Imagine the result

Bandeirantes Landfill Gas to Energy Project (BLFGE)

Monitoring Report – Version 01
12th Verification
Monitoring Period: 01/04/2009 to 30/06/2009

São Paulo, July 2nd 2009

Clean Development Mechanism

Monitoring Report – Version 01

Bandeirantes Landfill Gas to Energy Project (BLFGE)

12th Verification
Monitoring Period: 01/04/2009 to 30/06/2009

Biogás Energia Ambiental SA

São Paulo
July 2nd 2009

ARCADIS TETRAPLAN

Table of Contents

1. General Project Activity Information 1
1.1. Title and Registration Number of the Project Activity 1
1.2. Short Description of the Project Activity: 1
1.3. Real Project Implementation 1
1.4. Changes against the PDD 4
1.5. Monitoring Period 4
1.6. Methodology applied to the project activity 4
1.6.1. Baseline methodology 4
1.6.2. Monitoring methodology 4
1.7. Changes since last verification 4
1.8. Person(s) responsible for the preparation and submission of the monitoring report 4
2. Monitoring of the Project Activity 6
2.1. Monitoring Plan 6
2.2. Monitoring Equipment 7
2.2.1. Data Acquisition 10
2.2.2. Involvement of Third Parties 13
2.3. Quality assurance and quality control measures 13
2.3.1. Internal Procedures and ISO14001 13
2.3.2. Organizational Structure, responsibilities and competencies 14
2.3.3. Trainings 15
2.3.4. Data Protection Measures 15
3. Application of GHG determination methods 17
3.1. Calculation of Emission Reductions 17
3.1.1. Calculation of FE – Flare Efficiency 18
4. Monitored and Calculated Data 22
4.1. Table presenting the monitored data 22
4.2. Events registered 26
4.3. Description and consideration of measurement uncertainties and error propagation 28
4.4. Calculation of $LFG_{flared, y}$ 35
4.5. Calculation of $LFG_{electricity, y}$ 35
4.6. Calculation of EG_{y}, ... 37
4.7. List of default values 37
4.8. Table providing the formulas used 38
4.9. GHG emission reductions 38

List of Figures

Figure 1-1. Bandeirantes Landfill Cells 1

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

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

Figure 1-4. Turbine Flow-meter...3

Figure 1-5. Generators used to produce electricity....................................3

Figure 1-6. Flare used to destroy the surplus gas collected 3

Figure 2-1. Lay-out of the Degassing Station...8

Figure 2-2. PLC Controlling System panel
....1
0

Figure 2-3. General Organogram and Responsibility Matrix of Biogás Energia Ambiental 15

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. Three main units can be detached: the substation, the degassing stations and the power plant.

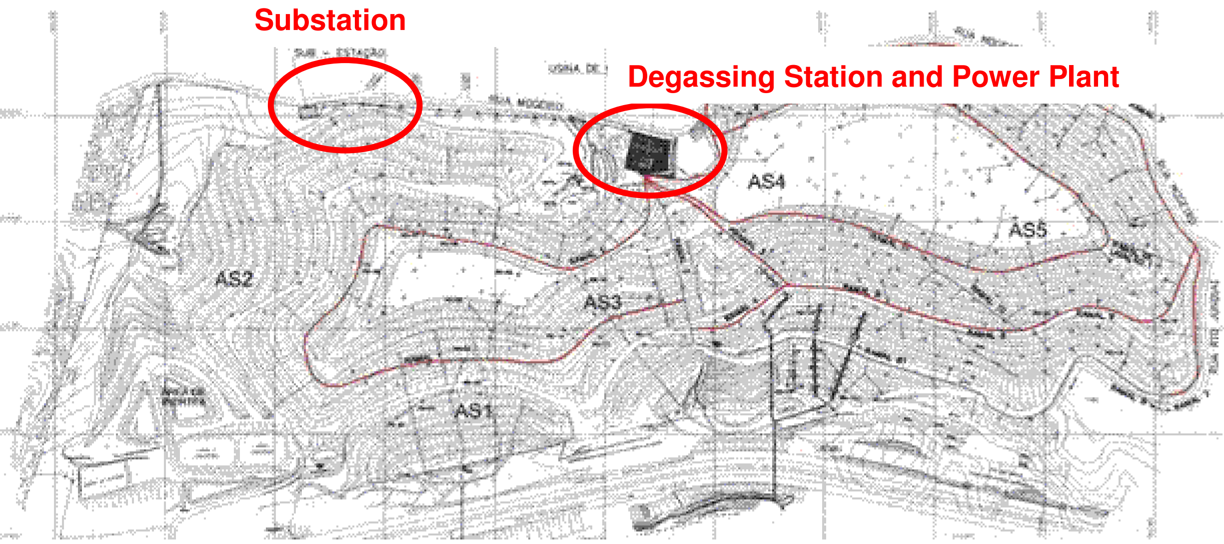


Figure 1-1. Bandeirantes Landfill Cells

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^{o}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, measured at the substation. 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;
- 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 4^{th} Verification.

1.5. Monitoring Period

The monitoring period is from 01/04/2009 to 30/06/2009.

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

The following changes were identified since the last verification:

- Installation of 4 new temperature transmitters in flow-meters FIR300, FIR400, FIR500 and FIR600, in 07/04/2009;
- Installation of a new flow-meter FIR700, in 11/05/2009, which was removed and sent to recalibration on 29/06/2009.

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

This monitoring report was developed and reviewed by:

Eduardo Cardoso Filho
ARCADIS Tetraplan S/A
Avenida Nove de Julho, 5966 – Térreo
São Paulo – SP
Brazil
CEP: 01406-200

Antônio Carlos Delbin
Biogás Energia Ambiental
Rua Mogeiro, 1510
São Paulo – SP
Brazil
CEP: 05206-240

ARCADIS TETRAPLAN

Biogás ENERGIA AMBIENTAL S/A

Phone/Fax: + 55 (11) 3060-8457
http://www.tetraplan.com.br
eduardo.cardoso@tetrapan.com.br

Phone/Fax: + 55 (11) 3918-4833
http://www.biogas-ambiental.com.br
delbin@biogas-ambiental.com.br

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 approved on 29/01/2008. 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	Measured by a flow meter, located in the gas line. Normal cubic meters represent the gas volume in cubic meters at STP. Data will be aggregated monthly and yearly. After the installation of the mini-blower, the measurements will be made by two flow meters – the first one was presented above and the second one located in a dedicated line connected to a mini-blower. 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: the operation hours (1) and methane content in the exhaust gas (2)	%	M / C	(1) Continuously, (2)quarterly, monthly if unstable	N/A	E	During the crediting period and two years after	(1) Continuous measurement of operation time of flare (e.g. with temperature). (2) 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 by continuous gas quality analyzer.
	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. BLFGE will measure the total electricity fed into the grid (via an electricity-meter).
EF_y[1]	Emission Factor	tCO_2/MWh	C	At baseline renewal	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.

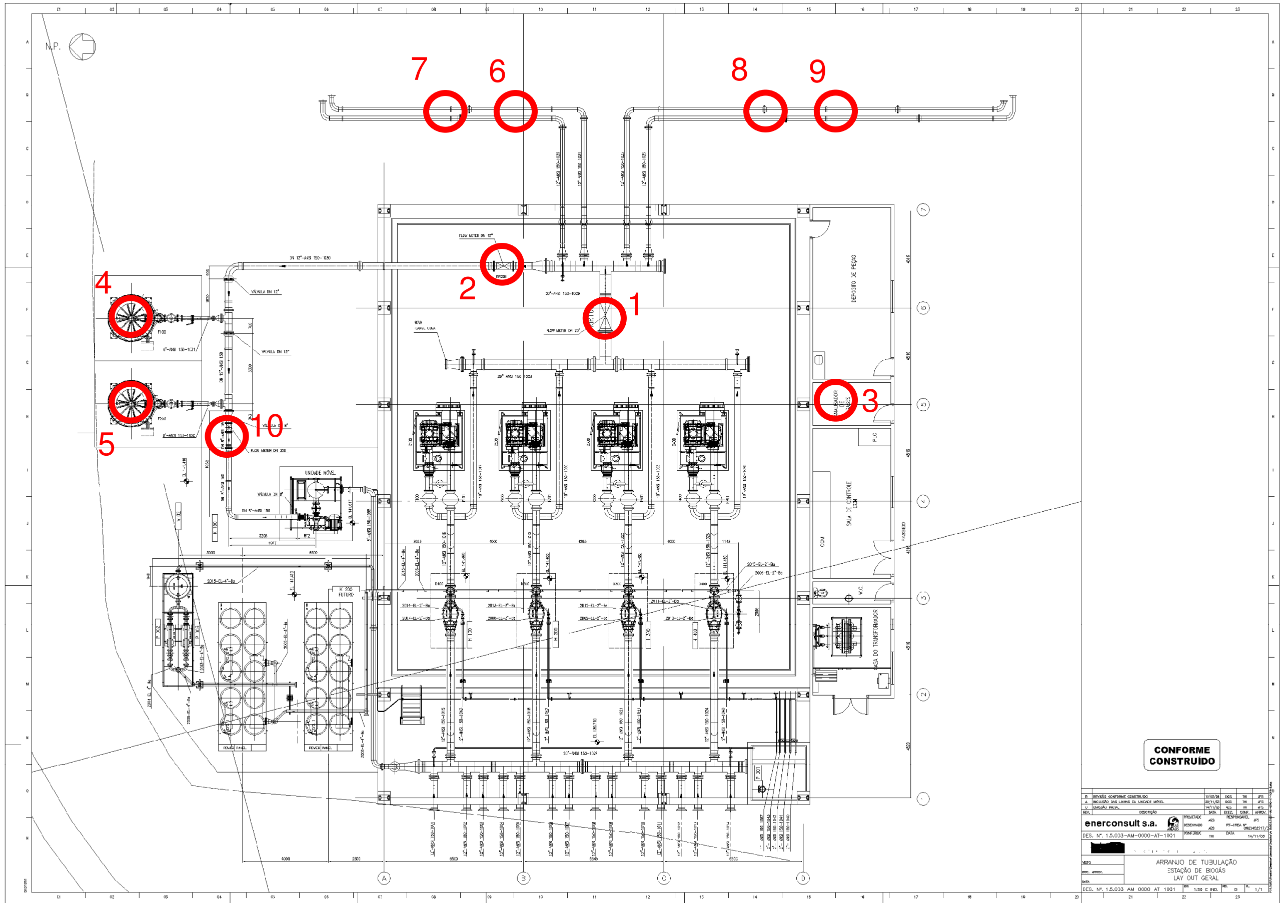


Figure 2-1. Lay-out of the Degassing Station

Method. ID	Equipment Number	Equipment	Location	TAG	Manufacturer	Model	Range	Error (%)
$LFG_{Total,\ y}$	1	Turbine Flow-meter [2]	Main Line	FIR100	Instromet	SM-RI-X-K	800-16,000 m^3/h	0.600
$LFG_{Flare,\ y}$	2 10	Turbine Flow-meters [2]	Line to Flare F100 Auxiliary Line	FIR200 FIR700	Instromet Incontrol[3]	SM-RI-X-K VTGEX-200	320-6,500 m^3/h 170-8,156 m^3/h	0.300 50.64
$LFG_{Electricity,\ y}$	6 7 8 9	Turbine Flow-meters [2]	Line to the Power House Line to the Power House Line to the Power House Line to the Power House	FIR300 FIR400 FIR500 FIR600	Incontrol Incontrol Incontrol Incontrol	VTGEX-200 VTGEX-200 VTGEX-200 VTGEX-200	170-8,156 m^3/h 170-8,156 m^3/h 170-8,156 m^3/h 170-8,156 m^3/h	0.772 0.596 0.632 0.811
FE_{F100}	4	(1) Thermocouple (2) Chromatographer – analysis made by a Third Party	Flare F100	(1) TAC520 (2)N/A	(1) Jumo (2) N/A	(1) type "S" L750 (2) N/A	(1) 0-1,600°C (2) N/A	N/A
FE_{F200}	5	(1) Thermocouple (2) Chromatographer – analysis made by a Third Party	Flare F200	(1) TAC570 (2)N/A	(1) Jumo (2) N/A	(1) type "S" L750 (2) N/A	(1) 0-1,600°C (2) N/A	N/A
$w_{CH4,\ y}$	3	Methane Analyzer	Analysis Room	A100	Rosemount-NUK	Binos 100	0-100%	1.000
EG_y		Electricity Meter	Substation	N/A	Merlin Gerin	Power Logic - CM 4000	240V/300V - 96mA MAX.	1.000

[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 monitored; however the erros from the transmitters were discounted from the final calculation.

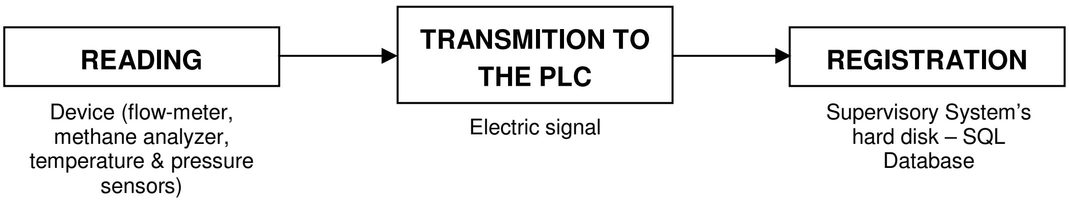
[3] The flow-meter was installed in 14/04/2009 but was connected to the PLC only from 11/05/2009 on, when it started to register the gas-flow, temperature and pressure.

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 presented in the figure below:



Depending on the paremeter, 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	Continuously	Continuously	Every 5 minutes	- Data accumulated every 1 hour is registered in the SQL's database, 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; - Every 3 hours, the operators perfom the "Print-Screen" of the controlling system panel; - Responsibilties of the routine: PLC (continuously) and plant supervisor (monthly)
$LFG_{Flare, y}$	FIR200 FIR700	Continuously Continuously	Continuously Continuously	Every 5 minutes Every 5 minutes	
$LFG_{Electricity, y}$	FIR300 FIR400 FIR500 FIR600	Continuously Continuously Continuously Continuously	Continuously Continuously Continuously Continuously	Every 5 minutes Every 5 minutes Every 5 minutes Every 5 minutes	
FE_{F100}	(1) TAC520 (2) N/A	(1) Continuously (2) Every 3 months, by a specialized company on gas analysis	(1) Continuously (2) Every 3 months, by a specialized company on gas analysis	(1) Every 5 minutes (2) Every 3 months, by a specialized company on gas analysis	- Temperatures below 900°C indicates that the flare is running out of the specified combustion temperature range; - A sudden decrease of temperature indicates that the main valve of the flare is closed and no gas is being sent to the flare (please, refer to item 3.1.1) - The methane analysis in the exhaust gas is made according with internal procedures from the hired company
FE_{F200}	(1) TAC570 (2) N/A	(1) Continuously (2) Every 3 months, by a specialized company on gas analysis	(1) Continuously (2) Every 3 months, by a specialized company on gas analysis	(1) Every 5 minutes (2) Every 3 months, by a specialized company on gas analysis	
$w_{CH4, y}$	A100	Continuously	Continuously	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

Methodology ID	Equipment TAG	Reading Frequency	Transmition Frequency	Registration Frequency	Comments
					(monthly)
EG_y	N/A	Continuously	Continuously	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 CORPLAB, 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. Additionally, the operators are oriented to perform the "Print-Screen" of the control system panel of the PLC. The picture is saved in the computer's hard-disk.

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 was certified with ISO 14001 in 21/10/2008, as per raised during the 1st Verification, in 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, according with the organogram below.

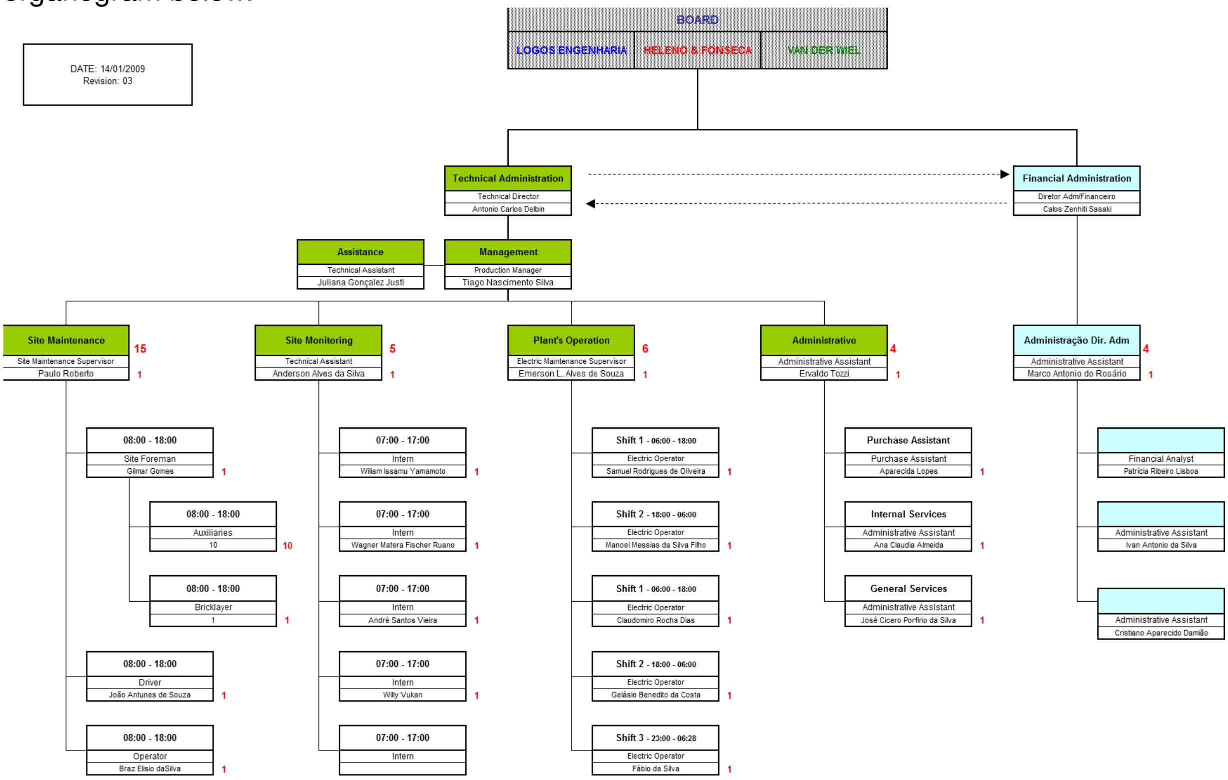


Figure 2-3. General Organogram of Biogás

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:

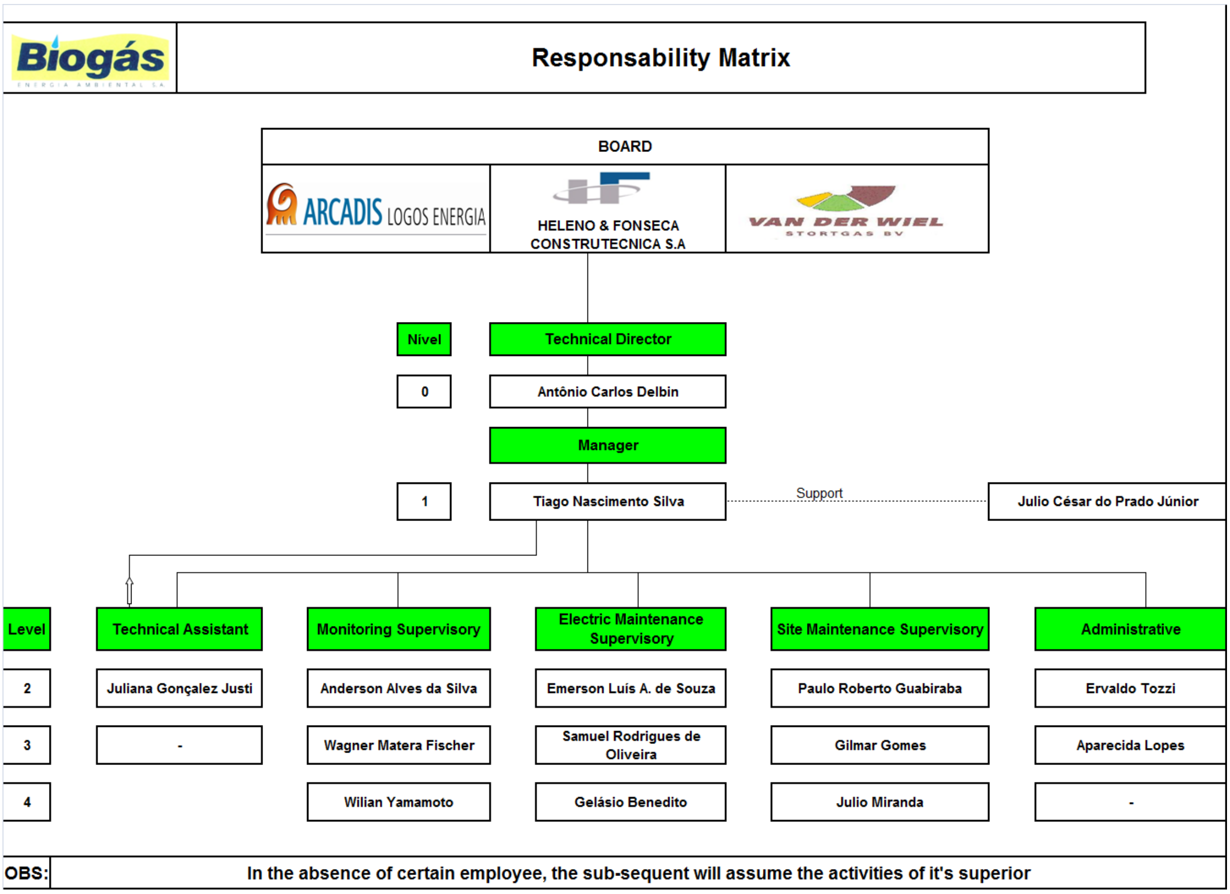


Figure 2-4. Responsibility Matrix of Biogás Energia Ambiental

2.3.3. Trainings

All training was supplied to operators and technical assistants before the project's implementation. The training certificates were presented to the Verification Team.

For this montoring period, no new operators were hired.

2.3.4. Data Protection Measures

As all data registered in the Supervisory 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, via a CARS (Central Alarming and Registration System);

- ARCADIS Tetraplan downloads regularly 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 reductions 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:

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

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:

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

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

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:

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

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

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 ($Flow_{Total}$):

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

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):

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

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

CORPLAB made two analysis of the methane content in the exhaust gas of the flares F200 and F100 on 20/01/2009 (Flare F200) and 23/01/2009 (Flare F100) and on 23/04/2009.

Flare	January/2009 [5]	April/2009 [6]
F100	1.0 mg/Nm^3	0.5 mg/Nm^3
F200	3.0 mg/Nm^3	0.5 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.
[5] The values presented from the analysis of January/2009 correspond to the highest value detected among 25 measurements
[6] The values presented from the analysis of November/2008 correspond to the highest value detected among 25 measurements

Measurement	$Flow_{FIRi}$		Methane %	
	FIR200	FIR700	F100	F200
January/2009	600 Nm^3/h	720 Nm^3/h	47.5%	48.0%
April/2009	8,400 Nm^3/h	7,440 Nm^3/h	46.0%	47.9%

The results were:

Measurement	Flare Efficiency Calculated	
	F100	F200
January/2009	99.9990%	99.9970%
April/2009	99.9995%	99.9995%

The flare efficiency adopted from 01/04/2008 to 22/04/2009 is 99.9970% and the flare efficieny adopted from 23/04/2009 to 30/06/2009 was 99.9995% (the lowest efficiencies calculated).

Monitoring of the operation time of the flares is made continuously by the PLC and every 5 minutes the instantaniouslly temperature is registered by the supervisory system. In order to guarantee the real destruction of the gas, the flares are equipped with an automatic system which can detects the existence of flame. The following operational procedure is applied:

- a signal of gas being collected is sent to the PLC, which sends a signal to a solenoid valve;
- the valve is opened and a small amount of gas is delivered to an ignition burner;
- the ignition burner ignites the gas;
- an UV-sond (part of the ignition burner) verifies the existence of an stable flame – if not, the flare is stopped;
- if the stable flame detection is succesfull, the UV-sond sends a signal to the PLC, which then opens the main valve, located in the entrance of the flare;
- the main burner is ignited and gas begans to be destroyed;
- after a few seconds, the ignition burner is switched off and UV-sond begans to monitor the existence of flame in the flare – if no flame is detected, the flare will be automatically stopped by a signal sent from the UV-sond to the PLC;

According with the manufacturer, if the temperature of the flare is higher than 1,350°C, the flare will be stopped automatically and if the temperature is below 900°C an alarm is indicating the operator that the flare is running out of the specified combustion temperature range.

If temperature decreases significantly from one registration to another (5 minutes interval), it means that the main valve is closed – the flare is stopped and no gas is being burned. It can be confirmed that no gas is being burned by the instant reading of gas flow from the flow-meters FIR200 and FIR700.

However, in some readings it was detected that the flare accepted gas, but with a combustion chamber temperature below 900°C. It happened because between a 5 minutes interval the

flare might have stopped and turned on again (p.e. the flare was stopped at 10:01 and tuned on on 10:04, not remaining enough time to register a temperature above 900°C). To discount the values below 900°C, the following procedure was applied:

- an hourly average of flares temperature was calculated, considering the temperature registers when the instant gas-flow was above 0 Nm^3/h (flares are accepting gas);
- If the average temperature is below 900°C, the gas-flow registered during this certain hour is considered equal to zero and excluded from ERs calculation.

Proper Excel sheets applying the above mentioned procedure were presented to the Verification Team.

Moreover, the flares are equipped with an hour-meter, which measures the accumulated operating hours of the flares. Despite of not being registered by BLFGE's computer supervisory system, Van der Wiel, one of Biogás shareholders, makes the registration of these accumulated operating hours of the flares every 00:01 via a CARS, a system which allows Van der Wiel to have total access to the PLC of BLFGE. This evidence was sent to the Verification Team.

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
01/04/2009	185.331	46,8430	*86.814,6003*	99,9970%	751	*351,7909*	*351,7803*	0	*0,0000*	*0,0000*	51.684	*24.210,3361*	30.306	*14.196,2395*	47.594	*22.294,4574*	55.531	*26.012,3863*	267,232
02/04/2009	181.971	47,1454	*85.790,9558*	99,9970%	0	*0,0000*	*0,0000*	0	*0,0000*	*0,0000*	43.241	*20.386,1424*	35.208	*16.598,9524*	53.724	*25.328,3946*	50.033	*23.588,2579*	265,056
03/04/2009	166.788	47,9107	*79.909,2983*	99,9970%	18.392	*8.811,7359*	*8.811,4715*	0	*0,0000*	*0,0000*	38.271	*18.335,9039*	27.462	*13.157,2364*	45.726	*21.907,6466*	37.013	*17.733,1873*	215,968
04/04/2009	178.960	48,2239	*86.301,4914*	99,9970%	5.449	*2.627,7203*	*2.627,6414*	0	*0,0000*	*0,0000*	35.665	*17.199,0539*	48.137	*23.213,5387*	49.542	*23.891,0845*	38.786	*18.704,1218*	256,192
05/04/2009	175.387	48,3569	*84.811,7162*	99,9970%	1.458	*705,0436*	*705,0224*	0	*0,0000*	*0,0000*	47.184	*22.816,7196*	39.106	*18.910,4493*	60.422	*29.218,2061*	26.233	*12.685,4655*	260,544
06/04/2009	178.694	48,7243	*87.067,4006*	99,9970%	220	*107,1934*	*107,1901*	0	*0,0000*	*0,0000*	41.283	*20.114,8527*	35.666	*17.378,0088*	67.365	*32.823,1246*	34.245	*16.685,6365*	269,920
07/04/2009	180.533	48,8937	*88.269,2634*	99,9970%	0	*0,0000*	*0,0000*	0	*0,0000*	*0,0000*	43.868	*21.448,6883*	30.419	*14.872,9746*	55.874	*27.318,8659*	51.462	*25.161,6758*	273,920
08/04/2009	188.929	47,6708	*90.063,9657*	99,9970%	144	*68,6459*	*68,6438*	0	*0,0000*	*0,0000*	50.051	*23.859,7121*	43.308	*20.645,2700*	63.824	*30.425,4113*	29.762	*14.187,7834*	277,984
09/04/2009	185.844	46,9541	*87.261,3776*	99,9970%	374	*175,6083*	*175,6030*	0	*0,0000*	*0,0000*	54.089	*25.397,0031*	29.193	*13.707,3104*	69.304	*32.541,0694*	33.303	*15.637,1239*	272,064
10/04/2009	184.034	47,0656	*86.616,7063*	99,9970%	1.388	*653,2705*	*653,2509*	0	*0,0000*	*0,0000*	62.204	*29.276,6858*	28.385	*13.359,5705*	59.584	*28.043,5671*	33.700	*15.861,1072*	270,144
11/04/2009	174.593	47,6315	*83.161,2647*	99,9970%	546	*260,0679*	*260,0600*	0	*0,0000*	*0,0000*	56.110	*26.726,0346*	38.173	*18.182,3724*	41.276	*19.660,3779*	31.073	*14.800,5359*	246,272
12/04/2009	187.470	46,1416	*86.501,6575*	99,9970%	1.251	*577,2314*	*577,2140*	0	*0,0000*	*0,0000*	53.802	*24.825,1036*	37.710	*17.399,9973*	61.565	*28.407,0760*	33.489	*15.452,3604*	269,536
13/04/2009	183.493	46,6204	*85.545,1705*	99,9970%	45	*20,9791*	*20,9784*	0	*0,0000*	*0,0000*	34.719	*16.186,1366*	34.800	*16.223,8992*	70.846	*33.028,6885*	46.466	*21.662,6350*	266,400
14/04/2009	179.567	47,9472	*86.097,3486*	99,9970%	419	*200,8987*	*200,8926*	0	*0,0000*	*0,0000*	33.761	*16.187,4541*	48.941	*23.465,8391*	51.209	*24.553,2816*	49.808	*23.881,5413*	269,728
15/04/2009	186.667	46,7281	*87.225,9424*	99,9970%	540	*252,3317*	*252,3241*	0	*0,0000*	*0,0000*	44.499	*20.793,5372*	38.438	*17.961,3470*	40.298	*18.830,4897*	65.869	*30.779,3321*	271,136
16/04/2009	187.311	46,7687	*87.602,9196*	99,9970%	180	*84,1836*	*84,1810*	0	*0,0000*	*0,0000*	57.771	*27.018,7456*	33.807	*15.811,0944*	42.519	*19.885,5835*	54.731	*25.596,9771*	273,248

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
17/04/2009	185.363	47,4020	*87.865,7692*	99,9970%	2.488	*1.179,3617*	*1.179,3263*	0	*0,0000*	*0,0000*	52.497	*24.884,6279*	29.282	*13.880,2536*	52.849	*25.051,4829*	50.429	*23.904,3545*	270,144
18/04/2009	184.639	47,5385	*87.774,6110*	99,9970%	0	*0,0000*	*0,0000*	0	*0,0000*	*0,0000*	48.726	*23.163,6095*	40.915	*19.450,3772*	52.861	*25.129,3264*	44.616	*21.209,7771*	273,056
19/04/2009	180.559	47,3822	*85.552,8264*	99,9970%	3.561	*1.687,2801*	*1.687,2294*	0	*0,0000*	*0,0000*	46.652	*22.104,7439*	35.740	*16.934,3982*	45.335	*21.480,7203*	49.880	*23.634,2413*	258,496
20/04/2009	184.962	46,8829	*86.715,5494*	99,9970%	658	*308,4894*	*308,4801*	0	*0,0000*	*0,0000*	43.753	*20.512,6752*	52.523	*24.624,3055*	48.703	*22.833,3787*	40.589	*19.029,3002*	268,864
21/04/2009	186.315	45,9809	*85.669,3138*	99,9970%	0	*0,0000*	*0,0000*	0	*0,0000*	*0,0000*	53.648	*24.667,8332*	37.545	*17.263,5289*	41.003	*18.853,5484*	55.500	*25.519,3995*	267,584
22/04/2009	185.683	46,7618	*86.828,7130*	99,9970%	6.763	*3.162,5005*	*3.162,4056*	0	*0,0000*	*0,0000*	50.752	*23.732,5487*	39.910	*18.662,6343*	39.129	*18.297,4247*	49.412	*23.105,9406*	259,040
23/04/2009	189.413	46,4281	*87.940,8570*	99,9995%	1.788	*830,1344*	*830,1302*	0	*0,0000*	*0,0000*	39.212	*18.205,3865*	52.726	*24.479,6800*	58.665	*27.237,0448*	35.002	*16.250,7635*	264,320
24/04/2009	189.911	46,3614	*88.045,3983*	99,9995%	922	*427,4521*	*427,4499*	0	*0,0000*	*0,0000*	35.846	*16.618,7074*	63.086	*29.247,5528*	59.432	*27.553,5072*	15.669	*7.264,3677*	273,792
25/04/2009	189.054	46,3486	*87.623,8822*	99,9995%	609	*282,2629*	*282,2614*	0	*0,0000*	*0,0000*	41.016	*19.010,3417*	53.572	*24.829,8719*	57.349	*26.580,4586*	54.702	*25.353,6111*	272,928
26/04/2009	188.717	46,1982	*87.183,8570*	99,9995%	0	*0,0000*	*0,0000*	0	*0,0000*	*0,0000*	48.029	*22.188,5334*	42.834	*19.788,5369*	54.705	*25.272,7253*	62.810	*29.017,0894*	271,744
27/04/2009	181.838	46,8152	*85.127,8233*	99,9995%	588	*275,2733*	*275,2719*	0	*0,0000*	*0,0000*	61.177	*28.640,1349*	17.156	*8.031,6157*	59.412	*27.813,8466*	50.374	*23.582,6888*	265,440
28/04/2009	177.877	47,4371	*84.379,6903*	99,9995%	78	*37,0009*	*37,0007*	0	*0,0000*	*0,0000*	49.238	*23.357,0792*	26.652	*12.642,9358*	58.094	*27.558,1088*	44.116	*20.927,3510*	264,992
29/04/2009	182.875	46,3666	*84.792,9197*	99,9995%	403	*186,8573*	*186,8563*	0	*0,0000*	*0,0000*	49.777	*23.079,9024*	31.205	*14.468,6975*	58.311	*27.036,8281*	43.859	*20.335,9270*	266,688
30/04/2009	175.476	46,7104	*81.965,5415*	99,9995%	174	*81,2760*	*81,2755*	0	*0,0000*	*0,0000*	52.232	*24.397,7761*	31.232	*14.588,5921*	58.142	*27.158,3607*	32.060	*14.975,3542*	258,880
01/05/2009	175.122	47,0788	*82.445,3361*	99,9995%	0	*0,0000*	*0,0000*	0	*0,0000*	*0,0000*	60.260	*28.369,6848*	25.854	*12.171,7529*	44.609	*21.001,3818*	42.927	*20.209,5164*	261,312
02/05/2009	174.986	46,9972	*82.238,5203*	99,9995%	0	*0,0000*	*0,0000*	0	*0,0000*	*0,0000*	57.699	*27.116,9144*	27.925	*13.123,9681*	43.474	*20.431,5627*	44.703	*21.009,1583*	261,600
03/05/2009	173.601	47,3128	*82.135,4939*	99,9995%	0	*0,0000*	*0,0000*	0	*0,0000*	*0,0000*	57.037	*26.985,8017*	27.901	*13.200,7443*	42.944	*20.318,0088*	44.336	*20.976,6030*	261,472
04/05/2009	173.169	47,0569	*81.487,9631*	99,9995%	5.586	*2.628,5984*	*2.628,5852*	0	*0,0000*	*0,0000*	54.478	*25.635,6579*	27.304	*12.848,4159*	39.611	*18.639,7086*	44.358	*20.873,4997*	247,328
05/05/2009	173.316	46,7201	*80.973,4085*	99,9995%	305	*142,4963*	*142,4955*	0	*0,0000*	*0,0000*	45.169	*21.103,0019*	38.720	*18.090,0227*	34.530	*16.132,4505*	49.486	*23.119,9086*	248,608
06/05/2009	175.958	46,2961	*81.461,6916*	99,9995%	166	*76,8515*	*76,8511*	0	*0,0000*	*0,0000*	48.238	*22.332,3127*	37.582	*17.399,0003*	43.150	*19.976,7671*	45.523	*21.075,3736*	258,048
07/05/2009	174.557	46,2281	*80.694,3845*	99,9995%	867	*400,7976*	*400,7955*	0	*0,0000*	*0,0000*	52.377	*24.212,8919*	34.616	*16.002,3190*	45.917	*21.226,5566*	39.005	*18.031,2704*	255,392
08/05/2009	177.186	46,9541	*83.196,0916*	99,9995%	753	*353,5643*	*353,5625*	0	*0,0000*	*0,0000*	52.947	*24.860,7873*	25.020	*11.747,9158*	53.225	*24.991,3197*	45.068	*21.161,2737*	261,120
09/05/2009	177.814	47,0850	*83.723,7219*	99,9995%	586	*275,9181*	*275,9167*	0	*0,0000*	*0,0000*	36.853	*17.352,2350*	44.380	*20.896,3230*	36.677	*17.269,3654*	59.192	*27.870,5532*	263,264
10/05/2009	177.215	47,1538	*83.563,6066*	99,9995%	311	*146,6483*	*146,6475*	0	*0,0000*	*0,0000*	48.831	*23.025,6720*	25.476	*12.012,9020*	40.858	*19.266,0996*	61.414	*28.959,0347*	261,440
11/05/2009	176.972	47,0864	*83.329,7438*	99,9995%	0	*0,0000*	*0,0000*	0	*0,0000*	*0,0000*	45.436	*21.394,1767*	38.426	*18.093,4200*	53.371	*25.130,4825*	33.306	*15.682,5963*	261,984
12/05/2009	176.148	47,1947	*83.132,5201*	99,9995%	0	*0,0000*	*0,0000*	0	*0,0000*	*0,0000*	38.164	*18.011,3853*	36.725	*17.332,2535*	54.155	*25.558,2897*	42.958	*20.273,8992*	261,408

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
13/05/2009	180.197	46,7958	*84.324,6277*	99,9995%	0	*0,0000*	*0,0000*	0	*0,0000*	*0,0000*	39.063	*18.279,8433*	35.102	*16.426,2617*	48.665	*22.773,1760*	53.763	*25.158,8259*	265,632
14/05/2009	180.341	48,0052	*86.573,0577*	99,9995%	0	*0,0000*	*0,0000*	0	*0,0000*	*0,0000*	40.427	*19.407,0622*	41.229	*19.792,0639*	47.439	*22.773,1868*	44.794	*21.503,4492*	267,136
15/05/2009	178.684	47,8871	*85.566,5857*	99,9995%	164	*78,5348*	*78,5344*	0	*0,0000*	*0,0000*	49.545	*23.725,6636*	34.994	*16.757,6117*	44.002	*21.071,2817*	44.967	*21.533,3922*	263,840
16/05/2009	174.972	47,8093	*83.652,8883*	99,9995%	436	*208,4485*	*208,4474*	0	*0,0000*	*0,0000*	49.946	*23.878,8329*	29.784	*14.239,5219*	43.842	*20.960,5533*	46.233	*22.103,6736*	253,440
17/05/2009	169.789	48,5482	*82.429,5032*	99,9995%	218	*105,8350*	*105,8344*	0	*0,0000*	*0,0000*	44.768	*21.734,0581*	32.389	*15.724,2764*	38.714	*18.794,9501*	48.257	*23.427,9048*	247,904
18/05/2009	170.847	48,4753	*82.818,5957*	99,9995%	388	*188,0841*	*188,0831*	0	*0,0000*	*0,0000*	39.036	*18.922,8181*	29.157	*14.133,9432*	52.225	*25.316,2254*	46.590	*22.584,6422*	248,736
19/05/2009	172.991	48,1711	*83.331,6676*	99,9995%	2.578	*1.241,8509*	*1.241,8446*	0	*0,0000*	*0,0000*	46.803	*22.545,5199*	32.825	*15.812,1635*	35.403	*17.054,0145*	49.670	*23.926,5853*	247,616
20/05/2009	175.068	46,2718	*81.007,1148*	99,9995%	247	*114,2913*	*114,2907*	0	*0,0000*	*0,0000*	41.250	*19.087,1175*	38.268	*17.707,2924*	42.254	*19.551,6863*	47.110	*21.798,6449*	251,648
21/05/2009	171.656	45,9204	*78.825,1218*	99,9995%	54	*24,7970*	*24,7968*	0	*0,0000*	*0,0000*	31.366	*14.403,3926*	45.057	*20.690,3546*	44.031	*20.219,2113*	45.048	*20.686,2217*	249,536
22/05/2009	162.847	46,6659	*75.994,0181*	99,9995%	389	*181,5303*	*181,5293*	0	*0,0000*	*0,0000*	33.070	*15.432,4131*	33.536	*15.649,8762*	47.299	*22.072,5040*	44.348	*20.695,3933*	239,328
23/05/2009	165.480	46,5270	*76.992,8796*	99,9995%	1.125	*523,4287*	*523,4260*	0	*0,0000*	*0,0000*	36.984	*17.207,5456*	32.727	*15.226,8912*	50.007	*23.266,7568*	40.392	*18.793,1858*	239,648
24/05/2009	163.112	47,0482	*76.741,2599*	99,9995%	322	*151,4952*	*151,4944*	0	*0,0000*	*0,0000*	37.274	*17.536,7460*	27.833	*13.094,9255*	39.202	*18.443,8353*	56.354	*26.513,5426*	243,456
25/05/2009	163.289	46,7968	*76.414,0267*	99,9995%	312	*146,0060*	*146,0052*	0	*0,0000*	*0,0000*	41.324	*19.338,3096*	33.393	*15.626,8554*	45.527	*21.305,1791*	38.131	*17.844,0878*	243,264
26/05/2009	161.413	46,5194	*75.088,3591*	99,9995%	350	*162,8179*	*162,8170*	0	*0,0000*	*0,0000*	48.482	*22.553,5355*	27.187	*12.647,2292*	53.272	*24.781,8147*	28.338	*13.182,6675*	239,584
27/05/2009	160.376	46,4815	*74.545,1704*	99,9995%	0	*0,0000*	*0,0000*	0	*0,0000*	*0,0000*	49.264	*22.898,6461*	24.677	*11.470,2397*	42.338	*19.679,3374*	40.448	*18.800,8371*	238,272
28/05/2009	161.700	46,3038	*74.873,2446*	99,9995%	1.779	*823,7446*	*823,7404*	0	*0,0000*	*0,0000*	59.657	*27.623,4579*	37.137	*17.195,8422*	28.702	*13.290,1166*	24.700	*11.437,0386*	236,000
29/05/2009	165.231	46,0968	*76.166,2036*	99,9995%	576	*265,5175*	*265,5161*	0	*0,0000*	*0,0000*	65.974	*30.411,9028*	34.793	*16.038,4596*	39.850	*18.369,5748*	14.589	*6.725,0621*	242,816
30/05/2009	164.897	46,6670	*76.952,4829*	99,9995%	472	*220,2682*	*220,2670*	0	*0,0000*	*0,0000*	59.680	*27.850,8656*	27.525	*12.845,0917*	50.110	*23.384,8337*	21.035	*9.816,4034*	246,624
31/05/2009	164.610	46,5982	*76.705,2970*	99,9995%	0	*0,0000*	*0,0000*	0	*0,0000*	*0,0000*	59.432	*27.694,2422*	25.862	*12.051,2264*	47.918	*22.328,9254*	26.692	*12.437,9915*	248,640
01/06/2009	160.894	46,4156	*74.679,9154*	99,9995%	0	*0,0000*	*0,0000*	0	*0,0000*	*0,0000*	46.970	*21.801,4073*	34.233	*15.889,4523*	51.075	*23.706,7677*	23.074	*10.709,9355*	240,224
02/06/2009	156.822	46,5545	*73.007,6979*	99,9995%	1.638	*762,5627*	*762,5588*	0	*0,0000*	*0,0000*	34.404	*16.016,6101*	34.798	*16.200,0349*	51.794	*24.112,4377*	29.286	*13.633,9508*	228,416
03/06/2009	152.110	46,9093	*71.353,7362*	99,9995%	555	*260,3466*	*260,3452*	0	*0,0000*	*0,0000*	39.645	*18.597,1919*	27.756	*13.020,1453*	51.510	*24.162,9804*	28.038	*13.152,4295*	222,912
04/06/2009	134.277	47,0548	*63.183,7737*	99,9995%	5.046	*2.374,3852*	*2.374,3733*	4.653	*2.189,4598*	*2.189,4488*	28.900	*13.598,8372*	32.436	*15.262,6949*	40.618	*19.112,7186*	18.778	*8.835,9503*	192,384
05/06/2009	155.045	47,3045	*73.343,2620*	99,9995%	2.694	*1.274,3832*	*1.274,3768*	0	*0,0000*	*0,0000*	32.166	*15.215,9654*	50.270	*23.779,9721*	37.092	*17.546,1851*	18.679	*8.836,0075*	221,536
06/06/2009	102.718	47,0463	*48.325,0184*	99,9995%	706	*332,1468*	*332,1451*	0	*0,0000*	*0,0000*	32.323	*15.206,7755*	41.405	*19.479,5205*	16.255	*7.647,3760*	0	*0,0000*	161,088
07/06/2009	143.333	47,3908	*67.926,6553*	99,9995%	4.043	*1.916,0100*	*1.916,0004*	0	*0,0000*	*0,0000*	41.938	*19.874,7537*	42.329	*20.060,0517*	35.410	*16.781,0822*	8.901	*4.218,2551*	215,392

DATE	MAIN PIPELINE							SECONDARY PIPELINE			ELECTRICITY GENERATION								
	COLLECTING SYSTEM				FLARE F100			FLARE F200			FIR300		FIR400		FIR500		FIR600		
	LFG measured FIR100 (Nm³)	Methane (%)	*Methane measured FIR100 (Nm³)*	Flares Efficiencies (%)	LFG measured FIR200 (Nm³)	*Methane measured FIR200 (Nm³)*	*Methne Destroyed in F100 (Nm³)*	LFG measured FIR700 (Nm³)	*Methane measured FIR700 (Nm³)*	*Methne Destroyed F200 (Nm³)*	LFG measured (Nm³)	*Methane measured (Nm³)*	LFG measured (Nm³)	*Methane measured (Nm³)*	LFG measured (Nm³)	*Methane measured (Nm³)*	LFG measured (Nm³)	*Methane measured (Nm³)*	Eletricity Exported (MWh)
	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
08/06/2009	150.867	47,4177	*71.537,6614*	99,9995%	0	*0,0000*	*0,0000*	0	*0,0000*	*0,0000*	26.953	*12.780,4926*	33.639	*15.950,8401*	59.817	*28.363,8456*	24.801	*11.760,0637*	226,112
09/06/2009	147.919	47,7951	*70.698,0339*	99,9995%	0	*0,0000*	*0,0000*	0	*0,0000*	*0,0000*	35.036	*16.745,4912*	24.239	*11.585,0542*	50.540	*24.155,6435*	34.878	*16.669,9749*	226,496
10/06/2009	151.591	47,4444	*71.921,4404*	99,9995%	422	*200,2153*	*200,2142*	0	*0,0000*	*0,0000*	34.608	*16.419,5579*	16.925	*8.029,9647*	55.605	*26.381,4586*	43.423	*20.601,7818*	229,728
11/06/2009	141.863	49,9013	*70.791,4812*	99,9995%	5.056	*2.523,0097*	*2.522,9970*	0	*0,0000*	*0,0000*	30.682	*15.310,7168*	25.244	*12.597,0841*	32.795	*16.365,1313*	43.214	*21.564,3477*	212,448
12/06/2009	148.781	49,0239	*72.938,2486*	99,9995%	514	*251,9828*	*251,9815*	0	*0,0000*	*0,0000*	39.906	*19.563,4775*	30.247	*14.828,2590*	51.042	*25.022,7790*	20.978	*10.284,2337*	231,968
13/06/2009	147.717	48,7524	*72.015,5827*	99,9995%	0	*0,0000*	*0,0000*	0	*0,0000*	*0,0000*	46.659	*22.747,3823*	35.258	*17.189,1211*	43.517	*21.215,5819*	13.742	*6.699,5548*	229,888
14/06/2009	140.879	49,0784	*69.141,1591*	99,9995%	3.204	*1.572,4719*	*1.572,4640*	0	*0,0000*	*0,0000*	43.812	*21.502,2286*	33.075	*16.232,6808*	39.446	*19.359,4656*	12.494	*6.131,8552*	209,568
15/06/2009	139.342	49,7364	*69.303,6944*	99,9995%	7.619	*3.789,4163*	*3.789,3973*	0	*0,0000*	*0,0000*	41.640	*20.710,2369*	14.550	*7.236,6462*	54.148	*26.931,2658*	17.281	*8.594,9472*	204,160
16/06/2009	158.398	47,6677	*75.504,6834*	99,9995%	0	*0,0000*	*0,0000*	0	*0,0000*	*0,0000*	48.420	*23.080,7003*	20.877	*9.951,5857*	37.600	*17.923,0552*	48.291	*23.019,2090*	242,400
17/06/2009	154.919	47,7197	*73.926,8820*	99,9995%	3.990	*1.904,0160*	*1.904,0064*	0	*0,0000*	*0,0000*	49.070	*23.416,0567*	21.066	*10.052,6320*	28.984	*13.831,0778*	48.162	*22.982,7619*	229,088
18/06/2009	154.511	47,9079	*74.022,9753*	99,9995%	2.881	*1.380,2265*	*1.380,2195*	0	*0,0000*	*0,0000*	63.220	*30.287,3743*	19.768	*9.470,4336*	21.846	*10.465,9598*	38.073	*18.239,9747*	227,264
19/06/2009	146.077	49,2767	*71.981,9250*	99,9995%	22.208	*10.943,3695*	*10.943,3147*	0	*0,0000*	*0,0000*	40.216	*19.817,1176*	11.115	*5.477,1052*	36.065	*17.771,6418*	36.323	*17.898,7757*	188,928
20/06/2009	160.919	47,1947	*75.945,2392*	99,9995%	3.627	*1.711,7517*	*1.711,7431*	0	*0,0000*	*0,0000*	39.930	*18.844,8437*	14.990	*7.074,4855*	51.784	*24.439,3034*	49.301	*23.267,4590*	233,728
21/06/2009	157.622	47,2642	*74.498,7773*	99,9995%	1.820	*860,2084*	*860,2040*	0	*0,0000*	*0,0000*	38.660	*18.272,3397*	23.832	*11.264,0041*	44.759	*21.154,9832*	44.097	*20.842,0942*	231,872
22/06/2009	157.383	47,2031	*74.289,6548*	99,9995%	0	*0,0000*	*0,0000*	0	*0,0000*	*0,0000*	41.717	*19.691,7172*	21.616	*10.203,4220*	48.496	*22.891,6153*	42.719	*20.164,6922*	236,928
23/06/2009	160.216	46,7618	*74.919,8854*	99,9995%	0	*0,0000*	*0,0000*	0	*0,0000*	*0,0000*	33.800	*15.805,4884*	32.501	*15.198,0526*	43.407	*20.297,8945*	46.004	*21.512,2984*	238,752
24/06/2009	161.178	46,4246	*74.826,2417*	99,9995%	0	*0,0000*	*0,0000*	0	*0,0000*	*0,0000*	32.325	*15.006,7519*	22.556	*10.471,5327*	61.517	*28.559,0211*	43.247	*20.077,2467*	239,520
25/06/2009	160.980	47,3590	*76.238,5182*	99,9995%	1.309	*619,9293*	*619,9262*	0	*0,0000*	*0,0000*	38.782	*18.366,7673*	27.504	*13.025,6193*	38.520	*18.242,6868*	51.174	*24.235,4946*	239,808
26/06/2009	157.147	48,3711	*76.013,7325*	99,9995%	217	*104,9652*	*104,9646*	0	*0,0000*	*0,0000*	39.949	*19.323,7707*	24.917	*12.052,6269*	29.389	*14.215,7825*	59.622	*28.839,8172*	238,464
27/06/2009	154.834	48,7708	*75.513,7804*	99,9995%	857	*417,9657*	*417,9636*	0	*0,0000*	*0,0000*	39.718	*19.370,7863*	15.040	*7.335,1283*	31.517	*15.371,0930*	67.727	*33.030,9997*	234,944
28/06/2009	151.536	49,7527	*75.393,2514*	99,9995%	842	*418,9177*	*418,9156*	0	*0,0000*	*0,0000*	57.340	*28.528,1981*	13.431	*6.682,2851*	31.096	*15.471,0995*	46.095	*22.933,5070*	233,472
29/06/2009	155.992	49,1562	*76.679,7395*	99,9995%	844	*414,8783*	*414,8762*	0	*0,0000*	*0,0000*	48.624	*23.901,7106*	22.109	*10.867,9442*	20.616	*10.134,0421*	54.570	*26.824,5383*	236,512
30/06/2009	158.708	47,8829	*75.993,9929*	99,9995%	3.592	*1.719,9537*	*1.719,9451*	0	*0,0000*	*0,0000*	47.865	*22.919,1500*	32.436	*15.531,2974*	21.937	*10.504,0717*	43.843	*20.993,2998*	227,744

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

If during a certain hour the average flare temperature (F100 or F200) is below 900°C **and** the instant gas-flow measured by FIR200 and FIR700 is higher than zero, this gas-flow is excluded from ERs calculation.

Total Methane Destroyed in Flare F100 (Nm^3)	**67.568,3542**
Total Methane Destroyed in Flare F200 (Nm^3)	**2.189,4488**
Total Methane Measured by FIR300 (Nm^3)	**1.943.002,4015**
Total Methane Measured by FIR400 (Nm^3)	**1.392.025,9208**
Total Methane Measured by FIR500 (Nm^3)	**1.993.531,2891**
Total Methane Measured by FIR600 (Nm^3)	**1.737.307,9860**
Total Electricity Exported (MWh)	**22.509,1520**

4.2. Events registered

For this monitoring period, the following events were registered:

EVENT #	DESCRIPTION	HOW THE EVENT WAS CONSIDERED
01	In 02/04/2009, a new pressure transmitter from flow-meter FIR600 (duly calibrated by a certified laboratory) was installed and connected to the PLC, replacing the existing one.	From this day on, the erros from this transmitter were updated and considered in the ERs calculation.
02	In 07/04/2009, new temperatura transmitters from FIR300, FIR400, FIR500 and FIR600 were installed, replacing the existing ones.	From this day on, the erros from the respective transmitters were updated and considered in the ERs calculation.
03	In 09/04/2009, a new pressure transmitter from flow-meter FIR400 (duly calibrated by a certified laboratory) was installed and connected to the PLC, replacing the existing one.	From this day on, the erros from this transmitter were updated and considered in the ERs calculation.

04	In 14/04/2009, the new flow-meter FIR700 and the respective temperature and pressure transmitters were installed in the Auxiliary Line and was connected to the PLC in 11/05/2009. The equipment was sent to recalibration in 29/06/2009.	From 11/05/2009 to 29/06/2009, the gas-flow sent to flare F200 was monitored according with the revised Monitoring Plan.
05	In 12/05/2009, a new pressure transmitter from flow-meter FIR300 (duly calibrated by a certified laboratory) was installed and connected to the PLC, replacing the existing one.	From this day on, the erros from this transmitter were updated and considered in the ERs calculation.

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 tables below. As during the monitoring period, there were 4 events related to instruments replacement, erros were calculated in 5 Parts:

PART 01 (01/04/2009)

Methodology ID	Equipment	TAG	Error (%)	Date of the last calibration	Date of the next calibration
$LFG_{Total, y}$	Turbine Flow-meter	FIR100	0.600	22/06/2004	22/06/2009
$LFG_{Flare, y}$	Turbine Flow-meters	FIR200 N/A	0.300 N/A	28/07/2004 N/A	28/07/2009 N/A
$LFG_{Electricity, y}$	Turbine Flow-meters	FIR300 FIR400 FIR500 FIR600	0.772 0.596 0.632 0.811	12/12/2006 12/12/2006 12/12/2006 12/12/2006	12/12/2011 12/12/2011 12/12/2011 12/12/2011
$w_{CH4, y}$	Methane Analyzer	A100	1.000	Dec/2003	Weekly, with a standard gas
T [7]	Temperature Transmitter	TTF101 TTF201 TTF701 TTF301 TTF401 TTF501 TTF601	0.233 0.180 N/A 0.870 0.870 0.870 0.870	09/10/2007 09/10/2007 N/A 26/03/2009[8] 26/03/2009[8] 26/03/2009[8] 26/03/2009[8]	09/10/2012 09/10/2012 N/A 26/03/2014 26/03/2014 26/03/2014 26/03/2014
p [7]	Pressure Transmitter	TPF101 TPF201 TPF701 TPF301 TPF401 TPF501 TPF601	0.15 0.15 N/A 0.0337 0.0387 0.0381 0.0440	17/08/2004 17/08/2004 N/A 10/11/2006 10/11/2006 10/11/2006 10/11/2006	17/08/2009 17/08/2009 N/A 10/11/2011 10/11/2011 10/11/2011 10/11/2011
EG_y	Electricity Meter	N/A	1.000	Sep/2004	Sep/2009

[7] Despite of not being included in the revised Monitoring Plan, pressure and tempreature erros were conidered in the error calculation as they are used to convert the measured flow to Nm^3 (STP conditions)

[8] No calibration certificate is available, as the same was not requested after calibration at factory, thus the Biogás decided to follow the recommendation of the verification team. According to the manual of the temperature transmitter PT-100 (manufacturer ASTA), the accuracy of the same is indicated with 0.5%. In order to be conservative, Biogás decided to use the maximum error identified in the calibration done for the follow up transmitters, namely 0.87%. The follow up transmitters are of exactly the same model, manufacturer and have the same characteristics as the temperature transmitters used for this given period.

PART 02 (from 02/04/2009 to 06/04/2009) – replacement of the TPF601

Methodology ID	Equipment	TAG	Error (%)	Date of the last calibration	Date of the next calibration
$LFG_{Total, y}$	Turbine Flow-meter	FIR100	0.600	22/06/2004	22/06/2009
$LFG_{Flare, y}$	Turbine Flow-meters	FIR200 N/A	0.300 N/A	28/07/2004 N/A	28/07/2009 N/A
$LFG_{Electricity, y}$	Turbine Flow-meters	FIR300 FIR400 FIR500 FIR600	0.772 0.596 0.632 0.811	12/12/2006 12/12/2006 12/12/2006 12/12/2006	12/12/2011 12/12/2011 12/12/2011 12/12/2011
$w_{CH4, y}$	Methane Analyzer	A100	1.000	Dec/2003	Weekly, with a standard gas
T[7]	Temperature Transmitter	TTF101 TTF201 TTF701 TTF301 TTF401 TTF501 TTF601	0.233 0.180 N/A 0.870 0.870 0.870 0.870	09/10/2007 09/10/2007 N/A 26/03/2009[8] 26/03/2009[8] 26/03/2009[8] 26/03/2009[8]	09/10/2012 09/10/2012 N/A 26/03/2014 26/03/2014 26/03/2014 26/03/2014
p[7]	Pressure Transmitter	TPF101 TPF201 TPF701 TPF301 TPF401 TPF501 TPF601	0.15 0.15 N/A 0.0337 0.0387 0.0381 0.0894	17/08/2004 17/08/2004 N/A 10/11/2006 10/11/2006 10/11/2006 17/04/2008	17/08/2009 17/08/2009 N/A 10/11/2011 10/11/2011 10/11/2011 17/04/2013
EG_y	Electricity Meter	N/A	1.000	Sep/2004	Sep/2009

PART 03 (from 07/04/2009 to 08/04/2009) – replacement of the TTF301, TTF401, TTF501 and TTF601

Methodology ID	Equipment	TAG	Error (%)	Date of the last calibration	Date of the next calibration
$LFG_{Total, y}$	Turbine Flow-meter	FIR100	0.600	22/06/2004	22/06/2009
$LFG_{Flare, y}$	Turbine Flow-meters	FIR200 N/A	0.300 N/A	28/07/2004 N/A	28/07/2009 N/A
$LFG_{Electricity, y}$	Turbine Flow-meters	FIR300 FIR400 FIR500 FIR600	0.772 0.596 0.632 0.811	12/12/2006 12/12/2006 12/12/2006 12/12/2006	12/12/2011 12/12/2011 12/12/2011 12/12/2011
$w_{CH4, y}$	Methane Analyzer	A100	1.000	Dec/2003	Weekly, with a standard gas
T[7]	Temperature Transmitter	TTF101 TTF201 TTF701 TTF301 TTF401 TTF501 TTF601	0.233 0.180 N/A 0.600 0.180 0.870 0.200	09/10/2007 09/10/2007 N/A 26/03/2009 26/03/2009 26/03/2009 26/03/2009	09/10/2012 09/10/2012 N/A 26/03/2014 26/03/2014 26/03/2014 26/03/2014
p[7]	Pressure Transmitter	TPF101 TPF201 TPF701 TPF301 TPF401 TPF501 TPF601	0.15 0.15 N/A 0.0337 0.0387 0.0381 0.0894	17/08/2004 17/08/2004 N/A 10/11/2006 10/11/2006 10/11/2006 17/04/2008	17/08/2009 17/08/2009 N/A 10/11/2011 10/11/2011 10/11/2011 17/04/2013
EG_y	Electricity Meter	N/A	1.000	Sep/2004	Sep/2009

PART 04 (from 09/04/2009 to 10/05/2009) – replacement of the TPF401

Methodology ID	Equipment	TAG	Error (%)	Date of the last calibration	Date of the next calibration
$LFG_{Total, y}$	Turbine Flow-meter	FIR100	0.600	22/06/2004	22/06/2009
$LFG_{Flare, y}$	Turbine Flow-meters	FIR200 FIR700	0.300 N/A	28/07/2004 N/A	28/07/2009 N/A
$LFG_{Electricity, y}$	Turbine Flow-meters	FIR300 FIR400 FIR500 FIR600	0.772 0.596 0.632 0.811	12/12/2006 12/12/2006 12/12/2006 12/12/2006	12/12/2011 12/12/2011 12/12/2011 12/12/2011
$w_{CH4, y}$	Methane Analyzer	A100	1.000	Dec/2003	Weekly, with a standard gas
T[7]	Temperature Transmitter	TTF101 TTF201 TTF701 TTF301 TTF401 TTF501 TTF601	0.233 0.180 N/A 0.600 0.180 0.870 0.200	09/10/2007 09/10/2007 N/A 26/03/2009 26/03/2009 26/03/2009 26/03/2009	09/10/2012 09/10/2012 N/A 26/03/2014 26/03/2014 26/03/2014 26/03/2014
p[7]	Pressure Transmitter	TPF101 TPF201 TPF701 TPF301 TPF401 TPF501 TPF601	0.15 0.15 N/A 0.0337 0.0643 0.0381 0.0894	17/08/2004 17/08/2004 N/A 10/11/2006 27/03/2009 10/11/2006 17/04/2008	17/08/2009 17/08/2009 N/A 10/11/2011 27/03/2014 10/11/2011 17/04/2013
EG_y	Electricity Meter	N/A	1.000	Sep/2004	Sep/2009

PART 05 (11/05/2009) – connection of the Flow-meter FIR700 and related instruments to the PLC

Methodology ID	Equipment	TAG	Error (%)	Date of the last calibration	Date of the next calibration
$LFG_{Total, y}$	Turbine Flow-meter	FIR100	0.600	22/06/2004	22/06/2009
$LFG_{Flare, y}$	Turbine Flow-meters	FIR200 FIR700	0.300 50.64	28/07/2004 02/04/2009	28/07/2009 02/04/2014
$LFG_{Electricity, y}$	Turbine Flow-meters	FIR300 FIR400 FIR500 FIR600	0.772 0.596 0.632 0.811	12/12/2006 12/12/2006 12/12/2006 12/12/2006	12/12/2011 12/12/2011 12/12/2011 12/12/2011
$w_{CH4, y}$	Methane Analyzer	A100	1.000	Dec/2003	Weekly, with a standard gas
T[7]	Temperature Transmitter	TTF101 TTF201 TTF701 TTF301 TTF401 TTF501 TTF601	0.233 0.180 0.647 0.600 0.180 0.870 0.200	09/10/2007 09/10/2007 26/03/2009 26/03/2009 26/03/2009 26/03/2009 26/03/2009	09/10/2012 09/10/2012 26/03/2014 26/03/2014 26/03/2014 26/03/2014 26/03/2014
p [7]	Pressure Transmitter	TPF101 TPF201 TPF701 TPF301 TPF401 TPF501 TPF601	0.15 0.15 0.213 0.0337 0.0643 0.0381 0.0894	17/08/2004 17/08/2004 27/03/2009 10/11/2006 27/03/2009 10/11/2006 17/04/2008	17/08/2009 17/08/2009 27/03/2014 10/11/2011 27/03/2014 10/11/2011 17/04/2013
EG_y	Electricity Meter	N/A	1.000	Sep/2004	Sep/2009

PART 06 (from 12/05/2009 to 30/06/2009) – replacement of the TPF301

Methodology ID	Equipment	TAG	Error (%)	Date of the last calibration	Date of the next calibration
$LFG_{Total, y}$	Turbine Flow-meter	FIR100	0.600	22/06/2004	22/06/2009
$LFG_{Flare, y}$	Turbine Flow-meters	FIR200 FIR700	0.300 50.64	28/07/2004 02/04/2009	28/07/2009 02/04/2014
$LFG_{Electricity, y}$	Turbine Flow-meters	FIR300 FIR400 FIR500 FIR600	0.772 0.596 0.632 0.811	12/12/2006 12/12/2006 12/12/2006 12/12/2006	12/12/2011 12/12/2011 12/12/2011 12/12/2011
$w_{CH4, y}$	Methane Analyzer	A100	1.000	Dec/2003	Weekly, with a standard gas
T[7]	Temperature Transmitter	TTF101 TTF201 TTF701 TTF301 TTF401 TTF501 TTF601	0.233 0.180 0.647 0.600 0.180 0.870 0.200	09/10/2007 09/10/2007 26/03/2009 26/03/2009 26/03/2009 26/03/2009 26/03/2009	09/10/2012 09/10/2012 26/03/2014 26/03/2014 26/03/2014 26/03/2014 26/03/2014
p[7]	Pressure Transmitter	TPF101 TPF201 TPF701 TPF301 TPF401 TPF501 TPF601	0.15 0.15 0.213 0.118 0.0643 0.0381 0.0894	17/08/2004 17/08/2004 27/03/2009 06/05/2009 27/03/2009 10/11/2006 17/04/2008	17/08/2009 17/08/2009 27/03/2014 06/05/2014 27/03/2014 10/11/2011 17/04/2013
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:

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

$$\varepsilon_{FIR700} = \sqrt{(\varepsilon_{Gas\ Flow\ FIR700})^2 + (\varepsilon_{Temperature\ FIR700})^2 + (\varepsilon_{Pressure\ FIR700})^2 + (\varepsilon_{Methane\ Analysis})^2}$$

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

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

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

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

OBS: the calculation of the error from FIR700 was considered only from 11/05/2009 on, as before this date the flow-meter was not connected to the PLC – thus no data was registered.

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:

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

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

$$\varepsilon_{FIR200} = \sqrt{0.300^2 + 0.1801^2 + 0.15^2 + 1.000^2} = 1.0701\%$$

$$\varepsilon_{FIR700} = \sqrt{50.64^2 + 0.025^2 + 0.647^2 + 1.000^2} = 50.6541\%$$

The measurements from the flow-meter FIR700 were considered only after 11/05/2009 on.

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:

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

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

PART 01 (01/04/2009)

$$\varepsilon_{FIR300} = \sqrt{0.772^2 + 0.870^2 + 0.0337^2 + 1.000^2} = 1.5343\%$$

$$\varepsilon_{FIR400} = \sqrt{0.596^2 + 0.870^2 + 0.0387^2 + 1.000^2} = 1.4539\%$$

$$\varepsilon_{FIR500} = \sqrt{0.632^2 + 0.870^2 + 0.0381^2 + 1.000^2} = 1.4960\%$$

$$\varepsilon_{FIR600} = \sqrt{0.811^2 + 0.870^2 + 0.0440^2 + 1.000^2} = 1.5546\%$$

PART 02 (from 02/04/2009 to 06/04/2009) – replacement of TPF601

$$\varepsilon_{FIR300} = \sqrt{0.772^2 + 0.870^2 + 0.0337^2 + 1.000^2} = 1.5343\%$$

$$\varepsilon_{FIR400} = \sqrt{0.596^2 + 0.870^2 + 0.0387^2 + 1.000^2} = 1.4539\%$$

$$\varepsilon_{FIR500} = \sqrt{0.632^2 + 0.870^2 + 0.0381^2 + 1.000^2} = 1.4960\%$$

$$\varepsilon_{FIR600} = \sqrt{0.811^2 + 0.870^2 + 0.0894^2 + 1.000^2} = 1.5565\%$$

PART 03 (from 07/04/2009 to 08/04/2009) – replacement of the TTF301, TTF401, TTF501 and TTF601

$$\varepsilon_{FIR300} = \sqrt{0.772^2 + 0.5992^2 + 0.0337^2 + 1.000^2} = 1.3987\%$$

$$\varepsilon_{FIR400} = \sqrt{0.596^2 + 0.1774^2 + 0.0387^2 + 1.000^2} = 1.1783\%$$

$$\varepsilon_{FIR500} = \sqrt{0.632^2 + 0.8716^2 + 0.0381^2 + 1.000^2} = 1.4699\%$$

$$\varepsilon_{FIR600} = \sqrt{0.811^2 + 0.1997^2 + 0.0858^2 + 1.000^2} = 1.3058\%$$

PART 04 (from 09/04/2009 to 10/05/2009) – replacement of the TPF401

$$\varepsilon_{FIR300} = \sqrt{0.772^2 + 0.5992^2 + 0.0337^2 + 1.000^2} = 1.3987\%$$

$$\varepsilon_{FIR400} = \sqrt{0.596^2 + 0.1774^2 + 0.0643^2 + 1.000^2} = 1.1794\%$$

$$\varepsilon_{FIR500} = \sqrt{0.632^2 + 0.8716^2 + 0.0381^2 + 1.000^2} = 1.4699\%$$

$$\varepsilon_{FIR600} = \sqrt{0.811^2 + 0.1997^2 + 0.0858^2 + 1.000^2} = 1.3058\%$$

PART 06 (from 12/05/2009 to 30/06/2009) – replacement of the TPF301

$$\varepsilon_{FIR300} = \sqrt{0.772^2 + 0.5992^2 + 0.1180^2 + 1.000^2} = 1.4032\%$$

$$\varepsilon_{FIR400} = \sqrt{0.596^2 + 0.1774^2 + 0.0643^2 + 1.000^2} = 1.1794\%$$

$$\varepsilon_{FIR500} = \sqrt{0.632^2 + 0.8716^2 + 0.0381^2 + 1.000^2} = 1.4699\%$$

$$\varepsilon_{FIR600} = \sqrt{0.811^2 + 0.1997^2 + 0.0858^2 + 1.000^2} = 1.3058\%$$

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}[9] (see last table from item 4.1)	Methane flow to the power house measured by FIRi (Nm^3)
	B_{FIRi}[9]	Total measuring error from FIRi (%) – see item 4.5
	C_{FIRi}[9] $= A_{FIRi} . (1 – B_{FIRi})$	**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 Methane	$A = C_{F100} + C_{F200} + D_{power\ house}$	Total methane destroyed in the period (Nm^3)
	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

	PART 01	PART 02	PART 03	PART 04	PART 05	PART 06	TOTAL
Total CO_2e from methane destroyed	1.024	5.006	2.100	32.457	940	44.116	**85.643**
Total CO_2e from electricity dispatched	70	335	146	2.240	69	3.171	**6.031**
TOTAL CO_2e	**1.094**	**5.341**	**2.246**	**34.697**	**1.009**	**47.287**	**91.674**

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

The difference between the PDD estimatives and the gas-flow monitored is due to the landfill's poor final layer cover, which increases the gas leakage through the landfill's surface.

VERSION HISTORY

Version	Date	Nature of Revision(s)
01	**02/07/2009**	Initial Adoption

ARCADIS Tetraplan S.A.

Av. Nove de Julho, 5966, térreo,
Jardim Paulista, São Paulo-SP
CEP 01406-200

Fone/fax: +55 (11) 3060 8457
E-mail: tetraplan@tetraplan.com.br

Website: www.tetraplan.com.br
www.arcadis-global.com