**Monitoring report form for CDM project activity**
**(Version 06.0)**

*Complete this form in accordance with the instructions attached at the end of this form.*

| MONITORING REPORT | | |
|---|---|---|
| **Title of the project activity** | Bandeirantes Landfill Gas to Energy Project (BLFGE) | |
| **UNFCCC reference number of the project activity** | 0164 | |
| **Version number of the PDD applicable to this monitoring report** | 03, dated 01/03/2012 | |
| **Version number of this monitoring report** | 01 | |
| **Completion date of this monitoring report** | 17/01/2018 | |
| **Monitoring period number** | 2nd monitoring period | |
| **Duration of this monitoring period** | 01/09/2012 – 22/12/2017 | |
| **Monitoring report number for this monitoring report** | Not applicable. The project is a large scale project type. | |
| **Project participants** | Prefeitura Municipal de São Paulo (Municipality of São Paulo)<br>Biogás Energia Ambiental S.A.<br>KfW<br>Fortis Bank N.V./S.A.<br>Mercuria Energy Trading SA | |
| **Host Party** | Brazil | |
| **Sectoral scopes** | 13 - Waste handling and disposal | |
| **Applied methodologies and standardized baselines** | ACM0001 – “Flaring or use of landfill gas” (version 11) | |
| **Amount of GHG emission reductions or net anthropogenic GHG removals achieved by the project activity in this monitoring period** | Amount achieved before 1 January 2013 | Amount achieved from 1 January 2013 |
| | 63,635 $tCO_2e$ | 778,365 $tCO_2e$ |
| **Amount of GHG emission reductions or net anthropogenic GHG removals estimated ex ante for this monitoring period in the PDD** | 1,175,518 $tCO_2e$ | |

## SECTION A. Description of project activity

### A.1. General description of project activity

Bandeirantes Landfill Gas to Energy Project (BLFGE) is a project designed to explore the landfill gas (LFG) produced in Bandeirantes landfill, one of the biggest landfills in Brazil. The Bandeirantes LFG is used for electricity generation for the Brazilian Interconnected System ("SIN" from the Portuguese *Sistema Interligado Nacional*).

The project is located in the metropolitan region of São Paulo, Brazil's biggest city and financial center of the country. Aiming to avoid environmental problems related to methane emissions, including also global warming, BLFGE created by Biogás Energia Ambiental S/A – the winner company of a public bid from the municipality of São Paulo. Its goal has been not only to generate renewable energy through 24 engines with 925kW capacity (total installed capacity equals to 22.2MW), but also find an environmental, social and financial solution to avoid landfill greenhouse gases (GHG) release into the atmosphere. Such solution is very replicable in a country like Brazil, where there was no landfill capturing methane under the three bottom-lines (social, environmental and financial).

The project started construction in 2003; the flaring system was installed in November 2003 and the first gas engine was installed in December 2003. The project commissioning started on December 23rd 2003, when the final environmental license – working license – was issued. Officially, the project activity started, with the implementation of the degassing station – on January 1st, 2004 – and with the power plant – on February 16th, 2004.

During this monitoring period – from 01/09/2012 to 22/12/2017 –, the project reduced 842,000 $tCO_2e$.

### A.2. Location of project activity

Bandeirantes landfill is located between km 25 and km 26 at Bandeirantes highway, which connects the city of São Paulo with Campinas Metropolitan Region. The landfill covers an area of approximately 1.35 million $m^2$, having Perus urban area (a São Paulo district) as North border; São Paulo – Jundiai old road as East border; in South lies the connection between this road and Bandeirantes highway and finally in West there is Bandeirantes highway. The geographic coordinates of project site are as follows:

Latitude: 23° 25' 11.13" S

Longitude: 45° 45' 21.69" W

**Figure 1** – São Paulo location (Source: http://pt.wikipedia.org)


**Figure 2** – BLFGE Landfill location (Source: adapted from Google Earth)

## A.3. Parties and project participants

| Parties involved | Project participants | Indicate if the Party involved wishes to be considered as project participant (Yes/No) |
|---|---|---|
| Brazil (host) | Public entity - Prefeitura Municipal de São Paulo (Municipality of São Paulo) | No |
| | Private entity - Biogás Energia Ambiental S.A. | |
| Germany | Private entity - KfW | No |
| Switzerland | Private entity - Mercuria Energy Trading SA | No |
| Netherlands | Private entitiy - Fortis Bank N.V./S.A. | No |

## A.4. Reference to applied methodologies and standardized baselines

BLFGE applies the ACM0001 – "*Consolidated baseline and monitoring methodology for landfill gas project activities*" (version 11.0). ACM0001 refers to the following methodological tools:

- Tool for the demonstration and assessment of additionality (version 6.0.0);
- Emissions from solid waste disposal site (version 6.0.0);
- Tool to calculate baseline, project and/or leakage emissions from electricity consumption (version 1);

- Tool to determine project emissions from flaring gases containing methane (version 1);
- Tool for calculation of emission factor for electricity systems (version 2.2.1);
- Tool to calculate project or leakage $CO_2$ emissions from fossil fuel combustion (version 2);
- Tool to assess the validity of the original/current baseline and to update the baseline at the renewal of a crediting period (version 3).

### A.5. Crediting period type and duration

2nd renewable crediting period: 7 years, 0 month.

## SECTION B. Implementation of project activity

### B.1. Description of implemented project activity

Bandeirantes landfill is divided into 5 cells, named AS-1, AS-2, AS-3, AS-4 and AS-5. The landfill received waste from 1979 to 2007, when it was closed. More than 37 million tons of waste were disposed in the landfill's area. The collection system encompasses mostly cells AS-4 and AS-5.

The LFG is extracted from the landfill through the gas wells and is transported to the gas plant by the pipelines for treatment before use as fuel or flaring. During the transportation there might occur the formation of condensates due to temperature gradients requiring drainage of the pipeline to condensate shafts placed along the pipeline. Once in the gas plant, the LFG is cooled again to remove moisture up to a minimum level. The removal of condensates from the LFG flow is a critical step in the gas treatment process should the LFG be used as fuel. LFG condensates contain silica components that can block the gas pipes or damage the gas engines ultimately. Once the condensates are removed, the LFG is heated again by passing through a second heat exchanger, or economizer, to a temperature of around 25 °C, far enough from the dew point of 4 °C to avoid further condensation.

As additional precaution, as per the reasons mentioned in the previous paragraph, a demister was also installed as an extra-guarantee of the LFG quality as fuel for gas engines. The demister is a stainless steel high density filter which separates liquid particles (small amounts of condensate) from the LFG. All liquid removed off the LFG is drained to a condensate shaft.

Blowers are used to provide correct suction pressure into the pipeline system for transportation of the LFG extracted from the landfill up to the gas plant. Flow capacity and pressure are adjusted by electrical motors with frequency control. In addition to that, the blowers are also equipped with necessary safety equipment as well as noise reducing housing.

Sophisticated gas analysing and gas measuring instruments are used on the pressure side of the gas plant to ensure safety, process and operating best controls. Once analysed and properly controlled and measured, the LFG can be used as a fuel for the gas engines which drive electrical generators. Any occasional surplus of the LFG might continue being burned off by the flares. BLFGE has 2 units "High temperature flare HOFGAS – Efficiency 2500" (manufactured by Hofstetter) installed at the site, with the following characteristics:

**Table 1** – Technical description of project's equipment

| | Blower* | Flare | El. Generator | Diesel Generator |
|---|---|---|---|---|
| *Manufacturer* | Aerzen | Hofstetter | Caterpillar | Cummins Brasil Ltda. |
| *Model* | GM 130 L / DN 300 | Hofgas Efficiency 2500 | G3516A | 125DGEB-1297 |
| *Quantity* | 4 | 2 | 24 | 1 |

| | Blower* | Flare | El. Generator | Diesel Generator |
|---|---|---|---|---|
| *Capacity per unit* | 4,250 $Nm^3$ | Min: 500$Nm^3$/hr<br>Max: 2,500 $Nm^3$/h | 925kW | 125kW |

*A mini-blower is also installed at the plant with 2,500 $Nm^3$ capacity.

**Figure 3** – Compressors (blue) and dryers (metal)

**Figure 4** – Backup diesel generator for emergency purposes

**Figure 5** – Enclosed flares for destruction of LFG surplus

**Figure 6** – Electricity generators

The whole LFG collecting process and gas plant are controlled by an electrical control system which is provided with a PLC (Programmable Logical Controller) and a SCADA system (visualization of the process on a personal computer), making possible to control and monitor the installation at distance, including through the internet. . All the measured process signals are processed by the PLC to feed input signals for the gas-coolers, blowers, flares and gas-engines.

Given the project magnitude in terms of power generation using exclusively LFG as fuel, it would not have happened without technology transfer. Among Biogás shareholders are Van der Wiel – worldwide known Dutch firm acting in the transport, infrastructure and environmental technique – and Arcadis, engineering, project management and consultancy Netherlands-based firm with a branch in Brazil (ArcadisLogos), responsible for landfill gas capture engineering design. In the case of BLFGE, the former has contributed

largely for the design of the LFG system, while the latter has used its broad experience in energy projects leading the project implementation and operation. Most of the equipment was imported, such as engines for energy generation, flow meters, gas analyser and flares, as the Brazilian industry was not prepared yet to supply this kind of equipment, at least with the size and characteristics demanded for the BLFGE project. Both project's implementation and operation have happened under strict environmental regulations, ensuring that technology transference could be made in safe and proper environmental conditions at BLFGE.

### B.2. Post-registration changes

#### B.2.1. Temporary deviations from the registered monitoring plan, applied methodologies or standardized baselines

Not applicable. No temporary deviations were made during this crediting period.

#### B.2.2. Corrections

Not applicable. No corrections were made during this crediting period.

#### B.2.3. Changes to the start date of the crediting period

Not applicable. No changes in the starting date of the crediting period were made.

#### B.2.4. Inclusion of monitoring plan

Not applicable. No revisions in the monitoring plan were made during this crediting period.

#### B.2.5. Permanent changes to the registered monitoring plan, or permanent deviation of monitoring from the applied methodologies, standardized baselines, or other applied standards or tools

Not applicable. No permanent changes were made in the PDD during this crediting period.

#### B.2.6. Changes to project design

Not applicable. No changes in the project design were made during this crediting period.

## SECTION C. Description of monitoring system

Section B.7.1. above describes the parameters that are to be monitored during the crediting period, as well as, the methods and procedures to be applied. The location of the instruments installed in the degassing and electricity generation plants is presented in the following diagram.

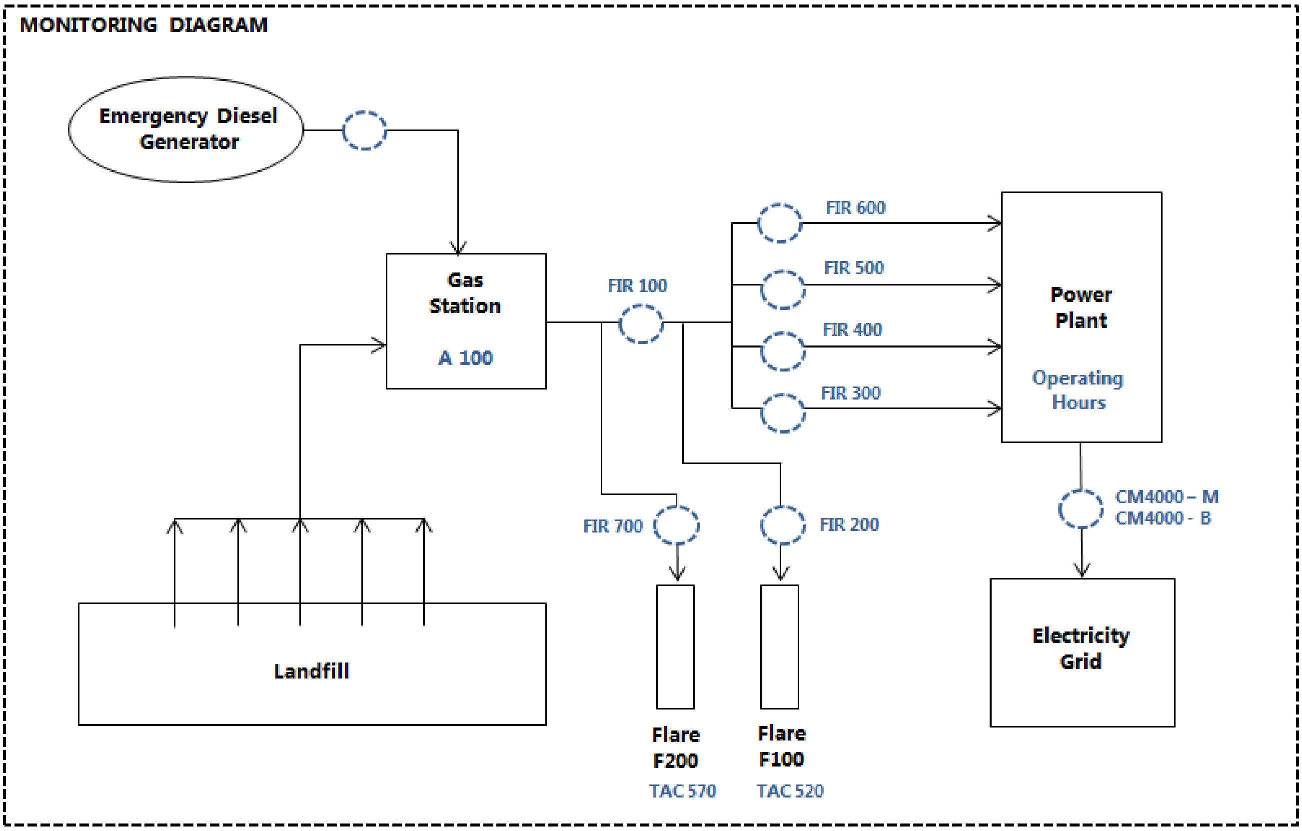


**Figure 7** – Simplified diagram of monitoring equipment.

- FIR100 and FIR 700: Flow meter - Register the total amount of landfill gas captured;
- FIR200 and FIR700: Flow meter - Register the amount of landfill gas flared;
- FIR300, FIR400, FIR500 and FIR600: Flow meter - Register the total amount of landfill gas combusted in the power plant to generate electricity;
- TAC520 and TAC 570: Temperature meters of the exhaust gas - Flares: F100 and F200, respectively;
- A100: methane fraction from the LFG;
- CM4000-M and CM4000-B: Electricity meter – Register electricity generation to the grid;
- Electricity meter - Diesel generator.

The detailed layout of degassing plants is as follows:

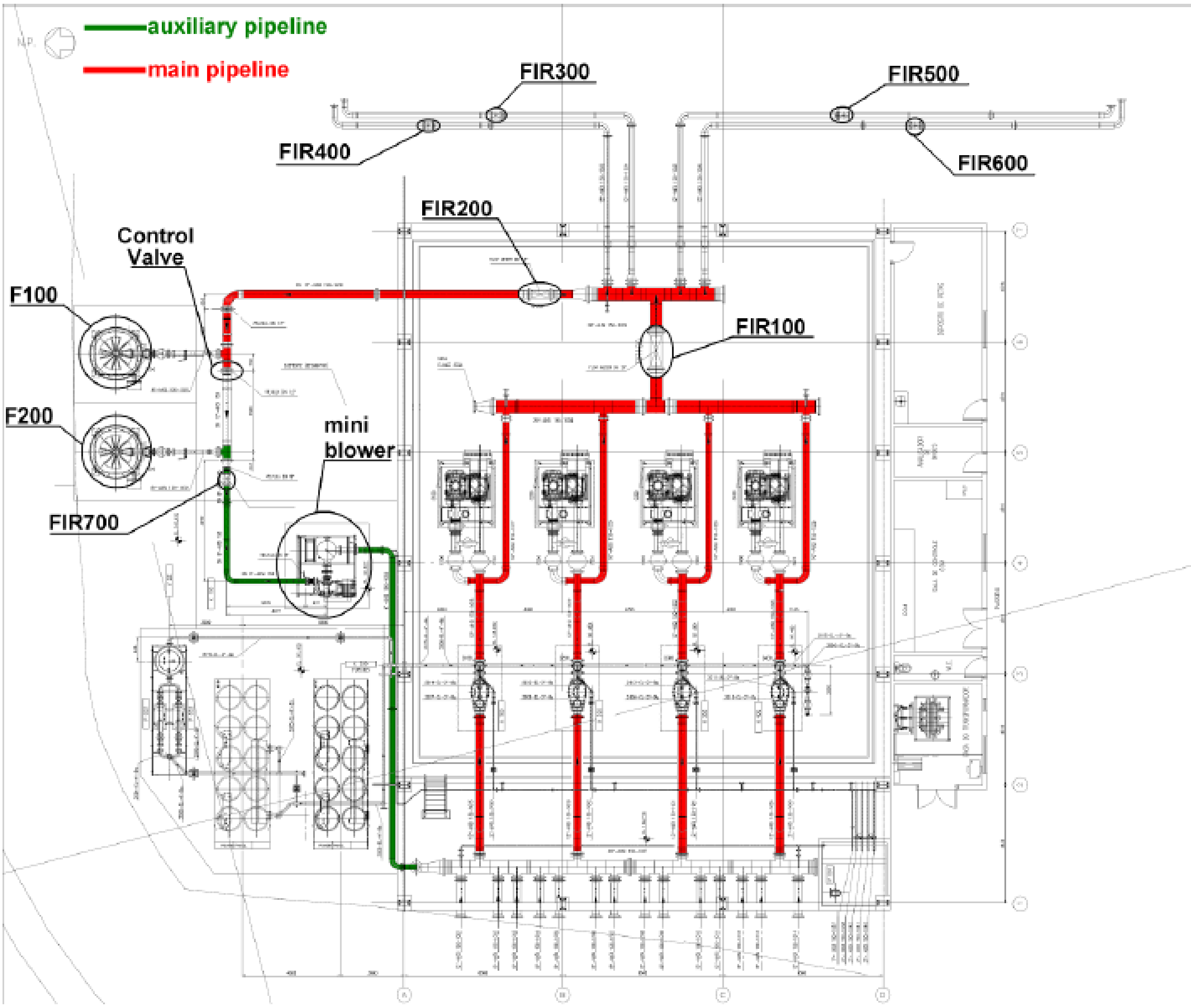


**Figure 8** – Lay-out of the degassing plant.

Procedures described below are also to be taken into account while performing monitoring activities related to the proposed project activity.

*a) Data transmission, processing and storage*

The variables described in item B.7.1 will be automatically registered in a supervisory computer system. Since all the registered data in the Supervisory System's hard disk is subjected to sabotage and technical failure, Biogás has developed the following actions to protect the monitoring system:

- The PLC is not connected to the Internet, thus the risk of virus is minimized;
- Only authorized persons have access to the data base of the system;
- Antivirus programs are installed at the system;
- Data backup:
  - A weekly CD backup of the Supervisory System's hard disk;
  - A weekly backup of the Supervisory System's hard disk is made by the server of Biogás;

- Biogás Operational Environment Unit downloads regularly the primary data for the elaboration of the monitoring report.

All monitored data and required for verification and issuance be kept and archived electronically for two years after the end of the crediting period or the last issuance of CERs, whichever occurs later.

*b) Responsibilities*

From the point of view of the plant operation, positions and roles for this CDM project activity are well defined. Duties, personnel replacement in the case of non-availability of the supervisor of monitoring and/or the electrical supervisor and hiring requirements for job positions are determined in documented procedures presented in the functional organogram ad responsibility matrix.

*c) Quality Assurance & Quality control*

Biogás counts with the internal procedure PO-005 which objective is to specify the monitoring procedures made inside the Degassing Station, as gas flows, temperature, pressure, electricity generation and methane concentration.

As presented above all parameters monitored inside the Degassing Station has the same reading / transmitting / registration routine and all routines have one person responsible: the plant supervisor.

Every week, the plant supervisor downloads all data registered from the PLC and makes a complete check to identify unconformities, such as unread registrations or troubles with the PLC (this unconformities happens mainly due to electricity black-outs). All unconformities raised are promptly compared with operational events, registered by the operators in the Operation Diary. The event is informed to the Production Manager of Biogás, which is responsible for taking the necessary actions to avoid it to happen again.

In order to avoid data loss, the operators are oriented to register all gas flow data manually in proper sheets every 3 hours, which are verified by the production manager weekly for legibility. Manual records are transferred to an Excel sheet. Additionally, the operators are oriented to perform a “Print-Screen” of the PLC Controlling System Panel every hour. The picture printed presents all monitoring parameters and is saved in the computer’s hard disk.

Other procedures developed at BLFGE are:

**PO-001:** Procedure about re-starting the plant after an electricity breakdown

**PO-002:** Calibration of methane analyser

**PO-003:** Calibration of valve (flare)

**PO-004:** Service orders and maintenance

**PO-005:** Procedure of monitoring parameters (including calibration plan)

**PO-006:** Procedure about internal monitoring of Bandeirantes

**PO-007:** Procedure about workers control

**PO-008:** Procedure for the elaboration of the monthly operational report

**PO-009:** Procedure in emergency situations

**PO-010:** Procedure for data back-up of the supervisory system

**PO-011:** Procedure for manual data collection

**PO-012:** Instruction for Refuelling the Diesel Device

**PO-013:** Identification of legal and other requirements

**PO-014:** Administrative Procedure

*d) Training*

All training was supplied to operators and technical assistants before the project's implementation. Before performing its activities, every new operator has performed a training consisting of the following:

- How to operate and start the plant;
- Reading instruments and recording of reports;
- Verification and calibration of gas analyser;
- Maintenance of equipment.
- Data Protection Measures.

## SECTION D. Data and parameters

### D.1. Data and parameters fixed ex ante

| Data/Parameter | $GWP_{CH4}$ |
|---|---|
| Unit | $tCO_2e/tCH_4$ |
| Description | Global Warming Potential value for methane |
| Source of data | IPCC |
| Value(s) applied | 21 |
| Choice of data or measurement methods and procedures | GWP applicable for the first commitment period of the Kyoto Protocol. |
| Purpose of data/parameter | Calculation of baseline and project emissions. |
| Additional comments | The GWP was applied to emission reductions achieved during the first commitment period of the Kyoto Protocol, i.e. up to December 31$^{th}$, 2012. |

| Data/Parameter | $GWP_{CH4}$ |
|---|---|
| Unit | $tCO_2e/tCH_4$ |
| Description | Global Warming Potential value for methane |
| Source of data | IPCC |
| Value(s) applied | 25 |
| Choice of data or measurement methods and procedures | GWP applicable for the second commitment period of the Kyoto Protocol. |
| Purpose of data/parameter | Calculation of baseline and project emissions |
| Additional comments | The GWP was applied to emission reductions achieved during the second commitment period of the Kyoto Protocol, i.e. January 1$^{st}$, 2013 onwards. |

| Data/Parameter | $D_{CH4}$ |
|---|---|
| Unit | $tCH_4/m^3CH_4$ |
| Description | Methane Density |
| Source of data | ACM0001 (version 11) |
| Value(s) applied | 0.0007168 |
| Choice of data or measurement methods and procedures | At standard temperature and pressure (0 degree Celsius and 1,013 bar). |
| Purpose of data/parameter | Calculation of baseline emissions |
| Additional comments | - |

| Data/Parameter | AF |
|---|---|
| Unit | % |
| Description | Adjustment Factor |
| Source of data | Registered PDD |
| Value(s) applied | 20 |

| | |
|---|---|
| Choice of data or measurement methods and procedures | AF applied in the first crediting period was considered for a conservative approach. |
| Purpose of data/parameter | Calculation of baseline emissions |
| Additional comments | - |

| **Data/Parameter** | **Regulatory requirements relating to landfill gas project** |
|---|---|
| Unit | % |
| Description | Regulatory requirements relating to landfill gas projects |
| Source of data | Publicly available information of regulatory requirements of the Host Country related to landfill gas. In Brazil, there are neither regulatory requirements nor legal obligations to destroy the LFG. |
| Value(s) applied | There are neither regulatory requirements nor legal obligations to destroy the LFG. |
| Choice of data or measurement methods and procedures | Official source of data |
| Purpose of data/parameter | Calculation of baseline emissions |
| Additional comments | The information though recorded annually, is used for changes to the adjustment factor (AF) or directly $MD_{reg,y}$ at renewal of the credit period – variable updated at renewal of each credit period. |

## D.2. Data and parameters monitored

<table>
<tr><td>Data/Parameter</td><td>$LFG_{Total,y}$</td></tr>
<tr><td>Unit</td><td>Nm³</td></tr>
<tr><td>Description</td><td>Total amount of landfill gas captured in normal cubic meters at standard temperature and pressure</td></tr>
<tr><td>Measured/calculated/ default</td><td>Measured</td></tr>
<tr><td>Source of data</td><td>PLC data records</td></tr>
<tr><td>Value(s) of monitored parameter</td><td>
<table>
<tr><th>Period</th><th>FIR100 (Nm³)</th><th>FIR700 (Nm³)</th></tr>
<tr><td>From 01/09/2012</td><td>11,159,205</td><td>6,468</td></tr>
<tr><td>2013</td><td>31,473,727</td><td>0</td></tr>
<tr><td>2014</td><td>18,374,358</td><td>4,005,455</td></tr>
<tr><td>2015</td><td>15,158,389</td><td>8,587,430</td></tr>
<tr><td>2016</td><td>19,273,530</td><td>323,795</td></tr>
<tr><td>Up to 22/12/2017</td><td>22,366,699</td><td>175,101</td></tr>
</table>
</td></tr>
<tr><td>Monitoring equipment</td><td>
<table>
<tr><th>Equipment</th><th>TAG</th><th>Manufacturer</th><th>Model</th><th>Serial Nr.</th><th>Accuracy according to test results (%)</th></tr>
<tr><td>1) Flow meter</td><td>FIR100</td><td>Endress + Hauser</td><td>t-mass 65 I DN175 / 7" (177.75 mm)</td><td>9407D902000</td><td>0.7020</td></tr>
<tr><td>2) Flow meter</td><td>FIR100</td><td>FCI</td><td>ST51-1F33FM 00</td><td>341992</td><td>0.2725</td></tr>
<tr><td>3) Flow meter</td><td>FIR700</td><td>FCI</td><td>ST51</td><td>328849</td><td>0.2099</td></tr>
</table>
</td></tr>
<tr><td>Measuring/reading/recording frequency</td><td>Continuous readings from the flow-meters FIR100 and FIR700 installed. Equipment is connected to a supervisory computer system, which registers continuously the LFG measured. The supervisory system makes records of instant gas-flow every 5 minutes and the accumulated gas-flow every hour. Data aggregated daily, monthly and yearly. The counter is reseted at 00:00.</td></tr>
<tr><td>Calculation method (if applicable)</td><td>N/A</td></tr>
</table>

<table>
<tr><td>QA/QC procedures</td><td>Flow meters are subjected to a regular maintenance and testing regime to ensure accuracy. Regular maintenance is made following general guidelines from the manufacturer.<br><br>Regarding the calibration of the instrument, the PPs decided to conservatively adopt a 5-years frequency because:<br>- in compliance with national laws (example in Germany the Netherlands, for turbine meters of this size of FIR100 and FIR700, calibration is never required;<br>- in Brazil there are no requirements on how often flow-meters must be calibrated;<br>- in Germany, a calibration every 10-years is enforce by law;<br>- the manufacturer states that it's up to the clients to determine the calibration frequency.<br><br>The procedure SGA IT 4.4.6-29 explains that the operator must check operational conditions for this kind of instrument, at least once a day. In the flow meters case, if the operator identifies some problem, instrument must be replaced or calibrated.</td></tr>
<tr><td>Purpose of data/parameter</td><td>The data flow generated from FIR100 is actually used on purpose to realize the cross checking of flow from the other flow meters (FIR200, FIR300, FIR400, FIR500 and FIR600). Values of the total gas flow are not used to calculate the amount of CERs.</td></tr>
<tr><td>Additional comments</td><td>-</td></tr>
</table>

<table>
<tr><td>Data/Parameter</td><td>$LFG_{Flare,y}$</td></tr>
<tr><td>Unit</td><td>$Nm^3$</td></tr>
<tr><td>Description</td><td>Amount of landfill gas to flares from the landfill site in normal cubic meters at standard temperature and pressure</td></tr>
<tr><td>Measured/calculated/<br>default</td><td>Measured</td></tr>
<tr><td>Source of data</td><td>PLC data records</td></tr>
<tr><td>Value(s) of monitored parameter</td><td>
<table>
<tr><th>Period</th><th>FIR200 ($Nm^3$)</th><th>FIR700 ($Nm^3$)</th></tr>
<tr><td>From 01/09/2012</td><td>244,917</td><td>6,468</td></tr>
<tr><td>2013</td><td>864,932</td><td>0</td></tr>
<tr><td>2014</td><td>15,906,438</td><td>4,005,455</td></tr>
<tr><td>2015</td><td>9,919,938</td><td>8,587,430</td></tr>
<tr><td>2016</td><td>673,439</td><td>323,795</td></tr>
<tr><td>Up to 22/12/2017</td><td>0</td><td>175,101</td></tr>
</table>
</td></tr>
<tr><td>Monitoring equipment</td><td>
<table>
<tr><th>Equipment</th><th>TAG</th><th>Manufacturer</th><th>Model</th><th>Serial Nr.</th><th>Accuracy according to test results (%)</th></tr>
<tr><td rowspan="2">Flow meter</td><td>FIR200</td><td>Incontrol</td><td>VTGE X-200</td><td>VG15239</td><td>0.2620</td></tr>
<tr><td>FIR700</td><td>FCI</td><td>ST51</td><td>328849</td><td>0.2099</td></tr>
<tr><td rowspan="2">Pressure transmitter</td><td>FIR200</td><td>SMAR</td><td>LD291</td><td>L454793</td><td>0.0382</td></tr>
<tr><td>FIR700</td><td>N/A</td><td>N/A</td><td>N/A</td><td>N/A</td></tr>
<tr><td rowspan="2">Temperature transmitter</td><td>FIR200</td><td>ASTA</td><td>PT-100</td><td>S377815</td><td>0.3099</td></tr>
<tr><td>FIR700</td><td>N/A</td><td>N/A</td><td>N/A</td><td>N/A</td></tr>
</table>
</td></tr>
<tr><td>Measuring/reading/recording frequency</td><td>Continuous readings from the flow-meters FIR200 and FIR700 installed. Equipment is connected to a supervisory computer system, which registers continuously the LFG measured. The supervisory system makes records of instant gas-flow every 5 minutes and the accumulated gas-flow every hour. Data aggregated daily, monthly and yearly. The counter is reseted at 00:00.</td></tr>
<tr><td>Calculation method<br>(if applicable)</td><td>N/A</td></tr>
</table>

| | |
|---|---|
| QA/QC procedures | Flow meters are subjected to a regular maintenance and testing regime to ensure accuracy in compliance with national laws. Regular maintenance is made following general guidelines from the manufacturer.<br><br>Regarding the calibration of the instrument, the PPs decided to conservatively adopt a 5-years frequency because:<br>- in the Netherlands, for turbine meters of this size of FIR200 and FIR700, calibration is never required;<br>- in Brazil there are no requirements on how often flow-meters must be calibrated;<br>- in Germany, a calibration every 10-years is enforce by law; - the manufacturer states that it's up to the clients to determine the calibration frequency.<br><br>The procedure SGA IT 4.4.6-29 explains that the operator must check operational conditions for this kind of instrument, at least once a day. In the flow meters case, if the operator identifies some problem, instrument must be replaced or calibrated. |
| Purpose of data/parameter | Calculation of baseline emissions |
| Additional comments | - |

| **Data/Parameter** | **$LFG_{Electricity, y}$** |
|---|---|
| Unit | $Nm^3$ |
| Description | Amount of landfill gas to powerhouse from the landfill site in normal cubic meters at standard temperature and pressure |
| Measured/calculated/ default | Measured by four flow meters (FIR300, FIR400, FIR500 and FIR600) |
| Source of data | PLC data records |
| Value(s) of monitored parameter | (see table below) |

| **Period** | **FIR300 ($Nm^3$)** | **FIR400 ($Nm^3$)** | **FIR500 ($Nm^3$)** | **FIR600 ($Nm^3$)** |
|---|---|---|---|---|
| From 01/09/2012 | 48,176 | 2,685,887 | 2,979,668 | 4,591,171 |
| 2013 | 3,446,382 | 4,976,184 | 12,900,404 | 7,588,926 |
| 2014 | 233,251 | 229,692 | 699,877 | 293,901 |
| 2015 | 2 | 2 | 2,643,105 | 1,544,345 |
| 2016 | 2 | 2 | 13,206,774 | 6,367,714 |
| Up to 22/12/2017 | 0 | 0 | 16,569,829 | 6,329,614 |

<table>
<tr><td>Monitoring equipment</td><td>
<table>
<tr><th>TAG</th><th>Equipment</th><th>Manufacturer</th><th>Model</th><th>Serial Nr.</th><th>Accuracy according to test results (%)</th></tr>
<tr><td rowspan="3">FIR300</td><td>Flow meter</td><td>Incontrol</td><td>VTGEX200</td><td>VG083B6</td><td rowspan="3">3.973</td></tr>
<tr><td>Pressure transmitter</td><td>SMAR</td><td>LD291</td><td>33007-06</td></tr>
<tr><td>Temperature transmitter</td><td>ASTA</td><td>PT- 100</td><td>S502986</td></tr>
<tr><td rowspan="3">FIR400</td><td>Flow meter</td><td>Incontrol</td><td>VTGEX200</td><td>VG084B6</td><td rowspan="3">5.597</td></tr>
<tr><td>Pressure transmitter</td><td>SMAR</td><td>LD291</td><td>L454794</td></tr>
<tr><td>Temperature transmitter</td><td>ASTA</td><td>PT- 100</td><td>S502987</td></tr>
<tr><td rowspan="3">FIR500</td><td>Flow meter</td><td>Incontrol</td><td>VTGEX200</td><td>VG086B6</td><td rowspan="3">5.876</td></tr>
<tr><td>Pressure transmitter</td><td>SMAR</td><td>LD291</td><td>33006-06</td></tr>
<tr><td>Temperature transmitter</td><td>ASTA</td><td>PT- 100</td><td>S502988</td></tr>
<tr><td rowspan="3">FIR600</td><td>Flow meter</td><td>Incontrol</td><td>VTGEX200</td><td>VG085B6</td><td rowspan="3">4.788</td></tr>
<tr><td>Pressure transmitter</td><td>SMAR</td><td>LD291</td><td>33005-06</td></tr>
<tr><td>Temperature transmitter</td><td>ASTA</td><td>PT- 100</td><td>S502989</td></tr>
</table>
</td></tr>
<tr><td>Measuring/reading/recording frequency</td><td>Continuous readings from the 4 flow-meters installed (tags FIR300, FIR400, FIR500 and FIR600). Equipments are connected to a supervisory computer system, which registers continuously the LFG measured. Data aggregated daily, monthly and yearly. For each flow-meter, the supervisory system makes records of instant gas-flow every 5 minutes and the accumulated gas-flow every hour. The counter is reseted at 00:00hs.</td></tr>
<tr><td>Calculation method<br>(if applicable)</td><td>N/A</td></tr>
<tr><td>QA/QC procedures</td><td>Flow meters are subjected to a regular maintenance and testing regime to ensure accuracy, in compliance with national laws. Regular maintenance is made following general guidelines from the manufacturer.<br><br>Regarding the calibration of the instrument, the PPs decided to conservatively adopt a 5-years frequency because:<br>- in the Netherlands, for turbine meters of this size of FIR300, FIR400, FIR500 and FIR600, calibration is never required;<br>- in Brazil there are no requirements on how often flow-meters must be calibrated;<br>- in Germany, a calibration every 10-years is enforce by law; - the manufacturer states that it’s up to the clients to determine the calibration frequency.<br><br>The procedure SGA IT 4.4.6-29 explains that the operator must check operational conditions for this kind of instrument, at least once a day. In the flow meters case, if the operator identifies some problem, instrument must be replaced or calibrated.</td></tr>
<tr><td>Purpose of data/parameter</td><td>Calculation of baseline emissions</td></tr>
<tr><td>Additional comments</td><td>Since Biogas has four lines that send gas to engines, one per meter (FIR300, FIR 400, FIR 500 and FIR 600), during the period of re-calibration of each meter, the respective line of the meter in calibration was closed until its return.</td></tr>
</table>

| **Data/Parameter** | **$PE_{Flares,y}$** |
|---|---|
| Unit | $tCO_2e$ |
| Description | Project emissions from flaring of the residual gas stream in year y |
| Measured/calculated/<br>default | Calculated |

<table>
<tr><td>Source of data</td><td>Calculated as per the “Tool to determine project emissions from flaring gases containing methane”.</td></tr>
<tr><td>Value(s) of monitored parameter</td><td>
<table>
<tr><th>Period</th><th>$PE_{flare\ F100,y}$ ($tCO_2e$)</th><th>$PE_{flare\ F200,y}$ ($tCO_2e$)</th></tr>
<tr><td>From 01/09/2012</td><td>157</td><td>4</td></tr>
<tr><td>2013</td><td>677</td><td>0</td></tr>
<tr><td>2014</td><td>12,325</td><td>3,009</td></tr>
<tr><td>2015</td><td>7,660</td><td>6,635</td></tr>
<tr><td>2016</td><td>547</td><td>252</td></tr>
<tr><td>Up to 22/12/2017</td><td>0</td><td>134</td></tr>
</table>
</td></tr>
<tr><td>Monitoring equipment</td><td>N/A</td></tr>
<tr><td>Measuring/reading/recording frequency</td><td>Calculated as per the “Tool to determine project emissions from flaring gases containing methane”.</td></tr>
<tr><td>Calculation method<br>(if applicable)</td><td>Calculated as per the “Tool to determine project emissions from flaring gases containing methane”.</td></tr>
<tr><td>QA/QC procedures</td><td>Calculated as per the “Tool to determine project emissions from flaring gases containing methane”.</td></tr>
<tr><td>Purpose of data/parameter</td><td>Calculation of project emissions</td></tr>
<tr><td>Additional comments</td><td>-</td></tr>
</table>

<table>
<tr><td>Data/Parameter</td><td>$w_{CH4,y}$</td></tr>
<tr><td>Unit</td><td>$m^3CH_4/m^3LFG$</td></tr>
<tr><td>Description</td><td>Methane fraction in the landfill gas</td></tr>
<tr><td>Measured/calculated/<br>default</td><td>Measured</td></tr>
<tr><td>Source of data</td><td>PLC data records.</td></tr>
<tr><td>Value(s) of monitored parameter</td><td>Daily average for the monitoring period
<table>
<tr><th>Period</th><th>$m^3CH_4/m^3LFG$</th></tr>
<tr><td>From 01/09/2012</td><td>47.12</td></tr>
<tr><td>2013</td><td>48.14</td></tr>
<tr><td>2014</td><td>47.94</td></tr>
<tr><td>2015</td><td>48.13</td></tr>
<tr><td>2016</td><td>48.19</td></tr>
<tr><td>Up to 22/12/2017</td><td>45.14</td></tr>
</table>
</td></tr>
<tr><td>Monitoring equipment</td><td>Manufacturer: Rosemount - NUK<br>Type: Binos 100M<br>TAG: A100<br>Error based on test results: 0.01%<br>Serial number: 99965398<br>Calibration frequency: weekly, with a standard certified gas cylinder</td></tr>
<tr><td>Measuring/reading/recording frequency</td><td>The data is continuously measured by the gas analyser and recorded electronically by PLC at least each five minutes and once per hour, instantaneously. The reading frequency is continuously and recorded by the PLC.</td></tr>
<tr><td>Calculation method<br>(if applicable)</td><td>N/A</td></tr>
<tr><td>QA/QC procedures</td><td>- The gas analyser is subjected to a regular maintenance and testing regime to ensure accuracy;<br>- The operation team is responsible for the testing/maintenance according to procedure SGA IT 4.4.6-10;<br>- The operation team performs a daily check list of the instrument to detect leaks and other defects;<br>- The filter replacement is performed when the team deems necessary;<br>- The calibration is also performed weekly using a standard certified gas.</td></tr>
<tr><td>Purpose of data/parameter</td><td>Calculation of baseline emissions</td></tr>
<tr><td>Additional comments</td><td>-</td></tr>
</table>

| **Data/Parameter** | $EL_{LFG,y}$ |
|---|---|
| Unit | MWh |
| Description | Net amount of electricity generated using LFG. |

| | |
|---|---|
| Measured/calculated/ default | Measured |
| Source of data | PLC data records |
| Value(s) of monitored parameter | <table><tr><th>Period</th><th>MWh</th></tr><tr><td>From 01/09/2012</td><td>12,831</td></tr><tr><td>2013</td><td>35,959</td></tr><tr><td>2014</td><td>1,576</td></tr><tr><td>2015</td><td>5,302</td></tr><tr><td>2016</td><td>25,576</td></tr><tr><td>Up to 22/12/2017</td><td>25,607</td></tr></table> |
| Monitoring equipment | Landfill:<br>Manufacturer: Schneider Eletronic<br>Type: Power Logic – CM4000<br>Error based on test results: 0.1804%<br>Serial number: 0011001414 / 0011001426<br>Calibration frequency: 2-5 years<br><br>AES Eletropaulo substation:<br>Manufacturer: Landis gyr<br>Type: Saga 1000<br>Error based on test results: 0.1778%<br>Serial number: 1168593/1168594<br>Calibration frequency: 2-5 years |
| Measuring/reading/recording frequency | Continuous readings from the electricity-meters located in the substation connected to the SIN. The substation has 2 measurement points: one belongs to Biogeração (manager of the power plant) and the other belongs to Eletropaulo (Electric Utility). Each set of meter has 2 meters installed and both of them are connected to the responsible supervisory system, which registers continuously the electricity exported. For conservativeness reasons, both records can be compared in a monthly basis and the lowest one will be applied to calculate ERs. |
| Calculation method (if applicable) | N/A |
| QA/QC procedures | Electricity meters are subject to regular maintenance following the ONS procedures. The meter´s supplier (Merlin Gerin) manual mentions that regular maintenance for the Power Logic CM4000 electricity meters is not necessary. |
| Purpose of data/parameter | Calculation of baseline emissions |
| Additional comments | - |

| **Data/Parameter** | **$EF_{OM,grid,y}$** |
|---|---|
| Unit | $tCO_2e/MWh$ |
| Description | $CO_2$ emission factor of the operating margin |
| Measured/calculated/ default | Calculated |
| Source of data | The Brazilian DNA |
| Value(s) of monitored parameter | <table><tr><th>Period</th><th>CO<sub>2</sub> OM EF</th></tr><tr><td>From 01/09/2012</td><td>0.6561</td></tr><tr><td>2013</td><td>0.5932</td></tr><tr><td>2014</td><td>0.5837</td></tr><tr><td>2015</td><td>0.5597</td></tr><tr><td>2016</td><td>0.6228</td></tr><tr><td>Up to 22/12/2017</td><td>0.5911</td></tr></table> |
| Monitoring equipment | N/A |
| Measuring/reading/recording frequency | Data available by the Brazilian DNA in hourly, monthly and yearly basis |
| Calculation method (if applicable) | Following the “Tool to calculate the emission factor for an electricity system” |
| QA/QC procedures | Official source of data |
| Purpose of data/parameter | Calculation of baseline emissions |

| | |
|---|---|
| Additional comments | The project applies the *ex-post* data vintage |

| **Data/Parameter** | **$EF_{BM,grid,y}$** |
|---|---|
| Unit | $tCO_2e$/MWh |
| Description | $CO_2$ emission factor of the build margin |
| Measured/calculated/ default | Calculated |
| Source of data | The Brazilian DNA |
| Value(s) of monitored parameter | <table><tr><th>Period</th><th>$CO_2$ BM EF</th></tr><tr><td>From 01/09/2012</td><td>0.2010</td></tr><tr><td>2013</td><td>0.2713</td></tr><tr><td>2014</td><td>0.2963</td></tr><tr><td>2015</td><td>0.2553</td></tr><tr><td>2016</td><td>0.1581</td></tr><tr><td>Up to 22/12/2017</td><td>0.1581*</td></tr></table> $CO_2$ BM EF is not public available for 2017 year and, therefore, data used for this year is based on 2016 year (the latest data available). |
| Monitoring equipment | N/A |
| Measuring/reading/recording frequency | Data available by the Brazilian DNA in yearly basis |
| Calculation method (if applicable) | Following the “Tool to calculate the emission factor for an electricity system” |
| QA/QC procedures | Official source of data |
| Purpose of data/parameter | Calculation of baseline emissions |
| Additional comments | The project applies the *ex-post* data vintage |

| **Data/Parameter** | **$CEF_{elecy,BL,y} = EF_{CM,grid,y}$** |
|---|---|
| Unit | tCO2e/MWh |
| Description | Carbon emission factor of electricity |
| Measured/calculated/ default | Calculated |
| Source of data | The Brazilian DNA |
| Value(s) of monitored parameter | <table><tr><th>Period</th><th>$CO_2$ CM EF</th></tr><tr><td>From 01/09/2012</td><td>0.3148</td></tr><tr><td>2013</td><td>0.3518</td></tr><tr><td>2014</td><td>0.3681</td></tr><tr><td>2015</td><td>0.3314</td></tr><tr><td>2016</td><td>0.2743</td></tr><tr><td>Up to 22/12/2017</td><td>0.2664</td></tr></table> |
| Monitoring equipment | N/A |
| Measuring/reading/recording frequency | Data available by the Brazilian DNA in hourly, monthly and yearly basis |
| Calculation method (if applicable) | Following the “Tool to calculate the emission factor for an electricity system” |
| QA/QC procedures | Official source of data |
| Purpose of data/parameter | Calculation of baseline emissions |
| Additional comments | The project applies the *ex-post* data vintage |

| **Data/Parameter** | **$PE_{EC,y}$** |
|---|---|
| Unit | $tCO_2$/year |
| Description | Project emissions from electricity consumption by the project activity during the year y |
| Measured/calculated/ default | Calculated |
| Source of data | PLC data records and calculated according to the “Tool to calculate baseline, project and/or leakage emissions from electricity consumption” |

<table>
<tr><td>Value(s) of monitored parameter</td><td><table><tr><th>Period</th><th>PE from electricity consumption (tCO2e)</th></tr><tr><td>From 01/09/2012</td><td>1.2</td></tr><tr><td>2013</td><td>0.7</td></tr><tr><td>2014</td><td>4.5</td></tr><tr><td>2015</td><td>96.3</td></tr><tr><td>2016</td><td>150.2</td></tr><tr><td>Up to 22/12/2017</td><td>0.4</td></tr></table></td></tr>
<tr><td>Monitoring equipment</td><td>PLC system</td></tr>
<tr><td>Measuring/reading/recording frequency</td><td>Continuous measurement and daily recording</td></tr>
<tr><td>Calculation method (if applicable)</td><td>As there is no diesel volume meter, 1.3tCO2e/MWh default value is used to calculate PE emissions. Calculated as per the “Tool to calculate baseline, project and/or leakage emissions from electricity consumption”</td></tr>
<tr><td>QA/QC procedures</td><td>A conservative default value is used from the “Tool to calculate baseline, project and/or leakage emissions from electricity consumption”</td></tr>
<tr><td>Purpose of data/parameter</td><td>Calculation of project emissions</td></tr>
<tr><td>Additional comments</td><td>The project has one backup diesel generator in case of power supply interruption located at the landfill. Generator is not used for electricity generation to the grid.</td></tr>
</table>

| **Data/Parameter** | **$fv_{i,h}$** |
|---|---|
| Unit | - |
| Description | Volumetric fraction of component i in the residual gas in the hour h where i= $CH_4$ |
| Measured/calculated/ default | Measured |
| Source of data | Continuous measurement using a certified gas analyser. |
| Value(s) of monitored parameter | Large amount of data. Please, refer to ER spreadsheet |
| Monitoring equipment | Please refer to parameter $w_{CH4,y}$ |
| Measuring/reading/recording frequency | As the residual gas temperature does not exceed 60°C, the requirement that flow rate and methane content measurements have to be carried out with the same basis (dry or wet) is not applicable. |
| Calculation method (if applicable) | N/A |
| QA/QC procedures | The gas analyser is recalibrated every week against a standard certified gas cylinder, according with an internal procedure. |
| Purpose of data/parameter | Calculation of baseline emissions |
| Additional comments | As a simplified approach, only the methane content of the residual gas is measured and the remaining part is considered as $N_2$. |

| **Data/Parameter** | **$FV_{RG,h}$** |
|---|---|
| Unit | $m^3/h$ |
| Description | Volumetric flow rate of the residual gas in dry basis at normal conditions in the hour h |
| Measured/calculated/ default | Measured |
| Source of data | Continuous measurements from the flow-meters FIR200 and FIR700. |
| Value(s) of monitored parameter | Large amount of data. Please, refer to ER spreadsheet |
| Monitoring equipment | FIR200 and FIR700. Please refer to $LFG_{flare,y}$ |
| Measuring/reading/recording frequency | As the residual gas temperature does not exceed 60°C, the requirement that flow rate and methane content measurements have to be carried out with the same basis (dry or wet) is not applicable. |
| Calculation method (if applicable) | N/A |
| QA/QC procedures | Flow meters are periodically calibrated (5-years frequency). Please refer to $LFG_{flare,y}$. |
| Purpose of data/parameter | Calculation of baseline emissions |
| Additional comments | - |

| Data/Parameter | Other flare operation parameters |
| --- | --- |
| Unit | - |
| Description | Data and parameters that are required to monitor whether the flare operates within the range of operating conditions according to the manufacturer's specifications |
| Measured/calculated/ default | Measured |
| Source of data | PLC data records |
| Value(s) of monitored parameter | - |
| Monitoring equipment | Please refer to $T_{flare}$ |
| Measuring/reading/recording frequency | Continuous readings from the thermocouples installed in each flare. Instruments are connected to a supervisory computer system, which registers continuously the combustion temperature measured. For each flare, the supervisory system makes records of instant temperature every 5 minutes and every hour. |
| Calculation method (if applicable) | N/A |
| QA/QC procedures | Thermocouples are replaced or calibrated every year. |
| Purpose of data/parameter | Baseline |
| Additional comments | Temperatures below 1,000° and above 1,200° indicate that the flare is out of the specified conditions. According to the manufacturer, if the temperature of the flare is higher than 1,350°C, the flare will stop automatically and an alarm is activated if the temperature is below 900°C. |

| Data/Parameter | $NCV_{D,t}$ |
| --- | --- |
| Unit | GJ/ (L) |
| Description | Average net calorific value of the diesel oil used in the period t |
| Measured/calculated/ default | Default |
| Source of data | 2017 Brazilian Energy Balance ("BEN 2017" from the Portuguese Balanço Energético Nacional). |
| Value(s) of monitored parameter | 0.0355 |
| Monitoring equipment | N/A |
| Measuring/reading/recording frequency | Yearly |
| Calculation method (if applicable) | N/A |
| QA/QC procedures | Official source of data |
| Purpose of data/parameter | Calculation of project emissions from diesel oil use |
| Additional comments | - |

| Data/Parameter | $EF_{CO2,i,t}$ |
| --- | --- |
| Unit | $tCO_2/GJ$ |
| Description | $CO_2$ emission factor of the diesel used in the period t |
| Measured/calculated/ default | Default |
| Source of data | 2006 IPCC Guidelines for National Greenhouse Gas Inventories, volume 2, chapter 1, table 1.4 |
| Value(s) of monitored parameter | 0.0748 |
| Monitoring equipment | N/A |
| Measuring/reading/recording frequency | At every IPCC revision |
| Calculation method (if applicable) | N/A |
| QA/QC procedures | Upper limit at 95% confidence interval |
| Purpose of data/parameter | Calculation of project emissions from diesel oil use |
| Additional comments | - |

### D.3. Implementation of sampling plan

Not applicable.

## SECTION E. Calculation of emission reductions or net anthropogenic removals

### E.1. Calculation of baseline emissions or baseline net removals

According to ACM0001 (version 11.0), baseline emissions are calculated as follows:

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

Where,

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

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

$MD_{BL,y} = MD_{project,y} \times AF$ **Equation 2**

Regarding the $GWP_{CH4}$, the CDM Project Standard for Project Activities establishes that:

> *"The project participants shall use the global warming potentials (GWPs) adopted by the CMP at its seventh session, in accordance with decision 4/CMP.7, to calculate the GHG emission reductions or net anthropogenic GHG removals achieved by the CDM project activity in the second commitment period of the Kyoto Protocol. This requirement shall apply from 1 January 2013, notwithstanding any GWPs stated to be applicable in the relevant procedures, standards, guidelines, methodologies, methodological tools and other rules being used in relation to that project activity".*

Therefore, the GWP applied up to 31/12/2012 is 21$tCO_2/tCH_4$ and 25$tCO_2/tCH_4$ was applied from 01/01/2013 onwards.

Calculation of baseline emissions is presented in the table below while applying equation 1. Since thermal energy is not produced in the project activity (but electricity only), $ET_{LFG,y}$ *and* $CEF_{ther,BL,y}$ *are zero.*

**Table 2** – Calculation of baseline emissions

| ***Year*** | ***$MD_{project,y}$ ($tCH_4$)*** | ***$MD_{BL,y}$ ($tCH_4$)*** | ***$EL_{LFG,y}$ (MWh)*** | ***$CEF_{elec,BL,y}$ ($tCO_2$/MWh)*** | ***$BE_y$ ($tCO_2$)*** |
|---|---|---|---|---|---|
| From 01/09/2012 | 3,547 | 709 | 12,831 | 0.3148 | 63,636 |
| 2013 | 10,211 | 2,042 | 35,959 | 0.3518 | 216,863 |
| 2014 | 6,137 | 1,227 | 1,576 | 0.3681 | 123,318 |
| 2015 | 6,888 | 1,378 | 5,302 | 0.3314 | 139,515 |
| 2016 | 6,883 | 1,377 | 25,576 | 0.2743 | 144,668 |
| Up to 22/12/2017 | 7,372 | 1,474 | 25,607 | 0.2664 | 154,253 |
| ***TOTAL*** | ***41,037*** | ***8,207*** | ***106,851*** | ***0.3178*** | ***842,254*** |

Detailed description of the calculation of baseline emissions are presented in the ER spreadsheet attached to this Monitoring Report.

***a) Methane that would have been destroyed/combusted ($MD_{project,y}$)***

In order to be conservative, the 20% AF considered in the 1st crediting period[1] was applied in this verification.

$MD_{project,y} = MD_{flared,y} + MD_{electricity,y} + MD_{thermal,y} + MD_{PL,y}$ **Equation 3**

Where,

$MD_{flared,y}$ = Quantity of methane destroyed by flaring ($tCH_4$);

$MD_{electricity,y}$ = Quantity of methane destroyed by generation of electricity ($tCH_4$);

$MD_{thermal,y}$ = Quantity of methane destroyed for the generation of thermal energy ($tCH_4$);

$MD_{PL,y}$ = Quantity of methane sent to the pipeline for feeding to the natural gas distribution network ($tCH_4$).

$MD_{thermal,y}$ and $MD_{PL,y}$ are not applied to the project activity and, therefore, their sum is zero. In the case of the project, $MD_{project,y}$ can be calculated as follows:

$MD_{project,y} = MD_{main\ line,y} + MD_{secondary\ line,y}$ **Equation 4**

$MD_{main\ line,y}$ is the sum of the amount of LFG destroyed in the flare F100 (measured by the flow-meter FIR200) and the sum of the amount of LFG destroyed in the power plant (measured by the flow-meters FIR300, FIR400, FIR500 and FIR600). $MD_{secondary\ line,y}$ is the amount of LFG destroyed in the flare F200 (measured by the flow-meter FIR700). Therefore:

– **Main line:**

$MD_{main\ line,y} = MD_{flareF100,y} + MD_{electricity,y}$ **Equation 5**

$MD_{flare\ F100,y} = (LFG_{FIR200,y} \times w_{CH4} \times D_{CH4}) - (PE_{flare\ F100,y} / GWP_{CH4})$ **Equation 6**

$MD_{electricity,y} = LFG_{electricity,y} \times w_{CH4} \times D_{CH4}$ **Equation 7**

[1] The value calculated to the Adjustment Factor for the 2nd crediting period is equal to 19.11%. In order to be conservative, the 20% AF value was applied during the 1st crediting period.

— **Secondary line:**

$MD_{secondary\ line,y} = MD_{flareF200,y}$ **Equation 8**

$MD_{flare\ F200,y} = (LFG_{FIR700,y} \times w_{CH4} \times D_{CH4}) - (PE_{flare\ F200,y} / GWP_{CH4})$ **Equation 9**

Where,

$w_{CH4}$ = Average methane fraction of the landfill gas as measured during the year and expressed as a fraction (in m³ $CH_4$/m³ LFG);

$D_{CH4}$ = Methane density expressed in tonnes of methane per cubic meter of methane ($tCH_4/m^3\ CH_4$);

$PE_{flare,y}$ = Project emissions from flaring of the residual gas stream in year y ($tCO_2e$).

Project emissions from flaring are calculated as established in the registered PDD and according to the "Tool to determine project emissions from flaring gases containing methane".

The amount of methane flared and used to generate electricity is presented in the table below following equations 3 to 9.

**Table 3** – Calculation of methane flared and used to generate electricity

| Year | $MD_{main\ line,y}$ | | $MD_{secondary\ line,\ y}$ | $MD_{project,y}$ ($tCH_4$) |
|---|---|---|---|---|
| | $MD_{FLARE\ F100,y}$ ($tCH_4$) | $MD_{electricity,y}$ ($tCH_4$) | $MD_{FLARE\ 200,y}$ ($tCH_4$) | |
| From 01/09/2012 | 67 | 3,478 | 2 | 3,547 |
| 2013 | 244 | 9,967 | 0 | 10,211 |
| 2014 | 4,423 | 510 | 1,203 | 6,137 |
| 2015 | 2,758 | 1,478 | 2,653 | 6,888 |
| 2016 | 197 | 6,585 | 101 | 6,883 |
| Up to 22/12/2017 | 0 | 7,318 | 54 | 7,372 |
| ***TOTAL*** | ***7,689*** | ***29,336*** | ***4,012*** | ***41,037*** |

Detailed description of the calculation of methane based on fraction of methane and LFG monitored is presented in the ER spreadsheet attached to this Monitoring Report.

***b) $CO_2$ emissions intensity of the baseline source of electricity displaced ($CEF_{elec,BL,y}$)***

In case the baseline is electricity generated by plants connected to the grid, the emission factor shall be calculated according to "Tool to calculate the emission factor for an electricity system". It is calculated as the combined margin (CM), comprised by two components: (i) the built margin (BM) and (ii) the operation margin (OM). As determined in the registered PDD, the BM and OM shall be monitored during the crediting period of the project (*ex-post*) and shall be based on data published by the Brazilian DNA ("CIMGC" from the Portuguese Comissão Interministerial de Mudança Global do Clima).

Values published by the Brazilian DNA follows the "Tool to calculate the emission factor for an electricity system" and consider option c) dispatch data analysis OM of the Tool. This option does not permit the ex-ante data vintage shall be updated at every verification.

The combined margin emission factor is calculated as follows:

$$EF_{grid,CM,y} = EF_{grid,OM,y} \times w_{OM} + EF_{grid,BM,y} \times w_{BM}$$ **Equation 10**

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 (%).

According with the Tool, values adopted for $w_{OM}$ and $w_{BM}$ were equal to 0.25 and 0.75, respectively, for the 2nd crediting period.

Results of the $CO_2$ emission factor of the grid is presented in the table below based on data from the Brazilian DNA and following equation 16 above.

**Table 4** – Calculation of the $CO_2$ emission factor of the grid

| Year | $EF_{grid,OM,y}$ | $EF_{grid,BM,y}$ | $EF_{grid,CM,y}$ |
|---|---|---|---|
| 2012 | 0.6561 | 0.2010 | 0.3148 |
| 2013 | 0.5932 | 0.2713 | 0.3518 |
| 2014 | 0.5837 | 0.2963 | 0.3681 |
| 2015 | 0.5597 | 0.2553 | 0.3314 |
| 2016 | 0.6228 | 0.1581 | 0.2743 |
| 2017 | 0.5911 | 0.1581* | 0.2664 |

*The $EF_{grid,BM,y}$ parameter is calculated in the beginning of the subsequent year and, therefore, 2017 data will be available in the beginning of 2018 only. In order to calculate the $EF_{grid,CM,2017}$ , data from 2016 is used.

Data presented above is public available at the Brazilian DNA website: <http://www.mctic.gov.br/portal>.

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

Project emissions from flaring are calculated as established in the registered PDD and according to the "Tool to determine project emissions from flaring gases containing methane":

$$PE_{flare\ F200,y} = \sum_{h=1}^{8760} TM_{RG,h} \times (1 - \eta_{flare,k}) \times (\frac{GWP_{CH4}}{1000})$$ **Equation 11**

Where,

$TM_{RG,h}$ = Mass flow rate of methane in the residual gas in the hour h;

$\eta_{flare,k}$ = Flare efficiency in hour h.

As described in the registered PDD, flare efficiency considered in the project activity is 90% (default value of the tool for enclosed flares).

Project emissions from flaring are presented in the table below following equation 9. Since $TM_{RG,h}$ parameter considered in calculation is in $tCH_4$, the value is not divided by 1,000 as presented in equation 9.

**Table 5** – Calculation of project emissions from flaring

| Year | $TM_{flare\ F100,RG,y}$ ($tCH_4$) | $TM_{flare\ F200,RG,y}$ ($tCH_4$) | $PE_{flare\ F100,y}$ ($tCO_2e$) | $PE_{flare\ F200,y}$ ($tCO_2e$) | $PE_{flare,y}$ ($tCO_2e$) |
|---|---|---|---|---|---|
| From 01/09/2012 | 75 | 2 | 157 | 4 | 161 |
| 2013 | 271 | 0 | 677 | 0 | 677 |
| 2014 | 4,915 | 1,203 | 12,287 | 3,009 | 15,295 |
| 2015 | 3,064 | 2,653 | 7,660 | 6,632 | 14,291 |
| 2016 | 219 | 101 | 547 | 252 | 800 |

| | | | | | |
|---|---|---|---|---|---|
| Up to 22/12/2017 | 0 | 54 | 0 | 134 | 134 |
| ***TOTAL*** | ***8,543*** | ***4,012*** | ***21,328*** | ***10030*** | ***31,359*** |

Detailed calculation of project emissions from flaring is presented in the ER spreadsheet attached to this Monitoring Report.

### E.2. Calculation of project emissions or actual net removals

According to ACM0001 (version 11.0), project emissions are calculated as follows:

$PE_y = PE_{EC,y} + PE_{FC,j,y}$ **Equation 12**

Where,

$PE_{EC,y}$ = Emissions from consumption of electricity in the project case;

$PE_{FC,j,y}$ = Emissions from consumption of heat in the project case.

Project emissions from electricity consumption ($PE_{EC,y}$) are calculated following the procedures set out by the methodological tool *"Baseline, project and/or leakage emissions from electricity consumption and monitoring of electricity generation"*.

$$PE_{EC,y} = \sum_j EC_{PJ,j,y} \times EF_{EL,j,y} \times (1 + TDL_{j,y})$$ **Equation 13**

Where,

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

$EC_{PJ,y}$ = 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 ($tCO_2$/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

$$EF_{EL,j,y} = \frac{\sum_j FC_{n,i,y} \times NCV_{i,t} \times EF_{CO2,i,t}}{\sum_n EG_{n,t}}$$ **Equation 14**

Where $EC_{PJ,y} = EG_{n,t}$ *and:*

$FC_{n,i,y}$ = Quantity of fossil fuel type i fired in the captive power plant n in the time period t (mass or volume unit);

$NCV_{i,t}$ = Average net calorific value of fossil fuel type i used in the period t (GJ / mass or volume unit);

$EF_{CO2,i,t}$ = Average $CO_2$ emission factor of fossil fuel type i used in the period t (t CO2 / GJ);

$EG_{n,t}$ = *Quantity of electricity generated in captive power plant n in the time period t (MWh);*

*n* = *Fossil fuel fired captive power plants installed at the site of the electricity consumption source j, k or i;*

*i* = *are the fossil fuel types fired in captive power plant n in the time period t;*

*t* = *Time period for which the emission factor for electricity generation is determined.*

Electricity produced by the diesel generator is continuously monitored by the project developer. In order to calculate project emissions is calculated based on $EF_{CO2,D,t}$ from the 2006 IPCC Guidelines for National Greenhouse Gas Inventories, volume 2, chapter 1, table 1.4 (upper limit at 95% confidence interval). Since the diesel generator is located inside BLFGE, there are no transmission loses and, therefore, $TDL_{j,y}$ is zero.

**Table 6** – Calculation of project emissions from diesel oil electricity generation

| *Year* | $FC_{ECDG,D,y}$ *(GJ)* | $PE_{EC,scenarioB,y}$ *($tCO_2$/yr)* |
|---|---|---|
| From 01/09/2012 | 16 | 1.2 |
| 2013 | 9 | 0.7 |
| 2014 | 60 | 4.5 |
| 2015 | 1,288 | 96.3 |
| 2016 | 2,008 | 150.2 |
| Up to 22/12/2017 | 5 | 0.4 |
| ***TOTAL*** | ***3,387*** | ***253.3*** |

As described in the registered PDD, the diesel generator is not connected to the grid and, therefore, it cannot dispatch electricity to the grid.

Project emissions from flaring are presented in section E.1, since it is used to calculate $MD_{project,y}$ *and* $MD_{BL,y}$ following equations from 3 to 9.

## E.3. Calculation of leakage emissions

According to ACM0001 (version 11.0), no leakage effects need to be accounted under this methodology.

## E.4. Calculation of emission reductions or net anthropogenic removals

| | **Baseline GHG emissions or baseline net GHG removals (t $CO_2$e)** | **Project GHG emissions or actual net GHG removals (t $CO_2$e)** | **Leakage GHG emissions (t $CO_2$e)** | **GHG emission reductions or net anthropogenic GHG removals (t $CO_2$e)** | | |
|---|---|---|---|---|---|---|
| | | | | **Before 01/01/2013** | **From 01/01/2013** | **Total amount** |
| **Total** | 842,253 | 253 | 0 | 63,635 | 778,365 | 842,000 |

## E.5. Comparison of emission reductions or net anthropogenic removals achieved with estimates in the registered PDD

| **Amount achieved during this monitoring period (t $CO_2$e)** | **Amount estimated ex ante (t $CO_2$e)** |
|---|---|
| 842,000 | 1,175,518 |

## E.6. Remarks on increase in achieved emission reductions

Not applicable since there was a reduction in the monitored emission reductions in relation to the ones calculated ex-ante in the registered PDD.

\- - - - -

## Document information

| Version | Date | Description |
|---|---|---|
| 06.0 | 7 June 2017 | Revision to:<br>• Ensure consistency with version 01.0 of the “CDM project standard for project activities” (CDM-EB93-A04-STAN);<br>• Make editorial improvements. |
| 05.1 | 4 May 2015 | Editorial revision to correct version numbering. |
| 05.0 | 1 April 2015 | Revisions to:<br>• Include provisions related to delayed submission of a monitoring plan;<br>• Provisions related to the Host Party;<br>• Remove reference to programme of activities;<br>• Overall editorial improvement. |
| 4.0 | 25 June 2014 | Revisions to:<br>• Include the Attachment: Instructions for filling out the monitoring report form (these instructions supersede the "Guideline: Completing the monitoring report form" (Version 04.0));<br>• Include provisions related to standardized baselines;<br>• Add contact information on a responsible person(s)/ entity(ies) for completing the CDM-MR-FORM in A.6 and Appendix 1;<br>• Change the reference number from F-CDM-MR to CDM-MR-FORM;<br>• Editorial improvement. |
| 03.2 | 5 November 2013 | Editorial revision to correct table in page 1. |
| 03.1 | 2 January 2013 | Editorial revision to correct table in section E.5. |
| 03.0 | 3 December 2012 | Revision required to introduce a provision on reporting actual emission reductions or net GHG removals by sinks for the period up to 31 December 2012 and the period from 1 January 2013 onwards (EB 70, Annex 11). |
| 02.0 | 13 March 2012 | Revision required to ensure consistency with the "Guidelines for completing the monitoring report form" (EB 66, Annex 20). |
| 01.0 | 28 May 2010 | EB 54, Annex 34. Initial adoption. |

Decision Class: Regulatory
Document Type: Form
Business Function: Issuance
Keywords: monitoring report