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

CONTENTS

Annexes

SECTION A. General description of project activity

A.1 Title of the project activity:

Puebla Landfill Gas to Energy Project
Document version: 01
Date completed: 27/04/2012

A.2. Description of the project activity:

The **Puebla Landfill Gas to Energy Project** (the Project) is promoted by Rellenos Sanitarios RESA (RESA, the Project Developer) who manages the landfill site (the Chiltepeque landfill) in the State of Puebla, Mexico (the Host Country). The Chiltepeque landfill started operation in 1995 and is expected to continue operations until 2022.

The purpose of the Project is to develop the landfill gas (LFG) collection and utilization system, aimed at capturing methane (CH_4) from the LFG released by the Chiltepeque landfill and to utilize it to generate electricity. The project will be developed in two phases: a) Phase I – LFG collection and flaring, and b) Phase II – electricity generation. The landfill consists of two sections, A and B. About 6.9 million metric tonnes of waste have been disposed of in section A of the landfill until November 2010. It is anticipated that this section will receive another 1.5 million metric tonnes of waste until 2013. After 2013, waste deposition will continue in section B of the landfill. The proposed project activity will be implemented on section A only. It is expected to reduce emissions by approximately 1.3 million metric tonnes of CO_2 equivalent over the crediting period of 10 years.

Currently there is no system in place to actively capture or flare the LFG. The LFG is vented to the atmosphere. The situation prior to the implementation of the proposed project activity (venting of the landfill gas generated) is the same as the baseline scenario.

The proposed project will reduce greenhouse gas emissions from the decomposition of municipal solid waste that would have been otherwise emitted to the atmosphere. Furthermore, the captured landfill gas, which contains approximately 50% CH_4 by volume, will be combusted to generate electricity which will be fed into the national power grid, the Interconnected National System (SIN). The electricity generated from the LFG will reduce greenhouse gas emissions from fossil fuel-based electricity generation. The proposed project will thus reduce greenhouse gas emissions in two ways:

1) Eliminate a significant portion of methane (CH_4), which has a 21 times higher global warming potential than carbon dioxide (CO_2), and which would otherwise be emitted to the atmosphere. All LFG collected but not used for electricity generation will be flared.
2) Displace fossil fuel-based electricity generation that would have otherwise emitted CO_2.

The proposed Project activity will contribute to sustainable development in the following ways:

- Reducing potential health risks from exposure to noxious emissions generated by the waste deposited in the landfill and odours associated with these emissions by reducing the release of LFG to the atmosphere.
- Reducing the risks of explosion in and around the landfill by actively capturing and destroying the LFG generated in the landfill and thus avoiding uncontrolled accumulation of LFG in the landfill.
- Improving surface water quality by improving site grading and better management of surface run-off.
- Improving air quality around the landfill by providing a proper landfill cover system and by capturing and destroying the LFG. Improve overall environmental conditions of the surrounding area and introduce good operating practices when the landfill ceases operation by developing viable closure and LFG utilization plans.
- Reducing greenhouse gas emissions.
- Providing short-term employment opportunities for local contractors and labourers during construction and long-term employment opportunities for local people to operate and maintain the LFG capture and utilization system.
- Promoting transfer of proven and reliable waste management and renewable energy technologies from a developed country.
- Diversifying the country's energy supply mix by supplying electricity generated by LFG and feeding it into the Interconnected National System (SIN), thereby displacing the electricity that would otherwise be generated by fossil fuel-fired power plants.

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)
Mexico (host)	Private entity: Rellenos Sanitarios RESA	No
(*) In accordance with the CDM modalities and procedures, at the time of making the CDM-PDD public at the stage of validation, a Party involved may or may not have provided its approval. At the time of requesting registration, the approval by the Party(ies) involved is required.		

A.4. Technical description of the project activity:

A.4.1. Location of the project activity:

Km 6 of the road to the Chiltepeque landfill, San Francisco Totimehuacán, Puebla, Mexico

A.4.1.1. Host Party(ies):

Mexico which ratified the Kyoto Protocol on 7 September 2000.

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

State of Puebla

A.4.1.3. City/Town/Community etc:

Town of San Francisco Totimehuacán

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

The Chiltepeque site is located approximately 12 km to the northeast of the Puebla City core in the State of Puebla (Figure 1). The city of Puebla is located approximately 107 km southeast of Mexico City.

Section A of the landfill site occupies an area of 32 ha[1] divided into eight cells.

Access to the site is from the west. The landfill site is located in an area of natural rolling hills with abundance of trees and other variety of vegetation of native species. There is a large industrial park and a military base located approximately 8 km and 3 km, respectively, from the landfill site. There is no concentration of residents in the proximity of the landfill site. The geographical coordinates of the entrance of the site are: Latitude 18.982833° N and longitude -98.139664° W (Figure 2).

[1] 27.94 ha according to document “Resolución Manifestación de Impacto Ambiental” (Environmental Impact Study Resolution), page 2; plus 4.1 ha according to document “Proyecto de Ampliación” (Expansion Project), page 113.

Figure 1: Location of the State of Puebla, Mexico[2]

Figure 2: Aerial photo of the Chiltepeque Landfill[3]

[2] Source: http://www.pickatrail.com/jupiter/location/north_america/mexico/puebla.htm

[3] Source: Google Earth map

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

Sectoral scope 13: Waste handling and disposal

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

In order to actively capture and flare the LFG from the existing landfill, a state-of-the-art LFG management system will be implemented in phase 1, including surface cover, landfill capture system and enclosed flares. In phase 2, LFG engines will be installed in order to generate electricity from the LFG.

S*urface Cover*

Each of the closed landfill cells is to be finally covered with adequate surface cover to prevent release of the LFG into the atmosphere and to enable its efficient recovery for flaring and/or utilisation. As part of its contract with the municipality, the project proponent RESA has a mandate to provide a basic cover over the accumulated waste to avoid waste littering and to provide odour control. However, this cover is not sufficient for LFG recovery. A modified surface cover with the following components will be provided as final cover at the time of closure of each cell:

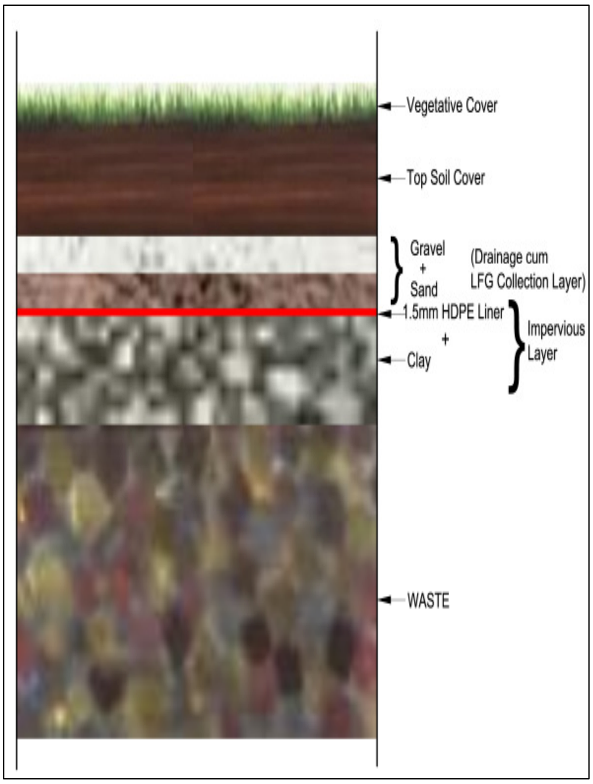

Figure 3: Schematic of the Surface Cover

Top Soil - Vegetative layer made up of 45 cm thick topsoil as the topmost layer. The soil for this layer will be transported from approved borrow pits suitable for growing vegetation and developing landscaping.

LFG Collection cum Drainage Layer - A layer of granular soil with a permeability coefficient (k) greater than 10-2 cm/sec of 30 cm thickness is to be laid below the top soil to accommodate a network of header and feeder pipes for LFG collection and to act also as a drainage layer.

Impervious Layer - An impervious layer consisting of a clay layer of 45 cm thickness with a 1.5 mm thick HDPE (high density polyethylene) liner is to be provided to prevent LFG from being released into the atmosphere and infiltration of water into the closed cell.

LFG Capture System

LFG extraction wells- A Gas well design has been developed as per the guidelines specified in USEPA CFR Test Method 2E "Determination of LFG Production Flow Rate"[4]. LFG collection wells are 500 mm diameter wells to be drilled, down to 75% of the depth of the landfill. To extract the LFG, 15-cm diameter HDPE pipe is proposed to be inserted into the extraction well, with perforations along two-thirds the length of the pipe from the bottom.

To facilitate the lateral movement of the LFG and also to provide lateral pressure, the annular core would be filled with 2.5 cm to 4-cm size gravels. The top of the well is to be sealed with bentonite and capped (Figure 4). The spacing between any two extraction wells will not be more than twice the radius of influence of the wells.

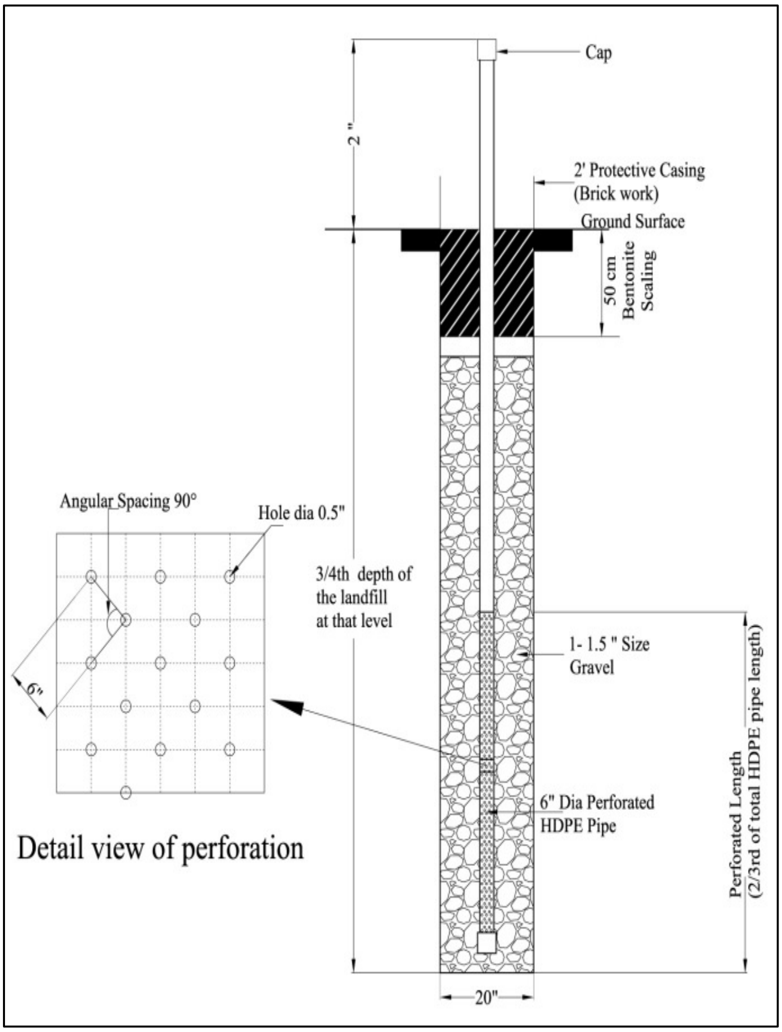

Figure 4: Schematic Diagram of the LFG Extraction Well

Gas piping Network - It is proposed to install a gas collection network comprising an adequate number of inter-connected headers (200 mm HDPE pipes) and feeder pipes (150 mm HDPE pipe). The gas will be actively extracted from the wells using a vacuum. The gas extracted from each individual well will flow through a feeder pipe into a header. The pipes are to be made of HDPE. This is to compensate for the corrosive nature of LFG and its condensate.

LFG Flare

[4] http://www.epa.gov/ttn/emc/promgate/m-02e.pdf

In project phase I, the collected LFG will be combusted in an enclosed flare. In phase II, only the LFG which is not used for electricity generation will be flared. The basic flare arrangement for the Chiltepeque landfill is shown below (Figure 5).

The enclosed type flare assembly comprises:

Condensate Knock out: The condensate knock-out vessel removes the solid debris from the LFG in addition to the moisture. As the LFG cools, the condensate accumulates in the gas collection pipe and needs to be removed before gas enters the flare unit for combustion.

Gas Blowers: The LFG from the gas wells shall be extracted with several vacuum blowers.

Flare System: The flare system will include a minimum of two enclosed flares, each with a capacity of approximately 500 to 1200 m^3/h. Details of the flare system and its components are shown in Figure 5:

Table 1: Technical specifications of the blowers and flares:

	Details[5]
Blowers	
Capacity	528 m^3/h per blower
Motor	15 HP
Enclosed Flares	
Capacity	500 to 1200 m^3/h per flare
Operating temperature	760 - 870 °C
Efficiency	Minimum 98%

Diesel Generator

The diesel generator will provide electricity to the LFG collection and flaring system until the project is connected to the Interconnected National System (SIN) or electricity is generated on-site from the landfill gas. According to RESA, the diesel generator may have a capacity between approximately 0.03 MW and 0.05 MW.

Table 2: Technical Specifications of the diesel generator

Diesel generator	**Details**[6]
Capacity	Approx. 0.03 to 0.05 MW
Quantity	1
Diesel consumption	7.6 to 14.2 l/h

LFG Power Plant

[5] According to the technical specifications provided by John Zink

[6] According to indications by the provider (document: Diesel_consumption.pdf)

The LFG power plant shall consist of one set of LFG engines. The set will comprise two generators, each with a nominal capacity of 1.6 MW but with a real capacity of 1.355 MW as calculated by the equipment provider according to the project location's altitude above sea level. The generators will be connected to a transformer station from where electricity is supplied to the Interconnected National System (SIN). The LFG engines shall enter into operation on 01/10/2012.

Table 3: Technical specifications of the generator set

Generator set	Details[7]
Number of generators per set	2
Type	G3520C with DM5740 (Caterpillar)
Nominal capacity (technical specifications)	1.6 MW per generator
Capacity on-site	1.355 MW per generator
Efficiency	40.1%

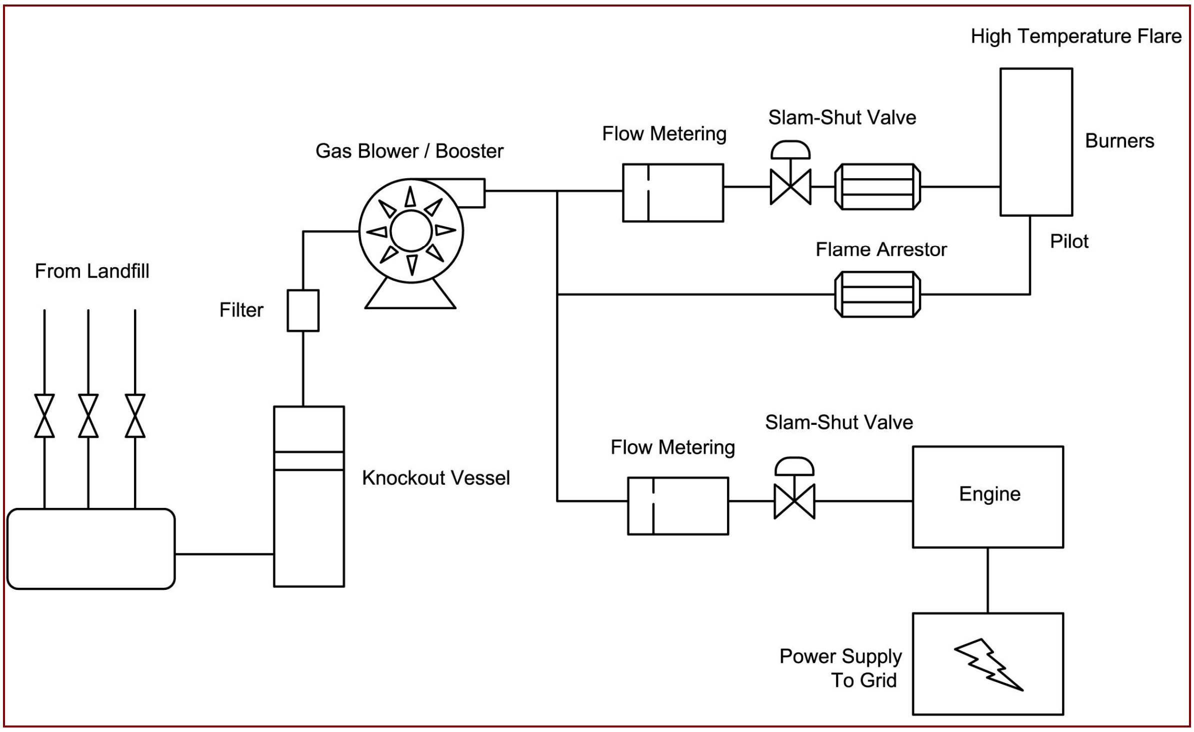

Figure 5: Combustion Scheme for LFG Engines at the Chiltepeque Landfill

The flares will be used either during closure or during maintenance of the LFG engines or for combustion of LFG collected in excess of gas engine capacity.

[7] According to the technical specifications provided by Caterpillar/Madisa

The Project will transfer the above environmentally-safe and sound technology to Mexico as well as transfer knowledge by training local labour to carry out operation and maintenance.

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

Table 4: Annual estimation of emission reductions

Year	Annual estimation of emission reductions in tonnes of CO_2e
2012 (3 months)	53,064
2013	211,281
2014	184,775
2015	162,312
2016	143,237
2017	127,001
2018	113,150
2019	101,303
2020	90,988
2021	80,916
2022 (9 months)	54,170
Total estimated reductions (tonnes of CO_2e)	**1,322,197**
Total number of crediting years	10
Annual average over the crediting period of estimated reductions (tonnes of CO_2e)	**132,220**

A.4.5. Public funding of the project activity:

No public funding from Annex I Parties is involved in this project.

SECTION B. Application of a baseline and monitoring methodology

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

The baseline and monitoring methodology used for the proposed project activity is the approved consolidated baseline methodology ACM0001, Version 11 – "*Consolidated baseline and monitoring methodology for landfill gas project activities.*"

For the assessment of additionality, Version 5.2.1 of the "*Tool for the demonstration and assessment of additionality*" has been used, and the following guidelines have been considered: Version 5 of the

"Guidelines on the assessment of investment analysis" and Version 4 of the *"Guidelines on the demonstration and assessment of prior consideration of the CDM"*.

For the calculation of the baseline emissions Version 05.1.0 of the "*Tool to determine methane emissions avoided from disposal of waste at solid waste disposal site"* has been used.

For the calculation of the CO_2 emission factor of the Interconnected National System (SIN) to determine baseline emissions from electricity generation, Version 02.2.1 of the "*Tool to calculate the emission factor for an electricity system"* has been used.

For the calculation of project emissions, the following tools have been used:

- Version 01 of the "*Tool to determine project emissions from flaring gases containing methane"*
- Version 02 of the "*Tool to calculate project or leakage CO_2 emissions from fossil fuel combustion"*
- Version 01 of the "*Tool to calculate baseline, project and/or leakage emissions from electricity consumption"*

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

The methodology, ACM0001 Version 11 is applicable to LFG capture project activities, where the baseline scenario is the partial or total atmospheric release of the gas and the project activities include situations such as:

a) The captured gas is flared; and/or
b) The captured gas is used to produce energy (e.g. electricity/thermal energy). Emission reductions can be claimed for thermal energy generation, only if the LFG displaces use of fossil fuel either in a boiler or in an air heater. For claiming emission reductions for other thermal energy equipment (e.g. kiln), project proponents may submit a revision to this methodology;
c) The captured gas is used to supply consumers through a natural gas distribution network. If emissions reductions are claimed for displacing natural gas, project activities may use approved methodology AM0053.

The proposed project activity is a combination of situation a) and b) mentioned above. In phase 1, the captured LFG will be flared. In phase 2, the captured LFG will be used for electricity generation and flared in case part of the captured LFG can not be used for electricity generation. Therefore, the methodology ACM0001 is applicable and suitable to be used to establish the baseline scenario for the proposed project.

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

According to the consolidated baseline methodology ACM0001,
"*The project boundary is the site of the project activity where the gas will be captured and destroyed/used.*

If the electricity for project activity is sourced from grid or electricity generated by the LFG captured would have been generated by power generation sources connected to the grid, the project boundary shall include all the power generation sources connected to the grid to which the project activity is connected.
If the electricity for project activity is from a captive generation source or electricity generated by the captured LFG would have been generated by a captive power plant, the captive power plant shall be included in the project boundary"

The project activity does not involve any captive power plant, hence the project boundary is the site of the project activity where the gas will be captured and destroyed/used and includes all the power generation sources connected to the Interconnected National System (SIN) to which the project activity is connected.

Table 5: Emission sources and gases included in the project boundary

	Source	Gas	Included?	Justification/explanation
Baseline	Emissions from decomposition of waste at the landfill site	CO_2	No	CO2 emissions from the decomposition of organic waste are not accounted.
		CH_4	Yes	The major source of emissions in the baseline.
		N_2O	No	N2O emissions are small compared to CH4 emissions from landfills. Exclusion of this gas is conservative.
	Emissions from electricity consumption	CO_2	Yes	Electricity may be consumed from the grid or generated onsite/offsite in the baseline scenario.
		CH_4	No	Excluded for simplification. This is conservative.
		N_2O	No	Excluded for simplification. This is conservative.
	Emissions from thermal energy generation	CO_2	No	No thermal energy generation is included in the project activity.
		CH_4	No	Excluded for simplification. This is conservative.
		N_2O	No	Excluded for simplification.

	Source	Gas	Included?	Justification/explanation
				This is conservative.
Project Activity	On-site fossil fuel consumption due to the project activity other than for electricity generation	CO_2	Yes	Accounted.
		CH_4	No	Excluded for simplification. This emission source is assumed to be very small.
		N_2O	No	Excluded for simplification. This emission source is assumed to be very small.
	Emissions from on-site electricity use	CO_2	Yes	An important emission source, in case the project uses electricity from the grid.
		CH_4	No	Excluded for simplification. This emission source is assumed to be very small.
		N_2O	No	Excluded for simplification. This emission source is assumed to be very small.

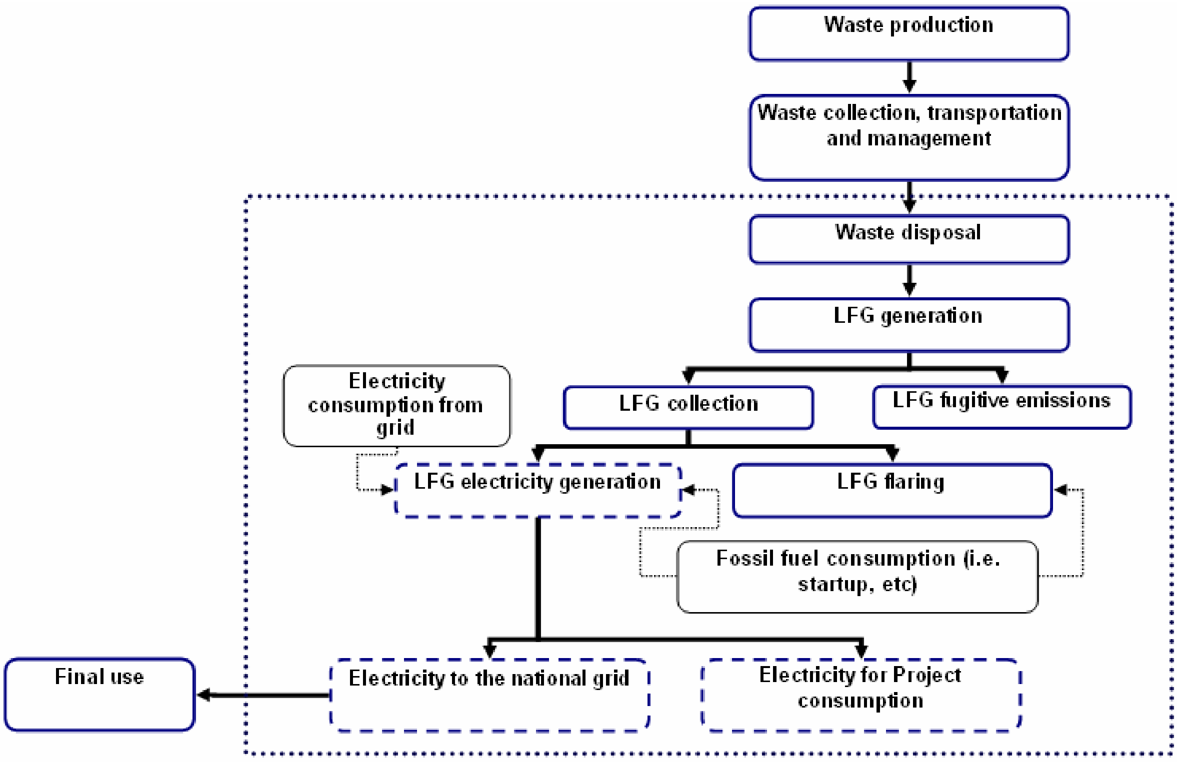

Figure 6: Project boundary

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

The baseline scenario is identified following the steps mentioned by the approved baseline and monitoring methodology ACM0001.

Step 1: Identification of alternative scenarios

To identify all realistic and credible baseline alternatives, Step 1 of the latest version of the "Tool for the demonstration and assessment of additionality" is applied.

Sub-step1(a) Define alternatives to the project activity

As indicated in the methodology, the following alternatives are considered for the landfill gas**:**

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

As the project activity will include generation of electricity, the following alternatives for power generation are considered as indicated by the methodology:

- **P1:** Power generated from landfill gas undertaken without being registered as CDM project activity.
- **P2:** Existing or construction of a new on-site or off-site fossil fuel fired cogeneration plant.
- **P3:** Existing or construction of a new on-site or off-site renewable based cogeneration plant
- **P4:** Existing or construction of a new on-site or off-site fossil fuel fired captive power plant.
- **P5:** Existing or construction of a new on-site or off-site renewable based captive power plant
- **P6:** Existing and/or construction of new grid connected power plants

Even when several renewable power generation options exist, many of these renewable resources (such as hydro, or marine currents, etc.) are not available at a landfill site. Since, the landfill is still operating and there is unabated emission of landfill gas from the accumulated waste, the site is unsuitable for any new constructions for safety reasons (wind farms etc.). Therefore, renewable power generation options at the landfill site do not comprise realistic nor credible baseline scenarios. Hence, options P3 and P5 are eliminated.

The project proponent RESA is the contractor to the Puebla municipality for providing solid waste management services. This means, it is not dedicated or involved in power generation. Therefore, off-site power generation is not an alternative to the project activity.

The installation of cogeneration system or power plants cannot be considered as an alternative to the proposed activity, since the main scheme and advantage in the proposed project is to utilize a free-fuel cost given by LFG for electricity generation. Therefore, P2 and P4 are also not considered as practical alternatives to the proposed project activity.

Power plants connected to the Interconnected National System (SIN) are operated by Federal Commission for Electricity ("Comision Federal de Electricidad", CFE), not by the project participant. Even after the beginning of the project implementation, the project participant would continue to meet its demand through the Interconnected National System (SIN) until it starts generating power onsite by using LFG.

The only remaining plausible baseline alternatives for power generation are then (P1) "Power generated from landfill gas undertaken without being considered as CDM project activity" and (P6) "Power plants connected to the grid".

The project does not include thermal energy generation because the project activity only proposes to generate electricity with LFG.

From the above considerations, it is clear that the alternatives LFG1 and LFG2 for landfill gas and P1 and P6 for power generation are the only alternatives to be considered as possible real alternatives to the proposed project activity, as described below:

a) **Option I:** LFG1 and P1, with the LFG being flared and/or used to generate electricity. This is the proposed project activity without being registered as a CDM project activity.
b) **Option II:** LFG2 and P6, which is the current practice.

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

Alternatives LFG1 and P1 comply with all applicable laws and regulations. The Mexican government has no regulations requiring the reduction of GHG emissions. Mexican National Standards (NOM-083-SEMARNAT-2003)[8] of the Environment and Natural Resources Secretariat (SEMARNAT) establish specifications for siting, design, construction, operation, monitoring, closure, and associated works for the final disposal of urban solid waste and other waste. This standard establishes that the LFG produced

[8] http://www.semarnat.gob.mx/leyesynormas/Pages/nom_residuos.aspx

in a landfill may be used or flared. However, the standard provides recommendations only and does not specify requirements for the collection, flaring, and/or utilization of LFG, or define the types of technologies to be used. Therefore, it is not mandatory by Mexican legislation to install an active LFG collection and flaring system or to produce electricity at the landfill.

Alternatives LFG2 and P6, a continuation of the current situation, represents the business as usual practice for the project developer and most of the landfills in Mexico. The fact that the partial or total release of LFG to the atmosphere is the business as usual practice in Mexico has been documented in numerous PDDs that have been published to date. The PDDs for the Proactiva Medio Ambiente Tlalnepantla Landfill Gas to Energy Project and the Proactiva Merida Landfill Gas Capture and Flaring Project indicated that there are 110 registered landfills in Mexico, of which only two (Monterrey I (pilot phase) and Prados de la Montana) have active LFG collection systems that were not developed under the CDM. The Milpillas Landfill Gas Recovery Project PDD and the Tecamac-EcoMethane Landfill Gas to Energy Project PDD also indicated that Monterrey I (pilot phase) and Prados de la Montana are the only landfills in Mexico with active LFG collection system developed outside of the CDM context. These PDDs point out that Prados de la Montana Landfill collects and partially flares the LFG generated because the area where it is located (Santa Fe, Mexico City) "was slated to become a prime real estate investment opportunity at the time, and the landfill was closed and „cleaned up" in order to encourage investments there", while the Monterrey I PDD says that the pilot phase of Monterrey I was developed as a demonstration project financed by the Global Environment Facility.[9] Therefore, the only exceptions to the business as usual practice of the partial or total release of LFG to the atmosphere are CDM projects or the two landfills with special circumstances.

For the NOM-083-SEMARNAT-2003 to become legally binding, it would have to be adopted by municipalities, a scenario which is unlikely to happen considering the wider institutional arrangements and dedications of resources that would be required. In Mexico, according to the Political Constitution of the United Mexican States[10], municipalities have complete sovereignty over landfills. Therefore, unless the municipal authority decides to apply this federal regulation, it cannot be considered as a mandatory law or regulation. Thus, the regulation NOM-083-SEMARNAT-2003 has become more a guideline and policy document rather than a regulation.

Although existing regulations (NOM-083-SEMARNAT-2003) provide recommendations, they do not include specific requirements for the active collection and combustion of LFG. Furthermore, NOM-083-SEMARNAT-2003 has not been enforced in Mexico and no local authorities have adopted this federal regulation to make it legally binding. As stated by the "Tool for the demonstration and assessment of

[9] Tecamac-EcoMethane Landfill Gas to Energy Project PDD, p. 15, and Monterrey I LFG to Energy Project PDD, p. 2.

additionality", regulations that "are systematically not enforced and that non-compliance with those requirements is widespread throughout the country" do not need to be considered in determination of the baseline scenario.

Therefore, both options, Option I and Option II, are in compliance with the mandatory laws and regulations. The current situation at the Chiltepeque landfill corresponds to Option II, meaning the combination of alternatives LFG2 and P6.

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

For power generation there were two scenarios remaining:

- **P1:** Power generation from landfill gas undertaken without being registered as CDM project activity.
- **P6:** Existing and/or new grid-connected power plants.

No specific baseline fuel has to be chosen. The fuels in the power plants connected to the Interconnected National System (SIN) are defined by the corresponding company (Federal Commission for Electricity, "CFE"), and their emission factors are calculated using the "Tool to calculate the emission factor for an electricity system".

Therefore, the options listed above, Option I and Option II are the only realistic alternatives to be considered as possible baseline scenarios.

Step 3: Step 2 and/or Step 3 of the latest approved version of the "Tool for demonstration and assessment of additionality" shall be used to assess which of these alternatives should be excluded from further consideration (e.g. alternatives facing prohibitive barriers or those clearly economically unattractive).

As concluded above, the following options are the only realistic alternatives to be considered as possible baseline scenarios:

- **Option I**: LFG1 and P1, with the LFG being flared and/or used to generate electricity. This is the proposed project activity without being registered as a CDM project activity.
- **Option II**: LFG2 and P6, which is the current practice.

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[10] Political Constitution of the United States of Mexico ("Constitución Política de los Estados Unidos Mexicanos"),

An investment analysis, Step 2 of the "Tool for demonstration and assessment of additionality", for Option I is presented in section B.5 where it is demonstrated that it is not an economically feasible option. Option I can therefore be excluded from further consideration.

Option II, which is the continuation of the current practice, is thus the only remaining alternative baseline scenario

Step 4: Where more than one credible and plausible alternative remains, project participants shall as a conservative assumption, use the alternative baseline scenario that results in the lowest baseline emissions as the most likely baseline scenario.

This step is not applied as only one alternative remains after applying step 1 to 3.

The baseline scenario is thus Option II, the continuation of the current practice, where the landfill gas would continue to be released into the atmosphere and the electricity would be generated by existing and/or new grid-connected power plants.

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

Prior CDM Consideration

The following table provides an overview on the activities undertaken before and after the project starting date in order to demonstrate continued actions to achieve CDM registration:

Table 6: Project starting date and activities undertaken to achieve CDM registration

N°	Date	Activity
1	05/11/2007	Working plan for PDD development for the LFG Flaring and Waste to Energy Project in Puebla – Memorandum between RESA and SENES
2	21/12/2007	Preliminary assessment by SENES to determine the viability of the LFG project as a CDM project.
3	09/01/2008	Internal letter from RESA where they decide to hire Alfa for the construction and operation of the LFG project in Puebla (date of investment decision)

Article 115 Section 3rd, c

4	14/04/2008	Signature of the contract for civil works for the LFG project at the Chiltepeque landfill. (Project Starting Date)
5	27/11/2008	Letter of approval for the LFG project in Puebla from Mexican DNA
6	15/12/2008	Contract for CDM validation with AENOR
7	30/12/2008 – 29/01/2009	Publication of the PDD on the UNFCCC website

The project starting date is the date when the contract was signed for civil works for the LFG project at the Chiltepeque landfill since it represents the first real action where the project proponent committed to make first expenditures for the construction of the project.

Items 1 and 2 in Table 6 above prove that CDM was taken into consideration prior to the investment decision (09/01/2008) and prior to the project starting date (14/04/2008):
a) The MoU signed between RESA and SENES on 05/11/2007 provides the working plan and payment conditions for the PDD development of the LFG Flaring and Waste to Energy Project in Puebla.
b) The SENES Consultants Puebla Report dated 21/12/2007 provides a preliminary assessment to provide the necessary information to determine the viability of the LFG project as a CDM project (RESA makes the decision to develop the project based on this study).

Items 5 to 7 prove that there was continued action to achieve CDM registration of the project activity after the project starting date.

Additionality

According to methodology ACM0001, the "Tool for the demonstration and assessment of additionality" shall be applied to demonstrate additionality.

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

This step has been applied in section B.4.

Outcome of step 1: There are two realistic and credible alternative scenarios to the project activity that are in compliance with mandatory legislation and regulations:

- **Option I**: LFG1 and P1, with the LFG being flared and/or used to generate electricity. This is the proposed project activity without being registered as a CDM project activity.

- **Option II**: LFG2 and P6, which is the current practice.

Step 2: Investment analysis

Sub-step 2a: Determine appropriate analysis method

According to the Tool for the demonstration and assessment of additionality, there are three options available for investment analysis:

Option I- Simple cost analysis: This option is applicable when the alternatives to the proposed project activity do not have any economic benefits other than CDM benefits;
Option II: Investment comparison analysis (where comparative alternatives to the project exists); or
Option III: Benchmark analysis.

In the proposed project activity, revenues are expected from the sale of electricity even in the absence of CDM benefits; hence, Option III- benchmark analysis has been applied here.

Sub-step 2b: Option III: Apply benchmark analysis

For the benchmark analysis of the project, the financial indicator chosen is the Project Internal Rate of Return (IRR), which is compared with the benchmark.
The benchmark is determined based on the average Government Bond Rate in 2007 of the Bank of Mexico plus a country risk premium for Mexico:

- Government Bond Rates: According to the Bank of Mexico the average rate of 10 year fixed rate bonds in 2007 was 7.77% (http://www.banxico.org.mx/estadisticas/index.html).
- Country Risk: Based on a country risk classification carried out by the "Organization for Economic Cooperation and Development" (OECD) the country risk premium for Mexico in 2007 is 2% (http://www.oecd.org/dataoecd/9/12/35483246.pdf).

Based on the above information, a benchmark of 9.77% was selected for the project IRR.

Sub-step 2c: Calculation and comparison of financial indicators

Table 7 provides an overview of the input parameters used for the investment analysis.

Table 7: Input parameters for the investment analysis

	Value	Unit	Date	Source
Investment Costs				
LFG Collection and Flaring System	2,488,500	CAD	21/12/2007	Project budget presented in the study "Landfill gases flaring and waste to energy project, Chiltepeque, Puebla, Mexico" elaborated by SENES Consultants, excluding any CDM costs. Document: SENES Consultants Puebla_Report_21_Dec_2007.pdf
Electricity Generation	5,116,261	USD/generator set	1999/2007	According to U.S. Methane Emissions 1990-2020: Inventories, Projections, and Opportunities for Reductions, EPA, September 1999, page 2-8, Table 2-7 (http://www.epa.gov/methane/reports/02-landfills.pdf) the cost per internal combustion engine/generator with a capacity of 1.5 MW was estimated with 1,927,000 USD. For a set of two generators, each with a nominal capacity of 1.6 MW, the cost is estimated as follows: 2*1,927,000 USD/1.5*1.6 = 4,110,933 USD. This value has been corrected for the year 2007 applying the US inflation rate from 1999 to 2007 using the inflation calculator available at http://www.usinflationcalculator.com
Operation & Maintenance Costs				
LFG Collection and Flaring System	85,615	USD	2004/2007	Handbook for the Preparation on Landfill Gas to Energy Projects in Latin America and the Caribbean, World Bank, January 2004, page 124. (http://www.bancomundial.org.ar/lfg/gas_access_008.htm): USD 30,000-40,000 plus USD 1,500-2,500/ha. With a total waste deposition area of section A of 32 ha and using the low end values, this amounts to USD 78,000. This value has been corrected for the year 2007 applying the US inflation rate from 2004 to 2007 using the inflation calculator available at http://www.usinflationcalculator.com The waste deposition area according to the EIA was 27.94 ha (Document: EIA) and is now extended by another 4.1 ha (Document: Extension Project), leading to a total waste deposition area of section A of 32 ha.
Electricity Generation	0.013	USD/kWh	2004/2007	Handbook for the Preparation on Landfill Gas to Energy Projects in Latin America and the Caribbean, World Bank, January 2004, page 124. (http://www.bancomundial.org.ar/lfg/gas_access_008.htm): 0.012-0.015 USD/kWh for facilities with a capacity of 1-3 MW. The low end value of 0.012 USD/kWh has been corrected for the year 2007 applying the US inflation rate from 2004 to 2007 using the inflation calculator available at http://www.usinflationcalculator.com
Other parameters				
Exchange rate Canadian Dollar -> USD	0.9946	CAD/USD	21/12/2007	http://www.xe.com/ict/

Electricity tariff	58.39	USD/MWh	Maximum 2007	According to Mexican law, independent generators can use the power for their own use or sell it to the National Electricity Commission (CFE) at a price that is 10% below CFE's short-term marginal cost (Resolution No. RES/156/2002 available at: http://www.cre.gob.mx/documento/52.pdf). The short term marginal costs (called CTCP) are published by CFE for all electricity interconnection points, called nodes, in http://app.cfe.gob.mx/Aplicaciones/OTROS/costostotales/ConsultaArchivoProyectado.aspx. The sub-station to which the Chiltepeque landfill will be connected belongs now to the interconnection point "Puebla" which is operational only since August 2008. At the moment of investment decision, the same sub-station belonged to the interconnection point "Oriente" as confirmed by CFE (Documents: "CFERESACRTELEC 3MW.pdf" and email confirmation by CFE). For this reason, the historical data from the interconnection point "Oriente" available at the moment of investment decision have been used.
Inflation	3.864%		Average 2005-2007	http://www.banxico.org.mx/PortalesEspecializados/inflacion/inflacion.html
Project lifetime	11.5	years	Dec.07	The LFG collection and flaring system has a technical lifetime of up to 25 years if maintained and operated according to the manufacture's recommendations (Document: Lifetime_Flare_John-Zink.doc) The electricity generators have a technical lifetime of at least 15 years, considering two major overhauls (each after five years) as recommended by the manufacturer. According to the manufacturer's experience, the generators' lifetime is usually even higher. (Documents: Letter on maintenance by Madisa). The project lifetime is however determined by the concession RESA obtained from the municipality of Puebla which is valid until end of 2022. Operation start is on 01/07/2011, which leads to a project lifetime of 11.5 years.
Corporate income tax rate	28%		2007	According to the income tax law (Ley de Impuesto sobre la renta), Art. 10 (valid since December 2004) http://www.diputados.gob.mx/LeyesBiblio/ref/lisr.htm
Depreciation on the LFG collection and flaring system	10%		2007	According to the income tax law (Ley de Impuesto sobre la renta), Art. 41 (valid since January 2002) http://www.diputados.gob.mx/LeyesBiblio/ref/lisr.htm
Depreciation on electricity generators	100%		2007	According to the income tax law (Ley de Impuesto sobre la renta), Art. 40 (valid since January 2002) http://www.diputados.gob.mx/LeyesBiblio/ref/lisr.htm
Price per CER	11.40	USD/CER	May.07	State and Trends of the Carbon Market 2007, World Bank, page 32 (Document: State-Trends-Carbon-Market_2007.pdf) available at: http://web.worldbank.org/WBSITE/EXTERNAL/NEWS/0,,contentMDK:21319781~pagePK:64257043~piPK:437376~theSitePK:4607,00.html Estimated CER price for early-stage projects: between 10.40 USD and 12.40 USD. The average of 11.40 USD/CER has been applied.
Residual value	0.00	USD		According to the income tax law.

Commissioning LFG Collection and Flaring System				Operation start: 01/07/2011
Commissioning of Electricity Generation Systems				Start of operation of the 2 generators (nominal capacity: 2 * 1.6 MW, capacity in-situ: 2 * 1.355 MW) on 01/10/2012

With the input parameters and assumptions presented above, the project activity not implemented as a CDM project achieves a project IRR of 3.93%. This is clearly below the benchmark of 9.77%. The project activity implemented as a CDM project achieves a project IRR of 20.76% which is clearly above the benchmark. Hence, the project activity not implemented as a CDM project (Option I) can not be considered financially attractive. Only implemented as a CDM project, the project activity becomes financially attractive.

Sub-step 2d: Sensitivity analysis

The purpose of the sensitivity analysis is to examine whether the conclusion regarding the financial viability of the proposed project is sound and tenable with reasonable variations in the critical assumptions.
For the sensitivity analysis, a variation of +/- 10% of the total investment costs, the total operation and maintenance costs, the electricity generation and the electricity tariff has been applied. Table 8 shows the results of the sensitivity analysis.

Table 8: Overview on the outcome of the sensitivity analysis

	Investment Costs	Investment Costs	O&M Costs	O&M Costs	Electricity Generation	Electricity Generation	Electricity Tariff	Electricity Tariff
Variation	10%	-10%	10%	-10%	10%	-10%	10%	-10%
Project IRR	2.53%	5.53%	3.27%	4.57%	5.54%	2.20%	5.99%	1.68%

The sensitivity analysis shows that the project IRR remains below the benchmark of 9.77% for each scenario.

Outcome of Step 2:

The sensitivity analysis shows that variations of up to 10% in critical project performance parameters do not result in the project IRR surpassing the stated IRR benchmark rate. Hence, the project activity not implemented as a CDM project (Option I) can not be considered financially attractive.

Step 3: Barrier Analysis

Step 3 is not applied.

Step 4: Common practice analysis

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

Table 9 provides an overview on similar projects to the project activity implemented in Mexico. Most of them are CDM projects and do not have to be considered in this analysis. There are only two projects which have been implemented without the support of CDM. These are the Simeprode Landfill in

Monterrey (pilot phase) and the Prados de Montana Landfill in Mexico City. The Prados de la Montana Landfill project was developed as part of site closure activities in order to encourage local real estate investment due to the perceived high value of real estate in the location of the landfill[11]. The Monterrey I pilot project, which was completed in 2003, was designed specifically as a demonstration project to promote the development of CDM projects and received substantial outside financing (from Global Environment Facility)[12]. Both of these projects were developed outside of the CDM due to exceptional circumstances.

Table 9: Projects which are similar to the proposed activity

Project Name	LFG Energy Use	CDM Registration Date (as of January 2011)	UNFCC Ref. Number
Aguascalientes – EcoMethane Landfill Gas to Energy Project	Electricity generation	15 July 2006	0425
Ecatepec – EcoMethane Landfill Gas to Energy Project	Electricity generation	2 October 2006	0523
Hasars Landfill Gas Project	Possible electricity generation	5 October 2007	1240
Tultitlan – EcoMethane Landfill Gas to Energy Project	Possible electricity generation	30 November 2007	1242
Ciudad Juarez Landfill Gas to Energy Project	Electricity generation	30 November 2007	1123
Proactiva Mérida Landfill Gas Capture and Flaring project	(Flaring only)	31 January 2008	1371
Durango – EcoMethane Landfill Gas to Energy Project	Flaring, initially; later electricity generation	25 February 2008	1307
Milpillas Landfill Gas Recovery Project	(Flaring only)	6 November 2008	1944
Monterrey II LFG to Energy Project	Electricity generation	12 February 2009	2186
Tecamac – EcoMethane Landfill Gas to Energy Project	Flaring, initially; later electricity generation	21 March 2009	2271
Landfill Gas Management Project Puerto Vallarta Landfill site	Leachate evaporation	30 November 2009	1699

[11] http://www.bvsde.paho.org/bvsaidis/resisoli/mexico/03529e14.pdf

[12] http://www.iie.org.mx/boletin042003/apli.pdf

Coyula Landfillgas Project	Electricity generation	29 April 2010	3074
Culiacan Northern Landfill Gas project	Possible electricity generation	09 July 2010	3127
Landfill gas recovery and Flaring Project in the El Verde Landfill, Leon	Possible electricity generation	27 October 2010	3378
Monterrey I (pilot phase)	Electricity generation	Landfill gas collection and utilisation Project, funded with support from the GEF as demonstration project	---
Prados de la Montaña	Possible electricity generation	LFG collection and flaring system installed prior to the commercial development of the surrounding zone	---

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

As shown in Table 9, no landfill has developed active LFG collection and flaring or utilization systems without the support of CDM, except the Simeprode (pilot phase) and Prados de la Montana landfills. These two projects are similar to the proposed project, but have been implemented under exceptional circumstances as they enjoyed benefits (GEF funding) or incentives (high local real estate values) that rendered them financially attractive and that would not typically be available for the vast majority of landfills in Mexico.

For all the reasons mentioned above, the project is considered to be additional.

Based on sub-steps 4a and 4b, it may be inferred that it is not a common practice in Mexico to produce actively capture and flare LFG and to generate electricity from LFG unless it is supported by CDM. Hence, the proposed project activity is additional.

B.6. Emission reductions:

B.6.1. Explanation of methodological choices:

Baseline emissions:

$$BE_y = (MD_{project,y} - MD_{BL,y}) * GWP_{CH4} + EL_{LFG,y} * CEF_{elec,BL,y} + ET_{LFG,y} * CEF_{ther,BL,y} \quad \textbf{(1)}$$

Where,

BE_y = Baseline emissions in year y (tCO_2e)

$MD_{project,y}$ = The amount of methane that would have been destroyed/combusted during the year, in tonnes of methane (tCH_4) in project scenario
$MD_{BL,y}$ = The amount of methane that would have been destroyed/combusted during the year in the absence of the project due to regulatory and/or contractual requirement, in tonnes of methane (tCH_4)
GWP_{CH4} = Global Warming Potential value for methane for the first commitment period is 21 t CO_2e/tCH_4
$EL_{LFG,y}$ = Net quantity of electricity produced using LFG, which in the absence of the project activity would have been produced by power plants connected to the grid or by an onsite/ off-site fossil fuel based captive power generation, during year y, in megawatt hours (MWh).
$CEF_{elec,BL,y}$ = CO_2 emissions intensity of the baseline source of electricity displaced, in tCO_2e/MWh.
$ET_{LFG,y}$ = The quantity of thermal energy produced utilizing the LFG, which in the absence of the project activity would have been produced from onsite/offsite fossil fuel fired boiler, during the year y in TJ.
$CEF_{ther,BL,y}$ = CO_2 emissions intensity of the fuel used by boiler/air heater to generate thermal energy which is displaced by LFG based thermal energy generation, in t CO2e/TJ.

Since the project activity does not include any thermal energy production, $ET_{LFG,y}$ is 0. The formula for the calculation of the baseline emissions is therefore reduced to the following equation:

$$BE_y = (MD_{project,y} - MD_{BL,y}) * GWP_{CH4} + EL_{LFG,y} * CEF_{elec,BL,y} \quad \textbf{(2)}$$

$$\mathbf{MD_{BL,y} = MD_{project,y} * AF} \quad \textbf{(3)}$$

Since in the baseline scenario no landfill gas is destroyed/combusted, the adjustment factor, AF, is 0 in this project.

$MD_{project,y}$ will be determined *ex post* by monitoring the actual quantity of methane captured and destroyed once the project activity is operational.

The methane destroyed by the project activity ($MD_{project,y}$) during a year is determined by monitoring the quantity of methane actually flared and gas used to generate electricity and/or produce thermal energy and/or supply to end users via natural gas distribution pipeline, if applicable, and the total quantity of methane captured.

The sum of the quantities fed to the flare(s), to the power plant(s), to the boiler(s) and to the natural gas distribution network must be compared annually with the total quantity of methane generated. The lowest value of the two must be adopted as $MD_{project,y}$."

In case the total amount of methane generated is the highest value, $MD_{project,y}$ is given by:

$$\mathbf{MD_{project,y} = MD_{flared,y} + MD_{electricity,y} + MD_{thermal,y} + MD_{PL,y}} \quad \textbf{(4)}$$

Where:

$MD_{flared,y}$ = Quantity of methane destroyed by flaring (tCH_4)
$MD_{electricity,y}$ = Quantity of methane destroyed by generation of electricity (tCH_4)
$MD_{thermal,y}$ = Quantity of methane destroyed for the generation of thermal energy (tCH_4)
$MD_{PL,y}$ = Quantity of methane sent to the pipeline for feeding to the natural gas distribution network (tCH_4)

Since the project activity does not include thermal energy generation and feeding of methane to a natural gas distribution network, the components, $MD_{thermal,y}$ and $MD_{PL,y}$ in equation 4 become 0. Equation 4 is thus reduced to:

$$\mathbf{MD_{project,y} = MD_{flared,y} + MD_{electricity,y}} \quad \textbf{(5)}$$

As per the methodology, the quantity of methane destroyed by flaring is calculated as follows:

$$\mathbf{MD_{flared,y} = \{LFG_{flare,y} * w_{CH4,y} * D_{CH4}) - (PE_{flare,y}/GWP_{CH4})} \quad \textbf{(6)}$$

Where:

$LFG_{flare,y}$ = Quantity of LFG fed to the flare(s) during the year measured in cubic meters (m^3)
$w_{CH4,y}$ = Average methane fraction of the landfill gas as measured during the year and expressed as a fraction (in m^3 CH_4 / m^3 LFG)
D_{CH4} = Methane density expressed in tonnes of methane per cubic meter of methane (t CH_4/m^3 CH_4)
$PE_{flare,y}$ = Project emissions from flaring of the residual gas stream in year y (t CO2e) determined following the procedure described in the *"Tool to determine project emissions from flaring gases containing methane"*. If methane is flared through more than one flare, the $PE_{flare,y}$ shall be determined for each flare using the tool. The project will use an enclosed flaring system and monitoring will be done continuously.

$$\mathbf{MD_{electricity,y} = LFG_{electricity,y} * w_{CH4,y} * D_{CH4}} \quad \textbf{(7)}$$

Where:

$MD_{electricity,y}$ = Quantity of methane destroyed by generation of electricity
$LFG_{electricity,y}$ = Quantity of LFG fed into electricity generator.

Ex-ante estimation of the amount of methane that would have been destroyed/combusted during the year, in tonnes of methane ($MD_{project,y}$)

The ex-ante estimation of the amount of methane that would have been destroyed/combusted during the year, in tonnes of methane ($MD_{project,y}$) 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"*, considering the following additional equation:

$MD_{project,y}$ = $\mathbf{BE_{CH4,SWDS,y}/GWP_{CH4}}$ **(8)**

Where:

$BE_{CH4,SWDS,y}$ = Methane generation from the landfill in the absence of the project activity at year y (tCO2e), calculated as per the *"Tool to determine methane emissions avoided from disposal of waste at a solid waste disposal site"*. The tool estimates methane generation adjusted for, using adjustment factor (f), any LFG in the baseline that would have been captured and destroyed to comply with relevant regulations or contractual requirements, or to address safety and odor concerns. As this is already accounted for in equation 3, "f" in the tool shall be assigned a value 0.

Furthermore, according to the methodology ACM0001, the following guidance should be taken into account:

- In the tool x will refer to the year since the landfill started receiving wastes (x runs from the first year of landfill operation (x=1) to the year for which the emission are calculated (x=y);
- Sampling to determine the different waste types is not necessary, the waste composition can be obtained from previous studies.

The methodology ACM0001 also indicates that the efficiency of the degassing system which will be installed in the project activity should be taken into consideration while estimating the *ex ante* estimation. This is taken into consideration by the application of a LFG collection efficiency (CE) of 65% to the methane generation in year y ($BE_{CH4,SWDS,y}$).

Note: the same term $MD_{project,y}$ is used for the ex-post measurement of methane destruction as in Equations (4) and (5) as well as for the ex-ante estimation of methane destruction using Equation (8). In fact, Equation (8) refers to the ex-ante estimation of methane captured without taking into account the methane destruction efficiency of the flare. Since the amount of methane flared depends on other uses of methane, the ex-ante estimation for this project activity starts from an estimate of methane captured using Equation (8) and considering the collection efficiency (CE), then estimates how much of the methane is used for power generation, with the remainder going to the flare. Finally, the methane destruction efficiency of the flare is taken into consideration in determining the methane destruction in the project scenario.

As per the *"Tool to determine methane emissions avoided from disposal of waste at a solid waste disposal site", t*he amount of methane generated in the year *y* ($BE_{CH4,SWDS,y}$) is calculated as follows:

$$BE_{CH4,SWDS,y} = \varphi \cdot (1-f) \cdot GWP_{CH4} \cdot (1-OX)\frac{16}{12} \cdot F \cdot DOC_f \cdot MCF \cdot \sum_{x=1}^{y}\sum_{j} W_{j,x} \cdot DOC_j \cdot (1-e^{-k_j}) \cdot e^{-k_j \cdot (y-x)} \qquad \mathbf{(9)}$$

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 (tCO_2e)[13]

φ = Model correction factor to account for model uncertainties (0.9)

f = Fraction of methane captured at the SWDS and flared, combusted or used in another manner (0)

GWP_{CH4} = Global Warming Potential (GWP) of methane, valid for the relevant commitment period (21)

OX = Oxidation factor (reflecting the amount of methane from SWDS that is oxidised in the soil or other material covering the waste)

F = Fraction of methane in the SWDS gas (volume fraction) (0.5)

DOC_f = Fraction of degradable organic carbon (DOC) that can decompose

MCF = Methane correction factor

$W_{j,x}$ = Amount of organic waste type *j* prevented from disposal in the SWDS in the year *x* (tons).

DOC_j = Fraction of degradable organic carbon (by weight) in the waste type *j*

k_j = Decay rate for the waste type *j*

j = Waste type category (index)

x = Year since the landfill started receiving wastes (x runs from the first year of landfill operation (x=1) to the year for which the emission are calculated (x=y)

y = Year for which methane emissions are calculated

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

In the baseline, electricity is generated by plants connected to the Interconnected National System (SIN). The emission factor is therefore calculated by using the "Tool to calculate the emission factor for an electricity system"

According to the "Tool to calculate the emission factor for an electricity system", CEF is calculated as a combined margin (CM), consisting of the combination of operating margin (OM) and built margin (BM) factor by applying the following steps:.

STEP 1. Identify the relevant electricity systems.
STEP 2. Choose whether to include off-grid power plants in the project electricity system (optional).
STEP 3. Select a method to determine the operating margin (OM).
STEP 4. Calculate the operating margin emission factor according to the selected method.
STEP 5. Calculate the build margin (BM) emission factor.
STEP 6. Calculate the combined margin (CM) emissions factor.

$CEF_{elec,BL,y}$ corresponds to $EF_{grid,CM,y}$ in the "Tool to calculate the emission factor for an electricity system".

Step 1: Identify the relevant electricity systems

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[13] Note: Methane emissions avoided during the year *y* from preventing waste disposal at the solid waste disposal site (SWDS) means in this case, as explained above, methane generated from the landfill in the absence of the project activity.

The grid emission factor is calculated based on the last version of the "Electricity Sector Outlook" developed by the Mexican Secretary of Energy (SENER) (2008-2017)

The relevant power system is the one where the landfill is located, and comprises the Interconnected National System (SIN) which covers all of Mexico, except Baja California and Baja California South, each of which has an isolated system, not connected to the Interconnected National System (SIN), or to each other.

For imports from a connected electricity system, the emission factor is 0 tCO_2/MWh.

Electricity exports are not subtracted from the electricity generation data used for calculating and monitoring the electricity emission factors.

Step 2: Choose whether to include off-grid power plants in the project electricity system (optional)

Option I is chosen: only grid power plants are included in the calculation.

Step 3: Select a method to determine the operating margin (OM)

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

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

Option (a), simple OM is chosen for the calculation of the operating margin emission factor.

The simple OM method (option a) can only be used if low-cost/must-run resources constitute less than 50% of total grid generation in: 1) average of the five most recent years, or 2) based on long-term averages for hydroelectricity production.

In Mexico electricity generation is dominated by thermal power plants. Low-cost/must-run resources constitute less than 50% of total grid generation. Table 10 shows the average of the five most recent years:

Table 10: Share of low-cost/must-run resources

	2003	2004	2005	2006	2007
Share of low-cost/must-run	18%	20%	21%	21%	19%
Average share of low-cost/must-run					**20%**

The tool provides for ex-ante or ex-post calculation of the operating margin. The ex ante option is selected which means that the operating margin emission factor is calculated ex-ante based on a 3-year generation weighted average.

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

(a) Simple OM
The simple OM emission factor is calculated as the generation-weighted average CO_2 emissions per unit net electricity generation (tCO_2/MWh) of all generating power plants serving the system, not including low-cost/must-run power plants/units.

The simple OM may be calculated:

Option A: Based on the net electricity generation and a CO_2 emission factor of each power unit; or

Option B: Based on the total net electricity generation of all power plants serving the system and the fuel types and total fuel consumption of the project electricity system.

In this case Option B is chosen given that the necessary data for Option A is not available.

With Option B, the simple OM emission factor is calculated based on the net electricity supplied to the grid by all power plants serving the system, not including low-cost/must-run power plants/units, and based on the fuel type(s) and total fuel consumption of the project electricity system, as follows:

$$EF_{grid,OMsimple,y} = \frac{\sum_{i}(FC_{i,y} * NCV_{i,y} * EF_{CO2,i,y})}{EG_y} \quad \textbf{(10)}$$

Where:

$EF_{grid,OMsimple,y}$	= Simple operating margin CO_2 emission factor in year y (tCO_2/MWh)
$FC_{i,y}$	= Amount of fossil fuel type *i* consumed in the project electricity system in year y (mass or volume unit)
$NCV_{i,y}$	= Net calorific value (energy content) of fossil fuel type *i* in year y (GJ/mass or volume unit)
$EF_{CO2,i,y}$	= CO_2 emission factor of fossil fuel type *i* in year y (tCO_2/GJ)
EG_y	= Net electricity generated and delivered to the grid by all power sources serving the system, not including low-cost/must-run power plants/units, in year y (MWh)
i	= All fossil fuel types combusted in power sources in the project electricity system in year y
y	= The relevant year as per the data vintage chosen in Step 3

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

For the calculation of the build margin (BM) emission factor the tool provides for ex ante and ex post calculation. Option 1 ex ante calculation has been chosen.

The sample group of power units *m* used to calculate the build margin is determined as follows:

(a) Identify the set of five power units, excluding power units registered as CDM project activities that started to supply electricity to the grid most recently ($SET_{5\text{-units}}$) and determine their annual electricity generation ($AEG_{SET\text{-}5\text{-units}}$, in MWh);
(b) Determine the annual electricity generation of the project electricity system, excluding power units registered as CDM project activities (AEG_{total}, in MWh). Identify the set of power units, excluding power units registered as CDM project activities, that started to supply electricity to the grid most recently and that comprise 20% of AEG_{total} (if 20% falls on part of the generation of a unit, the generation of that unit is fully included in the calculation) ($SET_{\geq 20\%}$) and determine their annual electricity generation ($AEG_{SET\text{-}\geq 20\%}$ in MWh).
(c) From $SET_{5\text{-units}}$ and $SET_{\geq 20\%}$ select the set of power units that comprises the larger annual electricity generation (SET_{sample})

For Mexico, the set of power capacity addition in the electricity system that comprise 20% of the system generation ($SET_{\geq 20\%}$) comprise a larger annual generation than the set of five power plants that have been built most recently ($SET_{5\text{-units}}$). SET_{sample} thus corresponds to the $SET_{\geq 20\%}$.. The oldest power unit included in the $SET_{\geq 20\%}$ started to supply electricity to the grid in the year 2003 (see Annex 3, Table 30). Therefore, none of the power units in SET_{sample} started to supply electricity to the grid more than 10 years ago SET_{sample} is therefore used to calculate the build margin.

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

$$EF_{grid,BM,y} = \frac{\sum_m EG_{m,y} * EF_{EL,m,y}}{\sum_m EG_{m,y}} \qquad \textbf{(11)}$$

Where:

$EF_{grid,BM,y}$	= Build margin CO_2 emission factor in year y (tCO_2/MWh)
$EG_{m,y}$	= Net quantity of electricity generated and delivered to the grid by power unit *m* in year y (MWh)
$EF_{EL,m,y}$	= CO_2 emission factor of power unit m in year y (tCO_2/MWh)
m	= Power units included in the build margin
y	= Most recent historical year for which power generation data is available.

The CO_2 emission factor of each power unit m ($EF_{EL,BM,y}$) is determined using either option A1, A2 or A3 provided in the tool for the calculation of the simple OM emission factor. Option A2 has been chosen.

$$EF_{EL,m,y} = \frac{EF_{CO2,m,i,y} * 3.6}{\eta_{m,y}} \qquad \textbf{(12)}$$

Where

$EF_{EL,m,y}$	= CO_2 emission factor of power unit *m* in year y (tCO_2/MWh)
$EF_{CO2,m,i,y}$	= Average CO_2 emission factor of fuel type *i* used in power unit *m* in year y (tCO_2/GJ)
$\eta_{m,y}$	= Average net energy conversion efficiency of power unit *m* in year y (ratio)
m	= All power units serving the grid in year y except low- cost / must – run power units

i = All fossil fuel types combusted in power unit m in year y
y = The relevant year as per the vintage chosen in Step 5.

Step 6: Calculate the combined margin emission factor

The tool provides for the following methods for the calculation of the combined margin (CM) emission factor ($EF_{grid,CM,y}$):

(a) Weighted average CM; or
(b) Simpliefied CM.

Option (a), the weighted average CM, has been chosen.

With Option (a), the combined margin emission factor is calculated as follows:

$$EF_{grid,CM,y} = EF_{grid,OM,y} * w_{OM} + EF_{grid,BM,y} * w_{BM} \quad \textbf{(13)}$$

Where:
$EF_{grid,BM,y}$ = Build margin CO_2 emission factor in year y (t CO_2/MWh)
$EF_{grid,OM,y}$ = Operating margin CO_2 emission factor in year y (t CO_2/MWh)
w_{OM} = Weighting of operating margin emission factor (%)
w_{BM} = Weighting of build margin emission factor (%)

The following weightings are applied: $w_{OM} = w_{BM} = 0.5$

Project Emissions:

According to ACM0001, the project emissions PE_y are calculated using the following equation:

$$PE_y = PE_{EC,y} + PE_{FC,j,y} \quad \textbf{(14)}$$

Where:
$PE_{EC,y}$ = Emissions from consumption of electricity in the project case. The project emissions from electricity consumption ($PE_{EC,y}$) will be calculated following the latest version of the "*Tool to calculate baseline, project and/or leakage emissions from electricity consumption*".

$PE_{FC,j,y}$ = Emissions from consumption of heat in the project case. The project emissions from fossil fuel combustion ($PE_{FC,j,y}$) will be calculated following the latest version of the "*Tool to calculate project or leakage CO_2 emissions from fossil fuel combustion*". For this purpose, the process j in the tool corresponds to all fossil fuel combustion in the landfill, as well as any other on-site fuel combustion for the purposes of the project activity.

Project Emissions from electricity consumption ($PE_{EC\,y}$)

The electricity consumed by the project activity is bought from the Interconnected National System (SIN). Hence, scenario A: "Electricity consumption from the grid", as provided in the "*Tool to calculate baseline, project and/or leakage emissions from electricity consumption*", is used to determine the project emissions from electricity consumption.

$PE_{EC,y} = \Sigma_j EC_{PJ,j,y} * EF_{EL,j,,y} *(1+TDL_{j,y})$ **(15)**

Where:

$PE_{EC,y}$ = Project emissions from electricity consumption in year y (tCO_2/yr)
$EC_{PJ,j,y}$ = Quantity of electricity consumed by the project in year y (MWh/yr)
$EF_{EF,j,y}$ = Emission factor for the grid electricity generation (tCO_2/MWh)
$TDL_{j,y}$ = Average technical transmission and distribution losses for providing electricity to the project in year y

Emissions from electricity consumption are only calculated in case electricity is bought from the Interconnected National System (SIN) and no electricity is generated onsite from LFG. When electricity is generated from the captured LFG (phase 2), electricity consumption by the project activity is already considered in the net electricity export to the Interconnected National System (SIN) ($EL_{LFG,y}$) which is the electricity generated minus the electricity consumed by the project activity.

For the determination of the emission factor ($EF_{EL,j,y}$) for the grid electricity generation, Option A1 has been chosen, where the emission factor is determined by applying the "Tool to calculate the emission factor for an electricity system". The calculation steps are the same as outlined above for $CEF_{elec,BL,y}$, with $EF_{EL,j,y} = EF_{grid,CM,y}$.

Project Emissions from onsite fuel consumption ($PE_{FC,j,y}$)

Project emissions from fossil fuel combustion ($PE_{FC,j,y}$) in the project are determined using the *"Tool to calculate project or leakage CO_2 emissions from fossil fuel combustion",* as follows:

$PE_{FC,j,y} = \Sigma_i FC_{i,j,y} * COEF_{i,y}$ **(16)**

Where:

$PE_{FC,j,y}$	CO_2 emissions due to on-site fuel consumption in the year y (tCO_2)
$FC_{i,j,,y}$	Quantity of fuel type *i* combusted in process *j* during the year y (mass or volume unit/yr)
$COEF_{i,y}$	CO_2 emission coefficient of fuel type *i* in year y (tCO_2/mass or volume unit)
i	Fuel type combusted in process *j* during the year y

The CO_2 emission coefficient $COEF_{i,y}$ is determined using Option B given in *"Tool to calculate project or leakage CO_2 emissions from fossil fuel combustion"* since the necessary data for Option A is not available.

$COEF_{i,y} = NCV_{i,y} * EF_{CO2,i,y}$ **(17)**

Where:

$COEF_{i,y}$	CO_2 emission coefficient of fuel type *i* in year y (tCO_2/mass or volume unit)
$NCV_{i,y}$	Weighted average net calorific value of the fuel type *i* in year y (GJ/mass or volume unit)
$EF_{CO2,i,y}$	Weighted average CO_2 emission factor of fuel type *i* in year y (tCO_2/GJ)
I	Fuel type combusted in process *j* during the year y

Project emissions from flaring ($PE_{flare,y}$)

According to ACM0001, the project emissions from flaring are considered as $PE_{flare,y}$ in the calculation of $MD_{Project}$. $PE_{flare,y}$ is calculated following the procedure described in the *"Tool to determine project emissions from flaring gases containing methane"*. If methane is flared through more than one flare, the $PE_{flare,y}$ shall be determined for each flare using the tool.

The project will use an enclosed flaring system. According to the tool, there are two options for determining the efficiency of enclosed flares:

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

The second option, "continuous monitoring of the methane destruction efficiency of the flare (flare efficiency)" is used to determine the flare efficiency.

According to the *"Tool to determine project emissions from flaring gases containing methane"* the temperature in the exhaust gas of enclosed flares is measured to determine whether the flare is operating or not. 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.

For the calculation of the flare efficiency, the seven steps described in the *"Tool to determine project emissions from flaring gases containing methane"* are followed.

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

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

$$FM_{RG,h} = \rho_{RG,n,h} * FV_{RG,h} \quad \textbf{(18)}$$

Where:

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

and

$$\rho_{RG,n,h} = \frac{P_n}{\frac{R_u}{MM_{RG,h}} \times T_n} \quad \textbf{(19)}$$

Where:

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

and

$$MM_{RG,h} = \sum_i (fv_{i,h} * MM_i) \quad \textbf{(20)}$$

Where:

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

According to the tool, project participants may only measure the volumetric fraction of methane and consider the difference to 100% as being nitrogen (N_2). This simplified approach will be applied to this project activity.

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:

$$fm_{j,h} = \frac{\sum_i fv_{i,h} \cdot AM_j \cdot NA_{j,i}}{MM_{RG,h}} \quad \textbf{(21)}$$

Where:

Variable	SI Unit	Description
$fm_{i,h}$	-	Mass fraction of element *j* in the residual gas in hour *h*
$fv_{i,h}$	-	Volumetric fraction of component *i* in the residual gas in the hour *h*
AM_i	kg/kmol	Atomic Mass of element *j*
$NA_{j,i}$	-	Number of atoms of element *j* in component *i*
j		The elements carbon, hydrogen, oxygen, and nitrogen. With the simplified approach, only methane is measured and the balance

		assumed to be nitrogen.
i		The components CH_4 and N_2 (simplified approach)

<u>Step 3: Determination of the volumetric flow rate of the exhaust gas on a dry basis</u>

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

$$TV_{n,FG,h} = V_{n,FG,h} * FM_{RG,h} \quad \textbf{(22)}$$

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*

$$V_{n,FG,h} = V_{n,CO2,h} + V_{n,O2,h} + V_{n,N2,h} \quad \textbf{(23)}$$

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

$$V_{n,O2,h} = n_{O2,h} * MV_n \quad \textbf{(24)}$$

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 O_2 in the exhaust gas of the flare per kg residual gas flared in hour *h*
MV_n	m^3/kmol	Volume of one mole of any ideal gas at normal temperature and

		pressure (22.4 L/mol)

$$V_{n,N_2,h} = MV_n * \left\{ \frac{fm_{N,h}}{200 AM_N} + \left(\frac{1 - MF_{O_2}}{MF_{O_2}} \right) * \left[F_h + n_{O_2,h} \right] \right\} \quad (25)$$

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 L/mol)
$fm_{N,h}$	-	Mass 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	Stoichiometric 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*

$$V_{n,CO_2,h} = \frac{fm_{C,h}}{AM_C} * MV_n \quad (26)$$

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 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 L/mol)

$$n_{O_2,h} = \frac{t_{O_2,h}}{\left(1 - (t_{O_2,h} / MF_{O_2})\right)} \times \left[\frac{fm_{C,h}}{AM_C} + \frac{fm_{N,h}}{2 AM_N} + \left(\frac{1 - MF_{O_2}}{MF_{O_2}} \right) \times F_h \right] \quad (27)$$

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	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 the hour *h*

AM_i	kg/kmol	Atomic mass of element *j*
j		The elements carbon (index C) and nitrogen (index N)

$$F_h = \frac{fm_{C,h}}{AM_C} + \frac{fm_{H,h}}{4AM_H} - \frac{fm_{O,h}}{2AM_O} \quad \textbf{(28)}$$

Where:

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

Since only the volumetric fraction of methane ($fv_{CH4,h}$) will be measured and the difference to 100% is considered to be nitrogen (N_2) (simplified approach mentioned in Step 1), $fm_{O,h}$ will be equal to zero.

Step 4: Determination of methane mass flow rate in the exhaust gas on a dry basis

This step is applicable because the methane combustion efficiency of the flare will be measured continuously. The mass flow of methane in the exhaust gas is based on the volumetric flow of the exhaust gas and the measured concentration of methane in the exhaust gas, as follows:

$$TM_{FG,h} = \frac{TV_{n,FG,h} * fv_{CH4,FG,h}}{1000000} \quad \textbf{(29)}$$

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 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 ($\rho_{CH4,n}$) in the same reference conditions (normal conditions and dry or wet basis).

$$TM_{RG,h} = FV_{RG,h} * fv_{CH4,RG,h} * \rho_{CH4,n} \quad \textbf{(30)}$$

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 hour *h*
$fv_{CH4,RG,h}$	-	Volumetric fraction of methane in the residual gas on dry basis in hour *h*
$\rho_{CH4,n}$	kg/m^3	Density of methane at normal conditions (0.716)

Step 6: Determination of the hourly flare efficiency

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

• 0% if the temperature of the exhaust gas of the flare (T_{flare}) is below 500 °C during more than 20 minutes during the hour *h*.

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

$$\eta_{flare,h} = 1 - \frac{TM_{FG,h}}{TM_{RG,h}} \quad \textbf{(31)}$$

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*

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:

$$PE_{flare,y} = \sum_{h=1}^{8760} TM_{RG,h} * (1 - \eta_{flare,h}) * \frac{GWP_{CH4}}{1000} \quad \textbf{(32)}$$

Where:

Variable	SI Unit	Description
$PE_{flare,y}$	tCO_2e	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*
$\eta_{flare,h}$	-	Flare efficiency in hour *h*

GWP_{CH4}	tCO_2e/tCH_4	Global Warming Potential of methane valid for the commitment period

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

Parameter	SI Unit	Description	Value
MM_{CH4}	kg/kmol	Molecular mass of methane	16.04
MM_{CO}	kg/kmol	Molecular mass of carbon monoxide	28.01
MM_{CO2}	kg/kmol	Molecular mass of carbon dioxide	44.01
MM_{O2}	kg/kmol	Molecular mass of oxygen	32.00
MM_{H2}	kg/kmol	Molecular mass of hydrogen	2.02
MM_{N2}	kg/kmol	Molecular mass of nitrogen	28.02
AM_C	kg/kmol (g/mol)	Atomic mass of carbon	12.00
AM_H	kg/kmol (g/mol)	Atomic mass of hydrogen	1.01
AM_O	kg/kmol (g/mol)	Atomic mass of oxygen	16.00
AM_N	kg/kmol (g/mol)	Atomic mass of nitrogen	14.01
P_n	Pa	Atmospheric pressure at normal conditions	101,325
R_u	Pa m^3/kmol K	Universal ideal gas constant	8,314.472
T_n	K	Temperature at normal conditions	273.15
MF_{O2}	Dimensionless	O_2 volumetric fraction of air	0.21
GWP_{CH4}	tCO_2/tCH_4	Global warming potential of methane	21
MV_n	m^3/kmol	Volume of one mole of any ideal gas at normal temperature and pressure	22.414
$\rho_{CH4,n}$	kg/m^3	Density of methane gas at normal conditions	0.716
$NA_{i,j}$	Dimensionless	Number of atoms of element j in component i, depending on molecular structure	

Data / Parameter:	**D_{CH4}**
Data unit:	tCH_4/m^3CH_4
Description:	Methane Density
Source of data used:	
Value applied:	At standard temperature and pressure the density of methane is 0.0007168 tCH_4/m^3CH_4.
Justification of the choice of data or description of measurement methods and procedures actually applied :	Value as provided in the methodology ACM0001.
Any comment:	

Data / Parameter:	**$BE_{CH4,SWDS,y}$**

Data unit:	tCO_2e
Description:	Methane generation from the landfill in the absence of the project activity at year y
Source of data used:	Calculated as per the "Tool to determine methane emissions avoided from disposal of waste at a solid waste disposal site".
Value applied:	See section B.6.3
Justification of the choice of data or description of measurement methods and procedures actually applied :	As per the "Tool to determine methane emissions avoided from disposal of waste at a solid waste disposal site".
Any comment:	Used for ex ante estimation of the amount of methane that would have been destroyed/combusted during the year.

Parameter:	**Regulatory requirements relating to landfill gas**
Unit:	-
Description:	Regulatory requirements relating to landfill gas
Source of data	Publicly available information of the host country's regulatory requirements relating to landfill gas
Value of data	-
Justification of the choice of data or description of measurement methods and procedures actually applied :	No methane is captured and destroyed/combusted at the Chiltepeque landfill in the absence of the project activity. According to applicable mandatory laws and regulations there is no obligation to capture and destroy/combust methane generated through the deposition of waste in landfills. This has been explained in more detail in section B.4 above.
Any comment:	The information though recorded annually, is used for changes to the adjustment factor (AF) or directly $MD_{BL,y}$ at renewal of the credit period. Relevant regulations for LFG project activities shall be updated at renewal of each credit period. Changes to regulation should be converted to the amount of methane that would have been destroyed/combusted during the year in the absence of the project activity ($MD_{BL,y}$). Project participants should explain how regulations are translated into that amount of gas.

Parameter:	**AF**
Unit:	-
Description:	Adjustment factor
Source of data	Local information on existing facilities at landfills in the Host Country and information regarding existing regulations in the Host Country.
Value of data	0
Justification of the choice of data or description of measurement methods and procedures	No methane is captured and destroyed/combusted at the Chiltepeque landfill in the absence of the project activity. According to applicable mandatory laws and regulations there is no obligation to capture and destroy/combust methane generated through the deposition of waste in landfills. This has been explained in more detail in section B.4 above.

actually applied :	
Any comment:	

Data / Parameter:	**CE**
Data unit:	-
Description:	Collection efficiency of the degassing system which will be installed in the project activity
Source of data used:	U.S. EPA Landfill Methane Outreach Program (2007). Users Manual, Central America Landfill Gas Model, page 2-6. (www.epa.gov/lmop/index.html)
Value applied:	65%
Justification of the choice of data or description of measurement methods and procedures actually applied :	The collection efficiency has been estimated according to the guidelines provided in the Users Manual for the Central America Landfill Gas Model, Table 6, page 2-6.
Any comment:	Used for ex ante estimation of baseline emissions.

Data / Parameter:	**Φ**
Data unit:	-
Description:	Model correction factor to account for model uncertainties
Source of data used:	See below
Value applied:	0.9
Justification of the choice of data or description of measurement methods and procedures actually applied :	Default value as proposed by the "Tool to determine methane emissions avoided from disposal of waste at a solid waste disposal site".
Any comment:	Oonk et el. (1994) have validated several LFG models based on 17 realized LFG projects. The mean relative error of multi-phase models was assessed to be 18%. Given the uncertainties associated with the model and in order to estimate emission reductions in a conservative manner, a discount of 10% is applied to the model results.

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:	See below
Value applied:	0.1
Justification of the choice of data or description of measurement methods and procedures actually applied :	0.1 is to be used for managed solid waste disposal sites that are covered with oxidizing material such as soil or compost. For other solid waste disposal sites a value of 0 can be used. The Chiltepeque landfill where the waste would be disposed of in the absence of the project activity is covered with oxidizing material (clay); hence a value of 0.1 is applied.
Any comment:	-

Data / Parameter:	**F**
Data unit:	-
Description:	Fraction of methane in the SWDS gas (volume fraction)
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 :	Default value as proposed by the "Tool to determine methane emissions avoided from disposal of waste at a solid waste disposal site".
Any comment:	This factor reflects the fact that some degradable organic carbon does not degrade, or degrades very slowly, under anaerobic conditions in the SWDS. A default value of 0.5 is recommended by IPCC.

Data / Parameter:	**DOC_f**
Data unit:	-
Description:	Fraction of degradable organic carbon 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 :	Default value as proposed by the "Tool to determine methane emissions avoided from disposal of waste at a solid waste disposal site".
Any comment:	-

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 landfill site at Puebla where the waste would have been disposed of in the absence of the project activity is a managed landfill site with controlled placement of waste, with compaction and levelling and thus meets the criteria of a managed SWDS in the absence of the project activity. Hence a value of 1 is applied.
Any comment:	The methane correction factor (MCF) accounts for the fact that unmanaged SWDS produce less methane from a given amount of waste than managed SWDS, because a larger fraction of waste decomposes aerobically in the top layers of unmanaged SWDS.

Data / Parameter:	**DOC_j**
Data unit:	-
Description:	Fraction of degradable organic carbon (by weight) in the waste type *j*
Source of data used:	IPCC 2006 Guidelines for National Greenhouse Gas Inventories (adapted from Volume 5, Tables 2.4 and 2.5)
Value applied:	see table below
Justification of the choice of data or description of measurement methods and procedures actually applied :	Default value for wet waste has been used as proposed by the “Tool to determine methane emissions avoided from disposal of waste at a solid waste disposal site”.
Any comment:	-

Type of Waste	**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

Data / Parameter:	**k_j**
Data unit:	-
Description:	Decay rate for the waste type j
Source of data used:	IPCC 2006 Guidelines for National Greenhouse Gas Inventories (adapted from Volume 5, Table 3.3)

<table>
<tr><td>Value applied:</td><td><table><tr><td colspan="2">Waste type</td><td>k</td></tr><tr><td>slowly degrading</td><td>Pulp, paper and cardboard, (other than sludge), textiles</td><td>0.06</td></tr><tr><td>slowly degrading</td><td>Wood, wood products and straw</td><td>0.03</td></tr><tr><td>moderately degrading</td><td>other (non food) organic putrescible garden and park waste</td><td>0.1</td></tr><tr><td>rapidly degrading</td><td>Food, food waste, sewage sludge, beverages and tobacco</td><td>0.185</td></tr></table></td></tr>
<tr><td>Justification of the choice of data or description of measurement methods and procedures actually applied :</td><td>Puebla is located in a temperate region of Mexico with a mean annual temperature (MAT) of 16.2 °C (Source: www.worldclimate.com -> Puebla), i.e.< 20 °C. The mean annual precipitation (MAP) is 844 mm (Source: www.worldclimate.com -> Puebla). The annual potential evapotranspiration (PET) is 749.7 mm
(Source: Recursos hidrológicos del centro de Mexico ante un cambio climatico global (Hydrologic resources of the central part of Mexico in the view of a global climate change), page 44, Table 2. (Puebla is situated in the Balsas river basin)
http://www.atmosfera.unam.mx/editorial/libros/cambio_climatico/hidrologicos.pdf)
Thus, MAP>PET, which means a wet climate.</td></tr>
<tr><td>Any comment:</td><td></td></tr>
</table>

Combined margin emission factor

Data / Parameter:	$FC_{i,m,y}$
Data unit:	TJ/yr
Description:	Amount of fossil fuel type *i* consumed in the project electricity system in year y (2005-2007)
Source of data used:	Official statistics from the Secretary of Energy, SENER (Prospectiva del Sector Eléctrico (Electricity Sector Outlook), 2006-2015, 2007-2016,2008-2017. (http://www.sener.gob.mx/webSener/portal/Default.aspx?id=1433)
Value applied	Values applied are provided in Annex 3.
Justification of the choice of data or description of measurement methods and procedures actually applied:	Total fuel consumption is indicated by SENER in TJ/day per fuel type. This value is multiplied by 365 days to obtain the fuel consumption in TJ per year.
Any comment:	No monitoring is needed as the total fuel consumption in the electricity system is used for the calculation of the operating margin emission factor which is determined ex ante.

Data / Parameter:	**$EF_{CO2,i,y}$ and $EF_{CO2,m\ i,y}$**
Data unit:	tCO_2 /GJ
Description:	CO_2 emission factor of fossil fuel type i in year y
Source of data used:	IPCC default values at the lower limit of the uncertainty at a 95% confidence interval as provided in table 1.4 of Chapter1 of Vol. 2 (Energy) of the 2006 IPCC Guidelines on National GHG Inventories
Value applied	**Fuel type i** / **Value** / **Unit**: Fuel oil / 0.0755 / tCO_2/GJ Natural gas / 0.0543 / tCO_2/GJ Diesel / 0.0726 / tCO_2/GJ Coal / 0.0895 / tCO_2/GJ
Justification of the choice of data or description of measurement methods and procedures actually applied:	According to the *"Tool to calculate the emission factor for an electricity system"*, IPCC default values at the lower limit of the uncertainty at a 95% confidence interval as provided in table 1.4 of Chapter1 of Vol. 2 (Energy) of the 2006 IPCC Guidelines on National GHG Inventories
Any comment:	No monitoring is needed as the emission factors for the fuel types indicated above are used for the calculation of the operating margin and the build margin which are determined ex ante.

Data / Parameter:	**EG_y and $EG_{m,y}$**
Data unit:	MWh
Description:	Net electricity generated and delivered to the Interconnected National System (SIN) by power unit m in year y
Source of data used:	Official statistics from the Secretary of Energy, SENER (Prospectiva del Sector Eléctrico (Electricity Sector Outlook) 2008-2017. (http://www.sener.gob.mx/webSener/portal/Default.aspx?id=1433)
Value applied	Values applied are provided in Annex 3.
Justification of the choice of data or description of measurement methods and procedures actually applied:	For EG_y (for the calculation of the operating margin emission factor) data for 2005-2007 is used. For $EG_{m,y}$ (for the calculation of the build margin emission factor) data for the year 2007 is used.
Any comment:	No monitoring is needed as these values are used for the calculation of the operating margin and the build margin which are determined ex ante.

Data / Parameter:	**$\eta_{m,y}$**
Data unit:	-
Description:	Average net energy conversion efficiency of power unit m in year y
Source of data used:	Official statistics from the Secretary of Energy, SENER (Prospectiva del

	Sector Eléctrico (Electricity Sector Outlook) 2008-2017. (http://www.sener.gob.mx/webSener/portal/Default.aspx?id=1433)
Value applied	<table><tr><td></td><td>**Efficiency (%)**</td></tr><tr><td>Natural gas (single cycle)</td><td>35.19%</td></tr><tr><td>Natural gas (combined cycle)</td><td>52.18%</td></tr><tr><td>Internal combustion</td><td>42.36%</td></tr></table>
Justification of the choice of data or description of measurement methods and procedures actually applied:	The values applied are average values of a set of different values indicated by SENER for the year 2007 (Prospectiva del Sector Eléctrico (Electricity Sector Outlook) 2008-2017, page 168)
Any comment:	No monitoring is needed as these values are used for the calculation of the build margin emission factor which is determined ex-ante.

Data / Parameter:	**$EF_{grid,CM,y}$.= $CEF_{elec,BL,y}$ = $EF_{EL,j,,y}$**
Data unit:	tCO_2/MWh
Description:	Combined margin CO_2 emission factor for the project electricity system in year y
Source of data used:	Calculated ex-ante using the "*Tool to calculate the emission factor for an electricity system*". The calculation is based on official data from the Secretary of Energy, SENER (Prospectiva del Sector Eléctrico (Electricity Sector Outlook) 2004-2013, 2005-2014, 2006-2015, 2007-2016, 2008-2017 (http://www.sener.gob.mx/webSener/portal/Default.aspx?id=1433)
Value applied:	0.4864
Justification of the choice of data or description of measurement methods and procedures actually applied:	Calculated according to the *"Tool to calculate the emission factor for an electricity system"*
Any comment:	No monitoring is needed as the $EF_{grid,CM,y}$. is determined ex-ante

Project emissions from electricity consumption

Data / Parameter:	**$TDL_{j,y}$**
Data unit:	-
Description:	Average technical transmission and distribution losses for providing electricity to the project in year y
Source of data used:	Default value as per the *"Tool to calculate baseline, project and/or leakage emission from electricity consumption"*

Value applied:	20%
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:

Baseline emissions

$$BE_y = (MD_{project,y} - MD_{BL,y}) * GWP_{CH4} + EL_{LFG,y} * CEF_{elec,BL,y}$$ **Equation (2) in section B.6.1**

For ex-ante calculation of $MD_{Project,y}$, equation (5) and (8) are used, considering the collection efficiency (CE) and the destruction efficiency of the flare as explained in section B.6.1.

The amount of methane produced in the year *y* ($BE_{CH4,SWDS,y}$) is calculated with equation (9):

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

Table 11: Parameters applied for the calculation of $BE_{CH4,SWDS,y}$

Variable	Value applied
j	0.9
f	0
GWP_{CH4}	21
OX	0.1
F	0.5
DOC_f	0.5
MCF	1

Table 12: k_i and DOC_i applied for the calculation of $BE_{CH4,SWDS,y}$

Waste type category j	k_j (temperate, wet)	DOC_j (% wet waste)
Wood and wood products	0.03	43
Pulp, paper and cardboard (other than sludge)	0.06	40

Food, food waste, beverages and tobacco (other than sludge)	0.185	15
Textiles	0.06	24
Garden, yard and park waste	0.1	20
Glass, plastic, metal, other inert waste	0	0

Data on waste amount and waste composition used for the calculation of $BE_{CH4,SWDS,y}$ in Annex 3.

Table 13: Ex-ante estimation of $MD_{project,y}$

		CH_4 captured = $BE_{CH4,SWDS,y}$ / GWP * CE			$MD_{flared,y}$ = (CH_4 captured * % flared) – ($PE_{flare,y}$ / GWP)	$MD_{electricity,y}$ = CH_4 captured * (1 - % flared)	$MD_{project,y}$ = $MD_{flared,y}$ + $MD_{electricity,y}$
Year	**$BE_{CH4,SWDS,y}$ (tCO_2e)**	**CH_4 captured (tCH_4)**	**% flared (%)**	**$PE_{flare,y}$ (tCO_2e)**	**$MD_{flared,y}$ (tCH_4)**	**$MD_{electricity,y}$ (tCH_4)**	**$MD_{project,y}$ (tCH_4)**
2012	78,633	2,434	60.03%	614	1,432	973	2,405
2013	312,997	9,688	59.83%	2,435	5,681	3,891	9,572
2014	271,329	8,398	53.66%	1,893	4,417	3,891	8,308
2015	236,017	7,305	46.73%	1,434	3,346	3,891	7,237
2016	206,028	6,377	38.98%	1,044	2,436	3,891	6,327
2017	180,506	5,587	30.35%	712	1,662	3,891	5,553
2018	158,731	4,913	20.79%	429	1,001	3,891	4,893
2019	140,106	4,337	10.27%	187	436	3,891	4,328
2020	124,132	3,842	0.00%	-	-	3,842	3,842
2021	110,392	3,417	0.00%	-	-	3,417	3,417
2022	73,902	2,287	0.00%	-	-	2,287	2,287

The % flared is calculated according to the power generation potential according to installed capacity (Table 15), assuming that captured LFG is only flared in case it can not be combusted in the LFG engines. The percentage of captured LFG which is combusted in the LFG engines is therefore calculated as 100% minus the % flared.

The net amount of electricity generated using LFG ($EL_{LFG,y}$) is calculated as follows:
$EL_{LFG,y}$ = Power generation – $EC_{PJ,i,y}$

Table 14: Input parameters for the ex-ante estimation of the electricity generation from LFG

	Value	**Unit**	*Source*
NCV of methane	50.02	GJ/t	*http://www.engineeringtoolbox.com/gross-net-heating-values-d_420.html*
Methane fraction in LFG	0.5		*As per the "Tool to determine methane emissions avoided from disposal of waste at a solid waste disposal site"*
Power plant efficiency	40.1%		*Technical data sheet for the gas generator set, provided by Caterpillar*

Operation hours	8,000	h	*Assumed by RESA*
Capacity on-site per generator	1.355	MW	*According to the equipment provider*

The power generation with LFG is the estimated as the lower value of the power generation potential according to LFG availability and the power generation potential according to the installed capacity.
The power generation potential according to the LFG availability is estimated from the amount of captured methane, the NCV of methane and the efficiency of the power plant.
The power generation potential according to the installed capacity is calculated by multiplying the installed capacity by the operation hours of the power plant.

Table 15: Ex-ante estimation of the power generation using LFG

Year	CH_4 captured (tCH_4)	Power generation potential according to LFG availability (MWh)	Power generation potential according to installed capacity (MWh)	Power generation (MWh)
2012	2,434	13,560	5,420	5,420
2013	9,688	53,974	21,680	21,680
2014	8,398	46,788	21,680	21,680
2015	7,305	40,699	21,680	21,680
2016	6,377	35,528	21,680	21,680
2017	5,587	31,127	21,680	21,680
2018	4,913	27,372	21,680	21,680
2019	4,337	24,160	21,680	21,680
2020	3,842	21,406	21,680	21,406
2021	3,417	19,036	21,680	19,036
2022	2,287	12,744	16,260	12,744

The electricity consumption ($EC_{PJ,i,y}$) by the project activity is estimated based on the electricity consumption of the blowers. The electricity consumption of the blowers is calculated from the capacity of their motors and the operation hours. Since it is not yet defined exactly how many blowers will be installed, the total operation hours of the blowers is estimated from the volume of LFG captured and the capacity of the blowers.

Table 16: Input parameters for the ex-ante estimation of the electricity consumption ($EC_{PJ,i,y}$) by the project activity

Blowers	Value	Unit	*Source:*
Motor	0.0112	MW	*John Zink, JZ specification sheet*
Capacity	528	m3/h	*John Zink, JZ specification sheet*

Table 17: Ex-ante estimation of the electricity consumption ($EC_{PJ,i,y}$) by the project activity

Year	LFG captured (m^3)	Operation hours (h)	$EC_{PJ,j,y}$ (MWh/yr)
2012	6,790,955	12,852	144
2013	27,031,253	51,158	572
2014	23,432,704	44,347	496
2015	20,383,017	38,576	431
2016	17,793,171	33,674	377
2017	15,588,943	29,503	330
2018	13,708,422	25,944	290
2019	12,099,950	22,900	256
2020	10,720,397	20,289	227
2021	9,533,741	18,043	202
2022	6,382,404	12,079	135

Table 18: Ex-ante estimation of the net amount of electricity generated using LFG

Year	Power generation (MWh)	$EC_{PJ,j,y}$ (MWh/yr)	$EL_{LFG,y}$ (MWh)
2012	5,420	144	5,276
2013	21,680	572	21,108
2014	21,680	496	21,184
2015	21,680	431	21,249
2016	21,680	377	21,303
2017	21,680	330	21,350
2018	21,680	290	21,390
2019	21,680	256	21,424
2020	21,406	227	21,179
2021	19,036	202	18,834
2022	12,744	135	12,609

The detailed calculation of the combined margin emission factor ($EF_{grid,CM,y}$) is provided in Annex 3.

Table 19: Ex-ante estimation for the baseline emissions (BE_y)

Year	$MD_{project,y}$ (tCH_4)	$MD_{BL,y}$ (tCH_4)	$EL_{LFG,y}$ (MWh)	$CEF_{elec,BL,y}$ = $EF_{grid,CM,y}$ (tCO_2/MWh)	BE_y (tCO_2e/yr)
2012	2,405	-	5,276	0.4864	53,064
2013	9,572	-	21,108	0.4864	211,281
2014	8,308	-	21,184	0.4864	184,775
2015	7,237	-	21,249	0.4864	162,312
2016	6,327	-	21,303	0.4864	143,237
2017	5,553	-	21,350	0.4864	127,001
2018	4,893	-	21,390	0.4864	113,150
2019	4,328	-	21,424	0.4864	101,303
2020	3,842	-	21,179	0.4864	90,988

2021	3,417	-	18,834	0.4864	80,916
2022	2,287	-	12,609	0.4864	54,170

Project Emissions

$PE_y = PE_{EC,\,y} + PE_{FC,\,j,\,y}$ **Equation (14) in section B.6.1**

Project emissions from electricity consumption ($PE_{EC,\,y}$) are only calculated in case electricity is bought from the Interconnected National System (SIN) and no electricity is generated onsite from LFG. When electricity is generated from the captured LFG (phase 2), electricity consumption by the project activity is already considered in the net electricity export to the Interconnected National System (SIN) ($EL_{LFG,y}$) which is the electricity generated minus the electricity consumed by the project activity. For the ex-ante estimation of the project emissions from electricity consumption ($PE_{EC,\,y}$), it is assumed that before the grid connection the electricity consumed by the project activity will be generated by a diesel generator whose emissions are considered as project emissions from fossil fuel combustion ($PE_{FC,j,y}$).

Project emissions from fossil fuel combustion ($PE_{FC,j,y}$) are estimated based on the operation hours of the diesel generator and its fuel consumption per hour. According to RESA, a diesel generator with a capacity between approximately 0.03 and 0.05 MW will be installed, with diesel consumption according to the equipment provider between 7.6 and 14.2 l/h. For the calculation of the project emissions from fossil fuel consumption a consumption of 14.2 l diesel/hour is applied. The diesel generator will only be used if no electricity is generated onsite and if no electricity is obtained from the Interconnected National System.

Table 20: Ex-ante estimation of the project emissions from fossil fuel consumption ($PE_{FC,j,y}$)

Year	Operation hours (h)	$FC_{i,j,y}$ (m^3/yr)	$COEF_{i,y}$ (tCO_2/m^3)	$PE_{FC,j,y}$ (tCO_2e/yr)
2012	-	-	2.80	-
2013	-	-	2.80	-
2014	-	-	2.80	-
2015	-	-	2.80	-
2016	-	-	2.80	-
2017	-	-	2.80	-
2018	-	-	2.80	-
2019	-	-	2.80	-
2020	-	-	2.80	-
2021	-	-	2.80	-
2022	-	-	2.80	-

Table 21: Ex-ante estimation of the project emissions (PE_y)

Year	$PE_{EC,y}$ (tCO_2e/yr)	$PE_{FC,j,y}$ (tCO_2e/yr)	PE_y (tCO_2e/yr)
2012	-	-	-

2013	-	-	-
2014	-	-	-
2015	-	-	-
2016	-	-	-
2017	-	-	-
2018	-	-	-
2019	-	-	-
2020	-	-	-
2021	-	-	-
2022	-	-	-

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

Table 22: Summary of ex-ante estimation of emission reductions

Year	Estimation of project activity emissions (tCO2 e)	Estimation of baseline emissions (tCO2 e)	Estimation of leakage (tCO2 e)	Estimation of overall emission reductions (tCO2 e)
2012	-	53,064	0	53,064
2013	-	211,281	0	211,281
2014	-	184,775	0	184,775
2015	-	162,312	0	162,312
2016	-	143,237	0	143,237
2017	-	127,001	0	127,001
2018	-	113,150	0	113,150
2019	-	101,303	0	101,303
2020	-	90,988	0	90,988
2021	-	80,916	0	80,916
2022	-	54,170	0	54,170
Total (tCO_2)	**0**	**1,322,197**	**0**	**1,322,197**

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

B.7.1 Data and parameters monitored:

Data / Parameter:	**GWP_{CH4}**
Data unit:	tCO_2e/tCH_4
Description:	Global Warming Potential (GWP) of methane, valid for the relevant commitment period
Source of data to be used:	Decisions under the UNFCCC and the Kyoto Protocol (a value of 21 is to be applied for the first commitment period if the Kyoto Protocol)
Value of data applied	21

for the purpose of calculating expected emission reductions in section B.5	
Description of measurement methods and procedures to be applied:	Global Warming potential of Methane
QA/QC procedures to be applied:	
Any comment:	-

Data / Parameter:	**$LFG_{total,y}$**
Data unit:	m^3
Description:	Total amount of LFG captured at Normal Temperature and Pressure
Source of data to be used:	Measurements by the project participants
Value of data applied for the purpose of calculating expected emission reductions in section B.5	This parameter is not used for the ex ante calculation of expected emission reductions.
Description of measurement methods and procedures to be applied:	Measured continuously by a flow meter. Measured values are averaged in a time interval not greater than hour and afterwards.
QA/QC procedures to be applied:	The flow meter will be subject to regular maintenance and will be calibrated periodically according to the manufacturer's recommendation.
Any comment:	

Data / Parameter:	**$LFG_{flare,y}$**
Data unit:	m^3
Description:	Total amount of LFG flared at Normal Temperature and Pressure
Source of data to be used:	Measurements by the project participants
Value of data applied for the purpose of calculating expected emission reductions in section B.5	This parameter is not used for the ex ante calculation of expected emission reductions.
Description of measurement methods and procedures to be applied:	Measured continuously by a flow meter. Measured values are averaged in a time interval not greater than hour and afterwards.
QA/QC procedures to	The flow meter will be subject to regular maintenance and will be calibrated

be applied:	periodically according to the manufacturer's recommendation.
Any comment:	

Data / Parameter:	**$LFG_{electricity,,y}$**
Data unit:	m^3
Description:	Amount of LFG combusted in power plant at Normal Temperature and Pressure
Source of data to be used:	Measurements by the project participants
Value of data applied for the purpose of calculating expected emission reductions in section B.5	This parameter is not used for the ex ante calculation of expected emission reductions.
Description of measurement methods and procedures to be applied:	Measured continuously by a flow meter. Measured values are averaged in a time interval not greater than hour and afterwards.
QA/QC procedures to be applied:	The flow meter will be subject to regular maintenance and will be calibrated periodically according to the manufacturer's recommendation.
Any comment:	

Data / Parameter:	**$w_{CH4,y}$**
Data unit:	m^3CH_4/m^3LFG
Description:	Methane fraction in the LFG
Source of data:	Measured continuously by project participants using certified equipment
Value of data applied for the purpose of calculating expected emission reductions in section B.5	This parameter is not used for the ex ante calculation of expected emission reductions.
Description of measurement methods and procedures to be applied:	Measured continuously with a gas quality analyzer. Measured values are averaged hourly.
QA/QC procedures to be applied:	The gas analyzer will be calibrated periodically 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:	**T**
Data unit:	°C
Description:	Temperature of the landfill gas
Source of data:	Measurements by the project participants

Value of data applied for the purpose of calculating expected emission reductions in section B.5	This parameter is not used for the ex ante calculation of expected emission reductions.
Description of measurement methods and procedures to be applied:	Measured to determine the density of methane. No separate monitoring of temperature is necessary when using flow meters that automatically measure temperature and pressure, expressing the LFG volumes in normalized cubic meters. Continuous measurement.
QA/QC procedures to be applied:	Measuring instruments should be subject to a regular maintenance and testing regime in accordance to the appropriate national/international standards.
Any comment:	

Data / Parameter:	**P**
Data unit:	Pa
Description:	Pressure of the landfill gas
Source of data:	Measurements by the project participants
Value of data applied for the purpose of calculating expected emission reductions in section B.5	This parameter is not used for the ex ante calculation of expected emission reductions.
Description of measurement methods and procedures to be applied:	Measured to determine the density of methane. No separate monitoring of pressure is necessary when using flow meters that automatically measure temperature and pressure, expressing the LFG volumes in normalized cubic meters. Continuous measurement.
QA/QC procedures to be applied:	Measuring instruments should be subject to a regular maintenance and testing regime in accordance to the appropriate national/international standards.
Any comment:	

Data / Parameter:	$EL_{LFG,y}$
Data unit:	MWh
Description:	Net amount of electricity generated from LFG in year y
Source of data to be used:	Measurements by the project participant
Value of data applied for the purpose of calculating expected emission reductions in section B.5	see table below

Year	$EL_{LFG,y}$ **(MWh)**
2012	5,276
2013	21,108
2014	21,184
2015	21,249
2016	21,303
2017	21,350

	2018 — 21,390 2019 — 21,424 2020 — 21,179 2021 — 18,834 2022 — 12,609
Description of measurement methods and procedures to be applied:	Continuous measurement with an electricity meter.
QA/QC procedures to be applied:	The electricity meter will be subject to regular maintenance and testing as recommended by the manufacturer to ensure accuracy.
Any comment:	

Data / Parameter:	**Operation of the energy plant**
Data unit:	Hours
Description:	Operation of the energy plant
Source of data to be used:	Project participants
Value of data applied for the purpose of calculating expected emission reductions in section B.5	8000 as estimated by RESA
Description of measurement methods and procedures to be applied:	Annually
QA/QC procedures to be applied:	
Any comment:	This is monitored to ensure methane destruction is claimed for methane used in electricity plant when it is operational.

Project emissions from electricity consumption

Data / Parameter:	$PE_{EC,y}$
Data unit:	tCO_{2e}
Description:	Project emissions from electricity consumption by the project activity during the year y
Source of data to be used:	Calculated as per the "Tool to calculate baseline, project and/or leakage emissions from electricity consumption"
Value of data applied for the purpose of calculating expected emission reductions in section B.5	Refer to section B.6.3
Description of	As per the "Tool to calculate baseline, project and/or leakage emissions from

measurement methods and procedures to be applied:	electricity consumption”
QA/QC procedures to be applied:	As per the “Tool to calculate baseline, project and/or leakage emissions from electricity consumption”
Any comment:	

Data / Parameter:	**$EC_{PJ,j,y}$**
Data unit:	MWh
Description:	Total quantity of electricity consumed by the project activity during year y
Source of data to be used:	Measurements by the electricity provider
Value of data applied for the purpose of calculating expected emission reductions in section B.5	Year: $EC_{PJ,j,y}$ 2012: 144 2013: 572 2014: 496 2015: 431 2016: 377 2017: 330 2018: 290 2019: 256 2020: 227 2021: 202 2022: 135
Description of measurement methods and procedures to be applied:	Continuous measurement with an electricity meter.
QA/QC procedures to be applied:	As recommended by the manufacturer.
Any comment:	The values mentioned above are the electricity consumption values as estimated ex-ante. Once electricity is generated onsite with LFG, $EC_{PJ,j,y}$ is already considered in the net amount of electricity generated using LFG ($EL_{LFG,y}$). Prior to any electricity generation on-site from LFG, electricity demand on-site is assumed to be covered by a diesel generator. These emissions are included in the project emissions as emissions from fossil fuel consumption. In case, electricity needed to be purchased from the Interconnected National System (SIN) for any reason, the electricity consumption would be measured by the electricity provider, and the electricity consumption values indicated in the invoices from the electricity provider would be used to calculate the emission from electricity consumption.

Project emissions from fuel consumption

Data / Parameter:	**$PE_{FC, j, y}$**

Data unit:	tCO_{2e}
Description:	Project emissions from fossil fuel combustion in process j during the year y
Source of data to be used:	Calculated as per the "Tool to calculate project or leakage CO_2 emissions from fossil fuel combustion"
Value of data applied for the purpose of calculating expected emission reductions in section B.5	Refer to section B.6.3
Description of measurement methods and procedures to be applied:	As per the "Tool to calculate project or leakage CO_2 emissions from fossil fuel combustion"
QA/QC procedures to be applied:	As per the "Tool to calculate project or leakage CO_2 emissions from fossil fuel combustion"
Any comment:	

Data / Parameter:	$\mathbf{FC_{i,j,y}}$
Data unit:	m^3/yr
Description:	Quantity of fuel type i combusted in process j during the year y.
Source of data to be used:	Onsite measurements
Value of data applied for the purpose of calculating expected emission reductions in section B.5	0 The diesel generator will only be used if no electricity is generated on-site and if no electricity is obtained from the grid (Interconnected National System).
Description of measurement methods and procedures to be applied:	• Use either mass or volume meters. In cases where fuel is supplied from small daily tanks, rulers can be used to determine mass or volume of the fuel consumed, with the following conditions: The ruler gauge must be part of the daily tank and calibrated at least once a year and have a book of control for recording the measurements (on a daily basis or per shift) • Accessories such as transducers, sonar and piezoelectronic devices are accepted if they are properly calibrated with the ruler gauge and receiving a reasonable maintenance; • In case of daily tanks with pre-heaters for heavy oil, the calibration will be made with the system at typical operational conditions.
QA/QC procedures to be applied:	The consistency of metered fuel consumption quantities should be cross-checked by an annual energy balance that is based on purchased quantities and stock changes. Where the purchased fuel invoices can be identified specifically for the CDM project, the metered fuel consumption quantities should also be cross-checked with available purchase invoices from the financial records.
Any comment:	-

Data / Parameter:	$EF_{CO2,i,y} = EF_{CO2,diesel,y}$
Data unit:	tCO_2/GJ
Description:	CO_2 emission factor of fuel type i (diesel) in year y
Source of data used:	2006 IPCC Guidelines for National Greenhouse Gas Inventories, Vol. 2, Chapter 1, Table 1.4, upper value
Value of data applied for the purpose of calculating expected emission reductions in section B.5	0.0748
Description of measurement methods and procedures to be applied:	The IPCC default value is used since no data from the fuel provider is available. Any future revisions of the IPCC Guidelines will be taken into account.
QA/QC procedures to be applied:	
Any comment:	

Data / Parameter:	$NCV_{i,y} = NCV_{diesel,y}$
Data unit:	GJ/t
Description:	Net Calorific Value of fossil fuel type i (diesel) in year y
Source of data used:	2006 IPCC Guidelines for National Greenhouse Gas Inventories, Vol. 2, Chapter 1, Table 1.2, upper value
Value of data applied for the purpose of calculating expected emission reductions in section B.5	43.3
Description of measurement methods and procedures to be applied:	The IPCC default value is used since no data from the fuel provider is available. Any future revisions of the IPCC Guidelines will be taken into account.
QA/QC procedures to be applied:	
Any comment:	

Data / Parameter:	$\rho_{i,y} = \rho_{diesel,y}$
Data unit:	t/m^3
Description:	Density of fuel type i (diesel) in year y
Source of data used:	Density of diesel in Mexico as indicated by the National Commission for an Efficient Use of Energy
Value of data applied for the purpose of calculating expected emission reductions in section B.5	0.865

Description of measurement methods and procedures to be applied:	The density of diesel in Mexico as indicated by the National Commission for an Efficient Use of Energy as density values from the diesel provider are not available. http://www.conae.gob.mx/wb/CONAE/CONA_694_a2_tablas_y_figura?page=2
QA/QC procedures to be applied:	
Any comment:	

Project emission from flaring

Data / Parameter:	**$PE_{flare, y}$**
Data unit:	tCO_{2e}
Description:	Project emissions from flaring of the residual gas stream in year *y*
Source of data to be used:	Calculated as per the "Tool to determine project emissions from flaring gases containing methane"
Value of data applied for the purpose of calculating expected emission reductions in section B.5	Refer to section B.6.3
Description of measurement methods and procedures to be applied:	As per the "Tool to determine project emissions from flaring gases containing methane"
QA/QC procedures to be applied:	As per the "Tool to determine project emissions from flaring gases containing methane"
Any comment:	

Data / Parameter:	**$fv_{i,h}$**
Data unit:	-
Description:	Volumetric fraction of component *i* in the residual gas in the hour *h* where i= CH_4
Source of data to be used:	Measurements by project participants using a continuous gas analyser
Value of data applied for the purpose of calculating expected emission reductions in section B.5	This parameter is not used for the ex ante calculation of expected emission reductions.
Description of measurement methods and procedures to be applied:	Measured continuously with a gas analyzer. Measured values are averaged hourly.
QA/QC procedures to	The gas analyzer will be calibrated periodically according to the

be applied:	manufacturer's recommendation. A zero check and a typical value check will be performed by comparison with a standard certified gas.
Any comment:	Only the methane content of the residual gas is measured and the remaining part is considered as N_2. The same basis (dry or wet) has to be considered for this measurement and the measurement of the volumetric flow rate of the residual gas ($FV_{RG,h}$) when the residual gas temperature exceeds 60 °C.

Data / Parameter:	$\mathbf{FV_{RG,h}}$
Data unit:	m^3/h
Description:	Volumetric flow rate of the residual gas in dry basis at normal conditions in the hour *h*
Source of data to be used:	Measurements by project participants using a continuous flow meter
Value of data applied for the purpose of calculating expected emission reductions in section B.5	This parameter is not used for the ex ante calculation of expected emission reductions.
Description of measurement methods and procedures to be applied:	Measured continuously with a flow meter. Measured values are averaged hourly or at a shorter time interval.
QA/QC procedures to be applied:	The flow meter will be calibrated periodically according to the manufacturer's recommendation. .
Any comment:	The same basis (dry or wet) has to be considered for this measurement and the measurement of the volumetric flow rate of the residual gas ($fv_{i,h}$) when the residual gas temperature exceeds 60 °C.

Data / Parameter:	$\mathbf{t_{O2,h}}$
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:	Measurements by project participants using a continuous gas analyser
Value of data applied for the purpose of calculating expected emission reductions in section B.5	This parameter is not used for the ex ante calculation of expected emission reductions.
Description of measurement methods and procedures to be	Measured continuously with a gas analyser. Measured values are averaged hourly. Extractive sampling analysers with water and particulates removal devices or in

applied:	situ analysers for wet basis determination. The point of measurement 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 temperature levels. An excessively high temperature at the sampling point (above 700 °C) may be an indication that the flare is not being adequately operated or that its capacity is not adequate to the actual flow.
QA/QC procedures to be applied:	The gas analyser will be calibrated periodically 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:	$\mathbf{fv_{CH4,FG,h}}$
Data unit:	mg/m^3
Description:	Concentration of methane in the exhaust gas of the flare in dry basis at normal conditions in the hour *h*
Source of data to be used:	Measurements by project participants using a continuous gas analyzer
Value of data applied for the purpose of calculating expected emission reductions in section B.5	This parameter is not used for the ex ante calculation of expected emission reductions.
Description of measurement methods and procedures to be applied:	Measured continuously with a gas analyser. Measured values are averaged hourly. Extractive sampling analysers with water and particulates removal devices or in situ analysers for wet basis determination. The point of measurement 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 temperature levels. An excessively high temperature at the sampling point (above 700 °C) may be an indication that the flare is not being adequately operated or that its capacity is not adequate to the actual flow.
QA/QC procedures to be applied:	The gas analyser will be calibrated periodically 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:	Measurement instruments may read ppmv or % values. To convert from ppmv to mg/m3 simply multiply by 0.716. 1% equals 10 000 ppmv.

Data / Parameter:	$\mathbf{T_{flare}}$
Data unit:	°C
Description:	Temperature in the exhaust gas of the flare
Source of data to be used:	Measurements by project participants
Value of data applied for the purpose of calculating expected	None, since this parameter is not used for the ex ante calculation of expected emission reductions.

emission reductions in section B.5	
Description of measurement methods and procedures to be applied:	Measured continuously by a thermocouple. A temperature above 500 °C indicates that a significant amount of gases are still being burnt and that the flare is operating.
QA/QC procedures to be applied:	Thermocouples will be replaced or calibrated as per the manufacturer's recommendations every year.
Any comment:	An excessively high temperature at the sampling point (above 700 ºC) may be an indication that the flare is not being adequately operated or that its capacity is not adequate to the actual flow.

Data / Parameter:	$\eta_{flare,h}$
Data unit:	-
Description:	Flare efficiency in hour h
Source of data to be used:	Calculated
Value of data applied for the purpose of calculating expected emission reductions in section B.5	98%
Description of measurement methods and procedures to be applied:	In case of enclosed flares and continuous monitoring of the flare efficiency, the flare efficiency in the hour *h* ($\eta_{flare,h}$) is: • 0% if the temperature of the exhaust gas of the flare (T_{flare}) is below 500 °C during more than 20 minutes during the hour *h*. • determined according to equation 31 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* :
QA/QC procedures to be applied:	Not applicable
Any comment:	

B.7.2 Description of the monitoring plan:

According to ACM0001, the monitoring methodology is based on direct measurement of the amount of LFG captured and destroyed by flaring and utilized to produce electricity. The monitoring plan provides for continuous measurement of the quantity and quality of LFG flared. The main variables that need to be determined are the quantity of methane actually captured $MD_{project,y}$, the quantity of methane sent to the flare ($MD_{flared,y}$), the quantity of methane used to generate electricity ($MD_{electricity,y}$), and the quantity of methane generated ($MD_{total,y}$). The methodology also measures the energy generated by the use of LFG ($EL_{LFG,y}$), the energy consumed by the project activity from the Interconnected National System (SIN) ($EC_{PJ,j,y}$) and the fossil fuel consumption ($FC_{PJ,j,y}$)..

All parameters to be monitored are listed and described in Section B.7.1. Figure 4 shows the parameters to be monitored to determine the quantity of methane destroyed by the project activity.

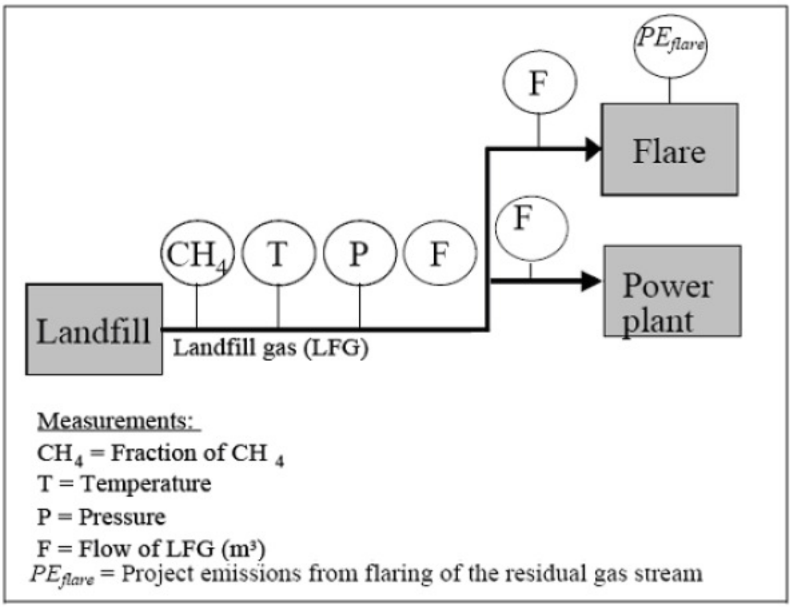

Figure 7: Parameters to be monitored to determine the quantity of methane destroyed by the project activity.

Operational/management structure and responsibilities:

The project is implemented and managed by RESA who nominated a project director who is responsible for the project management, monitoring and quality control.

Part of the monitoring data will be measured online and stored directly in RESA's databases. The responsible project manager will be in charge of observing the online measurements and aggregating the data. The data monitored online are also sent via internet connection to the provider of the monitoring equipments (Landtec) who will analyse and store the data in order to be able detect any equipment failure or other irregularities.

The field technicians will perform activities such as monitoring and adjusting LFG extraction wells, checking operations o the blower and flare, recording data which is not measured online, routine maintenance of collection system components, preparing daily logs, completing check lists, sending the data sheets to the project manager and informing the project manager of any irregularities observed in the field.

The project manager is responsible for reviewing, analysing and archiving the monitoring data collected manually, reviewing and analysing the data monitored online, making any recommendations and/or implementing system adjustments to maximize methane capture and destruction, scheduling of maintenance and calibration activities, coordinating with the provider of the online monitoring equipment (Landtec) and the manufacturers/providers of equipments in general in case of any irregularity, reporting operation and monitoring data regularly to the project director.

Figure 3 provides an overview on the operational and management structure.

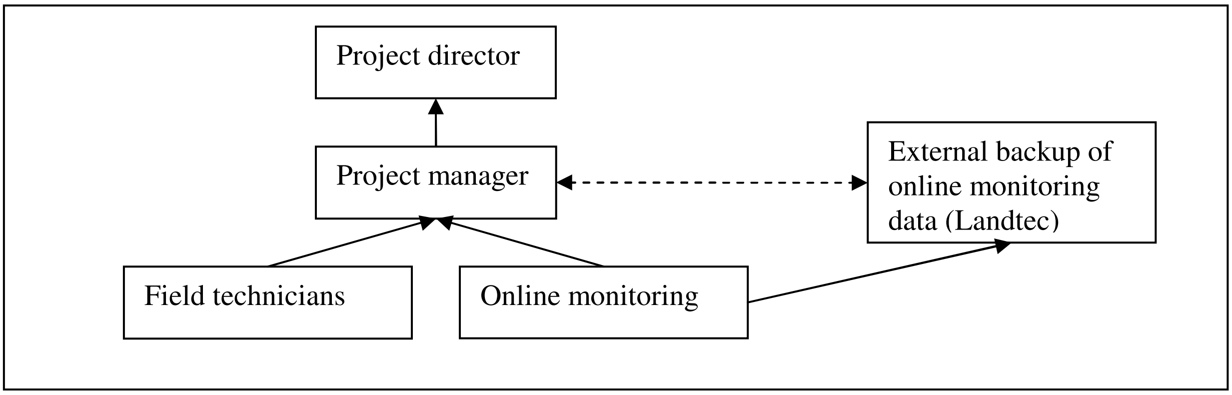

Figure 8: Operational and management structure

Training:
The responsible staff will receive training from the equipment providers with regard to the operation, maintenance and calibration of the equipments, as well as an internal training with regard to the collection of monitoring data.

Calibration and maintenance:
The monitoring equipments shall undergo regular maintenance and calibration according to the manufacturers' recommendations.

Monitoring frequency:
As indicated in section B.7.1

Data analysis:
The collected data will be reviewed and analysed on a daily basis by the project manager in order to be able to quickly detect any irregularities with regard to the project operation, monitoring equipments or data collection and to take corrective actions.

Data recording:
All collected data is stored onsite in a data base. The data monitored online is also stored by the provider of the online monitoring system (Landtec).
All data will be archived electronically with frequent data back-up. This information will be kept for two years after the crediting period or for two years after the last issuance of CERs for this project activity, whichever occurs later.

Reporting:

The project manager prepares periodic reports including key data and analysis results and presents them to the project director.

Emergency procedures:

Emergency prevention through design measures, appropriate operation & maintenance schedule and regular inspection are essential to reduce the probability of occurrence of any eventualities on project site. However, it is not possible to totally eliminate such eventualities and random failures of equipment or human errors, omissions and unsafe acts cannot be ruled out. An essential part of project operation control is therefore also the mitigation of the effects of any emergency at the earliest.

LFG is primarily methane and carbon dioxide, along with non-methane volatile organic compounds (NMVOC) that can ignite and explode under certain circumstances. Methane is explosive when present in the range of five percent (lower explosive limit, LEL) to 15 percent (upper explosive limit, UEL) by volume in air. Hence an emergency response programme is required in case of

a) Elevated gas levels being detected by presence of gas odour or by automatic monitoring system
b) Fire and explosion

Gas leakage alerts within the project site shall be made by the Automatic Monitoring System. On detecting methane gas in excess of 0.5% volume (5000 ppm) or carbon dioxide in excess of 1.5% volume (15000 ppm) the automatic monitoring system will automatically activate the alarm and emergency response program can be initiated. Following actions should be taken in case of leakage/ fire.

Basic Actions

- Take immediate steps to stop gas leakage/fire.
- Stop all operations and ensure closure of all isolation valves.
- As gas fires develop and spread quickly, so all out efforts should be made to contain the spread of leakage/fire.
- Plant personnel without any specific duties should assemble at the nominated place.
- All vehicles except those that are required for emergency use should be moved away from the operating area in an orderly manner at pre nominated route.
- Electrical system except the lighting and fire fighting system should be isolated.
  If the feed to the fire cannot be cut off, the fire must be controlled and not extinguished.
- Start water spray systems in the areas involved in or exposed to secondary fire risks.
- In case of leakage of LFG without fire and inability to stop the flow, take all precautions to avoid source of ignition and most importantly, evacuate persons from the downwind area- crosswind would be the best option (shortest path to safety). Actions necessary for H_2S may be taken.
- Block all roads in the adjacent area and enlist police support for the purpose, if warranted.

Actions in the Event of Fire

- Basic actions as detailed above.
- Extinguishing fires: A small fire at a point of leakage should be extinguished by enveloping with a water spray or a suitable smothering agent such as CO_2. However, LFG fire should not, unless under exceptional circumstances, be extinguished until the escape of product has been stopped. If escaping gas cannot be stopped, water should be directed at the point of leakage to assist rapid dispersion. Ensure that static charge is not generated in the LFG vapor cloud - solid jets of water into the cloud should be avoided. Fog nozzles should be used instead.
- Fire fighting personnel working in or close to un-ignited vapor clouds or close to fire, must be protected continuously by water sprays. Fire fighters should advance towards the fire downwind if possible. Care should be taken to avoid H_2S Exposure.
- In case the only valve that can be used to stop the leakage is surrounded by fire, it may be possible to close it manually. The person attempting the closure should be continuously protected by water sprays, fire entry suit, water jet blanket etc. The person must be equipped with a safety belt and a manned lifeline.

Leakage of LFG from pipeline without fire:

- Cordon off the area around 20 meters radius so that no vehicle or source of ignition approached the area. Attempt to close the control/ manual valve.
- Avoid getting entrapped in the cloud vapor.
- Warn the surrounding areas to put off all naked flames.
- In case water is used, ensure effluent is treated before disposal.

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

19/01/2012

Entity : First Climate AG
Phone : +41 298 2800
Address: Stauffacherstrasse 45, 8004 Zürich, Switzerland
email : cad@firstclimate.com

First Climate AG is not a project participant.

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:

14/04/2008

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

11 years and 6 months (from the start of project operation on 01/07/2011).

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

The Project activity will use a fixed crediting period of 10 years.

C.2.1. Renewable crediting period

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

N.A.

C.2.1.2. Length of the first crediting period:

N.A.

C.2.2. Fixed crediting period:

C.2.2.1. Starting date:

01/10/2012 or the date of registration, whichever is later.

C.2.2.2. Length:

10 years

SECTION D. Environmental impacts

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

One of the major objectives of the project activity is to collect and combust the LFG generated in the Chiltepeque landfill, resulting in the improvement of the landfill conditions including the control and management of leachate and the reduction of methane emissions from the landfill to the atmosphere. The environmental impacts of the proposed project activity are essentially beneficial and will result in the following important environmental benefits:

- A reduction of methane emissions to the atmosphere by about 65%. Methane will be collected and flared and eventually used for electricity generation.
- Reduction of malodour close to the landfill due to the reduction of landfill gas emissions to the atmosphere. The LFG contains over one hundred trace components that will be also partially eliminated due to the activity of this project.
- The majority of the LFG components are quickly diluted in the atmosphere but in confined spaces there is a risk of explosion and fire within the boundaries of the landfill. Proper operations to maximize the collection and destruction of LFG will reduce this risk significantly.
- The improvement of the landfill management will also reduce the pollution risk to natural water bodies.

The installation of a LFG collection and combustion systems is part of a broader effort by the landfill operator to continue improving waste management practices. This will result in faster waste stabilization due to the controlled and accelerated decomposition of the organic waste.

According to Mexican legislation, no environmental impact assessment is required for the proposed project activity.

The project activity may have a minimal impact on the environment during construction due to dust generation, soil movements and noise; but these impacts can not be considered significant. Once the project activity is implemented, it has a much higher positive impact on the environment as summarized above.

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:

The negative environmental impacts are not considered significant.

SECTION E. Stakeholders' comments

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

The stakeholder consultation for the project was held on March 14, 2008 at the Landfill Site in Chiltepeque outside of Puebla, in order to facilitate the attendance of the local communities. The project participants invited the local project stakeholders, representatives from the local authorities, academia, local communities and local media. The event allowed stakeholders to understand the basic concepts related to climate change, its consequences and the aims of the Kyoto Protocol as well as the most important features of the RESA – Landfill to Energy Project undertaken by the project developer.

The event was properly announced in the local newspaper (*La Opinion* newspaper). The advertisement invited the general public to the landfill facility and a similar notice was posted on RESA's website (www.rsanitarios.pue-mx.com), in order to increase the awareness of the event.

The event was well attended, with more than 90 people attending. All participants were registered with appropriate formats kept in the Project Developer's files.

The stakeholder consultation included a brief description of the project, and its benefits in reducing the impacts of climate change through the CDM of the Kyoto Protocol and the technical details of the project.

Figure 9: Local stakeholder consultation

E.2. Summary of the comments received:

To date, no formal comments have been received from stakeholders. During the Public Consultation, the members of the community raised various questions about the project and the project developer provided comments as follows:

One of the questions asked about the potential social benefits that this project would bring to the community.

The project developer indicated that the implementation of the project will support the local economic development by the creation of employment opportunities. Staff will be required to operate and maintain the LFG network and flare and power generation components. The staff will be trained to optimize the LFG collection system. Finally, additional contractors and labourers will be required during the construction phase of the project.

A number of questions focused on how would this project help with the protection of the environment and if it would help reducing the smell emitted by the site.

Since the project will collect and combust the LFG generated, there will be a significant reduction of emissions to the atmosphere, with local and global implications. Locally, the impacts will be reduction in toxic gases in the local environment since a large fraction of the gas will be captured and flared resulting in a significant improvement of atmospheric conditions including improvement of odours in the area.

At the global level, the project will make a significant contribution towards the reduction of methane emissions to the atmosphere.

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

To date, no formal comments have been submitted by the stakeholders. The comments and concerns related to the benefits for the community, potential environmental risks and mitigations of the projects were answered during the event. Overall, the stakeholder consultation was a very positive event with stakeholders congratulating the Project Developers for undertaking the project.

The local population is already employed at the landfill and more employment is likely to be generated. This has been received with enthusiasm by the local population.

ANNEX 1

CONTACT INFORMATION ON PARTICIPANTS IN THE PROJECT ACTIVITY

Organization:	Rellenos Sanitarios RESA
Street/P.O.Box:	Av. Revolución 528, Col. San Pedro de los Pinos, C.P. 03800
Building:	
City:	Mexico D.F.
State/Region:	
Postfix/ZIP:	
Country:	Mexico
Telephone:	+5255 5574-8077
FAX:	+5255 5273-5007
E-Mail:	josefabed@gmail.com
URL:	www.rellenossanitarios.com
Represented by:	José Felipe Abed Rouanett
Title:	
Salutation:	
Last Name:	Abed Rouanett
Middle Name:	Felipe
First Name:	José
Department:	
Mobile:	
Direct FAX:	---
Direct Tel:	---
Personal E-Mail:	josefabed@gmail.com

Annex 2

INFORMATION REGARDING PUBLIC FUNDING

NO PUBLIC FUNDING IS INVOLVED IN THIS PROJECT

ANNEX 3

BASELINE INFORMATION

Waste composition

Waste type	% of total waste amount
Wood and wood products	0.0
Pulp, paper and cardboard (other than sludge)	10.0
Food, food waste, beverages and tobacco (other than sludge)	51.0
Textiles	5.0
Garden, yard and park waste	2.4
Glass, plastic, metal, other inert waste	31.6
Total	100.0

Source: Análisis Cualitativo: Residuos Sólidos Urbanos en el Relleno Sanitario "Chiltepeque" (Qualitative Analysis: Municipal Solid Wastes in the "Chiltepeque" Landfill), RESA, 2008, page 13

Waste deposition in Section A of the Chiltepeque landfill

Table 23: Waste deposition in Section A of the Chiltepeque landfill in tons

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
1995	19,926	20,059	23,032	20,756	23,473	22,472	22,635	24,225	22,792	23,895	22,497	21,354	**267,115**
1996	23,578	20,204	21,226	22,241	23,819	23,073	24,950	23,615	22,969	23,977	22,707	24,231	**276,590**
1997	23,663	21,211	23,326	24,888	26,011	25,325	26,214	24,008	25,523	25,933	24,443	26,293	**296,837**
1998	25,804	22,327	25,293	25,172	25,568	26,535	28,700	36,594	29,216	30,285	27,421	29,504	**332,419**
1999	26,478	25,531	30,083	28,436	30,728	31,797	34,367	34,904	32,578	32,061	33,280	33,786	**374,029**
2000	33,123	33,435	36,555	31,950	37,320	37,788	37,196	38,649	35,661	35,607	35,404	35,518	**428,207**
2001	39,075	35,167	37,126	34,595	37,925	38,869	39,635	38,685	36,869	39,098	34,804	38,197	**450,044**
2002	39,112	33,940	38,820	39,058	39,378	38,489	40,862	38,648	37,692	42,248	37,395	37,825	**463,467**
2003	37,800	34,539	38,156	37,443	39,909	40,175	46,004	41,271	42,992	40,162	36,324	38,223	**472,998**
2004	37,861	35,277	40,894	38,655	41,900	44,770	45,571	43,974	41,020	42,628	39,627	40,458	**492,635**
2005	40,564	36,571	41,470	41,002	42,624	43,346	43,368	43,488	40,371	40,610	40,863	43,103	**497,379**
2006	41,843	37,354	41,667	38,511	43,281	40,641	44,653	45,886	43,512	45,222	42,136	40,448	**505,154**
2007	40,597	36,559	41,238	38,617	44,011	43,618	47,769	47,551	43,866	43,866	39,144	41,770	**508,606**
2008	40,958	37,355	37,953	40,822	43,251	43,251	47,445	44,356	44,600	42,100	39,767	42,599	**504,456**
2009	41,287	37,189	41,368	41,512	44,770	45,538	46,002	44,427	48,172	46,626	44,538	46,875	**528,304**
2010	44,107	38,861	42,065	41,353	44,024	45,271	50,978	52,214	49,134	47,525	46,059		**501,593**

Source: Data recorded by RESA

Estimation of the future waste deposition in Section A of the Chiltepeque landfill (tons)

Remaining capacity in Section A on the 30th of May 2009 as estimated by RESA [1]	2,380,100	tons
Remaining capacity in Section A on the 30th of November 2010	1,556,329	tons
Average waste deposition 2009-2010	44,778	tons/month
Remaining waste deposition months	34.8	months

[1] *Proyecto de Ampliación del Relleno Sanitario de Puebla (Expansion Project of the Puebla Landfill), RESA, May 2009, page 129*

Table 24: Expected future waste deposition in Section A of the Chiltepeque landfill in tons

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
2010												44,778	**44,778**
2011	44,778	44,778	44,778	44,778	44,778	44,778	44,778	44,778	44,778	44,778	44,778	44,778	**537,338**
2012	44,778	44,778	44,778	44,778	44,778	44,778	44,778	44,778	44,778	44,778	44,778	44,778	**537,338**
2013	44,778	44,778	44,778	44,778	44,778	44,778	44,778	44,778	44,778	33,873			**436,876**
													1,556,329

Table 25: Summary of recorded and expected waste deposition in Section A of the Chiltepeque landfill

Year	Waste (tons)
1995	267,115
1996	276,590
1997	296,837
1998	332,419
1999	374,029
2000	428,207
2001	450,044
2002	463,467
2003	472,998
2004	492,635
2005	497,379
2006	505,154
2007	508,606
2008	504,456
2009	528,304
2010	546,371
2011	537,338
2012	537,338
2013	436,876

Combined margin emission factor

Step 1. Identify the relevant electricity systems.
-> section B.6.1

Step 2. Choose whether to include off-grid power plants in the project electricity system (optional).
-> section B.6.1

Step 3. Select a method to determine the operating margin (OM).

Table 26: Share of low-cost/must run generation

Generation Type	Unit	2003	2004	2005	2006	2007	Low-cost/must-run
Total generation National Public Service	GWh	203,555	208,634	218,971	225,079	232,552	
Conventional thermoelectric power plant	GWh	73,743	66,334	65,077	51,931	49,482	No
Dual	GWh	13,859	7,915	14,275	13,875	13,375	No
Combined cycle	GWh	55,047	72,267	73,381	91,064	102,674	No
Gas turbine	GWh	6,933	2,772	1,358	1,523	2,666	No
Internal combustion	GWh	751	610	780	854	1,139	No
Hydroelectric	GWh	19,753	25,076	27,611	30,305	27,042	Yes
Coal	GWh	16,681	17,883	18,380	17,931	18,101	No
Nuclear	GWh	10,502	9,194	10,805	10,866	10,421	Yes
Geothermal	GWh	6,282	6,577	7,299	6,685	7,404	Yes
Wind	GWh	5	6	5	45	248	Yes
Import	GWh	71	47	87	523	277	
Low-cost/must-run	GWh	36,542	40,853	45,720	47,901	45,115	
Total Generation	GWh	203,555	208,634	218,971	225,079	232,552	
Share of low-cost/must-run	%	**18%**	**20%**	**21%**	**21%**	**19%**	
Average share of low-cost/must-run	%					**20%**	

Source: Prospectiva del Sector Eléctrico (Electricity Sector Outlook) 2008-2017, Table 22, page 111

The simple OM method is applied to determine the operating margin emission factor.

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

Table 27: Fuel consumption in the project electricity system ($FC_{i,y}$)

	2005 [1]			2006 [2]			2007 [3]		
Fuel type	**Share (%)**	**Fuel consumption (TJ/yr)**	**Emissions (tCO_2e)**	**Share (%)**	**Fuel consumption (TJ/yr)**	**Emissions (tCO_2e)**	**Share (%)**	**Fuel consumption (TJ/yr)**	**Emissions (tCO_2e)**
Fuel oil	39.1%	624,664	47,162,098	32.0%	514,738	38,862,689	28.9%	477,531	36,053,560
Natural gas	39.6%	632,652	34,352,981	47.0%	756,021	41,051,932	52.0%	859,225	46,655,896
Diesel	0.9%	14,378	1,043,875	1.0%	16,086	1,167,811	0.5%	8,262	599,805
Coal	20.5%	327,509	28,591,538	20.0%	321,711	28,085,370	18.5%	305,686	26,686,359
Total	**100%**	**1,597,605**	**111,150,492**	**100%**	**1,608,555**	**109,167,802**	**100%**	**1,652,355**	**109,995,620**

[1] *Source: Prospectiva del Sector Eléctrico (Electricity Sector Outlook) 2006-2015, Figure 31, page 90*
[2] *Source: Prospectiva del Sector Eléctrico (Electricity Sector Outlook) 2007-2016, Figure 40, page 116*
[3] *Source: Prospectiva del Sector Eléctrico (Electricity Sector Outlook) 2008-2017, Figure 39, page 148*

Table 28: Electricity generated and delivered to the Interconnected National System (SIN) (EG_y)

Electricity generation	**Unit**	**2005**	**2006**	**2007**
Total generation delivered to the grid	MWh	173,251,000	177,178,000	187,437,000
Total generation delivered to the grid + Imports	MWh	173,338,000	177,701,000	187,714,000

Table 29: Simple operating margin CO_2 emission factor ($EF_{grid,OMsimple,y}$)

Operating Margin CO_2 emission factor		**2005**	**2006**	**2007**
$EF_{grid,OMsimple,y}$	tCO_2/MWh	0.6412	0.6143	0.5860
3-year weighted average OM	**tCO_2/MWh**			**0.6131**

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

Table 30: Group of power units included in the build margin

Start of Operation	Plant/Unit Name	Technology	Fuel	Added Capacity [MW]	Total Generation 2007 [GWh]	Total Capacity 2007 [MW]	Gross Generation by Added Capacity 2007 [GWh]	Self Use [%]	Net Generation [GWh]	% of Total Generation (cumulative)
2007	El Cajon	HID		750.0	989.0	750	989	0.00%	989	0.43%
	Tamazunchale	CC	Natural Gas	1,135	4,117	1,135	4,117	2.78%	4,003	2.15%
2006	Valladolid III (PIE)	CC	Natural Gas	525	3,573	525	3,573	2.78%	3,474	3.64%
	Tuxpan V (PIE)	CC	Natural Gas	495	3,921	495	3,921	2.78%	3,812	5.28%
	Altamira V (PIE)	CC	Natural Gas	1,121	8,391	1,121	8,391	2.78%	8,158	8.79%
	Chihuahua II (El Encino)	CC	Natural Gas	65.3	4,301.0	619	454	2.78%	441	8.98%
2005	La Laguna II PIE	CC	Natural Gas	498	3,521	498	3,521	2.78%	3,423	10.45%
	Rio Bravo IV PIE	CC	Natural Gas	500	2,576	500	2,576	2.78%	2,504	11.53%
	Hermosillo	CC	Natural Gas	93.3	1,526.0	227	627	2.78%	610	11.79%
2004	Chicoasén	HID		900	3,378	2,400	1,267	0.00%	1,267	12.33%
	Rio Bravo III PIE	CC	Natural Gas	495	2,063	495	2,063	2.78%	2,006	13.20%
	Tuxpan	TG	Natural Gas	163	10,189	2,263	734	1.00%	727	13.51%
	El Sauz	CC	Natural Gas	128	2,294	603	487	2.78%	473	13.71%
2003	Altamira III y IV (PIE)	CC	Natural Gas	1,036	6,052	1,036	6,052	2.78%	5,884	16.24%
	Tuxpan III y IV (PIE)	CC	Natural Gas	983	6,875	983	6,875	2.78%	6,684	19.12%
	Transalta Chihuahua III (PIE)	CC	Natural Gas	259	1,428	259	1,428	2.78%	1,388	19.71%
	Naco Nogales (PIE)	CC	Natural Gas	258	1,996	258	1,996	2.78%	1,941	20.55%
						Total GWh			**47,782**	
						Total Generation 2007*			**232,552**	

HID: Hydroelectric, CI: Internal Combustion, CC: Combined Cycle, TG: Turbogas, GEO: Geothermal

Source:

Prospectiva del Sector Eléctrico (Electricity Sector Outlook) 2008-2017, Table 5, page 205

Prospectiva del Sector Eléctrico (Electricity Sector Outlook) 2008-2017, Table 19, page 101
Prospectiva del Sector Eléctrico (Electricity Sector Outlook) 2007-2016, Table 19, page 77
Prospectiva del Sector Eléctrico (Electricity Sector Outlook) 2006-2015, Table 13, page 57
Prospectiva del Sector Eléctrico (Electricity Sector Outlook) 2005-2014, Table 14, page 51
Prospectiva del Sector Eléctrico (Electricity Sector Outlook) 2004-2013, Table 9, page 44

* *Prospectiva del Sector Eléctrico (Electricity Sector Outlook) 2008-2017, Table 22, page 111*

$SET_{5\text{-units}}$	El Cajon, Tamazunchale, Valladolid III (PIE), Tuxpan V (PIE), and Altamira V (PIE)	AEG_{total}	232,552,000	MWh
$SET_{\geq 20\%}$	All power units included in the table above	$AEG_{SET\text{-5-units}}$	20,434,944	MWh
SET_{sample}	is $SET_{\geq 20\%}$ since $AEG_{SET\text{-}\geq 20\%}$ is larger than $AEG_{SET\text{-5-units}}$	$AEG_{SET\text{-}\geq 20\%}$	47,782,141	MWh

Table 31: Average efficiency of power plants according to technology type and average self use of generated electricity per technology type

	Technology	Efficiency (%)	Self use (%)
Natural gas (single cycle)	TG	35.19%	1.00%
Natural gas (combined cycle)	CC	52.18%	2.78%
Internal combustion	CI	42.36%	6.77%
Hydroelectric	HID		0.00%
Geothermal	GEO		0.00%

Source: Prospectiva del Sector Eléctrico (Electricity Sector Outlook) 2008-2017, Table 49, page 168

Table 32: Build margin CO_2 emission factor ($EF_{grid,BM,y}$)

Plant/Unit Name	Technology	Fuel	$EG_{m,y}$ [MWh]	Efficiency $h_{m,y}$ [%]	$EF_{CO2,m,i,y}$ [tCO_2/GJ]	$EF_{EL,m,y}$ [tCO_2/MWh]	Emissions [tCO_2]
El Cajon	HID	no	989,000	0.00%	0	0.0000	-
Tamazunchale	CC	Natural Gas	4,002,547	52.18%	0.0543	0.3747	1,499,574
Valladolid III (PIE)	CC	Natural Gas	3,473,671	52.18%	0.0543	0.3747	1,301,428
Tuxpan V (PIE)	CC	Natural Gas	3,811,996	52.18%	0.0543	0.3747	1,428,183

Altamira V (PIE)	CC	Natural Gas	8,157,730	52.18%	0.0543	0.3747	3,056,335
Chihuahua II (El Encino)	CC	Natural Gas	441,111	52.18%	0.0543	0.3747	165,264
La Laguna II PIE	CC	Natural Gas	3,423,116	52.18%	0.0543	0.3747	1,282,488
Rio Bravo IV PIE	CC	Natural Gas	2,504,387	52.18%	0.0543	0.3747	938,281
Hermosillo	CC	Natural Gas	609,770	52.18%	0.0543	0.3747	228,453
Chicoasén	HID	no	1,266,750	0.00%	0	0.0000	-
Rio Bravo III PIE	CC	Natural Gas	2,005,649	52.18%	0.0543	0.3747	751,426
Tuxpan	TG	Natural Gas	726,557	35.19%	0.0543	0.5555	403,602
El Sauz	CC	Natural Gas	473,415	52.18%	0.0543	0.3747	177,367
Altamira III y IV (PIE)	CC	Natural Gas	5,883,754	52.18%	0.0543	0.3747	2,204,378
Tuxpan III y IV (PIE)	CC	Natural Gas	6,683,875	52.18%	0.0543	0.3747	2,504,147
Transalta Chihuahua III (PIE)	CC	Natural Gas	1,388,302	52.18%	0.0543	0.3747	520,134
Naco Nogales (PIE)	CC	Natural Gas	1,940,511	52.18%	0.0543	0.3747	727,022
				Build margin CO_2 emission factor 2007 (tCO_2/MWh)			**0.3597**

Step 6. Calculate the combined margin (CM) emissions factor.

Table 33; Combined margin CO_2 emission factor ($EF_{grid,CM,y}$)

		Value	Unit
Operating Margin CO_2 Emission Factor	$EF_{grid,OM,y}$	0.6131	tCO_2/MWh
	w_{OM}	0.5	
Build Margin CO_2 Emission Factor	$EF_{grid,BM,y}$	0.3597	tCO_2/MWh
	w_{BM}	0.5	
Combined Margin CO_2 Emission Factor	$EF_{grid,CM,y}$	**0.4864**	**tCO_2/MWh**

ANNEX 4

MONITORING INFORMATION

-> section B.7