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

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SECTION A. General description of project activity

A.1 Title of the project activity:

Alto-Tietê landfill gas capture project

Version 04. PDD completed on 29/03/2007.

A.2. Description of the project activity:

The Project activity aims to extract the landfill gas (LFG) produced at the *Itaquaquecetuba* municipal landfill by means of using a gas collection and gas flaring system. In contrast to the project activity, the baseline scenario shows a landfill operating only with a passive ventilation system.

The implementation of the project activity foresees the interconnection of the current and future vertical drains ended up by a gas pumping equipment through aerial horizontal tubing. At this point two torches will be installed in order to burn the extracted gases. Through this process, the oxidation of the methane generates H_2O and CO_2 gases that will be monitored, measured and controlled directly on site. Finally, the income generated from the CER sales will make possible to eliminate the barriers preventing the implementation of this project.

The landfill is currently operated by the *Empreiteira Pajoan Ltd*, (hereafter referred to as *Pajoan Ltd*) a private landfill operator company. The landfill was the second private site licensed in the State of *Sao Paulo*, attending around 1,670,000 inhabitants and providing high quality waste management services.

The *Alto-Tietê* landfill was opened on March 2000 and was designed to manage waste type class 2, 3 (non-hazardous waste). The waste disposition area is of 500,000 m^2 from a total surface of 884,000 m^2, being 2,319 m^2 of constructed areas, were now is central office and the area for equipments storage. Currently, the landfill receives around 600,000 tones of waste per year (1,500 tonnes/day) from the metropolitan area of *São Paulo*. The release of landfill gas at the baseline scenario brings negative impacts to the quality of the environment and to the health of the local inhabitants, also increasing risks of explosions. Furthermore the *Alto-Tietê* project can be seen in association with a large program of rationalization and management of urban waste collection, initiated by the *Itaquaquecetuba* municipality and its influence area, to manage the growing development of the local economy. The project activity will improve the waste handling and waste management of many small municipalities, industries and commercial establishments within the *São Paulo* State.

In addition to its efforts in reducing the levels of GHG emissions, the project activity promotes local sustainable development as it foresees the creation of jobs in different fields associated with the project activity operation (i.e., garbage selection, flare operations and waste management) and the further possibility of energy generation from a renewable source.

Moreover, the project activity will strength the already in place social responsibility programs, such as environmental education, construction of sport facilities, afforestation activities (tropical forest conservation) and reforestation with native species. The already ongoing reforestation plan covers an area of 55,400 m^2 and makes use of native species coming from a sampling nursery built at the landfill premises. The native species produced are also distributed for use at local schools and green public areas.

A.3. Project participants:

Name of the Party involved	Private and/or public entity (ies) project participants	Kindly indicate if the Party involved whishes to be considered as project participant
UK	*BGC International*	No
Brazil (Host Country)	*EMPREITEIRA PAJOAN LTDA.*	No

A.4. Technical description of the project activity:

A.4.1. Location of the project activity:

The landfill is located at the Municipality of *Itaquaquecetuba*, northeast of *Sao Paulo* State, in the *Alto Tietê* Region.

A.4.1.1. Host Party(ies):

Brazil.

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

Sao Paulo State. Southeast Brazil.

A.4.1.3. City/Town/Community etc:

Itaquaquecetuba.

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

Nossa Senhora das Graças Avenue, *599*, *Jardim Pinheirinho*, *Itaquaquecetuba/SP*, Brazil, ZIP: 08589-140. The geographical coordinates are Latitude South: 23°26'00'' and 23°26'20'', Longitude West: 46°17'30" and 46°17'45".

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

The sectoral scope for the project activity is waste handling and disposal (Sectoral number 13).

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

The LFG is composed primarily of carbon dioxide and methane and, in minor degree of additional trace constituents such as hydrogen sulphide, mercaptans, vinyl chloride, and numerous other non methanic volatile organic compounds (NVOCs). The production of LFG is a consequence of a methanogenesis reaction influenced by the composition and moisture of the waste present at the landfill, the absence of oxygen and toxics, a relatively neutral waste moisture pH, 6.7 - 7.2, and an appropriate internal temperature.

At the first phase, the project activity begins with the installation of a gas collection and flaring system (enclosed flares) through a network of pipes connected to the wellheads at the already ongoing cells. The second phase foresees the infrastructure of the gas extraction and flaring system at the new cells in parallel to the waste disposal.

The gas collection system will mainly be composed by the following elements:

- Vertical progressive drains to extract gas made on PVC perforated material. The drains are equipped with gas sensors (sampling points) to monitor the LFG flux and quality in order to analyse the trace gases.

- Horizontal drains (HDPE type) are installed each 4 meters high to maximize the extraction efficiency; the project activity forecasts an intensive use of these horizontal wells on the shallow areas to increase gas yields and to reduce the number of wells required for proper gas pumping.

The pipes used for the gas network system (HDPE) are placed down on slope downwards to the water-collection points. By doing so, the condensate can be drained away by gravity. Attached to the vertical progressive drain, a sampling point will regulate and monitor the LFG passing through.

The LFG must be condensed and stored on the lowest collecting points for further decantation and pumping. At the flare point, the combustion temperature is controlled to achieve a value range from 700°C to 1,000°C during 0.3 seconds of retention time for 50% methane content on the landfill gas. Eventually the enclosed flare must allow a homogeneous temperature distribution across the combustion chamber at the flare.

The monitoring and control equipment will optimize the LFG pressure, volume and temperature at the flare inlet for the best burning efficiency (90%). According to the Brazilian environmental regulations on flaring gas emissions, the flare operation must ensure that emissions on carbon monoxide (CO), oxides of nitrogen (NO_x) and unburned hydrocarbons are kept under standard values.

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

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

Year	Annual estimation of emission reductions in tonnes of CO_2equ
2008	131,365
2009	159,535
2010	178,250
2011	196,977
2012	215,795
2013	234,782
2014	253,959
Total estimated reductions (tCO_2 equ.)	1,370,663 **tCO2equ.**
Total number of crediting years	*7*
Annual average over the crediting period of estimated reductions (tonnes of CO_2 equ.)	195,809

Table 1: Estimated emission reductions during the crediting period.

A.4.5. Public funding of the project activity:

No public financing for 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 approved baseline methodology ACM0001 Version 05: "Consolidated baseline methodology for landfill gas project activities". The project activity relates to the sectoral scope "Waste handling and disposal".

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

This methodology is applicable to landfill gas capture project activities, where the baseline scenario is the partial or total atmospheric release of the gas. The proposed project activity does not consider the energy (electricity and/or thermal) generation, therefore no emission reductions are claimed from this source.

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

For the *Alto-Tietê* landfill there is only one primary source of CO_2 emissions within the boundary of the project activity. The emissions are due to the use of electricity in extracting and pumping the landfill gas.

The emissions due to the project activity are likely to be lower than < 0.1%[1] (< 241 tCO2equ.) of the total project emissions, classified as "insignificant" for the project activity. Moreover 40% of the baseline emissions are considered as a fugitive emissions or 1,358,140.6 tCO2equ for the period of 2008-2014.

	Gas	Source	Included?	Justification
Baseline	CO2	Waste	No	Emissions from biomass that can be defined as zero
	CH4	Waste	Yes	Anaerobic decay of the biomass
	N20	Waste	No	Emissions from biomass that can be defined as zero
Project Activity	CO2	Flaring equipment	No	Emissions from biomass combustion that can be defined as zero
	CH4	Flaring equipment	Yes	Methane capture and flaring with efficiency of 90%
	N20	Flaring equipment	No	Emissions from biomass combustion that can be defined as zero

[1] *Based on a diesel based pump system with 30kW. A diesel pump was considered for keeping conservative assumptions, however the emissions factor from the grid are less carbon intensive due to the high share of hydro power generation.*

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

According to the National Inventory of Greenhouse Effect Gas Emission conducted by CETESB[2] in 1994, Brazil has more than 6,000 garbage dumping sites that receive more than 60,000 tons of garbage per day.

Related to the same study, the 76% of the total waste amount produced currently in Brazil is disposed in unmanaged "dumping sites", 12% on basic landfills, 10% on controlled landfills (sanitary landfills) and 2% on other disposal ways (see table 2). Moreover, the ABETRE (Brazilian Association for Waste Treatment) estimates nearly 3 millions tonnes of industrial waste are disposed on uncontrolled dump sites and only the 20% are disposed under some technical regulations. Overall figures show that 84% of methane emissions in Brazil are from unmanaged waste dumpsites.

Final waste destination	Percentage	Source
Open Dump	76 %	*CETESB*[3]
Controlled landfill	12 %	*CETESB*
Sanitary landfill	10 %	*CETESB*

Table 2: Final waste deposition in Brazil.

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

The baseline scenario shows the atmospheric release of the LFG gas with no regulations and/or contractual requirements governing the landfill gas emissions. For the *Alto-Tietê* landfill, the baseline scenario represents a basic LFG ventilation system currently ongoing under no basic flaring at the wellhead. In opposite, the project activity foresees, as defined on section B.6.4, a total GHGs (green house gases) emissions reduction of 1,370,663 tonnes of CO_2equ.

The baseline scenario relates to the waste management activities currently ongoing on the *Alto-Tietê* landfill operated by the project developer, *Pajoan Ltd*. The sanitary landfill currently serves a total population of 1,500,000 inhabitants, gathering the cities of *Arujá, Carapicuíba, Ferraz de Vasconcelos, Itaquaquecetuba, Mairipora, Mogi das Cruzes, Poá, Suzano* and *São Paulo* (only commercial waste).

The core business of *Pajoan* is the control and management of the waste disposition of municipal and commercial waste in an environmental sustainable way. No hazardous waste material is on place, in compliance with the Brazilian technical standard 10-0004 for such landfill type.

Under this scenario the company operates a landfill based on a simple landfill gas venting system that releases the LFG generated as a consequence of the anaerobic decomposition of the waste. The *Alto-Tietê* landfill covers an approximate surface of 500,000 m² and sanitary cells of 5 meters depth with a bottom covered by a PVC coating to avoid leachate leakage into the freatic layers.

The leachate is being treated by a sanitary service provider, *SABESP*[4]. Furthermore, a processing plant (aerobic lagoon) was implemented with the following characteristics:

1. Sludge sedimentation and blending.
2. Physic-Chemical treatment stage.

[2] *CETESB (Environmental and Sanitation Company of the São Paulo State)*

[3] *Methane emissions from waste treatment and waste disposal in Brazil, MCT.*

[4] *São Paulo state sanitation company www.sabesp.com.br*

3. Biological (bacterial) treatment stage, aerobic treatment (lagoon).
4. Water free sludge decantation.
5. Decanted water goes to treatment plant for recycling.
6. Recycled water is returned to the natural watercourse (local stream course, *Taboãozinho*).

Moreover, a waste recycling facility was build, the equipments covers about 10% of the daily waste in (1,500 tonnes/day).

In opposition to the business as usual scenario (BAU), the project activity will capture and flare the landfill gas through forced gas exhaustion. Both scenarios above are covered and defined under the applicability of the ACM0001 methodology.

On Table 3, project data relating to the baseline scenario.

Variable	Units	Definition	Value	Data Source
k	(1/yr)	Methane generation rate	0.09	*Pajoan Ltd*
L_o	m^3/ Mg	Methane generation potential	132.5	*Pajoan Ltd*
MCF	--	Methane correction factor	1	IPCC/ *Pajoan Ltd*
$R_{x,y}$	Mg	Daily waste in at the landfill	1,500	*Pajoan Ltd*
O_d	Year	Opening date of the landfill	2000	*Pajoan Ltd*
C_d	Year	Closing date of the landfill	2020	*Pajoan Ltd*
FE	%	Flaring efficiency	90	*Pajoan Ltd*
EE	%	Extraction efficiency	70	*Pajoan Ltd*
F	--	Fraction of CH_4 in landfill gas	0.5	IPCC

Table 3 Key project variables and data used to determine 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):

This chapter is constructed based on the document: "Tool for the demonstration and assessment of additionality" as defined from the Sixteenth Meeting of the Executive Board.

"Step 0. Preliminary screening based on the starting date of the project activity"

According to the operation and environmental licenses the landfill operates without an active landfill gas system extraction. The project activity foresees the project implementation before the starting of the first crediting period.

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

The Brazilian Association for Waste treatment, Recycling and Management (*ABETRE*) states that no legislation will/may be prescribed in the future obliging LFG flaring within the next 10 years in Brazil[5]. Therefore there are no current specific regulations governing LFG flaring and it is not expected to have any regulation within the near future.

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

Definition of possible/potential alternatives to the project activity:

[5] *The letter was sent by ARBETRE to ONYX relating the CDM project "Projeto Onyx de Recuperação de Gás de Aterro" approved the 9th September of 2005 by the Brazilian DNA.(http://www.mct.gov.br/clima/cigmc/projaprov.htm)*

ALTERNATIVE 1

Continuation of the current situation

Business as usual in Brazil

This scenario defines the business as usual in Brazil. The current regulations oblige passive venting in order to avoid potential risk of explosion. Under this scenario, the project developer would continue to use a venting system for safety reasons as conformed by the regulations.

ALTERNATIVE 2

The proposed project activity not undertaken as a CDM project activity

Landfill gas is extracted and flared, with no use or energy generation.

Under this alternative, *Pajoan Ltd* will invest on the implementation of a gas collection, flaring and monitoring system. The technology to be employed presents the following characteristics:

- Use of a collection piping system, installed to convey the landfill gas from the well network to the blower/flare/evaporator station.
- Use of a leachate evaporator (EVAP), which uses landfill gas as a fuel/heat source to evaporate leachate collected from the lined disposal areas.
- Use of an enclosed flare that serves as an after burner to assure the thermal destruction of NVOC's (Non volatile organic compounds) and to control odours.
- Use of a control system to outfit flare and evaporator with an automatic safety and monitoring controls of the waste disposal and of the GHGs, such as CO_2, CH_4, N_2O, NO_x and CO gases.

The total investment for the project activity is estimated on USD 2,512,880. The investment would not have any financial return. Under the current Brazilian legislation for landfill gas management this scenario has no advantages for the landfill operator and is not economically feasible.

ALTERNATIVE 3

Credible alternatives to the project activity that deliver outputs and on services

LFG commercial use off-site

Upgrading the landfill from the current scenario (passive venting) into a natural gas producer scenario will face high investment cost for the gas capture and treatment phase. Therefore, the project is economically and technically not interesting for the project developer.

ALTERNATIVE 4

Credible alternatives to the project activity that deliver outputs and on services

Landfill gas is extracted for energy generation

The landfill gas will be captured and flared for commercial purposes (energy generation). This option foresees the installation of an electric generation system based on LFG. Moreover an electrical transformer of 12.5kVA will be necessary to step up the energy generated for the local transmission lines, specially built for the project.

However the high investment cost surrounding the landfill gas treatment stage (gas quantity and quality) brings the generation cost into uncompetitive market prices. Moreover, the fact that the energy generation is not on the core business of the landfill operator and the uncertainty to secure a fare selling price for the energy results on a high risk and unprofitable activity. It would represent a non attractive option for the landfill operator.

Sub-step 1b. Enforcement of applicable laws and regulations:

There is no landfill gas extraction and/or flaring system on site, only a passive ventilation system attending all applicable legal requirements and therefore all its necessary licenses in date. Potential alterations in the possible future of the baseline will be followed by the monitoring plan elaborated for the project.

As stated at A.4.4, there are no specific laws governing LFG mitigation in Brazil. Nevertheless local environmental agencies at state level are acting towards closing rubbish dumps and forcing municipalities and industries to give proper destination to the waste generated through concessions to private entities. In all cases, however, active collection and flaring of the landfill gas has never been enforced by law.

Therefore, from the analysis of all possible alternatives in "Step 1", the continuation of the current situation (Alternative 1) is the most probable scenario for the baseline.

Step 2. Investment analysis.

Option I. Simple cost analysis is chosen.

Sub-step 2b – Option I. Simple cost analysis.

The *Alto-Tietê* landfill has currently no LFG flaring system installed. The installation of a LFG capture and flaring system, even an undeveloped one, would require costs for the landfill operator with no sort of financial compensation. On table 4 below, the costs associated with the CDM project activity are specified.

The investment costs for the LFG collection system are proportional to the landfill surface, cell dimensions, waste volume and the landfill topography.

BIOGAS CAPTURE AND FLARING IMPLEMENTATION COST					
Item #		**Description**	**Amount**	**Unit**	**Total (US$)**
1	**Invoice for projects and environmental license**				
	1.1	Civil works and Environmental license	1.00	--	103,841.73
				Sub-total	**103,841.73**
2	**Gas drain and gas capture**				
	2.1	Auxiliary vertical drains	2,000.00	meters	186,915.11
	2.2	Primary network	3,000.00	meters	349,039.04
	2.3	Secondary network	8,000.00	meters	690,339.81
				Sub-total	**1,226,293.97**
3	**Gas management**				
	3.1	Gas collection point	1.00	unit	186,981.56
	3.2	Gas filter	3.00	unit	462,388.109
	3.3	Civil works	1.00	--	80,921.78
				Sub-total	**730,291.45**
4	**Gas flaring**				

	4.1	Decantation network	500.00	meters	50,659.19
	4.2	Burners	2.00	un	401,793.97
				Sub-total	**452,453.16**
Total (US$): 2,512,880					

Table 4. Cost related to the CDM project activity.

Under this scenario (investment with no financial returns) the project activity produces no economic benefits and therefore is not financially attractive without the CDM revenue stream (as defined on *Sub-step 2b*).

Step 4. Common practice analysis

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

There is not a similar project activity implemented previously or currently underway (other than CDM project activities) in Brazil.

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

No similar activities as the project activity are carried out in Brazil out of the CDM.

Step 5. Impact of CDM registration

As stated previously, the project activity is different form the BAU scenario and will not be implemented without the incentives derived from the CDM project activity. Thus, the major impact will be the project replicability and the technology transfer.

As result of the previous analysis, it may be concluded that the project activity would lead to substantial reduction in anthropogenic greenhouse gas emission and, without such a potential, no Annex 1 company would be interested in investing in this project. Therefore it may be concluded that the project activity is additional and the baseline scenario is the passive LFG venting.

B.6. Emission reductions:

B.6.1. Explanation of methodological choices:

The greenhouse gas emission reductions achieved by the project activity during a given year "y" (ERy) are estimated as follows (Equation 1):

$$ER_y = \left(MD_{project,y} - MD_{reg,y}\right) * GWP_{CH4} + EL_y \cdot CEF_{electricity,y} - ET_y * CEF_{thermal,y}$$

Where:

ER_y	Is emissions reduction, in tonnes of CO_2 equivalents (tCO_2e).
$MD_{project,y}$	Amount of methane that would have been destroyed/combusted during the year, in,tonnes of methane (tCH_4)
$MD_{reg,y}$ [3]	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 value for methane for the first commitment period is 21 tCO_2e/tCH_4
EL_y	Net quantity of electricity exported during year y, in megawatt hours (MWh).
$CEF_{electricity}$	CO_2 emissions intensity of the electricity displaced, in tCO_2e/MWh. This can be estimated using either ACM0002 or AMSI.D, if the capacity is within the small scale threshold values, when grid electricity is used or displaced, or AMS-I.A if captive electricity is used or displaced.
ET_y	Incremental quantity of fossil fuel, defined as difference of fossil fuel used in the baseline and fossil use during project, for energy requirement on site under project activity during the year y, in TJ.
$CEF_{thermal,y}$	CO_2 emissions intensity of the fuel used to generate thermal/mechanical energy, in tCO_2e/TJ

The proposed project activity do not foresees electricity generation to be exported to the grid or for captive utilization, thus the "EL_y" is assumed to be zero.

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. For the *Alto Tietê* project the adjustment factor has been estimated to be 20% of the gas captured by the passive venting system, it represents the amount of LFG flared that would have been destroyed/combusted in the absence of the proposed project.

For the Project Design Document (PDD), *ex ante* emission reductions estimative are made by projecting the future greenhouse gas emissions of the landfill using a first order kinetic model. These estimates are for reference purposes only, since emission reductions will be determined (*ex post*) by metering of the quantity of methane captured and flared once the project activity is operational.

1. Baseline emissions.

The baseline is the atmospheric release of the gas and the baseline methodology considers that some of the methane generated by the landfill may be captured and destroyed to comply with regulations or contractual requirements, or to address safety and odour concerns.

Estimating baseline emissions from the *Alto-Tietê* landfill requires a kinetic approach. The IPCC advices a first order decay model to determine the rate of CH_4 generation over time. Further derivation of the mathematical model allows also waste variances in annual acceptance rates.

$$Q_{T,x} = k\, R_x\, L_O\, e^{-k(T-x)} \qquad \textbf{\textit{Equation 2}}$$

Where:

$Q_{T,x}$ = the amount of methane generated in the current year (T) by the waste R_x

x = the year of waste input.

R_x = the amount of waste disposed in year x (Mg).

T = current year.

k = methane generation rate

Lo = methane generation potential

The yearly waste input (R_x) at the landfill is as follows:

Year	Waste input (Tonnes)	Waste on place (Tonnes)	Data Source
2000	200,000	200,000	*Pajoan Ltd*
2001	350,000	550,000	*Pajoan Ltd*
2002	480,000	1,030,000	*Pajoan Ltd*
2003	540,000	1,570,000	*Pajoan Ltd*
2004	573,937	2,143,937	*Pajoan Ltd*
2005	602,633	2,746,570	*Pajoan Ltd*
2006	632,764	3,379,334	*Pajoan Ltd*
2007	664,402	4,043,736	*Pajoan Ltd*
2008	697,622	4,741,358	*Pajoan Ltd*
2009	732,503	5,473,861	*Pajoan Ltd*
2010	769,128	6,242,989	*Pajoan Ltd*
2011	807,584	7,050,573	*Pajoan Ltd*
2012	847,963	7,898,536	*Pajoan Ltd*
2013	889,150	8,787,686	*Pajoan Ltd*

Table 5: Waste input and on place disposal

In order to estimate the current emissions from waste placed in all years, Equation 2 can be solved for all values of R_x and the results summed.

Values for the Equation 2 above are sourced from the table 6 and 7.

Variable	Units	Definition	Value	Data Source
k	(L/yr)	Methane generation rate	0.09	Pajoan Ltd
Lo	m3/ Mg	Methane generation potential	132.5	Pajoan Ltd

Table 6: Values of k and Lo for equation 2.

2. Methane destroyed/flared at the project activity *($MD_{project,y}$)*

The methane destroyed by the project activity (MDproject,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. The *Alto-Tietê* landfill project do not consider any electricity and/or thermal generation, thus the quantity of methane for these applications is assumed to be zero.
The MDflared,y (quantity of methane destroyed by flaring) is calculated as follows (Equation 3):

$$MD_{flared,y} = \{LFG_{flare,y} * w_{CH4,y} * D_{CH4}) - (PE_{flare,y} / \mathrm{GWP}_{CH4})$$

Where 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 measured during the year and expressed as a fraction (in m³ CH4 / m³ LFG), DCH4 is the methane density expressed in tonnes of methane per cubic meter of methane (tCH4/m3CH4) 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".

Variable	Units	Definition	Value	Data Source
$W_{CH4,y}$	m³ CH_4 / m³ LFG	Average methane fraction of the landfill gas	0.5	IPCC
D_{CH4}	tCH_4/m^3CH_4	Density of methane	0.0007168[6]	IPCC

Table 7: Values for the variables of equation 4.

Finally, for ex ante calculation, the $LFG_{flared,y}$ is calculated as result of the methane generated when extracted, treated and finally available at the flaring point as follows:

$$LFG\ flared,y = FE * EE * Q_{T,x} \qquad \textbf{Equation 4}$$

Where the value $Q_{T,x}$ represents the amount of methane generated in the current year (T), *FE* is the flare efficiency (the fraction of the methane destroyed at the flare) and *EE* is the extraction efficiency of LFG at the landfill for the project activity.

The ex post emission reduction calculation is described in detail in Annex 4 esp. equation 6.

Landfill designers and landfill operators consulted by *Ecologica Assessoria* recommends a conservative approach for the flaring efficiency of 90% and a 70% on the extraction efficiency of the LFG. It means that 40% of the LFG will be released as fugitive emissions within the project boundary.

According to ACM0001 methodology, the increase in emissions outside the project boundary (leakage) does not need to be accounted.

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

Data / Parameter:	**Landfill Waste**
Data unit:	Metric tonnes
Description:	Waste disposal during a year in *Alto-Tietê* Landfill
Source of data used:	Data will be measured
Value applied:	Variable. Values available at table 5.
Justification of the choice of data or description of measurement methods and procedures actually applied :	Waste will be measured at weight bridge at landfill entrance. Data will be archived daily in paper and monthly in electronic format.
Any comment:	

[6] *At standard temperature and pressure (0 degree Celsius and 1,013 bar) the density of methane is 0.0007168 tCH4/m³CH4.*

B.6.3 Ex-ante calculation of emission reductions:

The graph below (Figure 1) shows an approximation on the LFG production (m^3/h) throughout the project activity lifetime. The LFG at the baseline represents the gas volume generated at the baseline scenario, where the project activity represents the amount of the LFG actually captured and flared.

The difference between the curves is due to the technical limitations imposed on the landfill extraction and flaring. The amount of landfill technically available for flaring is around 70% of the total LFG generated, the 40% represents unavoidable fugitive emissions.

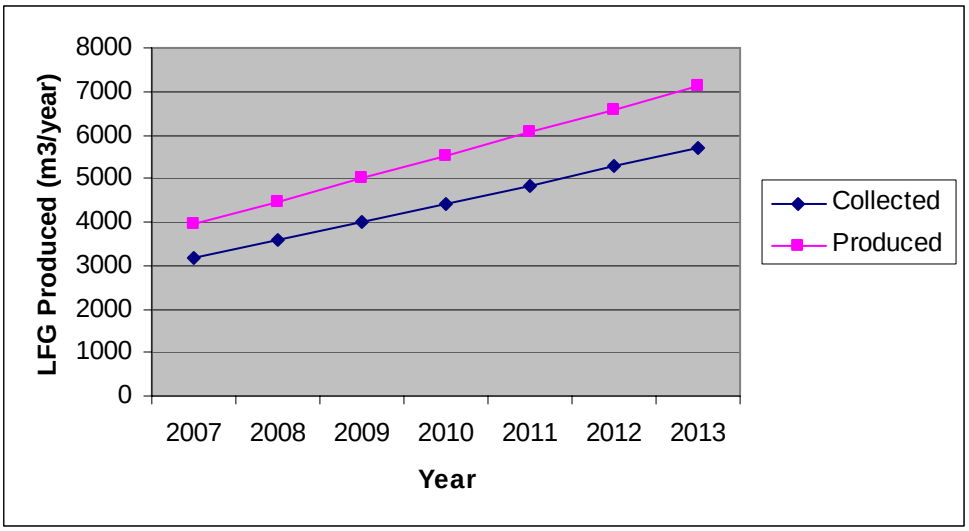

Figure 1. Amount of LFG and the estimative on baseline and the project.

The estimated emission reductions for each gas, source and formulae/algorithm due to the Project activity are presented at the table 8.

	LFG at baseline		CH_4 at baseline & Flared				CO_2 at baseline & reduced	
Variable	**m^3/hour**	**m^3/year generated**	**LFG flared (m^3)**	**Fugitive emissions**	**Methane flared**	**CH4 Baseline**	**Fugitive emissions**	**Project emissions reduction**
Parameter	**(a)**	**(b) = (a) x 8760**	**(c) = (b) x *EE x FE***	**(ton CH_4/year)**	**(ton/year)**	**(d) =(b) x D_{CH4} x W_{CH4}**	**(ton/year)**	**(tCO_2equ.) (e) = (d)x *EE x FE * 21***
2008	3,953.28	34,630,732.8	21,817,361.7	2,482.3	9,929.3	12,411.7	129,279.8	**131,365**
2009	4,480.96	39,253,209.6	24,729,522.0	3,014.6	12,058.6	15,073.2	157,002.8	**159,535**
2010	5,006.62	43,857,991.2	27,630,534.5	3,368.3	13,473.2	16,841.5	175,420.7	**178,250**
2011	5,532.61	48,465,663.6	30,533,368.1	3,722.2	14,888.7	18,610.8	193,850.2	**196,977**
2012	6,061.16	53,095,761.6	33,450,329.8	4,077.8	16,311.0	20,388.8	212,369.5	**215,795**
2013	6,594.46	57,767,469.6	36,393,505.8	4,436.5	17,746.2	22,182.7	231,055.1	**234,782**
2014	7,133.11	62,486,043.6	39,366,207.5	4,798.9	19,195.7	23,994.6	249,928.2	**253,959**
TOTAL	38,762.20	339,556,872.0	213,920,829.4	26,078.0	104,311.9	130,389.8	1,358,140.6	**1,380,046**

Table 8: Estimated emissions reductions for the gases due to the Project activity.

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

Year	Estimation of baseline emissions (tCO_2 equ.)	Estimation of the fugitive emissions (tCO_2 equ.)	Estimation of emission reductions (tCO_2 equ.)	Estimated extraction efficiency (EE)	Data source
2008	260,644.7	129,279.8	131,365	70 %	*Pajoan Ltd*
2009	316,537.9	157,002.8	159,535	70 %	*Pajoan Ltd*
2010	353,670.8	175,420.7	178,250	70 %	*Pajoan Ltd*
2011	390,827.1	193,850.2	196,977	70 %	*Pajoan Ltd*
2012	428,164.2	212,369.5	215,795	70 %	*Pajoan Ltd*
2013	465,836.9	231,055.1	234,782	70 %	*Pajoan Ltd*
2014	503,887.5	249,928.2	253,959	70 %	*Pajoan Ltd*
Total	2,719,569.1 **tCO2equ.**	1,358,140.6 **tCO2equ.**	1,380,046 **tCO2equ.**	--	--

Table 9. Values obtained when applying formulae above.

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

B.7.1 Data and parameters monitored:

Data / Parameter:	**$LFG_{total,y}$**
Data unit:	Nm^3
Description:	Total amount of landfill gas captured from project wells
Source of data to be used:	Measured
Value of data applied for the purpose of calculating expected emission reductions in section B.5	Please observe figure 1.
Description of measurement methods and procedures to be applied:	Measured by a flow meter. Data to be aggregated monthly and yearly.
QA/QC procedures to be applied:	Flow meters should be subject to a regular maintenance and testing regime to ensure accuracy

Data / Parameter:	**LFG flared,y**
Data unit:	m^3
Description:	Total amount of landfill gas flared

Source of data to be used:	Measured by PLC-Electronic device.
Value of data applied for the purpose of calculating expected emission reductions in section B.5	Please check figure 1
Description of measurement methods and procedures to be applied:	Measured continuously by a flow meter. Data to be aggregated monthly and yearly. Data will be archived in electronic format.
QA/QC procedures to be applied:	Flow meters should be subject to a regular maintenance and testing regime to ensure accuracy

Data / Parameter:	**FE**
Data unit:	%
Description:	Combustion efficiency
Source of data to be used:	Measured and calculated
Value of data applied for the purpose of calculating expected emission reductions in section B.5	90%
Description of measurement methods and procedures to be applied:	It will be perfomed: (1) Periodic measurement of methane content of flare exhaust gas. (2) Continuous measurement of operation time of flare (e.g. with temperature). Data will be measured weekly or monthly, if unstable.
QA/QC procedures to be applied:	The flare is monthly checked and the flare efficiency is measured on a semi-annual bases to ensure optimal operation

Data / Parameter:	**$WCH_{4,y}$**
Data unit:	m^3CH_4/ m^3LFG
Description:	Methane fraction in the landfill gas
Source of data to be used:	Measured by analyzer
Value of data applied for the purpose of calculating expected emission reductions in section B.5	0.5
Description of measurement methods and procedures to be applied:	Quarterly measured by continuous gas quality analyzer.
QA/QC procedures to be applied:	The gas sensor will be checked and tested to ensure accuracy

Data / Parameter:	**T**
Data unit:	*°C*
Description:	*Temperature of the landfill gas*
Source of data to be used:	*Temperature sensor*

Value of data applied for the purpose of calculating expected emission reductions in section B.5	60°*C*
Description of measurement methods and procedures to be applied:	Temperature will be continuously measured and data will be kept in electronic format.
QA/QC procedures to be applied:	The gas sensor will be checked and tested to ensure accuracy

Data / Parameter:	**Pressure**
Data unit:	mbar
Description:	Pressure of the landfill gas
Source of data to be used:	Measured by pressure sensor
Value of data applied for the purpose of calculating expected emission reductions in section B.5	200
Description of measurement methods and procedures to be applied:	Pressure will be continuously measured and data will be kept in electronic format
QA/QC procedures to be applied:	The gas sensor will be checked and tested to ensure accuracy

Data / Parameter:	**$T_{Flaring}$**
Data unit:	°C
Description:	Flaring temperature
Source of data to be used:	Measured by temperature sensor
Value of data applied for the purpose of calculating expected emission reductions in section B.5	700
Description of measurement methods and procedures to be applied:	Temperature will metered continuously and data will be kept in electronic format
QA/QC procedures to be applied:	The flaring temperature sensor will be checked to ensure a proper activity

Data / Parameter:	**Flare $_h$**
Data unit:	hours
Description:	Flare working hours
Source of data to be used:	Measured

Value of data applied for the purpose of calculating expected emission reductions in section B.5	8760
Description of measurement methods and procedures to be applied:	The period will be metered continuously and data will be recorded in electronic paper
QA/QC procedures to be applied:	Regular maintenance will ensure optimal operation of flares. Flare activity will be checked continuously, with daily checks if the efficiency shows significant deviations from previous values.

The Brazilian regulatory framework will also be monitored on an annual basis in order to confirm that the baseline scenario is still valid.

B.7.2 Description of the monitoring plan:

The monitoring plan at the *Alto-Tietê* landfill foresees the direct measurement of the amount of landfill gas destroyed (flared) where the two main variables to account are the quantity of methane flared ($MD_{flared,y}$) and the percentage of landfill gas that is methane (%).

The party responsible for implementing the monitoring plan shall be the landfill operation company *Pajoan Ltd*. The landfill operator will be also responsible for the day-to-day operation of the landfill gas monitoring, flaring and the party responsible for developing the data and registration forms for further classification.

1. **Operational structure.**

It will be based on daily monitoring of the LFG flow from the gas extraction stage to the landfill gas flaring. Continuous measurers of gas flow and flared gas meter will be installed along the landfill gas extraction network. The main purpose is the direct monitoring of any fugitive emissions and the empirical calculation of the landfill gas generated.

2. **Monitoring follow-up process.**

The project developer will directly monitor the data variable at the project site when possible or it will be otherwise carried out by a certified laboratory (on a quarterly basis). All data collected following the B.7.1 will be registered and transferred to electronic spreadsheets and/or other suitable electronic files.

The calibration certificates should be stored as paper copies and calibration data would be subject to quality control procedures as described in each description of data to be monitored (Quality control and Quality assurance) The management structure will also ensure that the monitoring equipment is perfectly equilibrated based on the INMETRO standards (Brazilian institute for metrology and calibration).

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

3. **The management structure.**

The landfill operator will be responsible for training of the monitoring and operation staff with the help of the equipment manufactures. Then, the technical team will manage the monitoring, quality

control and the quality assessment procedures carried out at the landfill premises. Further detailed procedures for monitoring shall be developed during the final design of the facilities.

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

The baseline study for the project activity and monitoring methodology were completed on 26/03/2006 by *Ecologica Assessoria*, which is not a project participant. Below, the name of person and entity determining the baseline:

Name of person/Organization	Project Participant
Paulo Zanardi Ecologica Assessoria Ltda. São Paulo, Brazil. Tel: +55 11 5083 3252 Fax: +55 11 5083 8442 e-mail: zanardi@ecologica.ws WWW: www.ecologica.ws	NO

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:

01/01/2008

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

21 years − 0m.

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

The CDM project activity will use a renewable crediting period.

C.2.1. Renewable crediting period

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

01/01/2008

C.2.1.2. Length of the first crediting period:

7 years – 0 m.

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:

The project will extract and flare landfill gas, therefore improving the landfill management by reducing adverse global and local environmental effects of uncontrolled releases of landfill gas. The project activity shall start operation with all operation and the environmental licenses in compliance with local and national regulations.

Baseline scenario: LFG contains over 150 trace components that may cause: odour nuisances, stratospheric ozone layer depletion and in concentrated amounts leads to asphyxia and/or toxic effects in humans.

Project activity: The installation of a set of wells designated for gas collection and further flaring will lead into a daily monitoring (as stated at the monitoring plan) and proper landfill operation. The operation will remove safety risks from the surrounding communities by reducing the risks of toxic effects on the local community, freatic layers, watercourse pollution and odour nuisances.The combustion of the LFG at the flare point will lead on the release of organic compounds and trace amounts of toxic materials, including mercury and dioxins.

Operation mitigation measures: A set of mitigation measures are defined during the operation of the project activity, i.e. concerning the noise of the flare and the mitigation of the NVOCs compounds present at the flare point, the project operator will follow local and national regulations and technical specifications defined by the ABNT (Brazilian technical standard association) for the project activity. The mitigation measures will be defined at the operation plan implemented by the project operator. Once the project activity is implemented, further studies and mitigation measures may be undertaken.

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 negative impacts applicable.

SECTION E. Stakeholders' comments

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

According to the Resolution number 1 of the Brazilian Inter-Ministerial commission on Climate Change[7], invitations for comments by local stakeholders are required by the Brazilian Designated National Authority (DNA) as part of the procedures for analyzing CDM projects and issuing letters of approval.

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

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

As defined by the Designated National Authority (DNA), the project developer sent information letters to the key institutions, describing the major aspects of the implementation and operation of the proposed project. The project participant should leave 30 days opened for comments. The letters were distributed by *Pajoan Ltd* via mail to the key institutions (see table 10, below).

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

Name of the Institution	Type of Entity	Address	Phone / Fax	Contact Point	E-mail
Brazilian Forum of NGOs	Association of NGOs	SCLN 210 Block C Room 102 CEP 70856-530 Brasília DF	(61) 3340-0741	--	forumbr@tba.com.br
Public Ministry of the State of São Paulo	Ministry	115 Riachuelo Street, Center São Paulo	(11) 3119-9015	--	web-master@mp.sp.gov.br
Itaquaquecetuba City Hall	City Hall	283, Ver. João Fernandes da Silva Avenue	(11) 4640-1000	Armando Tavares	--
CETESB	Environmental Organism	345, Prof. Frederico Hermann Jr Avenue, Alto de Pinheiros, São Paulo, ZIP Code: 05459-900	(11) 3030-6000	--	--
Foundation for the Conservation and Forestry Production of São Paulo	Governmental Organization	931, Horto Street, São Paulo, ZIP Code: 02377-000	(11) 6997-5000		fflorestal@fflorestal.sp.gov.br
Botany Institute	Governmental Organization	3687, Miguel Estéfano Avenue, Água Funda, São Paulo, ZIP Code: 04301-902	(11) 5073-6300	--	--
Geological Institute	Governmental Organization	3900, Miguel Estéfano Avenue, Água Funda, São Paulo, ZIP Code: 04301-903	(11) 5077-1155	--	igeologico@igeologico.sp.gov.br
State Secretariat of Health	Public Secretariat	188, Dr Enéas de Carvalho Aguiar Avenue, ZIP Code: 05403-000, São Paulo, SP	(11) 3066-8000	Danilo Vicente	--
Environment Secretariat of the State of São Paulo	Public Secretariat	345, Prof Frederico Hermann Jr Avenue, ZIP Code: 05489-900	(11) 3030-6477	José Goldemberg	ouvidoria@ambiente.sp.gov.br
Environmental Policing Command	Governmental Organization	345, Prof Frederico Hermann Jr Avenue, ZIP Code: 05489-900, 4th floor, Alto de Pinheiros	(11) 3030-6625	Deputy Marcelo Robis	cpambp5@polmil.sp.gov.br
Name of the Institution	Type of Entity	Address	Phone / Fax	Contact Point	E-mail
Waters and Electric Energy Department	Public Department	170, Boa Vista Street, 8th floor, Block 5 ZIP Code: 01014-000, São Paulo	(11) 3293-8571	Ubirajara Félix	ufelix@sp.gov.br
Ferraz de Vasconcellos City Hall	City Hall	1841, Brasil Avenue, Center, ZIP Code: 08529-310	(11) 4674-1000	Jorge Abissamra	ferrazadm@superig.com.br

Mogi das Cruzes City Hall	City Hall	277, Vereador Narciso Yague Guimaraes Avenue, ZIP Code: 08780-000	(11) 4798-5000	Jungi Abe	gabinete@pmmc.com.br
Health Secretariat of Mogi das Cruzes	Public Secretariat	277, Vereador Narciso Yague Guimaraes Avenue, ZIP Code: 08780-000	(11) 4795-4500	Cláudio Miyake	saude@pmmc.com.br
Poá City Hall	City Hall	198, Brasil Avenue, Center, ZIP Code: 08550-000	(11) 4634-8800	Carlos Roberto da Silva	--
Suzano City Hall	City Hall	501, Baruel Street, Center, ZIP Code: 08675-000	--	Marcelo Souza Candido	suzano.gabinete@uol.com.br
Health Secretariat of Suzano	Public Secretariat	179, Baruel Street, Vila Costa, ZIP Code: 08675-902	--	Célia Bortoletto	saude@suzano.sp.gov.br
Arujá City Hall	City Hall	90, José Basilio Alvarenga Street, Vila Flora Regina	(11) 4652-7600	Genésio da Silva	--
Carapicuíba City Hall	City Hall	205, Joaquim das Neves Street, Center, ZIP Code: 06310-030	(11) 6886-5200	--	carapic@pmcarapicuiba.com.br
Health Secretariat of Arujá	Public Secretariat	231, Pedro Severino Martins Street	(11) 4655-2871	Messias Covre	--
Health Secretariat of Carapicuíba	Public Secretariat	1304, President Tancredo Neves Street	(11) 4167-9116	--	--

Table 10.Participant entities.

E.2. Summary of the comments received:

No comments have been received.

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

Not applicable, as no comments were received.

Annex 1

CONTACT INFORMATION ON PARTICIPANTS IN THE PROJECT ACTIVITY

Organization:	*Empreiteira Pajoan Ltda.*
Street/P.O.Box:	Av. Nossa Senhora das Graças nº 599, Jardim Pinheirinho, Itaquaquecetuba
Building:	---
City:	Sao Paulo
State/Region:	SP
Postfix/ZIP:	08589-140
Country:	Brazil
Telephone:	+55 (11) 4649-3680 / 4649-3681 / 4649-5708
FAX:	+55 (11) 4649-3680 / 4649-3681 / 4649-5708
E-Mail:	kishi@pajoan.com.br
URL:	www.pajoan.com.br
Title:	Director
Salutation:	Sr.
Last Name:	Filho
Middle Name:	Augusto Cardoso
First Name:	José
Department:	Administration
Mobile:	---
Direct FAX:	+55 (11) 4649-3680 / 4649-3681 / 4649-5708
Direct tel:	+55 (11) 4747-7000
Personal E-Mail:	kishi@pajoan.com.br

Organization:	*BGC International*
Street/P.O.Box:	One America Square
City:	London
Postfix/ZIP:	EC3N 2LS
Country:	United Kingdom
Telephone:	+44 207 894 7054
E-Mail:	sdrummond@co2e.com
Title:	Managing Director
Salutation:	Mr.
Last Name:	Drummond
First Name:	Steve
Direct tel:	+44 207 894 7054
Personal E-Mail:	sdrummond@co2e.com

Annex 2

INFORMATION REGARDING PUBLIC FUNDING

There are no public financing for the project.

Annex 3

BASELINE INFORMATION

The fraction of the organic compounds presented in the waste for the project activity is defined as 64.4 %. Based on the Brazilian study about methane emissions from waste treatment and waste disposal, the estimative is that for the mayor part of the waste disposal, the 80% comes from domestical waste where almost 60% is composed of organic waste.

Landfill	Location	% Total of commercial and waste Disposal	% Organic Waste
Bandeirantes	São Paulo	75	55
Biguaçu	Florianópolis	95	60
Caximba	Curitiba	80	65
Goiânia	Goiânia	90	High
Joinville	Joinville	70	50 - 60
Lara	Mauá	72	65
Zona Norte	Porto Alegre	66	60

Table 11: Percentage of organic waste presented at the waste. Data Source: USAID, 1997.

Below, the parameters and data sources used to determine the baseline for the project activity. The key elements such as variables and parameters are provided below. The tables 12 and 13 show the values for the parameters used for the LFG emissions estimation.

PROJECT ACTIVITY MAIN INFORMATION	
Alto-Tietê landfill project specifications	
Year when operations started	2000
Year when flaring starts	2006
R=daily average deposition (t/day)	1,500
Lo (m^3/ Mg)	132.5
k (1/year)	0.09
Methane Global Warming Potential	21
% of Methane in landfill gas	50 %

Table 12: Alto-Tietê landfill project specifications

Fraction of Degradable Organic Carbon (DOC)		
Waste type	**Value**	**Data Source**
Paper & Cardboard	14.40 %	*Pajoan Ltd*
Plastics	12 %	*Pajoan Ltd*
Aluminum, other metallic compounds	3.2 %	*Pajoan Ltd*
Organic waste	64.4 %	*Pajoan Ltd*
Glass	1.1 %	*Pajoan Ltd*
Others	4.9 %	*Pajoan Ltd*

Table 13: Fraction of degradable organic carbon

For the *Alto-Tietê* landfill to gas project the type of weather is humid and the waste decomposition occurs under rapid degradation conditions. For the LFG estimation purposes the k value was defined, conservatively speaking, as of 0.09 (L/year). The Lo factor depends directly to the waste composition as well as the site physical conditions. The values here adopted for Lo are defined as 132.5 m3/Mg of waste for the year 2006. The old landfill site close to the new one is not considered in the project activity.

Photo 1: Alto-Tietê landfill entrance.

Photo 2: Alto-Tietê landfill top view.

Annex4

MONITORING INFORMATION

The Monitoring plan is based on the approved monitoring methodology ACM-0001, "Consolidated baseline methodology for landfill gas project activities". The monitoring methodology is based on direct measurement of the amount of landfill gas captured and destroyed at the flare platform and the electricity generating/thermal energy unit(s) to determine the quantities as shown in Figure 2.

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 (MDproject,y), quantity of methane flared (MDflared,y), the quantity of methane used to generate electricity (MDelectricity,y)/thermal energy (MDthermal,y), and the quantity of methane generated (MDtotal,y).

The monitoring plan for the project activity and the Quality control (QC) and quality assurance (QA) procedures are based on the ACM-0001. The monitoring plan provides for continuous measurement of the quantity and quality of LFG flared and the quality control and quality assurance procedures are needed to ensure consistency on monitoring equipment and the data collected.

1. Monitoring Process

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

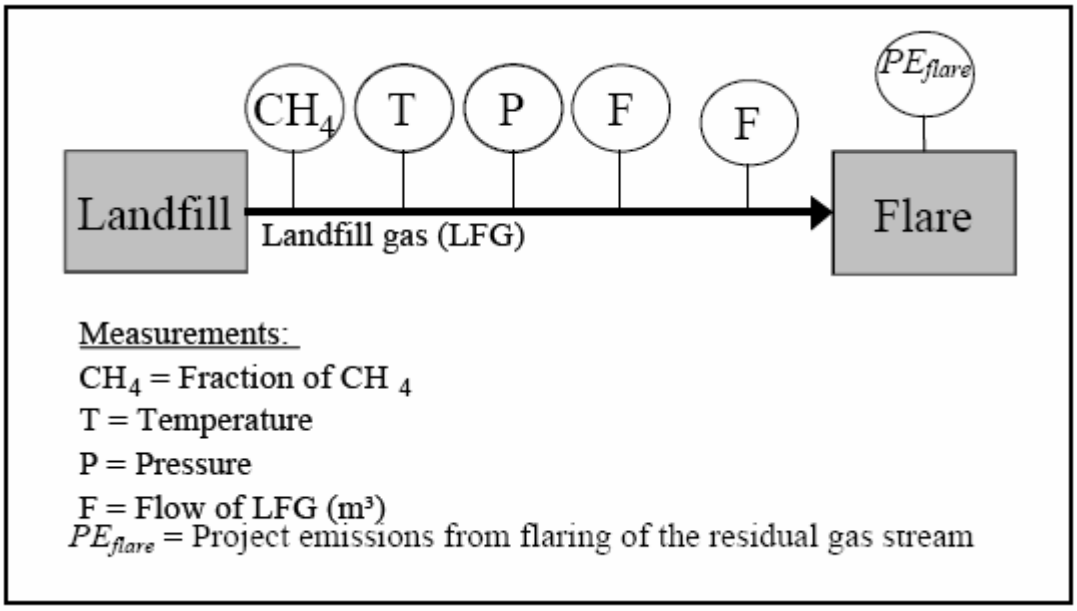

Figure 2. Monitoring plan scheme for the Alto-Tietê landfill to gas project.

At the figure 2, the landfill gas flows through the gas network up to the flaring point where the monitoring equipment is placed. Several sensors are placed on-line to the gas pipeline in order to measure continuous gas flows.

The party responsible for implementing the monitoring plan shall be the landfill operation company *Pajoan Ltda*. The landfill operator will also be responsible for developing the forms and registration formats for data collection and further classification.

2. Emissions reduction calculation process

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

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

$$tCO_2e\ (yearly) = A * B * W_{CH4} * LFG * FE - KWh * EF_{diesel} \qquad \textbf{Equation 6}$$

Parameter	Definition	Unit
tCO_2e (yearly)	CO_2-equivalent	tCO_2e
LFG	Quantity landfill gas	Nm^3
W_{CH4}	Methane content of the LFG	%
A	0.0007168 @ Air density = 1,013 kg/m3	$Tons/Nm^3$
B	21	ton CO_2eq/ton CH_4
kWh	Yearly consumed electrical power	kWh
EF_{diesel}	Diesel emissions factor (IPCC)	ton CO_2eq/kWh

Table 14. Parameter used at the equation 6.

The table 14 shows the parameters used at the equation 6 above. The parameters A, B in Equation 6 are constants, the values W_{CH4} and *LFG* are related to the waste composition on place, the *FE* and *KWh* are defined by the technical equipment (technical specifications and energy demand) for the LFG destruction. The EF_{diesel} value is issued from the IPCC default values (kg CO_2 equ/kWh). Likely the emissions from the flaring equipment due to the energy demand will represent less than 0.1 % of the total project emission reduction.

The monitoring methodology schedules a continuous screening of the defined values and the further storage on a data-logger (set on place). Finally the data will be daily download and archived on electronic format. Please refer to the B.7.1 for more information.

3. QA/QC procedures (Data consistency)

The planning procedures are set to ensure consistency on the monitoring equipment and sensors (Quality control) and the data collected (Quality assurance).

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

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

1. On-field sensors.

- LFG flow meter

The meter will provide two values, the daily amount of LFG (Nm^3) stored by the data-logger and the total value to date passed through that will be shown at the flow meter. The validator will check both for consistency.

- Sampling points.

  The sensors will be placed at the gas network directly connected to the data logger that will register the pressure of the flowing gas. The meter will be checked by the technical team for consistency.

- Methane analyzer.

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

- Temperature and pressure sensor.

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

2. Data logger

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

3. Energy meter

The electrical power consumption is measured by means of a kWh-meter. The purpose of the measurement is to check that the emissions due to the project activity (gas pumping) are below of 0.01 % and could be considered as insignificant.

4. Operation and validation

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

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

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

5. Regulatory requirements governing landfills in Brazil.

The Ecologica team will be responsible for the analysis and direct monitoring on the governmental rules regarding the landfill gas capture and destruction. Any changes on the baseline will be communicated to the project developer.

6. Corrective, Preventive and Improvement actions.

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

1. Problem analysis: Definition of the origin, causes and further actions to be undertaken.
2. Corrective actions: Administration staff will implement and reported to the technical staff the necessary measures.

Annex 5

CONTACT FOR THE CDM PROJECT ACTIVITY

Organization:	*Ecológica Assessoria*
Street/P.O.Box:	St. Dr. Bacelar nº 368 office 11/13

Building:	Building Cleveland
City:	Sao Paulo
State/Region:	SP
Postfix/ZIP:	04026-000
Country:	Brazil
Telephone:	+55 (11) 50833252
FAX:	+55 (11) 50833252 / 50838442
E-Mail:	divaldo@ecologica.ws
URL:	www.ecologica.ws
Title:	Director
Salutation:	Sr.
Last Name:	Rezende
Middle Name:	Costa
First Name:	Divaldo
Title:	Technical Coordinator
Salutation:	Sr.
Last Name:	Zanardi
First Name:	Paulo
Mobile:	+55 (11) 84294546
Direct FAX:	+55 (11) 50833252 / 50838442
Direct tel:	+55 (11) 50833252
Personal E-Mail:	zanardi@ecologica.ws