ARCADIS TETRAPLAN

Imagine the result

Bandeirantes Landfill Gas to Energy Project (BLFGE)

Monitoring Report – Version 01
6th Verification
Monitoring Period: 01/11/2007 to 31/12/2007

São Paulo, January 7th 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
January 7th, 2007

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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
ICE	Internal Combustion Engine

1. General Project Activity and Monitoring Information

1.1. Title and Registration Number of the Project Activity

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

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.

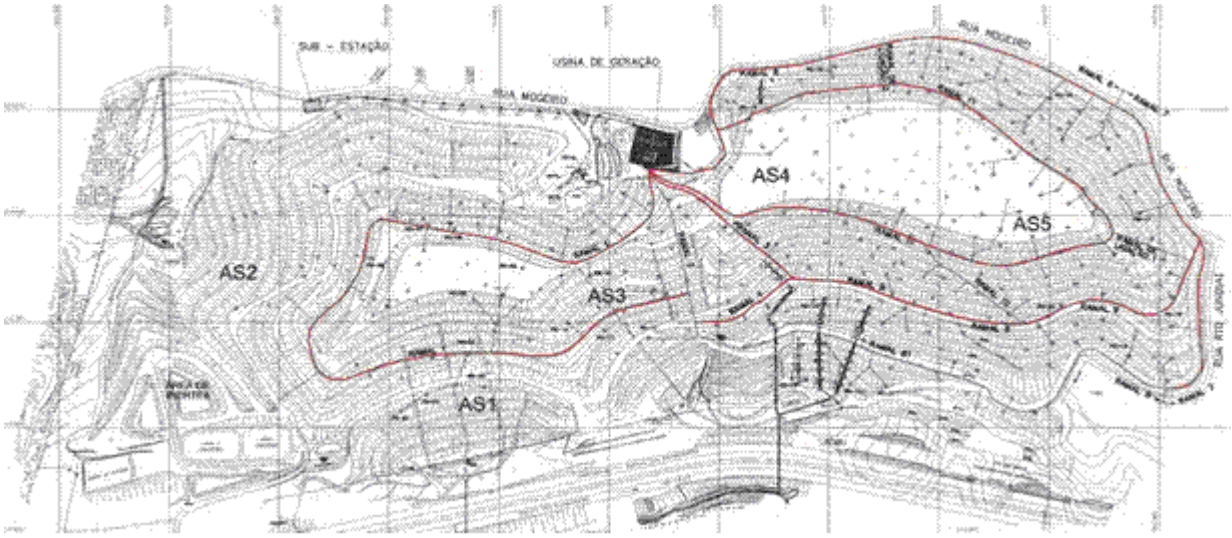

Figure 1.1. Bandeirantes Landfill Cells

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

The whole process is controlled by an electrical control system. This control system is provided with a PLC (Programmable Logical Controller). 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 1.7. PLC Controlling System panel

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

The changes made against the registered PDD are:

- 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 01/11/2007 to 31/12/2007.

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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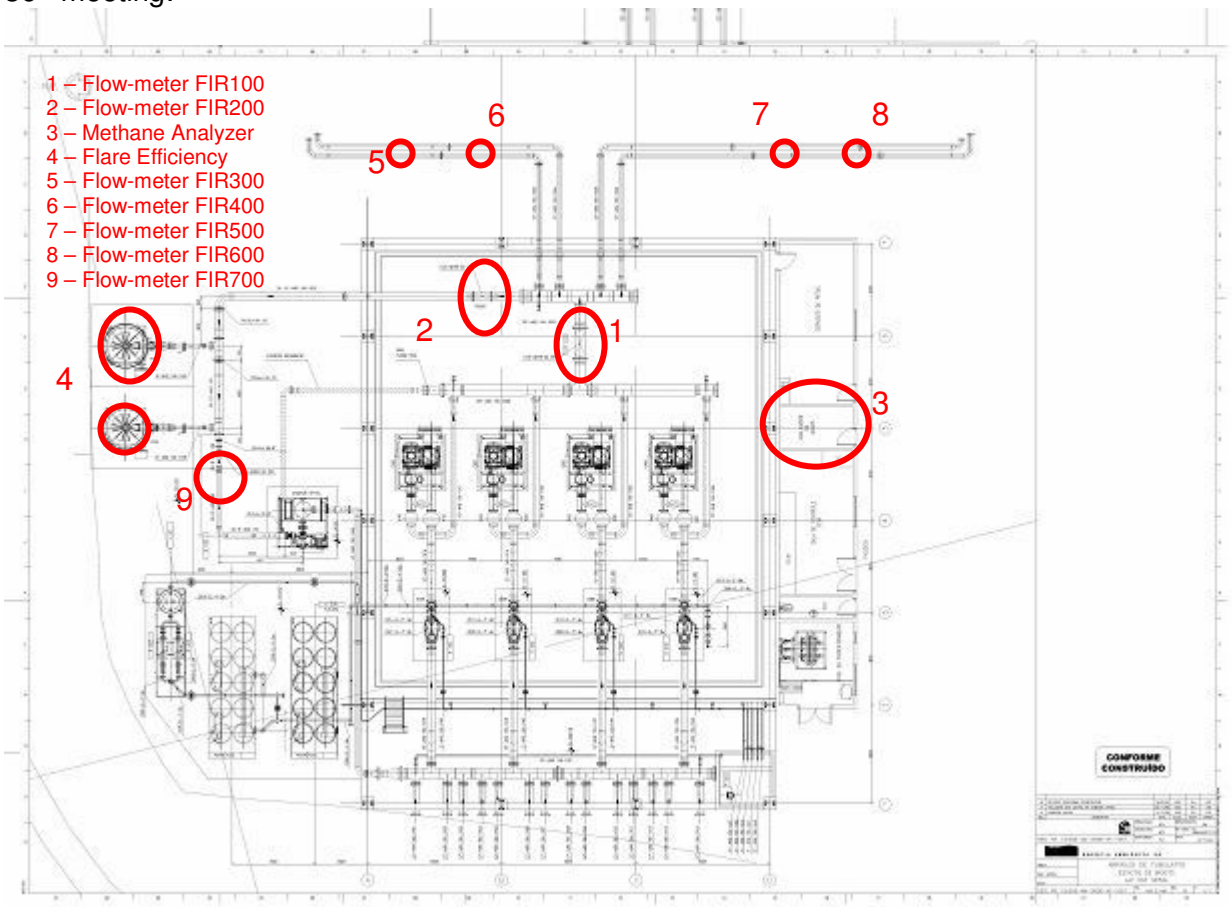
2. Key monitoring activities according to the monitoring plan

2.1. Monitoring equipment

The following equipment are used to monitor the operation of the project and to monitor the Emission Reduction, according with the revision of the Monitoring Plan, submitted to the EB 36th meeting:



1 – Flow-meter FIR100 (Gas Collected in the main pipeline) [1]

Variable	Type of Equipment	Manufacturer	Model	Error (+/- %)
Gas Flow	Flow Meter	Instromet	SM-RI X K	0,6000
Temperature	Temperature Transmiter	Ibrel	PT-100	0,2329
Pressure	Pressure Transmiter	Instromet	model 333-H	0,0100

[1] 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 4.2).

2 – Flow-meter FIR200 (Gas sent to Flare F100)

Variable	Type of Equipment	Manufacturer	Model	Error (+/- %)
Gas Flow	Flow Meter	Instromet	SM-RI X K	0,6000
Temperature	Temperature Transmiter	Ibrel	PT-100	0,1801
Pressure	Pressure Transmiter	Instromet	model 333-H	0,0100

3 – Methane Analyzer

Variable	Type of Equipment	Manufacturer	Model	Error (+/- %)
Methane Analyzer	Analyzer Panel	NUK	BINOS 100 - CH4 - O2	1,000

4 – Exhaust Gas Methane Concentration

Analysis made by specialized company.

5 – Flow-meter FIR300 (Gas sent to the Power House)

Variable	Type of Equipment	Manufacturer	Model	Error (+/- %)
Gas Flow	Flow Meter	Incontrol	VTGEX200	0,7720
Temperature	Temperature Transmiter	Incontrol	PT-100	0,0500
Pressure	Pressure Transmiter	Incontrol	LD291M	0,0337

6 – Flow-meter FIR400 (Gas sent to the Power House)

Variable	Type of Equipment	Manufacturer	Model	Error (+/- %)
Gas Flow	Flow Meter	Incontrol	VTGEX200	0,5960
Temperature	Temperature Transmiter	Incontrol	PT-100	0,0500
Pressure	Pressure Transmiter	Incontrol	LD291M	0,0381

7 – Flow-meter FIR500 (Gas sent to the Power House)

Variable	Type of Equipment	Manufacturer	Model	Error (+/- %)
Gas Flow	Flow Meter	Incontrol	VTGEX200	0,8100
Temperature	Temperature Transmiter	Incontrol	PT-100	0,0500
Pressure	Pressure Transmiter	Incontrol	LD291M	0,3700

8 – Flow-meter FIR600 (Gas sent to the Power House)

Variable	Type of Equipment	Manufacturer	Model	Error (+/- %)
Gas Flow	Flow Meter	Incontrol	VTGEX200	0,6320

Temperature	Temperature Transmiter	Incontrol	PT-100	0,0500
Pressure	Pressure Transmiter	Incontrol	LD291M	0,4440

9 – Flow-meter FIR700 (Gas sent to Flare F200)[2]

Variable	Type of Equipment	Manufacturer	Model	Error (+/- %)
Gas Flow	Flow Meter	Actaris	Fluxi TZ G1600	0,3300
Temperature	Temperature Transmiter			
Pressure	Pressure Transmiter			

2.1.1.1. Power House

Variable	Type of Equipment	Manufacturer	Model	Error (+/- %)
Electricity Dispathced	Electricity Meter	Merlin Gerin	Power Logic - CM 4000	1,00

2.1.2. Involvement of Third Parties

BFLGE has one third partie involved:

- Specialized company on gas analysis: As the analysis of methane concentration in the exhaust gas is made periodically, Biogás hired BIOAGRI, a national and certified laboratory.

- Sotreq: Sotreq is the company that produces the electricity in ICEs, using the gas from the landfill. Sotreq is responsible to monitor the electricity displaced to the local grid. The amount of electricity dispatched is monitored by Sotreq's PLC and by Biogás's PLC.

2.2. Data collection (accumulated data for the monitoring period)

2.2.1. List of fixed 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 $tons/Nm^3$

2.2.2. List of variables

$Q_{biogas,\ collected}$ = amount of biogas collected from the landfill (Nm^3)
$Q_{biogas,\ flares}$ = amount of biogas sent to flares (Nm^3)
$Q_{biogas,\ power\ house}$ = amount of biogas sent to the power house (Nm^3)
$\%_{CH4}$ = percentage of methane in the biogas (% volume);
EG_y = amount of electricity dispatched to the grid (MWh);

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

FE = Flare Efficiency (calculated using data from methane sent to flares and methane content in the exhaust gas);
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%).

2.2.3. Data concerning GHG emissions of the project activity

As BLFGE does not consume electricity that are not taken account in the Net Electricity value, $PE_y = 0$.

2.2.4. Data concerning GHG emissions of the baseline

DATE	MAIN PIPELINE							SECONDARY PIPELINE				ELECTRICITY GENERATION				
	COLLECTING SYSTEM			FLARE F100				FLARE F200								
	LFG measured by FIR100 (Nm^3)	Methane (%)	Methane measured by FIR100 (Nm^3)	LFG measured by FIR200 (Nm^3)	Methane measured by FIR200 (Nm^3)	F100 Efficiency (%)	Methne Destroyed in F100 (Nm^3)	LFG measured by FIR700 (Nm^3)	Methane measured by FIR700 (Nm^3)	F200 Efficiency (%)	Methne Destroyed in F200 (Nm^3)	Methane measured by FIR300 (Nm^3)	Methane measured by FIR400 (Nm^3)	Methane measured by FIR500 (Nm^3)	Methane measured by FIR600 (Nm^3)	Eletricity Exported (MWh)
01/11/2007	213.608	53,0371	113.291,4885	27.270	14.463,2171	99,99680	14.462,7542	25.527	13.538,7805	99,99680	13.538,3472	18.079,8170	25.507,6628	29.754,3434	25.902,2588	288,62
02/11/2007	235.045	53,3533	125.404,2639	40.296	21.499,2457	99,99680	21.498,5577	46.612	24.869,0401	99,99680	24.868,2442	18.983,1041	26.868,7218	31.958,0931	25.957,9810	308,05
03/11/2007	224.983	52,6416	118.434,6509	31.773	16.725,8155	99,99680	16.725,2802	41.616	21.907,3282	99,99680	21.906,6271	22.589,0369	23.939,8204	30.181,0085	24.919,4806	298,11
04/11/2007	278.936	51,5826	143.882,4411	39.695	20.475,7130	99,99680	20.475,0577	36.892	19.029,8527	99,99680	19.029,2437	29.055,4469	32.420,1799	36.487,4679	24.122,0870	378,32
05/11/2007	285.391	50,5093	144.148,9963	28.463	14.376,4620	99,99680	14.376,0019	39.737	20.070,8805	99,99680	20.070,2382	30.081,3187	28.252,3769	41.007,9955	29.915,6482	398,26
06/11/2007	304.265	50,6107	153.990,6463	27.314	13.823,8065	99,99680	13.823,3641	21.045	10.651,0218	99,99680	10.650,6809	28.919,9661	35.005,9028	40.615,5928	44.081,4135	430,18
07/11/2007	271.943	52,1485	141.814,1953	37.354	19.479,5506	99,99680	19.478,9272	35.448	18.485,6002	99,99680	18.485,0086	27.970,3694	32.494,2518	30.817,1560	29.546,8186	366,64
08/11/2007	304.242	50,1907	152.701,1894	29.494	14.803,2450	99,99680	14.802,7712	26.795	13.448,5980	99,99680	13.448,1676	29.781,1537	33.588,6202	40.052,6805	34.475,4899	424,62
09/11/2007	299.161	50,1215	149.943,9806	32.259	16.168,6946	99,99680	16.168,1772	29.311	14.691,1128	99,99680	14.690,6426	27.298,1737	31.625,1628	40.629,9915	34.671,5476	412,77
10/11/2007	312.221	50,0459	156.253,8094	39.476	19.756,1194	99,99680	19.755,4872	12.019	6.015,0167	99,99680	6.014,8242	30.161,1625	31.283,1916	40.718,8456	35.093,1859	422,18
11/11/2007	314.256	50,0364	157.242,3891	45.200	22.616,4528	99,99680	22.615,7290	10.405	5.206,2874	99,99680	5.206,1207	29.565,5080	32.995,0028	40.616,0469	31.737,5881	414,06
12/11/2007	296.926	49,8214	147.932,6901	30.340	15.115,8127	99,99680	15.115,3289	28.209	14.054,1187	99,99680	14.053,6689	29.051,3565	33.176,0702	37.708,3230	32.454,1581	408,26
13/11/2007	303.927	49,0947	149.212,0488	27.852	13.673,8558	99,99680	13.673,4182	25.123	12.334,0614	99,99680	12.333,6667	27.828,3488	33.558,1912	39.664,0990	34.092,3415	422,06
14/11/2007	302.809	49,3047	149.299,0690	33.173	16.355,8481	99,99680	16.355,3247	24.538	12.098,3872	99,99680	12.098,0000	27.821,6561	31.270,5198	39.270,7005	34.407,2848	415,79
15/11/2007	308.533	49,8348	153.756,8034	29.348	14.625,5171	99,99680	14.625,0490	27.291	13.600,4152	99,99680	13.599,9799	29.142,8926	34.327,2069	40.493,7650	34.572,8925	435,58
16/11/2007	305.126	49,6989	151.644,2656	36.045	17.913,9685	99,99680	17.913,3952	30.780	15.297,5281	99,99680	15.297,0385	29.714,4753	29.974,8975	38.021,1494	35.096,3692	414,21
17/11/2007	297.803	49,4885	147.378,2376	40.295	19.941,3910	99,99680	19.940,7528	34.027	16.839,2141	99,99680	16.838,6752	27.484,9231	25.251,5071	39.196,3766	35.603,5115	394,69
18/11/2007	297.372	49,4540	147.062,3488	35.432	17.522,5412	99,99680	17.521,9804	29.694	14.684,6872	99,99680	14.684,2172	26.410,4141	27.204,1508	38.427,2416	37.986,6064	404,19
19/11/2007	223.432	50,2158	112.198,1662	29.082	14.603,7589	99,99680	14.603,2915	27.642	13.880,6514	99,99680	13.880,2072	18.291,1051	18.593,4042	23.516,0591	23.463,8347	256,10
20/11/2007	278.831	50,7556	141.522,3470	45.370	23.027,8157	99,99680	23.027,0788	44.268	22.468,4890	99,99680	22.467,7700	24.903,7426	24.445,4196	38.185,4681	31.300,4709	365,36
21/11/2007	294.388	49,0647	144.440,5890	31.566	15.487,7632	99,99680	15.487,2675	29.952	14.695,8589	99,99680	14.695,3886	29.095,3671	26.406,6215	40.213,4281	32.895,9187	401,15
22/11/2007	234.775	51,6734	121.316,2248	37.686	19.473,6375	99,99680	19.473,0143	42.130	21.770,0034	99,99680	21.769,3067	22.374,5822	20.858,4846	31.964,1317	26.505,8705	303,28
23/11/2007	282.205	49,5252	139.762,5906	28.530	14.129,5395	99,99680	14.129,0873	34.736	17.203,0734	99,99680	17.202,5229	28.313,0615	27.002,1295	37.175,5961	33.066,4902	392,11
24/11/2007	285.065	49,3817	140.769,9431	31.168	15.391,2882	99,99680	15.390,7956	29.178	14.408,5924	99,99680	14.408,1313	30.030,9870	25.105,1624	38.664,3896	31.464,0439	392,42
25/11/2007	289.550	49,1498	142.313,2459	23.472	11.536,4410	99,99680	11.536,0718	23.709	11.652,9260	99,99680	11.652,5531	34.938,6268	25.731,3947	38.925,1671	31.268,6112	410,43
26/11/2007	280.949	49,3140	138.547,1898	14.896	7.345,8134	99,99680	7.345,5783	27.899	13.758,1128	99,99680	13.757,6725	34.996,1732	24.997,2666	40.110,5281	33.530,0680	417,60

DATE	MAIN PIPELINE							SECONDARY PIPELINE				ELECTRICITY GENERATION				
	COLLECTING SYSTEM			FLARE F100				FLARE F200								
	LFG measured by FIR100 (Nm^3)	Methane (%)	Methane measured by FIR100 (Nm^3)	LFG measured by FIR200 (Nm^3)	Methane measured by FIR200 (Nm^3)	F100 Efficiency (%)	Methne Destroyed in F100 (Nm^3)	LFG measured by FIR700 (Nm^3)	Methane measured by FIR700 (Nm^3)	F200 Efficiency (%)	Methne Destroyed in F200 (Nm^3)	Methane measured by FIR300 (Nm^3)	Methane measured by FIR400 (Nm^3)	Methane measured by FIR500 (Nm^3)	Methane measured by FIR600 (Nm^3)	Eletricity Exported (MWh)
27/11/2007	291.860	48,9164	142.767,4050	29.914	14.632,8518	99,99680	14.632,3835	28.153	13.771,4340	99,99680	13.770,9933	33.975,3747	26.318,0015	34.714,9907	33.132,5452	400,66
28/11/2007	293.963	48,9773	143.975,1403	30.959	15.162,8823	99,99680	15.162,3970	25.238	12.360,8909	99,99680	12.360,4953	31.176,5003	27.857,7984	40.133,9587	29.785,0552	402,13
29/11/2007	287.831	49,2467	141.747,2690	24.157	11.896,5253	99,99680	11.896,1446	27.342	13.465,0327	99,99680	13.464,6018	33.270,5780	27.498,8648	39.406,7168	29.618,4427	405,65
30/11/2007	295.931	49,4654	146.383,4528	22.409	11.084,7014	99,99680	11.084,3466	19.388	9.590,3517	99,99680	9.590,0448	32.659,0356	27.909,3679	40.205,9717	34.434,8435	421,94
01/12/2007	288.514	49,1686	141.858,2946	22.550	11.087,5193	99,99680	11.087,1644	28.171	13.851,2863	99,99680	13.850,8430	35.163,9076	27.289,5563	37.610,0455	30.535,1756	406,69
02/12/2007	286.870	49,3793	141.654,3979	20.617	10.180,5302	99,99680	10.180,2044	23.018	11.366,1272	99,99680	11.365,7634	34.639,5789	23.668,4860	35.503,2229	38.217,6030	408,83
03/12/2007	264.223	49,9239	131.910,4262	30.884	15.418,4972	99,99680	15.418,0038	31.318	15.635,1670	99,99680	15.634,6666	28.403,7036	20.327,5143	31.700,6780	32.058,6323	343,89
04/12/2007	282.527	49,5090	139.876,2924	23.767	11.766,8040	99,99680	11.766,4274	27.155	13.444,1689	99,99680	13.443,7386	31.582,7812	23.325,1751	36.303,9595	37.420,3874	399,15
05/12/2007	286.550	49,5172	141.891,5366	21.303	10.548,6491	99,99680	10.548,3115	22.463	11.123,0486	99,99680	11.122,6926	35.106,2092	24.105,4681	34.320,3713	37.954,4386	408,54
06/12/2007	283.642	49,9007	141.539,3434	19.877	9.918,7621	99,99680	9.918,4446	24.358	12.154,8125	99,99680	12.154,4235	35.243,3673	28.471,8423	37.082,2081	30.264,7745	411,46
07/12/2007	296.034	50,0606	148.196,3966	24.441	12.235,3112	99,99680	12.234,9196	22.791	11.409,3113	99,99680	11.408,9462	34.938,2939	27.854,7190	40.329,3199	33.031,4856	426,59
08/12/2007	246.937	51,6222	127.474,3120	34.569	17.845,2783	99,99680	17.844,7072	35.842	18.502,4289	99,99680	18.501,8368	25.294,3617	23.841,1968	32.626,2628	28.016,9166	332,35
09/12/2007	283.792	49,6897	141.015,3934	27.244	13.537,4618	99,99680	13.537,0286	30.400	15.105,6688	99,99680	15.105,1854	29.935,5597	24.437,8913	39.239,4591	34.523,4097	395,78
10/12/2007	289.920	49,9157	144.715,5974	28.994	14.472,5580	99,99680	14.472,0948	23.922	11.940,8337	99,99680	11.940,4515	29.051,4365	27.162,6264	39.720,9174	34.682,4266	404,18
11/12/2007	291.715	49,9199	145.623,8362	28.840	14.396,8991	99,99680	14.396,4383	23.329	11.645,8134	99,99680	11.645,4407	34.585,0059	27.568,7639	39.805,1298	28.871,6733	408,42
12/12/2007	293.660	50,2089	147.443,4557	34.061	17.101,6534	99,99680	17.101,1061	29.959	15.042,0843	99,99680	15.041,6029	35.096,5231	27.516,9876	39.968,7948	26.764,3562	405,60
13/12/2007	295.817	49,9385	147.726,5725	35.350	17.653,2597	99,99680	17.652,6947	36.968	18.461,2646	99,99680	18.460,6738	35.131,7347	28.792,0421	34.939,9709	29.956,6079	402,93
14/12/2007	285.251	50,2035	143.205,9857	40.342	20.253,0959	99,99680	20.252,4478	43.257	21.716,5279	99,99680	21.715,8329	34.336,1817	28.809,7805	30.413,2803	27.801,1921	379,79
15/12/2007	286.857	49,9593	143.311,7492	32.962	16.467,5844	99,99680	16.467,0574	39.421	19.694,4556	99,99680	19.693,8253	31.286,5120	28.238,9947	32.248,7281	34.647,7737	393,89
16/12/2007	287.097	49,9570	143.425,0482	19.650	9.816,5505	99,99680	9.816,2363	33.137	16.554,2510	99,99680	16.553,7212	34.584,2319	27.596,2468	36.925,7165	34.394,3953	415,14
17/12/2007	301.608	49,3797	148.933,1255	27.241	13.451,5240	99,99680	13.451,0935	23.885	11.794,3413	99,99680	11.793,9638	34.372,2215	27.418,0784	38.897,3772	34.558,3830	420,91
18/12/2007	297.372	49,7364	147.902,1274	35.432	17.622,6012	99,99680	17.622,0372	26.413	13.136,8753	99,99680	13.136,4549	35.157,6664	26.236,4483	38.644,6854	34.486,7223	417,36
19/12/2007	294.025	50,4842	148.436,1690	26.655	13.456,5635	99,99680	13.456,1328	30.057	15.174,0359	99,99680	15.173,5503	34.383,7789	28.617,4736	38.772,8752	32.965,1729	422,00
20/12/2007	287.708	50,5672	145.485,8797	28.473	14.397,9988	99,99680	14.397,5380	33.245	16.811,0656	99,99680	16.810,5276	33.706,0728	23.464,1921	38.251,5584	36.193,4734	409,76
21/12/2007	288.665	50,4031	145.496,1086	37.994	19.150,1538	99,99680	19.149,5409	37.347	18.824,0457	99,99680	18.823,4433	30.663,7339	24.214,6573	31.174,8213	41.090,1192	394,43
22/12/2007	288.845	50,1006	144.713,0780	20.836	10.438,9610	99,99680	10.438,6269	34.834	17.452,0430	99,99680	17.451,4845	28.458,6438	33.274,8144	31.593,9393	40.641,1057	419,07
23/12/2007	297.914	49,7898	148.330,7847	37.474	18.658,2296	99,99680	18.657,6325	26.645	13.266,4922	99,99680	13.266,0676	29.665,2607	31.540,3446	27.616,9083	40.185,8454	400,59

DATE	MAIN PIPELINE							SECONDARY PIPELINE				ELECTRICITY GENERATION				
	COLLECTING SYSTEM			FLARE F100				FLARE F200								
	LFG measured by FIR100 (Nm^3)	Methane (%)	Methane measured by FIR100 (Nm^3)	LFG measured by FIR200 (Nm^3)	Methane measured by FIR200 (Nm^3)	F100 Efficiency (%)	Methne Destroyed in F100 (Nm^3)	LFG measured by FIR700 (Nm^3)	Methane measured by FIR700 (Nm^3)	F200 Efficiency (%)	Methne Destroyed in F200 (Nm^3)	Methane measured by FIR300 (Nm^3)	Methane measured by FIR400 (Nm^3)	Methane measured by FIR500 (Nm^3)	Methane measured by FIR600 (Nm^3)	Eletricity Exported (MWh)
24/12/2007	292.909	49,4718	144.907,3546	33.980	16.810,5176	99,99680	16.809,9796	33.036	16.343,5038	99,99680	16.342,9808	33.692,7693	23.752,8953	30.207,9757	40.414,5028	395,42
25/12/2007	256.894	50,3921	129.454,2813	38.844	19.574,3073	99,99680	19.573,6809	41.426	20.875,4313	99,99680	20.874,7632	25.084,6834	27.289,8417	22.035,4574	34.984,2115	330,56
26/12/2007	283.762	49,5778	140.682,9568	30.790	15.265,0046	99,99680	15.264,5161	40.621	20.138,9981	99,99680	20.138,3536	30.817,5604	28.688,1939	26.396,2122	38.872,4656	387,74
27/12/2007	288.097	49,1658	141.645,1948	16.052	7.892,0942	99,99680	7.891,8416	35.949	17.674,6134	99,99680	17.674,0478	33.725,2805	32.916,5031	32.718,3649	33.209,5312	417,22
28/12/2007	276.466	50,1059	138.525,7774	19.462	9.751,6102	99,99680	9.751,2981	38.911	19.496,7067	99,99680	19.496,0828	32.458,6020	27.486,5935	31.473,0189	37.915,6355	399,01
29/12/2007	285.973	49,4003	141.271,5199	21.400	10.571,6641	99,99680	10.571,3258	35.083	17.331,1072	99,99680	17.330,5526	33.771,5270	32.754,8689	31.579,1417	31.202,7114	407,73
30/12/2007	282.913	49,0393	138.738,5548	17.863	8.759,8901	99,99680	8.759,6097	38.932	19.091,9802	99,99680	19.091,3692	31.158,1000	28.943,9756	32.351,2262	37.158,5487	406,96
31/12/2007	275.012	49,1014	135.034,7421	5.124	2.515,9557	99,99680	2.515,8751	44.562	21.880,5658	99,99680	21.879,8656	33.512,6875	27.654,3994	32.516,4201	38.479,7851	414,80

2.2.5. Data concerning leakage

According with ACM0001 – version 02, no leakage needs to be considered.

2.3. Special event log

No special event log was identified.

3. Quality assurance and quality control measures

3.1. Documented procedures and management plan

3.1.1. Roles and responsibilities

The following flow-chart represents the procedures and responsibilities on the monitoring of each parameter:

a) Pressure Readings

1. Data Reading	2. Data Transmission	3. Data Registration	4. Monitoring Report	5. Equipment Calibration
Equipment: Digital Manometer *Location:* Exit Collector *TAG:* PTC603 *Manufacturer:* E+H *Model:* PMC 41 *SN.:* 5A56701020 *Range:* -400 to 400 mbar	**Equipment:** Supervisory System	**Equipment:** Supervisory System and SQL Database	Every week, Biogás (Tiago Nascimento and Juliana Justi) send the data by e-mail to ARCADIS Tetraplan (Eduardo Cardoso Filho). ARCADIS Tetraplan is responsible for double checking and developing the Monitoring Report.	Last Calibration: Dec/2006
Reading Frequency Every 5 seconds	**Transmission Frequency** Every 5 seconds	**Registration Frequency** Every 5 minutes		**Calibration Frequency** Next Calibration: Aug/2008
Responsibility PLC (continuously) and plant supervisor (monthly)	**Responsibility** PLC (continuously) and plant supervisor (monthly)	**Responsibility** PLC (continuously) and plant supervisor (monthly)		

b) Temperature Readings

1. Data Reading	2. Data Transmission	3. Data Registration	4. Monitoring Report	5. Equipment Calibration
Equipment: Digital Termometer *Location:* Exit Collector *TAG:* TT604 *Manufacturer:* E+H *Model:* TST 10 *S.N:* 42622123 *Range:* 0 to 100°C	**Equipment:** Supervisory System	**Equipment:** Supervisory System and SQL Database	Every week, Biogás (Tiago Nascimento and Juliana Justi) send the data by e-mail to ARCADIS Tetraplan (Eduardo Cardoso Filho). ARCADIS Tetraplan is responsible for double checking and developing the Monitoring Report.	Last Calibration: Dec/2006
Reading Frequency Every 5 seconds	**Transmission Frequency** Every 5 seconds	**Registration Frequency** Every 5 minutes		**Calibration Frequency** Next Calibration: Aug/2008
Responsibility PLC (continuously) and plant supervisor (monthly)	**Responsibility** PLC (continuously) and plant supervisor (monthly)	**Responsibility** PLC (continuously) and plant supervisor (monthly)		

c) Total Flow (FIR100)

1. Data Reading	2. Data Transmission	3. Data Registration	4. Monitoring Report	5. Equipment Calibration
Equipment: *Type of Equipment:* Digital Flow-meter *Location:* Exit Collector *TAG:* FIR100 *Manufacturer:* Instromet *Model:* SM-RI-X-K *S.N.:* 10400826 *Range:* 800-16.000 m^3/h	**Equipment:** Supervisory System	**Equipment:** *Type of Equipment* Supervisory System and SQL Database	Every week, Biogás (Tiago Nascimento and Juliana Justi) send the data by e-mail to ARCADIS Tetraplan (Eduardo Cardoso Filho). ARCADIS Tetraplan is responsible for double checking and developing the Monitoring Report.	The flow-meter and the transmitters were delivered calibrated (September/2004). The temperature transmitter was recalibrated in October/2007.
Reading Frequency Every 5 seconds	**Transmission Frequency** Every 5 seconds	**Registration Frequency** Every 5 minutes		**Calibration Frequency** Every 5 years
Responsibility PLC (continuously) and plant supervisor (monthly)	**Responsibility** PLC (continuously) and plant supervisor (monthly)	**Responsibility** PLC (continuously) and plant supervisor (monthly)		

d) Flow to Flare F100 (FIR200)

1. Data Reading	2. Data Transmission	3. Data Registration	4. Monitoring Report	5. Equipment Calibration
Equipment: Digital Flows-meter *Location:* Entrance of flare F100 *TAG:* FIR200 *Manufacturer:* Instromet *Model:* SM-RI-X-K *S.N.:* 10400827 *Range:* 320-6.500 m^3/h	**Equipment:** Supervisory System	**Equipment:** Supervisory System and SQL Database	Every week, Biogás (Tiago Nascimento and Juliana Justi) send the data by e-mail to ARCADIS Tetraplan (Eduardo Cardoso Filho). ARCADIS Tetraplan is responsible for double checking and developing the Monitoring Report.	The flow-meter and the transmitters were delivered calibrated (September/2004). The temperature transmitter was recalibrated in October/2007.
Reading Frequency Every 5 seconds	**Transmission Frequency** Every 5 seconds	**Registration Frequency** Every 5 minutes		**Calibration Frequency** Every 5 years
Responsibility PLC (continuously) and plant supervisor (monthly)	**Responsibility** PLC (continuously) and plant supervisor (monthly)	**Responsibility** PLC (continuously) and plant supervisor (monthly)		

e) Flow to the Power House (FIR300)

1. Data Reading	2. Data Transmission	3. Data Registration	4. Monitoring Report	5. Equipment Calibration
Equipment: Digital flow-meter *Location:* entrance of the power house *TAG:* FIR300 *Manufacturer:* Incontrol *Model:* VTGEX200 *S.N.:* VG083B6 *Range:* 170 a 8156 m^3/h	**Equipment:** Supervisory System	**Equipment:** Supervisory System and SQL Database	Every week, Biogás (Tiago Nascimento and Juliana Justi) send the data by e-mail to ARCADIS Tetraplan (Eduardo Cardoso Filho). ARCADIS Tetraplan is responsible for double checking and developing the Monitoring Report.	The flow-meter and the transmitters were delivered calibrated (Jan/2007)
Reading Frequency Every 5 seconds	**Transmission Frequency** Every 5 seconds	**Registration Frequency** Every 5 minutes		**Calibration Frequency** Every 5 years
Responsibility PLC (continuously) and plant supervisor (monthly)	**Responsibility** PLC (continuously) and plant supervisor (monthly)	**Responsibility** PLC (continuously) and plant supervisor (monthly)		

f) Flow to the Power House (FIR400)

1. Data Reading	2. Data Transmission	3. Data Registration	4. Monitoring Report	5. Equipment Calibration
Equipment: Digital flow-meter *Location:* entrance of the power house *TAG:* FIR400 *Manufacturer:* Incontrol *Model:* VTGEX200 *S.N.:* VG084B6 *Range:* 170-8156 m^3/h	**Equipment:** Supervisory System	**Equipment:** Supervisory System and SQL Database	Every week, Biogás (Tiago Nascimento and Juliana Justi) send the data by e-mail to ARCADIS Tetraplan (Eduardo Cardoso Filho). ARCADIS Tetraplan is responsible for double checking and developing the Monitoring Report.	The flow-meter and the transmitters were delivered calibrated (Jan/2007)
Reading Frequency Every 5 seconds	**Transmission Frequency** Every 5 seconds	**Registration Frequency** Every 5 minutes		**Calibration Frequency** Every 5 years
Responsibility PLC (continuously) and plant supervisor (monthly)	**Responsibility** PLC (continuously) and plant supervisor (monthly)	**Responsibility** PLC (continuously) and plant supervisor (monthly)		

g) Flow to the Power House (FIR500)

1. Data Reading	2. Data Transmission	3. Data Registration	4. Monitoring Report	5. Equipment Calibration
Equipment: Digital flow-meter *Location:* entrance of the power house *TAG:* FIR500 *Manufacturer:* Incontrol *Model:* VTGEX200 *S.N.:* VG086B6 *Range:* 170-8156 m^3/h	**Equipment:** Supervisory System	**Equipment:** Supervisory System and SQL Database	Every week, Biogás (Tiago Nascimento and Juliana Justi) send the data by e-mail to ARCADIS Tetraplan (Eduardo Cardoso Filho). ARCADIS Tetraplan is responsible for double checking and developing the Monitoring Report.	The flow-meter and the transmitters were delivered calibrated (Jan/2007)
Reading Frequency Every 5 seconds	**Transmission Frequency** Every 5 seconds	**Registration Frequency** Every 5 minutes		**Calibration Frequency** Every 5 years
Responsibility PLC (continuously) and plant supervisor (monthly)	**Responsibility** PLC (continuously) and plant supervisor (monthly)	**Responsibility** PLC (continuously) and plant supervisor (monthly)		

h) Flow to the Power House (FIR600)

1. Data Reading	2. Data Transmission	3. Data Registration	4. Monitoring Report	5. Equipment Calibration
Equipment: Digital flow-meter *Location:* entrance of the power house *TAG:* FIR600 *Manufacturer:* Incontrol *Model:* VTGEX200 *S.N.:* VG085B6 *Range:* 170-8156 m^3/h	**Equipment:** Supervisory System	**Equipment:** Supervisory System and SQL Database	Every week, Biogás (Tiago Nascimento and Juliana Justi) send the data by e-mail to ARCADIS Tetraplan (Eduardo Cardoso Filho). ARCADIS Tetraplan is responsible for double checking and developing the Monitoring Report.	The flow-meter and the transmitters were delivered calibrated (Jan/2007)
Reading Frequency Every 5 seconds	**Transmission Frequency** Every 5 seconds	**Registration Frequency** Every 5 minutes		**Calibration Frequency** Every 5 years
Responsibility PLC (continuously) and plant supervisor (monthly)	**Responsibility** PLC (continuously) and plant supervisor (monthly)	**Responsibility** PLC (continuously) and plant supervisor (monthly)		

i) Flow to Flare F200 (FIR700)

1. Data Reading	2. Data Transmission	3. Data Registration	4. Monitoring Report	5. Equipment Calibration
Equipment: Digital flow-meter *Location:* after the mini-blower *TAG:* FIR700 *Manufacturer:* Actaris *Model:* Fluxi TZ G1600 *S.N.:* 1373501001 *Range:* 180-2.500 m^3/h	**Equipment:** -Manually (unti 17/12/2007) -Supervisory System (from 17/12/2007 on)	**Equipment:** -Operation Diary and Excel Spreadsheets (unti 17/12/2007) -Supervisory System (from 17/12/2007 on)	Every week, Biogás (Tiago Nascimento and Juliana Justi) send the data by e-mail to ARCADIS Tetraplan (Eduardo Cardoso Filho). ARCADIS Tetraplan is responsible for double checking and developing the Monitoring Report.	The flow-meter and the transmitters were delivered calibrated (June/2007)
Reading Frequency Every 5 seconds	**Transmission Frequency** - Every 3 hours (unti 17/12/2007) - Every 5 seconds (from 17/12/2007 on).	**Registration Frequency** -Every 3 hours (until 17/12/2007) -Every 5 minutes (from 17/12/2007 on)		**Calibration Frequency** Every 5 years
Responsibility Plant operator (every 3 hours). The value read is an accumulated of 3 hours. In 17/12/2007, the meter was connected to the PLC, which began to make the readings continuously, together with the plant supervisor (monthly)	**Responsibility** - Plant operator and plant supervisor (every 3 hours, until 17/12/2007) - PLC (continuously, from 17/12/2007 on) and plant supervisor (monthly)	**Responsibility** -Plant operator and plant supervisor (every 3 hours, until 17/12/2007) -PLC (continuously, from 17/12/2007 on) and plant supervisor (monthly)		

j) Methane Concentration

1. Data Reading	2. Data Transmission	3. Data Registration	4. Monitoring Report	5. Equipment Calibration
Equipment: *Type of Equipment:* Methane Analyzer *Location:* Analyzer Room *TAG:* A100 *Manufacturer:* NUK *Model:* Binos 100-CH_4-O_2 *Range:* O_2 (0-21%) CH_4 (0-100%)	**Equipment:** Supervisory System	**Equipment:** Supervisory System and SQL Database	Every week, Biogás (Tiago Nascimento and Juliana Justi) send the data by e-mail to ARCADIS Tetraplan (Eduardo Cardoso Filho). ARCADIS Tetraplan is responsible for double checking and developing the Monitoring Report.	The analyzer was delivered calibrated (December/2003)
Reading Frequency Every 5 minutes	**Transmission Frequency** Every 5 minutes	**Registration Frequency** Every 5 minutes		**Calibration Frequency** Weekly, with a standard gas certified by INMETRO
Responsibility PLC (continuously) and plant supervisor (monthly)	**Responsibility** PLC (continuously) and plant supervisor (monthly)	**Responsibility** Plant supervisor (monthly)		

k) Flare Efficiency

1. Data Reading	2. Data Transmission	3. Data Registration	4. Monitoring Report	5. Equipment Calibration
Equipment: According with the hired company *Location:* *Manufacturer:* *Model:* *Range:*	**Equipment:** MS Excel Spreadsheets	**Equipment:** MS Excel Spreadsheets	Every 3 months, Biogás (Tiago Nascimento and Juliana Justi) send the data by e-mail to ARCADIS Tetraplan (Eduardo Cardoso Filho). ARCADIS Tetraplan is responsible for double checking and developing the Monitoring Report.	N/A
Reading Frequency Every 3 months	**Transmission Frequency** N/A	**Registration Frequency** N/A		**Calibration Frequency** N/A
Responsibility Specialized company on gas analysis	**Responsibility** Plant supervisor (every 3 months)	**Responsibility** Plant supervisor (every 3 months)		

I) Flare Efficiency

1. Data Reading	2. Data Transmission	3. Data Registration	4. Monitoring Report	5. Equipment Calibration
Equipment: *Type of Equipment:* Electricity Meter *Location:* Sotreq's PLC *Manufacturer:* Merlin Gerin *Model:* Power Logic CM 4000 *Range:* 240V/300V - 96mA MAX.	**Equipment:** Supervisory System	**Equipment:** Supervisory System and SQL Database	Every week, Biogás (Tiago Nascimento and Juliana Justi) send the data by e-mail to ARCADIS Tetraplan (Eduardo Cardoso Filho). ARCADIS Tetraplan is responsible for double checking and developing the Monitoring Report.	The meter was delivered calibrated (September/2004)
Reading Frequency Every 5 minutes	**Transmission Frequency** Every 5 minutes	**Registration Frequency** Every 5 minutes		**Calibration Frequency** N/A[3]
Responsibility PLC (continuously) and Sotreq's plant supervisor (monthly)	**Responsibility** PLC (continuously) and Sotreq's plant supervisor (monthly)	**Responsibility** Sotreq's Plant supervisor (monthly)		

3.1.2. Trainings

All training was supplied before the project's implementation and as verified during the 1st verification. No employees were hired during the Monitoring Period.

3.1.3. Calibration:

According with an internal procedure from Biogás, the measuring equipment will be calibrated according with the following table:

Equipment	Device	Location	Date of the last calibration	Date of the next calibration
Turbine flow-meter FIR100	Flow-measurer	Degassing Station (totalizer)	Sep/2004	Sep/2009

[3] Acccording with the manufacturer, Power Logic models does not have to be calibrated; however, Biogás will make voluntary calibration every 5 years.

	Pressure Transmitter		Sep/2004	Sep/2009
	Temperature Transmitter		Oct/2007	Oct/2012
Turbine flow-meter FIR200	Flow-measurer	Degassing Station (gas to the flare F100)	Sep/2004	Sep/2009
	Pressure Transmitter		Sep/2004	Sep/2009
	Temperature Transmitter		Oct/2007	Oct/2012
Turbine flow-meter FIR300	Flow-measurer	Degassing Station (gas to the power house)	Jan/2007	Jan/2012
	Pressure Transmitter		Jan/2007	Jan/2012
	Temperature Transmitter		Jan/2007	Jan/2012
Turbine flow-meter FIR400	Flow-measurer	Degassing Station (gas to the power house)	Jan/2007	Jan/2012
	Pressure Transmitter		Jan/2007	Jan/2012
	Temperature Transmitter		Jan/2007	Jan/2012
Turbine flow-meter FIR500	Flow-measurer	Degassing Station (gas to the power house)	Jan/2007	Jan/2012
	Pressure Transmitter		Jan/2007	Jan/2012
	Temperature Transmitter		Jan/2007	Jan/2012
Turbine flow-meter FIR600	Flow-measurer	Degassing Station (gas to the power house)	Jan/2007	Jan/2012
	Pressure Transmitter		Jan/2007	Jan/2012
	Temperature Transmitter		Jan/2007	Jan/2012
Turbine flow-meter FIR700	Flow-measurer	Degassing Station (gas to the flare F200)	Jun/2007	Jun/2012
	Pressure Transmitter		Jun/2007	Jun/2012
	Temperature Transmitter		Jun/2007	Jun/2012
Methane Analyzer (Binos 100-CH_4)	Methane Analyzer	Analysis Room	Dec/2003	Weekly
Electricity Meter	Electricity Dispatched	Sotreq's PLC	Sep/2004	Sep/2009

4. Calculation of GHG emission reductions

4.1. Table providing the formulas used

Variable	Description
A	Total methane sent to flare F100 measured by FIR200 (Nm^3)
B	Flare Efficiency (%)
C = A . B	Total methane destroyed in the flare F100 (Nm^3)
D	Gas-flow error (%)
E	Temperature error (%)
F	Pressure error (%)
G	Methane Concentration error (%)
H = $\sqrt{D^2 + E^2 + F^2 + G^2}$	Total error from measuring equipment (%)
I = C . (1-H)	**Total methane corrected destroyed at the flare F100 (Nm^3)**
A_1	Total methane sent to flare F200 measured by FIR700 (Nm^3)
B_1	Flare Efficiency (%)
$C_1 = A_1 . B_1$	Total methane destroyed in the flare F200 (Nm^3)
D_1	Gas-flow error (%)
E_1	Temperature error (%)
F_1	Pressure error (%)
G_1	Methane Concentration error (%)
$H_1 = \sqrt{D_1^2 + E_1^2 + F_1^2 + G_1^2}$	Total error from measuring equipment (%)
$I_1 = C_1 . (1_1-H_1)$	**Total methane corrected destroyed at the flare F200 (Nm^3)**
J_{FIRi}[4]	Methane flow to the power house measured by FIRi (Nm^3)
K_{FIRi}[4]	Gas-flow error of FIRi (%)
L_{FIRi}[4]	Temperature error of FIRi (%)
M_{FIRi}[4]	Pressure error of FIRi (%)
N_{FIRi}[4]	Methane Concentration error (%)
O_{FIRi}[4] = $\sqrt{K_{FIRi}^2 + L_{FIRi}^2 + M_{FIRi}^2 + N_{FIRi}^2}$	Total measuring error from FIRi (%)
P_{FIRi}[4] = J_{FIRi} . (1 – O_{FIRi})	**Total methane corrected measured by FIRi (Nm^3)**
Q = P_{FIR300} + P_{FIR400} + P_{FIR500} + P_{FIR600}	**Total methane corrected destroyed at the electricity (Nm^3)**
R = I + I_1 + Q	Total methane destroyed in the period (Nm^3))
S = 0,0007168	Density of Methane at the STPC (tCH_4/Nm^3)
T = R . S	Total weight of methane destroyed (tCH_4)
U = 21	CO_2 equivalency (tCO_2e/tCH_4)

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

V = T . U	Total equivalent carbon (tCO_2e)
W = 20%	Adjustment Factor (%)
X = V . (1-W)	**Total Liquid Carbon (tCO_2e)**
Y	Total electricity exported (MWh)
Z	Electricity-meter error (%)
AA = Y . (1 – Z)	Total electricity corrected (MWh)
AB = 0,2677	Emission Factor (tCO_2e/MWh)
AC = AA . AB	**Total CO_2e from the energy exported (tCO_2e)**
AD = X + AC	**TOTAL CREDITS DURING THE PERIOD (tCO_2e)**

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:

$$\text{Flow}_{\text{methane}} = \text{Flow}_{\text{FIR i}} \times \frac{\%_{\text{methane}}}{100}$$, where:

- $Flow_{methane}$ = methane flow sent to the flare F_i (Nm^3/h);
- $Flow_{FIRi}$ = total flow measured by the flow-meter FIR_i 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 ($Flow_{remaining}$):

$$\text{Flow}_{\text{remaining}} = \text{Flow}_{\text{FIR i}} - \text{Flow}_{\text{methane}}$$, 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 ($Flow_{Total}$):

$$\text{Flow}_{\text{Total}} = \text{Flow}_{\text{methane}} + \left(\text{Flow}_{\text{methane}} \times \text{air}_{\text{ratio}}\right) + \text{Flow}_{\text{remaining}},$$

where[5]:

- $Flow_{total}$ = total gas sent to the flare F_i (Nm^3/h);
- air_{ratio} = theoretical air ratio (according with Hoffstetter, the flare manufacturer, the theoretical air admission into the flare is 5 volumes of air per 1 volume of methane);

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

$$\text{M}_{\text{methane}} = \text{Flow}_{\text{Total}} \times \frac{\text{CH}_{4,\text{eg}}}{1000}$$, where:

- $M_{methane}$ = amount of methane remaining in the exhaust gas (g), calculated using the result of the analysis;

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

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

e) Calculate the Flare Efficiency (FE):

$$FE = \frac{\left(Flow_{methane} \times 0{,}7168\right) - \frac{M_{methane}}{1000}}{\left(Flow_{methane} \times 0{,}7168\right)} \times 100$$

, where:

- FE = Flare Efficiency (%);
- 0,7168 = density of methane, at STP (kg/Nm^3).

BIOAGRI made an analysis of the methane content in the exhaust gas of the flares F200 and F100 on 29/09/2007.

Flare	September/2007
F100	3,25 mg/Nm^3
F200	2,32 mg/Nm^3

Other parameters used to calculate the flare efficiency were:

Measurement	$Flow_{FIRi}$		Methane %	
	FIR200	FIR700	FIR200	FIR700
September/2007	2.340 Nm^3/h	1.942 Nm^3/h	48,91%	49,82%

The results were:

Measurement	Flare Efficiency Calculated	
	F100	F200
September/2007	99,9968%	99,9977%

The flare efficiency adopted from 01/11/2007 to 31/12/2007 is 99,9968% (the lowest efficiency calculated).

4.2. Description and consideration of measurement uncertainties and error propagation

The formulae used to calculate the error of methane flow was (given specific error for each monitoring equipment, as presented on 2.1):

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

4.2.1. Gas to Flares

The flow-meters used to measure the gás sent to the flares are only two: FIR700 and FIR200.

$$\varepsilon_{FIR200} = \sqrt{0{,}600^2 + 0{,}1801^2 + 0{,}010^2 + 1{,}000^2} = 1{,}1801\%$$

The error from FIR700 is calculated as follows:

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

$$\varepsilon_{FIR700} = \sqrt{0{,}330^2 + 1{,}000^2} = 1{,}0531\%$$

4.2.2. Gas to the Power House

$$\varepsilon_{FIR300} = \sqrt{0{,}772^2 + 0{,}050^2 + 0{,}0337^2 + 1{,}000^2} = 1{,}2648\%$$

$$\varepsilon_{FIR400} = \sqrt{0{,}596^2 + 0{,}050^2 + 0{,}0381^2 + 1{,}000^2} = 1{,}1659\%$$

$$\varepsilon_{FIR500} = \sqrt{0{,}810^2 + 0{,}050^2 + 0{,}370^2 + 1{,}000^2} = 1{,}3400\%$$

$$\varepsilon_{FIR600} = \sqrt{0{,}632^2 + 0{,}050^2 + 0{,}444^2 + 1{,}000^2} = 1{,}2646\%$$

4.3. GHG emission reductions

	TOTAL
Total CO_2e from methane destroyed	114.156
Total CO_2e from electricity dispatched	6.358
TOTAL CO_2e	**120.514**

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