SECTION D. Application of a monitoring methodology and plan

D.1. Name and reference of approved monitoring methodology applied to the project activity:

The methodology applied to BLFGE is ACM0001, called "Consolidated baseline methodology for landfill gas project activities".

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

The applicability conditions for ACM0001 have already been considered under the baseline section of this PDD. In fact, BLFGE is a project activity undertaken with the purpose of capturing and flaring methane from landfill operations, and also using this methane as fuel for a power plant, generating electricity that will avoid fossil fuelled plants at the margin of the Brazilian electricity system, therefore causing a reduction in GHG emissions. ACM0001 is therefore fully applicable to BLFGE.

D.2. 1. Option 1: Monitoring of the emissions in the project scenario and the baseline scenario

D.2.1.1. Data to be collected in order to monitor emissions from the project activity, and how this data will be archived:

ID number *(Please use numbers to ease cross-referencing to D.3)*	Data variable	Source of data	Data unit	Measured (m), calculated (c) or estimated (e)	Recording frequency	Proportion of data to be monitored	How will the data be archived? (electronic/ paper)	Comment

D.2.1.2. Description of formulae used to estimate project emissions (for each gas, source, formulae/algorithm, emissions units of CO_2 equ.)

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D.2.1.3. Relevant data necessary for determining the baseline of anthropogenic emissions by sources of GHGs within the project boundary and how such data will be collected and archived :

ID number *(Please use numbers to ease cross-referencing to table D.3)*	Data variable	Source of data	Data unit	Measured (m), calculated (c), estimated (e),	Recording frequency	Proportion of data to be monitored	How will the data be archived? (electronic/ paper)	Comment

D.2.1.4. Description of formulae used to estimate baseline emissions (for each gas, source, formulae/algorithm, emissions units of CO_2 equ.)

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D. 2.2. Option 2: Direct monitoring of emission reductions from the project activity (values should be consistent with those in section E).

D.2.2.1. Data to be collected in order to monitor emissions from the project activity, and how this data will be archived:								
ID number *(Please use numbers to ease cross-referencing to D.3)*	Data variable	Source of data	Data unit	Measured (m), calculated (c) or estimated (e)	Recording frequency	Proportion of data to be monitored	How will the data be archived? (electronic/ paper)	Comment
1 LFG_{Total}	Total landfill gas captured	Flow meter to flares and powerhouse	Nm^3	M	Continuous	100%	Electronic	Measured by a flow meter. Data will be aggregated monthly and yearly. Normal cubic meters represent the gas volume in cubic meters at STP. Data will be kept for two years after the end of the crediting period.
2 LFG_{Flare}	Amount of landfill gas to flares	Flow meters to flares	Nm^3	M	Continuous	100%	Electronic	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 particular line connected to a mini-blower. Normal cubic meters represent the gas volume in cubic meters at STP. Data will be kept for two years after the end of the crediting period.
3 $LFG_{Electricity}$	Amount of landfill gas to powerhouse	Flow meters to powerhouse	Nm^3	M	Continuous	100%	Electronic	Measured by 4 flow meters. Data will be aggregated monthly and yearly. Normal cubic meters represent the gas volume in cubic meters at STP. Data will be kept for two years after the end of the crediting period.
4 FE	Flare/combustion efficiency. Determined by the operation hours (1) and the methane content in the exhaust	Flare efficiency	%	M / C	(1) continuously, (2) quarterly, monthly if unstable	n/a	Electronic	(1) Continuous measurement of operation time of flare (e.g. with temperature). (2) Periodic measurement of methane content of flare exhaust gas. Data will be kept for two years after the end of the crediting period.

	gas (2)							
5 w_{CH4}	Methane fraction in the landfill gas	Continuous analyzes	m^3CH_4/m^3 LFG	M	Continuous	100%	Electronic	Measured by continuous gas quality analyzer. Data will be kept for two years after the end of the crediting period.
6	Regulatory requirements relating to landfill gas projects	Environmental legislation	Test	n/a	Yearly	100%	Electronic / Paper	
7	Net quantity of electricity displaced during the year	Electricity meter	MWh	M	Continuous	100%	Electronic	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) Data will be kept for two years after the end of the crediting period.
8	CO_2 emission intensity of the electricity	Brazilian grid	tCO_2/MWh	C	At baseline renewal	100%	Electronic	CO_2 emission intensity of the electricity being generated by the grid will be determined through an approved baseline methodology, which is ACM0002. This data will be updated at the baseline renewal, in accordance with the considered methodology. Please refer to annex 3 – baseline determination, for how the emission factor will be determined. Data will be kept for two years after the end of the crediting period.

D.2.2.2. Description of formulae used to calculate project emissions (for each gas, source, formulae/algorithm, emissions units of CO_2 equ.):

BLFGE generates no emissions since it uses project-generated electricity to operate the landfill gas project, including the pumping equipment for the collection system and energy required to transport heat.

D.2.3. Treatment of leakage in the monitoring plan

D.2.3.1. If applicable, please describe the data and information that will be collected in order to monitor leakage effects of the project activity

ID number *(Please use numbers to ease cross-referencing to table D.3)*	Data variable	Source of data	Data unit	Measured (m), calculated (c) or estimated (e)	Recording frequency	Proportion of data to be monitored	How will the data be archived? (electronic/ paper)	Comment
								No leakages under ACM0001.

D.2.3.2. Description of formulae used to estimate leakage (for each gas, source, formulae/algorithm, emissions units of CO_2 equ.)

No leakages under ACM0001.

D.2.4. Description of formulae used to estimate emission reductions for the project activity (for each gas, source, formulae/algorithm, emissions units of CO_2 equ.)

Methane destruction: $ER = (MD_{project} - MD_{reg}) * GWP_{CH_4}$ $MD_{reg} = MD_{project} * AF$ $MD_{project} = MD_{flared} + MD_{electricity}$ $MD_{flared} = LFG_{flare} * w_{CH_4} * D_{CH_4} * FE$ $MD_{electricity} = LFG_{electricity} * w_{CH_4} * D_{CH_4}$	ER are the emission reductions; $MD_{project}$ is the amount of methane actually destroyed/combusted during the year; MD_{reg} is the methane that would have been destroyed/combusted during a year in the absence of the project activity; GWP_{CH4} is the approved global warming potential value for methane (considered 21 throughout BLFGE's lifetime for the purpose of estimating emission reductions); EG is net quantity of electricity displaced; and $CEF_{electricity}$ is the CO_2 emissions intensity of the electricity displaced. Considering there is no regulatory or contractual requirement determining MD_{reg}, an Effectiveness Adjustment Factor - EAF of 20% is used in BLFGE's case. MD_{flared} is the quantity of methane destroyed by flaring (tCH_4), LFG_{flare} is the quantity of landfill gas flared during a year measured in normal cubic meters (Nm^3), w_{CH4} is the average methane fraction of the landfill gas as measured during a year and expressed as a fraction CH_4 volume per LFG volume, FE is the flare efficiency (the fraction of the methane destroyed) and D_{CH4} is the methane density expressed in tonnes of methane per cubic meter of methane (tCH_4/m^3CH_4), measured at STP. This value is in fact 0.0007168 tCH_4/Nm^3CH_4. $MD_{electricity}$ is the quantity of methane destroyed by generation of electricity and $LFG_{electricity}$ is the quantity of landfill gas fed into electricity generator.

Electricity displacement: $ER_y = BE_{thermal,y} + BE_{electricity,y} - PE_y - L_y$ $BE_{thermal,y} = 0$ $PE_y = EC_y * EF_{electricity}$ $L_y = 0$ $BE_{electricity,y} = EF_{electricy} * EG_y$	*ERy:* are the emissions reductions of the project activity during the year y in tons of CO_2. *BEelectricity,y:* Are the baseline emissions due to displacement of electricity during the year y in tons of CO_2. *BEthermal,y:* Are the baseline emissions due to displacement of thermal energy during the year y in tons of CO_2. *PEy:* Are the project emissions during the year y in tons of CO_2. *Ly:* Are the leakage emissions during the year y in tons of CO_2.

D.3. Quality control (QC) and quality assurance (QA) procedures are being undertaken for data monitored

Data *(Indicate table and ID number e.g. 3.-1.; 3.2.)*	Uncertainty level of data (High/Medium/Low)	Explain QA/QC procedures planned for these data, or why such procedures are not necessary.
1-3 LFG	Low	Flow meters will be subject to a regular maintenance and testing regime to ensure accuracy.
4 FE	Medium	Regular maintenance will ensure optimal operation of flares. Flare efficiency should be checked quarterly, with monthly checks if the efficiency shows significant deviations from previous values.
5 w_{CH4}	Low	The gas analyzer will be subject to a regular maintenance and testing regime to ensure accuracy.
7	Low	Electricity meter will be calibrated periodically to ensure accuracy.

D.4 Please describe the operational and management structure that the project operator will implement in order to monitor emission reductions and any leakage effects, generated by the project activity

Both the gas plant and the energy plant have specific operators in charge of checking the gas flared, gas sent to engines, and electricity generated. Such personnel is responsible for getting relevant information from both units monitoring systems. Monthly reports will consider the main factors as well as emission reductions calculated in accordance with this PDD.

D.5 Name of person/entity determining the monitoring methodology:

ARCADIS Tetraplan is the entity determining the revision of the monitoring plan. ARCADIS Tetraplan is not a participant in this project. Contact information:

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Annex 4

MONITORING PLAN

From the monitoring methodology, it could be seen that there are five main variables to be measured:

- Methane flow from the landfill
- Methane flow into flares
- Methane flow into powerhouse
- Methane content in the landfill gas
- Flares' efficiencies
- Net electricity generated

The degasifying unit of BLFGE is installed with most up-to-date equipment to perform measures continually and allow for remote access to equipment and data. The system equipments are connected through a Programmable Logic Control tool that lets operators quickly check the unit's main variables through a user-friendly interface. Through the PLC, users have also access to continuously measured data, such as methane content in the landfill gas and the methane flows.

Methane flows:
There are seven flow meters installed for BLFGE operation:
- one in the main line straight after the blowers (FIR-100);
- one in the line to the flares (FIR-200);
- four in the lines to the power house (FIR-300, FIR-400, FIR-500 and FIR-600); and
- one in a particular line which is connected to the mini-blower (FIR-700).

The flow-meters installed in the main line, in the line to the flare and in the lines to the power house are the same model: Instromet B.V SM-RI-X-K, which have been calibrated by Nederlands Meetinstituut, Dutch institute for calibration and verification. The flow-meter installed in the line to the mini-blower is from TZ G1600.

The flow meters are connected to the gas facilities PLC, and data are recorded continuously. Moreover, the meters are sealed, which prevent data manipulation.

Attached to each of the flow meters is an electronic volume conversion device, which converts the volume measured by the flow meter to volume at 0^{o}C and 1,01325 bar, i.e., the STP. These devices have also been calibrated by Nederlands Meetinstituut.

Methane content in LFG:
Methane content in the LFG is critical in BLFGE, since it is the fuel to the powerhouse and therefore its concentration will lately determine the amount of electricity that can be generated. For measuring this information, BLFGE counts on a BINOS 100 continuous analyzer, manufactured by NUK, a German supplier. The analyzer is also connected to the data system through the PLC, with information easily accessible through a desktop computer.

Flares' efficiencies:
BLFGE was designed to ensure complete methane destruction at the installed flares. Nevertheless, complying with the monitoring methodology applied in this case, project owners will hire specialists to carry out exhaust gases analyses in order to determine if any methane is not being flared and, if so, how much of the gas is being released to the atmosphere.

Electricity sent to the grid:
Electricity dispatched to the grid is monitored by two electricity meters installed at the local electricity sub-station – one can be accessed by BLFGE while the other can be accessed only by the local utility company Eletropaulo. Although both meters are calibrated and comply with regulatory standards for energy commercialization in Brazil, the Eletropaulo meter has a higher accuracy (0,5%) while the BLFGE meter accuracy is 1%. Considering that the distance between the two equipments is very small, both meters measure indeed the same amount of electricity with a maximum difference of 1,5% due to the difference of accuracy between the two meters. Aiming a conservative approach, the lowest value between the two readings will be adopted for ERs calculation.

Biogás generates monthly reports covering all such information, but the flares efficiencies, which will be determined on a less often basis. Such reports will be delivered to the verifier for means of writing the verification report. Some of the included information is:

- Total energy generation
- Exported energy
- Internally consumed energy
- Total extracted biogas
- Total biogas destroyed in flares
- Total biogas destroyed in engines
- Monthly average methane content in biogas
- Monthly average hourly extracted volumes of biogas
- Emission reductions from destroyed methane

The way this variables are displayed in the report can undergo minor changes in order to incorporate verification suggestions and/or needs.