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

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Annexes

SECTION A. General description of project activity

A.1. Title of the project activity:

Constroeste Landfill Gas to Energy Project
Version 05
Completed on 20/06/2012

A.2. Description of the project activity:

The Constroeste Landfill Gas to Energy Project encompasses the construction and operation of a landfill gas (LFG) collection and flaring system (with the future possibility of electricity generation using LFG as fuel) at the Onda Verde landfill (Aterro de Codisposição Onda Verde), which is located close to the city of São José do Rio Preto, São Paulo, Brazil.

The landfill has an area of 164 ha and started its operations in January 2009, receiving Municipal Solid Waste (MSW) as well as industrial non-hazardous waste from several municipalities, with an expected operational lifetime of about 14 years (when considering a disposal rate of 1,500 ton of waste per day)[1].

Equipment that will be installed in the proposed project activity includes *inter alia* a LFG collection network comprising vertical LFG collection wells and eventually horizontal LFG collection trenches, a LFG flaring station (comprising high temperature enclosed flare(s) and monitoring and control systems). Possible alternative use for collected LFG also include using LFG as fuel for electricity generation in order to meet the internal landfill electricity demand for the project activity and for the landfill. Excess electricity generated on the project activity may also be exported trough the grid or all net electricity generation to be entirely exported to the grid (with electricity demand for the project activity being totally or partially being met by imports of grid electricity).

It is expected that the project's electricity generation component will only be implemented after one year of operation of the project activity as a LFG collection and destruction initiative (with collected LFG being combusted by flaring).

The baseline scenario is the same as the scenario existing prior to the implementation of the project activity for LFG management at the Onda Verde Landfill: the LFG (with high content of methane) being emitted into the atmosphere without any treatment, collection, combustion or control. While methane is a strong greenhouse gas (GHG), the current situation of emission of LFG into the atmosphere thus contributes to global warming. Furthermore, free emissions of methane trough the landfill surface also create a risk of fire, explosion as well as bad odours.

The collection and combustion of LFG through an active LFG collection and flaring system and/or electricity generation facility reduce such risks and also contribute to reduce GHG emissions from the

[1] The project participants acknowledge that forecasted MSW disposal rate can be changed (trend to be potentially increased).

Onda Verde landfill. Furthermore, the generation of electricity using collected LFG as fuel also displace existing electricity generation from fossil fuel sources that would otherwise be generated in the National Electricity Grid of Brazil. It is estimated that the methane destruction component of the project activity will promote average annual emissions reductions of approximately 156,000 tCO_{2e} per year over a selected 7-year renewable crediting period.

Besides climate change mitigation, the project provides important local environmental benefits. LFG contains trace amounts of volatile organic compounds, which are local air pollutants. Capture of LFG using an active forced collection system and its combustion (by flaring or use for power generation) greatly reduces such emissions and thereby contribute to sustainable development.

The project also provides the following additional important local environmental and social benefits:

- Destruction of other air pollutants, such as hydrogen sulphide, that is present in trace quantities in LFG.
- Reduction of risk of occurrence of fire and explosion at the Onda Verde Landfill, through improved LFG management.
- Reduction of odour in the Onda Verde Landfill.
- Promotion of non-conventional renewable energy generation (in case it is implemented).
- Local job opportunities

The project when fully implemented (including an electricity generation facility fuelled by LFG) can be used as a technological demonstration initiative for renewable electricity generation with a rational utilization of LFG as fuel for electricity generation. It is the intention of the project participant to establish cooperation agreements with local NGOs, academia and community to demonstrate and promote this type of projects.

A.3. Project participants:

Name of Party involved	Private and/or public entities Project Participant	Does the Party involved wish to be considered as a Project Participant
Brazil (host)	Constroeste Construtora e Participações Ltda. (private entity)	No

A.4. Technical description of the project activity:

A.4.1. Location of the project activity:

A.4.1.1. Host Party(ies):

Brazil

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

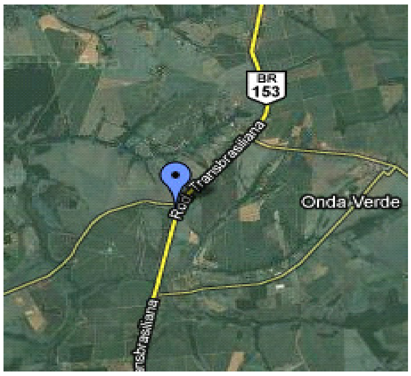
State of São Paulo

A.4.1.3. City/Town/Community etc.:

Onda Verde Municipality

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

The Onda Verde landfill is located in the Rural Area of Onda Verde city at km 1.3 of Estrada Vicinal Antonio Gonçalves do Carmo, 25 km from São José do Rio Preto city.



Project geographical coordinates are: -20.617240503129633; -49.33414936065674, in decimal degrees or 20° 37' 2.0634" S, 49° 20' 2.9358" W in DMS[2] format.

The Onda Verde landfill does not appear on the satellite picture of the location as the picture made available on Google Maps Satellite View is prior to the site construction.

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

Sectoral scope 13 - Waste handling and disposal.

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

The existing pre-project scenario prior to the implementation of the project activity is the non-existence of appropriate equipment and practice dedicated to promote LFG collection and destruction/utilization at the landfill site. In the existing pre-project scenario there are some wells which were implemented to allow passive venting of LFG (without combustion) in order to avoid significant LFG gas accumulation inside the landfill (thus reducing the risk of fire and explosions). At baseline scenario (absence of the proposed project activity) it is assumed that the landfill site would continue to have no proper equipment installed for promoting LFG and destruction or utilization.

The project activity encompasses the implementation of an advanced active LFG collection and flaring

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[2] Degree, Minute, Second.

system with eventual utilization of LFG as fuel for electricity generation (use of electricity generation engine-generator set fuelled uniquely by LFG). The equipment which will be installed as part of the project activity includes:

- New and/or existing vertical LFG wells[3] and/or horizontal trenches;
- LFG collection network, with PE pipes;
- High temperature enclosed flare(s);
- Monitoring and control systems to measure flow[4] and composition of the landfill gas and eventually equipment to measure the composition of exhaust gas of the flare(s) in terms of oxygen and methane;
- In case of utilization of LFG for electricity generation, installed equipment will also eventually include additional flow meter(s), engine-generator sets, LFG pre-treatment system (if required) and required electrical connections, including power transformers.

The operation of the project will consist on collecting LFG from the landfill in a forced manner with the use of blower(s) and direct collected LFG to combustion in high temperature flare(s) or in the engine-generator sets of the electricity generation facility. Such measures will enable methane contained in the LFG to be destroyed thus promoting GHG emission reductions. The project system is expected to be equipped with all needed monitoring system to ensure that all required measurements (as per ACM0001 (version 12) are performed (LFG flow, methane content in LFG, etc.).

The project activity will initially encompass only LFG collection and flaring (phase 1). As a second step (phase 2), collected LFG will eventually be used as fuel for electricity generation. Implementation of phase 2 will depend on confirmation of the technical operational feasibility of LFG collection system as well as confirmation of quality of collected LFG (as suitable for being used to electricity generation)[5].

The technology that will be used is environmentally safe and sound; it includes a LFG flaring system with the following characteristics:

- Safe and low emission combustion guaranteed by a high temperature enclosed flare;
- Safety devices such as flame arrester, slam shut valve and flame detection.

Studies and evaluations for the implementation of phase 2 are likely to start once the project is fully operational and uncertainties regarding LFG quality, LFG volumes, system efficiency etc. are addressed. Project phase 2 is estimated to be operational from 2014 once equipment would be installed, and local permits and sale agreements for electricity are obtained.

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[3] Depending on the outcome of the project engineering (which is expected to be initiated right after the successful registration of the project as a CDM project activity), exiting LFG venting wells may be converted into LFG collection well which will part of the project activity. As an alternative, existing LFG venting wells will be covered and new LFG collection wells will be built.

[4] As established by ACM0001 (version 12), dedicated LFG mass flow meters to measure the amount of LFG sent to the flare(s) and for the electricity generation facility will be used.

[5] Most of the manufacturers of engine-generator sets fuelled by LFG specify requirements in terms of the quality of LFG (e.g. minimum CH_4 content, etc.)

The project's electricity generation system may consist of a LFG pre-treatment system, in order to dry and clean the landfill gas, and engine-generator sets. The LFG pre-treatment system will dry the LFG and compress it. If applicable, the design of the LFG cleaning system will be depend on the quality of collected LFG.

The expected operational lifetime for the LFG flaring system and electricity generation facility is at least 20 years. However, project lifetime may even exceed 20 years if required maintenance is performed correctly. No technology substitution is expected during the 7-year renewable crediting period.

Although the equipment suppliers have not yet been defined, based on the volume predictions for collection of LFG and on preliminary consultation with existent equipment suppliers, the characteristics of typical equipment to be installed might be as follows:

Equipment	Characteristics[6]
Flare	3 x 2,000 m^3/h Enclosed Flares
Electricity generation equipment	6 containerized 1.2 MW LFG internal combustion engine-generator sets
LFG collecting network	Consisting on horizontal/vertical wells connected by PE pipes with a predicted flow of 15 m^3/h per well

The main GHG emissions source in the baseline scenario is methane, and these emissions will be reduced by the project activity compared to the baseline scenario in the absence of the project activity. The baseline scenario also includes the GHG emissions for the generation of equivalent amount of electricity that would, in the absence of the project activity, be generated by the operation of grid-connected thermal power plants and by the addition of new generation sources in the National Electricity Grid of Brazil.

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

Year	**Estimation of annual emission reductions** (tonnes of CO_2e)
2013	106,410
2014	127,396
2015	144,816
2016	159,800
2017	173,109
2018	185,266
2019	196,625
Total estimated reductions (tonnes of CO2e)	**1,093,423**
Total number of crediting years	7
Annual average of the estimated reductions over the crediting period (tCO_2e)	156,203

Expected start date of the crediting period is: 01/01/2013.

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[6] The characteristics of the equipment were delivered to the DOE during the validation process.

A.4.5. Public funding of the project activity:

No public funding involved in this project activity.

SECTION B. Application of a baseline and monitoring methodology

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

Baseline and monitoring CDM methodology ACM0001 - "Flaring or use of Landfill Gas" (version 12)[7];
Combined tool to identify the baseline scenario and demonstrate additionality (version 04.0.0, EB 66)
Emissions from solid waste disposal sites (version 06.0.1, EB66);
Tool to calculate baseline, project and/or leakage emissions from electricity consumption (version 1, EB39);
Tool to determine project emissions from flaring gases containing methane (version 1, EB 28);
Tool to determine the mass flow of a greenhouse gas in a gaseous stream (version 02.0.0);
Tool to calculate the emission factor for an electricity system (version 02.2.1, EB 63);

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

The approved monitoring methodology ACM0001 (version 12) is adopted, and, in addition, the following tools referred by the consolidating baseline and monitoring methodology have been applied. Demonstration of all applicable applicability conditions are included in the following tables:

Applicability Condition of ACM0001 (version 12)	Justification
"*This methodology 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 only vented or flared and not used prior to the implementation of the project activity; and*	The project activity encompasses the installation of a new LFG collection and destruction/utilization system in an existing SWDS, therefore complying with (a). Since there is no existing active LFG capture system that has been in operation in the last calendar year prior to the start of the project activity, condition (b) is not applicable.

7 Methodology and tools available at: http://cdm.unfccc.int/methodologies/DB/RNAKK7JRFWIKCFT3YSNKGPC1FR2DVA/view.html, accessed on 11/04/2012.
Baseline and monitoring CDM methodology ACM0001 - "Flaring or use of Landfill Gas" (version 12) - http://cdm.unfccc.int/filestorage/Y/9/4/Y94STJCQP5FEIVL21HWKUBMRXAOND6.1/EB65_repan15_ACM0001_ver12.0.0.pdf?t=TEZ8bTJ4cms3fDAYRRHtY_zBdH9v5vscUiih
Combined tool to identify the baseline scenario and demonstrate additionality (version 04.0.0, EB 66) – http://cdm.unfccc.int/methodologies/PAmethodologies/tools/am-tool-02-v4.0.0.pdf
Emissions from solid waste disposal sites (version 06.0.1, EB66) - http://cdm.unfccc.int/methodologies/PAmethodologies/tools/am-tool-04-v6.0.1.pdf
Tool to calculate baseline, project and/or leakage emissions from electricity consumption (version 1, EB39) – http://cdm.unfccc.int/Reference/tools/ls/meth_tool05_v01.pdf
Tool to determine project emissions from flaring gases containing methane (version 1, EB 28) - http://cdm.unfccc.int/methodologies/PAmethodologies/tools/am-tool-06-v1.pdf
Tool to determine the mass flow of a greenhouse gas in a gaseous stream (version 02.0.0) - http://cdm.unfccc.int/methodologies/PAmethodologies/tools/am-tool-08-v2.0.0.pdf
Tool to calculate the emission factor for an electricity system (version 02.2.1, EB 63) - http://cdm.unfccc.int/methodologies/PAmethodologies/tools/am-tool-07-v2.2.1.pdf

Applicability Condition of ACM0001 (version 12)	Justification
(ii) In the case of an existing active LFG capture system for which the amount of 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); and/or* *(iii) 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 project activity will use captured LFG for flaring in phase 1 and as fuel for electricity generation in phase 2. Therefore condition (c) (i) is satisfied. The project activity does not imply any change in the waste disposal activities at the Onda Verde landfill, therefore (d) is also satisfied.
"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) Partial or total release of the 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 heat 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 on-site equipment."*	As further demonstrated in Section B.4, the most plausible baseline scenario is the total release of the LFG from the SWDS into the atmosphere. In phase 2 the project activity will generate electricity of which equivalent amount would otherwise be generated by existing power plants the grid and new additions, and therefore fall into (b) (i).
Non applicability conditions	**Justification**
(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, where the purpose of the CDM project activity is to	Neither (a) and (b) occur, therefore ACM0001 (version 12) is applicable to the project activity. The only emission reductions claimed are originated in the LFG flaring and renewable energy

Applicability Condition of ACM0001 (version 12)	Justification
implement energy efficiency measures at the kiln; (b) *If the management of the SWDS in the project activity is deliberately changed in order to increase methane generation compared to the situation prior to the implementation of the project activity (e.g. other to meet a technical or regulatory requirement). For example, this may apply to the addition of liquids to a SWDS, pre-treating waste to seed it with bacteria for the purpose of increasing the anaerobic degradation environment of the SWDS or changing the shape of the SWDS to increase the Methane Correction Factor."*	generation form LFG. After the implementation of the project activity, the landfill operator will continue current waste disposal activities at the Onda Verde landfill as per its normal operation conditions.

Regarding the tools:

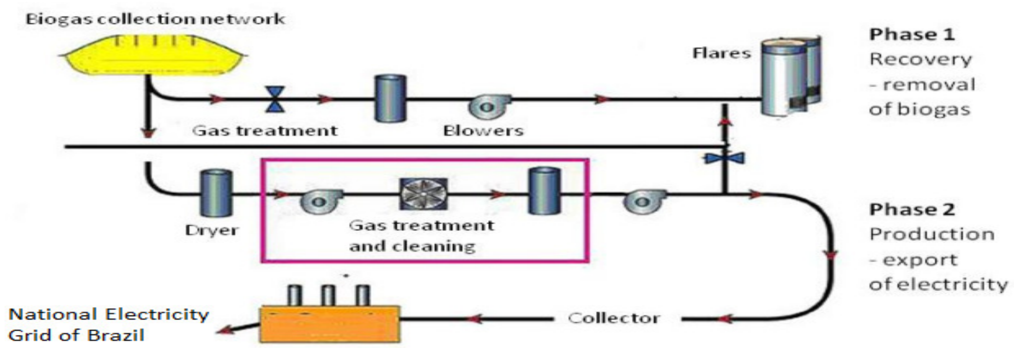
Tool	Version	Comments
"Tool to determine project emissions from flaring gases containing methane"	01	LFG combusted by the project's flare(s) is obtained from the decomposition of organic waste material through a landfill fulfilling the second applicability criteria defined in the tool. The gas combusted in the flare is LFG. No other gas, excepting air, is added in the residual gas stream. LFG is mainly composed by methane (CH_4) and carbon dioxide (CO_2). Trace elements of Volatile Organic Compounds could be found in LFG. The first applicability criterion of the tool is met. Therefore both applicability criteria of the Tool are met.
"Tool to calculate baseline, project and/or leakage emissions from electricity consumption"	01	This tool is applicable to calculate the emissions from electricity consumption as well as for the determination of project emissions due to the consumption of electricity by the project activity. All electricity demand from the project activity, if not met by the project's electricity generation component, will be met by imports of grid electricity.
"Emissions from solid waste disposal sites"	06.0.1	This tool provides stepwise approach to calculate baseline, emissions of methane from solid waste disposed or prevented from disposal at a SWDS. Application A is adopted. As per the tool: if "*(…) the CDM project activity mitigates methane emissions from a specific existing SWDS.", application A should be used"*
"Tool to calculate the emission factor for an electricity system"	02.2.1	This tool is applied for the calculation of the emission reductions from electricity generation as well as for the determination of project emissions due to the consumption of electricity by the project activity. Also, the "Tool to calculate baseline, project and/or leakage emissions from electricity consumption" refers to the "Tool to calculate the emission factor for an electricity system".
"Combined tool to	04.0.0	As established by ACM0001 (version 12), this tool is applied as

Tool	Version	Comments
identify the baseline scenario and demonstrate additionality"		per the methodology for the identification of the baseline scenario and to demonstrate the additionality of the CDM project activity.
"Tool to calculate project or leakage CO_2 emissions from fossil fuel combustion"	02	This tool is not applicable to the project activity since no fossil fuel is expected to be combusted within the project boundary.
"Tool to determine the mass flow of a greenhouse gas in a gaseous stream"	02.0.0	*"This tool is used to determine the mass flow of greenhouse gas i (CO_2, CH_4, N_2O, SF_6 or a PFC) in the time interval t."* This tool provides procedures to determine $F_{i,t}$ (kg/h). The mass flow of a greenhouse gas (CO_2, CH_4, N_2O, SF_6 or a PFC) in the gaseous stream in time interval t. based on measurements of: (a) the total volume flow or mass flow of the gas stream, (b) the volumetric fraction of the gas in the gas stream and (c) the gas composition and water content. Typical applications of this tool are methodologies where the flow and composition of residual or flared gases or exhaust gases are measured for the determination of baseline or project emissions, which is the case of the present project activity.

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

According to its definition, the project boundary shall encompass all anthropogenic emissions by sources of greenhouse gases under the control of the project participants that are significant and reasonably attributable to the CDM project activity.

As for ACM0001 (version 12), the project boundary is the site of the project activity where LFG is captured, destroyed and/or used. Also, any electricity sources for the project activity operation (from grid) shall be included in the project boundary. According to the "Tool to calculate the emission factor for an electricity system", the National Electricity Grid of Brazil is chosen as electric system for this project, and the system boundary includes all the power plants which are connected to this electricity grid. The figure below identifies the project boundary:



The following emission sources are considered within the project boundary:

Table 1: Summary of gases and sources included in the project boundary and justification/explanation where gases and sources are not included

	Source	Gas	Included?	Justification / Explanation
Baseline	Emissions from decomposition of waste at the SWDS site	CH_4	Yes	The major source of emissions in the baseline
		N_2O	No	N_2O emissions are very small compared to CH_4 emissions from SWDS. This is conservative
		CO_2	No	CO_2 emissions from decomposition of organic waste are not accounted since the CO_2 is also released under the project activity.
	Emissions from electricity generation	CO_2	Yes	Major emission source (if power generation is included in the project activity).
		CH_4	No	Excluded for simplification. This is conservative
		N_2O	No	Excluded for simplification. This is conservative
Project Activity	Emissions from electricity consumption due to the project activity	CO_2	Yes	May be an important emission source
		CH_4	No	Excluded for simplification. This emission source is assumed to be very small
		N_2O	No	Excluded for simplification. This emission source is assumed to be very small

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

On the next steps, it is identified the baseline scenario for the project activity. As established by ACM0001 (version 12) the stepwise approach of the "Combined tool to identify the baseline scenario and demonstrate additionality", Version 04.0.0, is adopted. The baseline scenario is identified for both the projects components involving destruction of LFG and utilization of LFG as fuel for power generation.

Step 0: Demonstration whether the proposed project activity is the *First-of-its-kind*

This optional step is not applied.

Step 1: Identification of alternative scenarios

Step 1a: Define alternatives to the proposed CDM project activity

In this step, the following baseline alternatives for the destruction of LFG, are taken into consideration:

LFG1: The project activity (i.e. capture of landfill gas and its flaring and/or its use) undertaken without being registered as a CDM project activity. This is a plausible alternative scenario, however involves significant investment and additional costs of landfill operations with no associated revenues.

LFG2: Atmospheric release of the landfill gas or partial capture of landfill gas and destruction to comply with regulations or contractual requirements, or to address safety and odour concerns. This scenario corresponds to the continuation of the current situation (no project activity or other alternatives undertaken).

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;

LFG5: LFG is partially not generated because part of the organic fraction of the solid waste is incinerated and not disposed in the SWDS.

The current project activity is developed at a landfill site whose purpose is the final disposition of waste through adopting of landfilling practices and techniques. With or without the project activity, no recycling of the organic fraction of the waste, neither aerobic treatment, neither incineration, is expected. Thus scenarios LFG3, LFG4 and LFG5 are excluded. In fact, recycling of organic matter, aerobic treatment and incineration are not common practice in Brazil[8].

[8] In fact all generated Municipal Solid Waste in Brazil is currently managed through deposition on dump sites or landfills (either controlled or uncontrolled). This is outlined in Figure 4.1.3.1 on page 46 of the publication

The following baseline alternatives for the utilization of LFG are taken into consideration:

Under implementation phase 2, LFG will be expected to be used as fuel for generation of electricity for export to a grid, so realistic and credible alternatives will also be separately determined for power generation in the absence of the project activity. Heat generation using LFG collected at the Onda Verde landfill as fuel is not considered and it is thus not part of the project activity. Therefore, scenarios H1 trough H7, are not considered on the present analysis. Supply of LFG to a natural gas distribution network is not considered. This is in accordance with ACM0001 (version 12).

For power generation, the realistic and credible alternative(s) may include:

E1: Electricity generation from LFG, undertaken without being registered as CDM project activity;

E2: Electricity generation in existing or new on-site or off-site renewable based captive power plant(s);

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

Scenario E2 is excluded. Since all electricity demand from the Onda Verde landfill site has been historically met by a reliable supply of grid electricity (since the starting of operations of the landfill), the utilization of a captive off-grid electricity generation source (using renewable or fossil energy sources) never occurred and it is not foreseen to occur in the project scenario either.

Outcome of Step 1a: the alternatives to be taken into consideration, after step 1a) are LFG1, LFG2, E1 and E3.

Step 1b: Consistency with mandatory applicable laws and regulations:

So far, there is still no legal restrictions or requirements for LFG gas collection and destruction in Brazil, neither for passive venting, therefore alternative LFG1 and LFG2 are thus in compliance with applicable mandatory laws and regulations. Also there is no legal requirement to destruct LFG either[9].

"Panorama dos Resíduos Sólidos no Brasi - l2010. Available online: http://www.abrelpe.org.br/Panorama/panorama2010.pdf, accessed on 20/04/2012

[9] Currently, Brazil has a National Waste Policy Directive called "*Política Nacional de Resíduos Sólidos*" (National policy for Solid Waste). This directive was instituted as a Federal Law by the Presidential Law 12305 (published on 02/08/2010). This Directive is applicable, according to §1 of Article 1 to companies or individuals, from public or private domain, responsible for waste generation and waste management. The law establishes legal grounds for waste management, including final destination, i.e. landfills. By establishing directives for management of solid waste, the law aims to be a legal framework for promoting overall improvement of waste management practices in Brazil. The "*Política Nacional de Resíduos Sólidos*" does not even refer to LFG, LFG flaring nor other types of LFG destruction or utilization technologies. Therefore it is demonstrated that LFG destruction or utilization is not an mandatory in Brazil. The "*Política Nacional de Resíduos Sólidos*" is available online: http://www.planalto.gov.br/ccivil_03/_ato2007-2010/2010/lei/l12305.htm

On 21/04/2012, there was 25 LFG flaring and/or power generation projects hosted in Brazil and registered as CDM project activities by UNFCCC. All LFG collection and destruction/utilization initiatives in Brazil are implemented as CDM project activities. That sustain that LFG destruction or utilization is not an obligation in Brazil.

Outcome of Sub-step 1b: the alternatives to be taken into consideration are LFG1, LFG2, E1 and E3.

The identification of the baseline scenario is further performed in section B.5. As further demonstrated in section B.5, the baseline scenario is identified as the combination of the alternatives LFG2 and E3.

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

On the next steps, it is demonstrated the additionality of the project by adopting Steps 2, 3 and 4 of the "Combined tool to identify the baseline scenario and demonstrate additionality" (version 04.0.0).

STEP 2: Barrier analysis

Step 2a: Identify barriers that would prevent the implementation of alternative scenarios

In Brazil there are no LFG flaring or power generation initiatives apart of the ones registered as CDM project activities or under registration stage. In the view of the project participants, as a positive externality of the CDM, competence in terms of technology for LFG collection and destruction in enclosed flares as well as its utilization for electricity generation has been developed within the latest years. Moreover, suppliers of related equipment are currently also established in Brazil. Therefore, in the view of the project participants, there is no barrier for the implementation of LFG collection and destruction and/or utilization initiatives in Brazil.

Outcome of Step 2a: No barriers are identified for the alternatives the implementation of the project activity (baseline alternatives LFG1 and E1) in the context of the assessment and demonstration of additionality for the project activity.

As the alternatives LFG2 and E3 represent the continuation of current practice (with no investment being performed by the project participants), no barriers are identified also for the alternatives LFG1 and E1 in the context of the identification of baseline scenario (continuation of identification of baseline scenario as described in Section B.4).

Step 2b: Eliminate alternative scenarios which are prevented by the identified barriers

In the context of the assessment and demonstration of additionality, the implementation of the proposed project activity without CDM – LFG1 and E1 – is identified as not prevented by the barriers.

In the context of the identification of the baseline scenario (continuation of Section B.4), the business-as-usual scenario (alternatives LFG2 and E3) are not prevented by any barrier either.

Outcome of Step 2b: No barriers were identified in Step 2a.

Step 2: Scenarios LFG1 + E1 and LFG 2 + E3 remain after this step, and since the project activity is not the first-of-its-kind, step 3, investment analysis, is applied.

Step 3: Investment analysis

In the context of the assessment and demonstration of additionality and identification of the baseline scenario, the financial attractiveness of the remaining alternatives after step 2 (scenarios LFG1 + E1 and LFG 2 + E3) is compared by conducting an investment analysis. As established in the "Combined tool to identify the baseline scenario and demonstrate additionality" the analysis includes alternative scenarios where the project participants do not undertake an investment, operational costs or revenues (S2 or S3).

For the present analysis the equivalence between the alternative scenarios defined in the "Combined tool to identify the baseline scenario and demonstrate additionality" and the scenarios defined in ACM0001 (version 12) are presented in the table below:

Alternative scenarios as per the "Combined tool to identify the baseline scenario and demonstrate additionality"		Applicable equivalent alternative baseline scenario as per the ACM0001 (for remaining alternatives after step 2)		Equivalence demonstrated?
S1	*"The proposed project activity undertaken without being registered as a CDM project activity"*	LFG1 and/or E1	LFG1: "*The project activity implemented without being registered as a CDM project activity (i.e. capture and flaring or use of LFG)"* E1: "*Electricity generation from LFG, undertaken without being registered as CDM project activity."*	Yes
S2	"*No investment is undertaken by the project participants but third party(ies) undertake(s) investments or actions which provide the same output to users of the project activity.*"	E3	*"Electricity generation in existing and/or new grid-connected power plants"*	Yes
S3	"*Where applicable, the continuation of the current situation, not requiring any investment or expenses to maintain the current situation such as (…) the continued venting of methane from a landfill*"	LFG2	"*Atmospheric release of the LFG or partial capture of LFG and destruction to comply with regulations or contractual requirements, or to address safety and odour concerns*";	Yes
S4	*"Continuation of the current situation, requiring an investment or expenses to maintain the current situation"*	N/A	-	-
S5	*"Other plausible and credible*	N/A	-	-

Alternative scenarios as per the "Combined tool to identify the baseline scenario and demonstrate additionality"		Applicable equivalent alternative baseline scenario as per the ACM0001 (for remaining alternatives after step 2)		Equivalence demonstrated?
	alternative scenarios to the project activity scenario, including the common practices in the relevant sector, which deliver the same output."			
S6	*"Where applicable, the .proposed project activity undertaken without being registered as a CDM project activity to be implemented at a later point in time (e.g. due to existing regulations, end of-life of existing equipment, financing aspects)."*	N/A	-	-

As one of the combined alternative scenarios remaining after Step 2 corresponds to the situation equivalent to S3 and S2 (when the project's electricity generation component is considered), the Net Present Value (NPV) is chosen as the financial indicator for the analysis of those alternative scenarios. This is in accordance with the the "Combined tool to identify the baseline scenario and demonstrate additionality". For alternative baseline scenarios LFG1 and E1 (equivalent to S1), the proposed project activity being undertaken without being registered as CDM project is analyzed below, also choosing the NPV as financial indicator.
As the project activity is comprised of two phases (where the component E1 may eventually not be implemented), the two possibilities are analyzed separately: "LFG1" and "LFG1+E1".

LFG1

In this scenario there are investment and operation & maintenance costs associated with LFG capture and flaring and there are no associated revenues being generated on this baseline scenario. Therefore the NPV of the scenario LFG 1 is always negative regardless of the magnitude of the associated investment and maintenance & operation costs being considered. As per available estimations the total investment is estimated as 3,358,560 €[16] , operational & maintenance costs are estimated in 284,083 € per year. The calculated NPV under these assumptions is -5,514,192€.

LFG1+E1

Main assumptions of the LFG1+ E1[17] scenario: electricity generation in the absence of CDM registration,

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[16] Details provided in Financial Constroeste Spreadsheet in Capex Opex LFG1.

[17] It is important to note that implementation of the project electricity generation component (defined as alternative E1 – when CDM revenues are not considered) is fully dependent on a prior implementation of a complete LFG capture and flaring system (which is defined as alternative LFG 1 – when CDM revenues are not considered). Normally, in a typical LFG collection and utilization initiative (with captured LFG being utilized for electricity generation), under a planned or unplanned interruption of operation of the electricity generation facility, LFG is normally sent to the flaring system for combustion (inter alia due to safety concerns). Due to that, alternative

are:

1. *Electricity sale price:* At this stage, the most reasonable assumption is that the project will sell its electricity in an electricity supply auction as per the rules and procedure of the regulated power market in Brazil. In Brazil, the last occurred two electricity supply auctions of electricity deemed (to be delivered from 2014, which is the year when phase 2 of the project activity is expected to become operational) were as follows:
   - The so-called "*Leilão de Energia de Reserva*" (Auction for reserve power) of which the results were made publicly available on 18/08/2011[18]. As per the results of this action, price ceiling for electricity generated from biomass source (which is the category that electricity generation using LFG as fuel fits within the rules and practice of the Brazilian power market) were set as BRL 100.40 per MWh;
   - The so-called "*Leilão de Energia A3/2011*" (Energy A3/2011 Auction) of which the results were made publicly available on 17/08/2011[19]. As per the results of this action, price ceiling for electricity generated from biomass source was set as BRL 102.41 per MWh.

   For sake of conservativeness, the highest electricity price is considered in the context of the investment analysis: BRL 102.41 per MWh.

2. *Refurbishment/Residual values of engine generation sets and remaining equipment for the project's electricity generation component*: As the lifetime of the project equipment is at least 20 years[20], no refurbishment is planned. The depreciation period is 10 years according to Brazilian Accounting Principles[21]; therefore at the end of the 20 year period of assessment, salvage value of the equipment is void.

3. *Exchange rate*: As exchange rate, an average value of 2.31 BRL/Euro was used in the financial analysis. This value corresponds to the average historical exchange rates for the previous 12 months.

4. *Benchmark rate:* In accordance with the "Guidelines on the assessment of investment analysis" (version 5) a default value for the expected minimum return on equity is used as a benchmark rate. The relevant benchmark for energy projects in Brazil (Group 1 with Moody's rating Baa3 as given in the guidelines) is 11.75% in real terms. Provided that the investment analysis is carried out in nominal terms, and as per the "Guidelines on the assessment of investment analysis" (version 5), the default value can be used.[22]

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baseline scenario E1 is analysed as an alternative which is combined with alternative LFG1.

[18] http://www.epe.gov.br/imprensa/PressReleases/20110818_1.pdf accessed in 10/12/2011.

[19] http://www.epe.gov.br/imprensa/PressReleases/20110817_1.pdf accessed in 10/12/2011.

[20] Source: Engine supplier.

[21] http://www.deloitte.com/assets/Dcom-Global/Local%20Assets/Documents/Tax/Intl%20Tax%20and%20Business%20Guides/2011/dtt_tax_highlight_2011_Brazil.pdf.

[22] The default value published in the "Guidelines on the assessment of investment analysis" (version 5) refers to real terms and the investment analysis is carried out in nominal terms. The "Guidelines on the assessment of investment analysis" (version 5) mention that: "*In situations where an investment analysis is carried out in nominal terms,*

5. *Taxes*[23]: The combined company income tax rate in Brazil is 34%. Sales tax in Brazil is composed by the so-called ICMS, PIS and COFINS taxes. ICMS will only be applicable if the energy is sold to a final client, since this option is not defined at this time, ICMS will not be included in the analysis. PIS is 1.65% and COFINS is 7.60% over the project electricity sales. This is in accordance with tax legislation in Brazil.

6. *Investment costs:* The installed capacities for both the LFG destruction and LFG utilization components of the project are entirely based on the LFG production model. While it is acknowledged there are significant uncertainty sources in the application such modeling, all the technical options and associated costs will be reviewed after the project is in stable and predictable operation and will account for new technical options available at that time. By considering the projections of LFG generation, it is assumed the implementation of electricity generation facility with nameplate installed capacity of 7.2 MW.

   Regarding the project's LFG destruction component (by flaring), it is assumed that required investments to capture and destroy LFG by combustion in enclosed flares remain essentially the same regardless of associated uncertainty sources in the application of the LFG production model (FOD model). Required investments include construction of the gas collecting network, landfill cover, blowers, etc. to collect the LFG and feed it to the generators.

   To be conservative, and since power generation outside the CDM does not require exact LFG and residual gas analysis, we excluded the investment required for the analysis system, that would be required for a CDM project activity.
   Ancillary equipment for the project's electricity generation component include a LFG treatment (filtering) unit (in order to clean LFG before it is fed into the generators), a supervision system, a connection to the grid (protection system, transformers, etc.) which were conservatively not included in the financial analysis (as the project participants are not aware of the interconnection point to deliver generated electricity – this is to be opportunely evaluated and decided by the local electricity distribution company) as well as involved engineering and project management costs.

   The total investment for 7.2 MW of installed capacity would be 8,356,182 €[24].

7. *Operation and maintenance costs (O&M costs):* Maintenance costs of biogas generators are assumed as proportional to the amount of electricity generated and are estimated at 19.47 € per MWh. Project

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*project participants **can** convert the real term values provided in the table below to nominal values by adding the inflation rate.".* Therefore it is left as an option to project participants to add or not to add the inflation rate. Not adding the inflation rate is a conservative approach as it results in a lower benchmark and therefore in a higher NPV. In the present financial analysis project participants, in a conservative approach, did not consider the effects of the inflation rate.

[23] dtt_corporate_tax_rates_2011 and dtt_tax_guide_2010_Brazil, documents delivered to the DOE describing the tax system in Brazil as well as the description of ICMS, PIS and COFINS taxes.

[24] Detailed analysis provided in financial spreadsheet Financial.Constroeste that contains the sources of the budgets obtained from suppliers to the equipment's that are expected to be installed as part of the project activity.

participants assume an availability of 85%[25], which results in an average generation of 37.42 GWh per year, during the first crediting period.

Other O&M costs are "fixed" and include manpower, maintenance of the gas collecting system and of the plant. These costs are estimated at approximately 284,083 € per year.

8. *NPV calculation and conclusion*: By considering_assumptions outlined above, the NPV for LFG capture and electricity generation (in the absence of CDM revenues) is negative: - 4,053,196 €.

A sensitivity analysis based on the variation of +/- 10% and +/-5% of the parameters – electricity sale price, investment cost, operating costs, exchange rate between Euro and Brazilian Real (BRL) and LFG generation shows that the NPV remains negative in all cases (see NPV figures in table below). The chosen parameters are considered to have a significant impact on the financials of the project:

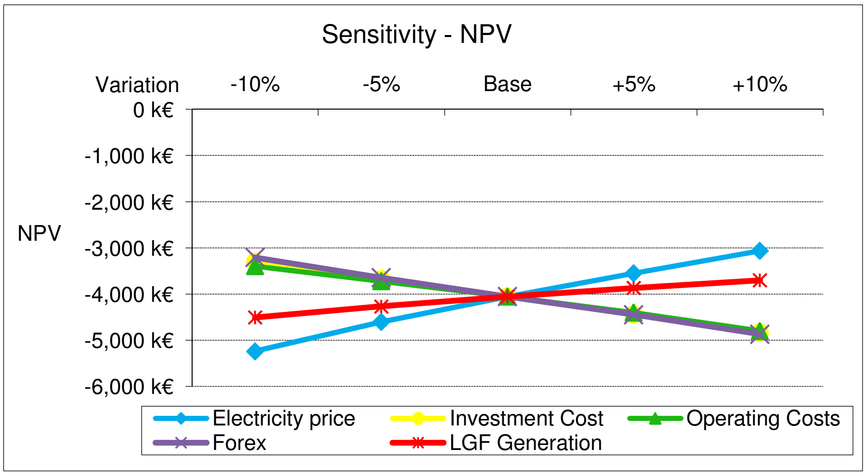
- Electricity sale price: project revenue in this scenario;
- Exchange rate: volatility of currencies to be taken into account as main equipment is bought in Europe whereas the project is located in Brazil;
- Investment cost: initial CAPEX;
- Operating costs: as stated above, operating costs include fixed costs and variable costs. Variable costs are related to the maintenance of generators and depend on electricity production. Both kinds of costs have been considered in the sensitivity analysis;
- LFG generation: direct impact on electricity production.

The next table shows a sensitivity analysis of the NPV, by changing parameters such as electricity price, investment costs, operating costs, forex and LGF generation in a -10%,-5%, base scenario, +5% and +10% ranges.

Sensitivity analysis

Parameter	Variation	Electricity price	Investment Cost	Operating Costs	Forex	LGF Generation
NPV	-10%	-5,236,994 €	-3,294,833 €	-3,393,230 €	-3,207,389 €	-4,505,451 €
	-5%	-4,602,698 €	-3,672,478 €	-3,719,987 €	-3,644,609 €	-4,264,443 €
	Base	-4,053,196 €	-4,053,196 €	-4,053,196 €	-4,053,196 €	-4,053,196 €
	+5%	-3,546,369 €	-4,437,985 €	-4,398,729 €	-4,443,953 €	-3,866,306 €
	+10%	-3,060,820 €	-4,827,181 €	-4,798,216 €	-4,867,145 €	-3,700,123 €

25 Availability was estimated by the genset supplier and it is mentioned in the E-004-11 OFERTA ECONÔMICA ESTIMATIVA - Aterro Onda Verde Final document delivered to the DOE.



The NPV reaches zero if electricity price is increased in 46%, or if investment cost is decreased in 57 %, or if total maintenance cost is annually decreased by 70 %[26]. A variation of the exchange rate and amount of methane generated to reach the NPV zero does not lead to plausible results. All such variations do not lead to plausible results.

LFG2 and E3

As per the application of the investment analysis as per the "Combined tool to identify the baseline scenario and demonstrate additionality" the NPV for the scenario LFG2 and E3 is 0[27].

Conclusion

Based on this analysis the alternative scenarios ranked by NPV decreasing order

Alternative scenarios by NPV decreasing order	NPV
LFG2 and E3	0 €
LFG1+E1 (Base scenario of the sensitivity analysis) (Phase 1+Phase 2)	- 4,053,196 €
LFG1(Phase 1)	- 5,514,192 €

The figures presented in the table above confirm that the most attractive scenario is the baseline scenario LFG2 and E3 (no investment is undertaken by the project participants but third parties undertake investments or actions which provide the same output to users of the project activity).

According to the "Combined tool to identify the baseline scenario and demonstrate additionality" the baseline scenario is not the project activity being undertaken without being registered as a CDM project.

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[26] Details provided in Financial Constroeste Spreadsheet in NPV I, II and III.
[27] As per the "Combined tool to identify the baseline scenario and demonstrate additionality" for alternative scenarios that correspond to the situation described in S2 or S3 and that do not involve any investment costs, operational costs or revenues, and if the financial indicator is the NPV, a value of zero is assumed to the NPV.

Outcome of step 3: The baseline scenario is the most attractive scenario and the baseline scenario is not the project activity being undertaken without being registered as a CDM project, and the project without the CDM revenues is demonstrated to be not economically attractive either on Phase 1 or Phase 1 + Phase 2 configurations.

Step 4. Common practice analysis

The proposed CDM project activity comprises Methane Destruction, listed in the definitions section of the the "Combined tool to identify the baseline scenario and demonstrate additionality", therefore we proceed to Step 4 a.

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

The second Brazilian Greenhouse Gases Emissions Inventory Report (published in July/2010)[34] , states that from 1990 to 2002 the total amount of recovered methane in Brazilian landfills were considered zero. Furthermore, from 2003 onwards, all flared/recovered methane considered in the Inventory came from CDM landfill projects in Brazil.

The São Paulo State Greenhouse Gases Emissions Inventory Report in Waste Sector (published in April/2011)[35], states that from 1990 to 2002 the total amount of recovered methane in São Paulo State landfills were considered zero. Furthermore, from 2003 onwards, all recovered methane considered in the State Inventory came from the CH_4 reductions of the CDM landfill projects in the State of São Paulo.

Performing a query on the ANEEL database[36] of power generation plants using LFG as fuel and on the UNFCCC website project search interface[37] we find the following registered projects, evidencing that all the power generation plants using LFG as fuel are also registered as CDM projects:

Plant	Company	Power (MW)	City	State	CDM UNFCCC Project	
UTE Biotérmica Recreio	Biotérmica Energia Ltda.	6.228	Minas do Leão	RS	648	Central de Resíduos do Recreio Landfill Gas Project (CRRLGP)

[34] Source: Ministry of Science and Technology. The second Brazilian Greenhouse Gases Emissions Inventory Report. Page 62. http://www.mct.gov.br/upd_blob/0213/213909.pdf, accessed on 10/11/2011.

[35] CETESB. São Paulo State Greenhouse Gases Emissions Inventory Report in Waste Sector. Page 253. http://www.cetesb.sp.gov.br/userfiles/file/mudancasclimaticas/geesp/file/docs/consulta/relatorios/residuos.pdf, accessed on 10/11/2011.

[36] http://www.aneel.gov.br/aplicacoes/autorizacoes/default_aplicacao_acompanhamento.cfm?IDACOMPANHAMENTOTIPO=1

[37] http://cdm.unfccc.int/Projects/projsearch.html

Plant	Company	Power (MW)	City	State	CDM UNFCCC Project	
UTE Sapopemba	Ecourbis Ambiental S.A.	25.6	São Paulo	SP	5947	CTL Landfill Gas Project
UTE Bandeirante	Biogás Energia Ambiental S.A.	20	São Paulo	SP	164	Bandeirantes Landfill Gas to Energy Project (BLFGE)
UTE São João Biogás	Enterpa Ambiental S.A.	20,00	São Paulo	SP	373	São João Landfill Gas to Energy Project (SJ)
UTE Salvador	UTE SVE Salvador S.A.	19.73	Salvador	BA	52	Salvador da Bahia Landfill Gas Management Project

Thus, there are no similar activities like the proposed project activity in Brazil operating or underway without CDM benefits, since all of the landfills that are developing capture and electricity generation using LFG, are being developed as CDM project activities.

Sub-step 4a(1): Not required since as previously demonstrated Nall=0;

Sub-step 4a(2): N_{all} =0;

Sub-step 4a(3): N_{diff} = 0;

Sub-step 4a(4): F=1;

Therefore the conditions for the proposed project activity being regarded as .common practice within a sector in the applicable geographical area: factor F greater than 0.2 and N_{all}-N_{diff} [38]greater than 3. are not fulfilled.

Outcome of Step 4: If outcome of Step 4 is that the proposed project activity is not regarded as common practice, then the proposed project activity is additional

Conclusion: <u>The project activity is additional.</u>

Prior consideration of CDM

The starting date of the project activity is after to 2 August 2008. In accordance with the "Guidelines on the demonstration and assessment of prior consideration of the CDM, EB 49 Annex 22, and although the Project Participants will develop a Global Stakeholders Consultation, the UNFCCC and Host Party DNA

[38] N_{all}-N_{diff} = 0.

have been informed of the intention to seek CDM status for a new project activity on 22/11/2011[41].

Chronology of events

Date	Event
July 2011 – Dec 2011	Feasibility study of landfill gas by project participant
Dec 2011	Decision to apply for CDM registration for LFG project evidenced by the letter informing the DNA of the intention to seek CDM status.
Dec 2012	Expected starting date of the project activity

B.6. Emission reductions:

B.6.1. Explanation of methodological choices:

In accordance with ACM0001 (version 12) and applicable tools, yearly emission reductions (ER_y) are determined (in tCO_2e) as follows:

Determination of Emission Reductions

$$ER_y = BE_y - PE_y \quad \textbf{(0)}$$

Where:

BE_y = Baseline emissions in year *y* (tCO2e/yr)

PE_y = Project emissions in year *y* (tCO_2/yr)

Baseline emissions

Baseline emissions (BE_y) are determined according to equation 1 and comprise the following sources:

(A) Methane emissions from anaerobic waste decomposition in the considered solid waste disposal site (SWDS) in the absence of the project activity;

(B) Electricity generation (in amount equivalent to the amount of electricity generated by the project's electricity generation component) using existing fossil fuel energy sources connected to

[41] Evidence of Prior CDM consideration information sent to the UNFCCC and DNA was delivered to the DOE.

the National Electricity Grid of Brazil and new additions of power generation sources in the absence of the project activity;

(C) Heat generation using fossil fuels in the absence of the project activity; and

(D) Natural gas used from the natural gas network in the absence of the project activity.

$$BE_{y} = BE_{CH4,y} + BE_{EC,y} + BE_{HG,y} + BE_{NG,y} \tag{1}$$

Where:

$BE_{CH4,y}$ = Baseline emissions of methane from the SWDS in year *y* (in tCO_2e/yr)

€ $BE_{EC,y}$ = Baseline emissions associated with electricity generation in year *y* (in tCO_2/yr)

$BE_{HG,y}$ = Baseline emissions associated with heat generation in year *y* (in tCO_2/yr)

$BE_{NG,y}$ = Baseline emissions associated with natural gas use in year *y* (in tCO_2/yr)

In the particular case of the project activity, as no collected LFG is expected to be used as gaseous fuel for heat generation purposes and as no collected LFG is expected to be injected in a natural gas distribution pipeline or even displace/complement the use of natural gas, $BE_{HG,}$y and $BE_{NG,y}$ are not applicable in the context of the determination of baseline emissions.

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

Baseline emissions of methane from the anaerobic waste decomposition in the considered SWDS ($BE_{CH4,y}$) are determined (in tCO_2e) as per the formulas presented below, based on the amount of methane that is actually captured and combusted under the project activity and also by taking in account the amount of methane that would be captured and destroyed in the landfill in the absence of the project activity (baseline scenario). In addition, the effect of methane oxidation that is assumed as existing in the baseline and not in the project scenario is taken into account:[42]

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

€ [42] As established by ACM0001 (version 12), the ex-ante determined parameter $OX_{top-layer}$ is the fraction of the methane that would oxidize in the top layer of the SWDS in the absence of the project activity. Under the project activity, this effect is reduced as a part of the LFG is captured and does not pass through the top layer of the SWDS. This oxidation effect is also accounted for in the methodological tool "Emissions from solid waste disposal sites". In addition to this effect, the installation of a LFG capture system under the project activity may result in the suction of additional air into the SWDS. In some cases, such as with a high suction pressure, the air may decrease the amount of methane that is generated under the project activity. However, in most circumstances where the LFG is captured and used this effect was considered to be very small, as the operators of the SWDS have in most cases an incentive to main a high methane concentration in the LFG. For this reason, this effect is neglected as a conservative assumption.

Where:

OX_{top_layer} = Fraction of methane in the LFG that would be oxidized in the top layer of the SWDS in the baseline scenario (dimensionless)

$F_{CH4,PJ,y}$ = Amount of methane in the LFG which is flared and/or used in the project activity in year *y* (in tCH_4)

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

GWP_{CH4} = Global warming potential of CH_4 (in tCO_2e/tCH_4)

Step A.1: Ex post determination of $F_{CH4,PJ,y}$

As per ACM0001 (version 12), during the crediting period, the amount of methane in the LFG which is flared and/or used in the project activity,$F_{CH4,PJ,y}$, is to be determined (in tCH_4/yr) as the sum of the measured quantities of methane flared and used in power plant(s), boiler(s), air heater(s), kiln(s) and natural gas distribution network, as follows:

$$F_{CH4,\ PJ,\ y} = F_{CH4,flared\ ,y} + F_{CH4,\ EL,\ y} + F_{CH4,\ HG,\ y} + F_{CH4,\ NG,\ y} \qquad \textbf{(3)}$$

Where:

$F_{CH4,flared,y}$ = Amount of methane in the LFG which is destroyed by flaring in year *y* (in tCH_4)

$F_{CH4,EL,y}$ = Amount of methane in the LFG which is used for electricity generation in year *y* (t CH_4/yr)

$F_{CH4,HG,y}$ = Amount of methane in the LFG which is used for heat generation in year *y* (in tCH_4), zero under the current project activity

$F_{CH4,NG,y}$ = Amount of methane in the LFG which is sent to the natural gas distribution network in year *y* (in tCH_4), zero under the current project activity

As also established by ACM0001 (version 12), the working hours of the power plant(s), boiler(s), air heater(s) and kiln(s) which use collected LFG, should be monitored and no emission reduction should be claimed for methane destruction during non-working hours.

In the particular case of the project activity, as no collected LFG is expected to be used as gaseous fuel for heat generation purposes and as no collected LFG is expected to be injected in a natural gas distribution pipeline or even displace/complement the use of natural gas, $F_{CH4,HG,y}$ and $F_{CH4,NG,y}$ are not applicable in the context of the determination of $F_{CH4,PJ,y}$.

$F_{CH4,Flared,y}$ and $F_{CH4,EL,y}$ are determined by following applicable guidance of the "Tool to determine the mass flow of a greenhouse gas in a gaseous stream". The following requirements apply:

- The gaseous stream the tool shall be applied to is the LFG delivery pipeline to flaring and to each item of electricity generation equipment *j*;

- CH_4 is the greenhouse gas for which the mass flow is determined;
- The flow of the gaseous stream is to be measured on continuous basis;
- The simplification offered for calculating the molecular mass of the gaseous stream is valid (equations 3 or 17 in the tool); and
- The mass flow should be summed to a yearly unit basis (in tCH_4).

Amount of methane 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(s) and any methane emissions from the flare(s), as follows:

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

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 directly using the "Tool to determine the mass flow of a greenhouse gas in a gaseous stream", applying the requirements described above where the gaseous stream the tool shall be applied to is the LFG delivery pipeline to the flare(s).

The mentioned "Tool to determine the mass flow of a greenhouse gas in a gaseous stream" will be applied to determine $F_{CH4,sent\_flare,y}$ and $F_{CH4,EL,y}$ using Option 2: *Simplified calculation without measurement of the moisture content*, and one of the options A, C or D, depending on project conditions and equipment, stated in the following table will be applied to the greenhouse gas measured by the methodology (CH_4).

Option 2: Simplified calculation without measurement of the moisture content

This option provides a simple and conservative approach to determine the absolute humidity by assuming the gaseous stream is dry or saturated depending on which is the conservative situation. If it is conservative to assume that the gaseous stream is dry, then mH_2O,t,db is assumed to equal 0. If it is conservative to assume that the gaseous stream is saturated, then mH_2O,t,db is assumed to equal the saturation absolute humidity (mH2O,t,db,sat) and calculated using equation (5).

$$m_{H_2O,t,db,SAT} = \frac{p_{H2O,t,Sat} * MM_{H2O}}{(P_t - p_{H2O,t,Sat}) * MM_{t,db}} \quad \textbf{(5)}$$

Where:
$m_{H2O,t,db,sat}$ = Saturation absolute humidity in time interval *t* on a dry basis (kg H_2O/kg dry gas)
$p_{H20,t,sat}$ = Saturation pressure of H_2O at temperature Tt in time interval t (Pa)
T_t = Temperature of the gaseous stream in time interval *t* (K)
P_t = Absolute pressure of the gaseous stream in time interval *t* (Pa)
MM_{H2O} = Molecular mass of H_2O (kg H_2O/kmol H_2O)
$MM_{t,db}$ = Molecular mass of the gaseous stream in a time interval *t* on a dry basis (kg dry gas/kmol dry gas) with $MM_{t,db}$ is estimated using the following equation.

$$MM_{t,db} = \sum_{i} (v_{i,t,db} * MM_k) \quad \textbf{(6)}$$

Where:
$MM_{t,db}$ = Molecular mass of the gaseous stream in time interval *t* on a dry basis (kg dry gas/kmol dry gas)
$v_{k,t,db}$ = Volumetric fraction of gas *k* in the gaseous stream in time interval *t* on a dry basis (m³ gas k/m³ dry gas)
MM_k = Molecular mass of gas *k* (kg/kmol)
k = All gases, except H_2O, contained in the gaseous stream (e.g. N_2, CO_2, O_2, CO, H_2, CH_4, N_2O, NO, NO_2, SO_2, SF_6 and PFCs). See available simplification below

The determination of the molecular mass of the gaseous stream ($MM_{t,db}$) requires measuring the volumetric fraction of all gases (*k*) in the gaseous stream. However as a simplification, the volumetric fraction of only the gases k that are greenhouse gases and are considered in the emission reduction calculation in the underlying methodology must be monitored and the difference to 100% may be considered as pure nitrogen. The simplification is not acceptable if it is differently specified in the underlying methodology.

Depending on the project conditions and equipment one of the following measurement options will be chosen and the following formulas applied:

Measurement options

Option	Flow of gaseous stream	Volumetric fraction
A	Volume flow dry basis	dry or wet basis[43]
C	Volume flow wet basis	wet basis
D	Mass flow dry basis	dry or wet basis

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:

[43] Flow measurement on a dry basis is not feasible at reasonable costs for a wet gaseous stream, so there will be no difference in the readings for volumetric fraction in wet basis analysers and dry basis analysers and both types can be used indistinctly for calculation Options A and D.

- 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
- Demonstrate that the temperature of the gaseous stream (Tt) is less than 60ºC (333.15 K) at the flow measurement point.

If it cannot be demonstrated that the gaseous stream is dry, then the flow measurement should be assumed to be on a wet basis and the corresponding option from the table above should be applied instead.

The mass flow of greenhouse gas *i* (Fi,t) is determined as follows:

$$F_{i,t} = V_{t,db} \times v_{i,t,db} \times \rho_{i,t} \quad \textbf{(7)}$$

with

$$\rho_{i,t} = \frac{P_t * MM_i}{R_u * T_t} \quad \textbf{(8)}$$

Where:

$F_{i,t}$ = Mass flow of greenhouse gas *i* in the gaseous stream in time interval *t* (kg gas/h)
$V_{t,db}$, n = Volumetric flow of the gaseous stream in time interval *t* on a dry basis at normal conditions (m³ dry gas/h)
$v_{i,t,db}$ = Volumetric fraction of greenhouse gas *i* in the gaseous stream in 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 (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 ($Pa.m^3/kmol.K$)
T_t = Temperature of the gaseous stream in time interval *t* (K)

Option C

The mass flow of greenhouse gas *i* (Fi,t) is determined as follows:

$$F_{i,t} = V_{t,wb,n} \times v_{i,t,wb} \times \rho_{i,n} \quad \textbf{(9)}$$

with

$$\rho_{i,n} = \frac{P_n * MM_i}{R_u * T_n} \quad \textbf{(10)}$$

Where:$F_{i,t}$ = Mass flow of greenhouse gas *i* in the gaseous stream in time interval *t* (kg gas/h)
$V_{t,wb,n}$ = Volumetric flow of the gaseous stream in time interval *t* on a wet basis at normal conditions (m³

wet gas/h)
$v_{i,t,wb}$ = Volumetric fraction of greenhouse gas *i* in the gaseous stream in time interval *t* on a wet basis (m³ gas *i*/m³ wet gas)
$\rho_{i,n}$ = Density of greenhouse gas *i* in the gaseous stream at normal conditions (kg gas *i*/m³ wet gas *i*)
P_n = Absolute pressure at normal conditions (Pa)
T_n = Temperature at normal conditions (K)
MM_i = Molecular mass of greenhouse gas *i* (kg/kmol)
R_u = Universal ideal gases constant (Pa.m^3/kmol.K)

The following equation should be used to convert the volumetric flow of the gaseous stream from actual conditions to normal conditions of temperature and pressure:

$$V_{t,wb,n} = V_{t,wb} * (T_n / T_t) * (P_t / P_n) \qquad \textbf{(11)}$$

Where:
$V_{t,wb,n}$ = Volumetric flow of the gaseous stream in a time interval *t* on a wet basis at normal conditions (m^3 wet gas/h)
$V_{t,wb}$ = Volumetric flow of the gaseous stream in time interval *t* on a wet basis (m³ wet gas/h)
P_t = Pressure of the gaseous stream in time interval *t* (Pa)
T_t = Temperature of the gaseous stream in time interval *t* (K)
P_n = Absolute pressure at normal conditions (Pa)
T_n = Temperature at normal conditions (K)

Option D

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:

- 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
- Demonstrate that the temperature of the gaseous stream (Tt) is less than 60ºC (333.15 K) at the flow measurement point.

If it cannot be demonstrated that the gaseous stream is dry, then the flow measurement should be assumed to be on a wet basis and the corresponding option from the above table should be applied instead.

The mass flow of greenhouse gas *i* (Fi,t) is determined using equations (7) and (8). The volumetric flow of the gaseous stream in time interval *t* on a dry basis (Vt,db) is determined by converting the mass flow of the gaseous stream to a volumetric flow as follows:

$$V_{t,db} = M_{t,db} / \rho_{t,db} \qquad \textbf{(12)}$$

Where:
$V_{t,db}$ = Volumetric flow of the gaseous stream in time interval *t* on a dry basis (m^3 dry gas/h)
$M_{t,db}$ = Mass flow of the gaseous stream in time interval *t* on a dry basis (kg/h)
$\rho_{t,db}$ = Density of the gaseous stream in time interval *t* on a dry basis (kg dry gas/m^3 dry gas)

The density of the gaseous stream ($\rho_{t,db}$) should be determined as follows:

$$\rho_{t,db} = \frac{P_t * MM_{t,db}}{R_u * T_t} \qquad \textbf{(13)}$$

Where:
$\rho_{t,db}$ = Density of the gaseous stream in a time interval *t* on a dry basis (kg dry gas/m^3 dry gas)
$MM_{t,db}$ = Molecular mass of the gaseous stream in a time interval *t* on a dry basis (kg dry gas/kmol dry gas)
P_t = Pressure of the gaseous stream in time interval *t* (Pa)
T_t = Temperature of the gaseous stream in time interval *t* (K)
The molecular mass of the gaseous stream ($MM_{t,db}$) is estimated using equation (6).

The option selected will be one of the options A, C or D as stated, however the selected option will depend on the environmental conditions (atmospheric and climatic conditions, humidity of the site etc.) and the choice of equipment (mass flow meter, gas dryer, etc.). So this option can be changed in a future stage, and will be address ex-post.

$PE_{flare,y}$ shall be determined using the "Tool to determine project emissions from flaring gases containing methane". If LFG is flared through more than one flare, then $PE_{flare,y}$ is the sum of the emissions for each flare determined separately.

Where $PE_{flare,y}$ is calculated using the "Tool to determine project emissions from flaring gases containing methane". The Tool allows two options to determine the flare efficiency of enclosed flares[44]. As per the referred Tool: "For enclosed flares, either of the following two options can be used to determine the flare efficiency:

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

The seven steps of the Tool are described next:

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

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

[44] As described in section A.4.3 this project activity will use enclosed flares.

$$FM_{RG,h} = \rho_{RG,n,h} * FV_{RG,h}$$ **(T.1)**[45]

Where:

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

And:

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

Where:

$\rho_{RG,n,h}$	kg/m^3	Density of the residual gas at normal conditions in hour *h*
P_n	Pa	Atmospheric pressure at normal conditions (101,325)
R_u	Pa.m^3/kmol.K	Universal ideal gas constant (8.314)
$MM_{RG,h}$	kg/kmol	Molecular mass of the residual gas in hour *h*
T_n	K	Temperature at normal conditions (273.15)

And:

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

Where:

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

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

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

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

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

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

Where:

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

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

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

Step 2 states:

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

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

Where:

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

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

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

"Determine the average volumetric flow rate of the exhaust gas in each hour h based on a stoichiometric calculation of the combustion process, which depends on the chemical composition of the residual gas,

the amount of air supplied to combust it and the composition of the exhaust gas, as follows:"

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

Where:

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

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

Where:

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

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

Where:

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

The Tool states:

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

Where:

$V_{n,N2,h}$	m^3/kg residual gas	Quantity of N_2 volume free in the exhaust gas of the flare at normal conditions per kg of residual gas in hour *h*
$fm_{N,h}$	-	Mass fraction of nitrogen in the residual gas in the hour *h*

AM_N	kg/kmol	Atomic mass of nitrogen
MF_{O2}	-	O_2 volumetric fraction of air (0.21)
F_h	kmol/kg residual gas	Stoichiometric quantity of moles of O_2 required for a complete oxidation of one kg residual gas in hour *h*

and other variables are as defined earlier.

Next we have:

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

Where:

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

and other variables are as defined earlier.

$$n_{O_2,h} = \frac{t_{O_2,h}}{\left(1-\left(t_{O_2,h}/MF_{O_2}\right)\right)} \times \left[\frac{fm_{C,h}}{AM_C} + \frac{fm_{N,h}}{200AM_N} + \left(\frac{1-MF_{O_2}}{MF_{O_2}}\right) \times F_h\right] \qquad \textbf{(T.10)}$$

Where:

$t_{O2,\ h}$ - Volumetric fraction of O_2 in the exhaust gas in hour *h*
and other variables are as defined earlier.

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

Where:

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

and other variables are as defined earlier.

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

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

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

Where:

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

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

The Tool states:

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

The Tool further elaborates:

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

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

Where:

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

Step 6: Determination of the hourly flare efficiency

The Tool states:

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

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

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

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

Where:

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

In case of the continuous measurement of the flare efficiency is not available due, for example to maintenance or failure, the following methods will be used:

- 0% if the temperature in the exhaust gas of the flare (T_{flare}) is below 500 °C for more than 20 minutes during the hour *h* .
- 50%, if the temperature in the exhaust gas of the flare (T_{flare}) is above 500 °C for more than 40 minutes during the hour *h,* but the manufacturer's specifications on proper operation of the flare are not met at any point in time during the hour *h*.
- 90%, if the temperature in the exhaust gas of the flare (T_{flare}) is above 500 °C for more than 40 minutes during the hour *h* and the manufacturer's specifications on proper operation of the flare are met continuously during the hour *h*.

STEP 7. Calculation of annual project emissions from flaring

The Tool states:

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

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

Where:

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

The following fixed constants will be used for the calculation

Parameter	SI Unit	Description	Value
MM_{CH4}	kg/kmol	Molecular mass of methane	16.04

Parameter	SI Unit	Description	Value
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
Pn	Pa	Atmospheric pressure at normal conditions	101,325
R_u	$Pa.m^3/kmol.K$	Universal ideal gas constant	8,314.472
T_n	K	Temperature at normal conditions	273.15
GWP_{CH4}	tCO_2/tCH_4	Global warming potential of methane	21
$D_{CH4,n,h}$	t/m^3	Density of methane gas at normal conditions	0.0007168
$NA_{i,j}$	Dimensionless	Number of atoms of element *j* in component *i*, depending on molecular structure	

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 2) in order to estimate the emission reductions of the proposed project activity in the CDM-PDD. It is determined as follows:

$$F_{CH4,PJ,y} = \eta_{PJ} \cdot BE_{CH4,SWDS,y} / GWP_{CH4} \qquad \textbf{(14)}$$

Where:

$F_{CH4,PJ,y}$ = Amount of methane in the LFG which is flared and/or used in the project activity in year *y* (in tCH_4)

$BE_{CH4,SWDS,y}$ = Amount of methane in the LFG that is generated from the SWDS in the baseline scenario in year *y* (in tCO_2e)

η_{PJ} = Efficiency of the LFG capture system that will be installed in the project activity

GWP_{CH4} = Global warming potential of CH_4 (in tCO_2e/tCH_4)

$BE_{CH4,SWDS,y}$ is determined using the methodological tool "Emissions from solid waste disposal sites". The following guidance should be taken into account 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.

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). The four cases in Table 2 are distinguished. The appropriate case should be identified and the corresponding instructions followed.

Cases for determining methane captured and destroyed in the baseline

Situation at the start of the project activity:	Requirement to destroy methane	Existing LFG capture system
Case 1	No	No
Case 2	Yes	No
Case 3	No	Yes
Case 4	Yes	Yes

In the current project activity no methane would be captured and destroyed (by flaring) in the baseline due to regulatory or contractual requirements. As mentioned there is no legal obligation to capture and destroy the LFG at the landfill. Also there is no system to capture and destroy the LFG. Case 1 applies: No requirement to destroy methane exists and no existing LFG capture and destruction system or obligation to flare methane exists, therefore:

$$F_{CH4,\,BL,\,y} = 0 \qquad \textbf{(15)}$$

For the ex-ante estimation of the amount of methane destroyed/combusted during the year, in tonnes of methane ($F_{CH4,\,PJ,y}$) we require the calculation of $BE_{CH_4,SWDS,y}$, given by:

$$BE_{CH4,SWDS,y} = \varphi_y \cdot (1-f_y) \cdot GWP_{CH4} \cdot (1-OX) \cdot \frac{16}{12} \cdot F \cdot DOC_{f,y} \cdot MCF_y \cdot \sum_{x=1}^{y} \sum_{j} W_{j,x} \cdot DOC_j \cdot e^{-k_j \cdot (y-x)} \cdot \left(1-e^{-k_j}\right) \qquad \textbf{(TW.1[46])}$$

Where:

$BE_{CH4,SWDS,y}$	Baseline 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

[46] Equation numbers from the “Emissions from solid waste disposal sites” are prefixed with the letter “TW” to distinguish them from equations from the methodology.

	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	
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 oxidized 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

The value and source of information for each of the variables above are given in section B.6.2.. The Project Participants wish to emphasize that the characteristics of the waste used as inputs for this ex-ante estimation are the ones recommended by IPCC, therefore no sampling of waste is necessary. Also the project activity does not prevent waste from being deposited at the landfill.

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*.

This Tool declares:

"In the generic approach, project, baseline and leakage emissions from consumption of electricity are calculated based on the quantity of electricity consumed, an emission factor for electricity generation and a factor to account for transmission losses…"

Specifically for baseline emissions we have:

$$BE_{EC,y} = \sum_{j} EC_{BL,k,y} \times EF_{EL,k,y} \times (1 + TDL_{k,y}) \qquad \textbf{(TE.1[47])}$$

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[47] Equation numbers from the Electricity Consumption Tool are prefixed with the letters "TE" to distinguish them from equations from the main methodology ACM0001, and from other tools.

Where:

$BE_{EC,y}$	=	Baseline emissions associated with electricity generation (tCO_2 / yr).
$EC_{BL,k,y}$	=	Net amount of electricity generated using LFG in year *y* (MWh)
$EF_{EL,k,,y}$	=	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 *j* in year *y*
k	=	sources of electricity generated identified in the selection of the most plausible baseline scenario

Since all electricity end uses at the proposed project site would be supplied by the same power grid, $EF_{EL,k,,y}$ and $TDL_{k,y}$ are independent of *k*. This interpretation is confirmed by the Option A1 for determining $EF_{EL,k,,y}$. We use this option which requires us to:
"Calculate the combined margin emission factor of the applicable electricity system, using the procedures in the latest approved version of the "Tool to calculate the emission factor for an electricity system" ($EF_{EL,j/k/l,y} = EF_{grid,CM,y}$)."

The "Tool to calculate the emission factor for an electric system" indicates that the emission factor of the grid is determined by the following seven steps:

1. Identify the relevant electric systems;
2. Choose whether to include off-grid power plants in the project electricity system;
3. Select a method to determine the operating margin (OM);
4. Calculate the operating margin emission factor according to the selected method;
5. Identify the group of power units to be included in the build margin (BM).
6. Calculate the build margin (BM) emission factor;
7. Calculate the combined margin (CM) emission factor.

Step 1: Identify the relevant electric systems

For the purpose of determining the electricity emission factors, a project electricity system is defined by the spatial extent of the power plants that are physically connected through transmission and distribution lines to the project activity (e.g. the renewable power plant location or the consumers where electricity is being saved) and that can be dispatched without signification transmission constraints.

The MCT has published a resolution (number 08 on 26/05/2008[48]) which establishes a unique emission factor for the entire national interconnected system.

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

Project participants 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;

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[48] http://www.mct.gov.br/upd_blob/0024/24719.pdf

Option II: Both grid power plants and off-grid power plants are included in the calculation;

The Brazilian DNA is responsible for calculating the emission factors and it is not included in calculation the off-grid power plants, therefore Option I is used.

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

Calculate the Operating Margin emission factor(s) ($EF_{grid,OM,y}$) based on one of the following four methods:

(a) Simple OM
(b) Simple adjusted OM
(c) Dispatch Data Analysis OM
(d) Average OM.

The $EF_{grid,OM,y}$ is given by the MCT and calculated under the method: ***Dispatch data analysis OM.***

All the emission factor calculation and explanation documents can be found on MCT website: www.mct.gov.br.[49]

For the option chosen: **Dispatch data analysis OM**, as per the tool project participants will "*…use the year in which the project activity displaces grid electricity and update the emission factor annually during monitoring.*"

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

The dispatch data analysis OM emission factor ($EF_{grid,OM-DD,y}$) is determined based on the grid power units that are actually dispatched at the margin during each hour *h* where the project is displacing grid electricity. This approach is not applicable to historical data and, thus, requires annual monitoring of $EF_{grid,OM-DD,y}$.

The emission factor is provided by the brazilin DNA:

Operating Margin Emission Factor of Brazilian Integrated Electric System for the year 2010

Operating Margin												
Average Emission Factor (tCO_2/MWh)												
Year	**Month**											
2010	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
	0.2111	0.2798	0.2428	0.2379	0.3405	0.4809	0.4347	0.6848	0.7306	0.7320	0.7341	0.6348

Average $EF_{grid,OM-DD,2010}$ is then 0.4787 tCO_2/MWh

Step 5. Identify the group of power units to be included in the build margin (BM).

[49] Calculation of Grid Emission Factor: Source ONS (http://www.mct.gov.br/index.php/content/view/327118.html#ancora)

The Brazilian DNA is responsible for calculating the BM emission factor in Brazil.

In terms of vintage of data, project participants can choose between one of the following two options:

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

Option 2: For the first crediting period, the build margin emission factor should be updated annually, ex-post, including those units built up to the year of registration of the project activity or, if information up to the year of registration is not yet available, including those units built up to the latest year for which information is available. For the second crediting period, the build margin 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.

The **Option 2** was chosen for the proposed project.

Step 6: Calculate the Build Margin emission factor ($EF_{grid,BM,y}$)

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

Build Margin Emission Factor of Brazilian Integrated Electric System

Build Margin	
Average Emission Factor (tCO_2/MWh)	
Year	**2010**
0.1404	

$EF_{grid,BM,2010} = 0.1404$ tCO_2/MWh

$EF_{grid,BM}$ is given by the MCT and explanation documents can be found on its website (www.mct.gov.br).

Step 7: Calculate the combined margin emission factor ($EF_{grid,CM,y}$)

The baseline emission factor is calculated as the weighted average of the operating margin and builds margin emission factors. To weight these two factors apply the 50% default value to both, the operating margin and build margin emission factors; the combined margin emission factor is obtained as follows:

$$EF_{grid,CM,y} = w_{OM} \times EF_{grid,OM,y} + w_{BM} \times EF_{grid,BM,y} \qquad \textbf{(T.E.3)}$$

Where:

$EF_{grid,BM,y}$ = Build margin CO_2 emission factor in year *y* (tCO_2/MWh)

$EF_{grid,OM,y}$	=	Operating margin CO_2 emission factor in year y (tCO_2/MWh)
w_{OM}	=	Weighting of operating margin emissions factor (%)
w_{BM}	=	Weighting of build margin emissions factor (%)

The values for w_{OM} and w_{BM} are selected as per the "Tool to calculate the emission factor for an electric system" as follow:

$w_{OM} = w_{BM} = 0.5$ (for the first crediting period).

Thus, the resulting grid emission factor for the year 2010 is:

$$EF_{grid,CM} = 0.5 \times 0.1404 + 0.5 \times 0.4787 = 0.3095 \ \ tCO_2e/MWh \qquad \textbf{(T.E.4)}$$

For $TDL_{j,y}$. we use a default value of 20%, so that the transmission and distribution losses also reduce to a single value *TDL* valid at least for the first crediting period.

The project activity does not require any consumption of heat.

Therefore:

$$BE_{EC,y} = \sum_j EC_{BL,j,y} \times 0.3095 \times (1 + 20\%) \qquad \textbf{(T.E.5)}$$

For the first crediting period, the build margin CO_2 emission factor will be updated annually, ex-post, including those units built up to the year of registration of the project activity or, if information up to the year of registration is not yet available, including those units built up to the latest year for which information is available.

Finally:

$$\boxed{BE_y = (1 - OX_{top\_layer}) \cdot (\eta_{PJ} \cdot BE_{CH4SWDSy}/GWP_{CH4} - 0) \cdot GWP_{CH4} + \sum_j EC_{BL,j,y} \times EF_{EL,j,y} \times (1 + TDL_{j,y}) \qquad \textbf{(16)}}$$

We then proceed to the determination of project emissions, given by:

Project emissions

Project emissions are calculated as follows:

$$PE_y = PE_{EC,y} + PE_{FC,y} \qquad \textbf{(17)}$$

Where:

PE_y = Project emissions in year *y* (t CO_2/yr)

$PE_{EC,y}$ = Emissions from consumption of electricity due to the project activity in year *y* (t CO_2/yr)

$PE_{FC,y}$ = Emissions from consumption of fossil fuels due to the project activity, for purpose other than electricity generation, in year *y* (t CO_2/yr)

Since the project activity will not consume any fossil fuel for purpose other than electricity generation, there will be no project emissions from fossil fuel consumption ($PE_{FC,y} = 0$).

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:

- Electricity sources *j* in the tool corresponds to the sources of electricity consumed due to the project activity. This 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.;
- 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.

$PE_{EC,y}$ is calculated by the following formulae:

$$PE_{EC,y} = \sum_j EC_{PJ\,j,y} \times EF_{EL,j,y} \times (1 + TDL_{j,y}) \qquad \textbf{(18)}$$

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)

$EF_{EL,j,,y}$ = 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

The values of $EF_{EL,j,,y}$ and $TDL_{j,y}$ are the same as the determined values for $EF_{EL,k,,y}$ and $TDL_{k,y}$, since the electricity source is the same (grid).

Leakage

No leakage effects are accounted for under ACM0001 (version 12).

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

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 used:	Consistent with how oxidation is accounted for in the methodological tool "Emissions from solid waste disposal sites", Version 06.0.1"
Value applied:	0.1
Justification of the choice of data or description of measurement methods and procedures actually applied :	Default value as per ACM0001"Flaring or use of landfill gas", Version 12.0.0
Any comment:	Applicable to Step A

Data / Parameter:	**GWP_{CH4}**
Data unit:	tCO_2e/tCH_4
Description:	Global Warming Potential (GWP) of methane
Source of data used:	IPCC
Value applied:	21 for the first commitment period. Shall be updated according to any future COP/MOP decisions
Justification of the choice of data or description of measurement methods and procedures actually applied :	-
Any comment:	

Data / Parameter:	**R_u**
Data unit:	$Pa.m^3/kmol.K$
Description:	Universal ideal gases constant
Source of data used:	Tool to determine the mass flow of a greenhouse gas in a gaseous stream (Version 02.0.0)
Value applied:	8.314
Justification of the choice of data or description of measurement methods and procedures actually applied :	-
Any comment:	-

Data / Parameter:	**MM_i**
Data unit:	kg/kmol
Description:	Molecular mass of greenhouse gas *i*
Source of data used:	Tool to determine the mass flow of a greenhouse gas in a gaseous stream (Version 02.0.0)
Value applied:	see table below
Justification of the choice of data or description of measurement methods and procedures actually applied :	-
Any comment:	-

Compound	Structure	Molecular mass (kg / kmol)
Carbon dioxide	CO_2	44.01
Methane	CH_4	16.04

Data / Parameter:	**MM_k**
Data unit:	kg/kmol
Description:	Molecular mass of gas *k*
Source of data used:	Tool to determine the mass flow of a greenhouse gas in a gaseous stream (Version 02.0.0)
Value applied:	For gases *k* that are greenhouse gases appy values for MM_i.
Justification of the choice of data or description of measurement methods and procedures actually applied :	-
Any comment:	-

Compound	Structure	Molecular mass (kg / kmol)
Nitrogen	N_2	28.01
Oxygen	O_2	32.00

Data / Parameter:	**MM_{H_2O}**
Data unit:	kg/kmol
Description:	Molecular mass of water
Source of data used:	Tool to determine the mass flow of a greenhouse gas in a gaseous stream (Version 02.0.0)
Value applied:	18.0152 kg/kmol
Justification of the choice of data or	-

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

Data / Parameter:	P_n
Data unit:	**Pa**
Description:	Total pressure at normal conditions
Source of data used:	Tool to determine the mass flow of a greenhouse gas in a gaseous stream (Version 02.0.0)
Value applied:	101,325 Pa
Justification of the choice of data or description of measurement methods and procedures actually applied :	-
Any comment:	-

Data / Parameter:	T_n
Data unit:	K
Description:	Temperature at normal conditions
Source of data used:	Tool to determine the mass flow of a greenhouse gas in a gaseous stream (Version 02.0.0)
Value applied:	273.15 K
Justification of the choice of data or description of measurement methods and procedures actually applied :	-
Any 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 used:	Project Proponents Value applied.
Value applied:	0.75
Justification of the choice of data or description of measurement methods and procedures actually applied :	Value obtained from the mentioned literature, based on the physical characteristics of the site and on the planned gas extraction network. http://homologa.ambiente.sp.gov.br/biogas/docs/artigos_dissertacoes/magalhaes_alves_santofilho_costa_kelson.pdf, accessed on 10/12/2011
Any comment:	Can also be used as percentage, since 0,75 = 75%

Data / Parameter:	$TDL_{k/j,y}$
Data unit:	Dimensionless
Description:	Transmission and distribution losses for electricity generation in the Brazilian grid connected to the project site.
Source of data used:	Default value given in “Tool to calculate baseline, project and/or leakage emissions from electricity consumption”
Value applied:	20%.
Justification of the choice of data or description of measurement methods and procedures actually applied :	Apply 20% in case of use of electricity imported from the grid
Any comment:	-

Data / Parameter:	w_{BM}
Data unit:	Dimensionless or percentage
Description:	Weighting of build margin emissions factor
Source of data used:	Default values given in “Tool to calculate the emission factor for an electricity system” (Version 02.2.1)
Value applied:	0.5 (50%) for the first crediting period
Justification of the choice of data or description of measurement methods and procedures actually applied :	As mentioned in the “Tool to calculate the emission factor for an alectricity sysyem” (Version 02.2.1): “The following default values should be used for w_{OM} and w_{BM}: • Wind and solar power generation project activities: w_{OM} = 0.75 and w_{BM} = 0.25 (owing to their intermittent and non-dispatchable nature) for the first crediting period and for subsequent crediting periods; • All other projects: w_{OM} = 0.5 and w_{BM} = 0.5 for the first crediting period , and w_{OM} = 0.25 and w_{BM} = 0.75 for the second and third crediting period
Any comment:	-

Data / Parameter:	w_{OM}
Data unit:	Dimensionless or percentage
Description:	Weighting of operating margin emissions factor
Source of data used:	Default values given in “Tool to calculate the emission factor for an alectricity sysyem” (Version 02.2.1)
Value applied:	0.5 (50%) for the first crediting period
Justification of the choice of data or description of measurement methods and procedures actually applied :	As mentioned in the “Tool to calculate the emission factor for an electricity system” (Version 02.2.1): “The following default values should be used for w_{OM} and w_{BM}: • Wind and solar power generation project activities: w_{OM} = 0.75 and w_{BM} = 0.25 (owing to their intermittent and non-dispatchable nature) for the first crediting period and for subsequent crediting periods; • All other projects: w_{OM} = 0.5 and w_{BM} = 0.5 for the first crediting period , and w_{OM} = 0.25 and w_{BM} = 0.75 for the second and third crediting period
Any comment:	-

Data / Parameter:	φ_y
Data unit:	-
Description:	Model correction factor to account for model uncertainties
Source of data used:	Default value given in the methodological tool "Emissions from solid waste disposal sites"
Value applied:	0.75
Justification of the choice of data or description of measurement methods and procedures actually applied :	Determined based on default value of table 3 of the referred tool as per Option 1, Application A when determining the model correction factor.
Any comment:	

Data / Parameter:	***OX***
Data unit:	-
Description:	Oxidation factor (reflecting the amount of methane from SWDS that is oxidized in the soil (or other material covering the waste)
Source of data used:	Default value given in the methodological tool "Emissions from solid waste disposal sites"
Value applied:	0.1
Justification of the choice of data or description of measurement methods and procedures actually applied :	-
Any comment:	

Data / Parameter:	***F***
Data unit:	-
Description:	Fraction of methane in the SWDS gas (volume fraction)
Source of data used:	Default value given in the methodological tool "Emissions from solid waste disposal sites"
Value applied:	0.5
Justification of the choice of data or description of measurement methods and procedures actually applied :	This factor reflects the fact that some degradable organic carbon does not degrade, or degrades very slowly, under anaerobic conditions in the SWDS. A default value of 0.5 is recommended by IPCC.
Any comment:	

Data / Parameter:	$DOC_{f,defaukt}$
Data unit:	Weight fraction
Description:	Fraction of degradable organic carbon (DOC) in MSW that decomposes in the

	SWDS.
Source of data used:	According to the methodological tool "Emissions from solid waste disposal sites", that refers to IPCC 2006 Guidelines for National Greenhouse Gas Inventories
Value applied:	0.5
Justification of the choice of data or description of measurement methods and procedures actually applied :	This factor reflects the fact that some degradable organic carbon does not degrade, or degrades very slowly, in the SWDS. The default value was applied as per Application A of the tool: *"The CDM project activity mitigates methane emissions from a specific existing SWDS".*
Any comment:	Application A is the case of the current project activity

Data / Parameter:	***$MCF_{default}$***
Data unit:	-
Description:	Methane correction factor
Source of data used:	According to the methodological tool "Emissions from solid waste disposal sites", that refers to IPCC 2006 Guidelines for National Greenhouse Gas Inventories
Value applied:	1.0
Justification of the choice of data or description of measurement methods and procedures actually applied :	Value was applied as per Application A of the tool, under the following conditions: "*1.0 for* ***anaerobic managed solid waste disposal sites****. These must have controlled placement of waste (i.e., waste directed to specific deposition areas, a degree of control of scavenging and a degree of control of fires) and will include at least one of the following: (i) cover material; (ii) mechanical compacting; or (iii) leveling of the waste;"* The disposal site uses cover material and mechanical compacting.
Any comment:	

Data / Parameter:	***DOC_j***
Data unit:	-
Description:	Fraction of degradable organic carbon (by weight) in the waste type *j*
Source of data used:	According to the methodological tool "Emissions from solid waste disposal sites",, that refers to IPCC 2006 Guidelines for National Greenhouse Gas Inventories, (adapted from Volume 5, Tables 2.4 and 2.5)
Value applied:	see table below
Justification of the choice of data or	The percentages listed in the previous table are based on a wet waste basis which are concentrations in the waste as it is delivered to the SWDS. The IPCC

Value applied:

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

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

Data / Parameter:	***K_j***
Data unit:	-
Description:	Decay rate for the waste type *j*
Source of data used:	According to the methodological tool "Emissions from solid waste disposal sites",, that refers to IPCC 2006 Guidelines for National Greenhouse Gas Inventories (adapted from Volume 5, Table 3.3)
Value applied:	see table below
Justification of the choice of data or description of measurement methods and procedures actually applied :	Parameters were chosen accordingly to the climate zone of the project site, Mean Annual Temperature (MAT) = 25 ^{o}C - Tropical climate Mean Annual Precipitation (MAP) = 1,493mm – Wet climate.
Any comment:	Sources delivered to the DOE: (MAT) - Conjuntura Economica de São José do Rio Preto 2010, Pg. 009 and 010. 2009 Data used. (MAP) - Conjuntura Economica de São José do Rio Preto 2010, Pg. 009 and 010. 2009 Data used

Value applied (K_j):

Degradation speed	***Waste Type***	***Kj***
Slowly degrading	Wood, wood products	0.035
	Pulp, paper and cardboard (other than sludge)	0.07
	Textiles	0.07
Moderately Degrading	other (non-food) organic putrescible Garden, yard and park waste	0.17
Rapidly degrading	Food, food waste, sewage sludge, beverages and tobacco	0.40

Data / Parameter:	**W_j**
Data unit:	-
Description:	Weight fraction of the waste type
Source of data used:	IPCC 2006 Guidelines for National Greenhouse Gas, Volume 5, Chapter 2, tables 2.3-2.5, MSW composition regional default values for South-America
Value applied	see table below

Value applied (W_j):

Waste type *j*	**W_j (% wet waste)**
Wood and wood products	4.7
Pulp, paper and cardboard (other than sludge)	17.1
Food, food waste, beverages and tobacco (other than sludge)	44.9
Textiles	2.6
Garden, yard and park waste	0.0
Glass, plastic, metal, other inert waste	30.7

Justification of the choice of data or description of measurement methods and procedures actually applied :	-
Any comment:	No analysis of the waste composition available for this landfill

B.6.3. Ex-ante calculation of emission reductions:

The following relevant equations and conditions are applied:

$$BE_{y} = BE_{CH4,\ y} + BE_{EC,\ y}$$

As outlined in ACM0001 (version 12): "If the energy component is intended to be implemented after the first year of the project activity, then project participants may exclude the energy component from the ex-ante estimation of baseline emissions." Therefore, and since this is the case of this project activity, in order to avoid overestimating *ex ante* estimate of emissions if energy generation is not implemented, do not take into account $BE_{EC,y}$.

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

Where:

OX_{top_layer}	=	0.1
$F_{CH4,PJ,y}$	=	Amount of methane in the LFG which is flared and/or used in the project activity in year *y* (t CH_4/yr)
$F_{CH4,BL,y}$	=	0
GWP_{CH4}	=	21

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

Where:

$F_{CH4,PJ,y}$	=	Amount of methane in the LFG which is flared and/or used in the project activity in year *y* (t CH_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}	=	0.75
GWP_{CH4}	=	Global warming potential of CH_4 (t CO_2e/t CH_4)

$$BE_{CH4,SWDS,y} = \varphi_y \cdot (1 - f_y) \cdot GWP_{CH4} \cdot (1 - OX) \cdot \frac{16}{12} \cdot F \cdot DOC_f \cdot MCF \cdot \sum_{x=1}^{y} \sum_{j} W_{j,x} \cdot DOC_j \cdot e^{-k(y-x)} \cdot (1 - e^{-kj}) \quad \textbf{(TW.1[50])}$$

With the values mentioned in the previous section.

Therefore, the ex-ante estimation of the baseline emissions is

BE_y	Estimation of $BE_{CH4,SWDS,y}$ (tCO_2e)	Estimation of $F_{CH4,PJ,Y}$ (tCH4)	Estimation of $F_{CH4,BL,y}$ (tCH4)	Estimation of baseline emissions (tCO_2e)
Year	$BE_{CH4,SWDS,y}$ = φ (1-f) * GWP_{CH4} * (1-OX) * 16/12 * F * DOC_f * MCF * ΣΣ $w_{i,x}$ * DOC_j * $e^{-kj(y-x)}$ * (1-e^{-kj})	$F_{CH4,PJ,y} = n_{PJ}$* $BE_{CH4,SWDS,y}/GWP_{CH4}$	$F_{CH4,BL,y} = 0$	BE_y = (1-OX_{top_layer})($F_{CH4,PJ,y}$-$F_{CH4,BL,y}$)*GWP_{CH4}
2013	158,513	5,661	0	106,996
2014	189,603	6,772	0	127,982
2015	215,410	7,693	0	145,402
2016	237,608	8,486	0	160,385
2017	257,326	9,190	0	173,695
2018	275,336	9,833	0	185,852
2019	292,165	10,434	0	197,211
Total	**1,625,960**	**58,070**	**0**	**1,097,523**

As there is energy consumption from the project, we present the ex-ante estimation of the corresponding project emissions below:

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

$$EF_{grid,CM} = 0.5 \times 0.1404 + 0.5 \times 0.4787 = 0.3095 \quad tCO_2e/MWh$$

$$PE_{EC,y} = \sum_{j} EC_{PJ,j,y} \times 0.3095 \times (1 + 20\%)$$

The project should consume energy from the grid, to supply the flare electricity requirements. If this situation changes, project participants will perform the necessary amendments to the PDD.
The electricity required by the biogas engines internal equipment's will not consume additional power from the grid. The required power is discounted from the electricity generated by the biogas engines, and therefore not taken in account in the next calculation.

[50] Equation numbers from the "Emissions from solid waste disposal sites" are prefixed with the letter "TW" to distinguish them from equations from the methodology.

PE_y	Electricity consumed by the flares (MWh)	Project emissions due to electricity consumption (tCO_2e)
Year	$EC_{PJ,flare,y}$	$PE_{EC,y} = (EC_{PJ,flare,y} + EC_{PJ,elec,y}) * EF_{grid} * (1+TDL)$
2013	1,577	586
2014	1,577	586
2015	1,577	586
2016	1,577	586
2017	1,577	586
2018	1,577	586
2019	1,577	586
Total	**11,038**	**4,100**

Therefore the ex-ante estimation of the emission reductions is:

ER_y	Emission reductions (tCO_2e)
Year	$ER_y = BE_y - PE_y$
2013	106,410
2014	127,396
2015	144,816
2016	159,800
2017	173,109
2018	185,266
2019	196,625
Total	**1,093,423**

The parameters used can be found on the previous section of this document, with the relevant explanations and sources of data used.

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

Ex-ante estimation of project emission reductions from methane destruction

Year	**Estimation of project activity emissions** (tCO2e)	**Estimation of baseline emissions** (tCO2e)	**Estimation of leakage** (tCO2e)	**Estimation of overall emission reductions** (tCO_2e)
2013	586	106,996	0	106,410
2014	586	127,982	0	127,396
2015	586	145,402	0	144,816
2016	586	160,385	0	159,800

2017	586	173,695	0	173,109
2018	586	185,852	0	185,266
2019	586	197,211	0	196,625
Total (tonnes of CO_2e)	4,100	1,097,523	0	1,093,423
Total number of crediting years	7	7	7	7
Annual average of the estimated reductions over the crediting period (tCO_2e)	586	156,789	0	156,203

As no emission reductions are claimed ex-ante for energy displacement, the project activity emission reduction becomes:

Year	**Estimation of annual emission reductions** (tCO_2e)
2013	106,410
2014	127,396
2015	144,816
2016	159,800
2017	173,109
2018	185,266
2019	196,625
Total (tonnes of CO_2e)	**1,093,423**
Total number of crediting years	7
Annual average of the estimated reductions over the crediting period (tCO_2e)	156,203

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

B.7.1 Data and parameters monitored:

Data monitored and required for verification and issuance. All the information listed in this section will be kept for two years after the end of the crediting period or the last issuance of CER's for this project activity, whichever occurs later.

Data / Parameter:	$\mathbf{V_{t,wb}}$
Data unit:	m³ wet gas/h
Description:	Volumetric flow of the gaseous stream in time interval *t* on a wet basis
Source of data to be	Flow meter

used:	
Value of data applied for the purpose of calculating expected emission reductions in section B.6.3	**Year** / **LFG generated (m^3/h)**: 2013: 2,404; 2014: 2,876; 2015: 3,267; 2016: 3,604; 2017: 3,903; 2018: 4,176; 2019: 4,431
Description of measurement methods and procedures to be applied:	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. Recording frequency at time interval *t*.
QA/QC procedures:	Periodic calibration against a primary device provided by an independent accredited laboratory is mandatory. Calibration and frequency of calibration is according to manufacturer's specifications
Any comment:	This parameter will be monitored in case option C applies. As per the methodology ACM0001 (Version 12): "The gaseous stream the tool shall be applied to is the LFG delivery pipeline to each item of electricity generation or heat generation equipment j, or the natural gas distribution system."

Year	LFG generated (m^3/h)
2013	2,404
2014	2,876
2015	3,267
2016	3,604
2017	3,903
2018	4,176
2019	4,431

Data / Parameter:	$V_{t,db}$
Data unit:	m^3 dry gas/h
Description:	Volumetric flow of the gaseous stream in time interval *t* on a dry basis
Source of data to be used:	Flow meter
Value of data applied for the purpose of calculating expected emission reductions in section B.6.3	See table below
Description of measurement methods and procedures to be applied:	Volumetric flow measurement should always refer to the actual pressure and temperature. Calculated based on the wet basis flow measurement plus water concentration measurement. Monitoring frequency: continuous. Recording frequency at time interval *t*.

Year	LFG generated (m^3/h)
2013	2,404
2014	2,876
2015	3,267
2016	3,604
2017	3,903
2018	4,176
2019	4,431

QA/QC procedures:	Periodic calibration against a primary device provided by an independent accredited laboratory is mandatory. Calibration and frequency of calibration is according to manufacturer's specifications
Any comment:	This parameter will be monitored in case option A applies. As per the methodology ACM0001 (Version 12): "The gaseous stream the tool shall be applied to is the LFG delivery pipeline to each item of electricity generation or heat generation equipment j, or the natural gas distribution system."

Data / Parameter:	$v_{CH4,t,db}$
Data unit:	m³ CH4 / m³ dry gas
Description:	Volumetric fraction of CH_4 in time interval *t* on a dry basis
Source of data to be used:	Onsite measurement
Value of data applied for the purpose of calculating expected emission reductions in section B.6.3	0.5
Description of measurement methods and procedures to be applied:	Continuous gas analyser operating in dry-basis. Volumetric flow measurement should always refer to the actual pressure and temperature. Recording frequency at time interval *t*.
QA/QC procedures:	Calibration should 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 must have a certificate provided by the manufacturer and must be under their validity period. Calibration frequency as per manufacturer specifications.
Any comment:	This parameter may be monitored in case option A or D applies. As per the methodology ACM0001 (Version 12): "The gaseous stream the tool shall be applied to is the LFG delivery pipeline to each item of electricity generation or heat generation equipment j, or the natural gas distribution system."

Data / Parameter:	$v_{CH4,t,wb}$
Data unit:	m³ CH_4 / m³ wet gas
Description:	Volumetric fraction of CH_4 in time interval *t* on a wet basis
Source of data to be used:	Onsite measurement
Value of data applied for the purpose of calculating expected emission reductions in section B.6.3	0.5
Description of measurement methods and procedures to be	Calculated based on the dry basis analysis plus water concentration measurement or continuous in-situ analyzers. Monitoring frequency: continuous. Recording frequency at time interval *t*.

applied:	
QA/QC procedures:	Calibration should 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 must have a certificate provided by the manufacturer and must be under their validity period. Calibration frequency as per manufacturer specifications.
Any comment:	This parameter will be monitored in case option C. This parameter may be monitored in case option A or D applies. As per the methodology ACM0001 (Version 12): "The gaseous stream the tool shall be applied to is the LFG delivery pipeline to each item of electricity generation or heat generation equipment j, or the natural gas distribution system."

Data / Parameter:	$\mathbf{M_{t,db}}$
Data unit:	kg/h
Description:	Mass flow of the gaseous stream in time in interval *t* on dry basis
Source of data to be used:	Onsite measurement
Value of data applied for the purpose of calculating expected emission reductions in section B.6.3	Not used in ex-ante estimates
Description of measurement methods and procedures to be applied:	Instruments with recordable electronic signal (analogical or digital) are required. Monitoring frequency: continuous. Recording frequency at time interval *t*.
QA/QC procedures:	Calibration and frequency of calibration is according to manufacturer's specifications
Any comment:	This parameter will be monitored in case option D applies.

Data / Parameter:	$\mathbf{T_t}$
Data unit:	^oC or K
Description:	Temperature of the gaseous stream in time interval *t*
Source of data to be used:	Onsite measurement
Value of data applied for the purpose of calculating expected emission reductions in section B.6.3	Not used in ex-ante estimates
Description of measurement methods and procedures to be applied:	No separate monitoring of temperature is necessary when using flow meters that automatically measure temperature and pressure, expressing LFG volumes in normalized cubic meters. Monitoring frequency: continuous. Recording frequency at time interval *t*. Calibration according to manufacturer specifications.

QA/QC procedures:	Instrument will be subject to a regular maintenance and testing regime in accordance to appropriate national / international standards
Any comment:	Provided all parameters are converted to normal conditions during the monitoring process, this parameter may not be needed, except if the applicability condition related to the gaseous stream flow temperature being below 60ºC is adopted, this parameter shall be monitored continuously to assure the applicability condition is met.

Data / Parameter:	**P_t**
Data unit:	Pa or mbar
Description:	Pressure of the gaseous stream in time interval *t*
Source of data to be used:	Onsite measurement
Value of data applied for the purpose of calculating expected emission reductions in section B.6.3	Not used in ex-ante estimates
Description of measurement methods and procedures to be applied:	No separate monitoring of pressure is necessary when using flow meters that automatically measure temperature and pressure, expressing LFG volumes in normalized cubic meters. Recording frequency at time interval *t*. Calibration according to manufacturer specifications.
QA/QC procedures:	Pressure sensor will be subject to a regular maintenance and testing regime in accordance to appropriate national / international standards
Any comment:	-

Data / Parameter:	**$p_{H20,t,Sat}$**
Data unit:	Pa or mbar
Description:	Saturation pressure of H_2O at temperature T_t in time interval *t*
Source of data to be used:	[1] Fundamentals of Classical Thermodynamics; Gordon J. Van Wylen, Richard E. Sonntag and Borgnakke; 4º Edition 1994, John Wiley & Sons, Inc.
Value of data applied for the purpose of calculating expected emission reductions in section B.6.3	Not used in ex-ante estimates
Description of measurement methods and procedures to be applied:	This parameter is solely a function of the gaseous stream temperature T_t and can be found at reference [1] for a total pressure equal to 101,325 Pa.
QA/QC procedures:	-
Any comment:	-

Data / Parameter:	**$EC_{PJ,y}$**
Data unit:	MWh
Description:	Quantity of electricity consumed by the project activity during the year *y*

Source of data to be used:	Onsite measurement
Value of data applied for the purpose of calculating expected emission reductions in section B.6.3	1,576.80 MWh per year
Description of measurement methods and procedures to be applied:	Use authorized electricity meters. Monitoring frequency: continuously, aggregated manually via onsite meter checking. Calibration according to manufacturer specifications.
QA/QC procedures:	Cross check measurement results with electricity invoices. Regular maintenance (upon the manufacturer's recommendation)
Any comment:	-

Data / Parameter:	**$EC_{BL,k,y}$**
Data unit:	MWh/yr
Description:	Net amount of electricity generated using LFG in year *y*
Source of data to be used:	Onsite measurement
Value of data applied for the purpose of calculating expected emission reductions in section B.6.3	Not used in ex-ante estimates.
Description of measurement methods and procedures to be applied:	Use authorized electricity meters. Monitoring frequency: continuously, aggregated manually via onsite meter checking. Calibration according to manufacturer specifications.
QA/QC procedures:	Electricity meter will be subject to regular maintenance (in accordance with stipulation of the meter supplier) and testing to ensure accuracy
Any comment:	As outlined in ACM0001 (version 12): "If the energy component is intended to be implemented after the first year of the project activity, then project participants may exclude the energy component from the ex-ante estimation of baseline emissions." Therefore, and since this is the case of this project activity, in order to avoid overestimating ex ante estimate of emissions if energy generation is not implemented resulting emission reductions were not taken in account.

Data / Parameter:	**$EF_{grid,OM,y}$**
Data unit:	tCO_2/MWh
Description:	Operation margin CO_2 emission factor in year *y*
Source of data to be used:	As per the "Tool to calculate the emission factor for an electricity system"
Value of data applied for the purpose of calculating expected	0.4787

emission reductions in section B.6.3	
Description of measurement methods and procedures to be applied:	As per the "Tool to calculate the emission factor for an electricity system"
QA/QC procedures:	As per the "Tool to calculate the emission factor for an electricity system"
Any comment:	-

Data / Parameter:	$\mathbf{EF_{grid,BM,y}}$
Data unit:	tCO_2/MWh
Description:	Build margin CO_2 emission factor in year *y*
Source of data to be used:	As per the "Tool to calculate the emission factor for an electricity system"
Value of data applied for the purpose of calculating expected emission reductions in section B.6.3	0.1404
Description of measurement methods and procedures to be applied:	As per the "Tool to calculate the emission factor for an electricity system"
QA/QC procedures:	As per the "Tool to calculate the emission factor for an electricity system"
Any comment:	-

Data / Parameter:	Operation of the energy plant
Data unit:	hr
Description:	Operation of the energy plant
Source of data to be used:	Project participants
Value of data applied for the purpose of calculating expected emission reductions in section B.6.3	Not used in ex-ante estimates
Description of measurement methods and procedures to be applied:	Hourly
QA/QC procedures:	-
Any comment:	This is monitored to ensure methane destruction is claimed for methane used in electricity plant when it is operational. As outlined in ACM0001 (version 12): "If the energy component is intended to be implemented after the first year of the project activity, then project participants may exclude the energy component from the ex-ante estimation of baseline emissions." Therefore, and since this is the case of

	this project activity, in order to avoid overestimating ex ante estimate of emissions if energy generation is not implemented resulting emission reductions were not taken in account.

The following variables are required to determine flare efficiency using the “Tool to determine project emissions from flaring gases containing methane”. A fixed flare efficiency is assumed for ex ante calculations, so estimates of these data are not needed for ex-ante estimates.

Data / Parameter:	$\mathbf{FV_{RG,h}}$
Data unit:	m^3/h
Description:	Volumetric flow rate of the residual gas in dry basis at normal conditions in the hour *h*.
Source of data to be used:	On-site measurements.
Value of data applied for the purpose of calculating expected emission reductions in section B.6.3	Not used in ex-ante estimates.
Description of measurement methods and procedures to be applied:	Measured continuously using a flow meter and recorded electronically, and data will be kept during the crediting period and two years after. Values to be averaged hourly or at a shorter time interval
QA/QC procedures to be applied:	Flow meters will be periodically calibrated according to the manufacturer’s recommendation.
Any comment:	The same basis (dry or wet) is considered for this measurement when the residual gas temperature exceeds 60ºC.

Data / Parameter:	$\mathbf{fv_{i,h}}$
Data unit:	-
Description:	Volumetric fraction of component *i* in the residual gas in the hour *h.*
Source of data to be used:	On-site measurements using a continuous gas analyser.
Value of data applied for the purpose of calculating expected emission reductions in section B.6.3	Not used in ex-ante estimates.
Description of measurement methods and procedures to be applied:	As a simplified approach (see Eq. T3a), only methane content of the residual gas will be measured and the remaining part will be considered as N_2. Methane concentration would be measured continuously using a continuous gas analyser, and data records will be kept during the crediting period and two years after. Values to be averaged hourly or at a shorter time interval
QA/QC procedures to be applied:	Analysers will be periodically calibrated according to the manufacturer’s recommendation. A zero check and typical value check to be performed by comparison with a standard certified gas.

Any comment:	The same basis (dry or wet) is considered for this measurement when the residual gas temperature exceeds 60ºC.

Data / Parameter:	$\mathbf{t_{O2,h}}$
Data unit:	-
Description:	Volumetric fraction of O_2 in the exhaust has of the flare in the hour *h*.
Source of data to be used:	On-site measurements using a continuous gas analyser.
Value of data applied for the purpose of calculating expected emission reductions in section B.6.3	Not used in ex-ante estimates.
Description of measurement methods and procedures to be applied:	Measured continuously using a continuous gas analyser and recorded electronically, and data will be kept during the crediting period and two years after. Extractive sampling analysers with water and particulates removal devices or in situ analysers for wet basis determination. The point of measurement (sampling point) will be in the upper section of the flare . Sampling will be conducted with appropriate sampling probes adequate to high temperatures level (e.g. inconel probes).
QA/QC procedures to be applied:	Analysers will be periodically calibrated according to the manufacturer's recommendation. A zero check and typical value check to be performed by comparison with a standard certified gas.
Any comment:	

Data / Parameter:	$\mathbf{fv_{CH4,FG,h}}$
Data unit:	mg/m^3
Description:	Concentration of methane in the exhaust gas of the flare at normal conditions in the hour *h*
Source of data to be used:	Measurements by project participants using a continuous gas analyser
Value of data applied for the purpose of calculating expected emission reductions in section B.6.3	Not used in ex-ante estimates.
Description of measurement methods and procedures to be applied:	Extractive sampling analysers with water and particulates removal devices or in situ analyser for wet basis determination. The point of measurement (sampling point) shall be in the upper section of the flare. Sampling shall be conducted with appropriate sampling probes adequate to high temperatures level (e.g. inconel probes). An excessively high temperature at the sampling point may be an indication that the flare is not being adequately operated or that its capacity is not adequate to the actual flow. Monitoring frequency: Continuously. Values to be averaged hourly or at a shorter time interval.
QA/QC procedures to be applied:	Analysers will be periodically calibrated according to manufacturer's recommendation. A zero check and a typical value check will be performed

	by comparison with a standard gas.
Any comment:	Monitoring of this parameter is only applicable in case of enclosed flares and continuous monitoring of the flare efficiency. Measurement instruments may read ppmv or % values. To convert from ppmv to mg/m^3 simply multiply by 0.716. 1% equals 10,000 ppmv.

Data / Parameter:	$\mathbf{T_{flare}}$
Data unit:	ºC
Description:	Temperature in the exhaust gas of the flare.
Source of data to be used:	On-site measurements using a thermocouple.
Value of data applied for the purpose of calculating expected emission reductions in section B.6.3	Not used in ex-ante estimates.
Description of measurement methods and procedures to be applied:	Continuous measurement of the temperature of the exhaust gas stream in the flare by a thermocouple.
QA/QC procedures to be applied:	Thermocouple will be replaced or calibrated every year.
Any comment:	An excessively high temperature at the sampling point may be an indication that the flare is not being adequately operated or that its capacity is not adequate to the actual flow.

Data / Parameter:	**Other flare operation parameters**
Data unit:	-
Description:	This should include all data and parameters that are required to monitor whether the flare operates within the range of operating conditions according to the manufacturer specifications including a flame detector in case of open flares.
Source of data to be used:	Measurements by project participants
Value of data applied for the purpose of calculating expected emission reductions in section B.6.3	Not used in ex-ante estimates
Description of measurement methods and procedures to be applied:	Continuously
QA/QC procedures to be applied:	-
Any comment:	Only applicable in case of use of a default value

B.7.2. Description of the monitoring plan:

The following instruments will monitor the required data, depending on the measurement option chosen[52]:

Instrument or Source of data	Measurement option		Data monitored	
Flowmeter(s)	A	Volume flow – dry basis; Volumetric fraction dry or wet basis	$\mathbf{V_{t,db,j}}$	Volumetric flow of the gaseous stream *j* in time interval *t* on a dry basis. (m^3 dry gas/h) *j* = LFG delivery pipeline to each item of electricity generation and LFG delivery pipeline to the flare(s)
	C	Volume flow – wet basis; Volumetric fraction wet basis	$\mathbf{V_{t,wb,j}}$	Volumetric flow of the gaseous stream *j* in time interval *t* on a wet basis. (m^3 wet gas/h) *j* = LFG delivery pipeline to each item of electricity generation and LFG delivery pipeline to the flare(s)
	D	Mass flow – dry basis; Volumetric fraction dry or wet basis	$\mathbf{M_{t,db,j}}$	Mass flow of the gaseous stream *j* in time interval *t* on a wet basis. (kg/h) *j* = LFG delivery pipeline to each item of electricity generation and LFG delivery pipeline to the flare(s)
Gas analyser	-		$\mathbf{v_{CH4,t,db/wb,j}}$	Volumetric fraction of methane on the gaseous stream *j* in a time interval t on a dry or wet basis (m^3 gas/m^3 dry or wet gas)
Pressure sensor	-		$\mathbf{P_t}$	Pressure of the LFG (not monitored when using flowmeter that automatically measures temperature and pressure, expressing LFG volumes in normalised cubic meters) (Pa or mbar)
Temperature sensor	-		$\mathbf{T_t}$	Temperature of the LFG (ºC)
Exhaust gas analyzer[53]	-		$\mathbf{fv_{CH4,FG,h}}$ $\mathbf{t_{O2,h}}$	Concentration of methane in the exhaust gas (mg/m^3) Volumetric fraction of O_2 in the exhaust gas
Thermocouple	-		$\mathbf{T_{flare}}$	Temperature of in the exhaust gas of the flare (ºC)
Electricity meter	-		$\mathbf{EC_{PJ,y}}$	Quantity of electricity consumed by the project activity during the year *y* (MWh/yr)
			$\mathbf{EC_{BL,k,y}}$	Net amount of electricity generated using LFG in year *y* (MWh/yr)
Counter	-		-	Operation of the energy plant (hr)
Project	-		-	Flare operation parameters monitored as per the

[52] Measurement options defined in the "Tool to determine the mass flow of a greenhouse gas in a gaseous stream" (Version 02.0.0).

[53] Optional as default value may be used.

Instrument or Source of data	Measurement option	Data monitored
participants		"Tool to determine project emissions from flaring gases containing methane", including all data and parameters that are required to monitor whether the flare operates within the range of operating conditions according to the manufacturer's specifications.

All continuously measured parameters (LFG flow, CH_4 concentration, flare temperature, operating hours, engine electrical output) will be recorded electronically via a datalogger, located within the site boundary which will have the capability to aggregate and print the collected data at the frequencies as specified above. It will be the responsibility of the Site Operator to provide all requested data logs which will be stored over the duration of the monitoring period at the Site office. The data logs will be summarized into emission reduction calculations prior to each verification. These logs will be available at the request of the DOE in order to prove the operational integrity of the Project.

Technical details on manufacturer / type / accuracy of instruments will be known only at the time of implementation.

DATA LOGGING, TRANSMISSION AND STORAGE

The data measured by the instruments will be collected and stored in a data logging system. The data will be retrieved remotely by modem or directly on site.
If automatic data logging failed, the data will be recorded manually, if possible.
If data cannot be retrieved, no emissions reductions will be claimed for the period of data failure.
The data collected will be recorded in a central data base. Access to production data will be restricted.
Copies of the files will be stored up to two years after the end of the crediting period or the last issuance of CERs for this project activity whichever occurs later.

CALIBRATION AND MAINTENANCE PROCEDURES, MALFUNCTION OF EQUIPMENT

Maintenance includes all preventive and corrective actions necessary for the good functioning of the equipment, such as:

- Visual control of the equipment state and real-time check of displayed parameters,
- Cleaning up the equipment and the sensors,
- Adding lubricant,
- Replacement and change of defective parts.

Calibration of equipment consists in verifying, by comparison with a standard, the accuracy of a measuring instrument. Measuring instruments will be periodically and appropriately calibrated according to the procedures, timing and methods recommended by the manufacturer, or national/international standards, as available.

General malfunction of equipment: if the equipment fails, the supplier will be notified and repairs will be carried out. If the damaged equipment cannot be repaired, it will be replaced at the earliest by the same or an equivalent unit. In some cases, portable tools will be used in order to carry out daily monitoring of the missing parameter(s). This data will be recorded manually.

Discrepancies: to avoid discrepancies between projected data in the PDD and actual data (e.g. due to deferred starting date, malfunction of equipment), cross-checks between internal meter readings and external sources (e.g. electricity invoices) will be carried out. Any source of inconsistencies will be clarified.

OPERATIONAL AND MANAGEMENT STRUCTURE

Will be defined during the implementation of the project.

TRAINING OF MONITORING PERSONNEL

Employees involved in the monitoring will be trained internally and/or externally. Training may include:

a) Review of equipment and captors
b) Calibration requirement
c) Configuration of monitoring equipment
d) Maintenance requirement
e) Emergency and safety procedures

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

The date of completion the application of the methodology to the project activity study is 15/12/2011.

The person/entity determining the baseline is as follows:

Carbono Dois Energia & Meio Ambiente Ltda.
São Paulo, Brazil
Contact person: Mr. Nuno Barbosa
Email: nuno@carbonodois.com.br

Carbono Dois is not a project participant.

SECTION C. Duration of the project activity / crediting period

C.1. Duration of the project activity:

C.1.1. Starting date of the project activity:

Project starting date: 01/12/2012.

The Project Participant is decided to take real action to implement the project (initial engineering and construction work, selection and ordering of project related equipment, etc.) only after the successful registration of the proposed project as a CDM project activity by UNFCCC. As per the current tentative schedule, this is forecasted to occur in December 2012. The selected project starting date corresponds to the date when initial engineering and construction work starts or date when ordering (acquisition) of project related equipment occurs.

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

At least 20 years and 0 months

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

C.2.1. Renewable crediting period:

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

The crediting period will start on 01/01/2013, or on the date of the registration of the CDM project activity (whichever is later).

C.2.1.2. Length of the first crediting period:

7 years and 0 months

C.2.2. Fixed crediting period:

C.2.2.1. Starting date:

Not applicable

C.2.2.2. Length:

Not applicable

SECTION D. Environmental impacts

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

According to the Brazilian laws, the possible environmental impacts are analyzed by the State Secretary of Environment (*Secretaria de Estado do Meio Ambiente*) through its executive branch CETESB (Agência *Ambiental do Estado de São Paulo*).

Regarding the Co disposition Landfill Site - Onda Verde (Aterro de Codisposição - Onda Verde), the landfill site were the project activity will be located, the landfill received, from CETESB, the Operational License no. 14003968, process number 14/00113/03, valid until 19/12/2014.

The EIA (Environmental Impact Study, or, Estudo de Impacto Ambiental) is regulated by Resolução Conama n° 1/86[54]. That mentions the activities that are subjected to the Environmental Impact Study. Landfill gas flaring is not subjected to the Environmental Impact Study, neither power generation plants below 10 MW, which is the case of the current project activity.

There will be no transboundary impacts resulting from this project activity. All the relevant impacts occur within Brazilian borders and have been mitigated to comply with the environmental requirements for project's implementation.

The environmental impact of the project activity on the landfill site can be summarized as follows:

Impact on fauna and flora
The project will have a positive influence on the local ecosystem by the destruction of gases like H_2S and derivatives of methane, which constitute a substantial nuisance in the neighbouring zones (because of their scents), will also contribute to the development of the local ecosystem.

Impact on air and climate
The destruction of the methane contained in landfill gas will contribute to the reduction of greenhouse gas emissions, which are proved to increase global warming.
The project activity will prevent all nuisance created by the total release of the landfill gas to the atmosphere, such as the release of H_2S, mercaptenes and other chemical compounds that result in bad odours and sanitary risks in the neighbouring populations, such as diseases and asthma due to the air pollution.

Impact on safety
The destruction of landfill gas will reduce risks of explosion in the landfill site and the neighbourhood, as LFG will be extracted and destroyed, avoiding accumulation in the landfill thus continuously controlling the risk of explosions.

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

All environmental assesses were analyzed by CETESB and the landfill has all pertinent Licenses for the operation. Thus, no significant environmental impact was identified.

SECTION E. Stakeholders' comments

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

According to the Resolutions Number 1, 4 and 7 of the Brazilian Designed National Authority (CIMGC –

[54] Available at http://licenciamento.cetesb.sp.gov.br/legislacao/federal/resolucoes/1986_Res_CONAMA_1_86.pdf, accessed on 11/04/2012.

Comissão Interministerial de Mudança Global do Clima / *Interministerial Commission on Global Climate Change*), project participants shall send letters to local stakeholders 15 days before the start of the validation period, in order to receive comments, including the following information:

- Name and type of the activity project;
- PDD (translated to Portuguese), made available through a website;
- Description of the project's contribution to the sustainable development also made available through a website.

The PDD was made available at www.carbonodois.com.br/dcp on the 23/12/2011, and the following letters were sent also on 23/12/2011 to the following stakeholders involved and affected by the project activity:

1. Interministerial Commission for the Global Climate Change

2. CETESB - São Paulo State Environmental Agency

3. Brazilian Forum of NGO´s

4. Brazilian Forum of Climate Change

5. Federal Public Prosecution Office

6. Federal Public Prosecution Office

7. São Paulo State Public Prosecution Office

8. Onda Verde City Hall

9. Onda Verde City Council

E.2. Summary of the comments received:

No comments received at this time.

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

Not comments received at this time.

Annex 1

CONTACT INFORMATION ON PARTICIPANTS IN THE PROJECT ACTIVITY

Organization:	Constroeste Construtora e Participações Ltda.
Street/P.O.Box:	Rodovia Assis Chateaubriand, km 2.5 - Jd Yolanda -
Building:	Centro Administrativo
City:	São José do Rio Preto
State/Region:	São Paulo
Postcode/ZIP:	15064-000
Country:	Brazil
Telephone:	+ 55 17 2136 2200
FAX:	
E-Mail:	evandro@constroeste.com.br
URL:	www.constroeste.com.br
Represented by:	Environmental Director
Title:	PhD
Salutation:	
Last name:	Tagliaferro
Middle name:	Roberto
First name:	Evandro
Department:	Environmental Department
Mobile:	
Direct FAX:	
Direct tel:	
Personal e-mail:	evandro@constroeste.com.br

Annex 2

INFORMATION REGARDING PUBLIC FUNDING

There is no Annex I public funding involved in the project activity

Annex 3

BASELINE INFORMATION

Refer to Section B.4

Annex 4

MONITORING INFORMATION

Refer to Sections B.7.1 and B.7.2

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