
- T = actual year;
- x = year of waste disposal;
- w = fraction of methane at the landfill gas.

Thus, the *ER y* is calculated as follows

$$MD\ flared,y = \left(\left(CE * FE* \left\{ \frac{k * Rx * L_0 * e - k * ^{(T-x)}}{w} \right\} \right) * w_{CH4,y} \square D_{CH4} \right) - (PE\ flare,y / GWP_{CH4})$$

Eq:6

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

Some of the parameters and data used in these equations are not monitored since they are constants, as listed in the table below. Most of the table is taken directly from the Methane 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	Atomic mass of carbon	12.00
AM_H	kg/kmol	Atomic mass of hydrogen	1.01
AM_O	kg/kmol	Atomic mass of oxygen	16.00
AM_N	kg/kmol	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	O2 volumetric fraction of air	0.21
GWP_{CH4}	tCO2/tCH4	Global warming potential of methane	21
MVn	m3/kmol	volume of one mole of any ideal gas at normal tempearture and pressure	22.414
$\rho_{CH4,n}$ / D_{CH4}	kg/m3	Density of methane gas at normal conditions	0.7168
NAi,j	Dimensionless	Number of atoms of elements j in component i, depending on molecular structure	

Data / Parameter:	**Proportion of CH4 to be destroyed due to safety reasons**
Data unit:	-
Description:	Specific % of generated amount of CH4 to be destroyed due to safety reasons Adjustment factor (for methane destruction in the baseline)
Source of data used:	Serrana
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.5, the current configuration of passive venting and limited burning at Laguna landfill, undertaken to meet safety requirements, would represent a destruction of 20% of the gas that would be flared by rough flare system.
Any comment:	

Data / Parameter:	**R**
Data unit:	Tonnes of waste/ day
Description:	Waste disposal rate
Source of data used:	Serrana
Value applied:	100 until the 4th year / 150 until for the 5th year / 200 fot the 6th years on
Justification of the choice of data or description of measurement methods and procedures actually applied :	Daily volumes until the 4th year are estimated to reach about 100 tonnes per day. This daily load increases to 150 in the 5th year and to 200 tonnes for the 6th year on. These data forms the foundation of the gas volume projection and is subject to change over the active lifetime of the landfill as refuse acceptance volumes vary. This implies that the gas volume projection will vary accordingly. Therefore, even though gas volumes may fluctuate over a period of time because of varying disposal rates, the ultimate total volume of gas projected for the site will remain constant.
Any comment:	

Data / Parameter:	**K**
Data unit:	$Year^{-1}$
Description:	Decay Constant
Source of data used:	USEPA; Turning a Liability into an Asset: A Landfill Gas-to-Energy Project Development Handbook; September 1996
Value applied:	0.1
Justification of the choice of data or description of measurement methods and procedures actually	The gas generation rate for this site was determined based on specific ranges given for Brazilian landfills. The gas generation rate is influenced by the temperature, humidity and composition of the waste. A figure of **0.1** was used as recommended by SCS Engineers in a presentation on behalf of the US EPA in Sao Paulo, Brazil (Part 5: Evaluating Landfill Gas Potential, June 26th 2001,

applied :	Training Workshop for the US EPA Landfill Methane Outreach Program, Sao Paulo Brazil). Available at: http://www.epa.gov/ttn/catc/products.html#
Any comment:	

Data / Parameter:	**L_0**
Data unit:	m^3 / tonne
Description:	Theoretical Yield
Source of data used:	USEPA; Turning a Liability into an Asset: A Landfill Gas-to-Energy Project Development Handbook; September 1996
Value applied:	170
Justification of the choice of data or description of measurement methods and procedures actually applied :	Another input into the computer model is theoretical maximum yield i.e. the total amount of landfill gas that one metric tonne of waste is expected to generate over its lifetime (cubic meters per tonne of MSW). Lo was recommended by SCS Engineers in a presentation on behalf of the US EPA in Sao Paulo, Brazil (Part 5: Evaluating Landfill Gas Potential, June 26th 2001, Training Workshop for the US EPA Landfill Methane Outreach Program, Sao Paulo Brazil). Available at: http://www.epa.gov/ttn/catc/products.html#
Any comment:	

Data / Parameter:	**t**
Data unit:	-
Description:	Time since landfill opened
Source of data used:	Serrana
Value applied:	2004
Justification of the choice of data or description of measurement methods and procedures actually applied :	These values varied depending on which site was being investigated. In the case of the Laguna landfill the opening year is 2004. Therefore the value used for **t** changed depending on which year landfill gas generation figures were being developed for.
Any comment:	

Data / Parameter:	**c**
Data unit:	-
Description:	Time since landfill closed
Source of data used:	Serrana
Value applied:	2023
Justification of the choice of data or description of measurement methods and procedures actually applied :	Again this varies depending on which site was investigated, and in which year. Laguna is predicted to operate for at least 20 years but its life may be extended.
Any comment:	

Data / Parameter:	GWP CH4
Data unit:	tCO2e / tCH4
Description:	Global Warning Potential of Methane
Source of data used:	US EPA and IPCC Guidelines, 2006
Value applied:	21
Justification of the choice of data or description of measurement methods and procedures actually applied :	Parameter Defied within the methodology ACM0001.
Any comment:	

Data / Parameter:	DCH4
Data unit:	tonnes / m3
Description:	Methane Density
Source of data used:	ACM0001
Value applied:	0.0007168
Justification of the choice of data or description of measurement methods and procedures actually applied :	Parameter defined within the methodology ACM0001. This factor will be adjusted depending the on-site pressure and temperature conditions.
Any comment:	At standard temperature and pressure (273 Kelvin and 1.013 bar)

B.6.3 Ex-ante calculation of emission reductions:

The estimation of baseline emissions is principally carried out to determine approximate gas volumes and by deduction emissions reductions. The following model is NOT part of the monitoring methodology per se, but rather suited for the **ex ante calculation** of potential emission reductions.

An assessment of the landfill gas generation of the Laguna Landfill was carried out using the **US EPA's Landfill Air Emissions Estimation Model**, which is consistent with the more complex methodology recommended by the Intergovernmental Panel on Climate Change (IPCC) for calculating methane emissions from landfills. The assumptions applied were those successfully used by the Brazilian NovaGerar project, whose two landfills operate under similar conditions as the Igarassu landfill.

Model Inputs

The US EPA first order exponential decay model equation from the US EPA manual 'Turning a Liability into an Asset: A Landfill Gas to Energy Handbook for Landfill Owners and Operators' (December 1994) is as follows:

$$\mathbf{QT, x = (k * Rx * L_0 * e\text{-}k *^{(t-x)})}$$

Where:
Rx = amount of waste disposed in year x (tonnes)
x = year of waste input
T = current year
QT, x = methane generated in current year (m3/yr) by waste Rx
L_0 = theoretical potential amount of landfill gas generated (m3/tonne)
k = constant rate of landfill gas generation (1/year)

$$\textbf{LFG generated, y} = \frac{\textbf{QT, x}}{\textbf{w}}$$

Where:

LFG generated,y = total landfill gas generated in current year (m3)
W = fraction of methane at the landfill gas.

Or:

$$\textit{LFG flared,y} = CE * FE * \{\frac{k * Rx * L_0 * e\text{-}k * ^{(T-x)}}{w}\}$$

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

Year	Estimation of project activity emissions (tonnes of CO_2 e)	Estimation of baseline emissions (tonnes of CO2 e)	Estimation of leakage (tonnes of CO2 e)	Estimation of overall emissions reductions (tonnes of CO2 e)
2008	17,100	5.077	0	12,022
2009	42,099	12.500	0	29,599
2010	49,246	14.622	0	34,624
2011	55,714	16.543	0	39,171
2012	61,566	18.280	0	43,286
2013	66,861	19.852	0	47,009
2014	71,653	21.275	0	50,378
2015	37,994	11,281	0	26,713

Total (tonnes of CO2 e)	**402,233**	**119,431**	**0**	**282,802**

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

B.7.1 Data and parameters monitored:

Data / Parameter:	**CE**
Data unit:	%
Description:	Collection Efficiency
Source of data to be used:	**USEPA**; *Turning a Liability into an Asset: A Landfill Gas-to-Energy Project Development Handbook*; September 1996
Value of data applied for the purpose of calculating expected emission reductions in section B.5	75%
Description of measurement methods and procedures to be applied:	According with USEPA, a collection efficiency for energy recovery between 75% and 85% sounds reasonable "because each cubic foot of gas will have a monetary value to the owner/operator". A conservative value of 75% was adopted. So, *LFGflare, y* is equal to 65% of total landfill gas emitted to the atmosphere at the baseline
QA/QC procedures to be applied:	
Any comment:	

Data / Parameter:	**R**
Data unit:	Tonnes of waste/ day
Description:	Waste disposal rate
Source of data to be used:	Serrana
Value of data applied for the purpose of calculating expected emission reductions in section B.5	153 on the 5-first years / 200 on the 6th year on.
Description of measurement methods and procedures to be	Daily volumes until the 4th year are estimated to reach about 100 tonnes per day. This daily load increases to 150 in the 5th year and to 200 tonnes for the 6th year on. These data forms the foundation of the gas volume projection and is subject

applied:	to change over the active lifetime of the landfill as refuse acceptance volumes vary. This implies that the gas volume projection will vary accordingly. Therefore, even though gas volumes may fluctuate over a period of time because of varying disposal rates, the ultimate total volume of gas projected for the site will remain constant.
QA/QC procedures to be applied:	
Any comment:	

Data / Parameter:	**LFGtotal,y = LFGflared,y**
Data unit:	m3
Description:	**Total amount of landfill gas flared**
Source of data to be used:	Measured by flow meter. Data to be aggregated monthly and yearly.
Value of data applied for the purpose of calculating expected emission reductions in section B.5	Average of 9,730.916 m^3/ year
Description of measurement methods and procedures to be applied:	A flow meter will be used. Data will automatically and continuously be monitored and recorded. Data will be checked each business day by the landfill gas manager.
QA/QC procedures to be applied:	Flow mete will be calibrated as per manufacturer recommendations. Flow meter will be subjected to a regular maintenance, testing and calibration regime in accordance with manufacturer specifications to ensure accuracy.
Any comment:	

Data / Parameter:	**$PE_{flare,y}$**
Data unit:	tCO2e
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.5	Average of 7,32 t CO2e
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* (**PEflare,y**) will be monitored as per the *"Tool to determine project emissions from flaring gases containing methane". The parameters used for the determination of PEflare,y are LFGflare,y, wCH4,y, fvi,h, fvCH4,FG,h and tO2 ,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 **PEflare,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:	η ***flare,h***
Data unit:	%
Description:	**Flare Efficiency**
Source of data to be used:	Values specified in Methane Flaring Tool.
Value of data applied for the purpose of calculating expected emission reductions in section B.5	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 (Tflare) is below 500°C for more than 20 minutes during the hour *h*. • 50%, if the temperature in the exhaust gas of the flare (Tflare) is above 500°C for more than 40 minutes during the hour *h*, but the manufacturer's specifications on proper operation of the flare are not met at any point in time during the hour *h*. • 90%, if the temperature in the exhaust gas of the flare (Tflare) is above 500°C for more than 40 minutes during the hour *h* and the manufacturer's specifications on proper operation of the flare are met continuously during the hour *h*.
QA/QC procedures to be applied:	
Any comment:	

Data / Parameter:	$\mathbf{w_{CH4}}$
Data unit:	%
Description:	**Methane fraction in LFG**
Source of data to be used:	Continous methane analyser
Value of data applied for the purpose of calculating expected emission reductions in section B.5	50
Description of measurement methods	Data will be aggregated monthly and yearly. Data shall be archived for two years following the end of the crediting period.

and procedures to be applied:	
QA/QC procedures to be applied:	Gas analyzer will be subject to a regular maintenance and testing regime to ensure accuracy
Any comment:	

Data / Parameter:	**P**
Data unit:	Pa
Description:	Pressure of the LFG.
Source of data to be used:	Pressure gauge
Value of data applied for the purpose of calculating expected emission reductions in section B.5	
Description of measurement methods and procedures to be applied:	Data will be used to calculate methane density. Data shall be archived for two years following the end of the crediting period.
QA/QC procedures to be applied:	Meters will be subject to a regular maintenance and testing regime to ensure accuracy.
Any comment:	

Data / Parameter:	**T**
Data unit:	ºC (degrees Celsius)
Description:	Temperature of the LFG
Source of data to be used:	Readings from the temperature-meter.
Value of data applied for the purpose of calculating expected emission reductions in section B.5	
Description of measurement methods and procedures to be applied:	Data will be used to calculate methane density. Data shall be archived for two years following the end of the crediting period.
QA/QC procedures to be applied:	Meters will be subject to a regular maintenance and testing regime to ensure accuracy.
Any comment:	

Data / Parameter:	**$MD_{project,y}$**
Data unit:	Tonnes of CH_4
Description:	**Amount of methane flared**
Source of data to be used:	Calculation
Value of data applied for the purpose of calculating expected emission reductions in section B.5	Average of 3,487.56 tonnes of CH4
Description of measurement methods and procedures to be applied:	It can measured or calculated with the following data: LGL flow to flare, methane fraction in LFG, LFG temperature and pressure, flare temperature, and flare working hours. Data shall be archived for two years following the end of the crediting period.
QA/QC procedures to be applied:	This value is going to be calculated and recorded using the data that is directly collected and monitored at the site.
Any comment:	

Data / Parameter:	**AF**
Data unit:	%
Description:	**Amount of methane flaring required in baseline**
Source of data to be used:	Calculation
Value of data applied for the purpose of calculating expected emission reductions in section B.5	30
Description of measurement methods and procedures to be applied:	20% total methane flared to avoid risks divided by the 75% from the collection efficiency multiplied by 90% from the flare efficiency
QA/QC procedures to be applied:	
Any comment:	

Data / Parameter:	**Regulatory**
Data unit:	-
Description:	**Regulatory requirements related to landfill gas projects**
Source of data to be used:	Legislation
Value of data applied for the purpose of	

calculating expected emission reductions in section B.5	-
Description of measurement methods and procedures to be applied:	Required for any changes to the adjustment factor. Data shall be archived for two years following the end of the crediting period.
QA/QC procedures to be applied:	This data will be determined from current legislation.
Any comment:	

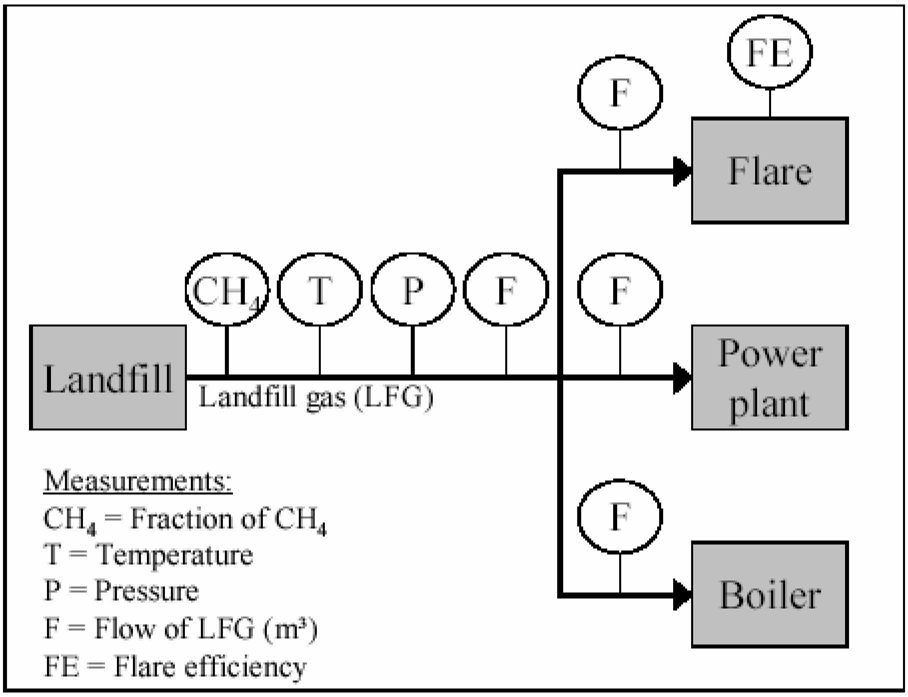
Data / Parameter:	$\mathbf{FV_{RG,h}}$
Data unit:	m3/h
Description:	Volumetric flow rate of the residual gas in dry basis at normal conditions in the hour *h*.
Source of data to be used:	On-site measurements.
Value of data applied for the purpose of calculating expected emission reductions in section B.5	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:	$\mathbf{fv_{i,h}}$
Data unit:	
Description:	Volumetric fraction of component *i* in the residual gas in the hour *h*.
Source of data to be used:	On-site measurements using a continuous gas analyser.
Value of data applied for the purpose of calculating expected emission reductions in section B.5	Not used in ex-ante estimates.
Description of	As a simplified approach (see Eq. 3a), only methane content of the residual gas

measurement methods and procedures to be applied:	will be measured and the remaining part will be considered as N2. 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.

B.7.2 Description of the monitoring plan:

The monitoring plan for the Laguna LFG Flaring project activity is based on the monitoring methodology of ACM0001. The following diagram is provided.



Please note that for this project activity there is no boiler or power plant but only a flare.

The principal variables that need to be calculated for monitoring purposes are as follows:

1. $MD_{project, y}$ for every project year
2. $MD_{reg, y}$ for every project year

The input data required for this will be stored in the following spreadsheet and archived for at least two years after the end of the crediting period or the last issuance of CERs for this project activity whatever occurs later.

The flare platform will be equipped with the relevant measurement devices (meters, etc.), which will allow direct daily measurement of the actual amount of methane flared. To ensure accurate monitoring and data integrity the management structures implemented in the project activity will be as follows:

Daily Monitoring Records: On the larger more active sites, site staff takes daily gas field and engine readings. These readings are then checked for any anomalies before being filed for future reference. The readings can be taken at weekly or other set periods depending on the activity and consistency of the gas field and engine operation. All engines have telemetry links back to a central computer, which continually monitors the performance of the engine detecting problems and highlighting them for attention.

Gas Field Monitoring Records: Taken on a weekly basis or at periods to be determined. The Site Technician walks the gas field taking readings at each gas well and recording these on a form. These readings are then checked for any anomalies before being filed for future reference. A gas analyser will be installed in order to enable continuous accurate measurement of the methane content on the landfill gas. These gas field inspections will also observe occurrence of any unintended releases of landfill gas. In case unintended releases are observed, appropriate corrective action will be taken immediately.

Routine Reminders for Site Technicians: All Site Technicians are issued with a reminder list to guide them through their daily, weekly and monthly routine. The Engineering Manager, Operations Manager and Training and Health & Safety Co-ordinator go through this routine during site visits to ensure all aspects of the role are being performed. In addition monitoring records, oil sample reports and meter readings that are due, are checked to ensure they have arrived. Again, the telemetry link records a lot of the data automatically.

Site Audits: The Engineering Manager, Operations Manager and Training and Health & Safety Co-ordinator make regular site visits. In addition to ensuring the site routines are being performed any additional training needs are assessed and an audit is taken of any outstanding task on site.

Outstanding Work Notice: Following the Site Audit a ‘Plant Outstanding Works Notice’ is issued to the Site Technician listing all the jobs that the management team consider necessary to be undertaken. This is checked on subsequent site audits to ensure these jobs have been carried out.

Calibration of measurement equipment: Calibration of measurement equipment will be done monthly in accordance with the requirements of the National Measurement Regulation Agency, INMETRO (Instituto Nacional de Metrologia).

Corrective Actions: Management structure measures include procedures to handle and correct non-conformities in the implementation of the Project or this Monitoring Plan. In case such non-conformities are observed:

- An analysis of the nonconformity and its causes will be carried out immediately by Serrana staff
- Serrana management will make a decision, in consultation with MaxAmbiental when needed, on appropriate corrective actions to eliminate the non-conformity and its causes.
- Corrective actions are implemented and reported back to Serrana and MaxAmbiental.

The landfill gas management team will receive adequate support and appropriate training for the implementation of this Monitoring Plan and of the project activity.

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)

This baseline study and monitoring methodology were concluded on September 16, 2007, by MaxAmbiental and Bioma:

Contact information:
Ingrid@biomads.com.br
Phone #: +55 21 3579 3279

paulo@maxambiental.com.br
Phone #: +55 11 3709 3440
Fax #: +55 11 3709 3446
www.maxambiental.com.br

SECTION C. Duration of the project activity / crediting period

C.1 Duration of the project activity:

C.1.1. Starting date of the project activity:

01/07/2008

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

21 years

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

C.2.1. Renewable crediting period

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

July 1st, 2008

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 applicable.

C.2.2.2. Length:

Not applicable.

SECTION D. Environmental impacts

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

Laguna Landfill was implemented in 2004 and all regulatory requirements were met at that time, including Environmental Impact Assessment as per Brazilian Regulations.

In Laguna landfill, LFG is generated as a result of decomposition of MSW under anaerobic conditions, which is mainly composed of CO2 and CH4.

Methane emissions from the landfill are associated with the following negative impacts:

- Undesirable odour especially for the human establishments surrounding the landfill area;
- Safety and health risks to landfills staff due to generation of methane concentration above safe limits as well as explosions and fires at the landfill sites.

A very small percentage of volatile organic compound is also found in the LFG, contributing to the undesirable odour.

Overall, the project activity leads to positive environmental impacts which contribute to the sustainable development of the area and no significant negative impacts are expected.

An operation Licence was given by FATMA (Fundação do Meio Ambiente, Brazil).

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.

SECTION E. Stakeholders' comments

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

According to the Brazilian legislation, CDM project activities must send a letter with description of the project activity and an invitation for comments by the local stakeholders. On December 2006, letters with receipts of confirmation were sent to local stakeholders including:

- Brazilian NGOs Forum (FBMOS - Fórum Brasileiro de ONGs e Movimentos Sociais para o Meio Mambiente e o Desenvolvimento), on December 22nd , 2006;
- State environmental authority - FATMA Tubarão (" Fundação do Meio Ambiente "), on December 22nd , 2006;
- State environmental authority - FATMA Florianópolis (" Fundação do Meio Ambiente "), on December 22nd , 2006;
- Public prosecution service of the State of Santa Catarina (Procuradoria da República de Santa Catarina) on December 27th, 2006;
- Santa Catarina Public Ministry (Ministério Público Estadual de Santa Catarina.)

- Florianópolis Municipal Chamber (Câmara Municipal de Florianópolis), on December 27nd , 2006;
- Local stakeholder, on June 22nd , 2007:

* Local NGO - ONG Colônia de Pescadores - Z14 Laguna
* Local Association - Associação Comunitária de Abastecimento da Água
* Local Association - Taquaraçu Laguna,
* Local Institute - Instituto Ambiental Boto Fliper Laguna,
* Local NGO - ONG Tamborete.

- A Public Audience occurred on January 24th, 2007 at a football club in São Thiago City (Botafogo Futebol Clube de São Thiago) and there was no opposition to the proposed project.

E.2. Summary of the comments received:

The Brazilian NGOs Forum sent a gratitude note to stakeholder's consultation on 9th, January, 2007.

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

Not applicable

Annex 1

CONTACT INFORMATION ON PARTICIPANTS IN THE PROJECT ACTIVITY

Organization:	MaxAmbiental S.A
Street/P.O.Box:	Av. Brigadeiro Faria Lima, 2894 – cj.44
Building:	
City:	São Paulo
State/Region:	SP
Postfix/ZIP:	01452-000
Country:	Brazil
Telephone:	+55 11 3709 3440
FAX:	+55 11 3709 3446
E-Mail:	paulo@maxmabiental.com.br
URL:	www.maxambiental.com.br
Represented by:	Paulo Braga
Title:	Director / Ms
Salutation:	Mr.
Last Name:	Braga
Middle Name:	
First Name:	Paulo
Department:	Technical
Mobile:	+55 21 9999 1741
Direct FAX:	
Direct tel:	
Personal E-Mail:	paulo@maxambiental.com.br

Organization:	Bioma Desenvolvimento Sustentável
Street/P.O.Box:	Av. das Américas, 500
Building:	
City:	Rio de Janeiro
State/Region:	RJ
Postfix/ZIP:	
Country:	Brazil
Telephone:	+55 21 3579 3279
FAX:	
E-Mail:	Ingrid@biomads.com.br
URL:	
Represented by:	
Title:	
Salutation:	
Last Name:	
Middle Name:	

First Name:	
Department:	
Mobile:	
Direct FAX:	
Direct tel:	
Personal E-Mail:	

Organization:	Serrana Engenharia Ltda
Street/P.O.Box:	Rua Ottokar Doerffel 841 Bairro Atiradores / 89.203-001
Building:	
City:	Joinville
State/Region:	SC
Postfix/ZIP:	
Country:	Brazil
Telephone:	(47) 3438-0036
FAX:	
E-Mail:	
URL:	www.serranaengenharia.com.br
Represented by:	
Title:	
Salutation:	Mr. Odair José Mannrich
Last Name:	Mannrich
Middle Name:	
First Name:	
Department:	Technical
Mobile:	
Direct FAX:	
Direct tel:	
Personal E-Mail:	odair@serranaengenharia.com.br

Organization:	Muncipality of Laguna
Street/P.O.Box:	
Building:	
City:	Laguna
State/Region:	SC
Postfix/ZIP:	
Country:	Brazil
Telephone:	
FAX:	
E-Mail:	
URL:	
Represented by:	
Title:	

Salutation:	Mr.
Last Name:	
Middle Name:	
First Name:	
Department:	Technical
Mobile:	
Direct FAX:	
Direct tel:	
Personal E-Mail:	

Annex 2

INFORMATION REGARDING PUBLIC FUNDING

There is no public funding involved in LS Project activity.

Annex 3

BASELINE INFORMATION

The baseline methodology "Consolidated baseline methodology for landfill Gas Project activities – ACM0001/Version 6 was used in conjunction with the approved monitoring methodology ("Consolidated monitoring methodology for landfill gas project activities)"

Emissions reductions result mainly from methane destruction resulting from the capture and burning of landfill gas.

.

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, the proposed project employed 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:

$$\mathbf{LFG, x = (k * R x * L_0 * e\text{-}k * ^{(t-x)})}$$

Where:

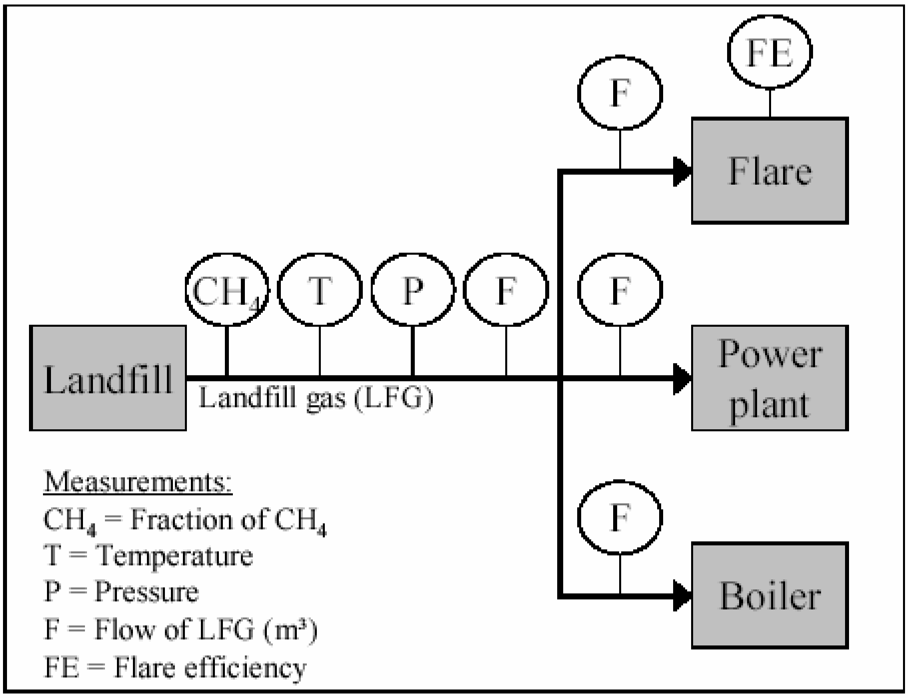
Rx = amount of waste disposed in year x (tonnes)
x = year of waste input
T = current year
LFG, x = Landfill gas generated in current year (m3/yr)
L_0 = theoretical potential amount of landfill gas generated (m3/tonne)
k = constant rate of landfill gas generation (1/year)

L_0 and k are default values of the Landfill Gas Emissions Model - USEPA 2006 available at: http://www.epa.gov/ttn/catc/products.html#software

Annex 4

MONITORING INFORMATION

The monitoring plan for Laguna LFG Flaring project activity is based on the monitoring methodology of ACM0001. The following diagram is provided.



Please note that for this project activity there is no boiler or power plant but only a flare.

The principal variables that need to be calculated for monitoring purposes are as follows:

1. $MD_{project, y}$ for every project year
2. $MD_{reg, y}$ for every project year

The input data required for this will be stored in the following spreadsheet and archived for at least two years after the end of the crediting period or the last issuance of CERs for this project activity whatever occurs later.

- - - - -