CLEAN DEVELOPMENT MECHANISM
PROJECT DESIGN DOCUMENT FORM (CDM-SSC-PDD)
Version 03 - in effect as of: 22 December 2006

CONTENTS

Annexes

Revision history of this document

Version Number	Date	Description and reason of revision
01	21 January 2003	Initial adoption
02	8 July 2005	• The Board agreed to revise the CDM SSC PDD to reflect guidance and clarifications provided by the Board since version 01 of this document. • As a consequence, the guidelines for completing CDM SSC PDD have been revised accordingly to version 2. The latest version can be found at <http://cdm.unfccc.int/Reference/Documents>.
03	22 December 2006	• The Board agreed to revise the CDM project design document for small-scale activities (CDM-SSC-PDD), taking into account CDM-PDD and CDM-NM.

SECTION A. General description of small-scale project activity

A.1 Title of the small-scale project activity:

Montería Landfill gas recovery and flaring
Version 05
PDD completed on August 9, 2011

A.2. Description of the small-scale project activity:

The Montería Landfill Gas Recovery and Flaring Project (MLGRF) intends to capture and flare the landfill gas (LFG) generated at the Montería Landfill (MLF) located in one of Colombia's most important middle-sized cities: Montería.

The project activity will improve solid waste final disposal practices in Montería as well as in other nearby municipalities of the Atlantic coastal plain of northern Colombia that dispose domestic wastes at the MLF[1]. This will be achieved through the installation of an active LFG recovery system. The system will flare the LFG and destroy the methane currently being released to the atmosphere. It is expected that more than 270,000 tCO2e emitted to the atmosphere will be avoided over a period of 7 years starting in 2011. The resulting emission reductions from the project activity are less than 60,000 of CO_2e per year. Therefore the project activity classifies it as a **small scale project.**

The project will involve the installation of a LFG extraction system that includes wells, pipes, blowers, analyzers, monitoring stations as well as an efficient flare to allow for a safe destruction and combustion of methane and non-methane organic compounds. The project will be jointly developed by Energie Baden-Württemberg AG (EnBW), Carbon BW Colombia S.A.S., SERVIGENERALES S.A. E.S.P. (SERVIGENERALES), and OPTIM Consult Ltda (OPTIM). EnBW is the third largest energy company in Germany and is focused on the electricity and gas energy business units, environmental services, as well as on CDM activities in selected host countries. EnBWhas constituted a local subsidiary company, Carbon BW Colombia S.A.S., which will take care of EnBW's operational tasks of the project. SERVIGENERALES is a private company that specializes in the operation of landfills in Colombia. OPTIM is a Colombian broker and consulting firm that specializes in the development of CDM projects in Colombia and in Latin America. SERVIGENERALES has an operation license to manage the landfill during its life span.

At a later stage, the landfill gas collected may be used as fuel for electricity generation or other purposes. The feasibility of electricity generation – including LFG quality and investment cost – will be revisited once the project is fully operational, and it is therefore not part of the small-scale project activity presented in this PDD. Electricity generation is not conceivable at a first stage for financial reasons. In case electricity production happens to be feasible in the future and the project participants decide to produce electricity on MLF, no CER will be claimed for electricity displacement.

[1]Other municipalities disposing at Monteria LF include: Arboletes, Ayapel, Cerete, Ciénaga de Oro, Cotorra, Los Cordobas, Lorica, Planeta Rica, Purísima, Pto Escondido, San Andrés de Sotavento, San Antero, San Carlos, San Pelayo, Tierra Alta and Valencia.

The landfill began operating as a landfill in 2006 and has a life span of 20 years. It occupies a total area of 6.5 hectares and has a capacity to accumulate 1´800,000 tons of solid waste. SERVIGENERALES has purchased additional 4 hectares for eventual expansion of their disposing capability. These 10.5 hectares are included in the project activity boundary. Approximately 250 tons of waste are currently being disposed at the site on a daily basis, but will soon be increased to 350 tons per day.

Colombia's national strategy related to Climate Change and relevant specific legislation that supports the project activity includes:

- Law 164 of October 27, 1994 approved by the Colombian Congress that ratified the United Nations framework Convention on Climate Change – Colombia became a party on June 20th, 1995;
- Law 629 of December 27, 2000 approved by the Colombian Congress that approved the Kyoto Protocol - Colombia ratified in November 2001;
- In April 2000, a Study for a National Strategy to Implement the CDM in Colombia was developed. The study assessed the Colombian market for GHG reductions and set specific strategies (Action Plan) to maximize the potential benefits of the CDM in Colombia;
- Ministerial Resolution 0340 of March 11, 2005 that created the Grupo de Mitigación de Cambio Climático. This Group part of the Vice Ministry of the Environment which is the Designated National Authority.
- Resolution 8861 of 2005 issued by the Regional Autonomous Corporation of the Sinú and San Jorge River Valleys (CVS), granted MLF the necessary environmental license to be constructed and to operate.
- Resolution 10536 of August 1 2006 transfers the environmental license from Parques Nueva Monteria S.A. E.S.P to SERVIGENERALES, and extends it for 20 years
- The project is also included in CVS´s Plan Integral para la Gestión de los Residuos Sólidos (PGIRS), which is the regional solid waste management plan and in the Plan de Ordenamiento Territorial (regional management plan).

The MLF is one of only five landfills that operate in proper conditions in Caribbean Coastal Plain of Colombia, which is one of the most populated regions of the country. MLF's operation is therefore crucial to securing proper waste management practices in Colombia. In addition, the implementation of the project activity at this critical site will:

- Contribute to establish a better practice for urban solid waste management and landfill gas recovery, reducing the current pressure over the local natural resources, as many open dumps are still common practice and waste disposal habits are incautious;
- Prove the use of a new technology and to demonstrate the viability of a LFG capture and flare project, while increasing demand for local labor;
- Encourage the local supply of equipment and other components for the construction and operation of the LFG plant, increasing local know-how;
- Generate local jobs both for low-skilled and skilled workers;
- Improve air quality in the area and local health conditions for the inhabitants of the municipality of Montería and its neighboring areas. Environmental and sanitary impacts associated with the emissions of methane and other organic compounds will be prevented.

- The capture and flaring of the landfill gas will also avoid emissions of other gases such as hydrogen sulfide (H_2S), mercaptanes and other odorous compounds which leads to a cleaner environment in the area surrounding the landfill. Odorous gas emissions actually do affect public health and quality of life. Bad odors can cause local health problems; they can also negatively affect investment in the surrounding communities and lower property values and its socioeconomic status.
- Capture and flaring of the landfill gas will reduce explosion and fire risks.
- Demonstrate the advantage of the GHG emission market and Kyoto mechanisms to finance new technologies.

A.3. Project participants:

Name of Party involved (*) ((host) indicates a host Party)	Private and/or public entity(ies) Project participants (*) (as applicable)	Kindly indicate if the Party involved wishes to be considered as project participant (Yes/No)
Republic of Colombia (host)	SERVIGENERALES S.A. E.S.P. (Servigenerales la Empresa de Servicios Públicos de Carácter Privado S.A. E.S.P.) OPTIM Consult Ltda	No
Federal Republic of Germany	EnBWENERGIE BADEN-WÜRTTEMBERG AG Carbon BW Colombia S.A.S.	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 small-scaleproject activity:

A.4.1. Location of the small-scale project activity:

A.4.1.1. Host Party(ies):

Colombia

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

Province of Córdoba

A.4.1.3. City/Town/Community etc:

Montería, capital city of Cordoba

A.4.1.4. Details of physical location, including information allowing the unique identification of this small-scale project activity :

The project site is located in the rural area of the city of Montería in the Caribbean Coastal Plain of Colombia. It is placed in the northern region of Colombia, 850 km away from Bogotá, the country's capital. Montería has a population of 380,000 inhabitants (National Statistics Department, DANE, 2006). It is set at 8° 45' North latitude and 75° 53' West longitude and at 18 meters above sea level.

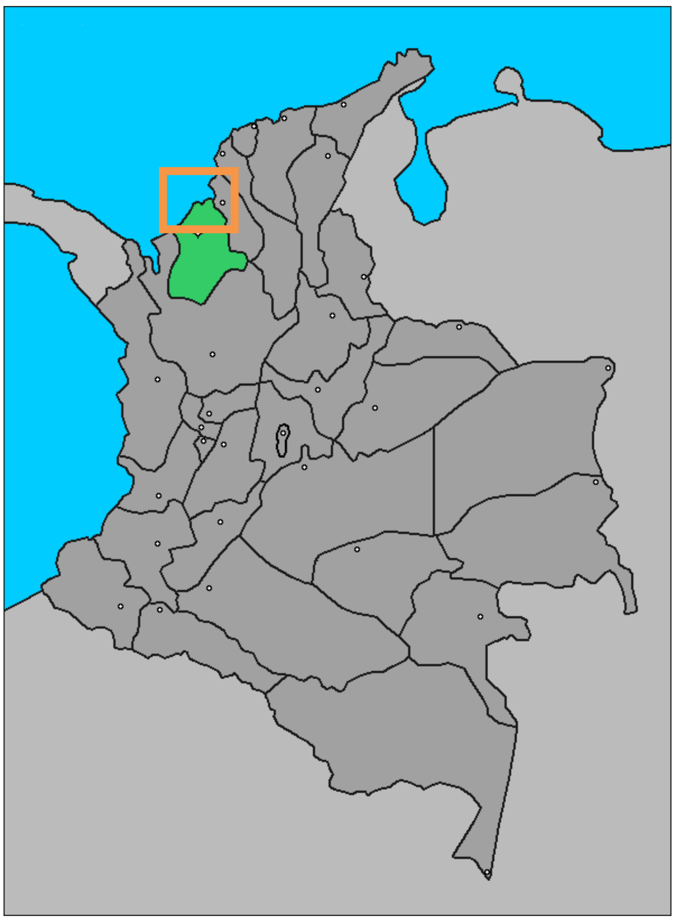


Fig 1 - Province of Córdoba, Colombia

Fig 2 - City of Monteria

The city of Montería is strategically located. It was founded as a port in the border of the Sinú River. Presently the region's s main economic activities are agriculture, cattle and commerce. Demographic growth, industrial and commercial expansion are critical challenges in terms of solid waste management for the region. Forests along the site have almost disappeared and transformed into agriculture and cattle farms. Landscapes and natural habitats have been substantially transformed and most forest systems have been eliminated.

Precipitation in the area is 1.800 mm per year with relative humidity of 85%. Annual average temperature is 28°C[2].

A.4.2. Type and category(ies) and technology/measure of the small-scale project activity:

The category of this project activity (Type III.G Landfill methane recovery capture and combustion of methane from the landfill) can be included in "Sectoral Scope 13: Waste Handling and Disposal".

No landfill gas collection or treatment systems presently exist at MLF. Therefore, the LFG is passively released to the atmosphere. A basic LFG wells system has been built from PVC pipes buried in 1m trenches filled with gravel. These are covered with metal nets that run vertically through the site.

The technology to be employed envisages special equipment to build and operate a system that will collect and flare landfill gas on site. The system will include:

1. Collection wells and piping: vertical and/or horizontal wells that will be interconnected by header piping and that will capture, monitor and transport the LFG to the extraction system;
2. Extraction (or vacuum) system: blowers, valves and flow control systems;

[2] Source: http://www2.ideam.gov.co/sectores/aero/climat/premonteria.htm, and http://bart.ideam.gov.co/cliciu/monter/temperatura.htm

3. Condensate systems: traps and knockout vessels, pipes to remove gas condensates. Condensation, which forms in the LFG piping network as warm gas cools, can cause significant operational problems if not managed properly. Specific piping will be designed to include self-draining condensate traps;
4. Blower: the blower will suck the LFG and blow it to the flare;
5. Flaring station: the station will include an enclosed flaring system with temperature level over 1000 C, as required by the methodology; also, the flare will have an efficiency of at least 98%
6. Monitoring and control system: the unit will measure among others, LFG flow, composition, temperature and pressure. The system will monitor methane inflow to the flare, and exhaust gas components. This should be sufficient to handle the maximum project LFG recovery rate under a mid-range scenario.

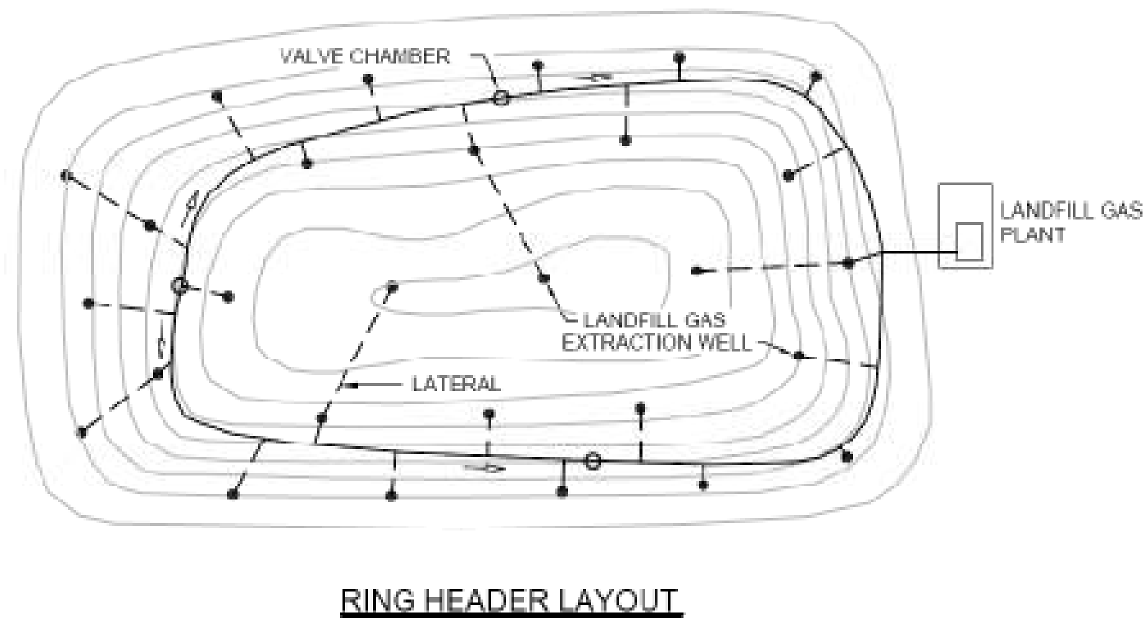


Fig. 3 – Typical configuration of gas collection system.
Source: World Bank Handbook for Preparation of LFG to energy Projects

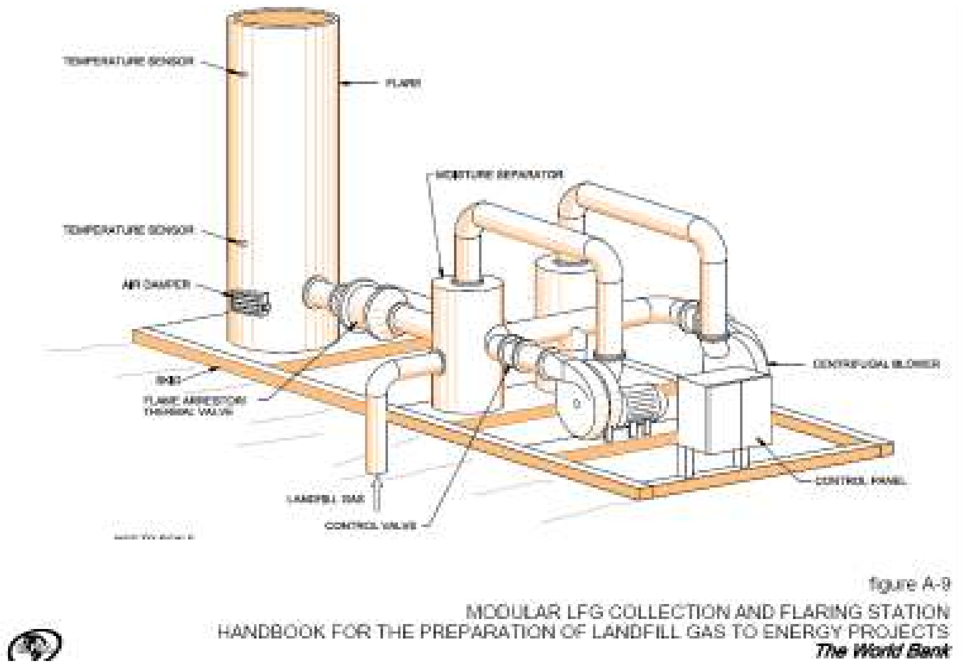


Fig. 4 – Typical gas flaring and blower system

Source: World Bank Handbook for Preparation of LFG to energy Projects

A.4.3 Estimated amount of emission reductions over the chosen crediting period:

Landfill gas is primarily composed of methane and carbon dioxide. Carbon dioxide from landfill gas is not considered an anthropogenic GHG but rather of biogenic origin by the Intergovernmental Panel on Climate Change (IPCC) and therefore part of the natural carbon cycle. CO_2 emissions are not considered as a source of GHG and will not be accounted for in the baseline emissions or in MLF's project emissions. Methane, however, is considered an anthropogenic GHG since it will not enter the carbon cycle unless flared.

Emission reductions will arise from the combustion of methane contained within the collected landfill gas. The proposed project activity will reduce most of the GHG emissions through the capturing and flaring of the methane contained in the LFG. This project activity will contribute to reduce methane emissions, and will improve the environmental conditions of the neighbouring areas. The emission reductions (ERs) to be achieved with the proposed project activity will be directly measured according to the Monitoring Plan described in Section D of this document.

Estimated annual GHG emission reductions at MLF (tons CO_2e)

Year	Emission Reductions (tCO2e)
7-year crediting period	
2011	30,134
2012	34,392
2013	37,799
2014	40,614
2015	43,013
2016	45,113
2017	46,995
Total First 7-year crediting period	**278,059**
Average First 7-year crediting period	**39,723**

A.4.4. Public funding of the small-scale project activity:

No public funding from Annex 1 parties is currently involved or will take place in the future in the Montería LFG Recovery and Flaring Project (MLFGRF).

A.4.5. Confirmation that the small-scale project activity is not a debundled component of a large scale project activity:

According to appendix C of the simplified modalities and procedures for the small-scale CDM project activities, a proposed small-scale project activity shall be deemed to be a debundled component of a large project activity if there is a registered small-scale CDM project activity or an application to register another small-scale CDM project activity:

- With the same project participants;
- In the same project category and technology/measure; and
- Registered within the previous 2 years; and
- Whose project boundary is within 1 km of the project boundary of the proposed small-scale activity at the closest point.

This project does not meet any of the above mentioned requirements. It is a stand-alone activity, thus not a debundled component of a large-scale 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 small-scale project activity:

AMS-III.G. version 06 “Landfill Methane Recovery.v6” has been applied to this project.

B.2 Justification of the choice of the project category:

The proposed small scale project activity includes the capture and flaring of LFG from the MLFGRF. According to the CDM Executive Board, the applicable methodology is the "Indicative simplified baseline methodology for selected small-scale CDM project activity categories"; Version 4 of December, 2006. The project corresponds to project type III category G (landfill methane gases).

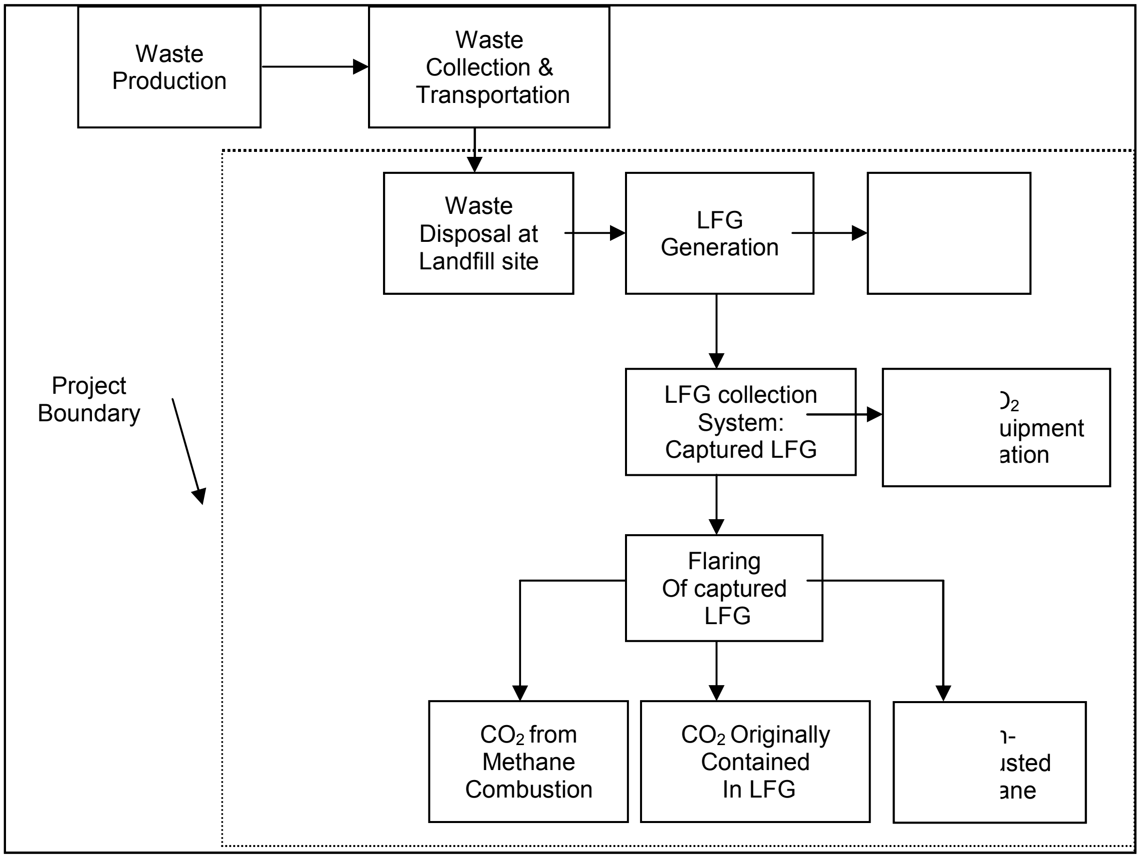
The project activity related emissions are estimated to be less that 60,000 t CO_2-eq in every year of the first crediting period. Therefore, the proposed project activity qualifies for small scale project as defined in Appendix B of M&P for small scale project activities (UNFCCC, 2006).

B.3. Description of the project boundary:

The project boundary is the physical, geographical site of the landfill where the gas is captured and destroyed/used. In this project, the following sources and gases are included in the project boundary:

	Source	Gas	Included?	Justification /Explanation
Baseline	Emissions from decomposition of waste at the landfill site	CO_2	No	Not accounted because of biogenic origin
		CH_4	Yes	Main source of GHG on the landfill
	Emissions from electricity consumption / generation	CO_2	No	No electricity is consumed / generated onsite in the baseline scenario
		CH_4	No	No electricity is consumed / generated onsite in the baseline scenario
Project Activities	On site fossil fuel consumption due to the project activity, other than electricity generation	CO_2	No	No fossil fuel consumption other than for electricity
		CH_4	No	No fossil fuel consumption other than for electricity
	Emissions resulting from the flare	CO_2	No	Not accounted because of biogenic origin
		CH_4	Yes	Methane not burned due to flare efficiency correction
	Emissions from on-site electricity use	CO_2	Yes	This project will use electricity on-site
		CH_4	No	Excluded for simplification. Assumed to be very small

The basic process and activities involved at the MLF site are described in the figure below:



MLF operations, project activity and project boundary for the MLF Capture and Flaring Project (project boundary marked by dashed line)

B.4. Description of baseline and its development:

The baseline scenario assumes the landfill will continue to generate and allow the LFG emissions, enabling methane to be released to the atmosphere. To estimate the amount of methane produced and vented, the project is using a First Order Multi-phase Decay model based on the discrete time estimate method of the IPCC Guidelines, described in category AMS III.G (Version 6) and the *"Tool to determine project emissions from flaring gases containing methane.v4"*.

The project's baseline emissions correspond to the LFG's methane emissions resulting from operating the landfill. MLF is expected to receive at least 2.6 million tons of waste until 2025. Currently, the landfill receives approximately 250 tons per day.

Monteria Sanitary Landfill Total Accumulated Waste 2005-2009	
Year/Month	(Ton)
2005	6,883
2006	25,184
2007	80,375
2008	80,756
2009	90,663

No landfill gas collection or treatment systems presently exist at MLF. The LFG is therefore passively released to the atmosphere. A basic LFG wells system has been built from 6'' PVC pipes buried in 1m trenches filled with gravel. These are covered with metal nets that run vertically through the site.

The baseline was first constructed in July of 2007 by OPTIM, and later updated on June 2010. OPTIM is a CDM advisor on the project, and it is also a project participant.

Contact data

Eduardo Uribe and Juan Andres Lopez-Silva
OPTIM Consult
Cra 7 No 80-49 Of. 302
Bogotá
Colombia
euribe@optimconsult.com
jlopezsilva@optimconsult.com
www.optimconsult.com

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 small-scale CDM project activity:

Early consideration of CDM

Prior to development of the project activity the project developer has considered CDM as part of its revenue. This can be proven with the signing of a Letter of Intent (LOI) with OPTIM Consult on May, 2007. A Project Idea Note (PIN) was prepared by OPTIM Consult and submitted to the National Designated Authority on June 28, 2007. A detailed project schedule is presented in the table below.

Action	**Date**
Signing of LOI	May 9, 2007
PIN submitted to DNA	June 28, 2007
Letter of No Objection	September 3, 2007
Public Consultation	September 5, 2007
PDD submitted to DNA	November 30, 2007

Action	Date
Letter of Approval	July 16, 2009
Submitted for validation	April 20, 2010
Gas exploitation contract signature	June 7, 2010
Starting date of the CDM project activity	June 7, 2010

The project consists of collecting and flaring the LFG of the MLF. In Colombia there is no legislation that enforces the collection and flaring of LFG. Currently the LFG is not flared, and it is emitted to the atmosphere. Therefore, in the absence of the project, the LFG would not be carefully collected for flaring and the landfill would continue to emit methane to the atmosphere. This small-scale project would not occur without the CDM project that is being designed.

As discussed, without this CDM project, all of the GHGs emitted by the anaerobic decay of solid waste would continue to be emitted to the atmosphere.

Additionality is demonstrated through the simple cost analysis, i.e. a financially more viable alternative to the project activity would have led to higher emissions, in accordance with Attachment A to Appendix B of simplified modalities and procedures for small-scale CDM project activities. The demonstration of investment barriers is guided by the use of the "The tool for the demonstration and assessment of additionality", Version 05.2, dated 26TH August 2008.

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

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

In the absence of the CDM project activity, there are three basic alternatives:

- Alternative A: the landfill operator continues the current business as usual, venting LFG directly to the atmosphere;
- Alternative B: the landfill operator invests in a LFG collection and flaring system;
- Alternative C: the landfill operator invests in a LFG collection system as well as in LFG power generation equipment. Power generation from other grid-connected sources would therefore be displaced.

Alternative A is the common practice for landfill management in Colombia. LFG is vented directly into the atmosphere by simple passive control systems installed for limited safety reasons in order to prevent explosions, in most landfills without registered CDM Project Activity. Alternative B is not feasible since the proposed activity of LFG capture and flare will not generate financial or economic benefits other than the CDM related income. That is, without assistance from the CDM or any other external sources, the collection and flaring system presents no economic incentive for landfill operators. It does involve however high investment costs. Alternative C is not financially viable. A LFG-based power generation facility offers little incentive in a country with a high percentage of renewable energy sources, which generally make methane to energy projects unattractive from a financial standpoint.

Neither Alternative B nor C are feasible at this stage and therefore Alternative A is the most likely to take place in the absence of the CDM. Thus, Alternative A will be considered as the baseline scenario for the project.

Sub-step 1b: Consistency with mandatory laws and regulations:

There is no existing law requiring landfills to adopt active LFG collection and combustion systems, nor does any law forbid the modification of the current waste treatment systems. All alternatives are therefore credible alternatives to the project developer and are consistent with applicable laws.

Step 2. Investment analysis

Sub-step 2a. Determine appropriate analysis method

A simple cost analysis has been carried out with and without CDM support to demonstrate additionality.

Sub-step 2b. – Option I. Apply simple cost analysis

As established by the "Tool for the Demonstration and Assessment of Additionality", Version 05.2., simple cost analysis requires that costs associated with the CDM project activity and the alternatives identified in Step 1. According to the tool, at least one alternative should be less costly than the project activity. If it is concluded that the proposed CDM project activity is more costly than at least one alternative then the additionality analysis can proceed to Step 4 (Common practice analysis).

The following table shows the costs attached to installing a LFG capture and flaring system in MLF, as stated by Alternative B[3].

ITEM	COST (USD)
Flare and blower, condensate traps, monitoring equipment (500-800 Nm3/h)	255,000
Technical Design	25,000
Installation civil works, management	31,000
Piping	12,000
Drilling	191,000
TOTAL	**514,000**
Tests	12,000
Contingencies (10%)	51,000
GRAND TOTAL	**577,000**

[3] To prepare this table, the project developers quoted more than 10 different flare system suppliers of different origin (ie, Brazil, India, UK, Netherlands, USA, Germany, Switzerland). Evidence has been provided to the DOE for validation purposes

Alternative A does not have any cost attached, so it is very clear from following the methodology, that without CDM resources the project activity would not be undertaken. With this, it is demonstrated that at least one alternative (ie, Alternative A) is less costly than the project activity alternative (ie, Alternative B). Therefore, the additionality analysis continues with step 4 (common practice analysis).

Step 4. Common practice analysis

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

The common practice in Colombia for new waste disposal landfills is to dispose solid wastes according to the required standards for proper waste management, that include proper insulation, structural conformation, rainwater drainage, leachate management, and daily coverage. The current Colombian national legislation does not require landfills to collect and destroy the gas generated. In 2008, 93% of the waste collected in Colombia was disposed in sanitary landfills and 7% was inappropriately managed, either thrown in open dump, buried or burnt. Even though the solid waste disposal situation 4 has recently improved (in 2006 only 81% of the waste was disposed in sanitary landfills), only 59 landfills out of 642 disposal sites (i.e. 9%) are sanitary landfills, whereas 294 are open dumps (i.e. 46%) with no gas control at all[5]. To date, none of the sanitary landfills of the country has incorporated a collection and flaring systems that actively burn the LFG such as the proposed CDM project activity. The very few exceptions are all disposal sites that apply for CDM.

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

There are some LFG capture and flaring projects under development in Colombia, all of them being developed under CDM. Three projects have already been registered (ie, Medellin Curva de Rodas and La Pradera; Bogota Doña Juana; and Pasto), and there are at least six additional projects being prepared. Therefore, the project cannot be considered as common practice and can be considered additional.

B.6. Emission reductions:

B.6.1. Explanation of methodological choices:

The simplified baseline and monitoring Methodology AMS III.G.v06 has been developed for projects comprising ".measures to capture and combust methane from landfills (i.e., solid waste disposal sites) used for disposal of residues from human activities including municipal, industrial, and other solid wastes containing biodegradable organic matter." The methodology is applicable to landfill gas projects where the baseline is the atmospheric release of the gas and the project activities

[4] Report on waste disposal situation in Colombia in 2008 from *Superintendencia de Servicios Públicos Domiciliarios* : http://www.superservicios.gov.co/home/c/document_library/get_file?uuid=56000814-976f-41db-86fe-88858843224e&groupId=10122

[5] Source: PDD for Bionersis Landfill Gas Project in Pasto, Colombia (http://cdm.unfccc.int/UserManagement/FileStorage/OE0GPJ2DVUMS6BXFR91Y48AWCK7NIL)

include situations such as when the captured gas is flared. The monitoring methodology is based on direct measurement of the amount of LFG captured and destroyed at the flare platform. SSC III.G. methodology applies to the case of the Montería project where part of the methane generated by the landfill will be captured and destroyed under the CDM project activity.

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

(Copy this table for each data and parameter)

Data / Parameter:	**Global Warming Potential of Methane**
Data unit:	TonCO2e/TonCH4
Description:	Tons of CO2 equivalent per ton of CH4
Source of data used:	IPCC
Value applied:	21
Justification of the choice of data or description of measurement methods and procedures actually applied :	IPCC
Any comment:	

Data / Parameter:	D_{CH4}
Data unit:	tCH_4 / m^3CH_4
Description:	Methane density
Source of data used:	ACM0001 version 11, adopted at EB 47, "Consolidated baseline and monitoring methodology for landfill gas project activities", page 14
Value applied:	0.0007168
Justification of the choice of data or description of measurement methods and procedures actually applied :	At standard temperature and pressure (0 degree Celsius and 1,013 bars), the density of methane is 0.0007168 t/m^3
Any comment:	

Data / Parameter:	F
Data unit:	m^3CH_4 / m^3LFG
Description:	Fraction of methane in the SWDS gas (volume fraction)
Source of data used:	IPCC 2006 Guidelines for National Greenhouse Gas Inventories
Value applied:	50%
Justification of the choice of data or	Default value according to Tool to determine methane emissions avoided from disposal of waste at a solid waste disposal site.v04

description of measurement methods and procedures actually applied :	
Any comment:	

Data / Parameter:	$W_{j,x}$
Data unit:	MT /year
Description:	Amount of waste being disposed in a given year
Source of data used:	SERVIGENERALES - Operation measurement (weight)
Value applied:	(see table below)
Justification of the choice of data or description of measurement methods and procedures actually applied :	Input for FOD model
Any comment:	The landfilled waste on site from 2005 to 2009 are based on statistic records. Quantities of waste from 2010 to 2017 are forecasted, using current and projected disposal rates, according to SERVIGENERALES business plans and contracts. SERVIGENERALES has also studied the potential for disposal of municipalities within a distance of 60km, which are still disposing on open dumps and would be disposing at the MLF. According to the new Government policies and regulations, these dumps must be closed and wastes previously disposed in those sites must be taken to proper sanitary landfills.

Year/Month	(Tons)	
2005	6,883	Records
2006	25,184	Records
2007	80,375	Records
2008	80,756	Records
2009	90,663	Records
2010	118,330	Forecast
2011	130,206	Forecast
2012	131,508	Forecast
2013	132,823	Forecast
2014	134,151	Forecast
2015	135,493	Forecast
2016	136,847	Forecast
2017	138,216	Forecast

Data / Parameter:	φ
Data unit:	-
Description:	Model correction factor to account for model uncertainties
Source of data used:	Tool to determine methane emissions avoided from disposal of waste at a solid waste disposal site.v04

Value applied:	0.9
Justification of the choice of data or description of measurement methods and procedures actually applied :	Default value
Any comment:	

Data / Parameter:	OX
Data unit:	-
Description:	Oxidation factor (reflecting the amount of methane from SWDS that is oxidized in the soil or other material covering the waste)
Source of data used:	Tool to determine methane emissions avoided from disposal of waste at a solid waste disposal site.v04
Value applied:	0.1
Justification of the choice of data or description of measurement methods and procedures actually applied :	As stated by the "Tool to determine methane emissions avoided from disposal of waste at a solid waste disposal site.v04", for properly managed solid waste sites, the recommended default value is 0.1. Based on IPCC 2006 Guidelines for National Greenhouse Gas Inventories
Any comment:	

Data / Parameter:	DOC_j
Data unit:	Percent
Description:	Fraction of degradable organic carbon (by weight) in EFB
Source of data used:	IPCC 2006 Guidelines for National Greenhouse Gas Inventories Volume 5, Tables 2.4 and 2.5
Value applied:	(see table below)
Justification of the choice of data or description of	As recommended by the Apply *Tool to determine methane emissions avoided from disposal of waste at a solid waste disposal site.v04*

Value applied:

Waste type *j*	**DOCj (% wet waste**
Wood and wood products	43
Pulp, paper and cardboard (other than sludge)	40
Food, food waste, beverages and tobacco (other than sludge)	15
Textiles	24
Garden, yard and park waste	20
Glass, plastic, metal, other inert waste	0

measurement methods and procedures actually applied :	
Any comment:	

Data / Parameter:	DOC_f
Data unit:	Fraction
Description:	Fraction of organic carbon (DOC_j) that can decompose
Source of data used:	IPCC 2006 Guidelines for National Greenhouse Gas Inventories
Value applied:	0.5
Justification of the choice of data or description of measurement methods and procedures actually applied :	As recommended by the *Tool to determine methane emissions avoided from disposal of waste at a solid waste disposal site.v04*
Any comment:	

<table>
<tr><td>Data / Parameter:</td><td>Kj</td></tr>
<tr><td>Data unit:</td><td>Factor</td></tr>
<tr><td>Description:</td><td>Decay rate for the waste stream type j (Empty Fruit Bunches = garden waste type waste)</td></tr>
<tr><td>Source of data used:</td><td>IPCC 2006 Guidelines for National Greenhouse Inventories (adapted from Volume 5, table 3,3)</td></tr>
<tr><td>Value applied:</td><td>Values are applied for tropical conditions with temperatures over 20 ºC and precipitation over 1000 mm
<table>
<tr><td colspan="2" rowspan="2">Waste type j</td><td>Tropical (MAT>20ºC)</td></tr>
<tr><td>Wet (MAP> 1000mm)</td></tr>
<tr><td rowspan="2">Slow degrading</td><td>Pulp, paper, cardboard (other than sludge), textiles</td><td>0.07</td></tr>
<tr><td>Wood, woo products and straw</td><td>0.035</td></tr>
<tr><td>Moderately Degrading</td><td>Other (non-food) organic putrescible garden and park waste</td><td>0.17</td></tr>
</table>
</td></tr>
</table>

<table>
<tr><td></td><td>
<table>
<tr><td>Rapidly degrading</td><td>Food, food waste, sewage sludge, beverages and tobacco)</td><td>0.40</td></tr>
</table>
</td></tr>
<tr><td>Justification of the choice of data or description of measurement methods and procedures actually applied :</td><td>
Factor applied as the plantation is located in a tropical, wet site (>1000 mm), as per the following default table:
<table>
<tr><th colspan="2" rowspan="2">Waste type j</th><th colspan="2">Boreal and Temperate (MAT<20ºC)</th><th colspan="2">Tropical (MAT>20ºC)</th></tr>
<tr><th>Dry (MAP/PET <1)</th><th>Wet MAP/PET >1)</th><th>Dry (MAP< 1000mm)</th><th>Wet (MAP> 1000mm)</th></tr>
<tr><td rowspan="2">Slow degrading</td><td>Pulp, paper, cardboard (other than sludge), textiles</td><td>0.04</td><td>0.06</td><td>0.045</td><td>0.07</td></tr>
<tr><td>Wood, woo products and straw</td><td>0.02</td><td>0.03</td><td>0.025</td><td>0.035</td></tr>
<tr><td>Moderately Degrading</td><td>Other (non-food) organic putrescible garden and park waste</td><td>0.05</td><td>0.10</td><td>0.065</td><td>0.17</td></tr>
<tr><td>Rapidly degrading</td><td>Food, food waste, sewage sludge, beverages and tobacco)</td><td>0.06</td><td>0.185</td><td>0.085</td><td>0.40</td></tr>
</table>
NB: MAT .mean annual temperature, MAP . Mean annual precipitation, PET .potential evapotranspiration. MAP/PET is the ratio between the mean annual precipitation and the potential evapotranspiration
</td></tr>
<tr><td>Any comment:</td><td>Average temperature is 28°C and average rainfall is 1,800 mm (source: http://www2.ideam.gov.co/sectores/aero/climat/premonteria.htm, and http://bart.ideam.gov.co/cliciu/monter/temperatura.htm) and the disposed waste is measured on wet basis
MAP/PET is larger than 1 as PET values range between 1300 and 1790 (source: http://www.persee.fr/web/revues/home/prescript/article/geo_0003-4010_1975_num_84_464_18972?_Prescripts_Search_tabs1=standard&)</td></tr>
</table>

Data / Parameter:	MCF
Data unit:	-
Description:	Methane Correction Factor
Source of data used:	IPCC 2006 Guidelines for National Greenhouse Gas Inventories
Value applied:	1

Justification of the choice of data or description of measurement methods and procedures actually applied :	The Tool to determine methane emissions avoided from disposal of waste at a solid waste disposal site.v04 recommends the following values for MCF: • 1.0 for **anaerobic managed solid waste disposal sites**. These must have controlled placement of waste (i.e., waste directed to specific deposition areas, a degree of control of scavenging and a degree of control of fires) and will include at least one of the following: (i) cover material; (ii) mechanical compacting; or (iii) leveling of the waste; • 0.5 for **semi-aerobic managed solid waste disposal sites**. These must have controlled placement of waste and will include all of the following structures for introducing air to waste layer: (i) permeable cover material; (ii) leachate drainage system; (iii) regulating pondage; and (iv) gas ventilation system; • 0.8 for **unmanaged solid waste disposal sites .deep and/or with high water table**. This comprises all SWDS not meeting the criteria of managed SWDS and which have depths of greater than or equal to 5 meters and/or high water table at near ground level. Latter situation corresponds to filling inland water, such as pond, river or wetland, by waste; • 0.4 for **unmanaged-shallow solid waste disposal sites.** This comprises all SWDS not meeting the criteria of managed SWDS and which have depths of less than 5 meters.
Any comment:	As recommended by the Tool to determine methane emissions avoided from disposal of waste at a solid waste disposal site.v04

Data / Parameter:	f
Data unit:	-
Description:	Fraction of methane captured at the SWDS and flared, combusted or used in other manner
Source of data to be used:	SERVIGENERALES
Value applied:	0
Justification of the choice of data or description of measurement methods and procedures actually applied :	There is no methane capture nor flaring in the baseline
Any comment:	

Data / Parameter:	Solid Waste composition (percentage of waste type j)
Data unit:	-
Description:	Solid waste composition at Montería landfill (percentage of waste type j)

Source of data to be used:	SERVIGENERALES
Value applied:	Waste type j: Percentage Food: 55% Paper, cardboard, textile: 21% Wood, straw: 1% Garden, Park: 0% Inorganic: 18%
Justification of the choice of data or description of measurement methods and procedures actually applied :	Source waste composition: IPCC 2006 Guidelines table 2.3 for region South America
Any comment:	

Data / Parameter:	LFG collection rate
Data unit:	%
Description:	Capture efficiency of the system used in the project activity
Source of data to be used:	Project participants
Value applied:	50%
Justification of the choice of data or description of measurement methods and procedures actually applied :	Ex-ante estimation of the capture efficiency used for ex-ante calculations of emissions reductions, based on the characteristics of the cover, the leachate system and the open areas of the landfill
Any comment:	This is a conservative estimate used in the industry

Data / Parameter:	$EF_{EL,j,y}$
Data unit:	tCO_2e/MWh
Description:	Default CO_2 emission factor from electricity consumption of the project activity
Source of data to be used:	Official factor produced by Unidad de Planeación Minero Energética (UPME), June 2010 –Resolución 180947, 4 junio 2010
Value applied:	0.2849
Justification of the choice of data or description of measurement methods and procedures actually	Grid factor calculation as per AMS I.D.

applied :	
Any comment:	GHG emissions from electricity consumption are almost nill.

Data / Parameter:	EC
Data unit:	MWh
Description:	Electricity consumption for LFG capture and flaring system
Source of data to be used:	Project participants
Value applied:	280
Justification of the choice of data or description of measurement methods and procedures actually applied :	
Any comment:	

B.6.3 Ex-ante calculation of emission reductions:

Following the instructions outlined in AMS-III.G, v06**,** *ex ante* emission reductions estimates are projected for reference purposes only. The project activity, once commissioned, will determine the emissions reductions on an *ex post* basis by measuring project data.

According to AMS-III.G, v06, the ex-ante estimation of the amount of methane that would have been destroyed/combusted during the year, in tonnes of methane (MDproject,y) will be done with the latest version of the approved Tool to determine methane emissions avoided from disposal of waste at a solid waste disposal site, version 04.

Baseline emissions

In order to calculate the emission reductions arising from the project we have followed the formula of the amount of methane that would be generated in the absence of the project activity at the solid waste disposal site ($BE_{CH4,SWDS,y}$) described in the AMS III.G (Version 06). The quantity of methane projected to be generated during a given year is estimated using a multi-phase model, based on a first order decay (FOD) model. The default values are given by the IPCC 2006 Guidelines.

Ex-ante Baseline emissions are calculated using the following expression:

$$BEy = BE_{CH4,SWDS,y} - MD_{reg,y} \quad (1)$$

where,

BE_y = Baseline methane emissions from solid waste decay at year "y" (tonnes of CO_2 equivalent)

$MD_{reg,y}$= methane that would be captured and destroyed to comply with national or local safety requirement or legal regulations in the year "y" (This parameter is 0 as there is no regulation in Colombia mandating for methane flare at landfills).

The amount of methane produced in year y ($BE_{CH4,SWDS,y}$) is calculated as follows:

$$BE_{CH4,SWDS,y} = \varphi \cdot (1-f) \cdot GWP_{CH4} \cdot (1-OX) \cdot \frac{16}{12} \cdot F \cdot DOC_f \cdot MCF \cdot \sum_{x=1}^{y} \sum_{j} W_{j,x} \cdot DOC_j \cdot e^{-k_j \cdot (y-x)} \cdot (1-e^{-k_j}) \quad (2)$$

Where:

$BE_{CH4,SWDS,y}$=Methane emissions avoided during the year *y* from preventing waste disposal at the solid waste disposal site (SWDS) during the period from the start of the project activity to the end of the year *y* (tons of CO_2e)
φ = Model correction factor to account for model uncertainties (default is 0.9)
OX = Oxidation factor = 0.1 (used for managed solid waste disposal sites that are covered with oxidizing material such as soil or compost)
f = Fraction of methane captured at the SWDS and flared or used (0.0)
F = Fraction of methane in the SWDS gas (default value 0.5)
DOC_f= Fraction of degradable organic carbon (DOC) that can decompose (default value 0.5)
DOC_j= Fraction of degradable organic carbon (by weight) in the waste type j
MCF = Methane correction factor (1.0)
$W_{j,x}$ = Amount of organic waste type j in the year x ($W_{j,x}= W_x*A_{jx}$)
W_x= Amount of organic waste in the year x
A_{jx}= Fraction of Wx corresponding to waste type j
K_j= Decay rate for the waste stream type j
x = year since the landfill started receiving wastes (2005)
y = years for which LFG emissions are calculated (2011 to 2017)

Equation (2) above includes a section on which there are fixed parameters that will be applied to all disposed waste. Also, Equation (2) has a section which estimates the future decaying rate for the disposed waste. Below is the calculation procedure.

1. Fixed parameters

Parameter	Variable	Value
Model correction factor	φ	**90%**
Fraction of methane captured at the SWDS and flared, combusted or used in another manner	f	**0**
Global Warming Potential of LFG	GWP_{CH4}	**21**
Oxidation factor: there is an oxidizing cover	OX	**0.1**
Fraction of methane in the LFG	F	**50%**

Parameter	**Variable**	**Value**
Fraction of degradable organic content that can decompose	DOC_f	**50%**
Anaerobic managed site	MCF	**1**

The equation used and the result of the calculation is thus:

φ (1-f) * GWP_{CH4} * (1-OX) * 16/12 * F * DOC_f * MCF =	**5.67**

2. Waste composition ($w_{j,x}$) and Degradable Organic Content (DOC_j)

The type and composition of the wastes of the MLF and the K_i values used are given below:

Waste *type* j	**% of Waste landfilledA_{jx}**	**% DOCjby weighton wet basis**	K_j
A. Paper and textiles	21	40%	0.07
B. Garden and park waste	0	20%	0.17
C. Food waste	55	15%	0.40
D. Wood and straw waste	1	43%	0.035
E. Inert material	18	0	0.000

3. Decaying rate calculation

Based on the above parameters, following is the calculation of the decaying rate for the next 10 years after disposal, using the equation presented below. A full calculation is presented in the Spreadsheet calculation annexed to the PDD.

$$\sum_{x=1}^{y}\sum_{j} W_{j,x} \cdot DOC_j \cdot e^{-k_j \cdot (y-x)} \cdot \left(1-e^{-k_j}\right) \qquad (3)$$

	Years									
Waste type	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
Organic	0.02719	0.01823	0.01222	0.00819	0.00549	0.00368	0.00246	0.00165	0.00110	0.00074
Paper and Cardboard	0.00567	0.00529	0.00493	0.00460	0.00429	0.00400	0.00373	0.00347	0.00324	0.00302
Wood	0.00014	0.00014	0.00013	0.00013	0.00012	0.00012	0.0001	0.00011	0.00011	0.00010
Textile	0	0	0	0	0	0	0	0	0	0
Inorganic and other	0	0	0	0	0	0	0	0	0	0
TOTAL	0.033025	0.02367	0.01729	0.01292	0.00991	0.00780	0.00631	0.00524	0.00446	0.00387

4. Calculation of Baseline Emissions (tCO2e)

Using Equation (1) above, and applying it to the data on waste disposal, following is the estimation of the Baseline Emissions, using the FOD model, up till 2017. The project will capture and destroy methane produced at the landfill, for which a conservative Recovery Rate (Rr) of 50% is assumed, and a Flare Efficiency (FE) of 99% is considered. The first crediting period of the project will last from 2011 to 2017 (7 year crediting period).

Year	Disposal Data (tons)	Baseline Emissions (tCO2e)	Ex-ante estimation of methane destroyed (tCO2e)
	Wj	BEy = ϕ (1-f) * GWPCH4 * (1-OX) * 16/12 * F * DOCf * MCF * ΣΣ wj,x * DOCj * e -kj(y-x) * (1-e -kj)	MDproject, y = BEy * Rr * FE
2005	6,883	1289	
2006	25,184	5640	
2007	80,375	19105	
2008	80,756	28883	
2009	90,663	37930	
2010	118,330	49857	
2011	130,206	60952	30,171
2012	131,508	69554	34,429
2013	132,823	76437	37,836
2014	134,151	82125	40,652
2015	135,493	86970	43,050
2016	136,847	91212	45,150
2017	138,216	95016	47,033
TOTAL	1,341,434	704,969	**278,321**

Project Emissions

PE is calculated using the following formula:

$PE_y = ECy * EF_{grid}$ (4)

Where

PE_y= Emissions from energy used to flare captured landfill gas
ECy = Estimated electricity consumption by project activity in year y (MWh)
$EF_{CO2,elect}$ = Grid Carbon Emission Factor (measured in tonnes CO_2e / MWh)

The electricity consumed by the blowers and other devices used by the closed flaring system results in CO_2 emission that have been calculated to be around 37 tons CO_2/year:

8700 hours * 0.015MW[6]* 0.2849 t CO_2/MWh = 37 t CO_2

Leakage

No leakage effects need to be accounted under this methodology. So: L_y=0

Ex-ante Calculation of Emission Reductions

The GHG emission reduction achieved by the project activity measured as the amount of methane recovered and combusted during a given year is calculated *ex ante* by using the formulae given in the CDM EB cited above:

$ER_{y,\ calculated} = MD_y - PE_y$ (5)

Emission Reductions during project implementation

As stated above, emission reductions for VERIFICATION purposes will be calculated utilizing measurements from CH4 flared, and electricity consumption, applying the formula below:

$ER_{y,\ calculated} = MD_y - MD_{reg,y} - PE_y - Leakage$ (6)

Where:

$ER_{y,\ calculated}$ = emission reduction of the project activity in year "y" (tons of CO_2 e)

MD_y= methane captured and destroyed by the project activity in year "y" (tons of CO_2 e), that will be measured using the conditions of the flaring process.

$MD_{reg,y}$= methane emissions that would be captured and destroyed to comply with national safety requirements or legal regulations in year "y" = 0

PE_y=project emissions in year "y", estimated as 37 tons of CO_2e result from the power used by the project activity facilities. Emission factors for electricity were calculated as described in category I.D.

Leakage = 0 (no equipment is transferred from another activity)

Thus, the equation becomes:

$ER_{y,\ calculated} = MD_y - PE_y$(7)

The methane captured and flared (MD_y) is calculated as follows:

$MD_y = LFG_{burt,y} * W_{CH4,y} * D_{CH4,y} * FE * GWP_{CH4}$(8)

Where:

$LFG_{burt,y}$ = landfill gas flared in year "y" (m^3)

[6] The electrical blower electrical capacity isa round 12 kW, which would require a total plant capacity of 15 kW (0.015 MW)

$W_{CH4,y}$ = methane content in landfill gas
$D_{CH4,y}$ = density of methane at the temperature and pressure of the landfill gas in year "y" (7.168 10^{-4} tons/m^3)
FE= flare efficiency in year "y" (fraction /default value = 0.9)
GWP_{CH4} = CH_4 global warming potential (21 tonnes of CO_2 e / ton CH_4)

PE is calculated using the following formula:

$$PE_y = ECy * EF_{grid} \quad (9)$$

Where
PE_y= Emissions from energy used to flare captured landfill gas
ECy = Actual electricity consumption by project activity in year y (MWh)
$CEF_{CO2,elect}$ = Grid Carbon Emission Factor (measured in tonnes CO_2e / MWh)

Project emissions from flaring of the residual gas stream (PE_{flare}) have to be determined according to the procedure described in the "Tool to determine project emissions from flaring gases containing methane".
As indicated by the tool, the hourly flare efficiency depends on the operation of the flare (eg, temperature), type of flare used (ie, enclosed). Since the flare is going to be enclosed, the project developers and sponsors will use continuous monitoring of the temperature in the gas exhaust of the flare.

The continuous monitoring of the methane destruction efficiency of the flare has been chosen taking into account that if there is no record of the temperature of the exhaust gas of the flare or if the recorded temperature is less than 500 °C for any particular hour, it shall be assumed that during that hour the flare efficiency is zero.

The following seven steps, as defined by the Tool, will be described below:

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 efficiency.

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.

$$FM_{RG,h} = \rho_{RG,n,h} x\ FV_{RG,h} \quad (10)$$

Where

Variable	SI Unit	Description
FMRG,h	kg/h	Mass flow rate of the residual gas in hour h
ρRG,n,h	kg/m^3	Density of the residual gas at normal conditions in hour h
FVRG,h	m^3/h	Volumetric flow rate of the residual gas in dry basis at normal conditions in the hour h

and

$$\rho_{RG,n,h} = \frac{P_n}{\frac{R_u}{MM_{RG,h}} \times T_n} \qquad (11)$$

Where

Variable	SI Unit	Description
ρRG,n,h	kg/m^3	Density of the residual gas at normal conditions in hour h
Pn	Pa	Atmospheric pressure at normal conditions (101 325)
Ru	$Pa.m^3/kmol.K$	Universal ideal gas constant (8 314)
MMRG,h	kg/h	Mass flow rate of the residual gas in hour h
Tn	K	Temperature at normal conditions (273.15)

And

$$MM_{RG,h} = \sum \left(fv_{i,RG,h} * MM_i \right) \qquad (12)$$

Where,

Variable	SI Unit	Description
$MM_{RG,h}$	kg/kmol	Molecular mass of the residual gas in hour *h*
$fv_{i,RG,h}$	-	Volumetric fraction of component *i* in the residual gas in the hour *h*
MM_i	kg/kmol	Molecular mass of residual gas component *i*
i	The components CH_4, N_2	

And

$$fv_{N2,RG,h} = 1 - fv_{CH4,RG,h} \qquad (13)$$

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

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:

$$fm_{j,h} = \frac{\sum_i fv_{i,RG,h} * AM_j * NA_{j,i}}{MM_{RG,h}} \qquad (14)$$

Where,

Variable	SI Unit	Description
$fm_{j,h}$	-	Mass fraction of element *j* in the residual gas in hour *h*
$fv_{i,RG,h}$	-	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 and nitrogen	
i	The components CH_4, N_2	

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

This step is applicable since the methane combustion efficiency of the flare will be continuously monitored. Determine the average volumetric flow rate of the exhaust gas in each hour *h* based on a stoichiometric calculation of the combustion process, which depends on the chemical composition of the residual gas, the amount of air supplied to combust it and the composition of the exhaust gas, as follows:

$$TV_{n,FG,h} = V_{n,FG,h} * FM_{RG,h} \qquad (15)$$

Where,

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

$$V_{n,FG,h} = V_{n,CO_2,h} + V_{n,O_2,h} + V_{n,N_2,h} \quad (16)$$

Where,

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

$$V_{nCO2,h} = \frac{fm_{C,h}}{AM_c} * MV_n \quad (17)$$

Where,

Variable	SI Unit	Description
$V_{n,CO2,h}$	m^3/kg residual gas	Quantity of CO_2 volume free in the exhaust gas of the flare at normal conditions per kg of residual gas in the hour ***h***
$fm_{C,h}$	-	Mass fraction of carbon in the residual gas in the hour ***h***
AM_C	kg/kmol	Atomic mass of carbon
MV_n	m^3/kmol	Volume of one mole of any ideal gas at normal temperature and pressure (22.4 m^3/Kmol)

$$V_{n,O_2,h} = n_{O_2,h} * MV_n \quad (18)$$

Where,

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

$$V_{n,N2,h} = MV_n * \left\{ \frac{fm_{N,h}}{200 AM_N} + \left(\frac{1-MF_{O_2}}{MF_{O_2}} \right) * \left[F_h + n_{O_2,h} \right] \right\}$$ (19)

Where,

Variable	SI Unit	Description
$V_{n,N2,h}$	m^3/kg residual gas	Quantity of N_2 volume free in the exhaust gas of the flare at normal conditions per kg of residual gas in the hour *h*
MV_n	m^3/kmol	Volume of one mole of any ideal gas at normal temperature and pressure (22.4 m^3/Kmol)
$fm_{N,h}$	-	Mass fraction of nitrogen in the residual gas in the hour *h*
AM_n	kg/kmol	Atomic mass of nitrogen
MF_{O2}	-	O_2 volumetric fraction of air
F_h	kmol/kg residual gas	Stochiometric quantity of moles of O_2 required for a complete oxidation of one kg residual gas in hour *h*
$n_{O2,h}$	kmol/kg residual gas	Quantity of moles O_2 in the exhaust gas of the flare per kg residual gas flared in hour *h*

$$V_{n,CO_2,h} = \frac{fm_{C,h}}{AM_C} * MV_n$$ (20)

Where,

Variable	SI Unit	Description
$V_{n,CO2,h}$	m^3/kg residual gas	Quantity of CO_2 volume free in the exhaust gas of the flare at normal conditions per kg of residual gas in the hour *h*
$fm_{C,h}$	-	Mass fraction of carbon in the residual gas in the hour *h*
AM_C	kg/kmol	Atomic mass of carbon
MV_n	m^3/kmol	Volume of one mole of any ideal gas at normal temperature and pressure (22.4 m^3/Kmol)

$$n_{O_2,h} = \frac{t_{O_2,h}}{\left(1-(t_{O_2,h}/MF_{O_2})\right)} \times \left[\frac{fm_{C,h}}{AM_C} + \frac{fm_{N,h}}{2AM_N} + \left(\frac{1-MF_{O_2}}{MF_{O_2}} \right) \times F_h \right]$$ (21)

Where,

Variable	SI Unit	Description
$n_{O2,h}$	kmol/kg residual gas	Quantity of moles O_2 in the exhaust gas of the flare per kg residual gas flared in hour *h*
$t_{O2,h}$	-	Volumetric fraction of O_2 in the exhaust gas in the hour *h*
MF_{O2}	-	Volumetric fraction of O_2 in the air (0.21)
F_h	kmol/kg residual gas	Stochiometric quantity of moles of O_2 required for a complete oxidation of one kg residual gas in hour *h*
$fm_{j,h}$	-	Mass fraction of element *j* in the residual gas in hour *h* (from equation 4)
AM_j	kg/kmol	Atomic mass of element *j*
j		The elements carbon (index C) and nitrogen (index N)

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

(22)

Where,

Variable	SI Unit	Description
F_h	kmol O_2/kg residual gas	Stoichiometric quantity of moles of O_2 required for a complete oxidation of one kg residual gas in hour *h*
$fm_{j,h}$	-	Mass fraction of element *j* in the residual gas in hour *h* (from equation 4)
AM_j	kg/kmol	Atomic mass of element *j*
j		The elements carbon (index C), hydrogen (index H) and oxygen (index O)

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

This step is only applicable if the methane combustion efficiency of the flare is continuouslymonitored, as it is the case for this project.The mass flow of methane in the exhaust gas is based on the volumetric flow of the exhaust gasand the measured concentration of methane in the exhaust gas, as follows:

$$TM_{FG,h} = \frac{TV_{n,FG,h} * fv_{CH_4,FG,h}}{1000000}$$

(23)

Where,

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

STEP 5. Determination of methane mass flow rate in the residual gas on a dry basis

The quantity of methane in the residual gas flowing into the flare is the product of the volumetric flow rate of the residual gas ($FV_{RG,h}$), the volumetric fraction of methane in the residual gas ($fv_{CH4,RG,h}$) and the density of methane ($\rho_{CH4,n,h}$) in the same reference conditions (normal conditions and dry or wet basis).

Both measurements (flow rate of the residual gas and volumetric fraction of methane in the residual gas) will be referred 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 will 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).

$$TM_{RG,h} = FV_{RG,h} * fv_{CH_4,RG,h} * \rho_{CH_4,n} \quad (24)$$

Where,

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

STEP 6. Determination of the hourly flare efficiency

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).

This project will make use of **enclosed flares and continuous monitoring** of the flare efficiency; therefore, the flare efficiency will be calculated as follows:

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

$$\eta_{flare,h} = 1 - \frac{TM_{FG,h}}{TM_{RG,h}} \quad (25)$$

Where,

Variable	SI Unit	Description
$\eta_{flare,h}$	-	Flare efficiency in the hour *h*
$TM_{FG,h}$	kg/h	Methane mass flow rate in exhaust gas averaged in a period of time t (hour, two months or year)
$TM_{RG,h}$	kg/h	Mass flow rate of methane in the residual gas in the hour *h*

However, for the estimations of emission reductions and if no records for monitoring exist, the default value for enclosed flare is selected and the flare efficiency in the hour *h* is:

- 0% if the temperature in the exhaust gas of the flare (T_{flare}) is below 500ºC for more than 20 minutes during the hour *h*.
- 50% if the temperature in the exhaust gas of the flare (T_{flare}) is above 500ºC 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 500ºC 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

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

$$PE_{flare,y} = \sum_{h=1}^{8760} TM_{RG,h} \times \left(1 - \eta_{flare,h}\right) \times \frac{GWP_{CH4}}{1000} \quad (26)$$

Where,

$PE_{flare,y}$	t_{CO2e}	Project emissions from flaring of the residual gas stream in year y
$TM_{RG,h}$	Kg/h	Mass flow rate of methane in the residual gas in the hour h
GWP_{CH4}	t_{CO2e}/t_{CH4}	Global Warming Potential of methane

The following fixed constants will be used for the calculation:

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

Parameter	SI Unit	Description	Value
MM_{N2}	kg/kmol	Molecular mass of nitrogen	28.02
AM_c	kg/kmol (g/mol)	Atomic mass of carbon	12.00
AM_h	kg/kmol (g/mol)	Atomic mass of hydrogen	1.01
AM_o	kg/kmol (g/mol)	Atomic mass of oxygen	16.00
AM_n	kg/kmol (g/mol)	Atomic mass of nitrogen	14.01
Pn	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
GWP_{CH4}	$tCO2/tCH_4$	Global warming potential of methane	21
MV_n	$m^3/Kmol$	Volume of one mole of any ideal gas at normal	22.414
$\rho_{CH4,n}$	kg/m^3	Density of methane gas at normal conditions	0.7168
$NA_{i,j}$	Dimensionless	Number of atoms of element j in component i, depending on molecular structure	

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

Year	Estimation of baseline emissions (tons CO_2e)	Estimation of Project emissions (tons CO_2e)	Estimation of Leakage (tons CO2e)	Estimation of overall emission reductions (tons CO_{2e})
2011	30,171	37	0	30,134
2012	34,429	37	0	34,392
2013	37,836	37	0	37,799
2014	40,652	37	0	40,614
2015	43,050	37	0	43,013
2016	45,150	37	0	45,113
2017	47,033	37	0	46,995
Total	**278,321**	**262**	**0**	**278,059**

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

B.7.1 Data and parameters monitored:

Data / Parameter:	**LFG flared**
Data unit:	Nm^3
Description:	Total amount of landfill gas captured and flared at Normal temperature and pressure
Source of data to be used:	Flow meter
Value of data	Tbd
Description of measurement methods and procedures to be applied:	Continuous measurement by flow meters. The meters will provide a cumulative flow reading. Measurements of cumulative flow will be recorded electronically backed up with a manual recording every 24 hours, these recorded values will be entered into a spreadsheet. In case of breakdown or suspected problems, the manufacturer will be called in.

QA/QC procedures to be applied:	The meters will be subject to maintenance and calibration according to manufacturer's recommendations. On site staff will receive some training in CDM monitoring and the maintenance requirements of the flow meters. Calibrations will be carried out by the manufacturer or a suitably qualified external company. Calibration and maintenance records will be retained. Data will be recorded in hard copy format and transferred to an electronic file.
Any comment:	Data stored in the meter and electronically transmitted. Data aggregated monthly and yearly. No separate monitoring of temperature and pressure is necessary when using flow meters that automatically compensate for temperature and pressure, expressing LFG volumes in normalized cubic meters (Nm3).Otherwise, LFG temperature and pressure sha11 be monitored as described in the tables below for each parameter in order to express LFG volumes in normalized cubic meters (Nm3).

Data / Parameter:	**Methane content**
Data unit:	%
Description:	% CH4 in LFG
Source of data to be used:	Gas analyzer
Value of data	Tbd
Description of measurement methods and procedures to be applied:	Methane content will be measured using a continuous gas analyzer. (Infra red LFG analyzer). Data will be measured at least once per hour, recorded electronically, and data will be kept during the crediting period and two years after. Data will also be aggregated monthly/yearly.
QA/QC procedures to be applied:	Gas analyzers should be subject to a regular calibration, maintenance and testing regime to ensure accuracy. The analyzers will be subject to maintenance and calibration according to manufacturer's recommendations.
Any comment:	Paired values of the methane fraction of the landfill gas and LFG flow which are averaged for the same time interval will be used in the calculation of methane destroyed.

Data / Parameter:	**Temperature**
Data unit:	ºC
Description:	LFG temperature
Source of data to be used:	Temperature sensor/probe
Value of data	Tbd
Description of measurement methods and procedures to be applied:	Data will be measured at least once per hour, recorded electronically. Data will also be aggregated monthly/yearly. Records will be kept during the crediting period and two years after.

QA/QC procedures to be applied:	Measurements instruments will be subject to a regular maintenance and calibration according to manufacturer's recommendations to ensure accuracy
Any comment:	No separate monitoring of temperature is necessary when using flow meters that automatically measure temperature and pressure, expressing LFG volumes in normalized cubic meters (Nm3).Temperature of the landfill gas will be measured to determine the density of methane in the landfill gas.

Data / Parameter:	**Pressure**
Data unit:	Pa
Description:	LFG pressure
Source of data to be used:	Pressure gauge
Value of data	Tbd
Description of measurement methods and procedures to be applied:	Data wi11 be measured at least once per hour, recorded electronically. Data will also be aggregated monthly/yearly. Records will be kept during the crediting period and two years after.
QA/QC procedures to be applied:	The gauges will be subject to regular maintenance and calibration according to manufacturer's recommendations to ensure accuracy.
Any comment:	No separate monitoring of pressure is necessary when using flow meters that automatically measure temperature and pressure, expressing LFG volumes in normalized cubic meters (Nm3). Pressure of the landfill gas will be measured to determine the density of methane in the landfill gas.

Data / Parameter:	**Combustion efficiency**
Data unit:	%
Description:	Flaring efficiency to indicate % of methane effectively combusted
Source of data to be used:	Thermistor, Samples, Calculation
Value of data	Tbd
Description of measurement methods and procedures to be applied:	Measured as the fraction of time in which the gas is combusted in the flare multiplied by the efficiency of the flaring process.
QA/QC procedures to be applied:	The meters will be subject to maintenance and calibration according to manufacturer's recommendations. Calibrations will be carried out by the manufacturer or a suitably qualified external company. Calibration and maintenance records will be retained. Data will be recorded in hard copy format and transferred to an electronic file.
Any comment:	

Data / Parameter:	Operating hours of the LFG recovery plant

Data unit:	Hours
Description:	
Source of data to be used:	Estimation of load to operate LFG recovery plant
Value of data	8700 hours/y
Description of measurement methods and procedures to be applied:	
QA/QC procedures to be applied:	Operating hours of the LFG recovery plant
Any comment:	Hours

Data / Parameter:	$EF_{CO2,elect}$
Data unit:	tCO2e/MWh
Description:	Grid Carbon Emission Factor, according to composition of power generation sources at Colombian grid
Source of data to be used:	UPME (Ministry of Energy)
Value applied:	0.2849
Justification of the choice of data or description of measurement methods and procedures actually applied :	As stated officially by UPME, through Resolución 180947 of June 4 2010 from the Ministry of Mines and Energy. To be updated every year according to UPME's calculation
Any comment:	

Data / Parameter:	**Electricity consumption at methane capture and flaring plant**
Data unit:	MWh
Description:	Consumption of electricity of plant for capture and flaring of LFG
Source of data to be used:	Servigenerales
Value applied:	TBD
Justification of the choice of data or description of measurement methods and procedures actually applied :	To be multiplied by Combined grid emission factor to determine project emissions
Any comment:	Resulting from consumption of power for flare, blower, analyzers, and lighting

Data / Parameter:	$W_{CH4,y}$

Data unit:	% (m^3/m^3LFG)
Description:	Methane fraction in LFG
Source of data to be used:	Gas analyzer
Value of data	TBD
Description of measurement methods and procedures to be applied:	Continuous measurement
QA/QC procedures to be applied:	The gas analyzer will be subject to a regular maintenance and testing regime to ensure accuracy.
Any comment:	The methane content will be measured on the same basis as the landfill gas flow

Data / Parameter:	$PE_{flare,y}$
Data unit:	tCO2e
Description:	Project emissions from flaring of the residual gas stream in the year y
Source of data to be used:	Calculated according to *Tool to determine project emissions from flaring gases containing methane*
Value of data	TBD
Description of measurement methods and procedures to be applied:	The parameters $fv_{i,h}$, $FV_{RG,h}$, $t_{O2,h}$, $fv_{CH4,FG,h}$and T_{flare} will be monitored, so $PE_{flare,y}$ can be calculated according to the *Tool* The flare efficiency will be continuously monitored.
QA/QC procedures to be applied:	See parameters $fv_{i,h}$, $FV_{RG,h}$, $t_{O2,h}$, $fv_{CH4,FG,h}$and T_{flare}
Any comment:	As a simplified approach, project participants will only measure the methane content of the residual gas and consider the remaining part as N_2

Data / Parameter:	$fv_{i,h}$
Data unit:	-
Description:	Volumetric fraction of component *i* in the residual gas in the hour h where *i* = CO, CO_2, O_2, H_2, N_2 and CH_4 (already considered as w_{CH4} above)
Source of data to be used:	Continuous gas analyzer
Value of data	TBD
Description of measurement methods and procedures to be applied:	Measured on the same basis as the measurement of the volumetric flow rate of the residual gas ($FV_{RG,h}$) when the residual gas temperature exceeds 60 ºC Continuously. Values to be averaged hourly or at a shorter time interval

QA/QC procedures to be applied:	Analyzers will be periodically calibrated according to the manufacturer's recommendation. A zero check and a typical value check will be performed by comparison with a standard certified gas.
Any comment:	As a simplified approach, project participants will only measure the methane content of the residual gas and consider the remaining part as N_2

Data / Parameter:	$FV_{RG,h}$
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:	Measurements by project participants using a flow meter.
Value of data	TBD
Description of measurement methods and procedures to be applied:	Measured on the same basis as the measurement of the volumetric flow rate of the residual gas ($fv_{i,h}$) when the residual gas temperature exceeds 60 ºC Continuously. Values to be averaged hourly or at a shorter time interval
QA/QC procedures to be applied:	The flow meter will be subject to a regular maintenance and testing regime to ensure accuracy. Periodical calibration
Any comment:	This parameter is the same as LFG_{flare}

Data / Parameter:	$T_{O2,h}$
Data unit:	-
Description:	Volumetric fraction of O_2 in the exhaust gas of the flare in the hour *h*
Source of data to be used:	Continuous gas analyzer
Value of data	TBD
Description of measurement methods and procedures to be applied:	Extractive sampling analyzers with water and particulates removal devices or in situ analyzer for wet basis determination. The point of measurement (sampling point) shall be in the upper section of the flare (80% of total flare height). Sampling shall be conducted with appropriate sampling probes adequate to high temperatures level (e.g. inconel probes). Frequency: Continuously. Values to be averaged hourly or at a shorter time interval
QA/QC procedures to be applied:	Analyzers will be periodically calibrated according to the manufacturer's recommendation. A zero check and a typical value check will be performed by comparison with a standard certified gas.
Any comment:	

Data / Parameter:	$fv_{CH4,FG,,h}$
Data unit:	Mg/m3

Description:	Concentration of methane in the exhaust gas of the flare in dry basis at normal conditions in the hour h
Source of data to be used:	Continuous gas analyzer
Value of data	TBD
Description of measurement methods and procedures to be applied:	Extractive sampling analyzers with water and particulates removal devices or in situ analyzer for wet basis determination. Measurement principle: Infrared + signal 4-20 mA. The point of measurement (sampling point) shall be in the upper section of the flare (80% of total flare height). Sampling shall be conducted with appropriate sampling probes adequate to high temperatures level (e.g. inconel probes). Frequency: Continuously. Values to be averaged hourly or at a shorter time interval
QA/QC procedures to be applied:	Analyzers will be periodically calibrated according to the manufacturer's recommendation. A zero check and a typical value check will be performed by comparison with a standard certified gas.
Any comment:	Monitoring of this parameter is only applicable in case of enclosed flares and continuous monitoring of the flare efficiency. Measurement instruments may read ppmv or % values. To convert from ppmv to mg/m^3 simply multiply by 0.7168. 1% equals 10 000 ppmv.

Data / Parameter:	T_{flare}
Data unit:	°C
Description:	Temperature in the exhaust gas of the flare
Source of data to be used:	Thermocouple
Value of data	TBD
Description of measurement methods and procedures to be applied:	Measure the temperature of the exhaust gas stream in the flare by a Type N thermocouple. A temperature of 500°C indicates that a significant amount of gases are still being burnt and that the flare is operating Frequency: Continuously.
QA/QC procedures to be applied:	Thermocouples should be replaced or calibrated every year
Any comment:	

Data / Parameter:	Other flare operation parameters
Data unit:	-
Description:	To be determined by the flare manufacturer (information not available at the validation stage)
Source of data to be used:	Measurement by project participants
Value of data	TBD

Description of measurement methods and procedures to be applied:	
QA/QC procedures to be applied:	
Any comment:	Only applicable in case of use of default values

B.7.2 Description of the monitoring plan:

Purpose of the Monitoring Plan

In the context of the Clean Development Mechanism (CDM) of the Kyoto Protocol, monitoring describes the systematic surveillance of a project's performance by measuring and recording performance-related indicators relevant to the project or activity. Verification is the periodic auditing of monitoring results, the assessment of achieved emission reductions (ER) and of the project's continued conformance with all relevant project criteria.

The Monitoring Plan (MP) for the Montería Landfill Gas Capture and Flaring Project described below describes the requirements for the collection, processing and auditing of data from the project for the purpose of calculating and verifying the ERs the project has produced.

Overview

According to the methodology, the monitoring methodology is based on direct measurement of the amount of landfill gas captured and destroyed at the flare platform. The Monitoring Plan provides for direct measurement of the quantity and quality of LFG flared and the non-combusted methane in the flare, and also continuous monitoring of the on site electricity consumption for project requirements.

Continuous on-site measurements of both the LFG volumetric flow and the fraction of methane in the LFG will be performed to calculate the amount of methane in the LFG captured. LFG temperature and pressure will be daily measured and recorded in order to calculate the methane density and therefore mass flow. Finally, methane content in the exhaust gases will also be monitored to verify the flare efficiency and to correct the amount of methane actually destroyed by the project activity.

Monitoring and Calculation of Emission Reductions (Operational Structure)

The emission reductions from the MLFGCF Project result from the avoided landfill methane emissions due to the collection and flaring (and conversion to CO2) of the methane contained in the landfill gas.

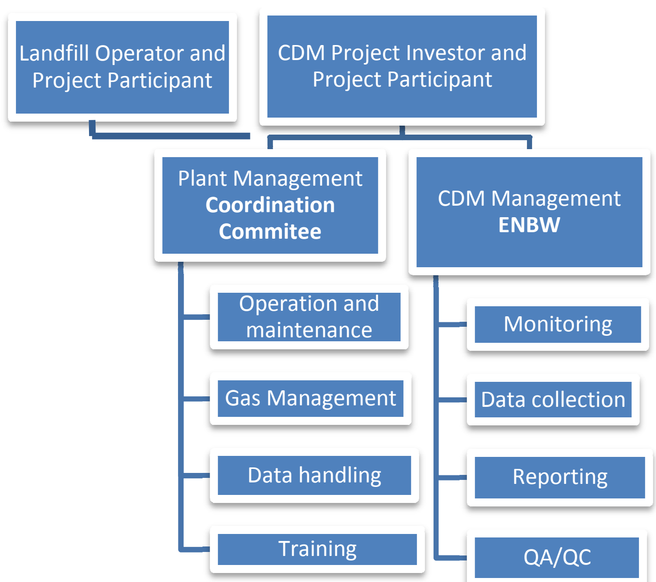
The amount of methane recovered will be determined by on-site continuous measurements from flow meters and gas analysers. These two measurements will be adjusted for the flare efficiency represented by the fraction of methane in LFG that is not combusted in the flare but emitted to the atmosphere. The operating hours of the system will be continuously monitored through a timer and will be take into account to determine the flare availability.

Thus, the amount of methane in the exhaust gas will be discounted from the product of the LFG captured (flow meter) and the methane content (gas analyzer). The resulting amount of methane must be multiplied by the methane density (t/m^3) at the corresponding temperature and pressure to obtain the methane emission reductions of the project activities in tCH_4. In order to obtain the result in tCO_2 equivalent, the tons of CH_4 will be multiplied by the methane Global Warming Potential.

Finally, the time in which the flare is in operation will be continuously recorded to calculate the amount of methane actually destroyed and also an energy counter will be used to record the electricity consumption to meet project activities.

The combustion efficiency in terms of the percentage of combusted methane will be determined by the difference between the amount of captured methane in LFG (before flare) and the non-combusted methane (from the sampling ports in the flare).

Organizational chart for Project Monitoring



Monitoring Plan Management

The Monitoring Plan (MP) will be used by all parties involved in Montería Landfill Gas Capture and Flaring Project with responsibilities in the project implementation and verification activities:

- EnBW will oversee the development of the project and will periodically carry out internal audits to assure that project activities are in compliance with operational and monitoring requirements.

- EnBW will constitute a Coordination Committee for the CDM project. This Management Unit will implement the monitoring plan. The Coordination Committee will be responsible for the activities related to implementation of the procedures as described in the monitoring plan. *SERVIGENERALES* will adopt the instructions given in the MP and accomplish all activities related to the implementation of the procedures given in the guidelines for LFG plant operation and monitoring.

- The main responsibilities of the operator are related to:

    - *Data handling*: maintaining an adequate system for collecting, recording and storing data according to the protocols determined in the MP, checking data quality, collection and record keeping procedures regularly.
    - *Reporting*: preparing periodic reports that include emission reductions generated and observations regarding MP procedures.
    - *Training*: assuring personnel training regarding the performance of the project activities and the MP.
    - *Quality control and quality assurance*: complying with quality control and quality assurance procedures to facilitate periodical audits and verification.

Training

For all staff involved in the CDM project, a training plan will be developed to provide them with the skills necessary to conduct their work in a safe manner and ensure the successful operation of the project activity. The CDM manager should ensure that only trained and skilled staff will work in the CDM project. Depending on task designation, the staff should attain a comprehensive knowledge with regard to the general and technical aspects of the project, as well as the basic understanding of CDM. Training will include:

a) Review of equipment and captors
b) Calibration requirement
c) Configuration of monitoring equipment
d) Maintenance requirement

Quality control and quality assurance procedures

A quality management system will be established to ensure the quality and accuracy of the measured data, including corrective measures in case of non-conformity. The quality management system will primarily include the following components:

<u>Data records</u>

Daily readings of all meters on site will be documented in paper worksheets. Additionally, all data collected will be recorded in electronic files and backups will be made regularly. Periodic controls of the LFG on site monitoring records will be carried out to check any deviations from the estimated ERs and to evaluate the project performance. Any divergence will be investigated and addressed by the Unit Manager and, recorded for future reference.

<u>Data evaluation</u>

Standard data evaluation methods will be followed in order to guarantee that the data is reliable and accurate.

Equipment calibration and maintenance

Flow meters, gas analyzers, other critical CDM project equipment will be subject to regular maintenance and testing according to technical specifications from the manufactures to ensure accuracy and good performance. Equipment calibration will be conducted periodically according to technical specifications.

Corrective actions

The quality control and quality assurance procedures include the handling and correction of non conformities in the implementation of the project or the monitoring plan.

Emergency procedures

In case of equipment malfunction or breakdown, corrective actions will be carried out to minimize the impact.

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

The base line was constructed in July of 2007 by OPTIM, and updated on September 2010. OPTIM is a CDM advisor on the project, and it is also a project participant.

Contact data

Mr. Eduardo Uribe
Mr. Juan Andrés López-Silva

OPTIM CONSULT LTDA
Carrera 7 No. 80-49, Of. 302
Bogotá, Colombia
Phone: + (571) 321 44 67
Fax:+ (571) 317 36 28
E-maíl: jlopezsilva@optimconsult.com
euribe@optimconsult.com
www.optimconsult.com

SECTION C. Duration of the project activity / crediting period

C.1 Duration of the project activity:

C.1.1. Starting date of the project activity:

June 7, 2010[7]

The project is already in the design phase, and potential equipment and material suppliers have already been identified and have provided quotes.

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

Three crediting periods of 7 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:

January 1st, 2011

C.2.1.2. Length of the first crediting period:

7 years, renewable for a total of three crediting periods, up to 21 years

C.2.2. Fixed crediting period:

C.2.2.1. Starting date:

N.A.

C.2.2.2. Length:

N.A.

[7] According to the CDM Glossary of Terms, "The starting date of a CDM project activity is the earliest date at which either the implementation or construction or real action of a project activity begins…In light of the above definition, the start date shall be considered to be the date on which the project participant has committed to expenditures related to the implementation or related to the construction of the project activity."

SECTION D. Environmental impacts

D.1. If required by the host Party, documentation on the analysis of the environmental impacts of the project activity:

According to Colombian regulations, an Environmental Impact Assessment is not required for the development of this CDM project. The installation and the operation of this CDM project is not expected to result in any significant negative environmental impacts.

Emissions from the flare include the carbon dioxide which is considered to be a natural product of the carbon cycle. In the combustion of landfill gas, carbon dioxide is additionally produced, but this is also considered to be part of the natural carbon cycle and not of anthropogenic origin. There will be minimal visual impact from the flare, and noise and vibration from the blower and flare will be limited to the localized site, which has no near settlements around. There is a positive environmental impact on the environment due to the project activity. Landfill gas emissions are decreased, reducing greenhouse gas emissions and impacts to localized air pollution. Bad odors will be diminished. Operationally, proper management of the landfill gas will reduce the potential for landfill fires and the associated release of incomplete combustion products. Further, the driving force for subsurface migration of landfill gas and landfill gas components is minimized.

The social impact of the project is expected to be positive, as implementing new technologies will have environmental benefits, while triggering climate change awareness in the community. In addition, the implementation of the proposed project activity and the commitment with the CDM will allow not only improvements in the landfill operation in the short term but also to establish sustainable MSW management practices in the long run. MLF will also deliver local community benefits, as it will create a new source of jobs during the construction, operation and maintenance of the LFG recovery plant. Similarly, it will also contribute to attract new players who could bring the capacity to implement a new technology. Monteria is a region of relative importance for northern Colombia's agro-industry. The project is critical the sense that the region faces numerous environmental problems and lack of adequate solid waste is still common place. At last, the project has an important replication potential, which will trigger environmental awareness (specifically in terms of climate change and renewable energy sources) and improved waste management techniques.

This CDM project, as requested by the local stakeholders, will also become an educational opportunity for the students of the local schools and universities. The project participants have offered to the local educational institutions full and unrestricted access to the information and to the site for the development of teaching, training and research activities.

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:

There are no significant negative environmental impacts due to the small-scale project activity. All the impacts of the project activity listed above will contribute to improve both local and global environment. There are no transboundary environmental impacts.

SECTION E. Stakeholders' comments

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

As presented in Annex 5, a meeting with the stakeholders was held on September 5th of 2007 in the city of Montería. The meeting was called and coordinated by SERVIGENERALES and OPTIM. Forty persons attended the meeting. The list of attendants is presented in annex four. During that meeting the CDM project was explained to the stakeholders, and their questions and doubts were answered and clarified.

The assistants made several proposition in relation to the development of the project. They proposed to evaluate the technical and economical viability of using the methane of the Landfill for energy generation or for domestic consumption. They also requested to have access to the project so that it could be used for educational and research purposes. SERVIGENERALES offered its office of community communications to ensure a constant dialog between local stakeholders and the project participants.

E.2. Summary of the comments received:

Most stakeholders were interested in the possibility of using the methane form the landfill for energy generation or for domestic consumption. It was explained that, at this time, those options were not economically feasible. However, the project participants indicated that if the prices of electricity and gas increase, the financial viability of the use of LFG would increase, and that, in that in such a case an energy use of LFG could be undertaken.

The participants form the local schools and universities proposed that the CDM project should become an opportunity for them to learn about climate change, waste management and disposal, landfill management and, eventually, about energy generation with methane. The Universities also saw the project as an opportunity for the development of research projects by its students and professors.

There was also a discussion regarding other potential CDM projects in this agricultural and cattle region. Among the alternatives identified for this region were the combustion of methane from the anaerobic decomposition of organic wastes from feedlots and anaerobic lagoons, and tree plantations.

The participants expressed their interest and their support for the development of this CDM project.

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

The projects participants offered the local universities and schools full and unrestricted access to the project. They offered to facilitate all the information related to the development of the project. They also offered unrestricted access to the landfill to undertake research and training activities. They also offered their staff to explain and to advise the development of the training and research activities of those universities and schools in areas related to the project. Following the interest of some stakeholders in relation to the economic use of LFG for energy generation or for domestic gas consumption, the project participants responded that under the current price energy policies this possibility was not economically feasible.

Annex 1

CONTACT INFORMATION ON PARTICIPANTS IN THE PROJECT ACTIVITY

Organization	OPTIM CONSULT LTDA
Street	Carrera 7 No. 80-49, Ofc. 302
Building	Centro de Negocios El Nogal
City	Bogotá, D.C.
State / Region	South America
Country	Colombia
Telephone	(571) 321 44 67
Fax	(571) 317 36 28
E.Mail	jlopezsilva@optimconsult.com,euribe@optimconsult.com
Represented by	Juan Andrés López
Title	President
Mobile	571 311 481 4086
Direct telephone	(571) 321 44 67
Direct fax	(571) 317 36 28
Personal E-Mail	jlopezsilva@optimconsult.com

Organization	SERVIGENERALES S.A ESP
Street	Carrera 15 # 95 – 51
Building	
City	Bogotá, D.C.
State / Region	South America
Country	Colombia
Telephone	(571) 622 7039
Fax	(571) 610 15 92
Represented by	Chad Muñoz
Title	

Organization	CARBON BW COLOMBIA S.A.S.
Street	Calle 94A No. 13-91 OFICINA 402
Building	
City	Bogotá, D.C.
State / Region	South America
Country	Colombia
Telephone	+49-721-63-23101
Fax	+49-721-63-23119
Represented by	Mr Johannes Laubach
Title	General Manager

Organization	EnBW Energie Baden-Württemberg AG
Street	DurlacherAllee 93
Building	
City	76131 Karlsruhe
State / Region	Europe
Country	Germany
Telephone	+49-721-63-23101
Fax	+49-721-63-23119
Represented by	Mr Bernhard Graeber
Title	Project Manager for International Climate Projects

Annex 2

INFORMATION REGARDING PUBLIC FUNDING

NO PUBLIC FUNDS FROM ANNEX 1 COUNTRY ARE INVOLVED IN THE PROPOSED PROJECT.

Annex 3

BASELINE INFORMATION

A spreadsheet detailing the calculation is provided for validation. Please find background information regarding the calculation in PDD section B.6.3 above.

Annex 4

MONITORING INFORMATION

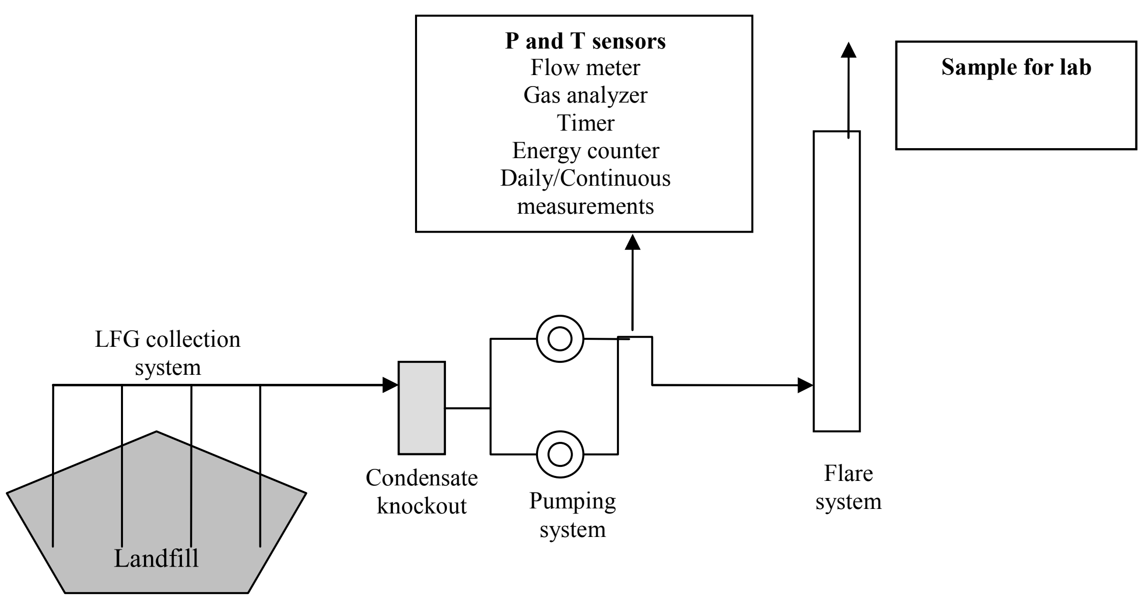
I. Monitoring procedures and layout

According to the AMS III.G V 6, methodology applied for this project activity, the monitoring methodology is based on direct measurement of the amount of landfill gas captured and destroyed at the flare platform. The Monitoring Plan provides for direct measurement of the quantity and quality of LFG flared and the non-combusted methane in the flare, and also continuous monitoring of the on site electricity consumption for project requirements.

Continuous on-site measurements of both the LFG volumetric flow and the fraction of methane in the LFG will be performed to calculate the amount of methane in the LFG captured. LFG temperature and pressure will be daily measured and recorded in order to calculate the methane density and therefore mass flow. Finally, methane content in the exhaust gases will also be monitored to verify the flare efficiency and to correct the amount of methane actually destroyed by the project activity.

*The amount of methane determined through direct monitoring and measurement of the captured LFG represents the actual methane emissions avoided by the project activities in a year "y", that is, the Emission Reductions (*ERy*) of this project.*

Figure A4.1. Basic scheme of the Monitoring Plan for Montería Landfill Gas Capture and Flare Project



The performance indicators, key data needs, and monitoring procedures are described in Section B.7.2 above. Figure A4.2 below shows the basic scheme of the monitoring plan.

In order to achieve a representative sample of the flare emissions, multiple monitoring ports along the flare are necessary due to the variability in the combustion gases emissions profile. According to the characteristics of the flare to be installed, two different planes across the perpendicular sections of the flare stack were defined. As given by the minimum recommendations of the Environment Agency of the United Kingdom, the sample plan must be at least 1 meter from the flare exit and without any flame near the sampling port to avoid uncertainties due the flame chemistry. Four sampling ports at each plane will be arranged (Figure A4.3). The number of sampling ports was determined according to the minimum established by ISO 9096 and from the flare dimensions (approximately 1 meter diameter).

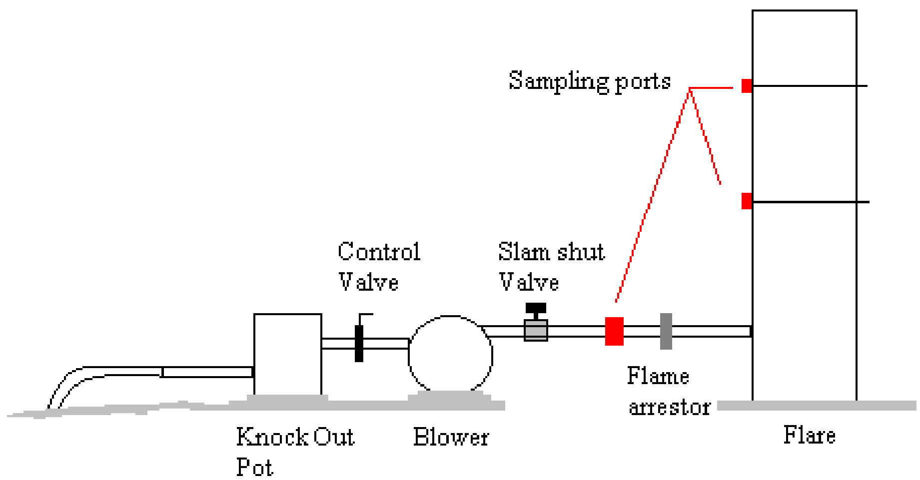
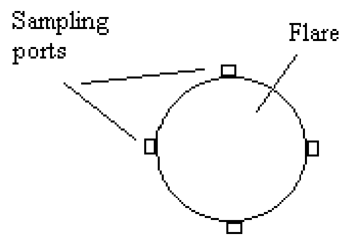


Figure A4.2. Sampling ports and basic arrangement of the flare system

Monitoring sampling points

The monitoring sampling points to measure the methane content in the LFG and in the flare emissions are shown in Figure A4.3 below. The point before the flare system will be daily monitored to record the landfill gas flow and the methane content in the LFG. The LFG composition will also be monitored in the wellheads for technical purposes.



FigureA4.3. Sampling ports at each plane

The combustion efficiency in term of the percentage of combusted methane will be determined by the difference between the amount of captured methane in LFG (before flare) and the non-combusted methane (from the sampling ports in the flare).

II. Qualitative explanation of how quality control (QC) and quality assurance (QA) procedures are undertaken

Regarding quality control and quality assurance procedures to be undertaken for the monitored data, the practices to be implemented in the context of the Montería Landfill Gas Capture and Flare Project are as follows:

Gas field monitoring records:

- Records of all field meters will be registered electronically.
- Periodic controls of the LFG field monitoring records will be carried out to check any deviation from the estimated ERs following the guidelines for LFG plant operation and monitoring for correction or future references.
- Recommendations on system and procedures improvements will be presented.
- Periodic reports to evaluate performance and assist with performance management will be elaborated.

Equipment calibration and maintenance:

- Flow meters, gas analyzers and other sensors will be subject to regular maintenance and testing regime according to the technical specifications from the manufacturers to ensure accuracy and good performance.
- Calibration of equipment will be performed periodically according to technical specifications.

Corrective actions:

- Actions to correct deviations from the Monitoring Plan and the guidelines for LFG plant operation and monitoring will be implemented as these deviations are observed either by the operator or during internal audits.
- If necessary, technical meetings between the operator, the developer and the sponsor of the project will be held in order to define the corrective actions to be undertaken.

Site audits:

- SERVIGENERALES will make regular site audits to ensure that monitoring and operational procedures are being observed in accordance with the Monitoring Plan and the guidelines for LFG plant operation and monitoring.

Training:

- *The operator personnel will be trained in equipment operation, data recording, reports writing, and operation, maintenance and emergency procedures in compliance with the guidelines for LFG plant operation and monitoring*.

Annex 5

MINUTES OF THE STAKEHOLDERS CONSULTATION

The meeting with the stakeholders of the Montería Landfill CDM project was held on September 5th of 2007 in the public auditorium of the city of Montería. The meeting was called and coordinated by SERVIGENERALES and OPTIM, the initial project participants. Forty persons attended the meeting. There were community members, representatives of the municipality and of regional government, the regional environmental institution (CVS) the universities, and NGOs among others. The list of attendants is presented in annex four.

The main objective of the meeting was to describe and explain the CDM project to the stakeholders of the landfill, to answer their questions, clarify their doubts and address their concerns in relation to the project. The meeting lasted three hours. A one hour presentation of the project by Mr. Eduardo Uribe from OPTIM, was followed by a session of questions.

The content of Mr. Uribe's presentation was the following:

- The nature, the causes and the consequences of Climate Change
- The legal and institutional framework for the control of Climate Change
- The Clean Development Mechanism (CDM)
- The application of the CDM to the Montería Landfill
- Process and technologies to capture and combust methane in a Landfill
- Local and global social and environmental benefits of the Montería CDM project.

This presentation was followed by a two hour session of questions and answers.

The main issued addressed, explained and discussed during that session were:

1. The dimension of the CDM project and its contribution to the control of climate change.
2. The financial viability of using LFG to generate electricity or for domestic consumption.
3. The role of the CDM project as an educational opportunity for high school and university students
4. The role of the CDM project as a research opportunity for the local universities.
5. The technology used to transform the LFG extracted into clean and useful methane.
6. The possibility of using an old garbage dump to generate LFG.
7. The participation of different local, regional and global institutions in the development of the CDM project
8. The international market of CERs.
9. Other opportunities in the region for the development of CDM projects.

Most stakeholders were particularly interested in the possibility of using the methane form the land fill for energy generation or for domestic consumption. It was explained that, at this time, the costs of generating electricity with LFG from the landfill were high (about US $ 0.10 per Kwh) in relation to the prices of electricity in Colombia (about US 0.04 per Kwh). It was also discussed that today the construction of a pipeline to transport the LFG to the city of Monteria (10 Kilometers away form the landfill) would not be economically feasible. It was explained and discussed that the economic viability of an electricity project and of the pipeline would depend on the future prices of electricity and natural gas. As their prices increase, those alternatives may become feasible.

The participants form the local schools and universities proposed that the CDM project should become an opportunity for them to learn about climate change, waste management and disposal, landfill management and, eventually, about energy generation with methane. The Universities also saw the project as an opportunity for the development of research projects by its students and professors. These ideas were well received by the project participants and incorporated into the project.

There was also a discussion regarding other potential CDM projects in this agricultural and cattle region. Among the alternatives identified for this region were the combustion of methane from the anaerobic decomposition of organic wastes from feedlots and anaerobic lagoons, and tree plantations.

After the discussion, the participants expressed their interest and their support for the development of this project

List of Participants

Name	Working place	Address (Montería)	Telephone
Jorge E. Carrillo Paéz	National Police	Calle 29 VA No. 5-69	3105548372
Mario Giraldo	Planning Department of Montería		
Jairo Berrocal Castaño	University of Sinú	Juan XXIII	3163150877
José Fernando Machado Cohen	University of Sinú	Cra. 1W Calle 38 Juan XXIII	3008144802
Adolfo Bedoya Cano	Regional Environmental Authority (C.V.S.)	Calle 29 No. 2-43	7860443
Hernán Artardiranía C.	Regional Environmental Authority (C.V.S.)	Calle 29 No. 2-43	7829950
John Jairo Feria	UPB Montería	Km. 8 Vía Cereté	3008102150
Reinaldo Padilla Henao	Servigenerales S.A.	Cra. 2 No. 44-50	7820404
Flor Angela Ruíz Solera	Fundación Santa Isabel (NGO)	Cra. 9 No. 39-06	79184559
Carmen Elena Villadiego	Regional Environmental Authority (C.V.S.).	Calle 29 No. 2-43	7829950 ext. 302
Karen Angela Paz	Regional Environmental Authority (C.V.S.)	Calle 29 No. 2-43	7829950 ext. 707
Vanessa Paola Ortega Mendoza	Regional Environmental Authority (C.V.S.)	Calle 29 No. 2-43	7829950 ext. 302
Rosella Mancuso O.	Regional Environmental Authority (C.V.S.)	Calle 29 No. 2-43	7927162
Juan Pacheco E.	Fundación Santa Isabel (NGO)	Cra. 9 No. 39-06	72860424

Name	Working place	Address (Montería)	Telephone
Juan Espriella	Regional Environmental Authority (C.V.S.)	Calle 29 No. 2-43	3012025746
Graciliano Palencia	University of Córdoba	Calle 36 No. 10-37	3008014105
Oswaldo Martínez Vásquez	Government of the Regional Department of Córdoba	Calle 27 Cra. 3-28	7823219
Isabel Jiménez Flórez	Servigenerales S.A.	Cra. 2 No. 54-50	7820404
Diana P. Arrieta	The La Salle School	M.G.-L.19 B/Panamá	7841292
Alicia Hoyos Merlani	The La Salle School	B/Pasatiempo	7866910
Ronny Barrera	The La Salle School	Calle 41 No. 16-25 P.5	3116618088
Harold Vergara	The La Salle School	Calle 25 No. 7-35W	3116866609
Nelsy Alvarez	The La Salle School	Trv. 3 No. 23-37 Urb. Santa Lucia	7919710
Alexandra Torecilla	The La Salle School	Calle 15 No. 3-44	7922859
Carlos Mario Martínez	Servigenerales	Cra. 15 No. 38-65	7821925
Elkin Urango Díaz	Servigenerales	Cra. 16 No. 38-87	7821461
Luz Elena Ríos	Servigenerales	Calle 29 No. 1-17	7900547
Ivan C. Belvas Serpa	Regional Environmental Authority (C.V.S.)	Calle 29 No. 2-43	7829950
Frank Rigeno Cheyne	C. V.S.	Cra. 7 No. 29-49	7825714
Efren Cardona Ayala	Government of the Regional Department of Cundinamarca	Calle 27 No. 3-28 P.5	7823245
Juan B. Parea	Servigenerales	Cra. 2 No. 44-50	3145157032
Luis Felipe Espinosa	New Montería Parks agency	Calle 29 No. 1-17	7900947
Viviana Soto Barrero	Waste Management Unit of Montería (Uniaseo)	Calle 33 No. 1-46	7824843
Nestor Suárez Soto	Regional Environmental Authority (C.V.S.)	Calle 29 No. 2-43	7829950
María Victoria Cabrales	Uni S.A. E.S.P.	Cra. 3 No. 68-70	7779517
Yaneth Soto Santos	Regional Environmental Authority (C.V.S.)	Calle 23 No.18A-64	721099
Debra Jan	Uni. S.A. E. S. P.	Calle 23 No. 18A-64	7821099
Juliana Mendoza	Fundación Valle Fértil	Centro	3103699856
Manuel	Regional Environmental Authority (C.V.S.)	Calle 29 No. 2-43	7824450 ext. 402
John Angulo	Government of the Regional Department of Córdoba	Calle 27 No. 3-23 P.5	7823245
Marina Bedoya	Sagrada Familia School	Diagonal 15 No. 4-70 G	7923897

Annex 6

PICTURES OF THE LANDFILL

- - - - -