ARCADIS TETRAPLAN

Imagine the result

Bandeirantes Landfill Gas to Energy Project (BLFGE)

Monitoring Report – Version 01
7th Verification
Monitoring Period: 01/01/2008 to 31/03/2008

São Paulo, April 1st 2008

Clean Development Mechanism

Monitoring Report – Version 01

Bandeirantes Landfill Gas to Energy Project (BLFGE)

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Biogás Energia Ambiental SA

São Paulo
April, 1st 2008

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Glossary

CDM	Clean Development Mechanism
CDM-EB	Clean Development Mechanism Executive Board
PDD	Project Design Document
CER	Certified Emission Reduction
GHG	Greenhouse Gas
GWP	Global Warming Potential
CH_4	Methane
EF	Grid CO_2 Electricity Emission Factor

1. General Project Activity Information

1.1. Title and Registration Number of the Project Activity

Bandeirantes Landfill Gas to Energy Project (BLFGE), Registration Number 0164

OBS: the presentation of values in this Monitoring Report, including those used for emission reductions, are in international standard format e.g 1,000 representing one thousand and 1.0 representing one.

1.2. Short Description of the Project Activity:

Bandeirantes Landfill Gas to Energy Project (BLFGE) is a project designed to explore the landfill gas produced in Bandeirantes landfill, one of the biggest landfills in Brazil. This landfill is located in the metropolitan region of São Paulo, Brazil's biggest city and financial center of the country. With an estimated population of around 10 million citizens in 2000, São Paulo generates nearly 15,000 tons of waste daily. Bandeirantes Landfill Gas to Energy Project (BLFGE)'s goal is to explore the gas produced in Bandeirantes landfill, using it to generate electricity.

1.3. Real Project Implementation

Bandeirantes landfill is divided into 5 cells, named AS-1, AS-2, AS-3, AS-4 and AS-5. The former 3 are the oldest ones, which operated from 1978 until 1995. Bandeirantes Landfill Gas to Energy Project (BLFGE) has since its start been extracting gas from the newest cells, where there is still waste being disposed. Two main units can be detached: the degassing stations and the power plant.

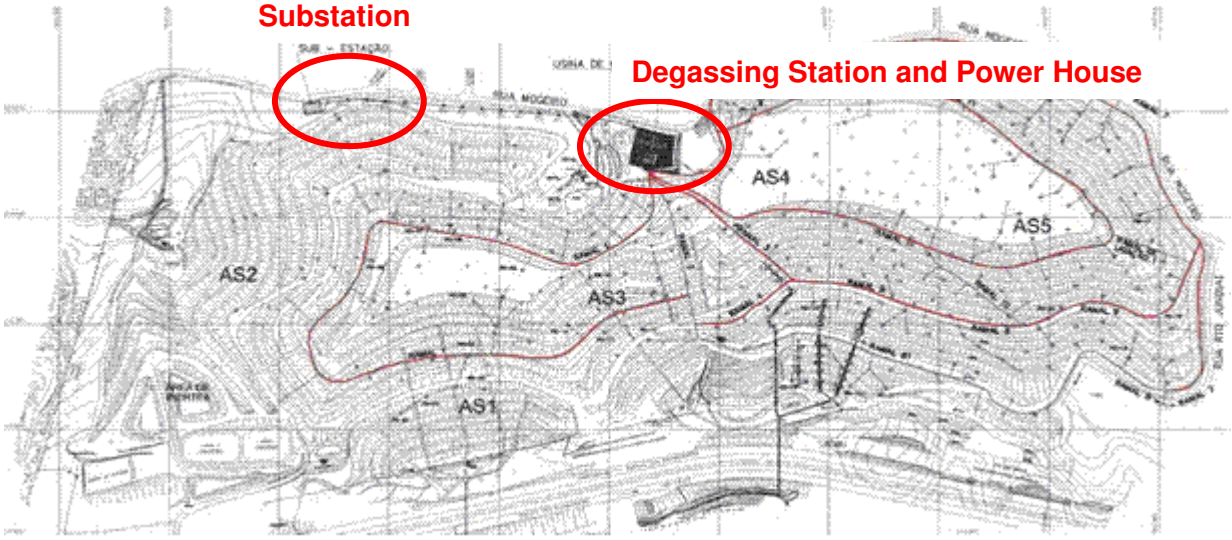

Figure 1-1. Bandeirantes Landfill Cells

The degassing stations are responsible for extracting the landfill gas from the landfill and transport it to the gas engines in the power plant. During the transportation, the gas goes through a treatment to allow its use as fuel for energy generation. Other functions of the degassing stations are: drying landfill gas by gas coolers; and measuring and analyzing the quantity and quality of the landfill gas for safety, process and operating purposes.

Figure 1-2. Degassing Station (A) and Power Plant (B)

The landfill gas cools down when transported from the landfill, resulting in a condensate. This is drained to condensate shafts, placed nearby the gas pipes. Once in the degassing stations, the landfill gas has to be cooled again to remove moisture. This is a very important step in the gas treatment process, since the condensate, which contains silicium components, could block the gas pipes and also damage the gas engines, due to the silicium. After this step, the gas is heated again through a second heat exchanger, or economizer, to a temperature of around 25ºC, far enough from the dew point of 4°C to avoid further condensation.

Considering demoisturing is fundamental for the energy generation, as per the reasons mentioned in the previous paragraph, a demister has been installed for extra-safety reasons. The demister is a stainless steel high density filter which separates liquid particles (small amounts of condensate) from the landfill gas. This liquid is to be drained off to a condensate shaft as well.

The blowers are used for transportation of the landfill gas from the landfill to the gas engines, under correct suction and pre-pressure. Capacity and pressure are adjusted through frequency controlled electromotors. Moreover, the blowers are equipped with all the necessary safety equipment, including a noise reducing housing.

Figure 1-3. Compressors (blue) and dryers (metal)

On the pressure side of the degassing station, all kinds of gas analyzing and gas measuring instruments are present. These instruments are very important for safety, process and operating purposes. After the described treatment, analyzing and measurement, the landfill gas is transported as a fuel to the gas engines. These drive electrical generators in order to generate electrical power. An occasional surplus of the landfill gas can be burned off by the flares.

Figure 1-4. Turbine Flow-meter

Figure 1-5. Generators used to produce electricity

Figure 1-6. Flare used to destroy the surplus gas collected

For electricity generation, a total of 24 Caterpillar engines, nominal capacity of 925 kW, model 3516 A were installed. They will burn the gas and generate energy, which is to be sent to

Eletropaulo's – the electric distributor supplying São Paulo metropolitan region – grid. This electricity will in fact not be commercialized directly; it will supply Unibanco's branches over São Paulo state.

1.4. Changes against the PDD

A revised Monitoring Plan was approved in order to reconsider the following changes from the previous Monitoring Plan:

- Installation of 4 new flow-meters to measure the gas flow to the power house;
- periodical monitoring of methane content in the exhaust flare gas, made by a specialized company on gas analysis;
- changes in the gas station's lay-out. This change was necessary in order to adapt the gas station to treat an increase of landfill gas collected (average 17,000 Nm^3/h) – changes were presented in the Monitoring Report from the 4th Verification.

1.5. Monitoring Period

The monitoring period is from 01/01/2008 to 31/03/2008.

1.6. Methodology applied to the project activity

1.6.1. Baseline methodology

The baseline applied to this project activity is **ACM0001 – version 2: "Consolidated baseline methodology for landfill gas project activities".**

1.6.2. Monitoring methodology

The monitoring methodology applied to this project activity is **ACM0001 – version 2: "Consolidated monitoring methodology for landfill gas project activities".**

1.7. Changes since last verification

No major changes were identified since the last verification.

1.8. Person(s) responsible for the preparation and submission of the monitoring report

This monitoring report was developed and reviewed by:

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2. Monitoring of the Project Activity

2.1. Monitoring Plan

The Monitoring Plan was developed based on **version 02** of the **"Consolidated monitoring methodology for landfill gas project activities" – ACM0001**. A review of this plan was submitted to the EB 36th Meeting and later approved. The data to be collected or used to monitor emissions from the project activity, and how this data will be archived are presented below:

Methodology ID	Data variable	Data Unit	Measured (M) Calculated (C) Estimated (E)	Recording frequency	Proportion of data to be monitored	Data archivement: Electronic (E) Paper (P)	For how long is archived data kept?	Comment
$LFG_{Total, y}$	Total amount of landfill gas captured	Nm^3	M	Continuously	100%	E / P	During the crediting period and two years after	Measured by a flow meter. Data will be aggregated monthly and yearly. Normal cubic meters represent the gas volume in cubic meters at STP.
$LFG_{Flare, y}$	Total amount of landfill gas flared	Nm^3	M	Continuously	100%	E / P	During the crediting period and two years after	Until 31/05/2007, measurements were made by one flow meter. From 01/06/2007 on, the measurements began to be made by two flow meters – the first one located in the main line and the second one located in a particular line connected to a mini-blower. Data will be aggregated monthly and yearly. Normal cubic meters represent the gas volume in cubic meters at STP.
$LFG_{Electricity, y}$	Total amount of landfill gas combusted in power plant	Nm^3	M	Continuously	100%	E / P	During the crediting period and two years after	Measured by 4 flow meters. Data will be aggregated monthly and yearly.

Methodology ID	Data variable	Data Unit	Measured (M) Calculated (C) Estimated (E)	Recording frequency	Proportion of data to be monitored	Data archivement: Electronic (E) Paper (P)	For how long is archived data kept?	Comment
								Normal cubic meters represent the gas volume in cubic meters at STP.
FE	Flare/combustion efficiency, determined by: methane content in the exhaust gas	%	M / C	Quarterly, monthly if unstable	N/A	E	During the crediting period and two years after	Periodic measurement of methane content of flare exhaust gas.
$w_{CH4, y}$	Methane fraction in the landfill gas	%	M	Continuously	100%	E	During the crediting period and two years after	Measured to determine the density of methane D_{CH4}.
T	Temperature of the landfill gas	ºC	M	Continuously	100%	E	During the crediting period and two years after	Measured to determine the density of methane D_{CH4}.
p	Pressure of the landfill gas	Pa	M	Continuously	100%	E	During the crediting period and two years after	Measured to determine the density of methane D_{CH4}.
	Regulatory requirements relating to landfill gas projects	Test	N/A	Annually	100%	E	During the crediting period and two years after	Required for any changes to the adjustment factor (AF) or directly $MD_{reg,y}$
EG_y[1]	Net Electricity Exported to the Grid	MWh	M	Continuously	100%	E	During the crediting period and two years	The net quantity of electricity displaced will be measured by an electricity meter. Double check by receipt of sales.
EF_y[1]	Emission Factor	tCO_2/MWh	C	Yearly	100%	E	During the crediting period and two years	This data will be updated at the baseline renewal, in accordance with the considered methodology.

2.2. Monitoring Equipment

The following equipment were installed in the Degassing Station, as per the revised Monitoring Plan:

[1] Monitoring parameters as per methodology ACM0002 – version 03 to calculate emission reductions due to the displacement of fóssil-fuel based energy in the Brazilian S-SE-CO Grid.

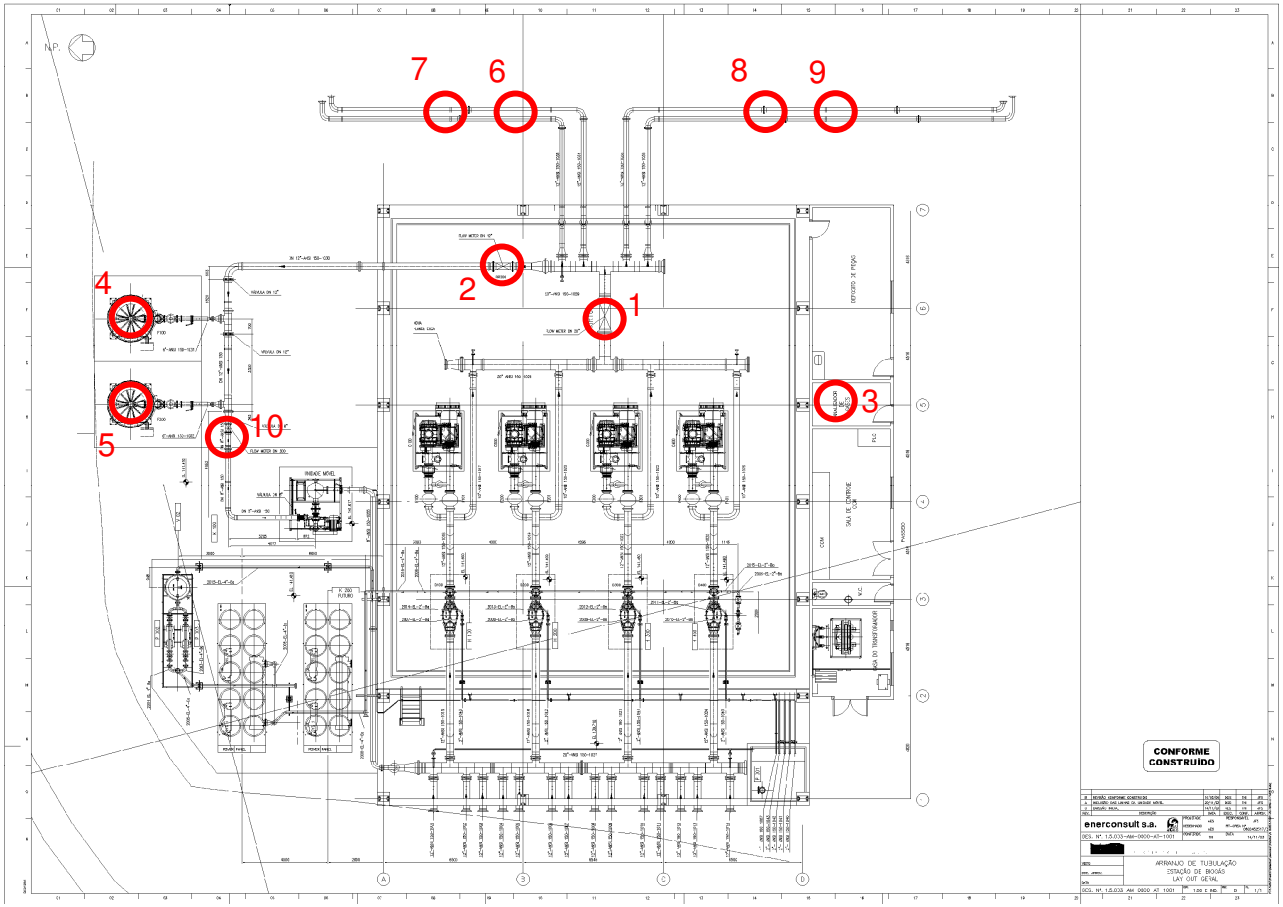


Figure 2-1. Lay-out of the Degassing Station

Method. ID	Equipment Number	Equipment	Location	TAG	Manufacturer	Model	Range	Error (%)
$LFG_{Total, y}$	1	Turbine Flow-meter	Main Line	FIR100	Instromet	SM-RI-X-K	800-16,000 m^3/h	0.600
$LFG_{Flare, y}$	2	Turbine Flow-meters	Line to Flare F200	FIR200	Instromet	SM-RI-X-K	320-6,500 m^3/h	0.600
	10		Secondary Line	FIR700	Actaris	Fluxi TZG1600	180-2,500 m^3/h	0.330
$LFG_{Electricity, y}$	6	Turbine Flow-meters	Line to the Power House	FIR300	Incontrol	VTGEX	170-8,156 m^3/h	0.772
	7		Line to the Power House	FIR400	Incontrol	VTGEX	170-8,156 m^3/h	0.596
	8		Line to the Power House	FIR500	Incontrol	VTGEX	170-8,156 m^3/h	0.810
	9		Line to the Power House	FIR600	Incontrol	VTGEX	170-8,156 m^3/h	0.632
FE_{F100}	4	Chromatographer – analysis made by a Third Party	Flare F100	N/A	N/A	N/A	N/A	N/A
FE_{F200}	5	Chromatographer – analysis made by a Third Party	Flare F100	N/A	N/A	N/A	N/A	N/A
$w_{CH4, y}$	3	Methane Analyzer	Analysis Room	A100	NUK	Binos 100	0-100%	1.000
T	1	Temperature Transmitter[2]	FIR100	TT100	Ibrel	333	0-100°C	0.233
	2		FIR200	TT200	Ibrel	333	0-100°C	0.180
	10		FIR700	TT700	Actaris[3]	Fluxi TZG1600	0-100°C	-
	6		FIR300	TT300	Incontrol	VTGEX	0-100°C	0.050
	7		FIR400	TT400	Incontrol	VTGEX	0-100°C	0.050
	8		FIR500	TT500	Incontrol	VTGEX	0-100°C	0.050
	9		FIR600	TT600	Incontrol	VTGEX	0-100°C	0.050
p	1	Pressure Transmitter[2]	FIR100	PT100	Instromet	PT-100	0.9–1.5 bara	0.010
	2		FIR200	PT200	Instromet	PT-100	0.9–1.5 bara	0.010
	10		FIR700	PT700		Fluxi TZG1600	0.0–16.0 bar	-

[2] The Turbine flow-meters installed are connected to a pressure and temperature transmitters, which allows the device to use those variables to make the conversion automatically to Nm^3. Thus, readings from pressure and temperature were not considered and the erros from the transmitters were discounted from the final calculation (refer to **Erro! Fonte de referência não encontrada.**).

[3] The calibration certificate from the flow-meter FIR700 consider the error from the three devices: gás flow, temperature transmitter and pressure transmitter

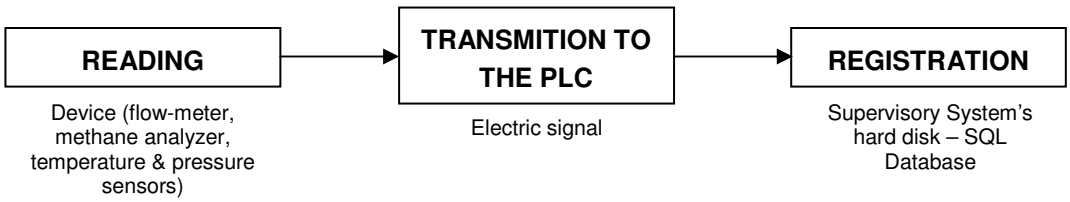
Method. ID	Equipment Number	Equipment	Location	TAG	Manufacturer	Model	Range	Error (%)
	6		FIR300	PT300	Actaris[3]	VTGEX	0.0–1.0 bar	0.034
	7		FIR400	PT400	Incontrol	VTGEX	0.0–1.0 bar	0.038
	8		FIR500	PT500	Incontrol	VTGEX	0.0–1.0 bar	0.370
	9		FIR600	PT600	Incontrol	VTGEX	0.0–1.0 bar	0.444
					Incontrol			
EG_y		Electricity Meter	Substation	N/A	Merlin Gerin	Power Logic - CM 4000	240V/300V - 96mA MAX.	1.000

2.2.1. Data Acquisition

All variables monitored are controlled by an electrical control system. This control system is provided with a PLC (Programmable Logical Computer). All the measured process signals are processed by the PLC to output signals for the gas-coolers, blowers, flares and gas-engines. Also the system counts on a SCADA system (process visualization on a personal computer). With this system it is possible to control and monitor the installation at a distance, including through the internet.

Figure 2-2. PLC Controlling System panel

For each parameter operationally monitored, the PLC makes a routine of reading / transmitting / registering in the Supervosory's System hard disk as presente in the figure below:



Depending on the paremeter the, the frequency of the PLC's routine may vary, as presented in the table below:

Methodology ID	Equipment TAG	Reading Frequency	Transmition Frequency	Registration Frequency	Comments
$LFG_{Total, y}$	FIR100	Every 5 seconds	Every 5 seconds	Every 5 minutes	- Data accumulated every 1 day in the Supervosory System's hard disk, in Nm^3; - Every 00:00, the PLC's counter is reseted; - The flow-computer installed in the flow-meter keeps registering the accumulated flow; - Every 00:00, the accumulated flow (in Nm^3) is manually registered by the operators; - Responsibilties of the routine: PLC (continuously) and plant supervisor (monthly)
$LFG_{Flare, y}$	FIR200 FIR700	Every 5 seconds Every 5 seconds	Every 5 seconds Every 5 seconds	Every 5 minutes Every 5 minutes)	
$LFG_{Electricity, y}$	FIR300 FIR400 FIR500 FIR600	Every 5 seconds Every 5 seconds Every 5 seconds Every 5 seconds	Every 5 seconds Every 5 seconds Every 5 seconds Every 5 seconds	Every 5 minutes Every 5 minutes Every 5 minutes Every 5 minutes	
FE_{F100}	N/A	Every 3 months, by a specialized company on gas analysis	Every 3 months, by a specialized company on gas analysis	Every 3 months, by a specialized company on gas analysis	- The flare efficiency analysis is made according with internal procedures from the hired company
FE_{F200}	N/A	Every 3 months, by a specialized company on gas analysis	Every 3 months, by a specialized company on gas analysis	Every 3 months, by a specialized company on gas analysis	- The flare efficiency analysis is made according with internal procedures from the hired company
$w_{CH4, y}$	A100	Every 5 minutes	Every 5 minutes	Every 5 minutes	- By the end of the day, an average of CH_4 concentration (registered every 5 minutes) is calculated. - Responsibilties of the routine: PLC (continuously) and plant supervisor (monthly)
T	TT100 TT200 TT700 TT300 TT400	Every 5 seconds Every 5 seconds Every 5 seconds Every 5 seconds Every 5 seconds	Every 5 seconds Every 5 seconds Every 5 seconds Every 5 seconds Every 5 seconds	Every 5 minutes Every 5 minutes Every 5 minutes Every 5 minutes Every 5 minutes	- The temperature readings are not transmitted and registered in by PLC because the flow-meters make the conversion to Nm^3 automatically.

Methodology ID	Equipment TAG	Reading Frequency	Transmition Frequency	Registration Frequency	Comments
	TT500	Every 5 seconds	Every 5 seconds	Every 5 minutes	
	TT600	Every 5 seconds	Every 5 seconds	Every 5 minutes	
p	PT100	Every 5 seconds	Every 5 seconds	Every 5 minutes	- The pressure readings are not transmitted and registered by the PLC because the flow-meters make the conversion to Nm^3 automatically.
	PT200	Every 5 seconds	Every 5 seconds	Every 5 minutes	
	PT700	Every 5 seconds	Every 5 seconds	Every 5 minutes	
	PT300	Every 5 seconds	Every 5 seconds	Every 5 minutes	
	PT400	Every 5 seconds	Every 5 seconds	Every 5 minutes	
	PT500	Every 5 seconds	Every 5 seconds	Every 5 minutes	
	PT600	Every 5 seconds	Every 5 seconds	Every 5 minutes	
EG_y	N/A	Every 5 minutes	Every 5 minutes	Every 15 minutes	- Sotreq's PLC registers the accumulated electricity sent to the grid every 00:00. Data is compared with Eletropaulo's invoices. - Responsibilities of the routine: PLC (continuously) and Sotreq's plant supervisor (monthly)

2.2.2. Involvement of Third Parties

BFLGE has three third parties involved:

- Specialized company on gas analysis, to perform the analysis of methane concentration in the exhaust gas. For this monitoring period, Biogás hired BIOAGRI, a certified national laboratory.

- Sotreq, the company responsible for the electricity production in the power house, using the gas from the landfill. Sotreq's PLC is responsible to monitor the electricity displaced to the local grid.

- ARCADIS Tetraplan is the company responsible to develop the Monitoring Report and is part of the quality assurance/quality control procedures.

2.3. Quality assurance and quality control measures

2.3.1. Internal Procedures and ISO14001

Biogás counts with the internal procedure SGA IT 4.4.6-26 which objective is to to specify the monitoring procedures made inside the Degassing Station, as gas flows, temperature, pressure, electricity generation and methane concentration.

As presented in item 2.2.1, all parameters monitored inside the Degassing Station have 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 make 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 on a daily basis (0:00 hour), which are verified by the production manager weekly for legibility.

Also, the BLGFE counts with a third-party, non-responsible for the project's monitoring: ARCADIS Tetraplan, which is the responsible for the development of the Monitoring Report. ARCADIS Tetraplan's role in the Project is to assure the quality of the registered data, through a double-check process, and to assure the quality of the calculation of ERs and is in constant contact with the Production Manager of Biogás.

Moreover, Biogás is implementing ISO 14001 certification, as per raised during the 1st Verification, on March 2006. With this certification, erros will be minimized through reinforecement of the procedures, such as:

- Document Control;
- Data safety measures (backup and sabotage);
- Monitoring Report Preparation (frequency, responsibilities, crosschecking measures, legal binding signature in monitoring reports,etc.);
- Data Spreadsheets;
- Error management (including software errors, material errors, etc.);

2.3.2. Organizational Structure, responsibilities and competencies

Positions and roles for this CDM project activity are well defined. From the point of view of the plant operation, positions and roles are defined. Duties, personel replacement in the case of non-availability of the supervisor of monitoring and/or the eletrical supervisor and hiring requirements for job positions are determined in documented procedures, as presented in the figures below:

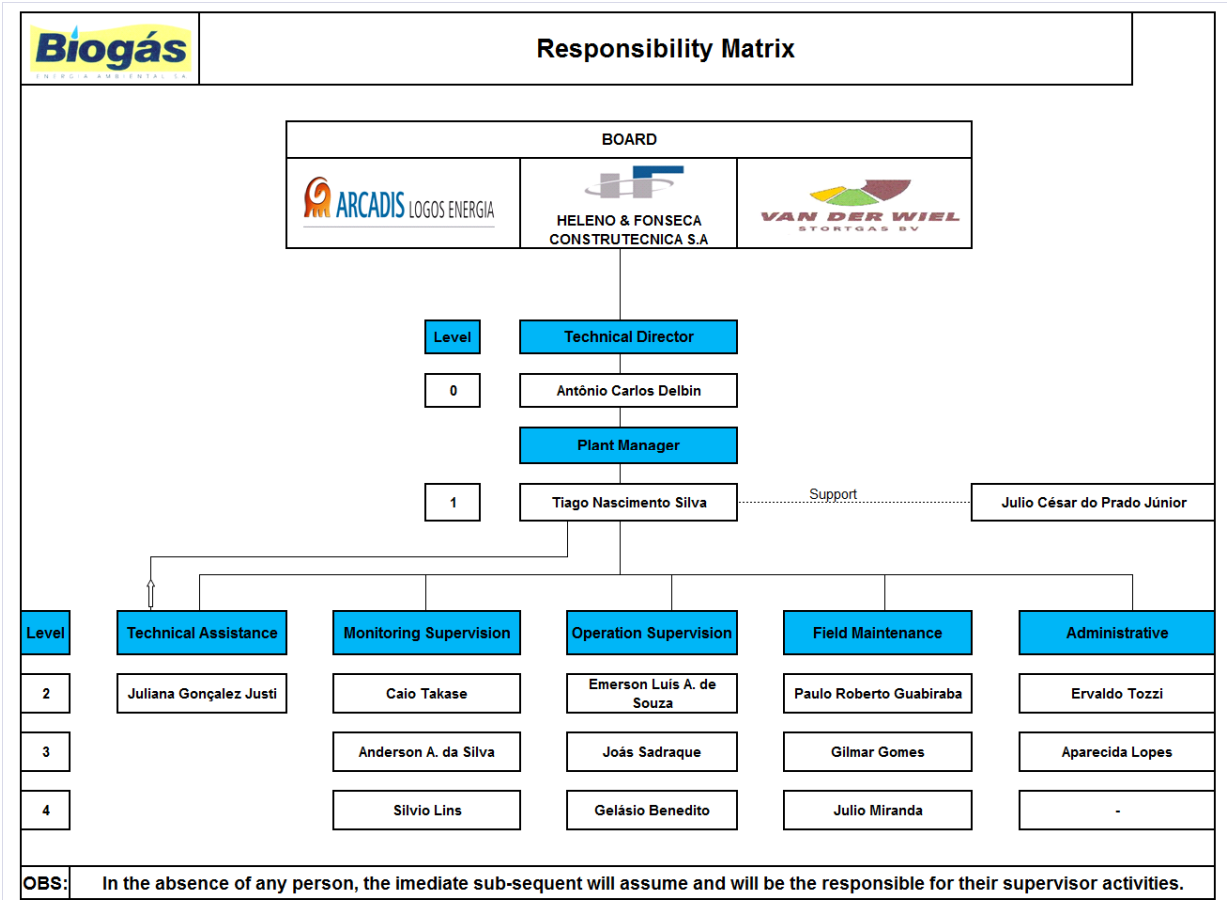


Figure 2-3. General Organogram and Responsibility Matrix of Biogás Energia Ambiental

2.3.3. Data Protection Measures

As all data registered in the Supervosory System's hard disk is subjected to sabotage and technical failure, Biogás 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 defined persons have access to the data base of the system;
- Antivirus programmes are installed at the system;
- Data backup:
  - A weekly CD backup of the Supervosory System's hard disk;
  - A weekly backup of the Supervosory System's hard disk is made by the server of Heleno & Fonseca (one of Biogás shareholders);
  - Van der Wiel (another Biogás shareholder) has radio access to the Supervisory System;
  - ARCADIS Tetraplan downloads every week the primary data for the elaboration of the monitoring report.

3. Application of GHG determination methods

3.1. Calculation of Emission Reductions

According with baseline methodology ACM0001 – version 02, Emission Reductions are calculated as follows:

$$ER_y = (MD_{project,\,y} - MD_{reg,\,y}) \times GWP_{CH4} + EG_y \times CEF + ET_y \times CEF_{thermal,\,y} \quad (1)$$

Where:

ER_y = Emission reduction achieved by the project activity during a given year y (tCO_2e);
$MD_{project,\,y}$ = Amount of methane actually destroyed/combusted during the year y (tCH_4);
$MD_{reg,\,y}$ = Amount of methane that would have been destroyed/combusted during the year y in the absence of the project activity (tCH_4);
GWP_{CH4} = Global Warming Potential value for methane (tCO_2e/tCH_4);
EG_y = Net quantity of electricity displaced during the year y (MWh)
$CEF_{electricity,\,y}$ = CO_2 emissions intensity of the electricity displaced (tCO_2e/MWh)
ET_y = Quantity of thermal energy displaced during the year y (TJ)
$CEF_{thermal,\,y}$ = CO_2 emissions intensity of the thermal energy displaced (tCO_2e/TJ).

$MD_{project,\,y}$ is calculated as the sum of methane flow destroyed in the flares, in the power house and in the heat generation, as follows:

$$MD_{project,\,y} = MD_{flared,\,y} + MD_{electricity,\,y} + MD_{thermal,\,y} \quad (2)$$

Where:

$MD_{flared,\,y}$ = quantity of methane destroyed in the flares in year y (tCH_4)
$MD_{electricity,\,y}$ = quantity of methane destroyed by the generation of electricity y (tCH_4);
$MD_{thermal,\,y}$ = quantity of methane destroyed for the generation of thermal energy in year y (tCH_4)

As the BLFGE does not use the methane to generate thermal energy, $MD_{thermal,\,y} = 0$.

$MD_{flared,\,y}$ is calculated as follows:

$$MD_{flared,\,y} = LFG_{flared,\,y} \times w_{CH4} \times D_{CH4} \times FE \quad (3)$$

Where:

$MD_{flared,y}$ = Quantity of methane destroyed by flaring (tCH_4);
$LFG_{flare,y}$ = Quantity of landfill gas flared during the year measured in cubic meters (Nm^3);
$w_{CH4,y}$ = Average methane fraction of the landfill gas as measured during the year and expressed as a fraction (m^3_{CH4}/m^3LFG)
FE = Flare efficiency (%);
D_{CH4} = Methane density expressed in tonnes of methane per cubic meter of methane (tCH_4/m^3_{CH4});

$MD_{electricity,\ y}$ is calculated as follows:

$$MD_{electricity,\ y} = LFG_{electricity,\ y} \times w_{CH4} \times D_{CH4} \quad (4)$$

Where:

$MD_{electricity,y}$ = Quantity of methane destroyed by generation of electricity (tCH_4);
$LFG_{flare,y}$ = quantity of landfill gas fed into electricity generator (Nm^3);
$w_{CH4,y}$ = Average methane fraction of the landfill gas as measured during the year and expressed as a fraction (m^3_{CH4}/m^3LFG)
D_{CH4} = Methane density expressed in tonnes of methane per cubic meter of methane (tCH_4/m^3_{CH4});

Thus, $MD_{project,\ y}$ is equal to:

$$MD_{project,\ y} = (LFG_{flared,\ y} \times w_{CH4} \times D_{CH4} \times FE) + (LFG_{electricity,\ y} \times w_{CH4} \times D_{CH4}) \quad (5.1)$$

$$MD_{project,\ y} = w_{CH4} \times D_{CH4} \times (LFG_{flared,\ y} \times FE + LFG_{electricity,\ y}) \quad (5.2)$$

The amount of methane that would have been destroyed/combusted during the year *y* in the absence of the project activity ($MD_{reg,\ y}$) is calculated adopting an "Adjustment Factor" (AF), as no regulatory or contractual requirements specifying a quantity of methane destruction exists. As will be presented below, the *AF* adopted for the 1st Crediting Period is equal to 20% of total gas collected. Thus, equation (1) is updated to:

$$ER_y = (MD_{project,\ y} - 0{,}2 \times MD_{project,\ y}) \times GWP_{CH4} + EG_y \times CEF \quad (6.1)$$

$$ER_y = (0{,}8 \times MD_{project,\ y}) \times GWP_{CH4} + EG_y \times CEF \quad (6.2)$$

A detailed step-by-step of the calculation is presented in item 3.6.

3.1.1. Calculation of FE – Flare Efficiency

To calculate the Flare Efficiency, the following formulae were applied, based on the mass-balance (an Excel spreadsheet was evidenced to the Verification Team):

a) Calculate the volume of CH_4 sent to flares F_i ($Flow_{methane}$), measured by the equipment FIR_i:

$$Flow_{methane} = Flow_{FIRi} \times \frac{\%_{methane}}{100}$$, where:

- $Flow_{methane}$ = methane flow sent to the flare Fi (Nm^3/h);
- $Flow_{FIRi}$ = total flow measured by the flow-meter FIRi sent to the flare F_i (Nm^3/h);
- % methane = methane measured by the gas analyzer (%);

b) Calculate the volume of other gases (residual gases) sent to flares ($Flow_{remaining}$):

$$Flow_{remaining} = Flow_{FIR\,i} - Flow_{methane}$$, where:

- $Flow_{remaining}$ = flow of residual gases sent to the flare F_i (Nm^3/h);

c) Calculate the total flow entering the flare F_i ($Flow_{Total}$):

$$Flow_{Total} = Flow_{methane} + (Flow_{methane} \times air_{ratio}) + Flow_{remaining},$$

where:

- $Flow_{total}$ = total gas sent to the flare F_i (Nm^3/h);
- air_{ratio} = theoretical air ratio[4];

d) Calculate the mass of methane in the exhaust gas ($M_{methane}$):

$$M_{methane} = Flow_{Total} \times \frac{CH_{4,eg}}{1000}$$, where:

- $M_{methane}$ = amount of methane remaining in the exhaust gas (g), calculated using the result of the analysis;
- $CH_{4,\,eg}$ = methane concentration in the exhaust gas (mg/Nm^3) – data acquired from the analysis form the specialized company;

e) Calculate the Flare Efficiency (FE):

$$FE = \frac{(Flow_{methane} \times 0.7168) - \frac{M_{methane}}{1000}}{(Flow_{methane} \times 0.7168)} \times 100$$, where:

- FE = Flare Efficiency (%);
- 0.7168 = density of methane, at STP (kg/Nm^3).

BIOAGRI made two analysis of the methane content in the exhaust gas of the flares F200 and F100 on 26/12/2007 and on 28/01/2008.

Flare	December/2007	January/2008
F100	1.46 mg/Nm^3	0.507 mg/Nm^3
F200	0.736 mg/Nm^3	1.15 mg/Nm^3

Other parameters used to calculate the flare efficiency were:

[4] Air_{ratio} is equal to 5, as reccomended by Hoffstetter, the flare manufacturer.

Measurement	$Flow_{FIRi}$		Methane %	
	FIR200	FIR700	FIR200	FIR700
December/2007	2,160 Nm^3/h	1,920 Nm^3/h	54.20%	50.20%
January/2008	2,280 Nm^3/h	2,220 Nm^3/h	48.60%	49.10%

The results were:

Measurement	Flare Efficiency Calculated	
	F100	F200
December/2007	99.9986%	99.9993%
January/2008	99.9995%	99.9989%

The flare efficiency adopted from 01/02/2008 to 27/01/2008 is 99.9986% and the flare efficiency adopted from 28/01/2008 to 31/03/2008 was 99.9989% (the lowest efficiencies calculated).

4. Monitored and Calculated Data

4.1. Table presenting the monitored data

For the whole monitoring period, the following table presents all measured data and the calculation of methane destroyed.

DATE	MAIN PIPELINE							SECONDARY PIPELINE			ELECTRICITY GENERATION								
	COLLECTING SYSTEM				FLARE F100			FLARE F200			FIR300		FIR400		FIR500		FIR600		Eletricity Exported (MWh)
	LFG measured FIR100 (Nm^3)	Methane (%)	*Methane measured FIR100 (Nm^3)*	Flares Efficiencies (%)	LFG measured FIR200 (Nm^3)	*Methane measured FIR200 (Nm^3)*	*Methne Destroyed in F100 (Nm^3)*	LFG measured FIR700 (Nm^3)	*Methane measured FIR700 (Nm^3)*	*Methne Destroyed F200 (Nm^3)*	LFG measured (Nm^3)	*Methane measured (Nm^3)*	LFG measured (Nm^3)	*Methane measured (Nm^3)*	LFG measured (Nm^3)	*Methane measured (Nm^3)*	LFG measured (Nm^3)	*Methane measured (Nm^3)*	
	A	B	*C = A . B*	D	E	*F = E . B*	*G = F . D*	H	*I = H . B*	*J = I . D*	K	*L = K . B*	M	*N = M . B*	O	*P = O . B*	Q	*R = Q . B*	S
01/01/2008	283,996	48.3354	137,270.6025	99.99860	10,647	*5,146.2700*	*5,146.1979*	42,580	*20,581.1925*	*20,580.9043*	71,451	*34,536.1266*	57,274	*27,683.6169*	66,376	*32,083.1051*	77,073	*37,253.5428*	413.47
02/01/2008	291,820	48.8368	142,515.5497	99.99860	14,614	*7,137.0099*	*7,136.9099*	33,511	*16,365.5321*	*16,365.3029*	71,488	*34,912.4515*	60,471	*29,532.1013*	61,012	*29,796.3084*	82,318	*40,201.4770*	422.53
03/01/2008	293,339	49.3385	144,729.0625	99.99860	13,162	*6,493.9333*	*6,493.8423*	28,710	*14,165.3261*	*14,165.1277*	69,009	*34,048.0054*	61,742	*30,462.5766*	67,029	*33,071.1031*	82,005	*40,460.0369*	429.89
04/01/2008	297,086	49.2823	146,410.8137	99.99860	18,900	*9,314.3547*	*9,314.2242*	35,091	*17,293.4151*	*17,293.1729*	70,307	*34,648.9066*	69,054	*34,031.3994*	62,999	*31,047.3561*	73,824	*36,382.1651*	427.17
05/01/2008	296,839	49.3763	146,568.1151	99.99860	20,345	*10,045.6082*	*10,045.4675*	34,155	*16,864.6372*	*16,864.4010*	64,553	*31,873.8829*	68,788	*33,964.9692*	66,787	*32,976.9494*	75,113	*37,088.0202*	427.12
06/01/2008	297,780	49.2922	146,782.3131	99.99860	14,523	*7,158.7062*	*7,158.6059*	30,885	*15,224.0519*	*15,223.8387*	70,558	*34,779.5904*	67,433	*33,239.2092*	60,361	*29,753.2648*	83,499	*41,158.4940*	436.54
07/01/2008	294,959	49.2161	145,167.3163	99.99860	23,030	*11,334.4678*	*11,334.3091*	33,118	*16,299.6071*	*16,299.3789*	69,575	*34,242.1015*	52,783	*25,977.7340*	67,383	*33,163.2846*	83,174	*40,934.9990*	417.38
08/01/2008	293,993	49.1961	144,633.0902	99.99860	26,265	*12,921.3556*	*12,921.1747*	30,895	*15,199.2494*	*15,199.0366*	71,251	*35,052.7132*	54,473	*26,798.5915*	62,689	*30,840.5431*	79,684	*39,201.4203*	411.26
09/01/2008	288,093	49.6485	143,033.8531	99.99860	27,172	*13,490.4904*	*13,490.3015*	29,696	*14,743.6185*	*14,743.4120*	70,607	*35,055.3163*	56,092	*27,848.8366*	62,132	*30,847.6060*	71,612	*35,554.2838*	403.78
10/01/2008	291,260	49.3449	143,721.9557	99.99860	17,501	*8,635.8509*	*8,635.7299*	35,396	*17,466.1208*	*17,465.8762*	71,406	*35,235.2192*	57,087	*28,169.5230*	68,020	*33,564.4009*	77,792	*38,386.3846*	422.18
11/01/2008	289,605	49.2250	142,558.0612	99.99860	14,078	*6,929.8955*	*6,929.7984*	33,329	*16,406.2002*	*16,405.9705*	70,983	*34,941.3817*	57,510	*28,309.2975*	63,556	*31,285.4410*	83,644	*41,173.7590*	424.51
12/01/2008	285,611	48.6452	138,936.0421	99.99860	13,694	*6,661.4736*	*6,661.3803*	40,689	*19,793.2454*	*19,792.9682*	71,327	*34,697.1618*	58,957	*28,679.7505*	56,613	*27,539.5070*	84,399	*41,056.0623*	415.06
13/01/2008	299,559	49.9528	149,638.1081	99.99860	29,377	*14,674.6340*	*14,674.4285*	33,637	*16,802.6233*	*16,802.3880*	64,400	*32,169.6032*	57,156	*28,551.0223*	66,654	*33,295.5393*	81,705	*40,813.9352*	421.82
14/01/2008	302,899	50.3318	152,454.5188	99.99860	33,854	*17,039.3275*	*17,039.0889*	29,735	*14,966.1607*	*14,965.9511*	68,935	*34,696.2263*	58,271	*29,328.8431*	62,346	*31,379.8640*	78,596	*39,558.7815*	422.91
15/01/2008	300,865	50.4758	151,864.0156	99.99860	31,642	*15,971.5526*	*15,971.3289*	32,242	*16,274.4074*	*16,274.1795*	66,560	*33,596.6924*	57,521	*29,034.1849*	66,249	*33,439.7127*	78,464	*39,605.3317*	424.90
16/01/2008	293,440	50.1204	147,073.3017	99.99860	25,149	*12,604.7793*	*12,604.6028*	36,629	*18,358.6013*	*18,358.3442*	70,229	*35,199.0557*	56,182	*28,158.6431*	62,025	*31,087.1781*	79,469	*39,830.1806*	420.35

DATE	MAIN PIPELINE							SECONDARY PIPELINE			ELECTRICITY GENERATION								
	COLLECTING SYSTEM				FLARE F100			FLARE F200			FIR300		FIR400		FIR500		FIR600		Eletricity Exported (MWh)
	LFG measured FIR100 (Nm^3)	Methane (%)	*Methane measured FIR100 (Nm^3)*	Flares Efficiencies (%)	LFG measured FIR200 (Nm^3)	*Methane measured FIR200 (Nm^3)*	*Methne Destroyed in F100 (Nm^3)*	LFG measured FIR700 (Nm^3)	*Methane measured FIR700 (Nm^3)*	*Methne Destroyed F200 (Nm^3)*	LFG measured (Nm^3)	*Methane measured (Nm^3)*	LFG measured (Nm^3)	*Methane measured (Nm^3)*	LFG measured (Nm^3)	*Methane measured (Nm^3)*	LFG measured (Nm^3)	*Methane measured (Nm^3)*	
	A	B	*C = A . B*	D	E	*F = E . B*	*G = F . D*	H	*I = H . B*	*J = I . D*	K	*L = K . B*	M	*N = M . B*	O	*P = O . B*	Q	*R = Q . B*	S
17/01/2008	297,173	49.7307	147,786.2131	99.99860	23,360	*11,617.0915*	*11,616.9288*	30,910	*15,371.7593*	*15,371.5440*	70,297	*34,959.1901*	57,601	*28,645.3805*	66,405	*33,023.6713*	79,525	*39,548.3391*	427.30
18/01/2008	303,916	50.1103	152,293.2193	99.99860	28,764	*14,413.7266*	*14,413.5248*	18,497	*9,268.9021*	*9,268.7723*	70,696	*35,425.9776*	57,724	*28,925.6695*	66,485	*33,315.8329*	79,981	*40,078.7190*	432.37
19/01/2008	293,262	52.0320	152,590.0838	99.99860	55,189	*28,715.9404*	*28,715.5383*	18,313	*9,528.6201*	*9,528.4866*	53,562	*27,869.3798*	44,754	*23,286.4012*	66,422	*34,560.6950*	74,829	*38,935.0252*	386.66
20/01/2008	308,917	50.3098	155,415.5248	99.99860	21,834	*10,984.6417*	*10,984.4879*	33,149	*16,677.1956*	*16,676.9621*	70,253	*35,344.1437*	56,149	*28,248.4496*	80,109	*40,302.6776*	81,242	*40,872.6877*	461.12
21/01/2008	302,251	50.4506	152,487.4430	99.99860	25,601	*12,915.8581*	*12,915.6772*	33,008	*16,652.7340*	*16,652.5008*	64,240	*32,409.4654*	52,878	*26,677.2682*	79,412	*40,063.8304*	81,376	*41,054.6802*	442.62
22/01/2008	305,871	49.6650	151,910.8321	99.99860	24,353	*12,094.9174*	*12,094.7480*	32,059	*15,922.1023*	*15,921.8793*	62,243	*30,912.9859*	56,066	*27,845.1789*	81,232	*40,343.8728*	82,174	*40,811.7171*	429.58
23/01/2008	305,331	49.5355	151,247.2375	99.99860	26,019	*12,888.6417*	*12,888.4612*	28,848	*14,290.0010*	*14,289.8009*	68,894	*34,126.9873*	53,695	*26,598.0867*	81,591	*40,416.5098*	74,490	*36,898.9939*	435.23
24/01/2008	299,328	49.8267	149,145.2645	99.99860	19,408	*9,670.3659*	*9,670.2305*	30,205	*15,050.1547*	*15,049.9439*	68,539	*34,150.7219*	51,977	*25,898.4238*	79,094	*39,409.9300*	80,289	*40,005.3591*	436.75
25/01/2008	242,362	52.7266	127,789.2422	99.99860	35,262	*18,592.4536*	*18,592.1933*	35,244	*18,582.9629*	*18,582.7027*	54,933	*28,964.3031*	42,505	*22,411.4413*	51,261	*27,028.1824*	57,499	*30,317.2677*	327.41
26/01/2008	311,259	49.0616	152,708.6455	99.99860	35,070	*17,205.9031*	*17,205.6622*	21,250	*10,425.5900*	*10,425.4440*	68,023	*33,373.1721*	55,441	*27,200.2416*	71,327	*34,994.1674*	81,953	*40,207.4530*	426.35
27/01/2008	329,225	48.8663	160,880.0761	99.99860	42,856	*20,942.1415*	*20,941.8483*	0	*0.0000*	*0.0000*	71,505	*34,941.8478*	59,445	*29,048.5720*	74,402	*36,357.5045*	80,547	*39,360.3386*	441.25
28/01/2008	330,097	48.6996	160,755.9186	99.99890	37,644	*18,332.4774*	*18,332.2757*	0	*0.0000*	*0.0000*	68,321	*33,272.0537*	60,439	*29,433.5512*	82,335	*40,096.8156*	81,636	*39,756.4054*	449.47
29/01/2008	333,349	50.2651	167,558.2081	99.99890	54,877	*27,583.9789*	*27,583.6754*	0	*0.0000*	*0.0000*	62,707	*31,519.7362*	59,088	*29,700.6422*	77,694	*39,052.9667*	80,896	*40,662.4552*	443.47
30/01/2008	328,800	50.5420	166,182.0960	99.99890	56,527	*28,569.8763*	*28,569.5620*	0	*0.0000*	*0.0000*	57,990	*29,309.3058*	57,842	*29,234.5036*	78,788	*39,821.0309*	80,283	*40,576.6338*	437.63
31/01/2008	334,246	49.2510	164,619.4974	99.99890	55,783	*27,473.6853*	*27,473.3830*	0	*0.0000*	*0.0000*	59,618	*29,362.4611*	58,905	*29,011.3015*	81,405	*40,092.7765*		*0.0000*	432.24
01/02/2008	322,460	49.6519	160,107.5167	99.99890	60,521	*30,049.8263*	*30,049.4957*	0	*0.0000*	*0.0000*	51,855	*25,746.9927*	56,710	*28,157.5924*	78,068	*38,762.2452*	78,469	*38,961.3494*	410.77
02/02/2008	319,640	49.6971	158,851.8104	99.99890	59,257	*29,449.0105*	*29,448.6865*	0	*0.0000*	*0.0000*	57,784	*28,716.9722*	56,122	*27,891.0064*	77,551	*38,540.5980*	70,925	*35,247.6681*	408.66
03/02/2008	325,503	48.6693	158,420.0315	99.99890	57,541	*28,004.8019*	*28,004.4938*	0	*0.0000*	*0.0000*	51,071	*24,855.8982*	58,365	*28,405.8369*	79,053	*38,474.5417*	81,941	*39,880.1111*	412.26
04/02/2008	326,777	48.5706	158,717.5495	99.99890	43,032	*20,900.9005*	*20,900.6705*	0	*0.0000*	*0.0000*	61,399	*29,821.8626*	59,628	*28,961.6773*	81,269	*39,472.8409*	82,298	*39,972.6323*	435.28
05/02/2008	318,766	49.8042	158,758.8561	99.99890	53,003	*26,397.7201*	*26,397.4297*	0	*0.0000*	*0.0000*	53,239	*26,515.2580*	53,720	*26,754.8162*	79,283	*39,486.2638*	82,007	*40,842.9302*	412.96
06/02/2008	329,648	49.5407	163,309.9267	99.99890	51,316	*25,422.3056*	*25,422.0259*	0	*0.0000*	*0.0000*	64,359	*31,883.8991*	57,481	*28,476.4897*	74,250	*36,783.9697*	81,969	*40,608.0163*	434.93
07/02/2008	331,231	49.5249	164,041.8215	99.99890	51,199	*25,356.2535*	*25,355.9745*	0	*0.0000*	*0.0000*	70,508	*34,919.0164*	59,389	*29,412.3428*	67,820	*33,587.7871*	82,246	*40,732.2492*	436.91
08/02/2008	331,040	49.7263	164,613.9435	99.99890	52,633	*26,172.4434*	*26,172.1555*	0	*0.0000*	*0.0000*	67,545	*33,587.6293*	58,198	*28,939.7120*	70,855	*35,233.5698*	82,086	*40,818.3306*	435.15
09/02/2008	327,260	49.5772	162,246.3447	99.99890	52,595	*26,075.1283*	*26,074.8414*	0	*0.0000*	*0.0000*	69,797	*34,603.3982*	57,994	*28,751.8013*	67,410	*33,419.9905*	79,329	*39,329.0969*	428.77
10/02/2008	328,380	49.0038	160,918.6784	99.99890	44,253	*21,685.6516*	*21,685.4130*	0	*0.0000*	*0.0000*	65,795	*32,242.0502*	58,261	*28,550.1039*	78,670	*38,551.2894*	82,511	*40,433.5254*	438.96
11/02/2008	325,345	49.6080	161,397.1476	99.99890	41,353	*20,514.3962*	*20,514.1705*	0	*0.0000*	*0.0000*	70,054	*34,752.3883*	54,924	*27,246.6979*	79,380	*39,378.8304*	80,470	*39,919.5576*	443.12

DATE	MAIN PIPELINE							SECONDARY PIPELINE			ELECTRICITY GENERATION								
	COLLECTING SYSTEM				FLARE F100			FLARE F200			FIR300		FIR400		FIR500		FIR600		Eletricity Exported (MWh)
	LFG measured FIR100 (Nm^3)	Methane (%)	*Methane measured FIR100 (Nm^3)*	Flares Efficiencies (%)	LFG measured FIR200 (Nm^3)	*Methane measured FIR200 (Nm^3)*	*Methne Destroyed in F100 (Nm^3)*	LFG measured FIR700 (Nm^3)	*Methane measured FIR700 (Nm^3)*	*Methne Destroyed F200 (Nm^3)*	LFG measured (Nm^3)	*Methane measured (Nm^3)*	LFG measured (Nm^3)	*Methane measured (Nm^3)*	LFG measured (Nm^3)	*Methane measured (Nm^3)*	LFG measured (Nm^3)	*Methane measured (Nm^3)*	
	A	B	*C = A . B*	D	E	*F = E . B*	*G = F . D*	H	*I = H . B*	*J = I . D*	K	*L = K . B*	M	*N = M . B*	O	*P = O . B*	Q	*R = Q . B*	S
12/02/2008	300,791	49.9147	150,138.9252	99.99890	40,565	*20,247.8980*	*20,247.6752*	0	*0.0000*	*0.0000*	63,821	*31,856.0606*	51,546	*25,729.0312*	70,042	*34,961.2541*	75,058	*37,464.9755*	404.51
13/02/2008	291,086	50.0794	145,774.1222	99.99890	24,804	*12,421.6943*	*12,421.5576*	17,615	*8,821.4863*	*8,821.3892*	65,172	*32,637.7465*	53,769	*26,927.1925*	68,848	*34,478.6653*	74,864	*37,491.4420*	418.56
14/02/2008	301,877	49.0742	148,143.7227	99.99890	12,103	*5,939.4504*	*5,939.3850*	30,687	*15,059.3997*	*15,059.2340*	71,333	*35,006.0990*	58,774	*28,842.8703*	80,370	*39,440.9345*	78,953	*38,745.5531*	448.61
15/02/2008	258,434	51.4487	132,960.9333	99.99890	26,083	*13,419.3644*	*13,419.2167*	27,404	*14,099.0017*	*14,098.8466*	60,927	*31,346.1494*	50,919	*26,197.1635*	60,051	*30,895.4588*	59,194	*30,454.5434*	365.73
16/02/2008	317,122	50.0619	158,757.2985	99.99890	27,240	*13,636.8615*	*13,636.7114*	28,601	*14,318.2040*	*14,318.0464*	70,034	*35,060.3510*	58,972	*29,522.5036*	77,805	*38,950.6612*	83,156	*41,629.4735*	436.66
17/02/2008	288,588	49.7063	143,446.4170	99.99890	21,979	*10,924.9476*	*10,924.8274*	35,571	*17,681.0279*	*17,680.8334*	69,469	*34,530.4695*	50,775	*25,238.3738*	69,972	*34,780.4922*	76,263	*37,907.5155*	431.26
18/02/2008	300,176	49.9779	150,021.6611	99.99890	24,807	*12,398.0176*	*12,397.8812*	32,322	*16,153.8568*	*16,153.6791*	70,242	*35,105.4765*	52,731	*26,353.8464*	70,264	*35,116.4716*	81,459	*40,711.4975*	431.98
19/02/2008	273,872	51.4088	140,794.3087	99.99890	24,473	*12,581.2756*	*12,581.1372*	33,805	*17,378.7448*	*17,378.5536*	58,280	*29,961.0486*	57,306	*29,460.3269*	60,744	*31,227.7614*	73,382	*37,724.8056*	396.86
20/02/2008	301,553	50.8838	153,441.6254	99.99890	32,809	*16,694.4659*	*16,694.2822*	28,877	*14,693.7149*	*14,693.5532*	64,572	*32,856.6873*	65,928	*33,546.6716*	60,478	*30,773.5045*	76,302	*38,825.3570*	429.02
21/02/2008	290,631	50.3778	146,413.5039	99.99890	28,027	*14,119.3860*	*14,119.2306*	27,705	*13,957.1694*	*13,957.0158*	60,207	*30,330.9620*	65,086	*32,788.8949*	60,575	*30,516.3523*	75,795	*38,183.8535*	411.78
22/02/2008	312,361	49.2066	153,702.2278	99.99890	28,780	*14,161.6594*	*14,161.5036*	26,294	*12,938.3834*	*12,938.2410*	69,455	*34,176.4440*	69,094	*33,998.8082*	66,654	*32,798.1671*	76,575	*37,679.9539*	438.27
23/02/2008	308,156	48.6409	149,889.8518	99.99890	18,869	*9,178.0514*	*9,177.9504*	30,100	*14,640.9109*	*14,640.7498*	72,748	*35,385.2819*	72,814	*35,417.3849*	67,741	*32,949.8320*	72,612	*35,319.1303*	430.42
24/02/2008	317,034	48.8416	154,844.4781	99.99890	25,220	*12,317.8515*	*12,317.7160*	17,019	*8,312.3519*	*8,312.2604*	72,639	*35,478.0498*	72,517	*35,418.4630*	68,949	*33,675.7947*	75,551	*36,900.3172*	459.50
25/02/2008	305,570	48.9982	149,723.7997	99.99890	23,734	*11,629.2327*	*11,629.1047*	16,845	*8,253.7467*	*8,253.6559*	71,766	*35,164.0482*	72,010	*35,283.6038*	66,284	*32,477.9668*	69,537	*34,071.8783*	428.91
26/02/2008	288,523	49.5207	142,878.6092	99.99890	29,733	*14,723.9897*	*14,723.8277*	30,702	*15,203.8453*	*15,203.6780*	66,654	*33,007.5273*	68,195	*33,770.6413*	56,686	*28,071.3040*	63,568	*31,479.3185*	399.31
27/02/2008	297,668	48.7706	145,174.4696	99.99890	16,322	*7,960.3373*	*7,960.2497*	29,306	*14,292.7120*	*14,292.5547*	71,012	*34,632.9784*	72,502	*35,359.6604*	65,806	*32,093.9810*	68,752	*33,530.7629*	430.06
28/02/2008	295,386	49.1048	145,048.7045	99.99890	21,052	*10,337.5424*	*10,337.4286*	21,900	*10,753.9512*	*10,753.8329*	71,748	*35,231.7119*	67,742	*33,264.5736*	67,380	*33,086.8142*	64,937	*31,887.1839*	422.06
29/02/2008	287,538	48.7954	140,305.3172	99.99890	9,334	*4,554.5626*	*4,554.5124*	27,241	*13,292.3549*	*13,292.2086*	72,253	*35,256.1403*	70,141	*34,225.5815*	65,755	*32,085.4152*	67,342	*32,859.7982*	428.83
01/03/2008	291,449	49.1622	143,282.7402	99.99890	21,187	*10,415.9953*	*10,415.8807*	31,616	*15,543.1211*	*15,542.9501*	70,582	*34,699.6640*	71,740	*35,268.9622*	60,974	*29,976.1598*	65,879	*32,387.5657*	417.92
02/03/2008	270,498	49.7516	134,577.0829	99.99890	38,228	*19,019.0416*	*19,018.8323*	36,001	*17,911.0735*	*17,910.8764*	57,362	*28,538.5127*	66,884	*33,275.8601*	44,519	*22,148.9148*	61,037	*30,366.8840*	359.39
03/03/2008	298,480	48.6701	145,270.5144	99.99890	27,165	*13,221.2326*	*13,221.0871*	24,258	*11,806.3928*	*11,806.2629*	70,976	*34,544.0901*	66,615	*32,421.5871*	65,070	*31,669.6340*	66,724	*32,474.6375*	414.26
04/03/2008	301,008	48.6898	146,560.1931	99.99890	20,331	*9,899.1232*	*9,899.0143*	17,530	*8,535.3219*	*8,535.2280*	69,039	*33,614.9510*	70,789	*34,467.0225*	74,275	*36,164.3489*	66,347	*32,304.2216*	431.36
05/03/2008	293,731	48.4543	142,325.2999	99.99890	14,732	*7,138.2874*	*7,138.2088*	26,103	*12,648.0259*	*12,647.8867*	69,889	*33,864.2257*	71,261	*34,529.0187*	76,293	*36,967.2390*	60,607	*29,366.6976*	425.49
06/03/2008	295,927	48.9228	144,775.7743	99.99890	11,395	*5,574.7530*	*5,574.6916*	17,093	*8,362.3742*	*8,362.2822*	72,151	*35,298.2894*	66,955	*32,756.2607*	77,634	*37,980.7265*	66,692	*32,627.5937*	436.86
07/03/2008	285,245	49.3268	140,702.2306	99.99890	5,169	*2,549.7022*	*2,549.6741*	20,739	*10,229.8850*	*10,229.7724*	69,843	*34,451.3169*	66,279	*32,693.3097*	76,898	*37,931.3226*	65,239	*32,180.3110*	432.03
08/03/2008	282,647	50.3274	142,248.8862	99.99890	27,985	*14,084.1228*	*14,083.9678*	18,161	*9,139.9591*	*9,139.8585*	65,167	*32,796.8567*	68,033	*34,239.2400*	59,806	*30,098.8048*	57,800	*29,089.2372*	395.74

DATE	MAIN PIPELINE							SECONDARY PIPELINE			ELECTRICITY GENERATION								
	COLLECTING SYSTEM				FLARE F100			FLARE F200			FIR300		FIR400		FIR500		FIR600		Eletricity Exported (MWh)
	LFG measured FIR100 (Nm^3)	Methane (%)	*Methane measured FIR100 (Nm^3)*	Flares Efficiencies (%)	LFG measured FIR200 (Nm^3)	*Methane measured FIR200 (Nm^3)*	*Methne Destroyed in F100 (Nm^3)*	LFG measured FIR700 (Nm^3)	*Methane measured FIR700 (Nm^3)*	*Methne Destroyed F200 (Nm^3)*	LFG measured (Nm^3)	*Methane measured (Nm^3)*	LFG measured (Nm^3)	*Methane measured (Nm^3)*	LFG measured (Nm^3)	*Methane measured (Nm^3)*	LFG measured (Nm^3)	*Methane measured (Nm^3)*	
	A	B	*C = A . B*	D	E	*F = E . B*	*G = F . D*	H	*I = H . B*	*J = I . D*	K	*L = K . B*	M	*N = M . B*	O	*P = O . B*	Q	*R = Q . B*	S
09/03/2008	301,260	49.6219	149,490.9359	99.99890	20,894	*10,367.9997*	*10,367.8856*	14,579	*7,234.3768*	*7,234.2972*	71,118	*35,290.1028*	70,960	*35,211.7002*	74,375	*36,906.2881*	61,037	*30,287.7191*	434.64
10/03/2008	293,126	49.8596	146,151.4510	99.99890	16,809	*8,380.9001*	*8,380.8079*	17,829	*8,889.4680*	*8,889.3702*	68,393	*34,100.4762*	69,744	*34,774.0794*	74,145	*36,968.4004*	61,159	*30,493.6327*	428.77
11/03/2008	291,141	48.7328	141,881.1612	99.99890	86	*41.9102*	*41.9097*	26,898	*13,108.1485*	*13,108.0043*	69,350	*33,796.1968*	71,000	*34,600.2880*	82,121	*40,019.8626*	66,697	*32,503.3156*	445.62
12/03/2008	301,434	48.9417	147,526.9239	99.99890	13,669	*6,689.8409*	*6,689.7673*	13,249	*6,484.2858*	*6,484.2144*	69,125	*33,830.9501*	68,643	*33,595.0511*	82,088	*40,175.2626*	65,991	*32,297.1172*	441.47
13/03/2008	298,664	49.6732	148,355.9660	99.99890	29,834	*14,819.5024*	*14,819.3393*	15,681	*7,789.2544*	*7,789.1687*	66,597	*33,080.8610*	66,269	*32,917.9329*	71,768	*35,649.4621*	63,657	*31,620.4689*	416.66
14/03/2008	303,784	49.5802	150,616.7147	99.99890	20,872	*10,348.3793*	*10,348.2654*	21,885	*10,850.6267*	*10,850.5073*	69,916	*34,664.4926*	68,069	*33,748.7463*	77,102	*38,227.3258*	66,090	*32,767.5541*	437.49
15/03/2008	299,378	49.6100	148,521.4258	99.99890	13,295	*6,595.6495*	*6,595.5769*	26,174	*12,984.9214*	*12,984.7785*	71,173	*35,308.9253*	68,473	*33,969.4553*	77,050	*38,224.5050*	67,309	*33,391.9949*	441.3
16/03/2008	296,489	50.1478	148,682.7107	99.99890	20,105	*10,082.2151*	*10,082.1041*	26,400	*13,239.0192*	*13,238.8735*	71,086	*35,648.0651*	67,711	*33,955.5768*	76,379	*38,302.3881*	57,818	*28,994.4550*	427.07
17/03/2008	308,444	50.4982	155,758.6680	99.99890	22,637	*11,431.2775*	*11,431.1517*	23,052	*11,640.8450*	*11,640.7169*	69,253	*34,971.5184*	67,614	*34,143.8529*	79,331	*40,060.7270*	66,488	*33,575.2432*	447.78
18/03/2008	244,377	53.7891	131,448.1889	99.99890	26,903	*14,470.8815*	*14,470.7223*	35,746	*19,227.4516*	*19,227.2400*	48,925	*26,316.3171*	56,549	*30,417.1981*	58,489	*31,460.7066*	51,167	*27,522.2687*	345.22
19/03/2008	268,806	52.4456	140,976.9195	99.99890	2,563	*1,344.1807*	*1,344.1659*	33,701	*17,674.6916*	*17,674.4971*	60,091	*31,515.0854*	67,500	*35,400.7800*	72,390	*37,965.3698*	63,256	*33,174.9887*	418.18
20/03/2008	268,894	52.4190	140,951.5458	99.99890	2,563	*1,343.4989*	*1,343.4841*	31,137	*16,321.7040*	*16,321.5244*	60,162	*31,536.3187*	67,621	*35,446.2519*	72,543	*38,026.3151*	63,369	*33,217.3961*	424.21
21/03/2008	267,318	51.9540	138,882.3937	99.99890	353	*183.3976*	*183.3955*	32,722	*17,000.3878*	*17,000.2007*	66,976	*34,796.7110*	69,642	*36,181.8046*	69,362	*36,036.3334*	60,452	*31,407.2320*	426.67
22/03/2008	281,271	51.1484	143,865.6161	99.99890	8,221	*4,204.9099*	*4,204.8636*	27,330	*13,978.8577*	*13,978.7039*	69,921	*35,763.4727*	63,539	*32,499.1818*	70,296	*35,955.2792*	66,948	*34,242.8308*	426.94
23/03/2008	304,941	48.8111	148,845.0564	99.99890	15,665	*7,646.2588*	*7,646.1746*	25,510	*12,451.7116*	*12,451.5746*	71,442	*34,871.6260*	69,827	*34,083.3267*	82,429	*40,234.5016*	63,087	*30,793.4586*	441.02
24/03/2008	304,608	49.0577	149,433.6788	99.99890	9,156	*4,491.7230*	*4,491.6735*	22,942	*11,254.8175*	*11,254.6936*	70,871	*34,767.6825*	71,621	*35,135.6153*	81,898	*40,177.2751*	68,740	*33,722.2629*	453.2
25/03/2008	296,823	49.5954	147,210.5541	99.99890	6,304	*3,126.4940*	*3,126.4596*	29,184	*14,473.9215*	*14,473.7622*	69,417	*34,427.6388*	70,917	*35,171.5698*	79,426	*39,391.6424*	67,847	*33,648.9910*	450.29
26/03/2008	308,999	49.0538	151,575.7514	99.99890	16,317	*8,004.1085*	*8,004.0204*	23,920	*11,733.6689*	*11,733.5398*	69,581	*34,132.1245*	70,504	*34,584.8911*	82,007	*40,227.5497*	68,367	*33,536.6114*	448.43
27/03/2008	307,418	49.0233	150,706.4483	99.99890	18,961	*9,295.3079*	*9,295.2056*	23,227	*11,386.6418*	*11,386.5165*	65,624	*32,171.0503*	71,555	*35,078.6223*	81,905	*40,152.5338*	68,822	*33,738.8155*	442.13
28/03/2008	306,720	49.2614	151,094.5660	99.99890	20,866	*10,278.8837*	*10,278.7706*	19,156	*9,436.5137*	*9,436.4098*	66,030	*32,527.3024*	70,345	*34,652.9318*	80,367	*39,589.9093*	68,555	*33,771.1527*	439.5
29/03/2008	303,434	48.5559	147,335.1096	99.99890	21,919	*10,642.9677*	*10,642.8506*	23,216	*11,272.7377*	*11,272.6136*	60,783	*29,513.7326*	64,162	*31,154.4365*	82,766	*40,187.7761*	73,831	*35,849.3065*	425.33
30/03/2008	298,663	48.3269	144,334.5693	99.99890	505	*244.0508*	*244.0481*	27,727	*13,399.5995*	*13,399.4521*	60,933	*29,447.0299*	73,118	*35,335.6627*	82,149	*39,700.0650*	81,067	*39,177.1680*	448.8
31/03/2008	298,393	48.8387	145,731.2620	99.99890	16	*7.8141*	*7.8140*	23,468	*11,461.4661*	*11,461.3400*	60,512	*29,553.2741*	72,728	*35,519.4097*	82,704	*40,391.5584*	81,759	*39,930.0327*	452.27

Obs: the calculation of *methane measured* and *methane destroyed* was conservatively made, using Excel tool “ROUND DOWN” with four decimal rounds.

Total Methane Destroyed in Flare F100 (Nm^3)	**1,170,766.9549**
Total Methane Destroyed in Flare F200 (Nm^3)	**1,015,883.7384**
Total Methane Measured by FIR300 (Nm^3)	**3,010,133.6244**
Total Methane Measured by FIR400 (Nm^3)	**2,812,058.7053**
Total Methane Measured by FIR500 (Nm^3)	**3,221,092.5724**
Total Methane Measured by FIR600 (Nm^3)	**3,277,818.9405**
Total Electricity Exported (MWh)	**38,736.4600**

4.2. Events registered

For this monitoring period, the following events were registered:

- In 27/01/2008 the flow-meter FIR700 faced some problems and was removed from the auxiliary pipeline until 13/02/2008, when it was reinstalled. During these 17 days, the gas sent to both flares was read by the flow-meter FIR200.

- In 16/02/2008, two readings of all variables were made from 23:00 to 23:59 due to the end of the Brazilian Summer Time (all clocks needed to delay one hour at 23:59:59). All variables (gas flows and methane concentration) were adjusted to incorporate the readings after the clock delay.

- In 31/01 and 19/03, the PLC has not registered the values of flow accumulated in the day, thus manual registrations at 23:59 from the operators were adopted.

4.3. Description and consideration of measurement uncertainties and error propagation

The readings from all equipments are subjected to internal errors from a standard value. These errors are measured and described in the Calibration Certificates, in terms of ± % from the standard adopted.

All calibrations usually have an expiration date, however the manufacturers of the flow-meters and pressure-temperature transmitters are Europeans and there are no rule in Europe specifying the calibration periodicity. Biogás decided to adopt a 5 years calibration frequency for every equipment.

The errors and the date of the calibration for each equipment are presented in the table below:

Methodology ID	Equipment	TAG	Error (%)	Date of the last calibration	Date of the next calibration
$LFG_{Total, y}$	Turbine Flow-meter	FIR100	0.600	Sep/2004	Sep/2009
$LFG_{Flare, y}$	Turbine Flow-meters	FIR200 FIR700	0.600 0.330	Sep/2004 Jun/2007	Sep/2009 Jun/2012
$LFG_{Electricity, y}$	Turbine Flow-meters	FIR300 FIR400 FIR500 FIR600	0.772 0.596 0.810 0.632	Jan/2007 Jan/2007 Jan/2007 Jan/2007	Jan/2012 Jan/2012 Jan/2012 Jan/2012
$w_{CH4, y}$	Methane Analyzer	A100	1.000	Dec/2003	Weekly, with a standard gas
T	Temperature Transmitter[2]	TT100 TT200 TT700 TT300 TT400 TT500 TT600	0.233 0.180 - 0.050 0.050 0.050 0.050	Oct/2007 Oct/2007 Jun/2007 Jan/2007 Jan/2007 Jan/2007 Jan/2007	Oct/2012 Oct/2012 Jun/2012 Jan/2012 Jan/2012 Jan/2012 Jan/2012
p	Pressure Transmitter[2]	PT100 PT200 PT700 PT300 PT400 PT500 PT600	0.010 0.010 - 0.034 0.038 0.370 0.444	Sep/2004 Sep/2004 Jun/2007 Jan/2007 Jan/2007 Jan/2007 Jan/2007	Sep/2009 Sep/2009 Jun/2012 Jan/2012 Jan/2012 Jan/2012 Jan/2012
EG_y	Electricity Meter	N/A	1.000	Sep/2004	Sep/2009

Adopting a conservative approach on Emission Reduction calculation, the equivalent error calculated was discounted from the amount of methane calculated for each flow-meter, according with the equations below:

$$\varepsilon_{FIR200} = \sqrt{\left(\varepsilon_{\text{Gas Flow}_{FIR200}}\right)^2 + \left(\varepsilon_{\text{Temperature}_{FIR200}}\right)^2 + \left(\varepsilon_{\text{Pressure}_{FIR200}}\right)^2 + \left(\varepsilon_{\text{Methane Analysis}}\right)^2}$$

$$\varepsilon_{FIR700} = \sqrt{\left(\varepsilon_{\text{Gas Flow, Pressure, Temperature}_{FIR700}}\right)^2 + \left(\varepsilon_{\text{Methane Analysis}}\right)^2}$$

$$\varepsilon_{FIR300} = \sqrt{\left(\varepsilon_{\text{Gas Flow}_{FIR300}}\right)^2 + \left(\varepsilon_{\text{Temperature}_{FIR300}}\right)^2 + \left(\varepsilon_{\text{Pressure}_{FIR300}}\right)^2 + \left(\varepsilon_{\text{Methane Analysis}}\right)^2}$$

$$\varepsilon_{FIR400} = \sqrt{\left(\varepsilon_{\text{Gas Flow}_{FIR400}}\right)^2 + \left(\varepsilon_{\text{Temperature}_{FIR400}}\right)^2 + \left(\varepsilon_{\text{Pressure}_{FIR400}}\right)^2 + \left(\varepsilon_{\text{Methane Analysis}}\right)^2}$$

$$\varepsilon_{FIR500} = \sqrt{\left(\varepsilon_{\text{Gas Flow}_{FIR500}}\right)^2 + \left(\varepsilon_{\text{Temperature}_{FIR500}}\right)^2 + \left(\varepsilon_{\text{Pressure}_{FIR500}}\right)^2 + \left(\varepsilon_{\text{Methane Analysis}}\right)^2}$$

$$\varepsilon_{FIR600} = \sqrt{\left(\varepsilon_{\text{Gas Flow}_{FIR600}}\right)^2 + \left(\varepsilon_{\text{Temperature}_{FIR600}}\right)^2 + \left(\varepsilon_{\text{Pressure}_{FIR600}}\right)^2 + \left(\varepsilon_{\text{Methane Analysis}}\right)^2}$$

4.4. Calculation of $LFG_{flared, y}$

The calculation of $LFG_{flared, y}$ is the sum of all measurements from FIR200 and FIR700 made during the monitoring period, minus the uncertainties of the flow-meters, as follows:

$$LFG_{\text{flared, y, corrected}} = \sum FIR_{200} \times \left(1 - \frac{\varepsilon_{FIR200}}{100}\right) + \sum FIR_{700} \times \left(1 - \frac{\varepsilon_{FIR700}}{100}\right)$$

Applying the erros from the table below in the equations previously presented:

$$\varepsilon_{FIR200} = \sqrt{0.600^2 + 0.1801^2 + 0.010^2 + 1.000^2} = 1.1801\%$$

$$\varepsilon_{FIR700} = \sqrt{0.330^2 + 1.000^2} = 1.0531\%$$

4.5. Calculation of $LFG_{electricity, y}$

The calculation of $LFG_{electricity, y}$ is the sum of all measurements from FIR300, FIR400, FIR500 and FIR600 made during the monitoring period, minus the uncertainties of the flow-meters, as follows:

$$LFG_{\text{electricity, y, corrected}} = \sum FIR_{300} \times \left(1 - \frac{\varepsilon_{FIR300}}{100}\right) + \sum FIR_{400} \times \left(1 - \frac{\varepsilon_{FIR400}}{100}\right) + \sum FIR_{500} \times \left(1 - \frac{\varepsilon_{FIR500}}{100}\right) + \sum FIR_{600} \times \left(1 - \frac{\varepsilon_{FIR600}}{100}\right)$$

Applying the erros from the table below in the equations previously presented:

$$\varepsilon_{FIR300} = \sqrt{0.772^2 + 0.050^2 + 0.0337^2 + 1.000^2} = 1.2648\%$$

$$\varepsilon_{FIR400} = \sqrt{0.596^2 + 0.050^2 + 0.0381^2 + 1.000^2} = 1.1659\%$$

$$\varepsilon_{FIR500} = \sqrt{0.810^2 + 0.050^2 + 0.370^2 + 1.000^2} = 1.3400\%$$

$$\varepsilon_{FIR600} = \sqrt{0.632^2 + 0.050^2 + 0.444^2 + 1.000^2} = 1.2646\%$$

4.6. Calculation of EG_y,

The calculation of EG_y is the sum of all measurements from the electricity-meter made during the monitoring period, minus the uncertainties of the electricity-meter, as follows:

$$EG_{y,\,corrected} = \sum EG_y \times \left(1 - \frac{\varepsilon_{EG}}{100}\right)$$

4.7. List of default values

- *Global Warming Potential of CH_4 (GWP_{CH4})* = 21 tCO_2e/tCH_4;
- *Emission Factor of the S-SE-CO Brazilian Grid (EF)* = 0.2677 tCO_2e/MWh;
- *Density of Methane, at STP (D_{CH4})* = 0.0007168 tons/Nm^3
- *AF* = Adjustment Factor (changes in the landfill legislation). For this monitoring period, no changes in the legislation were identified, thus the AF remains as the validated value (20%).

4.8. Table providing the formulas used

	Variable	Description
Flare F100	A_{F100} (see last table from item 4.1)	Total methane destroyed in flare F100 (Nm^3)
	B_{F100}	Total error from measuring equipment (%) – see item 4.4
	$C_{F100} = A_{F100} . (1-B_{F100})$	**Total methane corrected destroyed at the flare F100 (Nm^3)**
Flare F200	A_{F200} (see last table from item 4.1)	Total methane destroyed in flare F200 (Nm^3)
	B_{F200}	Total error from measuring equipment (%) – see item 4.4
	$C_{F200} = A_{F200} . (1-B_{F200})$	**Total methane corrected destroyed at the flare F200 (Nm^3)**
Power House	A_{FIRi}[5] (see last table from item 4.1)	Methane flow to the power house measured by FIRi (Nm^3)
	B_{FIRi}[5]	Total measuring error from FIRi (%) – see item 4.5
	C_{FIRi}[5] $= A_{FIRi} . (1 - B_{FIRi})$	**Total methane corrected measured by FIRi (Nm^3)**
	$D_{power\ house} = C_{FIR300} + C_{FIR400} + C_{FIR500} + C_{FIR600}$	**Total methane corrected destroyed at the electricity (Nm^3)**
CO_2e	$A = C_{F100} + C_{F200} + D_{power\ house}$	Total methane destroyed in the period (Nm^3)

[5] Obs: calculation made individually for each Flow-Meter (FIR_{300}, FIR_{400}, FIR_{500} and FIR_{600})

Methane	B = 0.0007168	Density of Methane at the STPC (tCH_4/Nm^3)
	C = A . B	Total weight of methane destroyed (tCH_4)
	D = 21	CO_2 equivalency (tCO_2e/tCH_4)
	E = C . D	Total equivalent carbon (tCO_2e)
	F = 20%	Adjustment Factor (%)
	G = E . (1-F)	**Total Liquid Carbon (tCO_2e)**
CO_2e Electricity	H (see last table from item 4.1)	Total electricity exported (MWh)
	I	Electricity-meter error (%)
	J = H . (1 – I)	Total electricity corrected (MWh)
	K = 0.2677	Emission Factor (tCO_2e/MWh)
	L = J . K	**Total CO_2e from the energy exported (tCO_2e)**
TOTAL	**M = G + L**	**TOTAL CREDITS DURING THE PERIOD (tCO_2e)**

Cells in red means that the calculation was made using the Excel tool "DOWN.ROUND" with zero decimal rounds, in order to assure conservativeness.

4.9. GHG emission reductions

	TOTAL
Total CO_2e from methane destroyed	172,536
Total CO_2e from electricity dispatched	10,266
TOTAL CO_2e	**182,802**

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