Project design document form
(Version 11.0)

BASIC INFORMATION	
Title of the project activity	Zone 3 Landfill Gas Project
Scale of the project activity	☒ Large-scale ☐ Small-scale
Version number of the PDD	4
Completion date of the PDD	09/12/2020
Project participants	Industrias de Biogás S.A. ALLCOT AG
Host Party	Guatemala
Applied methodologies and standardized baselines	ACM0001 ver. 13 - Flaring or use of landfill gas
Sectoral scopes	1: Energy industries 13: Waste handling and disposal
Estimated amount of annual average GHG emission reductions	167,210 metric tonnes CO2 equivalent per annum

SECTION A. Description of project activity

A.1. Purpose and general description of project activity

Description

The project activity will collect the landfill gas generated from 19 hectares of the site in areas that are accessible for the installation of the required equipment and will combust the gas in two state-of-the-art high temperature flares stack (1000ºC and 0.3 seconds retention time). The project will also utilize the landfill gas to generate electrical energy. The energy generated is intended to be sold under a power purchase agreement to the local distribution network.

The landfill is located in Zone 3 at the center of Guatemala City and is the primary location for disposal of municipal solid waste by the municipality of Guatemala and private individuals.

The site is located in a narrow gorge cut by the Barranca River and is now entirely encompassed by the growth of Guatemala City. One side of the site is low cost housing and the other is under development for industrial use. An older area of the site has been built with low cost housing and a school operated and funded by a non-governmental organization. A recycling center was constructed but its operation failed and the plant and machinery were removed from the site in 2005.

Purpose of the project activity

The project activity has the objective to capture, flare and generate electricity through the use of landfill gas (LFG) produced at Zone 3 Landfill site located in Guatemala City and hence, reduce GHG emissions at the site.

Baseline scenario

The site has been used for waste disposal and is projected to continue accepting waste in the future.

The current situation before the project implementation is the complete atmospheric release of landfill gas, as the site contains no control for capture of landfill gas. Hence, baseline scenario is the atmospheric release of the landfill gas and no use of the electricity is needed.

Greenhouse emissions reduction

The project is expected to reduce an annual average of 167,210 tCO_2 and a total of 1,170,468 tCO_2 for the first crediting period of 7 years, by reducing methane emissions in flares and electricity generators and by displacing of electricity generated by power plants connected the Guatemalan National Interconnected System (Sistema Nacional Interconectado or SIN).

Contribution to sustainable development

The project will contribute with the international efforts of climate change mitigation and will also have several positive social and environmental local impacts as the project will:

- capture and destroy a part of the landfill gas generated by the site improving the local and global environment,
- reduction of odors at the landfill site and nearby regions,
- contribute to the development of the area through the provision of electrical energy,
- create employment and develop local technical expertise,
- contribute financial and social benefits to the local population, and
- involve the local technical college and will serve as a technical demonstration of many engineering principles for the students. A financial contribution will be provided to local educational, health, environmental and small scale business development projects.

A.2. Location of project activity

The landfill is situated in Zone 3 of Guatemala City. The site is located in the Barranca Canyon which is bounded to the West by Zone 7 Colonia Landivar and to the East by Zone 3. The site is intersected by Calle 30 running between Zone 3 and Zone 7.

The waste disposal is currently progressing in a Northerly direction in the continuation of the Barranca Canyon. An old area of the landfill, to the South of Calle 30, has been developed with a mixture of commercial, industrial and residential property.

The site is located at 14.6247º and -90.5322º. The satellite image below shows the location of the site within Guatemala City:

A.3. Technologies/measures

The project activity consists in the installation of an active landfill gas collection and treatment system with energy recovery at Zone 3 Landfill site in Guatemala City.

The scenario prior to the start of the implementation of the project activity is the same as the baseline scenario: there is no existing landfill gas (LFG) capture system, no landfill gas is systematically treated or destroyed in the baseline scenario and no equipment for active gas collection or treatment is deployed.

The project activity will:

1) Capture landfill gas from the Zone 3 landfill site.
2) Use captured landfill gas to generate electricity that will be provided to the grid.
3) Oxidise methane not used for electricity generation to carbon dioxide by combustion with atmospheric oxygen in enclosed flare.

For an appropriate design, construction, installation, collection and operation of the LFG plant, it will be necessary to cover different settings to ensure the capture and flaring of the biogas generated and the electricity production. The installations of the LFG capture and collection and destruction system are composed by the following sub-systems:

- Collection: consists of a set of wells installed into the refuse, where the LFG is extracted from the inside.
- Extraction and piping: conformed by a network of pipes and equipment to extract the LFG to the power generation and/or to the flare units.
- Monitoring, analysis and cleaning of biogas: An automatic system assures a stable flow for the methane gas previous to be introduced to the power generation and/or to the flare units.
- Electricity production: Four engines are used for electricity generation, the first, with a capacity of 1,059 kW was installed on 22/03/2015 and the subsequent three engines, with a capacity of 1061 kW were installed at the project site on 02/06/2017. The electricity produced using the LFG recovered is used for project activity self-consumption purposes as well as for its selling to the local distribution network under a power purchase agreement.
  Flaring: Two high temperature enclosed flares stack (1,100°C and 0.3 seconds retention time, nominal flow of 400-2,000 Nmc/h LFG50) will be used in order to destroy the methane gas that is not sent to the power generation plant. Flare efficiency ($\eta_{flare,h}$) will be measured hourly as it is expected to have an average value of 99.9%. The project is currently operating with one flare and the installation of the second flare is expected during the year 2025.

The technology that will be implemented is environmentally safe and sound as it will prevent emissions to be released. The project will contribute to sustainable development, including technological and know- how transfer to the host party by means of employing local people during the construction and operation phases of the project, which will be adequately trained and will develop technical and practical knowledge that might be reproduced later on for other projects that will be taking place in the country.

A.4. Parties and project participants

Parties involved	Project participants	Indicate if the Party involved wishes to be considered as project participant (Yes/No)
Guatemala	Industrias de Biogás S.A.	Yes
Switzerland	ALLCOT AG	Yes

A.5. Public funding of project activity

There is no public funding involved in the proposed project activity.

A.6. History of project activity

Prior CDM consideration:

The project participants, during their decision to invest in the project, had seriously considered CDM benefits. In order to demonstrate the prior consideration of CDM, next is included a timetable indicating all the relevant information regarding the development of the project and the main events related to the CDM development (shown in bold font):

Milestones	Date
Pump-test	25/10/2005
SCS engineers "Report of the pump test and pre-feasibility study for landfill gas recovery and utilization at the el Trébol landfill [1], Guatemala"	December 2005
Start of stakeholders consultation process	**08/12/2006**
EIA approval	10/10/2007
Time of investment decision: Agreement for LFG extraction	21/12/2007
PDD public information in UNFCCC web	**15/05/2008**
Creation of Industrias del Biogás, S.A.society	26/08/2009
Withdrawal of Guatecarb as PP, communication to the Guatemalan DNA	**07/05/2010**
Purchase of Industrias del Biogás, S.A.by BBE (Borealia Biogas Energy)	04/10/2010
Contract between BBE/Industrias del Biogás, S.A. with consultant company for carrying out PDD revision and updating	**26/11/2010**
Contract BBE/Industrias del Biogás, S.A. with DOE for PDD validation	**13/01/2011**
Starting date: date when the contract of engineering works was signed	01/06/2011
Obtention of the environmental license	16/08/2011

[1] El Trebol is the Zone 3 landfill.

As per “Guidelines on the demonstration and assessment of prior consideration of the CDM” Version 04, prior consideration is demonstrated as the chronology of event, as set out in the previous table, clearly shows that real and continuing action to secure CDM status for the project activity was taken all over the project development.

Additionally:

- The proposed CDM project activity is neither registered as a CDM project activity nor included as a component project activity (CPA) in a registered CDM programme of activities (PoA);

- The proposed CDM project activity is not a project activity that has been deregistered.

- The proposed CDM project activity was not a CPA that has been excluded from a registered CDM PoA;

- A registered CDM project activity or a CPA under a registered CDM PoA whose crediting period has or has not expired does not exist in the same geographical location as the proposed CDM project activity.

A.7. Debundling

Not applicable.

SECTION B. Application of methodologies and standardized baselines

B.1. References to methodologies and standardized baselines

The baseline and monitoring methodology used for the proposed project activity is the approved consolidated baseline methodology ACM0001, version 13.0.0: "Flaring or use of landfill gas"[2].

Also the next methodological tools have been checked:

Methodological tools:

TOOL02: "Combined tool to identify the baseline scenario and demonstrate additionality"	version 05.0.0[3]
TOOL04: "Emissions from solid waste disposal sites"	version 06.0.1[4]
TOOL05: "Tool to calculate baseline, project and/or leakage emissions from electricity consumption"	version 01[5]
TOOL06: "Project emissions from flaring"	version 02.0.0[6]
TOOL07: "Tool to calculate the emission factor for an electricity system"	version 03.0.0[7]
TOOL08: "Tool to determine the mass flow of a greenhouse gas in a gaseous stream"	version 2.0.0[8]

B.2. Applicability of methodologies and standardized baselines

The selected methodology (ACM0001, version 13) is applicable to project activities which:

(a) ***"Install a new LFG capture system in a new or existing SWDS****; or*

(b) Make an investment into an existing LFG capture system to increase the recovery rate or change the use of the captured LFG, provided that:

(i) The captured LFG was vented or flared and not used prior to the implementation of the project activity; and
(ii) In the case of an existing active LFG capture system for which the amount of

[2] CDM link to the methodology ACM0001: https://cdm.unfccc.int/filestorage/E/Y/F/EYFHCV3K4J5P06DTQSG9WLMOBNUX2I/EB67_repan12_ACM0001_ver13.0.0.pdf?t=THB8cWZ6azFwfDDuUaU1iJiknUAeO-Brh_08

[3] CDM link to the TOOL02: https://cdm.unfccc.int/methodologies/PAmethodologies/tools/am-tool-02-v5.0.0.pdf

[4] CDM link to the TOOL04: https://cdm.unfccc.int/methodologies/PAmethodologies/tools/am-tool-04-v6.0.1.pdf

[5] CDM link to the TOOL05: https://cdm.unfccc.int/methodologies/PAmethodologies/tools/am-tool-05-v1.pdf

[6] CDM link to the TOOL06: https://cdm.unfccc.int/methodologies/PAmethodologies/tools/am-tool-06-v2.0.pdf

[7] CDM link to the TOOL07: https://cdm.unfccc.int/methodologies/PAmethodologies/tools/am-tool-07-v3.0.0.pdf

[8] CDM link to the TOOL08: https://cdm.unfccc.int/methodologies/PAmethodologies/tools/am-tool-08-v2.0.0.pdf

LFG cannot be collected separately from the project system after the implementation of the project activity and its efficiency is not impacted on by the project system: historical data on the amount of LFG capture and flared is available

(c) Flare the LFG and/or use the captured LFG in any (combination) of the following ways:

(i) Generating electricity;

(ii) Generating heat in a boiler, air heater or kiln (brick firing only) or glass melting furnace; and/or Supplying the LFG to consumers through a natural gas distribution network.

(d) Do not reduce the amount of organic waste that would be recycled in the absence of the project activity."

The proposed project activity involves the installation of a new LFG capture system in an existing SWDS (option a). Furthermore, it is intended to flare the LFG and/or use the captured LFG to generate electricity, which corresponds to option c, point (i). Also, it is not the purpose of this project to reduce the amount of organic waste that would be recycled in the absence of the project activity.

"The methodology is only applicable if the application of the procedure to identify the baseline scenario confirms that the most plausible baseline scenario is:

(a) Release of LFG from the SWDS*; and*

(b) In the case that the LFG is used in the project activity for generating electricity and/or generating heat in a boiler, air heater, glass melting furnace or kiln;

(i) For electricity generation: that electricity would be generated in the grid or in captive fossil fuel fired power plants; and/or
(ii) For heat generation: that heat would be generated using fossil fuels in equipment located within the project boundary."

The methodology is applicable because the most plausible baseline scenario is the release the LFG from the SWDS (option a) and, as the LFG is used in the project activity for generating electricity, the generation of electricity from the grid.

"This methodology is not applicable:

(a) In combination with other approved methodologies. For instance, ACM0001 cannot be used to claim emission reductions for the displacement of fossil fuels in a kiln or glass melting furnace, where the purpose of the CDM project activity is to implement energy efficiency measures at a kiln or glass melting furnace;

(b) If the management of the SWDS in the project activity is deliberately changed during the crediting in order to increase methane generation compared to the situation prior to the implementation of the project activity."

The methodology is not applied in combination with other approved methodologies and under the project activity management of the SWDS will not be changed from the situation prior to the implementation of the project activity in order to increase the methane generation. The

Zone 3 landfill will continue to receive and dispose of urban residual waste into dedicated and prepared cells and these practices will not be changed during the crediting period.

For all these reasons, the methodology ACM0001 is applicable to this project activity. The uses of the methodological tools required by ACM0001 are listed in chapter B.1. above included and used in this PDD.

B.3. Project boundary, sources and greenhouse gases (GHGs)

According to methodology ACM0001 version 13, the project boundary of the project activity shall include the site where the LFG is captured and, as applicable:

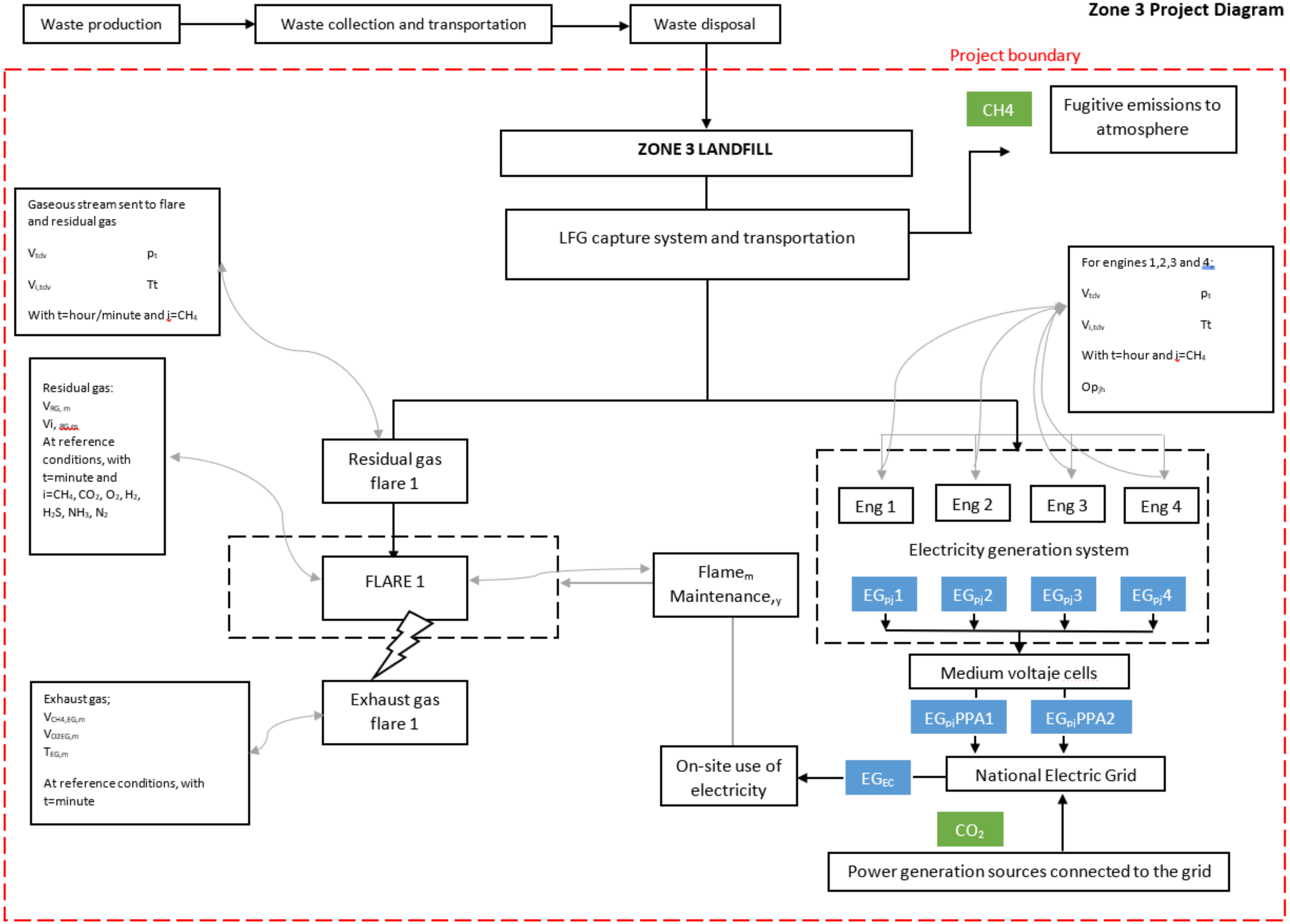
- Sites where the LFG is flared or used (in this case: flare and power plant);
- Power generation sources connected to the grid, which are supplying electricity to the project activity.

A summary of greenhouse gases and sources included in and excluded from the project boundary for the purpose of calculating project emissions and baseline emissions is presented next:

Source		GHGs	Included?	Justification/Explanation
Baseline scenario	Emissions from decomposition of waste at the SWDS site	**CH_4**	**Included**	Uncontrolled release of landfill gas contains approximately 50% methane (default value provided by ACM0001 v.13.0.0).This is the major source of emissions in the baseline.
		CO_2	Not included	CO_2 emissions from the decomposition of biomass are not counted as a GHG emission.
		N_2O	Not included	Excluded for simplification. This is conservative.
	Emissions from electricity generation	**CO_2**	**Included**	Emissions from national grid electricity generation have to be taken into account.
		CH_4	Not included	Electricity is not consumed from the grid in the baseline scenario as no landfill gas capture is undertaken before the implementation of the project activity.
		N_2O	Not included	
	Emissions from thermal energy generation	CH_4	Not included	Excluded. No thermal energy is generated.
		CO_2	Not included	
		N_2O	Not included	
	Emissions from the use of natural gas	CH_4	No	Excluded. No natural gas is consumed.
		CO_2	Yes	
		N_2O	No	
Project scenario	Emissions from fossil fuel consumption for purposes other than electricity generation or transportation due to the project activity	CH_4	Not included	There is no fossil fuel consumption under the project activity.
		CO_2	Not included	
		N_2O	Not included	
	Emissions from electricity consumption due to the project activity	**CO_2**	**Included**	On site electricity used is provided by the LFG captured and power plant. However, if the power plant would stop working, this emission source will be considered as project emissions.
		CH_4	Not included	Excluded for simplification. These emission sources are assumed to be very small.
		N_2O	Not Included	

The flow diagram of the project boundary is shown next, including the main equipment, energy and biogas flows and the monitored parameters:

Zone 3 Project Diagram



B.4. Establishment and description of baseline scenario

In this case, the baseline scenario is the release of the LFG to the atmosphere and the electricity demand being acquired from the national grid system.

In accordance to ACM001 version 13.0.0 and to the “Combined tool to identify the baseline scenario and demonstrate additionality”, the procedure for the selection of the most plausible scenario is described in detail in section B.5 below.

B.5. Demonstration of additionality

In accordance with ACM0001 the "Combined tool to identify the baseline scenario and demonstrate additionality" version 05.0.0 is applied in order to establish the baseline and show the additionality of the project activity. The tool integrates 5 steps:

- *Step 0: Demonstration that a proposed project activity is the First-of-its-kind;*
- *Step 1: Identification of alternative scenarios;*
- *Step 2: Barrier analysis;*
- *Step 3: Investment analysis;*
- *Step 4: Common practice analysis*

<u>Step 0: Demonstration whether the proposed project activity is the First-of-its-kind</u>

Although this project activity is a "First-of-its-kind" project as there are no similar projects in Guatemala as the letter from the Guatemalan DNA certifies, its additionality will not be demonstrated by this way as a crediting period of 7 years renewable once, instead of a maximum 10 years crediting period, has been chosen by project participants.

Outcome of step 0: The proposed project activity is the first-of-its-kind, although as crediting period doesn’t match with “Guidelines on additionality of first-of-its-kind project activities, demonstration of additionality is made through investment analysis.

<u>Step 1: Identification of alternative scenarios</u>

Step 1a: Define alternative scenarios to the proposed CDM project activity

Using the "<u>Combined tool to identify the baseline scenario and demonstrate additionality</u>" version 05.0.0 and the requirements of the ACM0001 version 13.0.0, the alternative scenarios that are available to the project participant, that cannot be implemented in parallel to the proposed project activity and that provide the same outputs as the proposed project activity, include:

- *LFG1: The project activity implemented without being registered as a CDM project activity.*

Alternative LFG1 for itself implies investments in equipment and operation for a LFG capture and flaring system. However, LFG1 is a possible alternative to the project activity when it is combined

with alternative E1 (electricity generation using the LFG; which is further discussed). This alternative will be valid for the project activity and shall be developed in the following steps.

- *LFG2: Atmospheric release of the LFG.*

The atmospheric release of the LFG is considered to be an alternative as it matches with baseline and current scenario. As no regulations force LFG collection and flaring in landfills in the country, no partial capture and destruction of LFG would be carried out.

- *LFG3: LFG is partially not generated because part of the organic fraction of the solid waste is recycled and not disposed in the SWDS.*
- *LFG4: LFG is partially not generated because part of the organic fraction of the solid waste is treated aerobically and not disposed in the SWDS; and*
- *LFG5: LFG is partially not generated because part of the organic fraction of the solid waste is incinerated and not disposed in the SWDS.*

Those alternatives which consist on not disposing in the SWDS part of the organic waste for being recycled, composted or incinerated is not considered a plausible alternative to the project activity as it is not the main object of the Zone 3 landfill and the waste management system in Guatemala is not so developed.

In addition to the alternatives identified for the destruction of LFG, alternative scenarios for the use of LFG, particularly for the electricity generation, are:

- *E1: Electricity generation from LFG, undertaken without being registered as CDM project activity.*

This is a credible alternative for Zone 3, which will be in line and combined with option *LFG1*, as the production and sale of electricity from landfill gas generates incomes which could pay for the investments for the landfill gas capture system. Option *LFG1* on its own is not a credible alternative as it does involve investments in equipment and operation without any financial return. The financial viability of alternative *LFG1+E1* will be assessed in the investment analysis below.

- *E2: Electricity generation in existing or new renewable or fossil fuel based captive power plant(s).*

In the absence of the project activity where LFG is entirely released to the atmosphere the equivalent electricity would not be generated by captive power plants. Thus this alternative will not be considered.

- *E3: Electricity generation in existing and/or new grid-connected power plants.*

In the absence of the project activity where LFG is entirely released to the atmosphere the equivalent electricity would be generated by the power plants connected to the Guatemalan national grid.

The project does not include thermal energy generation or supply of LFG to a natural gas distribution network, the project activity only proposes to generate electricity with LFG.

The outcome of Step 1a is a list of options that represents alternative scenarios to the proposed project activity, as follows:

- Alternative scenario I: Capture of LFG being used for electricity generation

purposes (*LFG1 + E1*), equivalent to the proposed project undertaken without being registered as a CDM project activity.
- Alternative scenario II: Atmospheric release of the landfill gas and electricity generation in existing and/or new grid-connected power plants (*LFG2+E3*), equivalent to current practice and to baseline scenario.

According to ACM0001 v. 13.0.0, project participants shall demonstrate that the identified baseline fuel used for generation of electricity and/or heat is available in abundance in the host country and there is no supply constraint. In this project, the identified baseline fuel used for generation of electricity is provided by the power plants connected to the national grid (and not by captive fossil fuel fired power plants). Hence this electricity supply from the grid is not seasonal nor constraint but constant, abundant and reliable.

Step 1b: Consistency with mandatory applicable laws and regulations

There are no mandatory laws or regulations requiring the control or landfill gas (methane) emissions based either on GHG mitigation or odour control or other health and safety concerns. There are no precedents or common practice set by other landfill sites within Guatemala. Since the landfill was opened there have been no attempts or projects to control the emission of methane from the site and there have been no legal actions taken to enforce methane recovery.

As there are no laws requiring the capture of methane from landfill, or the generation of energy through the use of methane captured from landfill, both identified alternative scenarios I and II are consistent with mandatory laws and regulations. Therefore both scenarios are credible and realistic alternatives to the project.

Step 2: Barrier analysis

No barriers that would prevent the implementation of the alternative scenarios have been identified. The barrier analysis has not been carried out.

Step 3: Investment analysis:

The objective of this step is to compare the financial attractiveness of the two remaining alternatives to the project activity (*LFG1+E1* and *LFG2+E3*).

In accordance with the "Combined tool to identify the baseline scenario and demonstrate additionality" version 05.0.0., in case of scenarios that not involving any investment costs, operational costs or revenues (case of alternative scenario II corresponding to *LFG2+E3*): "*either NPV or IRR must be used as financial indicator in the analysis, if the financial indicator is the NPV: assume a value of NPV equal to zero, if the financial indicator is the IRR: use as the IRR the financial benchmark*".

In this case, equity IRR is chosen as financial indicator for the project activity. Hence, equity IRR for alternative scenario II (*LFG2+E3*) is considered to be equal to the financial benchmark that is defined next. For project activity and alternative scenario I (*LGF1+E1*), investment analysis is provided next.

Benchmark determination:

According to the "Guidelines on the assessment of the investment analysis" (version 05), in cases of projects which could be developed by an entity other than the project participants, the

benchmark should be based on parameters that are standard in the market. In this project, values provided in Appendix A of these guidelines have been chosen.

Considering that the project (as well as its alternative scenarios) belongs to group 1 "waste handling and disposal" category, the default value for the expected return on equity in Guatemala provided by the Guidelines document is 12.5%. This is an after taxes value, without inflation, and it will be used as a benchmark.

As "Guidelines on the assessment of the investment analysis" was not available at the time of investment decision, an alternative benchmark available in 2007 has been calculated by using the "Combined tool to identify the baseline scenario and demonstrate additionality" version 05.0.0. option (a): "*Government bond rates, increased by a suitable risk premium to reflect private investment and/or the project type, as substantiated by an independent (financial) expert or documented by official publicly available financial data*".

Hence, an alternative benchmark of 16.2% is obtained at the time of investment decision as per:

- Guatemalan Government 10 year-bonds: 9.8%[9].
- Equity Risk Premium: 6.445%. Data provided by Bloomberg data base:

As this value is less conservative than the expected return on equity benchmark provided by "Guidelines on the assessment of the investment analysis", default value of 12.5% is used as benchmark to be compared to Equity IRR of the project activity.

Based on this benchmark, calculation and comparison of financial indicator are carried out in sub-step 2c.

Calculation and comparison of financial indicator:

[9] According to "Certificados de Representativos de Bonos del Tesoro" issued by the Guatemalan Central Bank, published by IMF Working Paper - Public Debt Markets in Central America, Panama, and the Dominican Republic in 2007.

Calculation and comparison of financial indicator of the project is implemented according to the last version of "Guidelines on the Assessment of Investment Analysis".

The project participants have applied an after tax equity IRR analysis, for a 14 years period of assessment and calculated at the time of the investment decision in December 2007, when the resolution for the approval of the Environmental Impact Assessment was obtained.

Relevant financial indicators of the project activity which were applicable at the time of the investment decision, used for equity IRR calculation, are listed next.

Update of the financial analysis due to design changes in electricity generation capacity:

As per the changes to project design requested in the PRC, instead of four engines of 1.2 MW each as it was planned as per registered PDD, it was implemented one engine of 1,059 kW on 22/03/2015 and three engines of 1,061 kW (each) on 02/06/2017. This means that the updated power generation capital cost of the project would be now slightly smaller, around 5.52 MUSD/4.242 MW=1,301 USD/kW).

Due to the change of the capacity, a new analysis has been performed to assess the financial additionality with the new generation configuration investment. Considering that the total electricity generation capacity was 4.8 MW and the change decreases the capacity to 4.242 MW, the total generation capacity has been updated to 4.242 MW in the financial analysis. Additionally, in the financial analysis, the new investment cost (less than the original expected costs with the original engines) has been updated.

The updated financial indicators are the following:

Parameter		Unit	Input data (applicable at the time of investment decision)	Source
Electric engines	Installed power	MW_l	4.242	• Biogas model spreadsheet
	Operating hours	h	8,000	• Pro2 manufacturer specifications
Power plant investment (4 engines)		MUSD	5.52	• Agreement with COBRA S.A. • Invoices from COBRA S.A. • Invoices from SMITCH POWER MEXICO S. DE R.L. DE C.V. • Invoices from SMITH POWER PRODUCTS, INC
Flaring investment (2 flares)		MUSD	0.87	• Offer from Pro2 Anlagentechnik GMBH
Collection and extraction investment		MUSD	0.77	• Building construction offer from Consultoria y Constructora del Kyrios. • Topographic survey offer from Topografia Profesional • Drilling offer from Rodio Swissboring • Degassing offer from Representaciones Plasticas Industriales, S.A de C.V.
O&M average annual costs for engines		USD/kWh	0.024	• Offer from Tracsa Energia S.A de C.V.

Overhaul for engines	USD/ 4 years	800,000	• According to previous experience at Queretaro landfill in Mexico
O&M average annual costs for flares	USD/ year	164,333	• 10% of the initial investment costs, according to SCS engineering study 2005
Electricity price	USD/ 100 kWh	8.96	• Administrador del Mercado Mayorista, AMM. Average Price 2007.
Depreciation	years	10	• Guatemala law order in council 26.92_ "Ley de impuesto sobre la renta" Article 19 g
Corporate tax	%	31	• Guatemala law order in council 26.92_ "Ley de impuesto sobre la renta" Article 72
Debt/ Equity finance structure	%	50/50	• Default values provided by "Guidelines on the Assessment of Investment Analysis" v.5, to be used when information related to typical finance structure in the sector of the country used is not available. As this is the first landfill of these characteristics in Guatemala, the use of default values is justified.
Debt interest amortization	years	10	• SCS engineering study 2005, section 7.1 Summary of assumptions.
Financial interest rate	%	12.82	• Bank of Guatemala (average data from January to November 2007)
Royalties on electricity sales	%	35	• Contract with Rellenos de Guatemala (page 6) • Contract with C. Hoegg.PDF (page 25) • Contract with Ricardo Asturias (page 8)
Exchange rate	USD/Euro	1.4341	• Bank of Canada[10] (Exchange rate for the before the investment decision)

Financial parameters comments:

- Electricity price was estimated as per public available information of the spot market as no Power Purchase Agreement (PPA) contract has been signed yet. Electricity price corresponds to the fixed price that will be paid for each MWh delivered to the grid. Price for electricity generation is the only party included in the income cash flow (without CER revenues), as there will be no additional incomes related to energy sale or capacity guarantee.
- Although cost for flare and degassing and collection system of the project activity (86 kUSD/ha) are increased because of the specific characteristics of the landfill, which is 100 m depth and is located in a cliff, this parameter is in line with other registered landfills projects.

[10] http://www.bankofcanada.ca/rates/exchange/10-year-converter/

- According to the Law for incentivize renewable energy development in Guatemala "Ley de Incentivos para el Desarrollo de Proyectos de Energía Renovable[11]" of 2003, those projects are exempted for paying taxes during the first 10 years. Since year 11, a 31% of taxes will be paid according to Guatemalan Tax law "Ley de Impuesto sobre la Renta, Decreto número 26-92".

The following table shows the after taxes equity IRR of the Zone 3 Landfill Gas Project without the sales of CERs, equivalent to the alternative scenario I, as well as for alternative scenario II, considering these changes in the electricity generation equipment:

Scenarios	Equity IRR	Financial benchmark
Alternative scenario I = *LFG1+E1* (LFG capture and flaring and electricity production without CER revenues)	-4.12%[12]	**12.5%**
Alternative scenario II = *LFG2+E3* (release of LFG to the atmosphere and electricity generation in existing and/or new grid-connected power plants)	12.5%	

Table 1. Financial analysis.

The ranking of the analysed scenarios according to the most suitable financial indicator is that the most economically attractive alternative is not implementing any project (alternative scenario II) and finally project activity without CER revenues (alternative scenario).

Considering this result, the IRR is not yet economically attractive (-4.12%) with these design change in the generation equipment as in the previous configuration as per registered PDD (-1.76%), being this value conservative.

Sensitivity Analysis:

The sensitivity analysis shall show whether the conclusion regarding the financial attractiveness is robust to reasonable variations in the critical assumptions and is a frequently used method for assessing the perceived uncertainties by identifying the potential changing ranges of some key elements and potential impacts of such changes on the economic model of the project.

According to the UNFCCC "Guidance on the Assessment of Investment Analysis" (v. 5) variables that constitute more than 20% of either total project costs or total project revenues should be subjected to reasonable variation.

For this project, the next parameters were selected as sensitive factors to check out the financial attractiveness without CRE income (these financial indicators are fluctuated within the range of -10% ton+10%). Additionally, the sensitivity analysis was reassessed considering the investment in

[11] http://www.oj.gob.gt/es/QueEsOJ/EstructuraOJ/UnidadesAdministrativas/CentroAnalisisDocumentacionJudicial/cds/CDs%20leyes/2003/Leyes%20en%20PDF/Decretos%202003/Decreto%2052-2003.pdf

[12] Despite the installation of the engines having occurred in 2015 (one engine) and 2017 (three engines), the total generation and consequently the commercial sale has been fully included in the financial analysis since 2013, which is more conservative.

the engines finally selected and the results have been the following when the different parameters have been altered to check the IRR variation:

Net.elec.	Eq IRR	Elec.price.	Eq IRR	O&M exp.	Eq IRR	Investment	Eq IRR	Royalties (elec	Eq IRR
-10%	-8.3%	-10%	-11.5%	-10%	-0.4%	-10%	-1.6%	-10%	-0.7%
-5%	-6.1%	-5%	-7.6%	-5%	-2.2%	-5%	-2.9%	-5%	-2.4%
+0%	-4.1%	+0%	-4.1%	+0%	0.7%	+0%	0.7%	+0%	0.7%
+5%	-2.2%	+5%	-0.9%	+5%	-6.2%	+5%	-5.2%	+5%	-6.0%
+10%	-0.4%	+10%	2.1%	+10%	-8.4%	+10%	-6.3%	+10%	-7.9%

As presented above, even if the best conditions are applied, the equity IRR will be lower than the chosen benchmark for alternative scenario I.

In order to evaluate how reasonable is the +/- 10% sensitivity analysis, it has been made an analysis of the variation needed for each variable to reach the benchmark of 12.5%:

Parameter	Variation to reach benchmark
Total investment cost	-45%
O&M expenses	-49%
Royalties applied to electricity	-54%
Electricity price cross benchmark	29%
Electricity generation	49%

- Total investment cost: The main part of the total investment is the acquisition of the electrical engines and electricity project. In this sense, total investment will have a similar variation to the electrical system. According to Irena Working Paper[13] from June 2012, using landfill gas for power generation has capital costs of between USD 1,920 and USD 2,440/kW, which is much higher than cost for Zone 3 landfill (5.52 MUSD/4.8MW=1.15 USD/kW). Actual costs estimations are even higher than Zone 3 landfill data used at the time of investment decision, hence, investment cost is not expected to decrease.

- O&M expenses: According to Irena Working Paper from June 2012, landfill gas systems have high fixed O&M costs which can be between 10% and 20% of initial capital costs per year, while Zone 3 project estimated O&M total costs of around 15%.

- Royalties on electricity sales: royalties on electricity sales were fixed in advance by signed contracts with land owners Rellenos de Guatemala S.A. and Carlos Antonio Hoegg Bosley, and with the in-situ business manager of the landfill Ricardo Asturias. Those contracts have already been signed and royalties' percentages are determined as fix percentages depending on electricity generation. Hence no variation can be expected in this parameter.

- Electricity price: According to the last tender from the Guatemalan government for renewable energy generation, in February 2012, offers for electricity price are all less than

[13] http://www.irena.org/DocumentDownloads/Publications/RE_Technologies_Cost_Analysis-BIOMASS.pdf

100 USD/MWh[14]. So, electricity price is not expected to increase more than 10% at the time when the project will enter into operation.

- Electricity generation: as no more engines than expected will be installed, and since the engines are expected to work 8,000 hours/year of the 8,760 total hours/year, electricity generation could not, from a technical point of view, surpass the 9.5% increase.

As can be seen, the variation needed to reach the benchmark of 12.5% is still important considering the updated investment in the electricity generation configuration. According to the "Combined tool to identify the baseline scenario and demonstrate additionality" version 05.0.0., the most economically or financially attractive alternative scenario is considered as baseline scenario. Hence, without CER, the continuation of current practice (alternative scenario II, corresponding to *LFG2+E3*), would be the baseline scenario for the project activity.

Thus, is concluded that, even considering this design change in the generation equipment, the project activity without being registered as a CDM project (alternative scenario I, composed by *LFG1+E1*), is not economically attractive as its equity IRR does not reach the defined benchmark. Hence, the project activity's financial additionality is demonstrated.

Step 4: Common practice analysis

The proposed CDM project activity applies to measure "Methane destruction" listed in the definitions of combined tool, hence Step 4 (a) is followed, and Step 4 (b) is not applicable:

***Step 4a: The proposed CDM project activity(s) applies measure(s) that are listed in the definitions* section above**

"Guidelines on common practice" version 02.0 is applied:

- Step 1: calculate applicable capacity or output range as +/-50% of the total design capacity or output of the proposed project activity.

The estimated power generation capacity of the project activity is 4.242 MW. So the applicable capacity range +/- 50% is 2.121 - 6.363 MW.

- Step 2: identify similar projects (both CDM and non-CDM) which fulfil all of the following conditions:

  a) The projects are located in the applicable geographical area;
  b) The projects apply the same measure as the proposed project activity;
  c) The projects use the same energy source/fuel and feedstock as the proposed project activity, if a technology switch measure is implemented by the proposed project activity;
  d) The plants in which the projects are implemented produce goods or services with comparable quality, properties and applications areas (e.g. clinker) as the proposed project plant;

[14] http://www.cnee.gob.gt/peg/index.html

e) The capacity or output of the projects is within the applicable capacity or output range calculated in Step 1;
f) The projects started commercial operation before the project design document (CDM-PDD) is published for global stakeholder consultation or before the start date of proposed project activity, whichever is earlier for the proposed project activity.

Identified similar projects must fulfil:

a) The applicable geographical area covers the entire host country, Guatemala, as a default.
b) The measure for emission reduction activities is in this case (iii) methane destruction.
c) The energy source is the LFG.
d) The service produced is the electricity generation.
e) The capacity range is 2.121 - 6.363 MW, as per step 1.
f) Start of commercial operation before 07/04/2014, the new date when the project proponent committed with the payment and acquisition of the well drilling works, needed to start with the construction of the biogas collection system, as per the delay in the start date due the PRC.

To identify similar projects registered under CDM, the database "UNEP DTU Partnership. Centre of Energy, Climate and Sustainable Development"[15] has been consulted and only two landfill gas flaring projects have been identified:

One registered project "Zone 3 Landfill Gas Project" and one validation terminated (not registered) project "AMSA Landfill Gas Project" with a planned crediting period start date in 01/03/2013. However, AMSA project finally started operation in 2015 with final completion by January 2018 as per the website of "SIMPSON Environmental Corporation"[16] as a pyrolysis project with a planned generation capacity of 71 MW so is not considered as similar project, not fulfilling the requirement exposed above.

Additionally, to identify other landfill gas to energy projects in Guatemala no participating in CDM during the year 2014, the database "Global Methane Initiative"[17] was checked and still there is not any methane destruction project in Guatemala.

- Step 3: within the projects identified in Step 2, identify those that are neither registered CDM project activities, project activities submitted for registration, nor project activities undergoing validation. Note their number Nall.

$N_{all} = 0$

- Step 4: within similar projects identified in Step 3, identify those that apply technologies that are different to the technology applied in the proposed project activity. Note their number Ndiff.

$N_{diff} = 0$

- Step 5: calculate factor F=1-Ndiff/Nall representing the share of similar projects (penetration rate of the measure/technology) using a measure/technology similar to the

[15] http://www.cdmpipeline.org/

[16] http://www.senvc.com/case-studies/closure-of-amsa-landfill-a-waste-to-energy-project/#:~:text=Waste%20to%20Energy%2C%20Guatemala,in%20the%20Lake%20Amatitlan%20region.

[17] https://www.globalmethane.org/advancedSearch.aspx#

measure/technology used in the proposed project activity that deliver the same output or capacity as the proposed project activity.

$F = 1 - N_{diff}/ N_{all} = 1\text{-}\infty$ and $N_{all}\text{-}N_{diff} = 0$

The proposed project activity is a common practice within a sector in the applicable geographical area if the factor F is greater than 0.2 and $N_{all}\text{-}N_{diff}$ is greater than 3.

As F is smaller than 0.2 and $N_{all}\text{-}N_{diff}$ is smaller than 3, this project activity is not a common practice in Guatemala.

***Step 4b: The proposed CDM project activity(s) does not apply any of the measures that are listed in* the definitions section above**

N/A

Outcome of Step 4: As outcome of Step 4 is that the proposed project activity is not regarded as "common practice" then the proposed project activity is additional.

B.6. Estimation of emission reductions

B.6.1. Explanation of methodological choices

The objective of the project activity is to avoid methane emissions to the atmosphere by installing an efficient landfill gas collection and flaring system and generating electricity with the captured LFG which will be exported to the grid. In conclusion, the project activity avoids emissions by:

- Capturing and destroying LFG methane in flares and in power generators.
- Reducing equivalent carbon dioxide emissions by displacement of electricity mix in the Guatemalan National Grid.

Next, it is described the baseline and project emissions choices given in the methodology ACM0001 version 13.0.0.

<u>Baseline emissions:</u>

Baseline emissions are determined according to equation 1 of ACM0001 and comprise the following sources:

(A) Methane emissions from the SWDS in the absence of the project activity;
(B) Electricity generation using fossil fuels or supplied by the grid in the absence

the project activity;

$BE_{Ey} = BE_{CH4,y} + BE_{EC,y}$ ACM0001 (1)

Where:
BE_y = Baseline emissions in year *y* (tCO_2e/yr)
$BE_{CH4,y}$ = Baseline emissions of methane from the SWDS in year *y* (tCO_2e/yr)
$BE_{EC,y}$ = Baseline emissions associated with electricity generation in year *y* (tCO_2/yr)

Note that baseline emissions associated with heat generation and with natural gas are equal to zero, since it is not part of the project activity ($BE_{HG,y}$ = $BE_{NG,y}$ = 0).

Step A: Baseline emissions of methane from the SWDS ($BE_{CH4,y}$)

Baseline emissions of methane from the SWDS are determined as follows, based on the amount of methane that is captured under the project activity and the amount that would be captured and destroyed in the baseline (which is zero). In addition, the effect of methane oxidation (OX_{top_layer}) that is present in the baseline and absent in the project is taken into account:

$$BE_{CH4,y} = (1 - OX_{top\_layer}) \times (F_{CH4,PJ,y} - F_{CH4,BL,y}) \times GWP_{CH4}$$ ACM0001 (2)

Where:

$BE_{CH4,y}$ = Baseline emissions of LFG from the SWDS in year *y* (tCO_2e/yr)
OX_{top_layer} = Fraction of methane in the LFG that would be oxidized in the top layer of the SWDS in the baseline (dimensionless)
$F_{CH4,PJ,y}$ = Amount of methane in the LFG which is flared and/or used in the project activity in year *y* (tCH_4/yr)
$F_{CH4,BL,y}$ = Amount of methane in the LFG that would be flared in the baseline in year *y* (tCH_4/yr)
GWP_{CH4} = Global warming potential of CH4 (tCO_2e/ tCH_4)

Step A.1: Ex-post determination of FCH4,PJ,y

During the crediting period, $F_{CH4,PJ,y}$ is determined as the sum of the quantities of methane flared and used in the power plant. Therefore:

$$F_{CH4,PJ,y} = F_{CH4,flared,y} + F_{CH4,EL,y}$$ ACM0001 (3)

Where:
$F_{CH4,PJ,y}$ = Amount of methane in the LFG which is flared and/or used in the project activity in year *y* (tCH_4/yr)
$F_{CH4,flared,y}$ = Amount of methane in the LFG which is destroyed by flaring in year *y* (tCH_4/yr)
$F_{CH4,EL,y}$ = Amount of methane in the LFG which is used for electricity generation in year *y* (tCH_4/yr)

Amount of methane in the LFG which is used for electricity generation ($F_{CH4,EL,y}$)

$F_{CH4,EL,y}$, is determined using the "Tool to determine the mass flow of a greenhouse gas in a gaseous stream" and monitoring the working hours of the power plant(s), so that no emission reductions are claimed for methane destruction during nonworking hours.

The tool provides following 6 options for measuring mass flow of a greenhouse gas *i* in a gaseous stream ($F_{i,t}$ = $F_{CH4,EL,y}$):

Option	Flow of gaseous stream	Volumetric fraction
A	Volume flow – dry basis	Dry or wet basis
B	Volume flow – wet basis	Dry basis
C	Volume flow – wet basis	Wet basis
D	Mass flow – dry basis	Dry or wet basis
E	Mass flow – wet basis	Dry basis
F	Mass flow – wet basis	Wet basis

Considering the measure meters used in this project, the Option A (*volume flow dry basis and volumetric fraction dry basis*) is applied for measuring $F_{i,t}$, in this case $F_{CH4,EL,y.}$ Under Option A, flow measurement on a dry basis is not doable for a wet gaseous stream. Therefore, it is necessary to demonstrate that the gaseous stream is dry to use this option. There are two ways to do this:

a) Measure the moisture content of the gaseous stream ($C_{H2O,t,db,n}$) and demonstrate that this is less or equal to 0.05 kg H_2O/m^3 dry gas; or
b) Demonstrate that the temperature of the gaseous stream (T_t) is less than 60ºC (333.15 K) at the flow measurement point.

For the project activity, temperature under 60ºC (option b) will be demonstrated and absolute humidity will not be measured.

The mass flow of methane ($F_{i,t}$) will be determined for the mass flow of methane sent to each electric engine (see flow diagram in Section B.3), as follows:

$$F_{i,t} = V_{t,db} * v_{i,t,db} * \rho_{i,t} \quad \text{with} \quad \rho_{i,t} = \frac{P_t * MM_i}{R_u * T_t} \qquad \text{Tool (5) and (6)}$$

Where:

$F_{i,t}$ = Mass flow of greenhouse gas *i* in the gaseous stream in time interval *t* (kg gas/h)
$V_{t,db}$ = Volumetric flow of the gaseous stream in time interval *t* on a dry basis (m³ dry gas/h)
$v_{i,t,db}$ = Volumetric fraction of greenhouse gas i in the gaseous stream in a time interval t on a dry basis (m³ gas i/m³ dry gas)
$\rho_{i,t}$ = Density of greenhouse gas i in the gaseous stream in time interval t (kg gas i/m³ gas i)
P_t = Absolute pressure of the gaseous stream in time interval t (Pa)
MM_i = Molecular mass of greenhouse gas i (kg/kmol)
R_u = Universal ideal gases constant (Pa.m³/kmol.K)
T_t = Temperature of the gaseous stream in time interval t (K)

As per methodology ACM0001, the following requirements apply:

- $F_{CH4,EL,y}$ is calculated as the sum of mass flows to each item of electricity generation,
- CH_4 is the greenhouse gas for which the mass flow is determined (hence i= CH_4),
- The simplification offered for calculating the molecular mass of the gaseous stream is valid (equations 3 or 17 in the tool),
- The mass flow should be calculated on an hourly basis for each hour h in year y (hence t = hour), and
- The mass flow calculated for hour h is 0 if the equipment is not working in hour h ($O_{pj,h}$=not working), the hourly values are then summed to a yearly unit basis.

Hence in this step the parameters that will need to be monitored are $O_{pj,h}$; $V_{t,db}$; $v_{i,t,db}$; P_t and T_t for gaseous streams going to each electric engine, t=hour and i=CH_4.

Amount of methane in the LFG which is destroyed by flaring ($F_{CH4,flared,y}$)

$F_{CH4,flared,y}$ is determined as the difference between the amount of methane supplied to the flare and any methane emissions from the flare, as follows:

$$F_{CH4,flared,y} = F_{CH4,sent\_flare,y} - \frac{PE_{flare,y}}{GWP_{CH4}}$$ ACM0001 (4)

Where:

$F_{CH4,flared,y}$	=	Amount of methane in the LFG which is destroyed by flaring in year *y* (t CH_4/yr)
$F_{CH4,sent\_flare,y}$	=	Amount of methane in the LFG which is sent to the flare in year *y* (t CH_4/yr)
$PE_{flare,y}$	=	Project emissions from flaring of the residual gas stream in year *y* (t CO_2e/yr)
GWP_{CH4}	=	Global warming potential of CH_4 (t CO_2e/t CH_4)

- **$F_{CH4,sent\_flare,y}$** is determined using the "Tool to determine the mass flow of a greenhouse gas in a gaseous stream". As for $F_{CH4,EL,y}$ determination, the same Option A (*volume flow dry basis and volumetric fraction dry basis*) is applied for measuring $F_{i,t}$, in this case $F_{CH4,sent\_flare,y}$.

Under Option A, flow measurement on a dry basis is not doable for a wet gaseous stream. Therefore, it is necessary to demonstrate that the gaseous stream is dry to use this option. There are two ways to do this:

a) Measure the moisture content of the gaseous stream ($C_{H2O,t,db,n}$) and demonstrate that this is less or equal to 0.05 kg H_2O/m^3 dry gas; or
b) Demonstrate that the temperature of the gaseous stream (T_t) is less than 60ºC (333.15 K) at the flow measurement point.

For the project activity, temperature under 60ºC (option b) will be demonstrated and absolute humidity will not be measured.

In this case, the tool shall be applied to the LFG delivery pipeline to the flares (see flow diagram in Section B.3), as follows:

$$F_{i,t} = V_{t,db} * v_{i,t,db} * \rho_{i,t} \quad \text{with} \quad \rho_{i,t} = \frac{P_t * MM_i}{R_u * T_t}$$ Tool (5) and (6)

Where:

$F_{i,t}$	= Mass flow of greenhouse gas *i* in the gaseous stream in time interval *t* (kg gas/h)
$V_{t,db}$	= Volumetric flow of the gaseous stream in time interval *t* on a dry basis (m^3 dry gas/h)
$v_{i,t,db}$	= Volumetric fraction of greenhouse gas i in the gaseous stream in a time interval t on a dry basis (m^3 gas i/m^3 dry gas)
$\rho_{i,t}$	= Density of greenhouse gas i in the gaseous stream in time interval t (kg gas i/m^3 gas i)
P_t	= Absolute pressure of the gaseous stream in time interval t (Pa)
MM_i	= Molecular mass of greenhouse gas i (kg/kmol)
R_u	= Universal ideal gases constant ($Pa.m^3/kmol.K$)
T_t	= Temperature of the gaseous stream in time interval t (K)

The following requirements apply:

- $F_{CH4,sent\_flare,y}$ is calculated as the sum of mass flows to each flare,
- CH_4 is the greenhouse gas for which the mass flow is determined (hence i= CH_4),

- The simplification offered for calculating the molecular mass of the gaseous stream is valid (equations 3 or 17 in the tool),
- The mass flow should be calculated on an hourly basis for each hour h in year y (hence t = hour), and
- The mass flow calculated for hour h is 0 if the flare is not working in hour h, the hourly values are then summed to a yearly unit basis.

Hence in this step the parameters that will need to be monitored are $V_{t,db}$; $v_{i,t,db}$; P_t and T_t for gaseous stream going to flare, being t=hour and i=CH_4.

- **$PE_{flare,y}$** shall be determined using the tool "Project emissions from flaring".

This tool provides procedures to calculate project emissions from flaring of a residual gas. This tool is applicable to our project activity as enclosed flares will be installed and methane is the component with the highest concentration in the flammable residual gas, which comes from a biogenic source (landfill gas).

The calculation procedure in this tool determines the project emissions from flaring the residual gas ($PE_{flare,y}$) based on the flare efficiency ($\eta_{flare,m}$) and the mass flow of methane to the flare ($F_{CH4,RG,m}$). The flare efficiency is determined for each minute m of year y based either on monitored data or default values.

The project emissions calculation procedure is given in the following steps:

STEP 1: Determination of the methane mass flow of the residualngas;
STEP 2: Determination of the flare efficiency;
STEP 3: Calculation of project emissions from flaring.

STEP 1: Determination of the methane mass flow of the residual gas

The "Tool to determine the mass flow of a greenhouse gas in a gaseous stream" shall be used to determine the mass flow of methane in the residual gaseous stream in the minute *m* parameter ($F_{CH4,m}$).

As for $F_{CH4,sent\_flare,y}$, *Option 2 "Simplified calculation without measurement of the moisture content*" and *option A* (*volume flow dry basis and volumetric fraction dry basis*) are selected to calculate the mass flow of methane in the residual gaseous stream, which corresponds to the amount of methane sent to flare ($F_{CH4,sent\_flare,y}$) explained before.

Also, the following requirements apply to $F_{CH4,RG,t}$:

- The gaseous stream tool shall be applied to the residual gas (which is equivalent to the gaseous stream sent to flare);
- The flow of the gaseous stream shall be measured continuously;
- CH4 is the greenhouse gas i for which the mass flow should be determined;
- The simplification offered for calculating the molecular mass of the gaseous stream is valid (equations 3 and 17 in the tool); and
- The time interval t for which mass flow should be calculated is every minute m.

$F_{CH4,m}$, which is measured as the mass flow during minute m, shall then be used to determine the mass of methane in kilograms fed to the flare in minute m ($F_{CH4,RG,m}$). $F_{CH4,m}$ shall be determined on a dry basis.

STEP 2: Determination of the flare efficiency

The flare efficiency depends on the efficiency of combustion in the flare and the time that the flare is operating. For determining the efficiency of combustion of enclosed flares there is the option to apply a default value or determine the efficiency based on monitored data. The time the flare is operating is determined by monitoring the flame using a flame detector and, for the case of enclosed flares, in addition the monitoring requirements provided by the manufacturer's specifications for operating conditions shall be met.

Project participants may choose between the following two options to determine the enclosed flare efficiency for minute m ($\eta_{flare,m}$):

- *Option A: Apply a default value for flare efficiency.*
- *Option B: Measure the flare efficiency.*

In this case, flare efficiency will be measured and hence, *Option B: Measure the flare efficiency* is chosen. As the flare efficiency in the minute *m* is a measured value ($\eta_{flare,m} = \eta_{flare,calc,m}$) the next conditions must be met to demonstrate that the flare is operating:

1. The temperature of the flare ($T_{EG.m}$) and the flow rate of the residual gas to the flare ($F_{RG,m}$) is within the manufacturer's specification for the flare ($SPEC_{flare}$) in minute m;

2. The flame is detected in minute m ($Flame_m$); and Otherwise $\eta_{flare,m}$ is 0%.

When applying Option B, the project participants may choose to determine $\eta_{flare,calc,m}$ using either Option B.1 or Option B.2. Under Option B.1 the measurement is conducted by an accredited entity on a biannual basis and under Option B.2 the flare efficiency is measured in each minute. Option B.2 is chosen.

Under Option B.2, the flare efficiency ($\eta_{flare,calc,m}$) is determined based on monitoring the methane content in the exhaust gas, the residual gas, and the air used in the combustion process during the minute m in year y, as follows:

$$\eta_{flare,calc,m} = 1 - \frac{F_{CH4,EG,m}}{F_{CH4,RG,m}} \qquad \text{Tool (2)}$$

Where:

$\eta_{flare,calc,m}$	= Flare efficiency in the minute m
$F_{CH4,EG,m}$	= Mass flow of methane in the exhaust gas of the flare on a dry basis at reference conditions in the minute m (kg)
$F_{CH4,RG,m}$	= Mass flow of methane in the residual gas on a dry basis at reference conditions in the minute m (kg)

$F_{CH4,RG,m}$ is calculated according to Step 1 and $F_{CH4,EG,m}$ is determined according to Steps 2.1 - 2.4 below:

Step 2.1: Determine the methane mass flow in the exhaust gas on a dry basis

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

$$F_{CH4,EG,m} = V_{EG,m} * fc_{CH4,EG,m} * 10^{-6} \quad \text{Tool (3)}$$

Where:

$F_{CH4,EG,m}$	= Mass flow of methane in the exhaust gas of the flare on a dry basis at reference conditions in the minute *m* (kg)
$V_{EG,m}$	= Volumetric flow of the exhaust gas of the flare on a dry basis at reference conditions in minute *m* (m^3)
$fc_{CH4,EG,m}$	= Concentration of methane in the exhaust gas of the flare on a dry basis at reference conditions in minute *m* (mg/m^3)

Step 2.2: Determine the volumetric flow of the exhaust gas ($V_{EG,m}$)

Determine the average volume flow of the exhaust gas in minute *m* based on a stoichiometric calculation of the combustion process. This depends on the chemical composition of the residual gas, the amount of air supplied to combust it and the composition of the exhaust gas. It is calculated as follows:

$$V_{EG,m} = Q_{EG,m} * M_{RG,m} \quad \text{Tool (4)}$$

Where:

$V_{EG,m}$	= Volumetric flow of the exhaust gas on a dry basis at reference conditions in minute *m* (m^3)
$Q_{EG,m}$	= Volume of the exhaust gas on a dry basis at reference conditions per kilogram of residual gas on a dry basis at reference conditions in minute *m* (m^3 exhaust gas/kg residual gas)
$M_{RG,m}$	= Mass flow of the residual gas on a dry basis at reference conditions in the minute *m* (kg)

Step 2.3: Determine the mass flow of the residual gas ($M_{RG,m}$)

Project participants select to calculate $M_{RG,m}$ based on the volumetric flow 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.

$$M_{RG,m} = \rho_{RG,ref,m} * V_{RG,m} \quad \text{Tool (5)}$$

Where:

$M_{RG,m}$	= Mass flow of the residual gas on a dry basis at reference conditions in minute *m* (kg)
$\rho_{RG,ref,m}$	= Density of the residual gas at reference conditions in minute *m* (kg/m^3)
$V_{RG,m}$	= Volumetric flow of the residual gas on a dry basis at reference conditions in the minute *m* (m^3), and

$$\rho_{RG,ref,m} = \frac{P_{ref}}{\frac{R_u}{MM_{RG,m}} \times T_{ref}} \qquad \text{Tool (6)}$$

Where:

$\rho_{RG,ref,m}$	= Density of the residual gas at reference conditions in minute m (kg/m^3)
P_{ref}	= Atmospheric pressure at reference conditions (Pa)
R_u	= Universal ideal gas constant ($Pa.m^3/kmol.K$)
$MM_{RG,m}$	= Molecular mass of the residual gas in minute m (kg/kmol)
T_{ref}	= Temperature at reference conditions (K)

Use the equation below to calculate $MM_{RG,m}$. When applying this equation, the project participant chooses to use the measured volumetric fraction of each component i of the residual gas. The next equation applies, irrespective of which option is selected.

$$MM_{RG,m} = \sum_i (v_{i,RG,m} \times MM_i) \qquad \text{Tool (7)}$$

Where:

$MM_{RG,m}$	= Molecular mass of the residual gas in minute m (kg/kmol)
MM_i	= Molecular mass of residual gas component i (kg/kmol)
$v_{i,RG,m}$	= Volumetric fraction of component i in the residual gas on a dry basis at reference conditions in the hour h.
i	= Components of the residual gas (where i = CH_4, CO, CO_2, O_2, H_2, H_2S, NH_3 and N_2).

Step 2.4: Determine the volume of the exhaust gas on a dry basis at reference conditions per kilogram of residual gas ($Q_{EG,m}$)

$Q_{EG,m} = Q_{CO2,EG,m} + Q_{O2,EG,m} + Q_{N2,EG,m}$ Tool (8)

Where:

$Q_{EG,m}$	= Volume of the exhaust gas on a dry basis per kg of residual gas on a dry basis at reference conditions in the minute m (m^3/kg residual gas)
$Q_{CO2,EG,m}$	= Quantity of CO_2 volume in the exhaust gas per kg of residual gas on a dry basis at reference conditions in the minute m (m^3/kg residual gas)
$Q_{N2,EG,m}$	= Quantity of N_2 volume in the exhaust gas per kg of residual gas on a dry basis at reference conditions in the minute m (m^3/kg residual gas)
$Q_{O2,EG,m}$	= Quantity of O_2 volume in the exhaust gas per kg of residual gas on a dry basis at reference conditions in the minute m (m^3/kg residual gas)

With

$Q_{O2,EG,m} = n_{O2,EG,m} * VM_{ref}$ Tool (9)

Where:

$Q_{O2,EG,m}$ = Quantity of O_2 volume in the exhaust gas per kg of residual gas on a dry basis at reference conditions in the minute m (m^3/kg residual gas)

$n_{O2,EG,m}$ = Quantity of O_2 (moles) in the exhaust gas per kg of residual gas flared on a dry basis at reference conditions in minute m (kmol/kg residual gas)

VM_{ref} = Volume of one mole of any ideal gas at reference temperature and pressure (m^3/kmol)

$$Q_{N2,EG,m} = VM_{ref} \times \left\{ \frac{MF_{N,RG,m}}{2 \times AM_N} + \left(\frac{1 - v_{O2,air}}{v_{O_2,air}} \right) \times \left[F_{O2,RG,m} + n_{O2,EG,m} \right] \right\} \quad \text{Tool (10)}$$

Where:

$Q_{N2,EG,m}$ = Quantity of N_2 (volume) in the exhaust gas per kg of residual gas on a dry basis at reference conditions in the minute m (m^3/kg residual gas)

VM_{ref} = Volume of one mole of any ideal gas at reference temperature and pressure (m^3/kmol)

$MF_{N,RG,m}$ = Mass fraction of nitrogen in the residual gas in the minute m

AM_N = Atomic mass of nitrogen (kg/kmol)

$v_{O2,air}$ = Volumetric fraction of O_2 in air

$F_{O2,RG,m}$ = Stochiometric quantity of moles of O_2 required for a complete oxidation of one kg residual gas in minute m (kmol/kg residual gas)

$n_{O2,EG,m}$ = Quantity of O_2 (moles) in the exhaust gas per kg of residual gas flared on a dry basis at reference conditions in minute m (kmol/kg residual gas)

$$Q_{CO_2,EG,m} = \frac{MF_{C,RG,m}}{AM_C} \times VM_{ref} \quad \text{Tool (11)}$$

Where:

$Q_{CO2,EG,m}$ = Quantity of CO_2 volume in the exhaust gas per kg of residual gas on a dry basis at reference conditions in the minute m (m^3/kg residual gas)

$MF_{C,RG,m}$ = Mass fraction of carbon in the residual gas in the minute m

AM_C = Atomic mass of carbon (kg/kmol)

VM_{ref} = Volume of one mole of any ideal gas at reference temperature and pressure (m^3/kmol)

$$n_{O2,EG,m} = \frac{v_{O_2,EG,m}}{\left(1 - \left(v_{O_2,EG,m}/v_{O_2,air}\right)\right)} \cdot \left[\frac{MF_{C,RG,m}}{AM_C} + \frac{MF_{N,RG,m}}{2 \times AM_N} + \left(\frac{1 - v_{O_2,air}}{v_{O_2,air}} \right) \times F_{O2,RG,m} \right] \quad \text{Tool (12)}$$

Where:

$n_{O2,EG,m}$ = Quantity of O_2 (moles) in the exhaust gas per kg of residual gas flared on a drybasis at reference conditions in minute m (kmol/kg residual gas)

$v_{O2,EG,m}$ = Volumetric fraction of O_2 in the exhaust gas on a dry basis at reference conditions in the minute m

$v_{O2,air}$ = Volumetric fraction of O_2 in the air

$M_{FC,RG,m}$ = Mass fraction of carbon in the residual gas in the minute m

AM_C = Atomic mass of carbon (kg/kmol)

$MF_{N,RG,m}$ = Mass fraction of nitrogen in the residual gas in the minute m

AM_N = Atomic mass of nitrogen (kg/kmol)

$F_{O2,RG,m}$ = Stochiometric quantity of moles of O_2 required for a complete oxidation of one kg residual gas in minute m (kmol/kg residual gas)

$$F_{O2,RG,m} = \frac{MF_{C,RG,m}}{AM_C} + \frac{MF_{H,RG,m}}{4AM_H} - \frac{MF_{O,RG,m}}{2AM_O} \qquad \text{Tool (13)}$$

Where:

$F_{O2,RG,m}$ = Stochiometric quantity of moles of O_2 required for a complete oxidation of one kg residual gas in minute m (kmol/kg residual gas)
$MF_{C,RG,m}$ = Mass fraction of carbon in the residual gas in the minute m
AM_C = Atomic mass of carbon (kg/kmol)
$MF_{O,RG,m}$ = Mass fraction of oxygen in the residual gas in the minute m
AM_O = Atomic mass of oxygen (kg/kmol)
$MF_{H,RG,m}$ = Mass fraction of hydrogen in the residual gas in the minute m
AM_H = Atomic mass of hydrogen (kg/kmol)

Determine the mass fractions of carbon, hydrogen, oxygen and nitrogen in the residual gas, using the volumetric fraction of component i in the residual gas and applying the equation below. In applying this equation, the project participants have chosen option a) "use the measured volumetric fraction of each component *i* of the residual gas", being *i* CH_4, CO, CO_2, O_2, H_2, H_2S, NH_3 and N_2.

$$MF_{j,RG,m} = \frac{\sum_i v_{i,RG,m} \times AM_j \times NA_{j,i}}{MM_{RG,m}} \qquad \text{Tool (14)}$$

Where:

$MF_{j,RG,m}$ = Mass fraction of element j in the residual gas in the minute m
$v_{i,RG,m}$ = Volumetric fraction of component i in the residual gas on a dry basis in the minute m
AM_j = Atomic mass of element j (kg/kmol)
$NA_{j,i}$ = Number of atoms of element j in component i
$MM_{RG,m}$ = Molecular mass of the residual gas in minute m (kg/kmol)
j = elements C, O, H and N
i = Component of residual gas (where i = CH_4, CO, CO_2, O_2, H_2, H_2S, NH_3 and N_2).

Step 3: Calculation of project emissions from flaring

Project emissions from flaring are calculated as the sum of emissions for each minute m in year y, based on the methane mass flow in the residual gas ($F_{CH4,RG,m}$) and the flare efficiency ($\eta_{flare,m}$), as follows:

$$PE_{flare,y} = GWP_{CH4} \times \sum_{m=1}^{525600} F_{CH4,RG,m} \times \left(1 - \eta_{flare,m}\right) \times 10^{-3} \qquad \text{Tool (15)}$$

Where:

$PE_{flare,y}$	= Project emissions from flaring of the residual gas in year y (tCO_2e)
GWP_{CH4}	= Global warming potential of methane valid for the commitment period (tCO_2e/tCH_4)
$F_{CH4,RG,m}$	= Mass flow of methane in the residual gas in the minute m (kg)
$\eta_{flare,m}$	= Flare efficiency in minute m

Hence in this step the next parameters will need to be monitored:

- At the residual gas: $P_{m,\ flame}$; $T_{m,\ flame}$; $V_{RG,m,flame}$; $v_{i,RG,m,flame}$, with m = minute and i=CH_4, CO, CO_2, O_2, H_2, H_2S, NH_3, N_2.
- At the exhaust gas: $fc_{CH4,EG,m}$; $V_{O2,EG,m}$; $T_{EG,m}$, with m = minute.
- At the flare: $Op_{j,h}$; $Flame_m$

Step A.1.1: Ex ante estimation of $F_{CH4,PJ,y}$

An ex ante estimate of $F_{CH4,PJ,y}$ is required to estimate baseline emission of methane from the SWDS (according to equation ACM0001 (2)) in order to estimate the emission reductions of the proposed project activity in the CDM-PDD. It is determined as follows:

$$F_{CH4,PJ,y} = \eta_{PJ} \times BE_{CH4,SWDS,y} / GWP_{CH4}$$ ACM0001 (5)

Where:

$F_{CH4,PJ,y}$	= Amount of methane in the LFG which is flared and/or used in the project activity in year y (tCH_4/yr)
$BE_{CH4,SWDS,y}$	= Amount of methane in the LFG that is generated from the SWDS in the baseline scenario in year y (t CO_2e/yr)
η_{PJ}	= Efficiency of the LFG capture system that will be installed in the project activity
GWP_{CH4}	= Global warming potential of CH_4 (t CO_2e/t CH_4)

$BE_{CH4,SWDS,y}$ is determined using the methodological tool "Emissions from solid waste disposal sites" and taken into account the following when applying the tool:

- f_y in the tool shall be assigned a value of 0 because the amount of LFG that would have been captured and destroyed is already accounted for in equation 2 of this methodology;
- In the tool, x begins with the year that the SWDS started receiving wastes (e.g. the first year of SWDS operation); and
- Sampling to determine the fractions of different waste types is not necessary because the waste composition can be obtained from previous studies.

The amount of methane generated by the site annually is calculated as follows:

$$BE_{CH4,SWDS,y} = \varphi_y \cdot (1-f_y) \cdot GWP_{CH4} \cdot (1-OX) \cdot \frac{16}{12} \cdot F \cdot DOC_{f,y} \cdot MCF_y \cdot \sum_{x=1}^{y} \sum_{j} W_{j,x} \cdot DOC_j \cdot e^{-k_j(y-x)} * (1-e^{-k_j})$$

Tool (1)

Where, for the yearly model:

$BE_{CH4,SWDS,y}$	=	Baseline, project or leakage methane emissions occurring in year *y* generated from waste disposal at a SWDS during a time period ending in year *y* (t CO_2e / yr)
x	=	Years in the time period in which waste is disposed at the SWDS, extending from the first year in the time period (*x* = 1) to year *y* (*x* = *y*).
y	=	Year of the crediting period for which methane emissions are calculated (*y* is a consecutive period of 12 months)
$DOC_{f,y}$	=	Fraction of degradable organic carbon (DOC) that decomposes under the specific conditions occurring in the SWDS for year *y* (weight fraction)
$W_{j,x}$	=	Amount of solid waste type *j* disposed or prevented from disposal in the SWDS in the year *x* (t)
φ_y	=	Model correction factor to account for model uncertainties for year *y*
f_y	=	Fraction of methane captured at the SWDS and flared, combusted or used in another manner that prevents the emissions of methane to the atmosphere in year *y*
GWP_{CH4}	=	Global Warming Potential of methane
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)
MCF_y	=	Methane correction factor for year *y*
DOC_j	=	Fraction of degradable organic carbon in the waste type *j* (weight fraction)
k_j	=	Decay rate for the waste type *j* (1 / yr)
j	=	Type of residual waste or types of waste in the MSW

Under the tool "Emissions from solid waste disposal sites", application A is chosen as "*The CDM project activity mitigates methane emissions from a specific existing SWDS".* So, the amount of wastes is based on information from the SWDS, collected by SGS engineers' study from 2005. The model correction factor (φ_y) is determined based on default value (option 1), for Application A, 0.75. More detailed ex-ante calculations of emission reductions are provided in Appendix 4.

Step A.2: Determination of $F_{CH4,BL,y}$

This step provides a procedure to determine the amount of methane that would have been captured and destroyed (by flaring) in the baseline due to regulatory or contractual requirements, or to address safety and odour concerns (collectively referred to as requirement in this step). In Zone 3 landfill the LFG is not captured but released to the atmosphere as no regulation related to this matter are applicable in Guatemala and there are no safety and odour contractual requirements between the project developer and the municipality (see provided evidence). Therefore, *"Case 1: No requirements to destroy methane exists and no existing LGF capture system*" applies. In this situation:

$$F_{CH4,BL,y} = 0 \qquad \text{Tool (6)}$$

Where:

$F_{CH4,BL,y}$ = Amount of methane in the LFG that would be flared in the baseline in year y (tCH_4/yr)

Step B: Baseline emissions associated with electricity generation ($BE_{EC,y}$)

The baseline emissions associated with electricity generation in year y ($BE_{EC,y}$) shall be calculated using the "Tool to calculate baseline, project and/or leakage emissions from electricity consumption".

When applying the tool:

- The electricity sources k in the tool correspond to the sources of electricity generated identified in the selection of the most plausible baseline scenario; and
- $EC_{BL,k,y}$ in the tool is equivalent to the net amount of electricity generated using LFG in year y ($EG_{PJ,y}$).

  In the absence of the project activity, this electricity would have been produced by power plants connected to the grid. Hence, scenario A described in the Tool applies for the calculation in the following equation:

$$BE_{EC,y} = \sum_k EC_{BL,k} * EF_{EL,k,y} * (1 + TDL_{k,y}) \quad \text{Tool (2)}$$

Where:

$BE_{EC,y}$	= Baseline emissions from electricity generated in year y (tCO_2/yr)
$EC_{BL,k}$	= Quantity of electricity generated in year *y* using LFG (MWh/yr)
$EF_{EL,k,y}$	= Emission factor for electricity generation for source *k* in year *y* (tCO_2/MWh)
$TDL_{k,y}$	= Average technical transmission and distribution losses for providing electricity to source k in year y
k	= Sources of electricity generated in the baseline

Following the option A1 of the scenario A, the $EF_{EL,k,y}$ will be determined by following the "Tool to calculate the emission factor for an electricity system" and $EF_{EL,k,y}$ = $EF_{grid,CM,y}$. This calculation is presented in appendix 4 and results in a value of 0.602 tCO_2/MWh, which will be a fixed value during the first crediting period.

Also, the default value of 13.55% will be used for $TDL_{k,y}$, according to host country specific data[18].

Step C: Baseline emissions associated with heat generation ($BE_{HG,y}$)

Step not taken since it will not be covered any heat generation in this project activity.

Step D: Baseline emissions associated with natural gas use (BENG,y)

Step not taken since it will not be covered any natural gas use from LFG in this project activity.

Project Emissions

According to the methodology ACM0001, project emissions are calculated as follows:

$$PE_y = PE_{EC,y} + PE_{FC,y} \quad \text{ACM0001 (22)}$$

Where:

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[18] Source: http://www.nationsencyclopedia.com/WorldStats/WDI-electric-power-transmission-output.html

PE_y	= Project emissions in year y (tCO_2/yr)
$PE_{EC,y}$	= Emissions from consumption of electricity due to project activity in year y (tCO_2/yr)
$PE_{FC,j,y}$	= Emissions from consumption of fossil fuels due to the project activity, for purpose other than electricity generation, in year y (t CO_2/yr). As no fossil fuels will be used due to the implementation of the project activity, this value is zero (0).

Hence, $PE_y = PE_{EC,y}$.

The project emissions from consumption of electricity by the project activity ($PE_{EC,y}$) shall be calculated using the "Tool to calculate baseline, project and/or leakage emissions from electricity consumption".

When applying the tool:

- $EC_{PJ,k,y}$ in the tool is equivalent to the amount of electricity consumed by the project activity in year y ($EC_{PJ,y}$); and
- If in the baseline a proportion of LFG is destroyed ($F_{CH4,BL,y} > 0$), then the electricity consumption in the tool ($EC_{PJ,j,y}$) should refer to the net quantity of electricity consumption (i.e. the increase due to the project activity). The determination of the amount of electricity consumed in the baseline shall be transparently documented in the CDM-PDD.

$$PE_{EC,y} = \sum_{k} EC_{PJ,j,y} * EF_{EL,j,y} * \left(1 + TDL_{j,y}\right) \qquad \text{Tool (1)}$$

Where:

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

For ex-post project emissions, $EC_{PJ,j,y}$ will be monitored.

The "Tool to calculate baseline, project and/or leakage emissions from electricity consumption" provides 3 scenarios for different sources of electricity consumption. Since the electricity generated through the proposed project is consumed from grid, scenario A is applicable. Following the option A1 of the scenario A, the $EF_{EL,j,y}$ will be determined by following the "Tool to calculate the emission factor for an electricity system" and $EF_{EL,j,y} = EF_{grid,CM,y}$. This calculation is presented in appendix 4 and results in a grid emission factor of 0.602 tCO_2/MWh, which will be a fixed value during the first crediting period.

Also, the default value of 13.55% will be used as for baseline emissions calculations.

Leakage

No leakage effects are accounted for under this methodology.

Emissions reductions

Emission reductions are calculated as follows:

$$ER_y = BE_y - PE_y \qquad \text{ACM0001 (23)}$$

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_2/yr)

As the energy component is intended to be implemented since the first year of the project activity, then the energy component is not excluded from the ex-ante estimation of baseline emissions or the determination of the baseline or demonstration of additionality.

B.6.2. Data and parameters fixed ex ante

Data/Parameter	OX_{top_layer}
Data unit	Dimensionless
Description	Fraction of methane that would be oxidized in the top layer of the SWDS in the baseline
Source of data	Consistent with how oxidation is accounted for in the methodological tool "Emissions from solid waste disposal sites", as indicated in methodology ACM0001 version 13.0.0
Value(s) applied	0.1
Choice of data or measurement methods and procedures	Not applicable as it is a default value provided by the tool "Emissions from solid waste disposal sites. Version 6.0.1" based on an extensive review of published literature on this subject, including the IPCC 2006 Guidelines for National Greenhouse Gas Inventories.
Purpose of data	Calculation of baseline emissions
Additional comment	Applicable to Step A of the methodology ACM0001 version 13.0.0. Note that this parameter would correspond as well as parameter OX indicated in the "Emissions from solid waste disposal sites".

Data/Parameter	$F_{CH4,BL,x-1}$
Data unit	t CH_4/yr
Description	Historical amount of methane in the LFG which is captured and destroyed in the year prior to the implementation of the project activity
Source of data	Information recorded by the SWDS operator
Value(s) applied	0
Choice of data or measurement methods and procedures	In the baseline scenario, LFG in zone 3 landfill is not captured but released to the atmosphere as no regulation related to this matter are applicable.
Purpose of data	Calculation of baseline emissions
Additional comment	-

Data/Parameter	GWP_{CH4}
Data unit	t CO2e/t CH_4
Description	Global warming potential of CH_4
Source of data	IPCC
Value(s) applied	25
Choice of data or measurement methods and procedures	Default data provided by methodology ACM0001 v13. Updated from 21 (default value as per methodology for the first commitment period) to 25 (applicable value for the second commitment period).
Purpose of data	Calculation of baseline emissions
Additional comment	-

Data/Parameter	NCV_{CH4}
Data unit	TJ/t CH_4
Description	Net calorific value of methane at reference conditions
Source of data	Technical literature
Value(s) applied	0.0504
Choice of data or measurement methods and procedures	Default data provided by methodology.
Purpose of data	Calculation of baseline emissions
Additional comment	-

Data/Parameter	η_{PJ}
Data unit	Dimensionless
Description	Efficiency of the LFG capture system that will be installed in the project activity
Source of data	-
Value(s) applied	50%
Choice of data or measurement methods and procedures	Default value to be applied as a conservative assumption when project specific efficiency of the LFG capture system is not available.
Purpose of data	Calculation of baseline emissions
Additional comment	-

Data and parameters available at validation according to methodological tool "Emissions from solid waste disposal sites" version 06.0.1:

Data/Parameter	$w_{j,x}$
Data unit	t
Description	Amount of solid waste type j disposed in the SWDS in the year x
Source of data	"Report of the pump test and pre-feasibility study for landfill gas recovery and utilization at the el Trébol landfill, Guatemala" 2005, from SCS engineers.
Value(s) applied	Please see Appendix 4.
Choice of data or measurement methods and procedures	As no historical records of waste disposal rates exist at Zone 3 landfill, waste input data have been provided by a third party study carried out by SCS Engineers Inc. (SCS) under contract to USAID and the US Environmental Protection Agency Landfill Methane Outreach Program in 2005, which was based on Parsons Report from 1999. Data from this report are project specific value and hence are considered to be the most adequate.
Purpose of data	Calculation of baseline emissions
Additional comment	-

Data/Parameter	φ_y
Data unit	-
Description	Default value for the model correction factor to account for model uncertainties.
Source of data	Methodological tool "Emissions from solid waste disposal sites".
Value(s) applied	0.75
Choice of data or measurement methods and procedures	Default value Application A.
Purpose of data	Calculation of baseline emissions
Additional comment	-

Data/Parameter	OX
Data unit	-
Description	Oxidation factor (reflecting the amount of methane from SWDS that is oxidized in the soil or other material covering the waste)
Source of data	Based on an extensive review of published literature on this subject, including the
Value(s) applied	IPCC 2006 Guidelines for National Greenhouse Gas Inventories
Choice of data or measurement methods and procedures	0.1
Purpose of data	Calculation of baseline emissions
Additional comment	-

Data/Parameter	F
Data unit	-
Description	Fraction of methane in the SWDS gas (volume fraction)
Source of data	IPCC 2006 Guidelines for National Greenhouse Gas Inventories
Value(s) applied	0.5
Choice of data or measurement methods and procedures	A default value of 0.5 is recommended by IPCC.
Purpose of data	Calculation of baseline emissions
Additional comment	Upon biodegradation, organic material is converted to a mixture of methane and carbon dioxide.

Data/Parameter	$DOC_{f,default}$
Data unit	Weight fraction
Description	Default value for the fraction of degradable organic carbon (DOC) in MSW that decomposes in the SWDS
Source of data	IPCC 2006 Guidelines for National Greenhouse Gas Inventories
Value(s) applied	0.5
Choice of data or measurement methods and procedures	This factor reflects the fact that some degradable organic carbon does not
Purpose of data	Calculation of baseline emissions
Additional comment	-

Data/Parameter	$MCF_{default}$
Data unit	-
Description	Methane correction factor
Source of data	IPCC 2006 Guidelines for National Greenhouse Gas Inventories
Value(s) applied	1.0
Choice of data or measurement methods and procedures	A value of 1.0 for anaerobic managed solid waste disposal sites has been chosen, as the landfill has a controlled placement of waste. Wastes are directed to specific deposition areas and is covered by excavation soil, compacted and levelled daily with heavy machines. The landfill will have with a degree of control of scavenging and a degree of control of fires.
Purpose of data	Calculation of baseline emissions
Additional comment	MCF accounts for the fact that unmanaged SWDS produce less methane from a given amount of waste than managed SWDS, because a larger fraction of waste decomposes aerobically in the top layers of unmanaged SWDS.

Data/Parameter	DOC_j
Data unit	-
Description	Fraction of degradable organic carbon in the waste type j (weight fraction)
Source of data	IPCC 2006 Guidelines for National Greenhouse Gas Inventories (adapted from Volume 5, Tables 2.4 and 2.5)
Value(s) applied	For MSW, the following values for the different waste types j should be applied: Table 4 Default values for DOC_j (see table below)
Choice of data or measurement methods and procedures	As per methodological tool "Emissions from solid disposal sites".
Purpose of data	Calculation of baseline emissions
Additional comment	The percentages listed in table above are based on a wet waste basis which areconcentrations in the waste as it is delivered to the SWDS. The IPCC Guidelines also specify DOC values on a dry waste basis, which are the concentrations after complete removal of all moist from the waste, which is not believed practical for this situation

Table 4 Default values for DOC_j

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

<table>
<tr><th>Data/Parameter</th><th>k_j</th></tr>
<tr><td>Data unit</td><td>1/yr</td></tr>
<tr><td>Description</td><td>Decay rate for the waste type j</td></tr>
<tr><td>Source of data</td><td>IPCC 2006 Guidelines for National Greenhouse Gas Inventories (adapted from Volume 5, Table 3.3)</td></tr>
<tr><td>Value(s) applied</td><td><table>
<tr><td rowspan="2">Slowly degrading</td><td>Pulp, paper, cardboard (other than sludge), textiles</td><td>0.04</td></tr>
<tr><td>Wood, wood products and straw</td><td>0.02</td></tr>
<tr><td>Moderately degrading</td><td>Other (non-food) organic putrescible garden and park waste</td><td>0.05</td></tr>
<tr><td>Rapidly degrading</td><td>Food, food waste, sewage sludge, beverages and tobacco</td><td>0.06</td></tr>
</table></td></tr>
<tr><td>Choice of data or measurement methods and procedures</td><td>According to Mean Annual Precipitation (MAP) = 1,188 mm Mean Annual Temperature (MAT) = 18 ºC
Potential Evapotranspiration (PET) = 1,500 mm
Hence, Boreal and temperature (MAT≤20ºC) and Dry (MAP/PET<1) values are chosen for parameter k.</td></tr>
<tr><td>Purpose of data</td><td>Calculation of baseline emissions</td></tr>
<tr><td>Additional comment</td><td>Climatic conditions of the project site are provided by www.worldclimate.com for data.</td></tr>
</table>

<table>
<tr><th>Data/Parameter</th><th>fy</th></tr>
<tr><td>Data unit</td><td>-</td></tr>
<tr><td>Description</td><td>Fraction of methane captured at the SWDS and flared, combusted or used in another manner that prevents the emissions of methane to the atmosphere in year y</td></tr>
<tr><td>Source of data</td><td>Historic data on the amount captured</td></tr>
<tr><td>Value(s) applied</td><td>0</td></tr>
<tr><td>Choice of data or measurement methods and procedures</td><td>Provided by the tool.</td></tr>
<tr><td>Purpose of data</td><td>Calculation of baseline emissions</td></tr>
<tr><td>Additional comment</td><td>fy in the tool shall be assigned a value of 0 because the amount of LFG that would have been captured and destroyed is already accounted for in equation 2 of this methodology.</td></tr>
</table>

Data and parameters available at validation according to "Tool to calculate baseline, project and/or leakage emissions from electricity consumption" version 1:

Data/Parameter	$EF_{grid,CM,y}$
Data unit	tCO2/MWh
Description	Combined margin emission factor for the grid in year y
Source of data	Calculate the combined margin emission factor, using the procedures in the latest approved version of the “Tool to calculate the emission factor for an electricity system”.
Value(s) applied	0.602
Choice of data or measurement methods and procedures	As per the “Tool to calculate the emission factor for an electricity system”.
Purpose of data	Calculation of baseline and project emissions
Additional comment	-

Data and parameters available at validation according tool “Project emissions from flaring” version 02.0.0:

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_{ref}	Pa	Atmospheric pressure at reference conditions	101 325
R_{u}	$Pa.m^3/kmol.K$	Universal ideal gas constant	0.008314472
T_{ref}	K	Temperature at reference conditions	273.15
$v_{O2,air}$	Dimensionless	O_2 volumetric fraction of air	0.21
GWP_{CH4}	tCO_2/tCH_4	Global warming potential of methane valid for the commitment period	21 (for the first commitment period)
MV_{n}	$m^3/Kmol$	Volume of one mole of any ideal gas at reference conditions	22.414
$\rho_{CH4,n}$	kg/m^3	Density of methane gas at reference conditions	0.716
$NA_{i,j}$	Dimensionless	Number of atoms of element j in component i, depending on molecular structure	
VM_{ref}	m^3 / kmol	Volume of one mole of any ideal gas at reference temperature and pressure	22.4

Data/Parameter	$SPEC_{flare}$
Data unit	Temperature- ºC Flow rate or heat flux – kg/h or m^3/h Maintenance schedule - number of days
Description	Manufacturer's flare specifications for temperature, flow rate and maintenance schedule.
Source of data	Flare manufacturer
Value(s) applied	1,100ºC 2,000 m^3/h Maintenance schedule according to the service plan ("Plan de servicio")
Choice of data or measurement methods and procedures	The flare specifications set by the manufacturer for the correct operation of the flare for the following parameters are: (a) Minimum and maximum inlet flow rate: 600 - 2,000 Nm^3/h (b) Minimum and maximum operating temperature: 800-1,200 ºC (c) Maximum duration in days between maintenance events: 90 days
Purpose of data	Calculation of baseline emissions
Additional comment	Applicable in case of enclosed flares.

Data and parameters available at validation according "Tool to determine the mass flow of a greenhouse gas in a gaseous stream" version 2.0.0:

Data/Parameter	Ru
Data unit	Pa.m3/kmol.K
Description	Universal ideal gases constant
Source of data	"Tool to determine the mass flow of a greenhouse gas in a gaseous stream"
Value(s) applied	0.008314472
Choice of data or measurement methods and procedures	Constant as per "Tool to determine the mass flow of a greenhouse gas in
Purpose of data	Calculation of baseline emissions
Additional comment	-

Data/Parameter	MMi
Data unit	kg/kmol
Description	Molecular mass of greenhouse gas i
Source of data	"Tool to determine the mass flow of a greenhouse gas in a gaseous stream"
Value(s) applied	MM_{CH4} = 16.04 kg/kmol
Choice of data or measurement methods and procedures	Constant as per "Tool to determine the mass flow of a greenhouse gas in a gaseous stream". Note that the methane (CH_4) contained in the LFG will constitute the main greenhouse gas to be monitored.
Purpose of data	Calculation of baseline emissions
Additional comment	-

<table>
<tr><th>Data/Parameter</th><th>MM_k</th></tr>
<tr><td>Data unit</td><td>kg/kmol</td></tr>
<tr><td>Description</td><td>Molecular mass of gas k</td></tr>
<tr><td>Source of data</td><td>“Tool to determine the mass flow of a greenhouse gas in a gaseous stream”</td></tr>
<tr><td>Value(s) applied</td><td>
<table>
<tr><th>Compound</th><th>Structure</th><th>Molecular mass (kg / kmol)</th></tr>
<tr><td>Nitrogen</td><td>N_2</td><td>28.01</td></tr>
<tr><td>Oxygen</td><td>O_2</td><td>32.00</td></tr>
<tr><td>Carbon monoxide</td><td>CO</td><td>28.01</td></tr>
<tr><td>Hydrogen</td><td>H_2</td><td>2.02</td></tr>
<tr><td>Nitric oxide</td><td>NO</td><td>30.01</td></tr>
<tr><td>Nitrogen dioxide</td><td>NO_2</td><td>46.01</td></tr>
<tr><td>Sulfur dioxide</td><td>SO_2</td><td>64.06</td></tr>
</table>
</td></tr>
<tr><td>Choice of data or measurement methods and procedures</td><td>Constant as per “Tool to determine the mass flow of a greenhouse gas in a gaseous stream”.</td></tr>
<tr><td>Purpose of data</td><td>Calculation of baseline emissions</td></tr>
<tr><td>Additional comment</td><td>-</td></tr>
</table>

Data/Parameter	P_n
Data unit	Pa
Description	Total pressure at normal conditions
Source of data	“Tool to determine the mass flow of a greenhouse gas in a gaseous stream”
Value(s) applied	101,325 Pa
Choice of data or measurement methods and procedures	Constant as per “Tool to determine the mass flow of a greenhouse gas in
Purpose of data	Calculation of baseline emissions
Additional comment	-

Data/Parameter	T_n
Data unit	K
Description	Temperature at normal conditions
Source of data	“Tool to determine the mass flow of a greenhouse gas in a gaseous stream”
Value(s) applied	273.15 K
Choice of data or measurement methods and procedures	Constant as per “Tool to determine the mass flow of a greenhouse gas in
Purpose of data	Calculation of baseline emissions
Additional comment	-

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 as well as the estimation of the electrical generation produced.

According to methodology ACM0001, emission reductions are calculated as follows:

$ER_y = BE_y - PE_y$ ACM0001 (23)

$BE_y = BE_{CH4,y} + BE_{EC,y}$ ACM0001 (1)

- **Baseline emissions of methane from the SWDS ($BE_{CH4,y}$)** calculation according to methodological tool "Emissions from solid waste disposal site":

$$BE_{CH4,y} = (1 - OX_{top\_layer}) \times (F_{CH4,PJ,y} - F_{CH4,BL,y}) \times GWP_{CH4}$$ ACM0001 (2)

Where, $F_{CH4,PJ,y} = \eta_{PJ} \times BE_{CH4,SWDS,y} / GWP_{CH4}$ ACM0001 (5)

Where, GWP_{CH4} is 21 according to the tool, η_{PJ} is the efficiency of the LFG capture system that will be installed in the project activity and is assumed to be 50% as default value and,

$$BE_{CH4,SWDS,y} = \varphi_y \cdot (1-f_y) \cdot GWP_{CH4} \cdot (1-OX) \cdot \frac{16}{12} \cdot F \cdot DOC_{f,y} \cdot MCF_y \cdot \sum_{x=1}^{y} \sum_j W_{j,x} \cdot DOC_j \cdot e^{-k_j(y-x)} * (1-e^{k_j})$$

Default values are provided by the tool and the amount of solid waste type j disposed in the SWDS is provided by the SCS engineers' specific study from 2005.

The reader is therefore asked to refer to Appendix 4 for more information on this model and the parameters used, as well as to the Excel spreadsheet in order to verify the formulae that were used and to check the results presented in this chapter.

- **Baseline emissions associated with electricity generation ($BE_{EC,y}$)** calculation according to "Tool to calculate baseline, project and/or leakage emissions from electricity consumption":

$$BE_{EC,y} = \sum_k EC_{BL,k} * EF_{EL,k,y} * (1 + TDL_{k,y})$$ Tool (2)

$EC_{BL,k}$ = The quantity of electricity consumed in the baseline corresponds to the electricity that the project activity will generate as electricity generation will be provided to the electrical national grid.

Estimation of this parameter is based on power engine characteristics and biogas capture capacity of the landfill. Calculations, which are explained in Appendix 4 and in biogas model spreadsheet, are based in the assumption of installation 4 power engines of 1.2 MW and 8,000 working hours. Please see Appendix 4 and in biogas model spreadsheet.

$EF_{EL,k,y}$ = Following the option A1 of the scenario A, the $EF_{EL,k,y}$ is determined by following the "Tool to calculate the emission factor for an electricity system" and $EF_{EL,k,y}$ = $EF_{grid,CM,y}$. This calculation is presented in appendix 4 and results in 0.602 tCO_2/MWh, which will be a fixed value during the first crediting period.

$TDL_{k,y}$ = default value of 13.55%, according to host country specific data.

- **Project emissions ($PE_{EC,y}$)** calculation according to "Tool to calculate baseline, project and/or leakage emissions from electricity consumption":

$$PE_{EC,y} = \sum_{k} EC_{PJ,j,y} * EF_{EL,j,y} * \left(1 + TDL_{j,y}\right) \quad \text{Tool (1)}$$

$EC_{PJ,j}$ = The quantity of electricity consumed by the project electricity consumption source j corresponds to the electricity consumed by the project from the grid whenever the power station is not working.

Estimation of this parameter is based on consumption of flare when power engines are not working. Calculations, which are explained in Appendix 4 and in biogas model spreadsheet, are based in the assumption of installation of 2 flares of 75 kW electricity consumption and working in continuous. Please see Appendix 4 and in biogas model spreadsheet.

$EF_{EL,j,y}$ = Following the option A1 of the scenario A, the $EF_{EL,k,y}$ is determined by following the "Tool to calculate the emission factor for an electricity system" and $EF_{EL,k,y}$ = $EF_{grid,CM,y}$. This calculation is presented in appendix 4 and results in 0.602 tCO_2/MWh, which will be a fixed value during the first crediting period.

$TDL_{j,y}$ = specific host country default value of 13.55%. This value will be checked annually in order to ensure the use of the most recent, accurate and reliable data available according to the Tool.

According to ex-ante emission reduction estimations:

First crediting period Years	Baseline emissions of methane from the SWDS							Baseline emissions associated with electricity generation				Project emissions				Emissions reductions (tCO2e)
	$BE_{CH4,SWDS}$ (tCO2e/y)	ηPJ	GWP_{CH4}	$F_{CH4,PJ}$ (t-CH4/y)	$F_{CH4,BL}$	OX	BE_{CH4} (tCO_2e)	$EC_{BL,k}$ (MWh)	$EF_{BL,k}$ (tCO_2/MWh)	TDL_k	BE_{EC} (tCO_2e)	$EC_{PJ,j}$ (MWh)	$EF_{EL,k}$ (tCO_2/MWh)	TDL_j	PE_{EC} (tCO_2e)	
26/07/2014	124,185	50%	25	2,484	0	0.1	55,883	13,657	0.602	13.55%	9,337	49	0.602	13.55%	34	**65,186**
2015	298,594	50%	25	5,972	0	0.1	134,367	31,532	0.602	13.55%	21,558	114.0	0.602	13.55%	78	**155,847**
2016	310,748	50%	25	6,215	0	0.1	139,836	31,532	0.602	13.55%	21,558	114.0	0.602	13.55%	78	**161,316**
2017	323,211	50%	25	6,464	0	0.1	145,445	31,532	0.602	13.55%	21,558	114.0	0.602	13.55%	78	**166,924**
2018	329,602	50%	25	6,592	0	0.1	148,321	31,532	0.602	13.55%	21,558	114.0	0.602	13.55%	78	**169,801**
2019	336,428	50%	25	6,729	0	0.1	151,393	31,532	0.602	13.55%	21,558	114.0	0.602	13.55%	78	**172,872**
2020	343,693	50%	25	6,874	0	0.1	154,662	31,532	0.602	13.55%	21,558	114.0	0.602	13.55%	78	**176,142**
25/07/2021	199,769	50%	25	3,995	0	0.1	89,896	17,926	0.602	13.55%	12,255	65	0.602	13.55%	44	**102,107**

Note: Calculations for first crediting period starting on July 2014. Hence 2014 and 2021 are not complete years.

Please refer to Appendix 4 and Biogas model spreadsheet for detailed calculations.

B.6.4. Summary of ex ante estimates of emission reductions

Year	Baseline emissions (t CO_2e)	Project emissions (t CO_2e)	Leakage (t CO_2e)	Emission reductions (t CO_2e)
26/07/2014	65,220	17	0	65,203
2015	155,925	39	0	155,886
2016	161,394	39	0	161,355
2017	167,002	39	0	166,963
2018	169,878	39	0	169,839
2019	172,950	39	0	172,911
2020	176,220	39	0	176,181
25/07/2021	102,151	22	0	102,129
Total	**1,170,741**	**273**	**0**	**1,170,468**
Total number of crediting years	7			
Annual average over the crediting period	167,249	39	0	167,210

Note: Calculations for first crediting period starting on July 2014. Hence 2014 and 2021 are not complete years

B.7. Monitoring plan

B.7.1. Data and parameters to be monitored

Data/Parameter	**Management of SWDS**
Data unit	-
Description	Management of SWDS
Source of data	Technical specifications for the management of the SWDS
Value(s) applied	The management of SWDS remains as per the description in the PDD.
Measurement methods and procedures	Project participants refer to the original design of the landfill to ensure that any practice to increase methane generation not occur after the implementation of the project activity. Any change in the management of the SWDS after the implementation of the project activity will need to be justified by referring to technical or regulatory specifications.
Monitoring frecuency	Annually
QA/QC procedures	-
Purpose of data	Baseline emissions calculation
Additional comment	-

Data/Parameter	**$Op_{j,h}$**
Data unit	Hours
Description	Operation of the equipment that consumes the LFG (Flare and 4 power generators).
Source of data	On-site measurements using Flame detector, Hour meter.

Value(s) applied	Ex-ante values: 8,000 h/yr for power generators
Measurement methods and procedures	For each equipment unit j using the LFG monitor that the plant is operating in hour h by the monitoring any one or more of the following three parameters: ▪ Temperature. Determine the location for temperature measurements and minimum operational temperature based on manufacturer's specifications of the burning equipment. Document and justify the location and minimum threshold in the PDD. ▪ Flame. Flame detection system is used to ensure that the equipment is in operation. ▪ Products generated. Monitor the generation of steam for the case of boilers and air-heaters and glass for the case of glass melting furnaces. This option is not applicable to brick kilns. As per technical specifications of the manufacturer, the installed engines include a working hours meter, as well as an output electricity meter. Hence, in this case, Opj,h=0 when: ▪ Hours meter detects a non-working hour, or ▪ No electricity is generated the power engine as per electricity meters monitoring. ▪ Otherwise, Opj,h=1
Monitoring frequency	Hourly
QA/QC procedures	Hour meters are subject to regular maintenance and testing regime to ensure accuracy.
Purpose of data	Baseline and project emissions calculation
Additional comment	-

Data/Parameter	**$EG_{PJ,y}$**
Data unit	MWh
Description	Amount of electricity generated using LFG by the project activity in year y
Source of data	Electricity meters
Value(s) applied	-
Measurement methods and procedures	Monitor net electricity generation by the project activity using LFG.
Monitoring frequency	Continuous
QA/QC procedures	Electricity meters are subject to regular maintenance in accordance with "maintenance schedule" provided from electricity meters supplier. Also meters are calibrated once a year in accordance to national calibration standards.
Purpose of data	Baseline emissions calculation
Additional comment	Main and back up bidirectional electricity meters are installed just before the connexion to the grid. Meters are crosschecked with electricity company monthly bills.

Data/Parameter	$EG_{EC,y}$ (equivalent to $EC_{PJ,j,y}$)
Data unit	MWh
Description	Amount of electricity consumed by the project activity in year y
Source of data	Electricity meters Sources of consumption shall include, where applicable, electricity consumed for the operation of the LFG capture system, for any processing and upgrading of the LFG, for transportation of the LFG to the flare or other applications (boilers, power generators), for the compression of the LFG into the natural gas network, etc.
Value(s) applied	-
Measurement methods and procedures	Monitor net electricity consumption by the project activity operation.
Monitoring frequency	Continuous
QA/QC procedures	Electricity meter is subject to regular (in accordance with stipulation of the meter supplier) maintenance and testing to ensure accuracy. The readings are double checked by the electricity distribution company.
Purpose of data	Project emissions calculation
Additional comment	This parameter is required for calculating project emissions from electricity consumption due to an alternative waste treatment process t ($PE_{EC,y}$) using the "Tool to calculate baseline, project and/or leakage emissions from electricity consumption".

Data and parameters to be monitored according to "Tool to calculate baseline, project and/or leakage emissions from electricity consumption" version 1, scenario A:

Data/Parameter	$TDL_{k,y}$
Data unit	%
Description	Average technical transmission and distribution losses for providing electricity to source k in year y
Source of data	The World Bank. Electric power transmission and distribution losses (% of output). IEA Statistics © OECD/IEA 2018. Guatemala. Most recent year: 2014 (https://data.worldbank.org/indicator/eg.elc.loss.zs?most_recent_year_desc=true)
Value(s) applied	13.55%
Measurement methods and procedures	As scenario A is chosen, first option is applied "use recent, accurate and reliable data available within the host country".
Monitoring frequency	Annually
QA/QC procedures	Default data is checked annually in order to ensure the use of the most recent, accurate and reliable data available, according to the Tool.
Purpose of data	Baseline and project emissions calculation
Additional comment	Not applicable

Data and parameters to be monitored according to "Tool to determine the mass flow of a greenhouse gas in a gaseous stream" version 02.0.0, Option A:

For gaseous stream sent to the flare:

Data/Parameter	V_{t,db_flare}
Data unit	m³ dry gas/h
Description	Volumetric flow of the gaseous stream sent to the flare in time interval t on a dry basis
Source of data	Flowmeter
Value(s) applied	-
Measurement methods and procedures	Volumetric flow measurement should always refer to the actual pressure and temperature. Instruments with recordable electronic signal (analogical or digital) are required.
Monitoring frequency	Continuous (each hour and each minute m)
QA/QC procedures	Periodic calibration against a primary device provided by an independent accredited laboratory will be carried out as it is mandatory according to the tool. Calibration and frequency of calibration will be carried out according to manufacturer's specifications.
Purpose of data	Baseline and project emission calculation
Additional comment	Monitored as Options A is chosen. This parameter is measured before the flare.

Data/Parameter	V_{i,t,db_flare}
Data unit	m³ gas i /m³ dry gas
Description	Volumetric fraction of greenhouse gas i in the gaseous stream sent to flare in time interval t on a dry basis
Source of data	On-site measurements using a continuous gas analyzer
Value(s) applied	-
Measurement methods and procedures	Continuous gas analyzer operating in dry basis. Volumetric flow measurement should always refer to the actual pressure and temperature.
Monitoring frequency	Continuous (each hour and each minute m)
QA/QC procedures	Calibration will include zero verification with an inert gas (e.g. N2) and at least one reading verification with a standard gas (single calibration gas or mixture calibration gas). All calibration gases will have a certificate provided by the manufacturer and will be under their validity period.
Purpose of data	Baseline and project emissions calculation
Additional comment	Monitored as Option A is chosen. This parameter will be measured before each flare.

Data/Parameter	T_{t_flare}
Data unit	K
Description	Temperature of the gaseous stream sent to the flare in time interval t
Source of data	Temperature sensor
Value(s) applied	-
Measurement methods and procedures	Instruments with recordable electronic signal (analogical or digital)
Monitoring frequency	Continuous (each hour and each minute m)
QA/QC procedures	Periodic calibration against a primary device provided by an independent accredited laboratory is carried out as it is mandatory according to the tool. Calibration and frequency of calibration is carried out according to manufacturer's specifications.

Purpose of data	Not used. The flow meters automatically measure temperature and pressure, expressing LFG volumes in normalized cubic meters (Nm3).
Additional comment	As the applicability condition related to the gaseous stream flow temperature being below 60ºC is adopted, this parameter must be monitored continuously to assure the applicability condition is met. This parameter will be measured before each flare.

Data/Parameter	$\mathbf{P_{t\_flare}}$
Data unit	Pa
Description	Absolute pressure of the gaseous stream sent to the flare in time interval t
Source of data	Pressure transmitter
Value(s) applied	-
Measurement methods and procedures	This parameter will be monitored unless equipment gives the pressure value already converted to normal conditions. This parameter will be measured before each flare.
Monitoring frequency	Continuous (each hour and each minute m)
QA/QC procedures	Annual calibration against a primary device is performed and records of calibration procedures will be kept available as well as primary device and its calibration certificate
Purpose of data	Not used. The flow meters automatically measure temperature and pressure, expressing LFG volumes in normalized cubic meters (Nm3).
Additional comment	-

For gaseous stream sent to electric engines:

Data/Parameter	$\mathbf{V_{t,db\_electricity}}$
Data unit	m³ dry gas/h
Description	Volumetric flow of the gaseous stream used for electricity generation in time interval t on a dry basis
Source of data	Flow meter
Value(s) applied	-
Measurement methods and procedures	The value of the monitored value shown in this table will be the result of the sum of the different measured flows at the entrance of each of the four electric engines in which raw data in the same time interval accomplish the following operational condition: • Condition 1: $V_{t,db\_electricity}$ between 400 and 2000 Nm3/h
Monitoring frequency	Continuous (each hour)
QA/QC procedures	Periodic calibration against a primary device provided by an independent accredited laboratory is carried out as it is mandatory according to the tool. Calibration and frequency of calibration is carried out according to manufacturer's specifications.
Purpose of data	Baseline emissions calculation
Additional comment	Monitored as Options A is chosen. This parameter will be measured at the entrance of each electric engine.

Data/Parameter	**$V_{i,t,db\_electricity}$**
Data unit	m³ gas i /m³ dry gas
Description	Volumetric fraction of greenhouse gas i in the gaseous stream used for electricity generation in time interval t on a dry basis
Source of data	On-site measurements using a continuous gas analyzer operating in dry basis.
Value(s) applied	-
Measurement methods and procedures	Continuous gas analyzer operating in dry basis. This parameter will be measured at the entrance of each electric engine.
Monitoring frequency	Continuous (each hour)
QA/QC procedures	Calibration will include zero verification with an inert gas (e.g. N2) and at least one reading verification with a standard gas (single calibration gas or mixture calibration gas). All calibration gases will have a certificate provided by the manufacturer and will be under their validity period.
Purpose of data	Baseline emissions calculation
Additional comment	Monitored as Option A is chosen.

Data/Parameter	**$T_{t\_electricity}$**
Data unit	K
Description	Temperature of the gaseous stream used for electricity generation in time interval t
Source of data	Temperature sensor
Value(s) applied	-
Measurement methods and procedures	The value of the monitored value shown in this table will be result of the weighted average. The flow meters automatically measure temperature and pressure, expressing LFG volumes in normalized cubic meters (Nm3).
Monitoring frequency	Continuous (each hour and each minute m)
QA/QC procedures	Periodic calibration against a primary device provided by an independent accredited laboratory is carried out as it is mandatory according to the tool. Calibration and frequency of calibration is carried out according to manufacturer's specifications.
Purpose of data	Not used in the baseline or project emissions calculation.
Additional comment	As the applicability condition related to the gaseous stream flow temperature being below 60ºC is adopted, this parameter must be monitored continuously to assure the applicability condition is met. This parameter will be measured at the entrance of each electric engine.

Data/Parameter	**$P_{t\_electricity}$**
Data unit	Pa
Description	Absolute pressure of the gaseous stream used for electricity generation in time interval t
Source of data	Pressure transmitter
Value(s) applied	-

Measurement methods and procedures	Measured but not used in the calculation. The flow meters automatically measure temperature and pressure, expressing LFG volumes in normalized cubic meters (Nm^3). The value of the monitored value shown in this table will be the result of the weighted average. The flow meters automatically measure temperature and pressure, expressing LFG volumes in normalized cubic meters (Nm^3).
Monitoring frequency	Continuous (each hour and each minute m)
QA/QC procedures	Annual calibration against a primary device is performed and records of calibration procedures will be kept available as well as primary device and its calibration certificate
Purpose of data	Not used. The flow meters automatically measure temperature and pressure, expressing LFG volumes in normalized cubic meters (Nm^3).
Additional comment	This parameter will be monitored unless equipment gives the pressure value already converted to normal conditions. This parameter will be measured at the entrance of each electric engine.

Data and parameters to be monitored according to tool "Project emissions from flaring" version 02.0.0, Option B.2:

At the residual gas:

Data/Parameter	**$V_{RG,m}$ (=V_{t,db_flare})**
Data unit	m^3
Description	Volumetric flow of the residual gas on a dry basis at reference conditions in the minute m
Source of data	Flow meter
Value(s) applied	-
Measurement methods and procedures	The value of the monitored value shown in this table will be the result of the accumulated flow in which raw data in the same time interval accomplish the following two operational conditions at the same time: • Condition 1: Operation of the flare that consumes the LFG: Tflare between 900 and 1200 ºC • Condition 2: V_{t,db_flare} between 400 and 2000 Nm3/h
Monitoring frequency	Continuously. Values to be averaged on a minute basis
QA/QC procedures	Periodic calibration against a primary device provided by an independent accredited laboratory is carried out as it is mandatory according to the tool. Calibration and frequency of calibration is carried out according to manufacturer's specifications
Purpose of data	Baseline and project emission calculation
Additional comment	Monitoring of this parameter is applicable in case of enclosed flares and continuous monitoring of the flare efficiency and if project participant selects to calculate MRG,m instead of monitoring directly. This parameter is measured before the flare.

Data/Parameter	**$V_{i,RG,m}$ (=V_{i,t,db_flare})**
Data unit	-
Description	Volumetric fraction of component i in the residual gas on a dry basis at minute m where i = CH4, CO, CO2, O2, H2, H2S, NH3 and N2.

Source of data	Continuous gas analyser operating in dry basis. On-site measurements using a continuous gas analyser
Value(s) applied	-
Measurement methods and procedures	The value of the monitored value shown in this table will be the result of the weighted average in which raw data in the same time interval accomplish the following two operational conditions at the same time: • Condition 1: Operation of the flare that consumes the LFG: Tflare between 900 and 1200 ºC • Condition 2: V_{t,db_flare} between 400 and 2000 Nm3/h
Monitoring frequency	Continuous (each hour and each minute m)
QA/QC procedures	Calibration includes zero verification with an inert gas (e.g. N_2) and at least one reading verification with a standard gas (single calibration gas or mixture calibration gas). All calibration gases has a certificate provided by the manufacturer and is under their validity period.
Purpose of data	Baseline and project emissions calculation
Additional comment	Monitoring of this parameter is applicable in case of enclosed flares and continuous monitoring of the flare efficiency. This parameter will be measured before each flare.

At the exhaust gas:

Data/Parameter	$T_{EG,m}$
Data unit	°C
Description	Temperature in the exhaust gas of the enclosed flare (n) in minute m
Source of data	Temperature sensor
Value(s) applied	-
Measurement methods and procedures	The value of the monitored value shown in this table will be the result of the weighted average in which raw data in the same time interval accomplish the following operational condition: • Condition 1: Operation of the flare that consumes the LFG: Tflare between 900 and 1200 ºC
Monitoring frequency	Each minute
QA/QC procedures	Measurements outside the operational temperature specified by the manufacturer may indicate that the flare is not functioning correctly and may require maintenance. Suitable monitoring ports for the monitoring of the temperature of the flare are provided by the manufacturers. Temperature measurement equipment will be replaced or calibrated in accordance with their maintenance schedule.
Purpose of data	Project emissions calculation
Additional comment	Unexpected changes such as a sudden increase/drop in temperature can occur for different reasons. These events will be noted in the site records along with any corrective action that was implemented to correct the issue. This parameter is measured in the exhaust gas released by the enclosed flare.

Data/Parameter	$v_{O2,EG,m}$
Data unit	-

Description	Volumetric fraction of O2 in the exhaust gas on a dry basis at reference conditions in the minute m
Source of data	Continuous gas analyser
Value(s) applied	-
Measurement methods and procedures	The value of the monitored value shown in this table will be the result of the weighted average in which raw data in the same time interval accomplish the following operational condition: • Condition 1: Operation of the flare that consumes the LFG: Tflare between 900 and 1200 ºC
Monitoring frequency	Continuously. Values to be averaged on a minute basis
QA/QC procedures	The point of measurement is in the upper section of the flare (80% of total flare height). Analysers are annually calibrated according to manufacturer's recommendation. A zero check and a typical value check is performed by comparison with a certified gas
Purpose of data	Project emissions calculation
Additional comment	Monitoring of this parameter is only applicable in case of enclosed flares and continuous monitoring of the flare efficiency.

Data/Parameter	**$fc_{CH4,EG,m}$**
Data unit	mg/m^3
Description	Concentration of methane in the exhaust gas of the flare (n) on a dry basis at reference conditions in the minute m
Source of data	Continuous gas analyser
Value(s) applied	-
Measurement methods and procedures	The value of the monitored value shown in this table will be the result of the weighted average in which raw data in the same time interval accomplish the following operational condition: • Condition 1: Operation of the flare that consumes the LFG: Tflare between 900 and 1200 ºC
Monitoring frequency	Continuously. Values to be averaged on a minute basis
QA/QC procedures	The point of measurement is in the upper section of the flare in order that the measurement is of the gas after consumption has taken place (80% of total flare height). Analysers are annually calibrated according to manufacturer's recommendation. A zero check and a typical value check is performed by comparison with a standard gas
Purpose of data	Project emissions calculation
Additional comment	Monitoring of this parameter is only applicable in case of enclosed flares and continuous monitoring of the flare efficiency.

Data/Parameter	**$Flame_m$**
Data unit	Flame on or Flame off
Description	Flame detection of flare in the minute m
Source of data	Optical flame detector

Value(s) applied	-
Measurement methods and procedures	Additionally, two operational conditions are used to check the operational time under the manufacturer conditions of the flare: • Condition 1: Operation of the flare that consumes the LFG: Tflare between 900 and 1200 ºC • Condition 2: Vt,db_flare between 400 and 2000 Nm3/h
Monitoring frequency	Monitoring frequency: Once per minute.
QA/QC procedures	Detection of flame recorded as a minute that the flame was on, otherwise recorded as a minute that the flame was off. Equipment is maintained and calibrated in accordance with manufacturer's recommendations.
Purpose of data	Project emissions calculation
Additional comment	Not applicable.

Data/Parameter	**$Maintenance_y$**
Data unit	Calendar dates
Description	Maintenance events completed in year y
Source of data	Manufacturer's specifications
Value(s) applied	Please see maintenance check registry.
Measurement methods and procedures	Record of maintenance events performed.
Monitoring frequency	Annual
QA/QC procedures	Date that maintenance events were completed are recorded. Records of maintenance logs include all aspects of the maintenance including the details of the person(s) undertaking the work, parts replaced, or needing to be replaced, source of replacement parts, serial numbers, and calibration certificates. Records are kept in a maintenance log for two years beyond the life of the flare.
Purpose of data	Record evidence of maintenance events and calibration of the monitoring equipment and project equipment.
Additional comment	Not applicable

B.7.2. Sampling plan

No sampling plan has been performed during this monitoring period.

B.7.3. Other elements of monitoring plan

The parameters monitored in the project activity are the following:

Op_{jh}	Operation hours of each power generator
Flame	Flame detection of flare in the minute m
$Maintenance_y$	Maintenance events completed in year Y
$EG_{PJ}1_{,y}$	Amount of electricity generated by engine 1 using LFG by the Project activity in year Y
$EG_{PJ}2_{,y}$	Amount of electricity generated by engine 2 using LFG by the Project activity in year Y
$EG_{PJ}3_{,y}$	Amount of electricity generated by engine 3 using LFG by the Project activity in year Y
$EG_{PJ}4_{,y}$	Amount of electricity generated by engine 4 using LFG by the Project activity in year Y
$EG_{PJ}PPA1_{,y}$	Amount of electricity generated using LFG by the Project activity in year Y under PPA 1
$EG_{PJ}PPA2_{,y}$	Amount of electricity generated using LFG by the Project activity in year Y under PPA 2
$EG_{EC,y}$	Amount of electricity consumed by the Project activity in year Y
$V_{t,db}$	Volumetric Flow of the gaseous stream in time Interval t on a dry basis
$V_{i,t,db}$	Volumetric fraction of greenhouse gas / in the gaseous stream in time Interval t on a dry basis
P_t	Absolute pressure of the gaseous stream in time Interval t
T_t	Temperature of the gaseous stream in time Interval t with t = hour /minute and i = CH_4

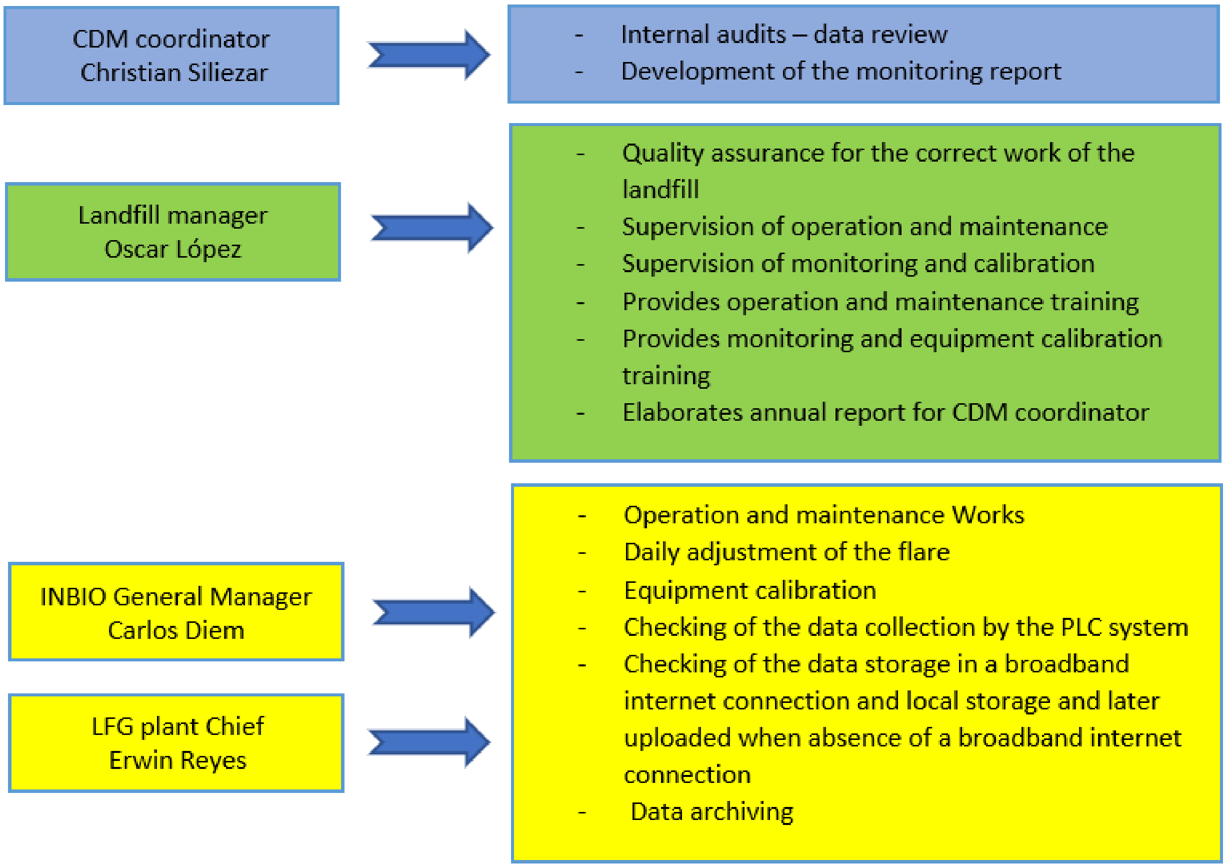
<u>Residual gas:</u>

$V_{RG,m}$	Volumetric Flow of the residual gas on a dry basis at reference conditions in the minute m
$V_{I,RG,m}$	Volumetric fraction of component i in the residual gas on a dry basis at minute m where i = CH_4, CO, CO_2, O_2, H_2, H_2S, NH_3 and N_2 At reference conditions, with t = minute and i = CH_4, CO, CO_2, O_2, H_2, H_2S, NH_3 and N_2

<u>Exhaust gas:</u>

$Fc_{CH4,EG,m}$	Concentration of methane in the exhaust gas of the flare on a dry basis at reference conditions in the minute m
$V_{O2,EG,m}$	Volumetric fraction of O_2 in the exhaust gas on a dry basis at reference conditions in the minute m

Roles and responsibilities in the Monitoring Plan:



Data collection and recording:

Please see the parameters to be monitored as well as the location of the measurement equipment at the flow diagram (Section B.3).

Daily readings of all field meters will be documented in paper worksheets. Additionally, all data collected will be recorded in electronic files and backups will be made regularly. Data from the different measuring instruments will be collected by a central PLC (programmable logic controller) and uploaded to a web storage facility.

All parameters will be measured continuously and logged at one minute intervals or one hour interval according to the methodological requirements detailed in section B.7.1. The data is uploaded to the web server at five (5) minute intervals when there is a broadband internet connection available. In the absence of a broadband internet connection the data is stored locally and uploaded when a connection becomes available. The PLC system includes an uninterruptable power supply to maintain data integrity in the event of grid power failure.

Quality control and quality assurance procedures

Internal audits will be carried out by the CDM coordinator in order to check any deviation. Any divergence will be investigated and dealt by the landfill manager, recorded for future reference. This will ensure data reliability and accuracy.

Equipment calibration and maintenance

Flow meters, gas analyzers, other critical CDM project equipment will be subject to regular maintenance and testing according to technical specifications from the manufactures to ensure accuracy and good performance. Equipment calibration will be conducted periodically according by the landfill operator and results will be supervised by landfill manager. Calibration checks will be recorded by the PLC and will be achieved during the monitoring period and 2 years after.

Training

For all employees involved in the CDM project, a Training Plan will be created to provide them the skills necessary to conduct their work in a safe manner and, ensuring the success of the project activity. The Training content will include operation and maintenance works, and also issues regarding CDM monitoring (data monitoring, collection, management, equipment calibration, etc.). Technical service supplier should provide introduction and trainings to the staff on the instalment, operation and maintenance of monitoring equipment.

Also, an operating manual will be developed for use by the project staff. This will include all of the requirements for maintenance of the equipment, calibration of the data analysers, data handling and quality assurance and emergency procedures. Periodic updates of the operating manual will be required.

SECTION C. Start date, crediting period type and duration

C.1. Start date of project activity

01/06/2011, date when the contract of engineering works was signed.

This is the date on which the project participant committed to expenditures related to the implementation of the project activity. No other expenditures have been made yet as the development of this project depend on CER revenues and hence PP are waiting for PDD registration before assuming other important costs.

C.2. Expected operational lifetime of project activity

14 years and 0 months, according to the 14 years signed contract with land owners.

C.3. Crediting period of project activity

C.3.1. Type of crediting period

First crediting period: 7 years crediting period– renewable twice.

C.3.2. Start date of crediting period

1st Crediting Period: 26/07/2014 – 25/07/2021.

C.3.3. Duration of crediting period

7 years and 0 months

SECTION D. Environmental impacts

D.1. Analysis of environmental impacts

The Ministry of Environment (MARN) in the host country (Guatemala) determined that a full Environmental Impact Assessment was not required for methane collection projects. A 'Plan de Gestión Ambiental" (Environmental Management Plan) was required and has been submitted and approved.

Documentation related to the PGA is publicly available on the MARN web site at; http://www.marn.gob.gt/aplicaciones/periodo/Default.aspx (year: 2007 and number: F-40).

A detailed description of the equipment to be installed in the landfill was presented to the Ministry of Environment in Guatemala. The project was considered by the Ministry of environment for its effects on;

No.	Aspect	Environmental Factor
1	Air	Gases or Particulates
		Noise
		Vibrations
		Odours
2	Water	Storage of water
		Waste water from domestic activities
		Waste water from special activities
		Rain water
3	Soil	Solid Wastes
		Dangerous or Hazardous wastes (with one or more of the following characteristics; Corrosives, Reactive, explosives, toxic wastes, flammable waste bio-infectious wastes)
		Discharge of waste water (where directly into the soil)
		Modification of the horizon or topography of the areas.
4	Biodiversity	Plants
		Fauna
		Ecosystems
5	Visual	Modification of the visual environment
6	Social	Change or modification of the social, economic cultural and archaeological structures.
7	Others	None

D.2. Environmental impact assessment

Environmental impacts are not considered significant. Project has a major net environmental benefit.

SECTION E. Local stakeholder consultation

E.1. Modalities for local stakeholder consultation

The Designated National Authority (MARN) identified the main stakeholders in the Zone'3' landfill in 2005 as follows;

Stakeholders	***Involvement in the Project***
Shareholders	Finance, construction and operation
Landowners	Land on which the
Municipality of Guatemala	Project is developed and the generation of methane Responsible
Waste Transportation	for the activity that generates methane
Waste recyclers	Workers on the landfill site Workers on the landfill site
Population of the Capital	Benefit from the Project because they are affected by the landfill

The MARN training course included 9 presentations on the issues related to LFG production, health and safety, global environment, LFG technology and details of the Zone '3' project.

A public stakeholders meeting was held on 28th February 2008. The following* identified stakeholders were invited;

* Personal details have been removed to maintain privacy. A full list including names, phone numbers and e-mail addresses can be made available to authorised entities.

LIST OF STAKEHOLDERS			
PROJECT: ZONE 3 LANDFILL			
NO.	**ENTITY**	**ADDRESS**	**POSITION**
	MUNICIPALITY OF GUATEMALA	**21 calle 6-77, zona 1**	
1	Mayor´s office	21 calle 6-77, zona 1	City Mayor
2	Mayor´s office	21 calle 6-77, zona 1	Municipal Manager
3	Mayor´s office	21 calle 6-77, zona 1	Legal Advisor
4	Direction of Infrastructure	21 calle 6-77, zona 1	Director
5	Direction of Environment	21 calle 6-77, zona 1	Director
6	Direction of Environment	21 calle 6-77, zona 1	Coodinator
7	Waste Management Modernization Program	21 calle 6-77, zona 1	Coodinator
8	Waste Management Modernization Program	21 calle 6-77, zona 1	Advisor
9	Department of Sanitation	1a calle 2-13 zona 2	Chief
10	Zone 3 Landfill	16 calle final zona 7	Manager
11	Zone 3 Landfill	16 calle final zona 7	Chief
12	Social Development Secretary	21 calle 6-77, zona 1	Director
	MINISTRY OF ENVIRONMENT	**20 calle 28-58 zona 10**	
13	Minister´s Office	20 calle 28-58 zona 10	Minister
14	Environmental Direction	20 calle 28-58 zona 10	Director
15	Environmental Direction	20 calle 28-58 zona 10	Technical Advisor
16	Designated National Agency	20 calle 28-58 zona 10	Chief
17	Climate Change Office	20 calle 28-58 zona 10	Chief
18	Solid Waste Management National Committe	20 calle 28-58 zona 10	Chief
	MINISTRY OF HEALTH	**5ta. Ave. 11-40, zona 11**	

19	Strategic Planification	2da. Ave. 0-61, Zona 10	Chief
20	Food Control		Chief
21	Central Health Area	11 Ave. “A” 12-19 Zona 7. Finca la Verbena	Director
22	Zone 3 Health Center	26 calle y 3a avenida zona 3	Director
	MINISTRY OF ENERGY	**Diagonal 17 29-78, Zona 11**	
23	Energy General Direction		Director
24	Environmental Unit		Chief
	EDUCATION ENTITIES		
25	Technical Institute KINAL	6a Ave 13-54 zona 7, colonia Landivar	Director
26	Santa Clara Children Garden	16 calle final zona 7	Director
27	Zone 3 Landfill Education Center	16 calle final zona 7	Director
	PRIVATE ENTITIES		
28	Landfills of Guatemala S.A.		CEO
29	Landfills of Guatemala S.A.		Director
30	EcoPlast S.A.	13 calle 3-92 zona 7, Parque ECOINDUSTRIAL	CEO
31	United Recyclers Association -ARU-		President
32	Guatemala´s Waste Recollectors and Transportation Association -ARTRADESGUA-	8a calle 15-73 zona 6 nivel 2,	President
33	Guatemalan Waste Recolector´s Union -URBAGUA-		President
34	Guatemalan Waste Recolector´s Association ARDSGUA-	7 Avenida 31-21 ZONA 3	President
35	CARVEL SERVICES	14 Ave.34-34 zona 13 Apto.11A	Manager
36	DIBASA		Manager
	NON GOVERNMENT ORGANIZATIONS NGO´s-		
37	Safe Passage	Calle del Hermano Pedro #4 Antigua	Director
38	Guatemalan Pediatric Foundation	4ta avenida 1-47 zona 1	Director
39	Potmaker House	29 Calle 7-42 Zona 3	Director
40	Solar Foundation		Director
41	Nature Defender´s Foundation		Manager

Presentations were given as follows:

Agenda
Date of the Event: Wednesday 28
February 2008 Time: 09:00 – 12:00

09:00 Reception of the attendees
09:30 Introduction of the presenters and companies
09:50 Presentation 1: Carbon Trade Limited
10:10 Presentation 2: Landfill Biogas projects and the CDM
10:40 Break
11:00 Presentation 4: The Zone ‘3’ Project
12:00 Question and Answer Session
12:30 Lunch

The presentations were made in Spanish and English. Simultaneous translation of the English presentation was provided.

E.2. Summary of comments received

Questions related to the Presentation of Biogas Project in Zone 3 Landfill

1. **What social benefits is there going to be at Zone 3 landfill?**

The project contemplates the creation of a donation committee that will provide economic support to develop environmental, education and health projects around the landfill.

2. **How much time is the Project going to last?**

The duration of the project will enable the sale of carbon credits for several years, however, the current Kyoto period is from 2008 to 2012 after which we are uncertain about the future sale of carbon credits although it is likely that there will be a market.

3. **Are there strategies to deal with the social group problems?**

The social situation of Zone 3 is known because there has been work done at the nearby communities, therefore the project will be engaging in various committees and development projects, although it is too early to define the exact subject of these projects. This meeting is part of the strategy to begin to understand how the social groups are reacting to the project.

We recognize the experience of people that have worked for many years with the main social groups (recyclers, buyers, recollectors, neighbours), therefore there´s more trust that has been built and it is important for us to have a good communication with the key leaders and clear doubts that may arise.

4. **What do you mean when you say Global Benefits?**

Since methane is one of the main greenhouse gases which contribute to global warming, the reduction of emissions of this gas becomes a global benefit.

5. **How do you intend to change the custom and processes of the recyclers (guajeros) as these are repeated with each family?**

There are 3 family generations working in the landfill and most of the business is family owned. The project does not intend to change their activities, but to contribute in the development of these businesses. We consider that the project can help support development ideas that derive from the community.

6. Do the old areas have more methane presence than the new ones?

The new areas, being new waste have greater methane generation rates than the old areas although methane will be collected from all accessible areas. The project has already defined areas with higher methane concentration.

7. Why can't this gas be stored and saved as propane gas and sell at more accessible prices and give aid to the most needy?

Because the storage process of biogas is more complex than propane and when it is extracted from waste it is not clean enough to be used at home.

8. How long will the flaring stage take?

2 years approximately until we are certain of the fuel resource for the second stage of power generation.

9. Is the new CDM (after 2012) different than the current one, or will it take more time?

That is a question that we ask ourselves. Although it is clear that all these projects cannot remain with the uncertainty and therefore we consider that there is a good chance that the CDM will continue in some form.

10. Will the pipeline be on the surface or buried at what depth?

It will be on the surface, but covered with a small amount of soil to prevent damage.

11. Can vandalism be avoided?

No. However you can raise awareness with the different social groups and let them know the benefit. There will be private security and constant monitoring.

12. Would it be possible to use biogas for the cremation of people buried in the cemetery next to the landfill?

Excellent idea we can analyze and propose.

13. Are you going to remove the guajeros from the area?

No, the guajeros will continue their work and will not be intervened by our project at any moment. However there may be some short periods where we need to install equipment in the working areas, we will endeavor to provide alternative working areas.

14. Will the project take charge of the management of the Landfill in zone 3?

No, the Landfill will remain operated by the municipality of Guatemala and at no time will the main process, which is which is waste management, be affected

15. Will this project affect the current waste management?

No, everything will be coordinated with the Municipality and a agreed plan will define all the steps to follow for the management of waste. Disposal will not be affected because we are interested in the continued progress towards filling areas where the municipality has planned.

16. Is the biogas burned from the Landfill harmful to health?

No it´s not, what we do is prevent the gas from getting lost and polluting, as it is happening right now, the more than 3,000 people that work in the landfill are breathing it without any protection and it is affecting their respiratory system. The project will extract the gas reducing this breathable emission, fires and explosions. The system will burn at high temperatures with good emission standards and destruction ratios

17. Do the Carbon Credits have a buyer, if so who are they?

The credits will be commercialized in an established market and it will depend on the investor on how, when and to who to sell.

18. How many Carbon Credits will you sell per year and what price does each sale have?

It is estimated to produce 100,000 Carbon Credits annually. The prices vary from $10.00 to $21.00 this can be sold at any stage, but again, it will depend on the investors decision.

19. Is it possible to help other Landfills in the country?

We are currently talking to other landfill owners, but most of them are very small, therefore a biogas project could not be established.

20. What is the Base Line? Does it include air and water contamination levels to compare if the project has made a difference?

The baseline is the amount of gas that is currently being liberated to the atmosphere and it will be reduced because we can measure how many tons are being burned. The project does not control other air emissions and water contamination in the area because there are many other activities going on that affect water and air which outside the control of the project.

21. How long do the recollection vehicles have to stop while the project is being built?

The project does not interfere with the current landfill activities.

22. Is the prime benefit, environmental or social?

Both, each one has its benefits, although it is clear that both go together to be able to develop this project.

23. Obviously these issues are critical as the landfill management, will this development agreement that you undertake help the guajeros be transfer to different work options

We do not intend to impose change in the landfill, but if the guajeros union has ideas to improve their activities and/or change them for other commercial activities and ask us for advice or help, we will kindly respond and assess. This is one of the purposes of the financial benefit committee established by the project.

24. What amount of money will the committee provide or what is provided and whether there will be control?

The amount will depend on the amount of methane extracted, the CER´s value and the time of sale. There will be follow up on the investments made by the committee, therefore we need to work with all of you in understanding the main problems in the area surrounding the landfill.

25. Which recycled materials will be used in the flaring project?

None of the recycled materials will be used, just the gas, therefore we encourage the recyclers to continue their work.

COMMENTS AND OBSERVATIONS FROM A FEW INSTITUTIONS:

Ing. Nery Pazetti said that the landfill was not going to stop, let alone be closed to the guajeros, however they have to look for other options so it seems that the project fits all and it is clear that this is not going to interfere with anything, since all trucks enter and leave without any problem because everything is planned and programmed.

Camino Seguro has requested information and details of the activity to be carried out in order to inform the people who visit them and ask about this topic. They are in favor of the project and understand the social benefits.

Rosario Villagran; hopes that the project runs efficiently and above all that it will meet the psycho-social problems because there are people within the Landfill that are drug addicts, alcoholics and other behavior patterns, in addition focus to the help at schools.
Edelberto Teos has congratulated the project and sees that it is a first step in the development and improvement of the site and the area which has been highly contaminated in the past, nevertheless he recommends that we analyze current situation (social and environmental) to define 10 years from now the improvements by the project.

The representative from ARTRADESGUA is also supportive of the project and is glad that we carried out this public presentation because he did not understand what it was about and now he knows that it does not affect their re-collection activity.

The leaders from ARU, the recyclers union, manifest their content with the project and thank us for letting them know and taking them into account, as they had heard some rumors about it, but now they fully understand what the project and its benefits are about and are interested in seeing the social benefits like the hot water for the guajeros.

E.3. Consideration of comments received

The comments and questions received during the public consultation were unanimously positive. It is not considered that any specific modification of the project is required. However the public meeting highlighted the sensitivity of the guajeros and recollectors who consider that changes to the management of the landfill will be detrimental to their interests.

As a result the project management reconfirms its intention to maintain good communication with the relevant unions.

SECTION F. Approval and authorization

The letter of approval (Number AND 021) from the Ministry of Environment and Natural Resources of Guatemala (Designated National Authority) was issued on 23/12/2010.

This letter authorizes the participation of the “Industrias de Biogás S.A as Project Participants in the Project and the CDM Executive Board to issue and allocate CERs for any verified greenhouse gas reduction from the Project.

Appendix 1. Contact information of project participants

Organization name	Industrias Biogás S.A
Country	Guatemala
Address	17 CALLE 10-31 ZONA 10
Telephone	00502 52021001 00502 23632950
Fax	
E-mail	rasturias@ufm.edu, comercial@borealia.es
Website	
Contact person	Carlos Lorente Carrasco-Muñoz carlos.lorente@borealia.es Mobile: +34 629025046 Fax: +34918593895 Telephone: +34918593374

Appendix 2. Affirmation regarding public funding

No public funding is used in this project

Appendix 3. Applicability of methodologies and standardized baselines

Waste Inputs

No historical records of waste disposal rates exist at Zone 3 landfill, although landfill is receiving wastes since 1966. Hence, waste input data has been provided by a third party study carried out by SCS Engineers Inc. (SCS) under contract to USAID and the US Environmental Protection Agency Landfill Methane Outreach Program in 2005[19], which has been based on Parsons Report from 1999 for being considered the best source of information until this date. Based on SCS engineers' study, the project participants consider that waste deposited before 1985 is now too old to be generating significant quantities of methane and therefore this wastes are not included in the gas models. Also, SCS engineers study provides an estimation of amount of SWDS until 2018. From 2019, data have been estimated by project participants by increasing the total amount of SWDS in a 3.35% annually, according to Parson Report forecast gathered in SCS engineers' study.

According to the mentioned studies, the waste inputs used are as follows:

Year	Total mass disposed (t)	Comments
Waste composition		
1985	222,025	Source: SCS engineers study 2005 ("Historical disposal rate"; page 2-4; table 2-1).
1986	224,244	
1987	226,485	
1988	228,749	
1989	231,035	
1990	233,132	
1991	266,383	
1992	274,743	
1993	283,361	
1994	292,243	
1995	301,398	
1996	311,505	
1997	321,950	
1998	332,743	
1999	343,897	
2000	355,423	
2001	367,334	
2002	379,641	
2003	392,360	
2004	405,502	
2005	419,100	Source: SCS engineers study 2005 ("Project future disposal rate"; page 2-5, table 2-2).
2006	433,100	
2007	447,600	
2008	462,600	
2009	478,100	
2010	494,100	
2011	510,700	
2012	527,800	
2013	545,500	
2014	563,800	
2015	582,700	
2016	602,200	

[19] SCS engineers, "Report of the pump test and pre-feasibility study for landfill gas recovery and utilization at the el Trébol landfill, Guatemala city, Guatemala", December 2005.

2017	622,400	
2018	497,916	
2019	514,596	Estimate by project participant of annual growth of 3.35%, equal to estimated annual growth rate by SCS in 2005-2018.
2020	531,835	
2021	549,652	
2022	568,065	
2023	587,095	
2024	606,763	
2025	627,089	
2026	648,097	
2027	669,808	

Table 2. Amount of wastes disposed in Zone 3 landfill.

Waste disposal excluding construction debris but prior to adjustment to account for moisture content (unadjusted MSW) have been used as, the percentages provided for fraction of degradable organic carbon in the waste type (DOCj) provided by the methodological tool "Emissions from solid waste disposal sites" version 06.0.1, are "based on a wet waste basis which are concentrations in the waste as it is delivered to the SWDS", as DOC values on a dry waste basis, which are the concentrations after complete removal of all moist from the waste, are not believed practical for this situation.

Also, SCS engineers' study provided the waste composition based on published reports:

MSW component (%)	
Source: REPORT OF THE PUMP TEST AND PRE-FEASIBILITY STUDY FOR LANDFILL GAS RECOVERY AND UTILIZATION AT THE EL TRÉBOL LANDFILL GUATEMALA CITY, GUATEMALA. SCS Engineers study, 2005 (page 4-5, table 4-2).	
Wood and Wood Products	0
Pulp, paper, and Cardboard	18,1
Food, Food waste beverages and tobacco	37,8
Textiles	4,8
Garden, Yard and Park waste	12,6
Glass, Metal, Plastic other Inert Waste	26,7
	100

Table 3. MSW component

Hence, amount of waste per type is the following:

		Percent of waste type by weight					
Year	Total mass disposed (t)	Wood and Wood Products (t)	Pulp, paper and Cardboard (t)	Food, Food waste beverages and tobacco (t)	Textiles (t)	Garden, Yard and Park waste (t)	Glass, Metal, Plastic other inert waste (t)
Waste composition		0%	18%	38%	5%	13%	27%
1985	222,025	0	40,187	83,925	10,657	27,975	59,281
1986	224,244	0	40,588	84,764	10,764	28,255	59,873
1987	226,485	0	40,994	85,611	10,871	28,537	60,471
1988	228,749	0	41,404	86,467	10,980	28,822	61,076
1989	231,035	0	41,817	87,331	11,090	29,110	61,686
1990	233,132	0	42,197	88,124	11,190	29,375	62,246
1991	266,383	0	48,215	100,693	12,786	33,564	71,124
1992	274,743	0	49,728	103,853	13,188	34,618	73,356
1993	283,361	0	51,288	107,110	13,601	35,703	75,657
1994	292,243	0	52,896	110,468	14,028	36,823	78,029
1995	301,398	0	54,553	113,928	14,467	37,976	80,473

1996	311,505	0	56,382	117,749	14,952	39,250	83,172
1997	321,950	0	58,273	121,697	15,454	40,566	85,961
1998	332,743	0	60,226	125,777	15,972	41,926	88,842
1999	343,897	0	62,245	129,993	16,507	43,331	91,820
2000	355,423	0	64,332	134,350	17,060	44,783	94,898
2001	367,334	0	66,487	138,852	17,632	46,284	98,078
2002	379,641	0	68,715	143,504	18,223	47,835	101,364
2003	392,360	0	71,017	148,312	18,833	49,437	104,760
2004	405,502	0	73,396	153,280	19,464	51,093	108,269
2005	419,100	0	75,857	158,420	20,117	52,807	111,900
2006	433,100	0	78,391	163,712	20,789	54,571	115,638
2007	447,600	0	81,016	169,193	21,485	56,398	119,509
2008	462,600	0	83,731	174,863	22,205	58,288	123,514
2009	478,100	0	86,536	180,722	22,949	60,241	127,653
2010	494,100	0	89,432	186,770	23,717	62,257	131,925
2011	510,700	0	92,437	193,045	24,514	64,348	136,357
2012	527,800	0	95,532	199,508	25,334	66,503	140,923
2013	545,500	0	98,736	206,199	26,184	68,733	145,649
2014	563,800	0	102,048	213,116	27,062	71,039	150,535
2015	582,700	0	105,469	220,261	27,970	73,420	155,581
2016	602,200	0	108,998	227,632	28,906	75,877	160,787
2017	622,400	0	112,654	235,267	29,875	78,422	166,181
2018	497,916	0	90,123	188,212	23,900	62,737	132,944
2019	514,596	0	93,142	194,517	24,701	64,839	137,397
2020	531,835	0	96,262	201,034	25,528	67,011	142,000
2021	549,652	0	99,487	207,768	26,383	69,256	146,757
2022	568,065	0	102,820	214,729	27,267	71,576	151,673
2023	587,095	0	106,264	221,922	28,181	73,974	156,754
2024	606,763	0	109,824	229,356	29,125	76,452	162,006
2025	627,089	0	113,503	237,040	30,100	79,013	167,433
2026	648,097	0	117,306	244,981	31,109	81,660	173,042
2027	669,808	0	121,235	253,187	32,151	84,396	178,839

Table 4. Amount of wastes disposed in Zone 3 landfill per type of waste.

Baseline emissions and emission reductions calculation ex-ante

The methodological tool “Emissions from solid waste disposal sites” version 06.0.1 defines that the amount of methane generated in each year y is:

$$BE_{CH4,SWDS,y} = \varphi_y \cdot (1-f_y) \cdot GWP_{CH4} \cdot (1-OX) \cdot \frac{16}{12} \cdot F \cdot DOC_{f,y} \cdot MCF_y \cdot \sum_{x=1}^{y} \sum_j W_{j,x} \cdot DOC_j \cdot e^{-k_j(y-x)} * (1-e^{k_j})$$

Where;

$BE_{CH4,SWDS,y}$	= Baseline, project or leakage methane emissions occurring in year y generated from waste disposal at a SWDS during a time period ending in year y (tCO2e/yr)
φ	= Model correction factor to account for model uncertainties for year y (0.75)
f	= Fraction of methane captured at the SWDS and flared, combusted or used in another manner that prevents the emissions of methane to the atmosphere in year y (0)
GWP_{CH4}	= Global Warming Potential of methane (21)
OX	= Oxidation factor (reflecting the amount of methane from SWDS that is oxidised in the soil or other material covering the waste) (0.1)
F	= Fraction of methane in the SWDS gas (volume fraction) (0.5)

DOC_f	= Fraction of degradable organic carbon (DOC) that can decomposes under the specific conditions occurring in the SWDS for year y (weight fraction) (0.5)
MCF	= Methane correction factor for year y (1)
$W_{j,x}$	= Amount of solid waste type j disposed or prevented from disposal in the SWDS in year x (see data provided in Table 2).
DOC_j	= Fraction of degradable organic carbon in the waste type j (weight fraction) (Default values from tool, see data provided in Table 5)
k_j	= Decay rate for the waste type j (1/yr)
x	= Years in the time period in which waste is disposed at the SWD, extending from the first year in the time period (x = 1) to the year y (x = y).
y	= Year of the crediting period for which methane emissions are calculated (y is a consecutive period of 12 months).

For application A as defined in tool "Emissions from solid waste disposal site", as it is our case, this time period may begin before the start of the project activity and typically starts when the SWDS starts receiving waste. In this case the time period starts in 1985.

Default values are shown in () following each variable where applicable. These values have been used in the biogas model in accordance with the recommendations of the tool. Also the next default values have been applied:

Other inputs are:

Fraction of degradable organic carbon in the waste type j (weight fraction) DOC_j	
Source: Methodological Tool Emissions from solid waste disposal sites . IPCC 2006 Guidelines for National Greenhouse Gas inventories (adapted from Volume 5, Tables 2.4 and 2.5)	
Wood and Wood Products	43
Pulp, paper, and Cardboard	40
Food, Food waste beverages and tobacco	15
Textiles	24
Garden, Yard and Park waste	20
Glass, Metal, Plastic other Inert Waste	0

Table 5. Fraction of degradable organic carbon in the waste type (DOC_j).

The Mean Annual Precipitation (MAP) in Guatemala is 1188 mm (www.worldclimate.com) and the average temperature is 18.3°C. The Potential Evapotranspiration Rate (PET) is obtained from data provided by the National Institute of Seismology, Volcanology; Hydrology and Meteorology ("Instituto Nacional de Sismologia, Vulcanologia, Metrologia e Hidrologia") of the State of Guatemala. This data is shown graphically below:

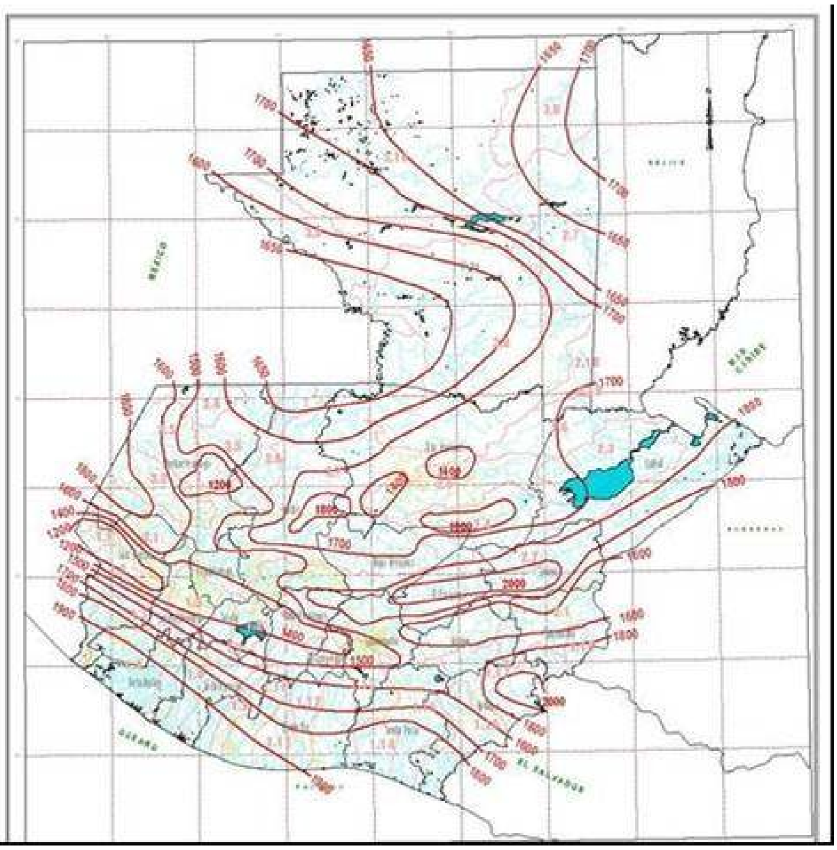


Figure 1. Annual Average Potential Evapotranspiration. Source: Republic of Guatemala, Department of investigation and meteorological services[20].

The Potential Evapotranspiration rate is 1500 mm. Therefore the default IPCC values for k_j for boreal and temperate dry climates were used:

Decay rate for the waste type j (kj)	
Wood and Wood Products	0.02
Pulp, paper, and Cardboard, Textiles	0.04
Food, Food waste beverages and tobacco	0.06
Garden, Yard and Park waste	0.05
Source: IPCC 2006 Guidelines for National Greenhouse Gas Inventories (adapted from Volume 5, Table 3.3)	

Table 6. Decay rate (k_j).

Model Results (please, for more details, check the biogas model excel spreasheet):

[20]Source:
http://www.insivumeh.gob.gt/hidrologia/ATLAS_HIDROMETEOROLOGICO/Atlas_Climatologico/etp.jpg

Baseline emissions (ex-ante)

For each of the waste types defined by the tool the methane model calculates the results by waste fraction. According to equation:

$$BE_{CH4,SWDS,y} = \varphi_y \cdot (1-f_y) \cdot GWP_{CH4} \cdot (1-OX) \cdot \frac{16}{12} \cdot F \cdot DOC_{f,y} \cdot MCF_y \cdot \sum_{x=1}^{y} \sum_{j} W_{j,x} \cdot DOC_j \cdot e^{-k_j(y-x)} * (1-e^{k_j})$$

As per next default values provided by methodology and tools:

Global Warming Potential of Methane	GWP_f	25
Model Correction Factor	φ	0.75
Oxidation Factor	OX	0.1
Fraction of Methane in SWDS Gas	F	0.5
Fraction of DOC that can decompose	DOC_f	0.5
Methane Correction Factor	MCF	1
Fraction of methane captured	f	0

The first part of the equation ($\varphi_y \cdot (1-f_y) \cdot GWP_{CH4} \cdot (1-OX) \cdot \frac{16}{12} \cdot F \cdot DOC_{f,y} \cdot MCF_y$) is equal to 4.73.

The second part of the equation ($\sum_{x=1}^{y} \sum_{j} W_{j,x} \cdot DOC_j \cdot e^{-k_j(y-x)} \cdot (1-e^{-k_j})$) is based on DOC_j and k_j above mentioned, with values per type of waste, as well as years in the time period in which waste are disposed of (x = 1985) and years of the crediting period (y).

Hence, baseline CO_2 equivalent emissions occurring in year y generated from waste disposal at SWDS are shown in the table below.

	Year (y)														
Year (x)	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**	**2023**	**2024**	**2025**	**2026**	**2027**
2013	4,267	4,059	3,861	3,674	3,495	3,326	3,165	3,013	2,867	2,729	2,598	2,474	2,355	2,243	2,136
2014		4,410	4,195	3,991	3,797	3,613	3,438	3,272	3,114	2,964	2,821	2,686	2,557	2,434	2,318
2015			4,558	4,335	4,124	3,924	3,734	3,553	3,381	3,218	3,063	2,916	2,776	2,643	2,516
2016				4,710	4,481	4,262	4,055	3,859	3,672	3,494	3,326	3,165	3,013	2,868	2,731
2017					4,868	4,631	4,405	4,191	3,988	3,795	3,612	3,437	3,272	3,114	2,965
2018						3,894	3,705	3,524	3,353	3,190	3,036	2,889	2,750	2,617	2,491
2019							4,025	3,829	3,642	3,465	3,297	3,138	2,986	2,842	2,705
2020								4,160	3,957	3,764	3,582	3,408	3,243	3,086	2,937
2021									4,299	4,090	3,891	3,702	3,522	3,351	3,189
2022										4,443	4,227	4,021	3,826	3,640	3,464
2023											4,592	4,368	4,156	3,954	3,762
2024												4,746	4,514	4,295	4,086
2025													4,905	4,666	4,439
2026														5,069	4,822
2027															5,239
	48,915	50,974	53,083	55,244	57,460	58,596	59,809	61,101	62,471	63,921	65,451	67,063	68,757	70,535	72,399

$BE_{CH4,SWDS,y}$ (tCO_2/yr)	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**	**2023**	**2024**	**2025**	**2026**	**2027**
	231,124	240,854	250,819	261,028	271,497	276,865	282,600	288,702	295,177	302,027	309,257	316,872	324,878	333,280	342,086

Adding the annual amount of methane produced during the first crediting period ($BE_{CH4,SWDS}$) and taking into account the 50% default value of efficiency of the degassing system, according to equation

$$F_{CH4,PJ,y} = \eta_{PJ} \times BE_{CH4,SWDS,y} / GWP_{CH4}$$

and,

$$BE_{CH4,y} = (1 - OX_{top\_layer}) \times (F_{CH4,PJ,y} - F_{CH4,BL,y}) \times GWP_{CH4}$$

the annual baseline emissions are calculated as:

First crediting period Years	Baseline emissions of methane from the SWDS						
	$BE_{CH4,SWDS}$ (tCO2e/y)	ηPJ	GWP_{CH4}	$F_{CH4,PJ}$ (t-CH4/y)	$F_{CH4,BL}$	OX	BE_{CH4} (tCO_2e)
26/07/2014	124,185	50%	25	2,484	0	0.1	55,883
2015	298,594	50%	25	5,972	0	0.1	134,367
2016	310,748	50%	25	6,215	0	0.1	139,836
2017	323,211	50%	25	6,464	0	0.1	145,445
2018	329,602	50%	25	6,592	0	0.1	148,321
2019	336,428	50%	25	6,729	0	0.1	151,393
2020	343,693	50%	25	6,874	0	0.1	154,662
25/07/2021	199,769	50%	25	3,995	0	0.1	89,896

Note: Calculations for first crediting period starting on July 2014.

As the project generates electricity by using the recovered LFG, baseline emissions avoided will also have an electric component, according to equation

$$BE_{EC,y} = \sum_k EC_{BL,k} * EF_{EL,k,y} * (1 + TDL_{k,y})$$:

Baseline emissions associated with electricity generation			
$EC_{BL,k}$ (MWh)	$EF_{BL,k}$ (tCO_2/MWh)	TDL_k	BE_{EC} (tCO_2e)
13,657	0.602	13.55%	9,337
31,532	0.602	13.55%	21,558
31,532	0.602	13.55%	21,558
31,532	0.602	13.55%	21,558
31,532	0.602	13.55%	21,558
31,532	0.602	13.55%	21,558
31,532	0.602	13.55%	21,558
17,926	0.602	13.55%	12,255

Note: Calculations for first crediting period starting on July 2014.

Since the electricity generated through the proposed project is consumed from grid, scenario A of the tool is applicable. Following the option A1 of the scenario A, the $EF_{EL,j,y}$ will be determined by following the "Tool to calculate the emission factor for an electricity system" and $EF_{EL,j,y} = EF_{grid,CM,y}$.

This calculation is presented later in appendix 4 and results in a grid emission factor of 0.602 tCO_2/MWh, which will be a fixed value during the first crediting period. Also, the default value of 13.55% will be used as for baseline emissions calculations.

Here, $EC_{BL,k}$ is calculated as per next steps and assumptions that are included in the biogas model spreasheet:

Electricity generation dimension data	Value	Comments / Sources
Fraction of Methane in SWDS Gas	0.5	IPCC2006
hPJ (Efficiency of the LFG capture system)	50%	Source: Default value provided by ACM0001 version 13.0.0
Engines operating hours (h/year)	8,000	22_"Technical specifications of the engine"
Number of engines	1	JGC 320 GS-B.L BOREALIA GUATEMALA with an electricity output of 1059 kW
Number of engines	3	JGC 320 GS-L.L TS JGC 320 C81 480V with an electrical output of 1061 kW
Unit power (MW/engine)	1.059	JGC 320 GS-B.L BOREALIA GUATEMALA with an electricity output of 1059 kW
Unit power (MW/engine)	1.061	JGC 320 GS-L.L TS JGC 320 C81 480V with an electrical output of 1061 kW
Installation self-consumption (%)	7.1%	23_ "autoconsumo motor"
Net electricity generation (KWh/engine-y)	7,872	JGC 320 GS-B.L BOREALIA GUATEMALA with an electricity output of 1059 kW
Net electricity generation (KWh/engine-y)	7,887	JGC 320 GS-L.L TS JGC 320 C81 480V with an electrical output of 1061 kW
Total net electricity generation (KWh/y)	31,532	Calculation
Engine electrical efficiency	42%	22_ "Technical specifications of the engine"
Density of CH4 (t/m3)	0.000716	Tool to determine project emissions from flaring gases containing methane
NCVCH4 (MJ/m3)	36.1	0.0504 TJ/t (from ACM0001) * 0.0007168 t/m3 (from ACM0001) * 1000000 MJ/TJ
TDLk,y	13.55%	Average technical transmission and distribution losses for providing electricity to source k in year y; Source: http://www.nationsencyclopedia.com/WorldStats/WDI-electric-power-transmission-output.html
MWh/t-CH4	5.88	Calculation
Nominal engine operation	100%	22_ "Technical specifications of the engine"
% time the power engines are not working	9%	Calculation

The installation of 4 engines has been estimated as per:

- Calculation of electricity production per amount of captured methane:

  $((36.1\ MJ/m^3 * 42\%) / (0.000716\ tCH_4/m^3) * 0.000278\ MJ/MWh = 5.88\ MWh/tCH_4$

- Knowing the total amount of methane in the LFG which is flared and/or used in the project activity ($F_{CH4,PJ,y}$), the theoric power (MW) to be installed at the landfill can be calculated:

Theoric power (MW) = ($F_{CH4,PJ,y}$ tCH_4/yr * 5.88 MWh/tCH_4) / (8,000 h/yr * 100%) = see table:

Year	$F_{CH4,PJ}$ (t-CH4/y)	Biogas captured (m3/y)	Theoric power (MW)	Power to be installed (MW)
2014	2,484	6,937,691	1.8	4.242
2015	5,972	16,681,204	4.4	4.242
2016	6,215	17,360,210	4.6	4.242
2017	6,464	18,056,456	4.8	4.242
2018	6,592	18,413,506	4.8	4.242
2019	6,729	18,794,877	4.9	4.242
2020	6,874	19,200,749	5.1	4.242
2021	3,995	11,160,282	5.1	4.242

According to the previous results, the theoric power capacity of project would reach 5.1 MW. Hence, assuming that the installed engines unitary capacity is 1.059 MW for 1 engine and 1.061 for 3 engines, 4 engines were installed.

So,

8,000 h *1.059 MW/engine * (100%- 7.1% of self-consumption) = 7,872 (kWh/engine-yr)

8,000 h *1.061 MW/engine * (100%- 7.1% of self-consumption) = 7,887 (kWh/engine-yr)

And

1 engine * 7,872 (kWh/engine-yr) + 3 engines * 7,887 (kWh/engine-yr) = 31,532 kWh/yr

Hence, baseline emissions are calculated as $BE_y = BE_{CH4,y} + BE_{EC,y}$ and results obtained are presented next:

First crediting period Years	Baseline emissions of methane from the SWDS							Baseline emissions associated with electricity generation			
	$BE_{CH4,SWDS}$ (tCO2e/y)	ηPJ	GWP_{CH4}	$F_{CH4,PJ}$ (t-CH4/y)	$F_{CH4,BL}$	OX	BE_{CH4} (tCO_2e)	$EC_{BL,k}$ (MWh)	$EF_{BL,k}$ (tCO_2/MWh)	TDL_k	BE_{EC} (tCO_2e)
26/07/2014	124,185	50%	25	2,484	0	0.1	55,883	13,657	0.602	13.55%	9,337
2015	298,594	50%	25	5,972	0	0.1	134,367	31,532	0.602	13.55%	21,558
2016	310,748	50%	25	6,215	0	0.1	139,836	31,532	0.602	13.55%	21,558
2017	323,211	50%	25	6,464	0	0.1	145,445	31,532	0.602	13.55%	21,558
2018	329,602	50%	25	6,592	0	0.1	148,321	31,532	0.602	13.55%	21,558
2019	336,428	50%	25	6,729	0	0.1	151,393	31,532	0.602	13.55%	21,558
2020	343,693	50%	25	6,874	0	0.1	154,662	31,532	0.602	13.55%	21,558
25/07/2021	199,769	50%	25	3,995	0	0.1	89,896	17,926	0.602	13.55%	12,255

Note: Calculations for first crediting period starting on July 2014.

Project Emissions (ex-ante)

Project emissions are released as per the electricity consumed by the flares from the grid when the power plant will not be providing electricity.

According to "Tool to calculate baseline, project and/ or leakage emissions from electricity consumption" the next equation is used:

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

The power engines installed will be working 8,000 hours according to the manufacturers specifications. In a conservative way, it will be assumed that the 4 installed engines will stop working at the same time, although it is more realistic to expect that the power systems will be continuously generating electricity and will be stopped one after another. Nevertheless, the project emissions will correspond to the grid electricity consumption from the flaring system when the 4 engines will not be working.

According to manufacturer specifications, each flare has a capacity of 75 kW and will work in continuous, meaning the 8,760 hours of the year. Hence each flare will consume:

Flare consumption = 75 kW* 8,760 h/yr = 657,000 kWh/yr.

As engines will only work for 8,000 hours/yr as they are estimated to be stopped during 760 h/yr (8.68% of the annual time for maintenance purposes.
Hence, as a conservative assumption since all 4 engines are not expected to be simultaneously unavailable, it it assumed that during 760 h/yr, the extracted methane will not be used for electricity generation and will be automatically destroyed by flaring. Hence, during this period, landfill will have to consume electricity from the grid, instead of self-consuming the one generated by the engines.

Hence, flaring system consumption from the grid is calculated as follows, depending the number of flare units installed:

One flare unit is installed: $EC_{PJ,j,y}$ = (657 MWh/yr * 8.68%) = 57 MWh/yr

Two flares installed, from 2025: $EC_{PJ,j,y}$ = (657 MWh/yr * 8.68%) * 2 = 114 MWh/yr

Since the electricity generated through the proposed project is consumed from grid, scenario A of the tool is applicable. Following the option A1 of the scenario A, the $EF_{EL,j,y}$ will be determined by following the "Tool to calculate the emission factor for an electricity system" and $EF_{EL,j,y} = EF_{grid,CM,y}$. This calculation is presented later in appendix 4 and results in a grid emission factor of 0.602 tCO_2/MWh, which will be a fixed value during the first crediting period. Also, the default value of 13.55% will be used as for baseline emissions calculations.

Project emissions results are presented next:

Project emissions			
$EC_{PJ,j}$ (MWh)	**$EF_{EL,k}$ (tCO_2/MWh)**	**TDL_j**	**PE_{EC} (tCO_2e)**
25	0.602	13.55%	17
57.0	0.602	13.55%	39
57.0	0.602	13.55%	39
57.0	0.602	13.55%	39
57.0	0.602	13.55%	39
57.0	0.602	13.55%	39
57.0	0.602	13.55%	39
32	0.602	13.55%	22

Note: Calculations for first crediting period starting on July 2014.

Appendix 4. Further background information on ex ante calculation of emission reductions

Emissions reductions (ex-ante)

According to ACM0001: ER = BE – PE. Results of emissions reductions are provided next:

First crediting period Years	Baseline emissions of methane from the SWDS								Baseline emissions associated with electricity generation				Project emissions				Emissions reductions (tCO2e)
	$BE_{CH4,SWDS}$ (tCO2e/y)	η_{PJ}	GWP_{CH4}	$F_{CH4,PJ}$ (t-CH4/y)	$F_{CH4,BL}$	OX	BE_{CH4} (tCO_2e)	$EC_{BL,k}$ (MWh)	$EF_{BL,k}$ (tCO_2/MWh)	TDL_k	BE_{EC} (tCO_2e)	$EC_{PJ,j}$ (MWh)	$EF_{EL,k}$ (tCO_2/MWh)	TDL_j	PE_{EC} (tCO_2e)	
26/07/2014	124,185	50%	25	2,484	0	0.1	55,883	13,657	0.602	13.55%	9,337	25	0.602	13.55%	17	**65,203**
2015	298,594	50%	25	5,972	0	0.1	134,367	31,532	0.602	13.55%	21,558	57.0	0.602	13.55%	39	**155,886**
2016	310,748	50%	25	6,215	0	0.1	139,836	31,532	0.602	13.55%	21,558	57.0	0.602	13.55%	39	**161,355**
2017	323,211	50%	25	6,464	0	0.1	145,445	31,532	0.602	13.55%	21,558	57.0	0.602	13.55%	39	**166,963**
2018	329,602	50%	25	6,592	0	0.1	148,321	31,532	0.602	13.55%	21,558	57.0	0.602	13.55%	39	**169,839**
2019	336,428	50%	25	6,729	0	0.1	151,393	31,532	0.602	13.55%	21,558	57.0	0.602	13.55%	39	**172,911**
2020	343,693	50%	25	6,874	0	0.1	154,662	31,532	0.602	13.55%	21,558	57.0	0.602	13.55%	39	**176,181**
25/07/2021	199,769	50%	25	3,995	0	0.1	89,896	17,926	0.602	13.55%	12,255	32	0.602	13.55%	22	**102,129**

Note: Calculations for first crediting period starting on July 2014.

The annual average emissions reductions for the first crediting period are 167,210 tCO_2/yr and the total emissions reductions for the whole first crediting period are 1,170,468 tCO_2/yr:

Year	Baseline emissions (t CO_2e)	Project emissions (t CO_2e)	Leakage (t CO_2e)	Emission reductions (t CO_2e)
26/07/2014	65,220	17	0	65,203
2015	155,925	39	0	155,886
2016	161,394	39	0	161,355
2017	167,002	39	0	166,963
2018	169,878	39	0	169,839
2019	172,950	39	0	172,911
2020	176,220	39	0	176,181
25/07/2021	102,151	22	0	102,129
Total (tCO2e)	**1,170,741**	**273**	**0**	**1,170,468**
Total number of crediting years	7			
Annual average over 1st crediting	**167,249**	**39**	**0**	**167,210**

Note: Calculations for first crediting period starting on July 2014.

A complete working landfill gas model is provided to the project´s DOE.

GRID EMISSION FACTOR

The “Tool to calculate the emission factor for an electricity system” version 03.0.0 has been used.

Step 1. Identify the relevant electricity systems

The project is connected to a national power grid, the Guatemalan National Interconnected System (Sistema Nacional Interconectado or SIN).

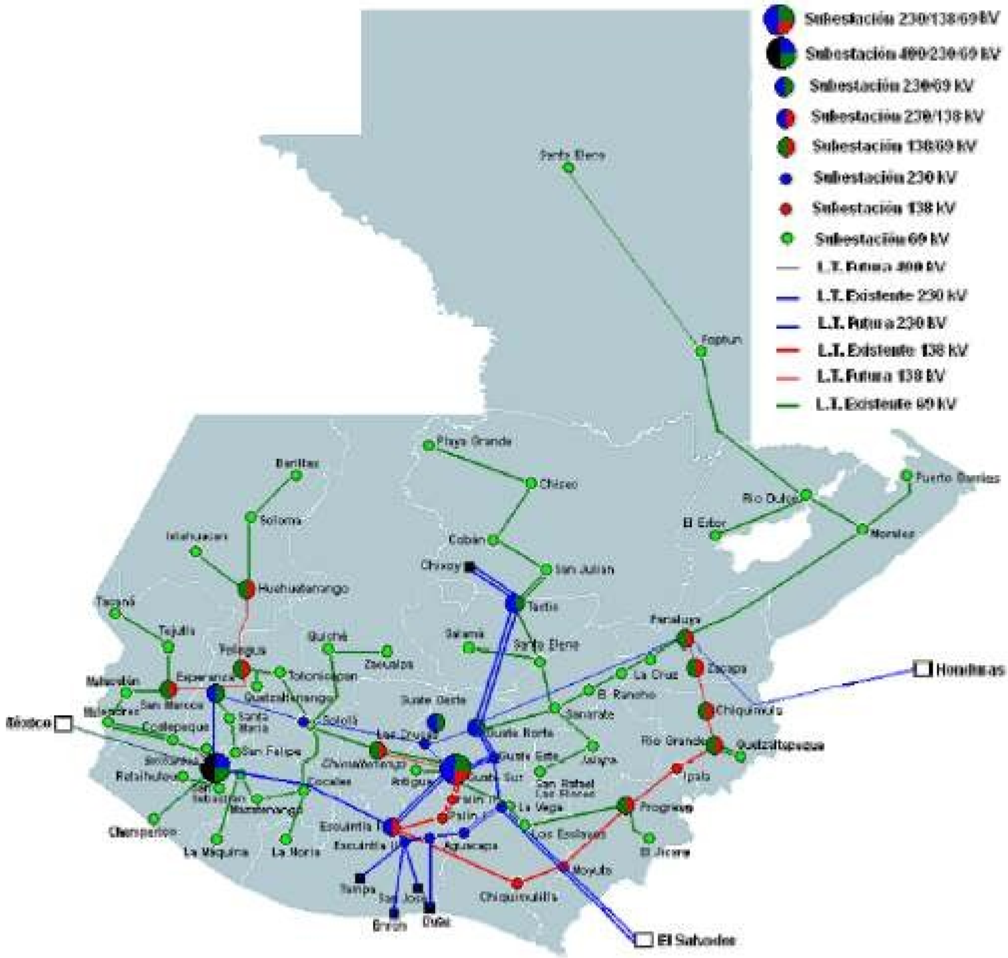


Figure 2. project electricity system. Source: CNEE[21]

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

Project participant may choose between the following two options to calculate the operating margin and build margin emission factor:

Option I: Only grid power plants are included in the calculation

Option II: Both grid power plants and off-grid power plants are included in the calculation. The option I is chosen, so only grid power plants are included in the calculation.

21 http://www.cnee.gob.gt/xhtml/informacion/Regezra/Caracterizacion%20de%20demanda%20en%20ZRA.pdf

Step 3. Select a method to determine the Operating Margin (OM)

The project parties select the Simple Operating Margin (Option a) method for calculation of $EF_{grid,OM,y}$ because:

i) Sufficient data is not available for using the Dispatch Data Analysis option, and

ii) Low-cost/must-run resources in Guatemala constitute less than 50% of total generation in average of the five most recent years (see the following table).

Data of net power generation for each plant were provided in private communications with AMM (*Administrador del Mercado Mayorista*, Wholesale Market Administrator), which is the entity responsible of the Guatemalan National Electric Grid operation, because they were not available for all the power plants in AMM webpage[22].

	2002	2003	2004	2005	2006
TOTAL NET GENERATION (GWh)	**6,212.51**	**6,560.89**	**7,009.25**	**7,221.63**	**7,436.61**
LOW-COST/MUST-RUN NET GENERATION (GWh)	2,802.54	2,927.62	3,336.65	3,753.14	4,160.71
LOW-COST/MUST-RUN NET GENERATION %	45.11%	44.62%	47.60%	51.97%	55.95%
AVERAGE LOW-COST/MUST-RUN GENERATION IN 2002-2006 PERIOD					**49.05%**

Table 7. Low-cost and must-run plants generation in Guatemala in the years 2002-2006.

As it can be seen, in the period 2002-2006 the low-cost/must-run resources constitute less than the 50% of total generation in average terms.

The Simple OM emission factor can be calculated using either of the two following data vintages for year(s):

- *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 factor during the crediting period, or
- *Ex post* option: The emission factor is determined for the year in which the project activity displaces grid electricity, requiring the emissions factor to be updated annually during monitoring.

Ex-ante option has been chosen due to the simplicity of the project development and also for the emission reduction verification.

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

The Simple OM Emission Factor ($EF_{OM,simple,y}$) is calculated as the generation-weighted average emissions per electricity unit (tCO_2/MWh) of all generating sources serving the system, not including low- cost and must-run power plants. It has been calculated following the “Option A” mentioned in the Step 4 of the “Tool to calculate the emission factor for an electricity system” (version 03.0.0). This option is based on the total net electricity generation and the CO_2 emission factor for each power unit.

[22] http://www.amm.org.gt/

Option A is used because no fuel consumption data are available in Guatemalan AMM (*Administrador del Mercado Mayorista*, Wholesale Market Administrator), which is the entity responsible of the Guatemalan National Electric Grid operation[23].

Under this option, the simple OM emission factor is calculated based on the net electricity generation of each power unit and emission factor for each power plant, as follows:

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

Where:

$EF_{grid,OMsimple,y}$	= is the simple operating margin CO_2 emission factor in year y (tCO_2/MWh);
$EF_{EL,m,y}$	=refers to the CO_2 emission factor of power unit m in year y (tCO_2/GJ);
$EG_{,m,y}$	=refers to the net electricity generated and delivered to the grid by all power unit *m* in the year *y*, not including low-cost/must-run power plants/units, in year y (MWh);
m	=the subscript *m* refers to the power plants/units delivering electricity to the grid, not including low-cost/must-run power plants/units, and including electricity imports to the grid. Electricity imports should be treated as one power plant *m*.
y	= refers to the relevant year as per the data vintage chosen in step 3.

As it was pointed before, data of net power generation for each plant were provided in private communications with AMM, because they were not available for all the power plants in their webpage.

The emission factor of each power plant is determined per option A2, since no fuel consumption data were available in AMM sources:

$$EF_{EL,m,y} = \frac{EF_{co2,m,i,y} \times 3.6}{\eta_{m,y}}$$

Where:

$EF_{EL,m,y}$	= refers to the CO2 emission factor of power unit m in year y (tCO2/MWh)
$EF_{CO2,m,i,y}$	= refers to the average CO2 emission factor of fuel type i used in power unit m in year y (tCO2/GJ)
$\eta_{m,y}$	= average net energy conversion efficiency of power unit m in year y (%).
y	= refers to the most recent historical year for which power generation data is available

[23] Private communication with AMM.

The emission factors for each kind of fuel were obtained from 95% lower confidence interval values from 2006 IPPC Guidelines for National GHG Inventories, Volume 2, Chapter 1, table 1.4. The average net energy conversion efficiencies of power plants were obtained from the “Tool to calculate the emission factor for an electricity system” (version 03.0.0), Annex 1.

The following generation information is used to determine the Operating Margin of the Guatemalan Grid in the years 2004, 2005 and 2006.

PLANT	Net energy produced (GWh) 2002	Net energy produced (GWh) 2003	Net energy produced (GWh) 2004	Net energy produced (GWh) 2005	Net energy produced (GWh) 2006	Fuel
STEAM TURBINES	**964.76**	**894.97**	**1,029.96**	**976.02**	**1,010.47**	
SAN JOSÉ	943.29	892.06	1,029.96	976.02	1,010.47	Bituminous Coal
ESCUINTLA VAPOR 2	3.10	0.08	0.00	0.00	0.00	Fuel oil No.6
LAGUNA VAPOR 3	11.39	2.81	0.00	0.00	0.00	Fuel oil No.6
LAGUNA VAPOR 4	6.97	0.01	0.00	0.00	0.00	Fuel oil No.6
GAS TURBINES	**146.81**	**84.78**	**7.02**	**19.17**	**8.46**	
TAMPA	78.45	15.25	1.87	3.36	6.49	Diesel
STEWART & STEVENSON	7.28	12.85	2.11	6.86	0.97	Diesel
ESC.GAS No. 3	14.85	8.99	0.95	3.21	0.00	Diesel
ESC.GAS No. 5	8.77	6.41	0.52	1.84	1.01	Diesel
LAG.GAS No. 1	5.50	2.72	1.58	3.90	0.00	Diesel
LAG.GAS No. 2	19.59	22.52	0.00	0.00	0.00	Diesel
LAG.GAS No. 4	12.37	16.03	0.00	0.00	0.00	Diesel
RECIPROCANT ENGINES	**2,246.82**	**2,605.17**	**2,621.56**	**2,427.24**	**2,219.66**	
ARIZONA	0.00	561.40	1,147.03	1,024.83	847.47	Oremulsion/Fuel Oil No. 6
LA ESPERANZA	808.84	739.98	606.49	523.27	476.74	Fuel oil No.6
PQPLLC	504.88	444.78	174.80	154.50	77.76	Fuel oil No.6
LAS PALMAS 1	104.13	104.20	70.61	69.70	88.40	Fuel oil No.6
LAS PALMAS 2	107.80	100.44	155.19	74.86	72.50	Fuel oil No.6
LAS PALMAS 3	108.58	113.25	29.89	77.09	75.12	Fuel oil No.6
LAS PALMAS 4	112.65	108.69	41.73	49.55	69.40	Fuel oil No.6
LAS PALMAS 5	72.62	34.33	9.73	20.65	15.50	Fuel oil No.6
GENOR	210.96	156.33	82.21	134.72	178.23	Fuel oil No.6
SIDEGUA	132.15	86.93	78.79	94.52	74.64	Fuel oil No.6
LAGOTEX	84.22	96.61	87.77	71.76	99.09	Fuel oil No.6
AMATEX	0.00	20.25	8.45	8.36	25.86	Fuel oil No.6
ELECTROGENERACIÓN	0.00	3.89	82.37	69.53	68.56	Fuel oil No.6
GENERADORA PROGRESO	0.00	34.11	46.48	53.91	50.40	Fuel oil No.6
COGENERATORS (STEAM TURBINES) NON HARVEST SEASON	**51.58**	**48.35**	**14.05**	**46.06**	**37.31**	
CONCEPCION	15.02	13.38	9.73	13.00	8.19	Fuel oil No.6
PANTALEON	7.15	14.19	0.00	8.48	15.83	Fuel oil No.6
SANTA ANA	26.23	5.16	3.20	8.63	5.06	Fuel oil No.6
MAGDALENA	0.00	4.16	0.00	4.59	0.41	Fuel oil No.6
LA UNION	1.73	5.71	0.08	6.07	4.17	Fuel oil No.6
MADRE TIERRA	1.46	3.99	0.01	3.99	2.51	Fuel oil No.6
TULULA	0.00	0.02	0.00	0.04	0.00	Fuel oil No.6
SAN DIEGO	0.00	0.00	0.00	0.00	0.00	Fuel oil No.6
TRINIDAD	0.00	0.00	0.00	0.00	0.00	Fuel oil No.6
DARSA	0.00	1.74	1.02	1.26	1.15	Fuel oil No.6
IMPORTS	37.35	23.52	33.50	15.02	1.92	

Table 8. Power generation and fuel consumption of the Guatemalan non low-cost/must-run electricity plants.

It is important to pinpoint that the cogeneration plants burn fuel oil during the non harvest season of the sugarcane (from June to October), while the rest of the year they burn bagasse obtained from the sugarcane, being considered as renewable biomass power plants during this season of the year.

The emission factors and emissions for each plan in the years 2004, 2005 and 2006 are shown next:

PLANT	Fuel	Date of installation	EF(CO2,m,i,y) [tCO2/GJ]	(? m,y) Efficiency (%)	EF(EL,m,y) [tCO2/GWh]	[tCO2] 2004	[tCO2] 2005	[tCO2] 2006
STEAM TURBINES								
SAN JOSÉ	Bituminous Coal	01/01/2000	89.5	37.0%	870.81	896,903.19	849,931.07	879,929.91
ESCUINTLA VAPOR 2	Fuel oil No.6	Estimated after	75.5	39.0%	696.92	0.00	0.00	0.00
LAGUNA VAPOR 3	Fuel oil No.6	Estimated after	75.5	39.0%	696.92	0.00	0.00	0.00
LAGUNA VAPOR 4	Fuel oil No.6	Estimated after	75.5	39.0%	696.92	0.00	0.00	0.00
GAS TURBINES								
TAMPA	Diesel	1995	72.6	30.00%	871.20	1,626.05	2,922.92	5,652.29
STEW ART & STEVENSON	Diesel	24/12/2005	72.6	39.50%	661.67	1,395.06	4,540.39	639.12
ESC.GAS No. 3	Diesel	1976	72.6	30.00%	871.20	828.39	2,798.21	0.00
ESC.GAS No. 5	Diesel	November 1985	72.6	30.00%	871.20	449.93	1,607.09	876.81
LAG.GAS No. 1	Diesel	1978	72.6	30.00%	871.20	1,377.75	3,398.47	0.00
LAG.GAS No. 2	Diesel	1978	72.6	30.00%	871.20	0.00	0.00	0.00
LAG.GAS No. 4	Diesel	Estimated after	72.6	39.50%	661.67	0.00	0.00	0.00
RECIPROCANT ENGINES								
ARIZONA	Oremulsion/Fuel Oil No. 6	April-May 2003	69.3/75.5 (*)	39.50%	631.59/688.10	724,457.73	705,183.43	583,145.02
LA ESPERANZA	Fuel oil No.6	Estimated after	75.5	39.50%	688.10	417,329.64	360,060.99	328,043.57
PQPLLC	Fuel oil No.6	Estimated after	75.5	39.50%	688.10	120,279.64	106,310.16	53,508.14
LAS PALMAS 1	Fuel oil No.6	September 1998	75.5	30.00%	906.00	63,968.92	63,151.84	80,087.60
LAS PALMAS 2	Fuel oil No.6	September 1998	75.5	30.00%	906.00	140,605.59	67,824.35	65,682.20
LAS PALMAS 3	Fuel oil No.6	September 1998	75.5	30.00%	906.00	27,083.57	69,840.12	68,061.65
LAS PALMAS 4	Fuel oil No.6	September 1998	75.5	30.00%	906.00	37,808.95	44,892.58	62,872.94
LAS PALMAS 5	Fuel oil No.6	September 1998	75.5	30.00%	906.00	8,818.23	18,710.99	14,045.47
GENOR	Fuel oil No.6	October 1998	75.5	30.00%	906.00	74,482.17	122,053.68	161,477.40
SIDEGUA	Fuel oil No.6	1995	75.5	30.00%	906.00	71,385.01	85,638.05	67,622.50
LAGOTEX	Fuel oil No.6	1996	75.5	30.00%	906.00	79,517.56	65,015.61	89,771.17
AMATEX	Fuel oil No.6	2003	75.5	30.00%	906.00	7,656.18	7,573.15	23,427.59
ELECTROGENERACION	Fuel oil No.6	November 2003	75.5	39.50%	688.10	56,680.14	47,840.80	47,175.70
GENERADORA PROGRESO	Fuel oil No.6	1993	75.5	30.00%	906.00	42,114.04	48,844.49	45,662.14
COGENERATORS (STEAM TURBINES) NON HARVEST SEASON								
CONCEPCION	Fuel oil No.6	1994	75.5	37.50%	724.80	7,054.33	9,421.11	5,935.00
PANTALEON	Fuel oil No.6	1991	75.5	37.50%	724.80	0.68	6,145.78	11,472.98
SANTA ANA	Fuel oil No.6	1995	75.5	37.50%	724.80	2,321.59	6,255.20	3,667.91
MAGDALENA	Fuel oil No.6	1994	75.5	37.50%	724.80	0.00	3,327.55	295.15
LA UNION	Fuel oil No.6	1995	75.5	37.50%	724.80	59.97	4,397.80	3,022.05
MADRE TIERRA	Fuel oil No.6	1996	75.5	37.50%	724.80	6.01	2,892.87	1,819.72
TULULA	Fuel oil No.6	February 2001	75.5	39.00%	696.92	0.00	25.96	0.56
SAN DIEGO	Fuel oil No.6	December 2004	75.5	39.00%	696.92	0.00	0.00	0.00
TRINIDAD	Fuel oil No.6	January 2006	75.5	39.00%	696.92	0.00	0.00	0.00
DARSA	Fuel oil No.6	2004	75.5	39.00%	696.92	713.66	880.38	800.05
TOTAL EMISSIONS (tCO_2)						**2,784,923.99**	**2,711,485.02**	**2,604,694.64**

Table 9. Emission factors and emissions of the non low-cost/must-run plants of the Guatemalan I Grid.

Data for year of installation of the power plants were available in AMM webpage (http://www.amm.org.gt/pdfs/capacidad_instalada.pdf). As data of the installation dates of some power plants were not provided by AMM, they were supposed to be installed after 2000, in a conservative approach, since in this case they will be more efficient and therefore their emission factor will be smaller.

It shall be pointed that the Arizona Reciprocant Engine plant consumed only orimulsion during the year 2004, while it consumed only fuel oil during the years 2005 and 2006.

The emissions of the year 2004, 2005 and 2006 are 2,784,924; 2,711,485 and 2,604,695 tCO_2 respectively.

Dividing the emissions of each year by the total yearly generation of non-low-cot/must-run plants plus the imports, the following operating margin emission factors are obtained:

SIMPLE OPERATING MARGIN EMISSION FACTOR (tCO_2/GWh)	2004	2005	2006	OPERATING MARGIN EMISSION FACTOR (tCO2/GWh)
	751.44	778.38	794.64	773.93

Table 10. Operating margin emissions factors.

Calculating the average operating margin emission factor of the years 2004, 2005 and 2006, and weighting these three emission factors by the non low-cot/must-run plants generation plus the imports, an operating margin emission factor of 773.93 tCO_2/GWh is obtained.

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

In terms of vintage data, one of the following two options must be chosen:

Option 1. Calculate, for the first crediting period, the BM emission factor *ex-ante* based on the most recent information available on units already built; and for the second crediting period, update the BM emission factor based on the most recent information available on units already built at the time of submission of the request for renewal of the crediting period to the DOE. For the third crediting period, the BM emission factor calculated for the second crediting period should be used. This option does not require monitoring the emission factor during the crediting period.

Option 2. Update the build margin emission factor annually, *ex-post*, for the first crediting period, including those units built up to the year of registration of the project activity or, if information up to the year of registration is no yet available, including those units built up to the latest year for which information is available. For the second crediting period, the BM 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.

Option 1 has been chosen. So the calculation of the Build Margin emission factor $EF_{grid,BM,y}$ *ex-ante* based on the most recent information available on plants already built for sample group *m* at the time of PDD submission has been carried out.

Accordingly to the “Tool to calculate the emission factor for an electricity system”, capacity additions from retrofits of power plants should not be included in the calculation of the build margin emission factor.

The sample group of power units m used to calculate the Build Margin has been determined as per the procedure of the mentioned tool, which is shown next:

(a) Identify the set of five power units, excluding power units registered as CDM project activities, that started to supply electricity to the grid most recently ($SET_{5-units}$) and determine their annual electricity generation ($AEGSET_{5-units}$, in MWh);

(b) Determine the annual electricity generation of the project electricity system, excluding power units registered as CDM project activities (AEG_{total}, in MWh).

Identify the set of power units, excluding power units registered as CDM project activities, that started to supply electricity to the grid most recently and that comprise 20% of AEG_{total} (if 20% falls on part of the generation of a unit, the generation of that unit is fully included in the calculation) ($SET_{\geq 20\%}$) and determine their annual electricity generation ($AEGSET_{\geq 20\%}$, in MWh);

(c) From $SET_{5\text{-units}}$ and $SET_{\geq 20\%}$ select the set of power units that comprises the larger annual electricity generation (SET_{sample});

Identify the date when the power units in SET_{sample} started to supply electricity to the grid.

If none of the power units in SET_{sample} started to supply electricity to the grid more than 10 years ago, then use SET_{sample} to calculate the Build Margin. Ignore steps (d), (e) and (f).

Otherwise:

(d) Exclude from SET_{sample} the power units which started to supply electricity to the grid more than 10 years ago. Include in that set the power units registered as CDM project activity, starting with power units that started to supply electricity to the grid most recently, until the electricity generation of the new set comprises 20% of the annual electricity generation of the project electricity system (if 20% falls on part of the generation of a unit, the generation of that unit is fully included in the calculation) to the extent is possible. Determine for the resulting set ($SET_{sample\text{-}CDM}$) the annual electricity generation ($AEGSET_{sample\text{-}CDM}$, in MWh);

If the annual electricity generation of that set is comprises at least 20% of the annual electricity generation of the project electricity system (i.e. $AEGSET_{sample\text{-}CDM} \geq 0.2 \times AEG_{total}$), then use the sample group $SET_{sample\text{-}CDM}$ to calculate the Build Margin. Ignore steps (e) and (f).

Otherwise:

(e) Include in the sample group $SET_{sample\text{-}CDM}$ the power units that started to supply electricity to the grid more than 10 years ago until the electricity generation of the new set comprises 20% of the annual electricity generation of the project electricity system (if 20% falls on part of the generation of a unit, the generation of that unit is fully included in the calculation);

(f) The sample group of power units m used to calculate the Build Margin is the resulting set ($SET_{sample\text{-}CDM>10yrs}$).

Once followed paragraphs (a), (b) and (c), it was found that $SET_{\geq 20\%}$ had a larger production than $SET_{5\text{- units}}$ (see Table 12), so SET≥20% is considered the sample set (SET_{sample}). As none of the plants started supplying electricity to the grid more than 10 years ago, the sample group of power units m used to calculate the Build Margin is the resulting set: $SET_{\geq 20\%}$.

The following table shows the Guatemalan Electricity plants installed in or before 2006, excluding CDM projects:

	Power plants characteristics			
	Name of the power plant	Technology *	Date of installation	Fuel
Additions 2006	MONTECRISTO	Hydro	01/05/2006	-
	TRINIDAD	Cogenerator	January 2006	Bagasse
	TRINIDAD	Cogenerator	January 2006	Fuel Oil No. 6
Additions 2005	PALIN II	Hydro	July 2005	-
	POZA VERDE	Hydro	22/06/2005	-
	MAGDALENA EXCEDENTES	Cogenerator	2005-2006	Bagasse
	MAGDALENA EXCEDENTES	Cogenerator	2005-2006	Fuel Oil No. 6
	PANTALEÓN EXCEDENTES	Cogenerator	2005	Bagasse
	PANTALEÓN EXCEDENTES	Cogenerator	2005	Fuel Oil No. 6
Additions 2004	DARSA	Cogenerator	2004	Bagasse
	DARSA	Cogenerator	2004	Fuel Oil No. 6
	RENACE	Hydro	March 2004	-
	SAN DIEGO	Cogenerator	December 2004	Bagasse
	SAN DIEGO	Cogenerator	December 2004	Fuel Oil No. 6
Additions 2003	ELECTROGENERACIÓN	Internal Combustion Engine	November 2003	Diesel
	AMATEX	Internal Combustion Engine	2003	Diesel
	ARIZONA	Internal Combustion Engine	April-May 2003	Fuel Oil No. 6*
Additions 2002	CALDERAS	Geothermal	01/12/2002	-

Table 11. Guatemalan Grid Installed Capacity 2006 with commissioning dates.

The BM emission factor has been addressed following the equation below, as indicated by the “Tool to calculate the emission factor for an electricity system” (version 03.0.0).

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

Where:

$EF_{grid,BM,y}$ = Build Margin CO_2 emission factor in year y (t CO2/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 (t CO2/MWh)

m = Power units included in the Build Margin
y = Most recent historical year for which electricity generation data is available.

$$EF_{EL,m,y} = \frac{EF_{co2,m,i,y} \times 3.6}{\eta_{m,y}}$$

Where:

$EF_{EL,m,y}$ =refers to the CO_2 emission factor of power unit m in year y (tCO$_2$/MWh)
$EF_{CO2,m,i,y}$ =refers to the average CO_2 emission factor of fuel type i used in power unit m in year y (tCO_2/GJ)[24]
$\eta_{m,y}$ =average net energy conversion efficiency of power unit m in year y (%)[25].
y =refers to the most recent historical year for which power generation data is available.

Resulting from the application of the formulae before, the following emissions were obtained for the plants included in the Build Margin in the year 2006:

	Power plants characteristics				Net generation 2006(GWh)	Accumulated net generation (GWh)	Accumulated net generation (%)	($\eta_{m,y}$) Efficiency (%)	$EF_{(CO2,m,i,y)}$ [tCO_2/GJ]	$EF_{(EL,m,y)}$ [tCO_2/GWh]	[tCO_2]
	Name of the power plant	Technology *	Date of installation	Fuel							
Additions 2006	MONTECRISTO	Hydro	01/05/2006	-	3.40	3.4	0.05%	-	0.00	-	-
	TRINIDAD	Cogenerator	January 2006	Bagasse	17.30	20.7	0.28%	-	0.00	-	-
	TRINIDAD	Cogenerator	January 2006	Fuel Oil No. 6	0.00	20.7	0.28%	39.0%	75.50	696.92	0.00
Additions 2005	PALIN II	Hydro	July 2005	-	9.86	30.6	0.41%	-	0.00	-	-
	POZA VERDE	Hydro	22/06/2005	-	45.87	76.4	1.03%	-	0.00	-	-
	MAGDALENA EXCEDENTES	Cogenerator	2005-2006	Bagasse	103.42	179.9	2.42%	-	0.00	-	-
	MAGDALENA EXCEDENTES	Cogenerator	2005-2006	Fuel Oil No. 6	0.00	179.9	2.42%	39.0%	75.50	696.92	0.00
	PANTALEÓN EXCEDENTES	Cogenerator	2005	Bagasse	34.49	214.3	2.88%	-	0.00	-	-
	PANTALEÓN EXCEDENTES	Cogenerator	2005	Fuel Oil No. 6	0.00	214.3	2.88%	39.0%	75.50	696.92	0.00
Additions 2004	DARSA	Cogenerator	2004	Bagasse	1.91	216.3	2.91%	-	0.00	-	-
	DARSA	Cogenerator	2004	Fuel Oil No. 6	1.15	217.4	2.92%	39.0%	75.50	696.92	800.05
	RENACE	Hydro	March 2004	-	320.52	537.9	7.23%	-	0.00	-	-
	SAN DIEGO	Cogenerator	December 2004	Bagasse	1.87	539.8	7.26%	-	0.00	-	-
	SAN DIEGO	Cogenerator	December 2004	Fuel Oil No. 6	0.00	539.8	7.26%	39.0%	75.50	696.92	0.00
Additions 2003	ELECTROGENERACIÓN	Internal Combustion Engine	November 2003	Diesel	68.56	608.4	8.18%	39.5%	72.60	661.67	45,363.65
	AMATEX	Internal Combustion Engine	2003	Diesel	25.86	634.2	8.53%	39.5%	72.60	661.67	17,109.66
	ARIZONA	Internal Combustion Engine	April-May 2003	Fuel Oil No. 6*	847.47	1481.7	19.92%	39.5%	75.50	688.10	583,145.02
Additions 2002	CALDERAS	Geothermal	01/12/2002	-	20.77	1502.4	20.20%	-	0.00	-	-
					1,502.45						646,418.39

Table 12. Emission of the plants of the Build Margin in the year 2006.

Dividing the total emissions by the total generation of the plants in the table before, a Build Margin Emission Factor of 430.24 tCO_2/GWh is obtained:

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

[24] As in the case of the operating margin, the emission factors for each kind of fuel were obtained from Annex 1 of the “Tool to calculate the emission factor for an electricity system” (version 03.0.0).

[25] Efficiency values were taken from the Annex 1 of the “Tool to calculate the emission factor for an electricity system” (version 03.0.0), considering all the non hydro diesel and fuel oil fired plants included in the Build Margin as Open Cycle, in a conservative approach.

$EF_{grid,BM,y}$ = 646,418.369 tCO_2 / 1,502.45 GWh = 430.24 tCO_2/GWh

Step 6. Calculate the Combined Margin Emission Factor

The calculation of the Combined Margin (CM) emission factor (EFgrid,CM,y) is based on one of the following methods:

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

The weighted average CM method (option a) should be used as the preferred option. The simplified CM method (option b) can only be used if:

- The project activity is located in a Least Developed Country (LDC) or in a country with less than 10 registered projects at the starting date of validation or a small island developing state (SIDS); and
- The data requirements for the application of step 5 above cannot be met.

The option (a), Weighted average CM, has been chosen because it should be used as the preferred one, and the project doesn't meet the requirements for the application of the simple CM method:

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

Where:

$EF_{grid,BM,y}$	=	Build margin CO2 emission factor in year *y* (t CO2/MWh)
$EF_{grid,OM,y}$	=	Operating margin CO2 emission factor in year *y* (t CO2/MWh)
w_{OM}	=	Weighting of operating margin emissions factor (per cent)
w_{BM}	=	Weighting of build margin emissions factor (per cent)

The following default values should be used for wOM and wBM:

- Wind and solar power generation project activities: wOM=0.75 and wBM=0.25 (owing to their intermittent and non-dispatchable nature) for the first crediting period and for subsequent crediting periods;

- All other projects: wOM=0.5 and wBM=0.5 for the first crediting period, and wOM=0.25 and wBM=0.75 for the second and third crediting period, unless otherwise specified in the approved methodology which refers to the "Tool to calculate the emission factor for an electricity system" (version 03.0.0).

As the project is not a wind farm, neither a solar farm, during the first crediting period w_{OM}=0.5 and w_{BM}=0.5 will be used. Accordingly, a Combined Margin Emission Factor of 602.09 tCO_2/GWh is obtained, as it can be seen in the following formula:

$EF_{grid,CM,y}$ = 773.93 tCO_2/GWh x 0.5 + 430.24 tCO_2/GWh x 0.5 = 602.09 tCO_2/GWh

Appendix 5. Further background information on monitoring plan

No further background information is included.

Appendix 6. Summary report of comments received from local stakeholders

Not applicable.

Appendix 7. Summary of post-registration changes

The following post-registration changes has been requested with this new version of the PDD:

Corrections

The new version of the PDD comply with all the parameters of the Monitoring Plan as per registered PDD. However, some names of ex-post parameters presented in the monitoring plan of the currently registered PDD have been updated in different names and descriptions depending where are they measured for better understanding and clarification of the monitoring system. These new parameters names that have been updated are the following:

Original name and description of the parameter as per PDD	**New name and description of the parameter in this MR**
For gaseous stream sent to flares:	
$V_{t,db}$ (Volumetric flow of the gaseous stream in time interval t on a dry basis)	$\mathbf{V_{t,db\_flare}}$ (Volumetric flow of the gaseous stream sent to the flare in time interval t on a dry basis)
$V_{i,t,db}$ (Volumetric fraction of greenhouse gas i in the gaseous stream in time interval t on a dry basis)	$\mathbf{V_{i,t,db\_flare}}$ (Volumetric fraction of greenhouse gas i in the gaseous stream sent to flare in time interval t on a dry basis)
T_t (Temperature of the gaseous stream in time interval t)	$\mathbf{T_{t\_flare}}$ (Temperature of the gaseous stream sent to the flare in time interval t)
P_t (Absolute pressure of the gaseous stream in time interval t)	$\mathbf{P_{t\_flare}}$ (Absolute pressure of the gaseous stream sent to the flare in time interval t)
For gaseous stream sent to electric engines:	
$V_{t,db}$ (Volumetric flow of the gaseous stream in time interval t on a dry basis)	$\mathbf{V_{t,db\_electricity}}$ (Volumetric flow of the gaseous stream used for electricity generation in time interval t on a dry basis)
$V_{i,t,db}$ (Volumetric fraction of greenhouse gas i in the gaseous stream in time interval t on a dry basis)	$\mathbf{V_{i,t,db\_electricity}}$ (Volumetric fraction of greenhouse gas i in the gaseous stream used for electricity generation in time interval t on a dry basis)
T_t (Temperature of the gaseous stream in time interval t)	$\mathbf{T_{t\_electricity}}$ (Temperature of the gaseous stream used for electricity generation in time interval t)
P_t (Absolute pressure of the gaseous stream in time interval t)	$\mathbf{P_{t\_electricity}}$ (Absolute pressure of the gaseous stream used for electricity generation in time interval t)
At the residual gas:	

$V_{RG,m}$ (Volumetric flow of the residual gas on a dry basis at reference conditions in the minute m)	**$V_{RG,m}$ (=V_{t,db_flare}) –** Volumetric flow of the residual gas on a dry basis at reference conditions in the minute *m*
$v_{i,RG,m}$ (Volumetric fraction of component i in the residual gas on a dry basis at minute m where i = CH4, CO, CO2, O2, H2, H2S, NH3 and N2.)	**$V_{i,RG,m}$ (=V_{i,t,db_flare}) –** Volumetric fraction of component *i* in the residual gas on a dry basis at minute *m* where *i* = CH_4, CO, CO_2, O_2, H_2, H_2S, NH_3 and N_2.

Additionally, an editorial mistake has been corrected in this version of the PDD. In the beginning of Section A.3. of the original PDD was used the expression "open flares" but in the rest of the original PDD the flare system was defined as "enclosed flare" since always the project had enclosed flare.

Changes to the start date of the crediting period

Change to the start date of the crediting period have been requested as Post Registration Change in this Monitoring Period.

The original start date stated in the registered PDD as crediting period start date (01/03/2013) was delayed and the starting date when the project initiated its operation was in 26/07/2014 that match with the first date when the raw data records are available. The commissioning date of the main project equipment were the following:

Engine 1: 22/03/2015
Engine 2: 02/06/2017
Engine 3: 02/06/2017
Engine 4: 02/06/2017

Thus, the original crediting period (01/03/2013 – 29/02/2020) has been changed to 26/07/2014 – 25/07/2021. Because the crediting period is after 01/01/2013, the value of parameter GWP_{CH4} was updated to in accordance with actual value for the 2nd commitment period.

This delay is due to the fact that the first acquisitions of the biogas collection and use equipment were made in 07/04/2014, due to the procedures required by the Ministry of Energy and Mines (MEN as per its Spanish acronym) of the Republic of Guatemala for renewable energy projects of less than 5 MW considered Generators of Renewable Distribution (GDR as per its Spanish acronym).

The General Directorate of Energy (DGE as per its Spanish acronym) of the MEN establishes that the project be developed in three phases, planning, execution and commercial operation. During the planning phase, the respective studies and procedures are prepared to obtain the approval of the renewable energy project before the MEN and the National Electric Energy Commission (CNEE as per its Spanish acronym), period in which equipment cannot be imported until the DGE and the MEN issue the project approval resolution. During this period, it was required to expand the environmental impact study including a list of tariff items of equipment necessary for the collection, thermal oxidation of biogas and generation of electrical energy, in such a way that the processes of procedures before the regulatory entities caused a delay in the start of the project execution. The execution stage was completed in 6 months.

Evidence of this delay is the "Resolution No 1175-2014/DIGARN/UCA/RMHH/aetf" issued on 27/03/2014 by the Environmental Quality Unit of the General Direction of Environmental Management and Natural Resources of the Ministry of Environment and Natural Resources of the Government of Guatemala.

Thus, the date of 07/04/2014 matches with the date when the project proponent committed with the payment and acquisition of the well drilling works, needed to start with the construction of the biogas collection system.

During this delay in the starting date of operation, there was not changes in the baseline emissions as the quantity of waste received by the landfill remained the same as per the Authorization Letter of the municipality of Guatemala to receive an average of 3,300 tons per day for the Zone 3 Landfill.

Additionally, no changes in the technical requirements and normative for landfill operation occurred in terms of biogas destruction as the current applicable technical normative “No DRPSA-004-2018” issued on 02/05/2018 by the Ministry of Public Health and Social Assistance. General Direction of Regulation, Surveillance and Health Control. Department of Regulation of Health and Environment Programs only oblige to include a collection and control system for the biogas generated in its Article 10 and 17.

According the normative, this collection and control system must include, as minimum:

- Design of the System to foresee protection measures for the works to collect the generated gases
- Design of the system that guarantees the effective collection of the gases generated, so that the methane concentration in the areas destined for final disposal does not exceed, at any time, when percent.
- Projected location of the works that do not represent a sanitary risk in relation to other hydro sanitary systems or sources of water supply for human consumption.
- It is not intended to use the system to combine and / or dilute leachates and / or wastewater
- The hydraulic capacity of the system has been designed according to the determined maximum flow rates.
- The system has an appropriate and pertinent operation manual
- The system has an appropriate and pertinent maintenance manual

Considering this, the recovery, destruction and/or use of the biogas generated in the landfill site is not recommended neither required by the current technical normative applicable.

Changes to project design

The change to the project design is a decrease in the electricity generation capacity specified in the registered PDD – at the registered PDD, the capacity is 4.8 MW and the change decreases the capacity to 4.242 MW.

The decision for this decrease occurred after the investment decision and validation of the project activity. It was taken due to a commercial decision. Therefore, instead of four engines of 1.2 MW each as it was planned as per registered PDD, it was implemented one engine of 1,059 kW on 22/03/2015 and three engines of 1,061 kW (each) on 02/06/2017.

The models of electricity generation engines finally installed are the following:

1 unit of JGC 320 GS-B.L BOREALIA GUATEMALA with an electricity output of 1059 kW.
3 units of JGC 320 GS-L.L TS JGC 320 C81 480V with an electrical output of 1061 kW.

Due the difference between the capacity of the engines, the financial analysis has been updated considering the real purchase price and the generation of the equipment finally installed. As can be seen in the section B.5 of this PDD, the project still complies with the financial additionality requirements and the IRR of the project scenario without CERs revenues (-4.12%) is below the benchmark established for Guatemala (12.5%).

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Document information

Version	*Date*	*Description*
11.0	31 May 2019	Revision to: • Ensure consistency with version 02.0 of the "CDM project standard for project activities" (CDM-EB93-A04-STAN); • Make editorial improvements.
10.1	28 June 2017	Revision to make editorial improvement.
10.0	7 June 2017	Revision to: • Improve consistency with the "CDM project standard for project activities" and with the PoA-DD and CPA-DD forms; • Make editorial improvement.
09.0	24 May 2017	Revision to: • Ensure consistency with the "CDM project standard for project activities" (CDM-EB93-A04-STAN) (version 01.0); • Incorporate the "Project design document form for small-scale CDM project activities" (CDM-SSC-PDD-FORM); • Make editorial improvement.
08.0	22 July 2016	EB 90, Annex 1 Revision to include provisions related to automatically additional project activities.
07.0	15 April 2016	Revision to ensure consistency with the "Standard: Applicability of sectoral scopes" (CDM-EB88-A04-STAN) (version 01.0).
06.0	9 March 2015	Revision to: • Include provisions related to statement on erroneous inclusion of a CPA; • Include provisions related to delayed submission of a monitoring plan; • Provisions related to local stakeholder consultation; • Provisions related to the Host Party; • Make editorial improvement.

Version	*Date*	*Description*
05.0	25 June 2014	Revision to: • Include the Attachment: Instructions for filling out the project design document form for CDM project activities (these instructions supersede the "Guidelines for completing the project design document form" (Version 01.0)); • Include provisions related to standardized baselines; • Add contact information on a responsible person(s)/ entity(ies) for the application of the methodology (ies) to the project activity in B.7.4 and Appendix 1; • Change the reference number from F-CDM-PDD to CDM-PDD-FORM; • Make editorial improvement.
04.1	11 April 2012	Editorial revision to change version 02 line in history box from Annex 06 to Annex 06b.
04.0	13 March 2012	Revision required to ensure consistency with the “Guidelines for completing the project design document form for CDM project activities” (EB 66, Annex 8).
03.0	26 July 2006	EB 25, Annex 15
02.0	14 June 2004	EB 14, Annex 06b
01.0	03 August 2002	EB 05, Paragraph 12 Initial adoption.

Decision Class: Regulatory
Document Type: Form
Business Function: Registration
Keywords: project activities, project design document