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

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Annexes

SECTION A. General description of project activity

A.1 Title of the project activity:

Landfill Gas Recovery and Flaring Project in the El Verde Landfill, León.
Version 3.
19 December 2007.

A.2. Description of the project activity:

The objective of El Verde Landfill Gas Recovery and Flaring Project (El Verde Landfill Gas Project) is to capture and flare the landfill gas (LFG) generated through the decomposition of the organic waste disposed at El Verde landfill site. This will involve investing in a landfill gas collection system and flare station. The principal components of landfill gas are methane (CH_4) and carbon dioxide (CO_2), both of which are greenhouse gases (GHG) covered by the Kyoto Protocol. Flaring or burning landfill gas for energy involves methane destruction leading to GHG emissions reductions. Some of the landfill gas collected may be used to generate electricity.

El Verde landfill is owned by Promotora Ambiental S.A.B. de C.V (hereinafter called PASA). The operation and maintenance as well as all landfill gas related projects and services were conceded to PASA by the León de los Aldama in Guanjuato State, Mexico). PASA is a private waste collection and disposal firm that offers integral solutions in the management of industrial and municipal solid wastes. PASA has more than 15 years of experience and, currently, has activities in 23 landfills in Mexico.

The El Verde landfill was designed for municipal waste treatment and currently occupies an area of 30 ha of the 60 ha planned for waste disposal. The area around the landfill has an average annual precipitation of 600 mm and an annual average temperature of 18°C. The climate is classified as "Mexican of altitudes".

The landfill began accepting waste in May 2002. By the end of September 2007, more than 2.9 million of tonnes of waste have been filled over the landfill's present 30 hectares. Upon completion, maximum waste thickness is expected to be about 34 meters; current maximum landfill height is about 28 meters. Currently, the landfill is filling at an average rate of 1,700 tonnes per day, or greater than 530,000 tonnes per year. In the coming years, PASA expects the disposal rate to increase by 7% per year. The landfill is expected to close in May 2016. Since landfill gas continues to be produced for many years afterwards, the proposed project is expected to have a useful life to December 2029.

Currently, there are 50 landfill gas vents (or passive gas wells) distributed in the 4 cells, covering the current 30 ha area. Such wells are venting the gas from inside the waste mass to the top of each vent, with no presence of flames.

Following the implementation of the proposed CDM project, the predicted LFG recovery rate for the landfill in 2008 is 1,500 m^3/h (assuming 50% capture of LFG generated), increasing to 2,200 m^3/h (50% capture) in 2012. At the end of the first crediting period (7 years) of the proposed CDM project, the predicted LFG recovery would reach 2,800 m^3/h (50% capture).

Possible uses for LFG energy include electricity generation for use at the landfill site and/or supply to the local grid.

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

A.3. Project participants:

Name of Party involved (*). ((host) indicates a host Party)	Private and/or public entity(ies) project participants (*) (as applicable)	Kindly indicates if the Party involved wishes to be considered as project participant (Yes/No)
Mexico (host)	Promotora Ambiental S.A.B. de C.V Private entity. Project Sponsor.	No
United Kingdom of Great Britain and Northern Ireland	MGM Carbon Portfolio, S.a.r.l.	No
(*) In accordance with the CDM modalities and procedures, at the time of making the CDM-PDD public at the stage of validation, a Party involved may or may not have provided its approval. At the time of requesting registration, the approval by the Party(ies) involved is required.		

A.4. Technical description of the project activity:

A.4.1. Location of the project activity:

A.4.1.1. Host Party(ies):

Mexico.

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

State of Guanajuato.

A.4.1.3. City/Town/Community etc:

León de los Adamas City.

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

The El Verde landfill is located in the Municipality of León de los Adamas (also called León), about 15 kilometres northwest of the centre of the city. The address is Carretera León, Lagos de Morenos km 18.5, León City, Guanajuato State.

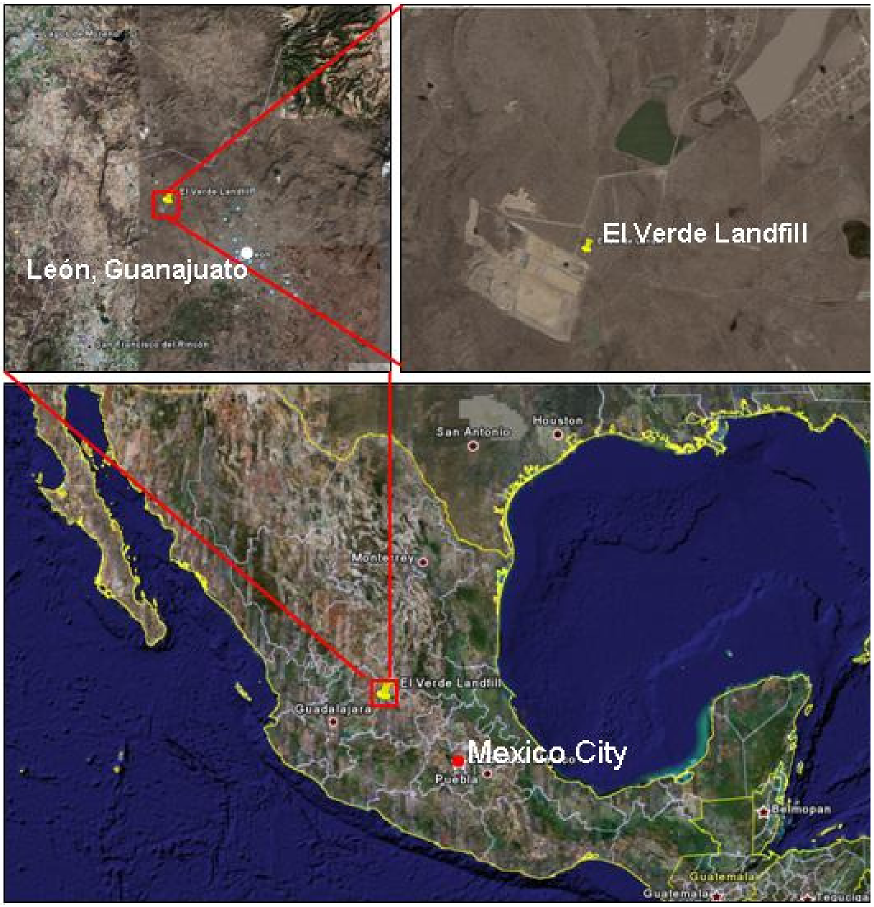

***Figure 1**. Location of El Verde landfill*

Gaunajuato State is located in Central Mexico, about 350 kilometres northwest of Mexico City. León is located 45 kilometres northwest of the Del Bajío International Airport. León city has a population of about 1,020,000 habitants.

Geographic Coordinates: N 21°10'28"; W 101°46'32".

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

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

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

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

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

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

Table 1. *Annual estimation of emission reduction for El Verde landfill*

Year	Annual estimation of emission reduction in tonnes of CO_2e
2008 (from July)	43,992
2009	114,340
2010	124,713
2011	139,618
2012	150,894
2013	166,827
2014	179,258
2015 (up to June)	95,912
Total estimated reductions for the first crediting period (tonnes of CO_2e)	**1,015,554**
Total number of crediting years	**21 (7x3)**
Annual average over the first crediting period of estimated reductions (tonnes of CO_2e)	**145,077**

A.4.5. Public funding of the project activity:

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

SECTION B. Application of a baseline and monitoring methodology

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

The baseline and monitoring methodology to be applied for the proposed project activity is the approved consolidated baseline methodology ACM0001, version 8, from CDM Executive Board 35th meeting: ***"Consolidated baseline and monitoring methodology for landfill gas project activities"***.

For project emissions calculation or emissions reduction associated with electricity generation using landfill gas and eventual project emissions from electricity consumption from the grid, ACM0001 recommends the ***"Tool to calculate the emission factor for an electricity system",*** from CDM Executive Board 35th Meeting, Annex 12. This is Version 1 of the Tool.

Also, we used the ***"Tool to calculate emissions from electricity consumption"***, recommended by the Executive Board 32nd Meeting Report, Annex 10. This is Version 1 of the Tool.

We also used the ***"Tool to calculate project or leakage CO_2 emissions from fossil fuel combustion (version 01)"*** recommended by the Executive Board 32nd Meeting report, Annex 09.

For additionality assessement, we used the tool recommended by the CDM Executive Board (as Annex 1 of their 16th Meeting Report) ***"Tool for the demonstration and assessment of additionality, version 4"***.

In order to determine the flare efficiency and/or to monitor the flare exhaust gases, we applied the ***"Tool to determine project emissions from flaring gases containing methane"*** recommended by the CDM Executive Board 28th Meeting Report, Annex 13. It is implicitly Version 1 of the Tool.

In order to estimate the potential LFG recovery rate for the landfill, we used the ***"Tool to determine methane emissions avoided from dumping waste at a solid waste disposal site"***, recommended by the CDM Executive Board at its 35th Meeting Report, Annex 10. It is implicitly Version 1 of the Tool.

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

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

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

The proposed project activity corresponds to alternatives a) and b). The collected landfill gas will generally be flared. Some LFG may be used to generate electricity to meet power requirements of the project itself and/or for sale to the power grid.

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

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

ACM0001 version 8 states: *"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."*

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

***Table 2**. Summary of gases and sources included in the project boundary, and justification/explanation where gases and sources are not included.*

	Source	Gas	Included?	Justification/Explanation
Baseline	Emissions from decomposition of waste at the landfill site (Passive LFG venting and no flaring)	CO_2	No	CO_2 emissions from decomposition of organic waste are not accounted.
		CH_4	Yes	The major source of emissions in the baseline
		N_2O	No	N_2O emissions are very small compared to CH_4 emissions from landfills. Exclusion of this gas is conservative.
Project Activity	Emissions from on-site electricity use (Active LFG capture and flaring)	CO_2	Yes	May be an important emission source.
		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.
	LFG combustion for power generation	CO_2	No	It is not considered because it is part of the natural carbon cycle.
		CH_4	Yes	Included as main component of LFG.
		N_2O	No	Not applicable

For the determination of baseline emissions of the possible electricity generation component of the project, the project boundary will account for the CO_2 emissions from electricity generation in fossil fuel power stations operating in the grid system, which will be displaced by electricity generated in the project activity. For the electricity generation component, according to the methodological "**tool to calculate the emission factor for an electricity system,**"*a project electricity system is defined by the spatial extent of the power plants that are physically connected through transmission and distribution lines to the project activity"*.

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

ACM0001, version 8, establishes procedures for the selection of the most plausible scenario. According to them, there are two steps to be followed:

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

The methodology states:

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

We used Version 4 of the Additionality Tool.

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

"Sub-step 1a. Define alternatives to the project activity."
ACM0001, version 8, indicates the separate determination of applicable baselines for landfill capture, for electricity generation and for thermal use of LFG. The possible alternatives for each part are considered below, using the codes defined in ACM0001.

ACM0001, ver. 8 states:
"Alternatives for the disposal/treatment of the waste in the absence of the project activity, i.e. the scenario relevant for estimating baseline methane emissions, to be analyzed should include, inter alia:

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

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

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

The project proposes to generate a certain amount of electricity. ACM0001 states:

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

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

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

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

The only remaining options for plausible baselines are then:
P1. Power generated from landfill gas undertaken without being registered as CDM project activity, and
P6. Power plants connected to the grid.

The project only only considers the possibility of generating electricity with LFG. So the thermal energy generation alternatives will not be considered in this analysis.

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

ACM0001, ver. 8 states how national and sectoral policies must be taken into account using Sub-step 1b of the additionality tool and the adjustment factor *AF*.

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

This sub-step requires that:

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

In Mexico, Regulation NOM-083-SEMARNAT-2003[2] defines the specifications for environmental protection from the selection, design, construction and operation, monitoring and closure of final disposal sites for urban and special solid waste. This comprehensive regulation provides guidelines for the construction and operation of landfills, and also provides guidance regarding LFG, including recommendations for the collection, utilisation and/or flaring of the LFG. However, the regulation does not specify minimum requirements regarding the amount of gas to be collected and utilised or flared.

NOM- 083-SEMARNAT-2003 is not enforced in Mexico, for the following circumstances:

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[2] www.semarnat.gob.mx/leyesynormas/Normas%20Oficiales%20Mexicanas%20vigentes/NOM-083-SEMAR-03-20-OCT-04.pdf

- NOM-083-SEMARNAT-2003 is a federal law. However, landfills are the responsibility of the municipalities, who have sovereignty in solid waste disposal. Thus, NOM-083-SEMARNAT-2003 would only be legally binding if the local authorities adopt it. So far, no local authorities have adopted NOM- 083-SEMARNAT-2003.
- NOM-083-SEMARNAT-2003 has never been enforced. Even the earlier regulation (NOM-083-SEMARNAT-1996) which NOM-083-SEMARNAT-2003 replaced and which only required the active venting of LFG for safety reasons, was not enforced.

Given these circumstances, NOM-083-SEMARNAT-2003 has become more of a document outlining policy guidance than a mandatory requirement.

While NOM-083-SEMARNAT-2003 does not indicate a mandatory requirement for LFG capture and flaring, the current situation implies LFG venting, without any active system for capturing LFG.

Thus, the adjustment factor AF was set at 0%. This value is justified based on the fact that the regulatory requirements above indicated do not indicate any specific amount of gas collection and destruction or utilisation and that in practice, no LFG is actually flared. Currently the landfill operator is only passively venting and the collected gas produced in the landfills, primarily for safety purposes.

The tool for demonstration of additionality states that:

> *"If an alternative does not comply with all mandatory applicable legislation and regulations, then show that, based on an examination of current practice in the country or region in which the law or regulation applies, those applicable legal or regulatory requirements are systematically not enforced and that non-compliance with those requirements is widespread in the country. If this cannot be shown, then eliminate the alternative from further consideration."*

The current configuration comprises passive venting with no burning.

Thus we can modify Scenarios LFG1 and LFG2 as follows:

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

LFG2: Disposal of the waste at the landfill with ***no*** burning of gas passively vented from the landfill, so that baseline destruction of LFG is 0% of the value with an active extraction system with centralized flaring.

Therefore both LFG1 and LFG2 would comply with local regulations.

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

ACM0001, ver. 8 further declares:

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

For power generation we have considered two plausible baselines:

P1. Power generated from landfill gas undertaken without being registered as CDM project activity, and

P6. Power plants connected to the grid.

There is no specific fuel choice to be made. The fuels in the power plants connected to the grid are what they are, with their emissions factor determined by the "*tool to calculate the emission factor for an electricity system*", that would be generated in the grid in the baseline.

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

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

Following a review of how individual baseline methodologies deal with the issue of additionality, the CDM Executive Board published, as Annex 1 of their 16th Meeting Report, a "Tool for the demonstration and assessment of additionality." Note that version 7 of *"Approved consolidated baseline methodology for landfill gas project activities"* makes the following comment regarding additionality:

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

Thus, in keeping with ACM0001, we apply the mentioned "Tool for the demonstration and assessment of additionality, version 4".

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

ACM0001, ver. 8 requires that the additionality test "*shall be applied for each component of the baseline, i.e. baseline for waste treatment, electricity generation and heat generation*".

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

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

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

For electricity generation (LFG1.2), there are substantial investments as well as revenues from electricity sales. We determine the cost effectiveness for LFG capture and power generation in the absence of the CDM. Our analysis is based on the following assumptions[3]:

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

- Substantial investments are required to capture LFG. These include the construction of active extraction wells, a well field and blowers, etc. to collect the LFG and take it to the location where the power plant would be located. For this project, this involves about USD 2.53 million in 2008, and about USD 120,000 yearly thereafter for well field expansion as the landfill expands;
- Operating costs for landfill gas collection are expected to be USD 75,689 in 2008 (assuming landfill gas recovery starting late in the year), USD 302,700 in 2009 and increase slowly in subsequent years as the landfill expands;
- 3.5 MW LFG power generators would be purchased, for a total investment including auxiliary equipment, such as power conditioning and connections, of 3.5 million USD. According to LFG estimated quantity available yearly, 2.0 MW could be operational in 2009, adding additional 500kW in 2011, 2013, and 2016, progressively, resulting the total of 3.5 MW capacity;
- Electricity operation and maintenance cost: USD 0.023 per kWh. Small, internal combustion engines have high operation and maintenance costs. Equipment would be imported from Europe or from North America;
- LFG flare and electricity generation equipment life: 10 years;
- Electricity sale price (levelized): US$0.065 per kWh, for sale to the grid, including estimated wheeling charges. There are no official projections for electricity prices.[4]
- Corporate tax rate: 35%.
- Discount rate: 10%. Note that in November 2007, the Interbank Rates TIIE (28 days) and one-year Mexibor rates were all around 7.5% (http://www.banxico.org.mx/). Five-year Mexican government bonds had an interest rate of 7.55% on November 4, 2007 (http://www.banxico.org.mx/polmoneinflacion/estadisticas/tasasInteres/tasasInteres.html). For a small or medium-sized company borrowing a relatively small amount of money, the applicable interest rate is likely to be about 5% higher, i.e. about 12.5%. Considering the risks of this new technology as well as the risks in effective biodegradation of waste and effective methane capture, another 5% may be added. Thus an appropriate benchmark rate for this type of investment would be 17.5%. The chosen benchmark discount rate of 10% is therefore very conservative.

The detailed economic analysis is shown in the electronic workbook:
Economic analysis LFG capture and power generation_El Verde_17Dec07.pdf.

For the assumptions stated above, the NPV for LFG capture and electricity generation is about -1 million USD (negative one million) in the absence of the CDM, and the IRR is 4.74%. The electronic workbook also includes a sensitivity analysis with respect to the key assumptions, electricity sale price, O&M costs and investment requirements, in each case considering values ± 20% with respect to the assumptions above. The results of the sensitivity analysis are shown in the table below. Except at extreme values of the range considered, e.g. electricity price 20% higher than the reference assumption, investment or O&M costs 20% below the reference assumptions, the NPV remains negative, which means that the project is not profitable without CER revenues.

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

	Electricity Sale Price				
	-20%	-10%	0%	10%	20%
NPV	-3,002,875	-1,977,326	-998,718	-28,061	941,068
IRR	N.A.	-2.44%	4.74%	9.87%	14.20%

[4] http://www.sener.gob.mx/webSener/res/PE_y_DT/pub/balance2005.pdf.

O&M Costs

	-20%	-10%	0%	10%	20%
NPV	70,279	-463,396	-998,718	-1,539,837	-2,085,504
IRR	10.33%	7.72%	4.74%	1.02%	-4.73%

Investment

	-20%	-10%	0%	10%	20%
NPV	300,142	-349,288	-998,718	-1,648,148	-2,297,578
IRR	11.79%	8.05%	4.74%	1.72%	-1.08%

With CER revenues, assuming a CER price of USD 10 per tCO_2e, the NPV would be USD 6.72 million and the IRR would be 37.6%, and the project would be profitable.

Thus, the proposed project meets the condition of economic additionality, except for extreme values in the range of sensitivity considered. Given the result of the sensitivity analysis, we will also apply ***Step 3 (Barrier Analysis)*** of the Additionality Tool, with special reference to electricity generation using LFG.

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

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

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

The demonstration involves two sub-steps:

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

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

1) *Investment barriers, other than the economic/financial barriers in Step 2 above,* inter alia*:*
   - *For alternatives undertaken and operated by private entities: Similar activities have only been implemented with grants or other non-commercial finance terms. Similar activities are defined as activities that rely on a broadly similar technology or practices, are of a similar scale, take place in a comparable environment with respect to regulatory framework.*
   - *No private capital is available from domestic or international capital markets due to real or perceived risks associated with investment in the country where the proposed CDM project activity is to be implemented, as demonstrated by the credit rating of the country or other country investments reports of reputed origin.*
2) *Technological barriers,* inter alia*:*
   - *Skilled and/or properly trained labour to operate and maintain the technology is not available, which leads to an unacceptably high risk of equipment disrepair and malfunctioning or other underperformance;*
   - *Lack of infrastructure for implementation and logistics for maintenance of the technology (e.g. natural gas can not be used because of the lack of a gas transmission and distribution network).*

- *Risk of technological failure: the process/technology failure risk in the local circumstances is significantly greater than for other technologies that provide services or outputs comparable to those of the proposed CDM project activity, as demonstrated by relevant scientific literature or technology manufacturer information.*
- *The particular technology used in the proposed project activity is not available in the relevant region.*

3) *Barriers due to prevailing practice,* inter alia*:*
   - *The project activity is the "first of its kind".*
4) *Other barriers, preferably specified in the underlying methodology as examples."*

According to our interpretation of ACM0001, ver. 8, the proposed project activity for which we need to demonstrate additionality needs to be divided into two parts:

- LFG collection and flaring;
- LFG collection for electricity generation using LFG;

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

Investment barriers
In most developing countries waste management sector is not given priority within the economy, so that project developers often face difficulties in obtaining investments funds for solid waste management projects. Moreover, the tipping fees (price for waste disposal) are very low compared to values in industrialized countries[5], so that even when investment has been secured, these revenues may not be enough to cover expenses for the proper operation and maintenance of the project activity.

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

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

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

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

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[5] For example, according to California State website, the average tipping fee for municipal waste in California State, in year 2000, was about USD 40.00 (http://www.ciwmb.ca.gov/Landfills/TipFees/TFSums.htm).

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

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

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

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

"Step 4. Common practice analysis".
Which states:

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

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

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

> *"Provide an analysis of any other activities implemented previously or currently underway that are similar to the proposed project activity. Projects are considered similar if they are in the same country/region and/or rely on a broadly similar technology, are of a similar scale, and take place in a comparable environment with respect to regulatory framework, investment climate, access to technology, access to financing, etc. Other CDM project activities are not to be included in this analysis. Provide documented evidence and, where relevant, quantitative information. On the basis of that analysis, describe whether and to which extent similar activities have already diffused in the relevant region"*

As it has been stated in the context of Step 3 above, there are some other activities currently operating in Mexico that are similar to the proposed project activity but without the energy component due to strong barriers presented at national level. there is only other project currently operating in Mexico, that generates electricity, in Monterrey, Nuevo Leon funded with subsidies from the Global Environment Facility.

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

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

The proposed project activity meets the conditions of Step 4 of the Additionality tool. Thus, we can assert that the proposed project activity is additional.

B.6. Emission reductions:

B.6.1. Explanation of methodological choices:

Baseline Emissions:

According to ACM0001, version 8:
The greenhouse gas baseline emissions during a given year *"y" (BE_y)* is given by:

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

Where:

BE_y	=	Baseline emissions in year y (tCO_2e).
$MD_{project,y}$	=	Amount of methane that would be destroyed/combusted during the year, in tonnes of methane (tCH_4) in project scenario.
$MD_{BL,y}$	=	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 tCO_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 on-site/off-site fossil fuel based captive power generation, during year *y*, in megawatt hours (MWh).
$CEF_{elec,BL,y}$	=	CO_2 emissions intensity of the baseline source of electricity displaced, in tCO_2e/MWh. This is estimated as per equation (9) below.
$ET_{LFG,y}$	=	The quantity of thermal energy produced utilizing the landfill gas, which in the absence of the project activity would have been produced from on-site/off-site fossil fuel fired boiler, during the year *y* in TJ.
$CEF_{ther,BL,y}$	=	CO_2 emissions intensity of the fuel used by boiler to generate thermal energy which is displaced by LFG based thermal energy generation, in tCO_2e/TJ. This is estimated as per equation (10) below.

ACM0001, version 8 offers several ways for determining $MD_{BL,y}$.
One option is *"In the case where the $MD_{BL,y}$ is given/defined in the regulation and/or contract as a quantity that quantity will be used"*. This is not the case here.

ACM0001 further adds: *"In situations where in the baseline LFG is captured and destroyed, for reasons other than regulation and/or contract, historic data on actual amount captured shall be used as $MD_{BL,y}$.* Since no LFG was captured and destroyed historically, and none will be captured and destroyed until the proposed project is operational, this is not the case here.

Another option is *"In cases where regulatory or contractual requirements do not specify $MD_{BL,y}$ or no historical data exist for LFG captured and destroyed, an "Adjustment Factor" (AF) shall be used and justified, taking into account the project context."*

$$MD_{BL,y} = MD_{project,y} * AF \quad \textbf{(2)}$$

There are no regulations requiring LFG capture and flaring and the configuration at El Verde landfill is passive venting and no burning of the LFG. Thus an appropriate value of AF is 0%, and is the value used for the first crediting period.

Since a specific system for the collection and destruction of methane is not mandated by regulatory or contractual requirements, Eqs. (3) to (7) and associated text of ACM0001, ver. 8 are not applicable.

In order to calculate $MD_{project,y}$, the methodology (ACM0001 ver. 8) states:
"The methane destroyed by the project activity ($MD_{project,y}$*) during a year is determined by monitoring the quantity of methane actually flared and gas used to generate electricity and/or produce thermal energy, and/or supply to end users via natural gas pipeline, if applicable, and the total quantity of methane captured."*

And,
"The sum of the quantities fed to the flare(s), to the power plant(s) and to the boiler(s) and to the natural das distribution network (estimated using equation (3)), must be compared annually with the total quantity of methane captured[6]*. The lowest value of the two must be adopted as* $MD_{project,y}$*".*

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

$$MD_{project,y} = MD_{flared,y} + MD_{electricity,y} + MD_{thermal,y} + MD_{PL,y} \quad \textbf{(8)}$$

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)

In the case of El Verde Landfill project, the right hand side of the equation (3) will be simplified to only the components of methane flared ($MD_{flared,y}$) and methane used for electricity generation ($MD_{electricity,y}$), because thermal energy generation and LFG sent to pipelines are not part of the scope of this project.

Thus we need to determine methane destroyed by flaring and electricity generation. Therefore Eq. (8) reduces to:

$$MD_{project,y} = MD_{flared,y} + MD_{electricity,y} \quad \textbf{(8a)}$$

Calculation of $MD_{flared,y}$:

[6] ACM0001 version 8 (and earlier versions) refers to the total quantity of methane generated, it is not possible to monitor methane generation. Moreover, the quantities of methane captured will be fed to the flare(s), power plant(s) and thermal plant(s), thus methane destroyed in project will be related to methane *captured*.

$$MD_{flared,y} = \left(LFG_{flare,y} * w_{CH4,y} * D_{CH4}\right) - \left(\frac{PE_{flare,y}}{GWP_{CH4}}\right) \quad \textbf{(9)}$$

Where:

$LFG_{flare,y}$	=	Quantity of landfill gas fed to the flare(s) during the year measured in cubic meters (m^3)
w_{CH4}	=	Average methane fraction of the landfill gas as measured[7] 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 (tCH_4/m^3CH_4)[8]
$PE_{flare,y}$	=	Project emissions from flaring of the residual gas stream in year y (tCO_2e) determined following the procedure described in the "*Tool to determine project emissions from flaring gases containing methane*". If methane is flared through more than one flare, the $PE_{flare,y}$ shall be determined for each flare using the tool.

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

$$MD_{flared,y} = \left(\sum_{h=1}^{8760} (LFG_{flare,h} * w_{CH4,h} * D_{CH4,h})\right) - \left(\frac{PE_{flare,y}}{GWP_{CH4}}\right) \quad \textbf{(9a)}$$

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

The gas density depends on temperature and pressure, and flow meter likely to be used for monitoring in LFG capture projects automatically compensate for gas density in flow measurement, so that in Eq (9a), $LFG_{flare,h}$ is already expressed in terms of standard temperature and pressure, so that $D_{CH4,h}$ (methane density) is in fact a constant, 0.0007168 tonne/m³, at standard temperature and pressure conditions (0°C, 1.013 bar). Thus, in practice, there is no difference between equations (9) and (9a).

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

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

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

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

> *(a) To use a 90% default value. Continuous monitoring of compliance with manufacturer's specification of flare (temperature, flow rate of residual gas at the inlet of the flare) must be performed. If in a specific hour any of the parameters are out of the limit of manufacturer's*

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

[8] At standard temperature and pressure (0 degree Celsius and 1.013bar) the density of methane is 0.0007168 tCH_4/m^3CH_4.

specifications, a 50% default value for the flare efficiency should be used for the calculations for this specific hour.
(b) Continuous monitoring of the methane destruction efficiency of the flare (flare efficiency).

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

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

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

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

$$FM_{RG,h} = \rho_{RG,n,h} * FV_{RG,h} \qquad \textbf{(T.1)}^{9}$$

Where:

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

And:

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

Where:

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

And:

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

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

Where:

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

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

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

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

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

Where:

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

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

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

Step 2 states:

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

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

Where:

$fm_{i,h}$	-	Mass fraction of element *j* in the residual gas in hour *h*
$fv_{i,h}$	-	Volumetric fraction of component *i* in the residual gas in the hour *h*
AM_j	kg/kmol	Atomic mass of element *j*
$NA_{j,i}$	-	Number of atoms of element *j* in component *i*

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

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

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

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

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

Where:

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

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

Where:

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

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

Where:

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

The Tool states:

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

Where:

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

and other variables are as defined earlier.

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

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

Next we have:

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

Where:

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

and other variables are as defined earlier.

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

Where:

$t_{O2, h}$ - Volumetric fraction of O_2 in the exhaust gas in hour *h*

and other variables are as defined earlier.

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

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

Where:

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

and other variables are as defined earlier.

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

The mass flow of methane in the exhaust gas is based on the volumetric flow of the exhaust gas and the measured concentration of methane in the exhaust gas, as follows:

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

Where:

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

Step 5: Determination of methane mass flow rate in the residual gas on a dry basis

The Tool states:

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

Note that this is identical to the first part of our reformulation Eq. (9a) of Eq. (9) of ACM0001.

The Tool further elaborates:

"It is necessary to refer both measurements (flow rate of the residual gas and volumetric fraction of methane in the residual gas) to the same reference condition that may be dry or wet basis. If the residual gas moisture is significant (temperature greater than 60ºC), the measured flow rate of the residual gas that is usually referred to wet basis should be corrected to dry basis due to the fact that the measurement of methane is usually undertaken on a dry basis (i.e. water is removed before sample analysis)."

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

Where:

$TM_{RG,h}$	kg/h	Mass flow rate of methane in the residual gas in the hour *h*

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

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

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

Step 6: Determination of the hourly flare efficiency

The Tool states:
"The determination of the hourly flare efficiency depends on the operation of flare (e.g. temperature), the type of flare used (open or enclosed) and, in case of enclosed flares, the approach selected by project participants to determine the flare efficiency (default value or continuous monitoring)."
"In case of enclosed flares and continuous monitoring of the flare efficiency, the flare efficiency in the hour h ($\eta_{flare,h}$) is:

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

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

Where:

$\eta_{flare,h}$	-	Flare efficiency in hour *h*
$TM_{FG,h}$	kg/h	Methane mass flow rate in exhaust gas averaged in hour *h*[10]
$TM_{RG,h}$	kg/h	Mass flow rate of methane in the residual gas in the hour *h*

STEP 7. Calculation of annual project emissions from flaring

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

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

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

Where:

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

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

Once project emissions $PE_{flare,y}$ has been calculated, the next formula from the methodology ACM0001 ver. 8 is:

$$MD_{electricity,y} = LFG_{electricity,y} \times w_{CH_4,y} \times D_{CH_4} \quad \textbf{(10)}$$

Where:

$MD_{electricity,y}$ = quantity of methane destroyed by generation of electricity (tCH_4/yr)

$LFG_{electricity,y}$ = quantity of landfill gas fed into electricity generator (m^3/yr)

Considering hourly variations in methane density and methane concentration in LFG, a more precise form of Eq. (10) is:

$$MD_{electricity,y} = \sum_{h=1}^{8760} (LFG_{electricity,h} \times w_{CH_4,h} \times D_{CH_4}) \quad \textbf{(10a)}$$

Since electricity generation using LFG is the only energy application of LFG being considered in the proposed project, Eqs. (11) and (12) relating to other uses of LFG are not relevant here.

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

Further, ACM0001 version 8 requires that:
"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 dumping waste at a solid waste disposal site".

This tool was elaborated to calculate baseline emissions of methane from waste that would in the absence of the project activity, be disposed at solid waste disposal sites (SWDS). Emissions reducctions are calculated with a first order decay model. Despite the fact that this tool is for avoided waste to disposal sites, it is very useful in order to calculate the quantity of methane generated by the waste landfilled in this project case.

The main formula is:

$$BE_{CH4,SWDS,y} = \varphi \cdot (1-f) \cdot GWP_{CH4} \cdot (1-OX) \cdot \frac{16}{12} \cdot F \cdot DOC_f \cdot MCF \cdot \sum_{x=1}^{y} \sum_{j} W_{j,x} \cdot DOC_j \cdot e^{-k(y-x)} \cdot (1-e^{-kj}) \quad \textbf{(TW.1}^{11}\textbf{)}$$

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)[12]
φ	=	Model correction factor to account for model uncertanties (0.9)
f	=	Fraction of methane captured at the SWDS and flared, combusted or used in another maner
GWP_{CH4}	=	Global Warming Potential (GWP) of methane, valid for the relevant commitment period
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 type j prevented from disposal in the SWDS in the year x (tonnes)
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 emissions are calculated (x=y)] Note: this definition represents a correction of the Tool as given in ACM0001, ver. 8.
y	=	Year for which methane emissions are calculated

ACM0001, ver. 8 further clarifies that "*Sampling to determine the different waste types is not necessary, the waste composition can be obtained from previous studies.*"

ACM0001, ver. 8 also states: "*The efficiency of the degassing system which will be installed in the project activity should be taken into account while estimating the ex-ante estimation.*" This is taken into consideration in the value assumed for *f* in the equation above.

The value and source of information for each of the variables above are given in section B.6.2. and Annex 3.

ACM0001 ver. 8 further states:

$$MD_{project,y} = \frac{BE_{CH_4,SWDS,y}}{GWP_{CH_4}} \quad \textbf{(13)}$$

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

[11] Equation numbers from the Waste Emission Tool are prefixed with the letter "TW" to distinguish them from equations from the methodology.

[12] Note that "methane emissions avoided" in this project case means methane emissions generated by the landfill. So, the period in consideration here will be since the landfill opening to the landfill closure.

The methodology states: "*In case the baseline is electricity generated by plants connected to the grid the emission factor should be calculated according to "Tool for calculation of emission factor for electricity systems*".

The calculation of the emission factor for the electricity system is demonstrated in Annex 3 using the tool recommended.

Since there is no thermal use of LFG either in the baseline or in the project, the following section of ACM0001 may be skipped: "Determination of $CEF_{ther,BL,y}$".

We next determine emissions associated with the project activity.

Project Emissions:

$$PE_y = PE_{EC,y} + PE_{FC,j,y} \tag{16}$$

Where:

$PE_{EC,y}$ = Emissions from consumption of electricity in the project case. The project wmissions from electricity consumption ($PE_{EC,y}$) will be calculated following the latest version of *"Tool to calculate project emissions from electricity consumption"*. If in the baseline a part of LFG was captured then the electricity quantity used in calculation is electricity used in the project activity net of that consumed in the baseline.

$PE_{FC,j,y}$ = Emissions from consumption of heat in the project case. The project emissions from fossil fuel consumption ($PE_{FC,j,y}$) will be calculated following the latest version of *"Tool to calculate project or leakage CO_2 emissions from fossil fuel combustion"*. For this purpose, the processes 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. If in the baseline part of a LFG was captured, then the heat quantity used in calculation is fossil fuel used in project activity net of that consumed in the baseline.

$PE_{EC,y}$ will be calculated using the "Tool to calculate project emissions from electricity consumption".

The tool presents three different possibilities, and the El Verde Landfill Project is inserted in Case A: Electricity consumption from the grid. In this case, the tool declares:
"Project emissions from consumption of electricity from the grid are calculated based on the power consumed by the project activity and the emission factor of the grid, adjusted for transmission losses, using the following formula:"

$$PE_{EC,y} = EC_{PJ,y} \times EF_{grid,y} \times (1 + TDL_y) \qquad \textbf{(TE.1}^{13}\textbf{)}$$

Where:

$PE_{EC,y}$ = Project emissions from electricity consumption by the project activity during the year y (tCO_2 / yr)

$EC_{PJ,y}$ = Quantity of electricity consumed by the project activity during the year y (MWh)

$EF_{grid,y}$ = Emission factor for the grid in year y (tCO_2/MWh)

TDL_y = Average technical transmission and distribution losses in the grid in year y for the

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

voltage level at which electricity is obtained from the grid at the project site.

The value and source of information for the elements above are given in section B.6.3 and B.7.1.

$PE_{FC,j,y}$ will be calculated according to the "*Tool to calculate project or leakage CO_2 emissions from fossil fuel combustion*" and is given by the formula:

$$PE_{FC,j,y} = \sum_i FC_{i,j,y} \times COEF_{i,y} \qquad \textbf{(TF.1}^{14}\textbf{)}$$

Where:

$PE_{FC,j,y}$ = CO_2 emissions from fossil fuel combustion in process j during the year y (tCO_2/yr)
$FC_{i,j,y}$ = 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 types combusted in process j during the year y

In order to calculate $COEF_{i,y}$, we chose the Option B of the tool, that is:
"The CO_2 emission coefficient $COEF_{i,y}$ is calculated based on net calorific value and CO_2 emission factor of the fuel type i, as follows:"

$$COEF_{i,y} = NCV_{i,y} \times EF_{CO2,i,y} \qquad \textbf{(TF.4)}$$

Where:

$COEF_{i,y}$ = Is the CO_2 emission coefficient of fuel type i in year y
$NCV_{i,y}$ = Is the weighted average net calorific value of the fuel type i in year y (GJ/mass or volume unit)
$EF_{CO2,i,y}$ = Is the weighted average CO_2 emission factor of fuel type i in year y (tCO_2/GJ)
i = Are the fuel types combusted in process j during the year y.

Finally, according to ACM0001 ver.8, emission reductions can be calculated as follows:

$$ER_y = BE_y - PE_y \qquad \textbf{(17)}$$

Where:

ER_y = Emission reductions in year y (tCO_2e/yr)
BE_y = Baseline emissions in year y (tCO_2e/yr)
PE_y = Project emissions in year y (tCO_2e/yr)

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

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

[14] Equation numbers from the Fossil Fuel Consumption Tool are prefixed with the letter "TF" to distinguish them from equations from the methodology.

that are available at the time of validation, and are not monitored are listed in individual data tables further below.

Parameter	SI Unit	Description	Value
MM_{CH4}	kg/kmol	Molecular mass of methane	16.04
MM_{CO}	kg/kmol	Molecular mass of carbon monoxide	28.01
MM_{CO2}	kg/kmol	Molecular mass of carbon dioxide	44.01
MM_{O2}	kg/kmol	Molecular mass of oxygen	32.00
MM_{H2}	kg/kmol	Molecular mass of hydrogen	2.02
MM_{N2}	kg/kmol	Molecular mass of nitrogen	28.02
AM_C	kg/kmol (g/mol)	Atomic mass of carbon	12.00
AM_H	kg/kmol (g/mol)	Atomic mass of hydrogen	1.01
AM_O	kg/kmol (g/mol)	Atomic mass of oxygen	16.00
AM_N	kg/kmol (g/mol)	Atomic mass of nitrogen	14.01
P_n	Pa	Atmospheric pressure at normal conditions	101,325
R_u	Pa m^3/kmol K	Universal ideal gas constant	8,314.472
T_n	K	Temperature at normal conditions	273.15
MF_{O2}	Dimensionless	O_2 volumetric fraction of air	0.21
GWP_{CH4}	tCO_2/tCH_4	Global warming potential of methane	21
MV_n	m^3/Kmol	Volume of one mole of any ideal gas at normal temperature and pressure	22.414
$\rho_{CH4,n}$ / D_{CH4}	kg/m^3	Density of methane gas at normal conditions	0.7168
$NA_{i,j}$	Dimensionless	Number of atoms of element *j* in component *i*, depending on molecular structure	

Data / Parameter:	Regulatory requirements relating to landfill gas projects
Data unit:	Dimensionless
Description:	Regulatory requirements relating to landfill gas projects
Source of data used:	Estimate (see justification below)
Value applied:	0%
Justification of the choice of data or description of measurement methods and procedures actually applied:	In the absence of the proposed project, all the landfill gas will be released to the atmosphere. As explained in B.4, the current configuration of passive venting and **no** burning at El Verde landfill.
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. Hence, because this value may change at the end of each crediting period, in case of changes in regulatory requirements, it will be monitored as table for variable 25 in B.7.1 below.

Data / Parameter:	GWP_{CH4}
Data unit:	tCO_2e/tCH_4
Description:	Global Warming Potential of CH_4
Source of data used:	IPCC
Value applied:	21
Justification of the choice	For the first commitment period. Shall be updated according to any future

of data or description of measurement methods and procedures actually applied:	COP/MOP decisions.
Any comment:	

Data / Parameter:	$\mathbf{D_{CH4}}$
Data unit:	tCH_4/m^3CH_4
Description:	Methane density
Source of data used:	
Value applied:	0.0007168
Justification of the choice of data or description of measurement methods and procedures actually applied:	At standard temperature and pressure (0°C and 1,013bar).
Any comment:	

Data / Parameter:	$\mathbf{BE_{CH4, SWDS,y}}$
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 "Tool to determine methane emissions avoided from dumping waste at a solid waste disposal site"
Value applied:	See B.6.3 and Annex 3.
Justification of the choice of data or description of measurement methods and procedures actually applied:	As per "Tool to determine methane emissions avoided from dumping 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.

Data / Parameter:	$\mathbf{CEF_{elec,BL,y}}$
Data unit:	tCO_2e/MWh
Description:	CO_2 emissions intensity of the baseline source of electricity displaced.
Source of data used:	CO_2 emissions factor for electricity generation in the Mexican grid connected to the project site, tCO_2e/MWh. Power generated using landfill gas would displace power generated in the interconnected power grid.
Value applied:	0.5133 (Combined Margin)
Justification of the choice of data or description of measurement methods and procedures actually applied:	For power generation below 15 MW, the emissions factor may be calculated using *"tool to calculate the emission factor for an electricity system"*, recommended by ACM0001 ver 8.
Any comment:	A single, fixed value is used for each crediting period. More calculation details are provided in Annex 3.

B.6.3 Ex-ante calculation of emission reductions:

An ex-ante emission reduction calculation requires an estimation of landfill gas production from the waste at the site. This estimation is made using the *'Tool to determine methane emissions avoided from dumping waste at a solid waste disposal site"*. For more information on this model and the parameters used, please refer to Annex 3.

The LFG collection efficiency for ex-ante estimations is assumed to be 50%, which is a conservative value compared to typical values considered in Mexican and others landfills. The amount of methane collected would represent $MD_{project,y}$.

As discussed in section B.4, in the absence of the proposed project activity, the configuration at El Verde landfill is passive venting and no burning of the LFG. Thus an appropriate value of AF is 0%.

Project sponsor expects to collect and flare landfill gas initially. At some later point, it may decide to generate electricity, in which case a part of the landfill gas collected would be sent to electricity generation unit. At present the landfill operator does not have permits to generate electricity. Therefore, electricity generation would be subject to obtaining the appropriate authorisation. Generation could start in 2009. The maximum electricity generation potential (MW) can be estimated from the flow rate of landfill gas collected (m^3/h). We estimated that a dedicated LFG engine-generator will need a flow of 688 m^3/h of landfill gas (@50% methane) to generate 1 MWe (one electric megawatt). This assumption was based on information sent by a LFG engine manufacturer (Waukesha Motors). This allows us to calculate the maximum power generation potential if all the LFG were converted to electricity. While LFG generation may vary continuously over time, power generation equipment is only available at specific power output capacities. Based on the amount of landfill gas available after satisfying the thermal plant demand, we assume that initial power generation in 2009 would be 2.0 MW, reaching up to 3.5 MW in 2016. While the LFG model indicates that gas may be available to generate almost 4.5 MW during the crediting period, given that no firm decision on power generation has yet been made, the present estimate limits power generation to a maximum of 3.5 MW. All these calculations are presented in the tables within this section.

All the landfill gas not sent to the power plant will be combusted in an enclosed flare. For conservativeness, the ex-ante estimations assume a default flare efficiency of 90%, as recommended in the Methodological *"Tool to determine project emissions from flaring gases containing methane"* (Version: EB28, Annex 13).

The project activity involves LFG recovery, which requires a blower for gas pumping, and electricity is needed for this purpose. If the project does not generate electricity, or until the power plant is operational, this electricity will be purchased from the grid and will constitute $PE_{EC,y}$ in Eq. (11). In case of electricity generation using the methane collected in the project, emissions reductions would be determined by the sum of the amount of electricity exported from the project site to the grid and the amount of electricity used on-site unrelated to the project activity —as it would have been imported in the absence of the project activity. This will constitute $EL_{LFG,y}$.

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

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

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

Emissions from this power consumption from the grid in the project activity will also depend on the emissions factor for electricity generation, which is estimated in Annex 3, according to the *"Tool to calculate the emission factor for an electricity system"*. A value of 0.5133 tCO_2/MWh (combined margin) was used in this project for imported (grid) electricity. This CO_2 emissions factor for power generation was determined using the same procedure indicated in the tool which allows for $EF_{grid,y}$ to remain fixed for each crediting period.

The El Verde landfill project does not contemplate thermal generation, and has no fossil fuel consumption at the baseline scenario. Thus, the thermal parameters at baseline scenario are considered to be zero ($CEF_{therm,BL,y}$ *and* $ET_{LFG,y}$).

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

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

$BE_y = (MD_{project,y} - MD_{BL,y}) * GWP_{CH4} + EL_{LFG,y} * CEF_{elec,BL,y}$ (1)		2008	2009	2010	2011	2012	2013	2014	2015
BE_y	*Baseline emissions (tCO_2e).*	44,037	114,347	124,721	139,626	150,903	166,837	179,269	95,918
$MD_{project,y}$	*Amount of methane that would have been destroyed/combusted during the year, in project scenario (tCH_4)*	2,097	5,054	5,548	6,160	6,697	7,358	7,950	4,275
$MD_{BL,y}$	*Amount of methane that would have been destroyed/combusted during the year y in the absence of the project due to regulatory and/or contractual requirement (tCH_4)*	0	0	0	0	0	0	0	0
GWP_{CH4}	*Global Warming Potential value for methane for the first commitment period (tCO_2e/tCH_4)*	21	21	21	21	21	21	21	21
$EL_{LFG,y}$	*Net quantity of electricity produced using LFG, which in the absence of the project activity would have been produced by power plants connected to the grid or by an on-site/off-site fossil fuel based captive power generation, during year y (MWh)*	0	16,000	16,000	20,000	20,000	24,000	24,000	11,967
$CEF_{elec,BL}$	*CO_2 emissions intensity of the baseline source of electricity displaced (tCO_2e/MWh).*	0.5133	0.5133	0.5133	0.5133	0.5133	0.5133	0.5133	0.5133

$MD_{BL,y} = MD_{project,y} * AF$ (2)		2008	2009	2010	2011	2012	2013	2014	2015
$MD_{BL,y}$	*Amount of methane that World have been destroyed/combusted during the year y in the absence of the Project (tCH_4)*	0	0	0	0	0	0	0	0
$MD_{project,y}$	*Amount of methane that would have been destroyed/combusted during the year y (tCH_4)*	2,097	5,054	5,548	6,160	6,697	7,358	7,950	4,275
AF	*Adjustment factor*	0%	0%	0%	0%	0%	0%	0%	0%

$MD_{project,y} = MD_{flared,y} + MD_{electricity,y}$ (8a)		2008	2009	2010	2011	2012	2013	2014	2015
$MD_{project,y}$	*Quantity of methane that would have been destroyed/combusted during the year y (tCH_4)*	2,097	5,054	5,548	6,160	6,697	7,358	7,950	4,275
$MD_{flared,y}$	*Quantity of methane destroyed by flaring (tCH_4)*	2,097	1,109	1,603	1,229	1,765	1,440	2,032	1,324
$MD_{electricity,y}$	*Quantity of methane destroyed by generation of electricity (tCH_4)*	0	3,945	3,945	4,932	4,932	5,918	5,918	2,951

$MD_{flared,y} = (LFG_{flare,y} * w_{CH4,y} * D_{CH4}) - (PE_{flare,y}/GWP_{CH4})$ (9)		2008	2009	2010	2011	2012	2013	2014	2015
$LFG_{flare,y}$	*Quantity of landfill gas fed to the flare during the year (m^3)*	6,500,955	3,437,388	4,968,466	3,809,192	5,472,981	4,465,213	6,299,333	4,105,196
$w_{CH4,y}$	*Average methane fraction of the landfill gas as measured during the year y and expressed as a fraction (m^3 CH_4 / m^3 LFG)*	50%	50%	50%	50%	50%	50%	50%	50%
D_{CH4}	*Methane density (tCH_4/m^3CH_4)*	0.0007168	0.0007168	0.0007168	0.0007168	0.0007168	0.0007168	0.0007168	0.0007168
$PE_{flare,y}$	*Project emissions from flaring of the residual gas stream (tCO_2e) determined following the procedure described in the "Tool to determine project emissions from flaring gases containing methane"*	4,893	2,587	3,739	2,867	4,119	3,361	4,741	3,090
GWP_{CH4}	*Global Warming Potential value for methane for the first commitment period (tCO_2e/tCH_4)*	21	21	21	21	21	21	21	21

$MD_{electricity,y} = LFG_{electricity,y} * w_{CH4} * D_{CH4}$ (10)		2008	2009	2010	2011	2012	2013	2014	2015
$MD_{electricity,y}$	*Quantity of methane destroyed by generation of electricity (tCH_4)*	0	3,945	3,945	4,932	4,932	5,918	5,918	2,951
$LFG_{electricity,y}$	*Quantity of landfill gas fed into the electricity generator (m^3)*	0	11,008,000	11,008,000	13,760,000	13,760,000	16,512,000	16,512,000	8,233,381
$w_{CH4,y}$	*Average methane fraction of the landfill gas as measured during the year y and expressed as a fraction (m^3 CH_4 / m^3 LFG)*	50%	50%	50%	50%	50%	50%	50%	50%
D_{CH4}	*Methane density (tCH_4/m^3CH_4)*	0.0007168	0.0007168	0.0007168	0.0007168	0.0007168	0.0007168	0.0007168	0.0007168

$MD_{project,y} = BE_{CH4,SWDS,y} / GWP_{CH4}$ (13)		2008	2009	2010	2011	2012	2013	2014	2015
$MD_{project,y}$	*Quantity of methane that would have been destroyed/combusted during the year y (tCH_4)*	4,747	10,547	11,665	12,828	14,043	15,316	16,655	9,009
$BE_{CH4,SWDS,y}$	*Methane generation from the landfill in the absence of the project activity (tCO_2e)*	99,678	221,489	244,965	269,386	294,896	321,641	349,763	189,186
GWP_{CH4}	*Global Warming Potential value for methane for the first commitment period (tCO_2e/tCH_4)*	21	21	21	21	21	21	21	21

$PE_{flare,y} = \sum TM_{RG,h} * (1 - \eta_{flare,h}) * GWP_{CH4} / 1000$ (T.15)		2008	2009	2010	2011	2012	2013	2014	2015
$PE_{flare,y}$	*Project emissions from flaring of the residual gas stream (tCO_2e) determined following the procedure described in the "Tool to determine project emissions from flaring gases containing methane"*	4,893	2,587	3,739	2,867	4,119	3,361	4,741	3,090
$\sum TM_{RG,h}$	*Total mass flow rate in the residual gas (kg)*	2,329,942	1,231,960	1,780,698	1,365,214	1,961,516	1,600,332	2,257,681	1,471,302
$\eta_{flare,h}$	*Flare combustion efficiency*	90%	90%	90%	90%	90%	90%	90%	90%
GWP_{CH4}	*Global Warming Potential value for methane for the first commitment period (tCO_2e/tCH_4)*	21	21	21	21	21	21	21	21

$CEF_{elec,BL,y}$ determined by "Tool for calculation of emission factor for electricity system" (seedetails in Annex 3)		2008	2009	2010	2011	2012	2013	2014	2015
$CEF_{elec,BL,y}$	*CO_2 emissions intensity of the baseline source of electricity displaced (tCO_2e/MWh)*	0.5133	0.5133	0.5133	0.5133	0.5133	0.5133	0.5133	0.5133

$PE_y = PE_{EC,y} + PE_{FC,j,y}$ (16)		2008	2009	2010	2011	2012	2013	2014	2015
PE_y	*Project emissions in year y (tCO_2e/yr)*	44.8	6.9	7.7	8.4	9.2	10.1	11.0	5.9
$PE_{EC,y}$	*Emissions from consumption of electricity in the project case (tCO_2e/yr)*	44.8	6.9	7.7	8.4	9.2	10.1	11.0	5.9
$PE_{FC,j,y}$	*Emissions from consumption of heat in the project case (tCO_2e/yr)*	0	0	0	0	0	0	0	0

$PE_{EC,y} = EC_{PJ,y} * EF_{grid} * (1+TDL_y)$ (TE.1)		2008	2009	2010	2011	2012	2013	2014	2015
$PE_{EC,y}$	*Project emissions from electricity consumption by the*	44.8	6.9	7.7	8.4	9.2	10.1	11.0	5.9

	project activity during the year y (tCO2 / yr)								
$EC_{PJ,y}$	*Quantity of electricity consumed by the project activity during the year y (MWh)*	73	11	12	14	15	16	18	10
EF_{grid}	*Emission factor for the grid in year y (tCO2/MWh)*	0.5133	0.5133	0.5133	0.5133	0.5133	0.5133	0.5133	0.5133
TDL_y	*Average technical transmission and distribution losses in the grid in year y for the voltage level at which electricity is obtained from the grid at the project site.*	20%	20%	20%	20%	20%	20%	20%	20%

$PE_{FC,j,y} = \Sigma FC_{i,j,y} * COEF_{i,y}$	*(TF.1)*	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**
$PE_{FC,j,y}$	*Emissions from consumption of heat in the project case (tCO_2e/yr)*	0	0	0	0	0	0	0	0
$FC_{i,j,y}$	*Quantity of fuel type i combusted in process j during the year y (mass or volume unit / yr)*	0	0	0	0	0	0	0	0
$COEF_{i,y}$	*CO_2 emission coefficient of fuel type i in year y (tCO_2/mass or volume unit)*	0	0	0	0	0	0	0	0

$COEF_{i,y} = NCV_{i,y} * EF_{CO2,i,y}$	*(TF.4)*	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**
$COEF_{i,y}$	*CO_2 emission coefficient of fuel type i in year y (tCO_2/mass or volume unit)*	0	0	0	0	0	0	0	0
$NCV_{i,y}$	*weighted average net calorific value of the fuel type i in year y (GJ/mass or volume unit)*	0	0	0	0	0	0	0	0
$EF_{CO2,i,y}$	*weighted average CO_2 emission factor of fuel type i in year y (tCO_2/GJ)*	0	0	0	0	0	0	0	0

$ER_y = BE_y - PE_y$	*(17)*	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**
ER_y	*Emission reductions in year y (tCO_2e/yr)*	43,992	114,340	124,713	139,618	150,894	166,827	179,258	95,912
BE_y	*Baseline emissions in year y (tCO_2e/yr)*	44,037	114,347	124,721	139,626	150,903	166,837	179,269	95,918
PE_y	*Project emissions in year y (tCO_2e/yr)*	45	7	8	8	9	10	11	6

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

Table 4: *Ex-ante estimation of landfill gas collected and flared/used at El Verde Landfill Project*

Year	$LFG_{total,y}$ m^3LFG /yr	$LFG_{electricity,y}$ m^3LFG /yr	$LFG_{flare,y}$ m^3LFG /yr
2008 (from July)	6,500,955	0	6,500,955
2009	14,445,388	11,008,000	3,437,388
2010	15,976,466	11,008,000	4,968,466
2011	17,569,192	13,760,000	3,809,192
2012	19,232,981	13,760,000	5,472,981
2013	20,977,213	16,512,000	4,465,213
2014	22,811,333	16,512,000	6,299,333
2015 (up June)	12,338,577	8,233,381	4,105,196

Note: All volume estimates are considered to be at 0 C, 1 atmosphere.

Table 5: *Ex-ante estimation of net emission reduction by methane destruction at El Verde Landfill Project*

Year	$MD_{electricity,y}$ tCH_4	$MD_{flare,y}$ tCH_4	$MD_{project,y}$ tCH_4	MD_{BL} tCH_4	***Net*** **ER by methane destruction** tCO_2e
2008 (from July)	0	2,097	2,097	0	44,037
2009	3,945	1,109	5,054	0	106,134
2010	3,945	1,603	5,548	0	116,508
2011	4,932	1,229	6,160	0	129,360
2012	4,932	1,765	6,697	0	140,637
2013	5,918	1,440	7,358	0	154,518
2014	5,918	2,032	7,950	0	166,950
2015 (up to June)	2,951	1,324	4,275	0	89,775

Table 6: *Ex-ante estimation of net emission reduction by fossil fuels displacement, due to electricity generation using landfill gas at El Verde Landfill Project*

Year	$EC_{PJ,y}$ *MWh*	$EL_{LFG,y}$ MWh	***Net*** **ER by electricity generation** tCO_2e
2008 (from July)	73	0	-45
2009	11	16,000	8,206
2010	12	16,000	8,205
2011	14	20,000	10,258
2012	15	20,000	10,257
2013	16	24,000	12,309
2014	18	24,000	12,308
2015 (up to June)	10	11,967	6,137

Table 7: *Summary of ex-ante estimation of total emission reduction at El Verde Landfill Project*

Year	**Total ER tCO_2e/yr**
2008 (from July)	43,992
2009	114,340
2010	124,713
2011	139,618
2012	150,894
2013	166,827
2014	179,258
2015 (up to June)	95,912
Total	**1,015,554**

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

B.7.1 Data and parameters monitored:

Data / Parameter:	**$LFG_{total,y}$**
Data unit:	m^3
Description:	Total amount of landfill gas captured at normal temperature and pressure
Source of data to be used:	Measured by a flow meter
Value of data applied for the purpose of calculating expected emission reductions in section B.5	Details of assumptions, calculations and resulting data are presented in sections B.6.3 and B.6.4.
Description of measurement methods and procedures to be applied:	Continuous mass flow meters will be used to measure flow rates. Data will be measured at least once per hour, recorded electronically, and data will be kept during the crediting period and two years after. Data will also be aggregated monthly/yearly.
QA/QC procedures to be applied:	Flow meters should be subject to a regular maintenance and testing regime to ensure accuracy. Also, an independent company, accredited by local authorities, will conduct contrasting and data checking in accordance with manufacturer specifications, to ensure accuracy.
Any comment:	Flow meter would adjust volume flow for temperature and pressure.

Data / Parameter:	**$LFG_{flare,y}$**
Data unit:	m^3
Description:	Amount of landfill gas flared at normal temperature and pressure
Source of data to be used:	Measured by a flow meter
Value of data applied for the purpose of calculating expected emission reductions in section B.5	Details of assumptions, calculations and resulting data are presented in sections B.6.3 and B.6.4.

Description of measurement methods and procedures to be applied:	Data will be measured for each flare at least once per hour, recorded electronically, and data will be kept during the crediting period and two years after. Data will also be aggregated monthly/yearly.
QA/QC procedures to be applied:	Flow meters should be subject to a regular maintenance and testing regime to ensure accuracy. Also, an independent company, accredited by local authorities, will conduct contrasting and data checking in accordance with manufacturer specifications, to ensure accuracy.
Any comment:	Flow meter would adjust volume flow for temperature and pressure.

Data / Parameter:	$\mathbf{LFG_{electricity,y}}$
Data unit:	m^3
Description:	Amount of landfill gas combusted in power plant at normal temperature and pressure
Source of data to be used:	Measured by a flow meter
Value of data applied for the purpose of calculating expected emission reductions in section B.5	Details of assumptions, calculations and resulting data are presented in sections B.6.3 and B.6.4
Description of measurement methods and procedures to be applied:	Continuous mass flow meters will be used to measure flow rates. Data will be measured for each power plant at least once per hour, recorded electronically, and data will be kept during the crediting period and two years after. Data will also be aggregated monthly/yearly.
QA/QC procedures to be applied:	Flow meters should be subject to a regular maintenance and testing regime to ensure accuracy. Also, an independent company, accredited by local authorities, will conduct contrasting and data checking in accordance with manufacturer specifications, to ensure accuracy.
Any comment:	Flow meter would adjust volume flow for temperature and pressure.

Data / Parameter:	$\mathbf{PE_{flare,y}}$
Data unit:	tCO_2e
Description:	Project emissions from flaring of the residual gas stream in year *y*
Source of data to be used:	On-site measurements / calculations
Value of data applied for the purpose of calculating expected emission reductions in section B.5	10% of CH_4 in gas stream
Description of measurement methods and procedures to be applied:	The parameters used for determining the project emissions from flaring of the residual gas stream in year *y* ($\mathbf{PE_{flare,y}}$) will be monitored as per the *"Tool to determine project emissions from flaring gases containing methane"*. The parameters used for the determination of $PE_{flare,y}$ are $LFG_{flare,y}$, $w_{CH4,y}$, $fv_{i,h}$, $fv_{CH4,FG,h}$ and $t_{O2,h}$.
QA/QC procedures to be applied:	Regular maintenance will ensure optimal operation of the flare. Analysers will be calibrated annually according to manufacturer's recommendations.
Any comment:	Note: A determination of $PE_{flare,y}$ using the flaring tool requires the measurements of a number of additional parameters. These are listed and described following the variables specifically mentioned in ACM0001.

Data / Parameter:	$w_{CH4,y}$
Data unit:	m^3 CH_4 / m^3 LFG
Description:	Methane fraction in the landfill gas
Source of data to be used:	Measured by a gas analyzer
Value of data applied for the purpose of calculating expected emission reductions in section B.5	50%
Description of measurement methods and procedures to be applied:	Methane content will be measured using a continuous gas analyzer. Data will be measured at least once per hour, recorded electronically, and data will be kept during the crediting period and two years after. Data will also be aggregated monthly/yearly.
QA/QC procedures to be applied:	Gas analyzers should be subject to a regular maintenance and testing regime to ensure accuracy. Also, an independent company will contrast certified instruments with reference instruments, in accordance with manufacturer specifications.
Any comment:	

Data / Parameter:	**T**
Data unit:	ºC
Description:	Temperature of the landfill gas
Source of data to be used:	Measured.
Value of data applied for the purpose of calculating expected emission reductions in section B.5	0
Description of measurement methods and procedures to be applied:	Data will be measured at least once per hour, recorded electronically. Data will also be aggregated monthly/yearly. Records will be kept during the crediting period and two years after.
QA/QC procedures to be applied:	Measuring instruments should be subject to a regular maintenance and testing regime to ensure accuracy. Also, an independent company will contrast the thermometers used for measurements with certified equipment.
Any comment:	No separate monitoring of temperature is necessary when using flow meters that automatically measure temperature and pressure, expressing LFG volumes in normalized cubic meters (Nm^3).

Data / Parameter:	**P**
Data unit:	Pa
Description:	Pressure of the landfill gas
Source of data to be used:	Measured.
Value of data applied for the purpose of calculating expected emission reductions in section B.5	101,325 (1 atm at STP conditions)
Description of measurement methods and	Data will be measured with pressure analyser at least once per hour, recorded electronically. Data will also be aggregated monthly/yearly.

procedures to be applied:	Records will be kept during the crediting period and two years after.
QA/QC procedures to be applied:	Measuring instruments should be subject to a regular maintenance and testing regime to ensure accuracy. Also, an independent company will contrast the thermometers used for measurements with certified equipment.
Any comment:	No separate monitoring of pressure is necessary when using flow meters that automatically measure temperature and pressure, expressing LFG volumes in normalized cubic meters (Nm^3).

Data / Parameter:	EL_{LFG}
Data unit:	MWh
Description:	Net amount of electricity generated using LFG.
Source of data to be used:	Measured.
Value of data applied for the purpose of calculating expected emission reductions in section B.5	Details of assumptions, calculations and resulting data are presented in sections B.6.3 and B.6.4
Description of measurement methods and procedures to be applied:	The quantities will be measured with electricity meters installed on the generators units. The readings will be made at least once per hour and electronically stored in a spreadsheet. Data will be recorded during crediting period and two years after.
QA/QC procedures to be applied:	Electric meters are quite accurate. Moreover, the meter will be calibrated periodically according to manufacturer's specification.
Any comment:	Required to estimate the emission reductions from electricity generation from LFG, if credits are claimed.

Data / Parameter:	**Regulatory requirements relating to landfill gas projects**
Data unit:	None
Description:	Regulatory requirements relating to landfill gas projects may affect the value of *AF* or $MD_{BL,y}$
Source of data to be used:	National legislation and mandatory regulations.
Value of data applied for the purpose of calculating expected emission reductions in section B.5	AF = 0%
Description of measurement methods and procedures to be applied:	Although the methodology only requires recording at the renewal of the crediting period, the information related to all relevant policies and circumstances will be collected and recorded annually. Information will be kept during crediting period and two years after.
QA/QC procedures to be applied:	Legal documents.
Any comment:	The information, though recorded annually, is used for changes in the adjustment factor (AF) or directly $MD_{BL,y}$ at renewal of the crediting period.

Data / Parameter:	**Operation of the energy plant**
Data unit:	hours

Description:	Operation of the energy plant
Source of data:	Measured with run meter connected to the power plant.
Value of data applied for the purpose of calculating expected emission reductions in section B.5	8,000
Description of measurement methods and procedures to be applied:	Records will be kept during the crediting period and two years after.
QA/QC procedures to be applied:	Meters are quite accurate. But it will be calibrated according to manufacturer specifications.
Any comment:	This is monitored to ensure methane destruction is claimed for methane used in electricity plant when it is operational.

Data / Parameter:	**Operation of the flare station**
Data unit:	hours
Description:	
Source of data:	Measurement with run meter connected to the blower
Value of data applied for the purpose of calculating expected emission reductions in section B.5	8,600
Description of measurement methods and procedures to be applied:	Records will be kept during the crediting period and two years after.
QA/QC procedures to be applied:	Meters are quite accurate. But it will be calibrated according to manufacturer specifications.
Any comment:	It was assumed that the flare station will operate 98% of the year

Data / Parameter:	$\mathbf{PE_{EC,y}}$
Data unit:	tCO_2
Description:	Project emissions from electricity consumption by the project activity during the year y
Source of data:	Calculated as per the “Tool to calculate project emissions from electricity consumption”
Value of data applied for the purpose of calculating expected emission reductions in section B.5	Details of assumptions, calculations and resulting data are presented in section B.6.3
Description of measurement methods and procedures to be applied:	As per the “Tool to calculate project emissions from electricity consumption”
QA/QC procedures to be applied:	As per the “Tool to calculate project emissions from electricity consumption”
Any comment:	-

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

Data unit:	tCO_2e
Description:	Project emissions from fossil fuel combustion in process j during the year y
Source of data:	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	0
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:	For ex-ante calculation purposes, there will be no fossil fuel consumption at project scenario, but any eventual fossil fuel consumption will be accounted.

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

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:	On-site measurements.
Value of data applied for the purpose of calculating expected emission reductions in section B.5	Not used in ex-ante estimates.
Description of measurement methods and procedures to be applied:	Measured at least one per hour and electronically using a flow meter, and will be kept during the crediting period and two years after.
QA/QC procedures to be applied:	Flow meters will be periodically calibrated according to the manufacturer's recommendation.
Any comment:	The same basis (dry or wet) is considered for this measurement when the residual gas temperature exceeds 60ºC.

Data / Parameter:	$\mathbf{fv_{i,h}}$
Data unit:	-
Description:	Volumetric fraction of component *i* in the residual gas in the hour *h*
Source of data:	On-site measurements using a continuous gas analyser.
Value of data applied for the purpose of calculating expected emission reductions in section B.5	Not used in ex-ante estimates.

Description of measurement methods and procedures to be applied:	As a simplified approach (see Eq. 3a), only methane content of the residual gas will be measured and the remaining part will be considered as N_2. Methane concentration would be measured at least once per hour using a continuous gas analyser, and data records will be kept during the crediting period and two years after.
QA/QC procedures to be applied:	Analysers will be periodically calibrated according to the manufacturer's recommendation. A zero check and typical value check to be performed by comparison with a standard certified gas.
Any comment:	The same basis (dry or wet) is considered for this measurement when the residual gas temperature exceeds 60ºC.

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

Data / Parameter:	$\mathbf{t_{O2,h}}$
Data unit:	-
Description:	Volumetric fraction of O_2 in the exhaust has of the flare in the hour *h*.
Source of data:	On-site measurements using a continuous gas analyser.
Value of data applied for the purpose of calculating expected emission reductions in section B.5	Not used in ex-ante estimates.
Description of measurement methods and procedures to be applied:	Measured at least once per hour and electronically using a continuous gas analyser, and will be kept during the crediting period and two years after. Extractive sampling analysers with water and particulates removal devices or in situ analysers for wet basis determination. The point of measurement (sampling point) will be in the upper section of the flare (80% of total flare height). Sampling will be conducted with appropriate sampling probes adequate to high temperatures level (e.g. inconel probes).
QA/QC procedures to be applied:	Analysers will be periodically calibrated according to the manufacturer's recommendation. A zero check and typical value check to be performed by comparison with a standard certified gas.
Any comment:	

Data / Parameter:	$fv_{CH4,FG,h}$
Data unit:	mg/m^3
Description:	Concentration of methane in the exhaust gas of the flare in dry basis at normal conditions in the hour *h*
Source of data:	Measurements by project participants using a continuous gas analyser
Value of data applied for the purpose of calculating expected emission reductions in section B.5	Not used in ex-ante estimates.
Description of measurement methods and procedures to be applied:	Extractive sampling analysers with water and particulates removal devices or in situ analyser for wet basis determination. The point of measurement (sampling point) shall be in the upper section of the flare (80% of total flare height). Sampling shall be conducted with appropriate

	sampling probes adequate to high temperatures level (e.g. inconel probes). An excessively high temperature at the sampling point (above 700 ºC) may be an indication that the flare is not being adequately operated or that its capacity is not adequate to the actual flow. Monitoring frequency: Continuously. Values to be averaged hourly or at a shorter time interval.
QA/QC procedures to be applied:	Analysers will be periodically calibrated according to manufacturer's recommendation. A zero check and a typical value check will be performed by comparison with a standard gas.
Any comment:	Monitoring of this parameter is only applicable in case of enclosed flares and continuous monitoring of the flare efficiency. Measurement instruments may read ppmv or % values. To convert from ppmv to mg/m^3 simply multiply by 0.716. 1% equals 10 000 ppmv.

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

Data / Parameter:	$\mathbf{T_{flare}}$
Data unit:	ºC
Description:	Temperature in the exhaust gas of the flare.
Source of data:	On-site measurements using a thermocouple.
Value of data applied for the purpose of calculating expected emission reductions in section B.5	Not used in ex-ante estimates.
Description of measurement methods and procedures to be applied:	Continuous measurement of the temperature of the exhaust gas stream in the flare by a thermocouple. A temperature above 500 ºC indicates that a significant amount of gases are still being burnt and that the flare is operating.
QA/QC procedures to be applied:	Thermocouples will be replaced or calibrated every year.
Any comment:	An excessively high temperature at the sampling point (above 700 ºC) may be an indication that the flare is not being adequately operated or that its capacity is not adequate to the actual flow.

Data / Parameter:	$\eta_{flare,h}$
Data unit:	Dimensionless
Description:	Flare efficiency in hour h
Source of data:	Values specified in Methane Flaring Tool.
Value of data applied for the purpose of calculating expected emission reductions in section B.5	0.9
Description of measurement methods and procedures to be applied:	Calculated as specified in Methane Flaring Tool as follows: ➢ 0%, if the temperature in the exhaust gas of the flare (T_{flare}) is below 500°C for more than 20 minutes during the hour *h*. ➢ 50%, if the temperature in the exhaust gas of the flare (T_{flare}) is above 500°C for more than 40 minutes during the hour *h*, but the

	manufacturer's specifications on proper operation of the flare are not met at any point in time during the hour *h*. ➢ 90%, if the temperature in the exhaust gas of the flare (T_{flare}) is above 500°C for more than 40 minutes during the hour *h* and the manufacturer's specifications on proper operation of the flare are met continuously during the hour *h*.
QA/QC procedures to be applied:	
Any comment:	

The following variables are required to determine the electricity consumption from the grid using the "Tool to calculate project emissions from electricity consumption".

Data / Parameter:	**$EC_{PJ,y}$**
Data unit:	MWh
Description:	On-site consumption of electricity provided by the grid and/or captive power plant(s) and attributable to the project activity during the year y
Source of data:	Onsite measurements
Value of data applied for the purpose of calculating expected emission reductions in section B.5	Details of assumptions, calculations and resulting data are presented in section B.6.3
Description of measurement methods and procedures to be applied:	Measured continuously, aggregated at least annually.
QA/QC procedures to be applied:	Meters will be calibrated according to manufacturer's speficications. Cross check measurements results with invoices for purchased electricity if relevant.
Any comment:	

Data / Parameter:	**$EF_{grid,y}$**
Data unit:	tCO_2/MWh
Description:	Emission factor for the grid in year y
Source of data:	As per "Tool to calculate the emission factor for an electricity system"
Value of data applied for the purpose of calculating expected emission reductions in section B.5	0.5133
Description of measurement methods and procedures to be applied:	As per "Tool to calculate the emission factor for an electricity system". See Annex 3 of this document.
QA/QC procedures to be applied:	As per "Tool to calculate the emission factor for an electricity system". See Annex 3 of this document.
Any comment:	

Data / Parameter:	**TDL_y**
Data unit:	-

Description:	Average technical transmission and distribution losses in the grid in year y for the voltage level at which electricity is obtained from the grid at the project site
Source of data:	As per "Tool to calculate project emissions from electricity consumption"
Value of data applied for the purpose of calculating expected emission reductions in section B.5	The default value is chosen, i.e., 20%.
Description of measurement methods and procedures to be applied:	Not applicable
QA/QC procedures to be applied:	As per "Tool to calculate project emissions from electricity consumption"
Any comment:	

The following variables are required to determine the CO_2 emissions from fossil fuel combustion using the "Tool to calculate project or leakage CO_2 emissions from fossil fuel combustion".

Data / Parameter:	**$FC_{i,j,y}$**
Data unit:	Mass or volume unit per year (tonne/yr or m^3/yr)
Description:	Quantity of fuel type i combusted in process j during the year y
Source of data:	Onsite measurements
Value of data applied for the purpose of calculating expected emission reductions in section B.5	Details of assumptions, calculations and resulting data are presented in section B.6.3.
Description of measurement methods and procedures to be applied:	Use mass or volume meters
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:	For ex-ante calculation purposes, there will be no fossil fuel consumption at project scenario, but any eventual fossil fuel consumption will be accounted.

Data / Parameter:	**$NCV_{i,y}$**
Data unit:	GJ per mass or volume unit (GJ/m^3 or GJ/tonne)
Description:	Weighted average net calorific value of fuel type i in year y
Source of data:	The following data sources may be used if the relevant conditions apply: **Data source** | **Conditions for using the data source**

	a) Values provided by the fuel supplier in invoices	This is the preferred source if the carbon fraction of the fuel is not provided (option A)
	b) Measurements by the project participants	If a) is not available
	c) Regional or national default values	If a) is not available These sources can only be used for liquid fuels and should be based on well documented, reliable sources (such as national energy balances)
	d) IPCC default values at the upper limit of the uncertainty at a 95% confidence interval as provided in Table 1.2 of Chapter 1 Vol. 2 (energy) of the 2006 IPCC Guidelines on National GHG Inventories.	If a) is not available.
Value of data applied for the purpose of calculating expected emission reductions in section B.5	Details of assumptions, calculations and resulting data are presented in section B.6.3.	
Description of measurement methods and procedures to be applied:	As per "Tool to calculate project or leakage CO_2 emissions from fossil fuel combustion"	
QA/QC procedures to be applied:	As per "Tool to calculate project or leakage CO_2 emissions from fossil fuel combustion"	
Any comment:	For ex-ante calculation purposes, there will be no fossil fuel consumption at project scenario, but any eventual fossil fuel consumption will be accounted.	

Data / Parameter:	**$EF_{CO2,i,y}$**	
Data unit:	tCO_2/GJ	
Description:	Weighted average CO_2 emission factor of fuel type i in year y	
Source of data:	The following data sources may be used if the relevant conditions apply:	
	Data source	**Conditions for using the data source**
	a) Values provided by the fuel supplier in invoices	This is the preferred source.
	b) Measurements by the project participants	If a) is not available
	c) Regional or national default values	If a) is not available These sources can only be used for liquid fuels and should be based on well documented, reliable sources (such as national

	energy balances)
	d) IPCC default values at the upper limit of the uncertainty at a 95% confidence interval as provided in Table 1.4 of Chapter 1 Vol. 2 (energy) of the 2006 IPCC Guidelines on National GHG Inventories. — If a) is not available.
Value of data applied for the purpose of calculating expected emission reductions in section B.5	Details of assumptions, calculations and resulting data are presented in section B.6.3.
Description of measurement methods and procedures to be applied:	As per "Tool to calculate project or leakage CO_2 emissions from fossil fuel combustion"
QA/QC procedures to be applied:	As per "Tool to calculate project or leakage CO_2 emissions from fossil fuel combustion"
Any comment:	For ex-ante calculation purposes, there will be no fossil fuel consumption at project scenario, but any eventual fossil fuel consumption will be accounted.

B.7.2 Description of the monitoring plan:

Unlike most methodologies that determine baseline and project emissions separately, and calculate emissions reductions as the difference between the two, the methodology ACM0001 determines emissions reductions directly. ACM0001 version 8 states:

"The monitoring methodology is based on direct measurement of the amount of landfill gas captured and destroyed at the flare platform(s) and the electricity generating/thermal energy unit(s) to determine the quantities as shown in Figure 1 [of ACM0001, ver. 8] *The monitoring plan provides for continuous measurement of the quantity and quality of LFG flared. The main variables that need to be determined are the quantity of methane actually captured* $MD_{project,y}$, *quantity of methane flared* ($MD_{flared,y}$), *the quantity of methane used to generate electricity* ($MD_{electricity,y}$)*/thermal energy* ($MD_{thermal,y}$), *the quantity of methane sent to the pipeline to the natural gas distribution network* ($MD_{PL,y}$) *and the quantity of methane generated* ($MD_{total,y}$)*.The methodology also measures the energy generated by use of LFG* ($EL_{LFG,y}$, $ET_{LFG,y}$) *and energy consumed by the project activity that is produced using fossil fuels"*.

Figure 1 of ACM0001, ver. 8 is shown as Figure 2 below.

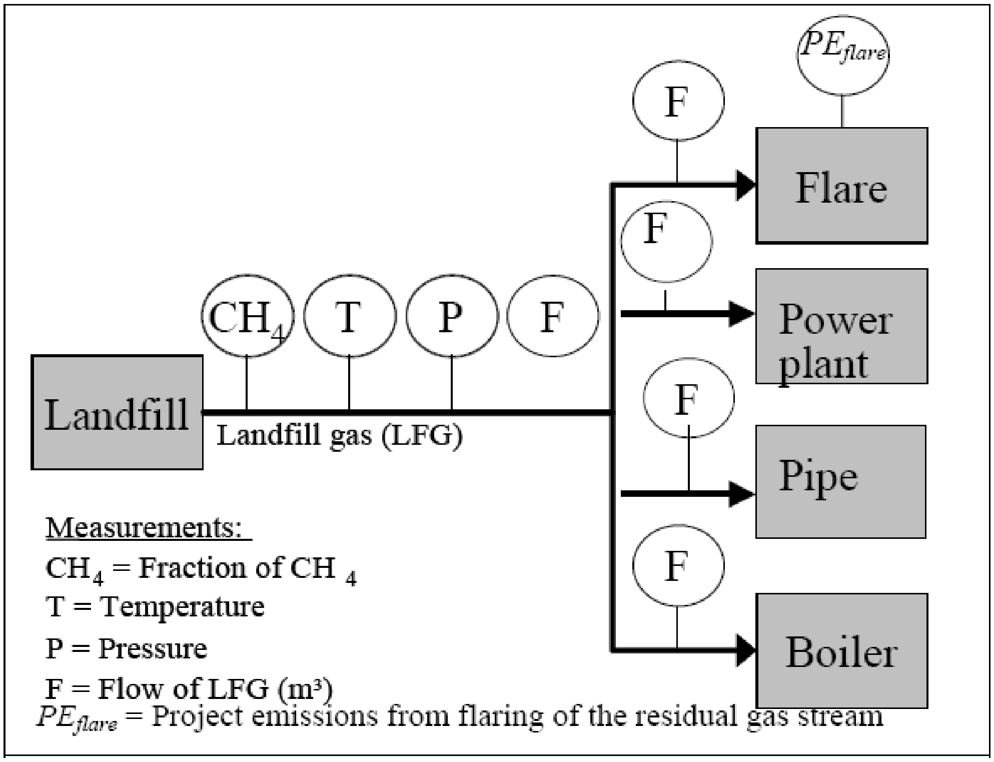

Figure 2. *Schematic of the monitoring system, according to ACM0001 version 8.* Since the proposed project at El Verde Landfill involves flaring and may involve electricity generation, the actual monitoring system would be simpler, with no LFG going to "Pipe" or to "Boiler".

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

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

PASA is the landfill operator and the investor of the proposed CDM project which involves investments for gas collection and power generation, as well as additional operation, maintenance and monitoring costs.

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

Data monitoring will be conducted by Landfill Gas Technical Operators supervised by the Landfill Gas Project Engineer, all of them belonging to the Project and Development and Investigation Departments of PASA. Other staff persons will be assigned by the Landfill Gas Project Engineer to assist in the monitoring tasks, as needed.

Certain activities (calibration of flow meters and electric meters) would be conducted by independent, outside laboratories, with the data archived by the landfill and PASA Project and Development and Investigation Departments.

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

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

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

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

***Table 8**. Operational Management Structure for El Verde Project Monitoring*

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

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

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

Detailed baseline information is provided in Annex 3 to this PDD.
Date of completion of the baseline study: 15/12/2007.
Baseline and monitoring analysis prepared by: Juliana Scalon, MGM International.

Contact information:

MGM International
Juliana Scalon
Ometusco 7, Piso 6,
Col. Hipódromo Condesa
Distrito Federal, CP 06170
Mexico
jscalon@mgminter.com

SECTION C. Duration of the project activity / crediting period

C.1 Duration of the project activity:

C.1.1. Starting date of the project activity:

01/7/08

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

21 years + 6 months (Up to 31 December 2029, see Section A)

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

C.2.1. Renewable crediting period

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

01/7/08 or the registration date.

C.2.1.2. Length of the first crediting period:

7 years

C.2.2. Fixed crediting period:

C.2.2.1. Starting date:

Not selected.

C.2.2.2. Length:

>>

SECTION D. Environmental impacts

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

Landfill gas collection, treatment and flaring are measured to improve the environmental management of waste in landfills. The detailed design and engineering of the proposed project will be conducted by PASA and a leading consulting company on landfill gas management.

- The project implementation would provide a number of local environmental benefits in addition to climate change mitigation:
- Destruction of non-methane hydrocarbons (NMHC) that contribute to photochemical smog in the local area. Moreover, volatile organic compounds are burnt in high-temperature flare, specially designed for this purpose;
- Destruction of air pollutants, such as hydrogen sulphide, that are sometimes present in landfill gas in trace quantities;
- Reduced fire and explosion risk through improved management of landfill gas.
- Reduced odour as landfill gas is captured and flared;
- Avoidance of methane leaking through the landfill cover. LFG displaces oxygen in the soil, thereby harming the roots of plants. Plants on the landfill surface protect the cover soil from erosion.

Erosion can lead to rainwater intrusion into the landfill and a consequent increase in leachate quantities. Erosion of the surface soil makes it more difficult for plants to grow. Plants promote transpiration of water, thereby minimizing both leachate and rainwater runoff.

Note that LFG combustion would produce small amounts of nitrogen oxides (NOx), particulate matter and carbon monoxide (CO), as would be the case in the kitchen stove or any other device burning natural gas.

The emissions of such gases are not regulated in Mexico. Nevertheless, the project would use enclosed flares specially designed to reduce these emissions to levels below that of an open flame. Note, however, that since the main fuel is methane, the emissions of particulate matter would be minimal. On the other hand a LFG flare is specially designed to operate at high temperature in order to burn the volatile organic compounds.

The landfill already has the permit necessary to operate the landfill as well as the proposed project activity:

- Authorization MIA-026-3357/2000 of December 10th, 2000. Guanajuato State Environment Authority - Institute of Ecology (Instituto de Ecología del Gobierno del Estado de Guanajuato). This Authorization also states that the Environmental Impact Assessment presented during the landfill conception and construction complies with the laws in force for LFG capture and use.
- Concession contract SPM/CRS/01/2000 between PASA the Public Service of Cleaning, Use and Final Disposal of Municipal Waste of León, Guanajuato (Servicio Público y de Limpia, Aprovechamiento y Disposición Final de los Residuos Municipales de León, Guanajuato).

The proposed project would not require a modification of the current Enviromental Impact Assessment (issued on December 20, 2000 by the Guanajuato Ecology Institute, MIA-026-3357/2000), as is stated in the document no. PAYDS-DS-902-2007 emited by the Sustainable Development Ministry of Leon Government.

At present, the project operator (PASA) expects only to flare the LFG collected. If at some point PASA decides to generate electricity, it will solicit all necessary permits prior to electricity generation.

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

No significant negative impacts are expected, as discussed in section D.1.

SECTION E. Stakeholders' comments

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

On October 3, 2007, letters were sent by Pablo Guzman Viera with return receipt in order to invite persons to attend the stakeholders presentation meeting. A total of 58 people were invited to attend the meeting from different sectors as listed below:
(14) Non-governmental organizations and/or consultancies and academic sector
(25) Local and Federal government
(3) Private sector
(15) Additional persons, representing the surrounding communities

The public event was held on October 16th at the Guanajuato Room in Hotel La Nueva Estancia in León, Guanajuato State, Mexico. This event was also open to the public in general, permitting an opportunity for all persons and institutions that feel affected by the project to provide their input to the proposed project activity.

The following table lists all the people that attended the meeting and /or submitted any comment (not including PASA's personnel):

Table 9. *People that attended the stakeholder meeting of El Verde Landfill Project*

Name	Charge	Company/Institution
Laura Maldonado Chavez	Chief of Environmental Management Unit	SEMARNAT
Blanca E. Moreno Valles	Director	Control and Management of Solid Waste
Dora Alicia Garcia Cruz	President of Settler Committee	Paseo De Los Laureles Committee
Angelica Ramirez Estrada	General Secretary	Paseo De Los Laureles Committee
Hector Reyes O		UMVALEON
Ivonne Marquez	General Attendant	Invited
Yinyer Bastidas	Housewife	Invited
Carlos Aaron Avila Plascencia	Fixed Sources Department	Institute of Ecology
Belen Ramirez Hernandez		Environmental Education
Jose Refugio Rocha Elias	Area Chief	Paydes, Environmental Education
Sergio Moreno T		León Town Hall
Gabriela Torral Vivero	General Director	La Palabra Magazine
Luz Adriana Rocha Gomez	Promoter	Environmental Education
Monica Aspeitia Gonzalez		Environmental Education
Cinthya G		A.M.
Cecilia Pimentel		Education and Environmental Management
Raul Tapia		Hermanos Tapia Ecologist Group
Alejandro Perez	Press Coordinator	Secretary of Sustainable Development
Luz Cristina Moreno	Coordinator of Control and Administration	Environment Protection and Solid Waste
Alicia Zuñiga	Technical Coordinator	PA Y DS
Maria Eugenia Gonzalez		PA Y DS
Ivan Jose M		S.E.C Y D
Iris Bañuelos		Televisa-Carpeta Information
Juan Carlos Samarrina Perez	Coordinator of Environmental Fulfillment	Control and Management of Solid Waste
Teresa Gonzalez Rodriguez	Environmental Director	Improvement and Environmental Assessment
J. Refugio	Information Chief	El Heraldo
Lorena Perez		Televisa
Noe Garcia		A.M.
Fernando Avila Gonzalez	Advisor	H. Town Hall
Luis Efren Ramos		Tv4
Estefania Flores		Tv4
Maria Elena Duran Padilla	General Coordinator	Public Security of Civil Protection
Andres Contreras S	Director of the Industrial Engineering Faculty	Leon University
Karla Gonzalez De La Mora		PA Y DS

Name	Charge	Company/Institution
Martha Alicia Perez	Coordinator	UNIVA
J. Jesus Gaytan F	Director of Civil Engineering	Leon University
Juan Antonio R		Monterrey Technician
Santiago Vargas	Director of Environmental Regulation and Verification	PA Y DS
Valeria Vivero	Support of Technical Direction	SEDESU
Jose De Jesus Vazquez G	Representative of Lagunillas Community	
Jose Alejandro Martinez P		PA Y DS
Ricardo Froylan Garcia B	Enlace De La Juventud	Angel A. C. Group
Fabiola Moreno Villegas		Environmental Education
Ivonne Garcia Lira	Coordinator of Sustainable Education Institutions	Environmental Education, Environmental Secretariat
Jesus Montoya		A.M.
Ricardo Ramirez H	Promoter	Environmental Education
Angelica Ramos		
Federico Pimentel	General Coordinator of Environemtal Management	PA, León Guanajuato Municipality
Hector Nava M	Projects Coordinator	S.O.P
Simon Pablo Gonzalez	Technical Secretary	General Director of Environmental Protection
R. Barrera		Televisa
Elba Valdivia	Chief of Environmental Assessment	Improvement and Environmental Impact, Environmental Protection
Salvador Lara Garcia	Coordinator of Emissions to Atmosphere	Improvement and Environmental Impact
Luis Miguel Lopez		Newspaper A.M.
Carlos Magdaleno	Director	NAFINSA
Fernando Araiza M	Public Coordinator	Angel A.C., Clase Ciudadana AC
Paulina Ramirez	Reporter	Multimedios TV
Alberto Gonzalez	Camera Man of Newscast	Multimedios
Gabriel Villagrana Garcia	Advisor	H. Town Hall
Jose Eleazar Lopez	General Director	Sedesu
Sergio Navarro	Advisor	H. Town Hall
Juan Jose Medina	Director of Municipal Education Development	Secretary of Education, Culture and Sports
Monserrat Castañeda	Reporter	AM newspaper

Support material:

- PowerPoint presentation of the project
- Brochure with the Executive Summary of the project
- Invitations

During the meeting, questionnaires were distributed to the people in order to stimulate comments on the project.

PROMOTORA AMBIENTAL	El Verde Landfill Gas Recovery Project	mgm INTERNATIONAL

YOUR OPINION IS IMPORTANT TO US

Please, answer the following questions and include all the pertinent comments in the columns on the right.	
Question	**Answer/Comment/Opinion**
With reference to climate change, the Kyoto Protocol and the Clean Development Mechanism, briefly express your opinion on the "El Verde Landfill Gas Recovery Project".	
Would you recommend private companies, government authorities and other organizations to develop projects of this nature: the capture and flaring and/or use of landfill gas as a contribution to the sustainable development?	
Do you believe "El Verde Landfill Gas Recovery Project" will contribute to the social, economic and environmental development (Sustainable Development) of the region and Mexico?	
Are there any additional comments you would like to make?	
Please, write your personal data: o Name and Last name: o Institution/Organization that you represent: o Position: o E-mail: o Telephone: Signature:	

Please, return this survey at the end of the meeting or send it back to the following addresses. Do not hesitate to consult us if you have any doubts. Thank you very much.

PROMOTORA AMBIENTAL S.A.
Julio César Martínez
jrodriguez@gen.tv
Fax:

MGM INTERNATIONAL
Casiopea Ramírez
cramirez@mgminter.com
Fax: (55) 2454.9139

PASA
Blvd. Antonio L. Rodríguez
1884 Torre 1 Piso 8 y 9
Col. Santa María
Monterrey, N.L.
Tel. (81) 8122-7600
www.gen.tv

MGM INTERNATIONAL
Ometusco 7, piso 6,
Col. Hipódromo-Condesa.
México D.F.
Tel: (55) 2454.9136 al 38
E-mail: cramirez@mgminter.com
www.mgminter.com

E.2. Summary of the comments received:

In general, the comments obtained regarding to the project presentation were positive. Some remarkable aspects mentioned were the contribution of this type of projects for improving waste management and reducing odours, benefiting the surrounding communities. Most of the participants expressed their interest in replicating these greenhouse gas emission reduction projects in Mexico and to receive more information about projects that reduce GHG emissions. The project contribution to greenhouse gases mitigations was clearly understood.

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

During the questions and answers session in the event held, participants expressed concern about several issues. Below we provide a list of the questions raised and answers given by PASA's representatives:

Q.- For how long will the landfill continue to produce gas using the waste that already exists?
A.- Maximum gas production is reached during the first 3 or 4 years after a cell is closed. Since this landfill is currently operating, it is estimated that it will continue to produce good levels for 15 to 20 years.

Q.- What will happen as a result of the law that obliges the administration of the León Municipality to manage separated wastes?
A.- The specific conditions for this type of projects do not exist here, due to the education level of people and the lack of infrastructure. The important thing about this project is that no gases will be released as in the current scenario; however, the Municipality needs private funds to finance this initiative.

Q.- Is it worth to spend millions to flare the gas or is it better to focus economic efforts on generating a model for the management of organic waste?
A.- The project focuses on the existing scenario; the problem is that the management of organic waste costs about 5-10 times more. In Mexico, the organizations do not have an incentive to pay this cost right now to not pay it in the future; the simplest thing to do, in the next 5 years, is to continue with the current method to collect waste and to maintain it in the landfill. The conversion of the system is good from the environmental point of view, but it involves a risk for PASA's business. The Kyoto Protocol will remain valid for another 5 years, so the project will be covered for that period.

Q.- If there exist previous studies, why not invest in electric generation from the beginning?
A.- Although there are studies, it is necessary to analyze wells and monitor the gas to be sure about the measurements; generally, the EPA models are used, but the Protocol says that measurements must be carried out.

Q.- If Mexico is obliged to reduce emissions in 2012, how will the market be managed?
A.- This issue is being currently discussed since Mexico contributes with very low emissions. The United Nations program related to Latin America and the Caribbean is focused on stopping deforestation and involves a voluntary carbon market. Probably, a similar mechanism will continue to operate.

Q.- What do gas flares generate?
A.- They do not generate electricity, only Carbon Credits. It is just a very efficient monitored flaring.

Q.- Does PASA have agreements with universities for the investigation of Bioenergy generation?
A.- Yes, PASA has an agreement with the Universidad de Nuevo León and the Fundación Mundo Sustentable (Sustainable World Foundation) will develop a course on climate change with an area of investigation.

Q.- Can a pilot compost project be implemented per colony in order to not spend so much money?
A.- A compost project per colony (neighborhood) is not recommended, it is better to transport the already separated waste to a single location. Currently, León already has separation programs and education is being provided in schools and colonies. Leon is now interested in making the most of waste. In the Mochis, PASA has an integral service where it collects municipal waste and transports it to a separation plant, where compost is produced and commercialized.

Annex 1

CONTACT INFORMATION ON PARTICIPANTS IN THE PROJECT ACTIVITY

Organization:	Promotora Ambiental S.A.B. de C.V.
Street/P.O.Box:	Av. Transportistas, 390
Building:	
City:	León
State/Region:	Guanajuato
Postfix/ZIP:	37140
Country:	Mexico
Telephone:	52 477 2114900
FAX:	52 477 2114902
E-Mail:	
URL:	http://www.gen.tv/
Represented by:	
Title:	Manager of Research and Development
Salutation:	Dr.
Last Name:	Munoz
Middle Name:	Martinez
First Name:	Alfonso
Department:	R&D
Mobile:	8115313173
Direct FAX:	52 8183227600 ext. 194
Direct tel:	52 81227600 ext. 316
Personal E-Mail:	amartinezm@gen.tv

Organization:	MGM Carbon Portfolio, S.a.r.l
Street/P.O.Box:	121, Avenue de la Faïencerie, L-15511
Building:	-
City:	-
State/Region:	-
Postfix/ZIP:	-
Country:	Luxemburg
Telephone:	-
FAX:	-
E-Mail:	-
URL:	-
Represented by:	Ivana Cepon
Title:	Business Developer Manager
Salutation:	Mrs.
Last Name:	Cepon
Middle Name:	-
First Name:	Ivana
Department:	-
Mobile:	54.9.11.5509.1592
Direct FAX:	+1.305.675.0968
Direct tel:	+ 54.11.5219.1230
Personal E-Mail:	icepon@mgminter.com

Annex 2

INFORMATION REGARDING PUBLIC FUNDING

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

Annex 3

BASELINE INFORMATION

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

The Annex contains two items:

1. A derivation of the parameters used to estimate landfill gas generation from solid waste using the *"tool to determine methane emissions from dumping waste at a solid waste disposal site"* from Executive Board 35th Meeting Report, Annex 10. Version 1 of the Tool was used in this PDD. These parameters are only used in the ex-ante estimation of emissions reductions; and
2. A calculation of the emissions factor for power generation in the interconnected power grid in Mexico, using the "*tool to calculate the emission factor for an electricity system*", from Executive Board 35th Meeting Report, Annex 12. Version 1 of the Tool was used here.

Methane emissions reductions from landfill gas capture

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

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

The k-parameters needed as input in the "tool to determine methane emissions…" model are based on IPCC recommendations (2006 IPCC Guidelines for National Greenhouse Gas Inventories, Vol. 5). The tool is described in detail below.

The tool states:
"The amount of methane that would in the absence of the project activity be generated from disposal of waste at the solid waste disposal site ($BE_{CH4,SWDS,y}$) is calculated with a multi-phase model. The calculation is based on a first order decay (FOD) model. The model differentiates between the different types of waste j with respectively different decay rates k_j and different fractions of degradable organic carbon (DOC_j). The model calculates the methane generation based on the actual waste streams $W_{j,x}$ disposed in each year x, starting with the first year after the start of the project activity until the until end of year y, for which baseline emissions are calculated (years x with x=1 to x=y)."

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

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

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)
□	=	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
GWP_{CH4}	=	Global Warming Potential (GWP) of methane, valid for the relevant commitment period
OX	=	Oxidation factor (reflecting the amount of methane from SWDS that is oxidised in the soil or other material covering 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 or organic waste type j prevented from disposal in the SWDS in the year x (tonnes)
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 emissions are calculated (x=y)] Note: this definition represents a correction of the Tool as given in ACM0001, ver. 8.
y	=	Year for which methane emissions are calculated

The tool used is usually for project activities that would avoid methane avoiding waste disposal at landfills. But in the same way, the methane generation can be estimated for landfills, only taking into account different years: the first year is the year of landfill opening and the last year is the last year of the project activity.

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

The value choice for each variable according to the tool recommendations are the following:

Table 3.1: *Variables and values chosen for methane generation El Verde Landfill Gas Project*

<table>
<tr><th>Variable</th><th>Value</th><th>Justification</th></tr>
<tr><td>φ</td><td>0.9</td><td>Default value recommended in methodology is used here.</td></tr>
<tr><td>f</td><td>50%</td><td>Conservative value according to observation to other landfills with active LFG extraction systems in place.</td></tr>
<tr><td>GWP_{CH4}</td><td>21</td><td>Global Warming Potential (GWP) of methane, valid for the first commitment period of the Kyoto Protocol (up to 2012).</td></tr>
<tr><td>OX</td><td>0</td><td>Oxidation factor in a well managed landfill with a good cover is not considerable and can be estimated as zero.</td></tr>
<tr><td>F</td><td>0.5</td><td>Most waste in SWDS generates a gas with approximately 50 percent of CH_4. Only material including substantial amounts of fat or oil can generate gas with substantially more than 50 percent of CH_4. Taking into account the IPCC default value, MGM estimates future methane content in landfill gas to be 50 percent.</td></tr>
<tr><td>DOC_f</td><td>0.5</td><td>The decomposition of degradable organic carbon does not occur completely and some of the potentially degradable material always remains in the site even over a very long period of time. IPCC recommends that values should vary from 0.5 to 0.77. Default value recommended in methodology is used here.</td></tr>
<tr><td>MCF</td><td>1.0</td><td>El Verde landfill is very well managed, with daily cover with soil, leachate drainage system and waste thickness is higher than 5 meters. The value is chosen according to IPCC table, cited in methodology:
<table>
<tr><th>MCF value</th><th>Type of site</th></tr>
<tr><td>1.0</td><td>For anaerobic managed solid waste disposal sites. These must have controlled placement of waste (i.e., waste directed to specific deposition areas, a degree of control of scavenging and a degree of control of fires) and will include at least one of the following: (i) cover material; (ii) mechanical compacting; or (iii) levelling of the waste.</td></tr>
<tr><td>0.5</td><td>For semi-aerobic managed solid waste disposal sites. These must have controlled placement of waste and will include all of the following structures for introducing air to waste layer: (i)</td></tr>
</table>
</td></tr>
</table>

<table>
<tr>
<td></td>
<td></td>
<td>
<table>
<tr><td></td><td>permeable cover material; (ii) leachate drainage system; (iii) regulating poundage; and (iv) gas ventilation system.</td></tr>
<tr><td>0.8</td><td>For unmanaged solid waste disposal sites – deep and/or with high water table. This comprises all SWDS not meeting the criteria of managed SWDS and which have depths of greater than or equal to 5 meters and/or high water table at near ground level. Latter situation corresponds to filling inland water, such as pond, river or wetland, by waste.</td></tr>
<tr><td>0.4</td><td>For unmanaged-shallow solid waste disposal sites. This comprises all SWDS not meeting the criteria of managed SWDS and which have depths of less than 5 metres.</td></tr>
</table>
</td>
</tr>
<tr>
<td>$W_{j,x}$</td>
<td>
<table>
<tr><th>Year</th><th>Waste input in El Verde Landfill (tonnes)</th></tr>
<tr><td>2001</td><td>279,091</td></tr>
<tr><td>2002</td><td>464,012</td></tr>
<tr><td>2003</td><td>448,379</td></tr>
<tr><td>2004</td><td>481,084</td></tr>
<tr><td>2005</td><td>474,761</td></tr>
<tr><td>2006</td><td>443,274</td></tr>
<tr><td>2007</td><td>474,303</td></tr>
<tr><td>2008</td><td>507,504</td></tr>
<tr><td>2009</td><td>543,030</td></tr>
<tr><td>2010</td><td>581,042</td></tr>
<tr><td>2011</td><td>621,715</td></tr>
<tr><td>2012</td><td>665,235</td></tr>
<tr><td>2013</td><td>711,801</td></tr>
<tr><td>2014</td><td>761,627</td></tr>
<tr><td>2015</td><td>814,941</td></tr>
<tr><td>2016</td><td>363,328</td></tr>
</table>
</td>
<td>The historical and projected future filling rates were provided by landfill personnel. The landfill is projected to close in 2016, at which time it will have reached a capacity of approximately 8.6 million tonnes.</td>
</tr>
</table>

<table>
<tr><td>DOC_j</td><td>
<table>
<tr><th>Waste type j</th><th>DOCj (% wet waste)</th><th>Fraction of Waste Type j</th></tr>
<tr><td>A. Wood and Wood Products</td><td>43%</td><td>0.67%</td></tr>
<tr><td>B. Pulp, Paper & Cardboard (other than sludge)</td><td>40%</td><td>18.11%</td></tr>
<tr><td>C. Food, Food Waste, Beverages & Tobacco (other than sludge)</td><td>15%</td><td>37.44%</td></tr>
<tr><td>D. Textile</td><td>24%</td><td>2.62%</td></tr>
<tr><td>E. Garden, Yard & Park Waste</td><td>20%</td><td>7.54%</td></tr>
<tr><td>F. Leather and Rubber (other than natural rubber)</td><td>39%</td><td>0.61%</td></tr>
<tr><td>G. Nappies (disposable diapers)</td><td>24%</td><td>8.20%*</td></tr>
<tr><td>H. Sludge</td><td>9%</td><td>0.00%</td></tr>
<tr><td>TOTAL</td><td></td><td>75.19%</td></tr>
</table>
</td><td>Waste composition in El Verde Landfill.
*Due to the high content of nappies in the waste composition and due to the fact that nappies have a significant content of plastics, in order to maintain the conservative approach of the estimations, the content of nappies was reduced by half (4.10%).</td></tr>
<tr><td>k_j</td><td>
<table>
<tr><th>Type of k</th><th>Value</th></tr>
<tr><td>Slow k1 - Pulp, Paper, Cardboard / Textiles</td><td>0,060</td></tr>
<tr><td>Slow k2 - Wood & Straw</td><td>0,035</td></tr>
<tr><td>Medium k3 - Garden & Park / Other Organics</td><td>0,100</td></tr>
<tr><td>Fast k4 - Food waste/sewage sludge</td><td>0,185</td></tr>
</table>
</td><td>Value according to IPCC (2006) Waste section, table 3.3</td></tr>
<tr><td>j</td><td>According to IPCC recommendations and for the categories in DOC_j</td><td></td></tr>
<tr><td>x</td><td>2001</td><td>Start of landfill operations</td></tr>
<tr><td>y</td><td>2008 - 2015</td><td>Year for which methane emissions are calculated for first crediting period.</td></tr>
</table>

Emission Factor for Electricity Generation in the Mexican Grid (EF_{grid})

ACM0001 ver.8 recommends calculating the grid emission factor using the *"Tool to calculate the emission factor for an electricity system"*.

The tool states that: *"This methodological tool determines the CO_2 emission factor for the displacement of electricity generated by power plants in an electricity system, by calculating the "combined margin" (CM). The operating margin refers to a cohort of power plants that reflect the existing power plants whose electricity generation would be affected by the proposed CDM project activity. The building margin refers to a cohort of power units that reflect the type of power units whose construction would be affected by the proposed CDM project activity."*

Moreover:

'This tool may be referred to in order to estimate the OM, BM and/or CM for the purpose of calculating baseline emissions for a project activity substitutes electricity from the grid, i.e., where a project activity supplies electricity to a grid or a project activity that results in saving of electricity that would have been provided by the grid (e.g. demand-side energy efficiency projects). Note that this tool is also referred (…) for the purpose of calculating project and leakage emissions in case where a project activity consumes electricity from the grid or results in increase of consumption of electricity from the grid outside the project boundary".

Hence, the combined margin calculated with this tool will be used for two cases: when El Verde Landfill Project is consuming energy from the grid in order to meet project energy demand and/or when the electricity generated with LFG is supplied to the grid and emission reductions will be claimed for energy displacement.

In order to calculate the emission factor so-called "combined margin", the tool establishes the following six steps:

STEP 1. Identify the relevant electric power system.
STEP 2. Select an operating margin (OM) method.
STEP 3. Calculate the operating margin emission factor according to the selected method.
STEP 4. Identify the cohort of power unites to be included in the build margin (BM).
STEP 5. Calculate the build margin emission factor.
STEP 6. Calculate the combined margin (CM) emission factor.

STEP 1. Identify the relevant electric power system.

The grid emission factor is calculated based on data provided by the CFE and in the last versions of the "Electricity Sector Prospective" developed by the Mexican Secretary of Energy (SENER) [15].

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[15] http://www.energia.gob.mx/

The geographic and system boundaries include all the geographic area and infrastructures within the whole territory of Mexico, taking into account the energy exports and imports outside the Mexican energy system.

STEP 2. Select an operating margin (OM) method.

Four different procedures are indicated for determining the operating margin emission factor ($EF_{grid,OM,y}$). These are denominated:

(a) Simple Operating Margin.
(b) Simple Adjusted Operating Margin.
(c) Dispatch Data Analysis Operating Margin.
(d) Average Operating Margin.

According to the tool, the Dispatch Data Analysis method should be the choice considered, but this method cannot be used for this project activity due to the hourly-based dispatch order generation is not publicly available.

The tool also states that the Simple Operating Margin method can only be used where 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 normals for hydroelectricity production.

The tool further states that low operating cost and must run resources typically include hydro, geothermal, wind, low-cost biomass, nuclear, and solar generation. If coal is obviously used as must-run, it should also be included in this list, i.e. excluded from the set of plants.

Electricity generation in Mexico is dominated by thermal power plants. Thus, for this project activity, in the calculation of the operating margin emission factor, the Simple Operating Margin method has been selected from the four options proposed in the methodology. The following table shows that the low-cost/must run resources in Mexico constitute less than 50% of the total grid generation in average of the five most recent years.

Table 3.2: *Power generation in Mexico*[16]

Type	Low cost or must run	2001	2002	2003	2004	2005
Residual fuel oil and/or gas	no	90,395	79,300	73,743	66,334	65,077
Dual	no	14,109	13,879	13,859	7,915	14,275
Combined cycle	no	25,377	44,765	55,047	72,267	73,381
Gas turbine	no	5,456	6,394	6,933	2,772	1,358
Internal combustion	no	467	555	751	610	780
Hydroelectric	yes	28,435	24,862	19,753	25,076	27,611
Coal	no	18,567	16,152	16,681	17,883	18,380

[16] Source: Electricity Sector Prospective 2006-2015, Page 65, Table 16.

Nuclear	yes	8,726	9,747	10,502	9,194	10,805
Geothermal	yes	5,567	5,398	6,282	6,577	7,299
Wind	yes	7	7	5	6	5

Table 3.3: *Low cost/must run generation percentage in the total electricity generation in Mexico*

	2001	2002	2003	2004	2005	
Total generation (GWh)	197,106	201,059	203,556	208,634	218,971	
Low cost/must run generation (GWh)	42,735	40,014	36,542	40,853	45,720	
Low cost/must run generation (%)	21.68%	19.90%	17.95%	19.58%	20.88%	**< 50%**

As shown above, the average low-cost/must run generation in the last five years is below 50%. Coal is not included under the low-cost/must run category, but even adding coal generation to it, it would be always lower than 50%.

The tool states that the operating margin emission factor can be calculated using one of the following data vintages:

- *Ex ante option: A 3-year generation-weighted average, based on the most recent data available at the time of submission of the CDM-PDD to the DOE for validation, without requirement to monitor and recalculate the emissions factors during the crediting period, or*
- *Ex-post option: The year in which project activity displaces grid electricity, requiring the emissions factor to be updated annually during monitoring. If the data required to calculate the emission factor for year y is usually only available later than six months after the end of year y, alternatively the emission factor of the previous year (y-1) may be used. If the data is usually only available 18 months after the end of year y, the emission factor of the year proceeding the previous year (y-2) may be used. The same data vintage (y, y-1 or y-2) should be used throughout all crediting periods.*

In this particular PDD, the first, ex-ante option is selected. As a consequence, the operating margin emission factor is calculated ex-ante and it is considered fixed for the first crediting period.

STEP 3. Calculate the operating margin emission factor according to the selected method.

As shown in STEP 2, the operating margin calculation method chosen was Simple OM (method a).

For calculating the operating margin emission factor, the generation-weighted average CO_2 emissions per unit net electricity generation (tCO_2/MWh) of all generating power plants serving the system excluding the low-cost/must run generation units is considered.

Also, the tool gives three different options to calculate OM emission factor, as follows:

- Option A. Based on data fuel consumption and net electricity generation of each power plant / unit.

- Option B. Based on data on net electricity generation, the average efficiency of each power unit and the fuel type(s) used in each power unit or
- Option C. Based on data on the total net electricity generation of all power plants serving the system and the fuel consumption of the project electricity system.

Here we chose Option C. The OM emission factor is given by the formula:

$$EF_{grid,OMsimple,y} = \frac{\sum_i FC_{i,y} \times NCV_{i,y} \times EF_{CO_2,i,y}}{EG_y}$$

Where:

$EF_{grid,OMsimple,}$	=	Simple operating margin CO_2 emission factor in year *y* (tCO_2/MWh)
$FE_{i,y}$	=	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 / unit, in year *y* (MWh)
i	=	All fossil fuel types combusted in power plant / unit *m* in year *y*
y	=	Either the three most recent years for which data is available at the time of submission of the CDM-PDD to the DOE for validation (ex-ante option) or the applicable year during monitoring (ex-post option), following the guidance on data vintage step 2

For determining the operating margin emission factor, it is necessary to determine the electricity imports. The Mexican electricity imports and exports with other electric systems are the following:

Table 3.4: *Electricity exportation and importation[17] (GWh)*

Year	2002	2003	2004	2005
Imports (from USA)	531	71	47	87
Exports (to Belize and USA)	344	953	1,006	1,006
Net exchange	**-187**	**882**	**959**	**1,204**

Electricity exports are not subtracted from electricity generation data used for calculating the grid emission factor.

There are no imports from other systems inside Mexico. For imports from connected electricity system located in another country, the emission factor is 0 tCO_2/MWh.

[17] Source: Electricity Sector Prospective 2006-2015, Page 55, Table 12.

Thus, the total generation of electricity considered in calculation of the operating margin emission factor results to be:

Table 3.5: *Electricity generation for OM emission factor calculation (GWh)*

Year	2003	2004	2005
Total generation	203,556	208,634	218,971
Low cost/must run generation	36,542	40,853	45,720
Imports	71	47	87
Electricity generation for OM (Σ_j GEN_j)	**167,085**	**167,828**	**173,338**

Data for fuel consumption is found in TJ/day in the "Electricity Sector Prospective". Thus, the total annual consumption per fuel source is calculated multiplying times 365 (days per year). The values are summarized in the following table:

Table 3.6: *Fossil fuel consumption for power generation*[18]

Fuel	2003		2004		2005	
	TJ/day	%	TJ/day	%	TJ/day	%
Residual fuel oil	1,859	42.2	1,732	41.1	1,711	39.1
Natural gas	1,630	37.0	1,795	42.6	1,733	39.6
Diesel	70	1.6	42	1.0	39	0.9
Coal	846	19.2	645	15.3	893	20.4
Total	**4,406**		**4,213**		**4,377**	

2006 IPCC Guidelines for National Greenhouse Gas Inventories provide values of carbon emissions from fuel combustion in terms of tonnes of C per TJ. Considering a factor of (44/12) to convert from C to CO_2 and the fraction of carbon oxidized ratio, also taken from IPCC, the CO_2 emissions corresponding to fuel consumption in Mexico's power sector in year 2003 to 2005 can be estimated.

The CO_2 emission coefficient of each fuel is obtained as shown in the table below:

Table 3.7: *CO_2 emission coefficient of each fuel*

Fuel	CO_2 emission factor[19] (tCO_2/TJ)	Oxidation factor[20]	CO_2 emission coefficient (tCO_2/TJ)
Residual fuel oil	77.40	0.990	76.63
Natural gas	56.10	0.995	55.82
Diesel	74.10	0.990	73.36
Coal	94.60	0.980	92.71

[18] Source: Electricity Sector Prospective 2006-2015, Page 90, Graphic 31. Electricity Sector Prospective 2005-2014, Page 82, Graphic 30. Electricity Sector Prospective 2004-2013, Page 72, Graphic 22.

[19] 2006 IPCC Guidelines for National Greenhouse Gas Inventories, Chapter 1, Table 1.4, Pages 1.23 and 1.24.

[20] 2006 IPCC Guidelines for National Greenhouse Gas Inventories.

Thus, total CO_2 emissions from fuel combustion by the power plants, excluding low-operating cost and must-run power plants, are shown in the following table:

Table 3.8: *Total CO_2 emissions*

Fuel	**CO_2 emission coefficient (tCO_2/TJ)**	**2003**		**2004**		**2005**	
		Fuel consumption (TJ/day)	**CO_2 emissions (tCO_2)**	**Fuel consumption (TJ/day)**	**CO_2 emissions (tCO_2)**	**Fuel consumption (TJ/day)**	**CO_2 emissions (tCO_2)**
Residual fuel oil	76.63	1,859	142,455	1,732	132,723	1,711	131,138
Natural gas	55.82	1,630	90,987	1,795	100,197	1,733	96,751
Diesel	73.36	70	5,135	42	3,081	39	2,890
Coal	92.71	846	78,433	645	59,798	893	82,780
Total CO_2 emissions ($\Sigma_i FC_{i,y} \times NCV_{i,y} \times EF_{CO2,i,y}$) x 365			**115,730,285**		**107,966,682**		**114,449,149**

Thus, the operating margin emission factor results to be:

Table 3.9: *Operating margin emission factor*

Year	**2003**	**2004**	**2005**
Total CO_2 emissions (tCO_2/year) $\Sigma_i FC_{i,y} \times NCV_{i,y} \times EF_{CO2,i,y}$	115,730,285	107,966,682	114,449,149
Electricity generation for OM (GWh/year) EG_y	167,085	167,828	173,338
OM emission factor (tCO_2/MWh)	**0.6926**	**0.6431**	**0.6603**
Average OM emission factor (tCO_2/MWh)	**0.6653**		

From the above table, the figure for the operating margin emission factor is obtained as 0.6653 tCO_2/MWh.

STEP 4. Identify the cohort of power units to be included in the build margin.

For the purpose of determining the build margin emission factor, the spatial extent is limited to the project electricity system, since the plans of transmission line construction for the next years to increase the electricity export capacity are very low and there are no plans to build any transmission line to Belize. For imports from the connected electricity system located in USA, the emission factor is 0 tCO_2/MWh. Furthermore, since 1998, the trend in Mexico is to reduce electricity imports.
According to the methodology, the build margin emission factor can be calculated using one of the following options:

- *Option 1: For the first crediting period, calculate the build margin emission factor ex-ante based on the most recent information available on units already built for sample group m at the time of CDM-PDD submission to the DOE for validation. For the second crediting period, the build* *margin emission factor should be updated based on the most recent information available on units already built at the time of submission of the requested for renewal of the crediting period to the DOE. For the third crediting period, the build margin emission factor calculated for the second crediting period should be used. This option does not require monitoring the emissions factor during the crediting period.*

- *Option 2: for the first crediting period, the build margin emission factor shall be updated annually, ex-post, including those units built up to the year of registration of the project activity or, if information up to the year of registration is not available, including those units built up to the latest year for which information is available. For the second crediting period, the build margin emission factor shall be calculated ex-ante, as described in Option 1 above. For the third crediting period, the build margin emission factor calculated for the second crediting period should be used.*

In this particular case, the most recent data available would correspond to one or two years prior to the year in which project generation occurs, thus the Option 1 is selected among the two options proposed by the methodology. As a consequence, the build margin emission factor is calculated *ex-ante* and it is considered fixed along the first crediting period.

The sample group *m* consists of either:

(a) The five power plants that have been built most recently, or

(b) The power plants capacity additions in the electricity system that comprise 20% of the system generation (in MWh) and that have been built most recently.

According to the methodology, from these two options, the sample group that comprises the larger annual generation should be used. As shown in the table below, the larger annual generation corresponds to the most recently built power plants capacity additions that comprise 20% of the system generation. The 20% of the system generation during 2005 results to be 0.20 × 218,971,000 MWh = 43,794,200 MWh.

Table 3.10: *New power plants installed*[21]

Year	Central	Capacity (MW)	Technology	Power generation (MWh/year)	Accumulated power generation (MWh/year)

[21] Source: Electricity Sector Prospective 2006-2015, Page 57, Table 13; Page 126, Table 4; Electricity Sector Prospective 2005-2014, Page 51, Table 14. Electricity Sector Prospective 2004-2013, Page 44, Table 9. Electricity Sector Prospective 2003-2012, Page 41, Table 8.

CC = Combined cycle; GT = Gas turbine; IC= Internal combustion; HYD = Hydroelectric; GEO = Geothermal

Year	Central	Capacity (MW)	Technology	Power generation (MWh/year)	Accumulated power generation (MWh/year)
2005	Holbox [22]	0.80	IC	1,230	1,230
	La Laguna II (PIE)	498.00	CC	2,754,000	2,755,230
	Río Bravo IV (PIE)	500.00	CC	1,885,000	4,640,230
	Botello[16]	9.00	HYD	39,999	4,680,229
	Baja California Sur I	42.90	IC	121,000	4,801,229
	Yécora [16]	0.70	IC	404	4,801,633
	Ixtaczoquitlán [16]	1.60	HYD	3,269	4,804,902
	Hermosillo	93.30	CC	68,420	4,873,322
2004	Chicoasén (Manuel Moreno Torres)	900.00	HYD	2,078,625	6,951,947
	Rio Bravo III (PIE)	495.00	CC	1,717,000	8,668,947
	San Lorenzo Potencia [16, 23]	266.00	GT		8,668,947
	Tuxpan (Pdte. Adolfo López Mateos)	163.00	GT	906,764	9,575,711
	El Sauz	128.00	CC	680,040	10,255,751
	Guerrero Negro II [16, 17]	10.80	IC		10,255,751
2003	Altamira III y IV (PIE)	1,036.00	CC	5,932,000	16,187,751
	Tuxpan III y IV (PIE)	983.00	CC	5,464,000	21,651,751
	Mexicali (PIE)	489.00	CC	2,191,000	23,842,751
	Transalta Chihuahua III (PIE)	259.00	CC	1,100,000	24,942,751
	Naco Nogales (PIE)	258.00	CC	1,819,000	26,761,751
	Transalta Campeche (PIE)	252.40	CC	1,782,000	28,543,751
	Los Azufres	79.80	GEO	608,580	29,152,331
	Los Azufres	26.80	GEO	204,385	29,356,716
2002	Río Bravo II (PIE)	495.00	CC	2,279,000	31,635,716
	Monterrey III (PIE)	449.00	CC	3,147,000	34,782,716
	Bajio (PIE)	591.70	CC	4,698,000	39,480,716
	Altamira II (PIE)	495.00	CC	3,083,000	42,563,716
	Valle de Mexico	249.30	CC	1,091,691	43,655,407
	El Encino	130.80	CC	720,817	44,376,224
	El Sauz	129.00	CC	685,353	45,061,576

[22] These power plants are not included in Electricity Sector Prospective 2006-2015, Page 126, Table 4. Thus, the technology and the power generation are obtained as follows:
- Technology: Electricity Sector Prospective 2006-2015, Page 57, Table 13. Electricity Sector Prospective 2005-2014, Page 51, Table 14. Electricity Sector Prospective 2004-2013, Page 44, Table 9. Electricity Sector Prospective 2003-2012, Page 41, Table 8.
- Power generation: data provided by CFE.

[23] There are no power generation data available for these power plants. However, since these have the least clean technologies (GT and IC), to not include these power plants in the build margin calculation is conservative.

In order to determine the fuel consumption of the sample group of power plants, the specific fuel consumption of each plant is estimated considering the most efficient factor of each technology provided in "Electricity Sector Prospective 2006-2015", as a conservative assumption.

STEP 5. Calculate the build margin emission factor

The build margin emission factor is calculated as the generation-weighted average emission factor (tCO_2/MWh) of a sample of power plants, calculated in a similar way as the operating margin.
The equation is given below:

$$EF_{grid,BM,y} = \frac{\sum_m EG_{m,y} \times EF_{EL,m,y}}{\sum_m EG_{m,y}}$$

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 ($FE_{EL,m,y}$) is determined according to what the tool recommends, i.e., *"as per guidance in step 3 (a) for the simple OM"*.

Finally, in order to calculate total CO_2 emissions from fuel combustion by the sample group of power plants, the CO_2 emission coefficients determined previously in Table 3.9 are used.

Fuel consumption of the sample group and the corresponding CO_2 emissions are calculated as shown below.

Table 3.11: *CO_2 emissions of the sample group of power plants*[24]

Year	Central [1]	Efficiency ($MWh_{electric}$ / MWh_{fuel})	Fuel consumption (TJ/year)	CO_2 emission coefficient (tCO_2/TJ)	CO_2 emissions (tCO_2)	Accumulated CO_2 emissions (tCO_2/year)
2005	Holbox [3]	0.4761	9	73.36	682	682
	La Laguna II (PIE)	0.5244	18,906	55.82	1,055,333	1,056,016
	Río Bravo IV (PIE)	0.5244	12,941	55.82	722,332	1,778,348

[24] Source: Electricity Sector Prospective 2006-2015, Page 102, Table 39.

	Botello [3]		0		0	1,778,348
	Baja California Sur I	0.4761	915	73.36	67,119	1,845,467
	Yécora [3]	0.4761	3	73.36	224	1,845,691
	Ixtaczoquitlán [3]		0		0	1,845,691
	Hermosillo	0.5244	470	55.82	26,219	1,871,909
2004	Chicoasén (Manuel Moreno Torres)		0		0	1,871,909
	Rio Bravo III (PIE)	0.5244	11,787	55.82	657,955	2,529,864
	San Lorenzo Potencia [3] [4]	0.3840	0	55.82	0	2,529,864
	Tuxpan (Pdte. Adolfo López Mateos)	0.3840	8,501	55.82	474,517	3,004,381
	El Sauz	0.5244	4,668	55.82	260,591	3,264,972
	Guerrero Negro II [3] [4]	0.4761	0	73.36	0	3,264,972
2003	Altamira III y IV (PIE)	0.5244	40,723	55.82	2,273,144	5,538,116
	Tuxpan III y IV (PIE)	0.5244	37,510	55.82	2,093,806	7,631,922
	Mexicali (PIE)	0.5244	15,041	55.82	839,592	8,471,514
	Transalta Chihuahua III (PIE)	0.5244	7,551	55.82	421,520	8,893,034
	Naco Nogales (PIE)	0.5244	12,487	55.82	697,041	9,590,075
	Transalta Campeche (PIE)	0.5244	12,233	55.82	682,863	10,272,938
	Los Azufres		0		0	10,272,938
	Los Azufres		0		0	10,272,938
2002	Río Bravo II (PIE)	0.5244	15,645	55.82	873,313	11,146,251
	Monterrey III (PIE)	0.5244	21,604	55.82	1,205,931	12,352,183
	Bajio (PIE)	0.5244	32,252	55.82	1,800,275	14,152,457
	Altamira II (PIE)	0.5244	21,165	55.82	1,181,406	15,333,864
	Valle de Mexico	0.5244	7,494	55.82	418,336	15,752,200
	El Encino	0.5244	4,948	55.82	276,217	16,028,417
	El Sauz	0.5244	4,705	55.82	262,627	16,291,044

Furthermore, the CO_2 emissions were calculated following exactly the same procedure as has been done in estimating operating margin emission factor, as follows:

Table 3.12: *Build margin emission factor*

Total CO_2 emissions (tCO_2) $\Sigma EG_{m,y} \times EF_{EL,m,y}$	16,028,417
Electricity generation for BM (MWh) $\Sigma EG_{m,y}$	44,376,224
BM emission factor (tCO_2/MWh)	**0.3612**

Thus, an estimate for the build margin emission factor would be 0.3612 tCO_2/MWh.

STEP 6. Calculate the combined margin emissions factor

In order to calculate the Combined Margin emission factor, the tool provides the following formula:

$$EF_{grid,CM,y} = EF_{grid,OM,y} \times w_{OM} + EF_{grid,BM,y} \times w_{BM}$$

The default values indicated to be used for w_{OM} and w_{BM} are:

- *Wind and solar power generation project activities: w_{OM} = 0.75 and w_{BM} = 0.25 (owing to their intermittent and non-dispachable nature) for the first crediting period and for subsequent crediting periods, or*
- *All other projects: w_{OM} = 0.5 and w_{BM} = 0.5 for the first crediting period, and : w_{OM} = 0.25 and w_{BM} = 0.75 for the second and third crediting period, unless otherwise specified in the approved methodology refers to this tool,*

According to the nature of the proposed project, the combined margin is calculated as follows:

$$EF_{grid,CM,y} = 0.6653 \times 0.5 + 0.3612 \times 0.5 = 0.5133 tCO_2 / MWh$$

Annex 4

MONITORING INFORMATION

Detailed information is in section B.7.