## Document typology

Revision of Monitoring Plan

## UNFCCC project reference

0908

## Project title

Landfill gas recovery and electricity generation at "Mtoni Dumpsite", Dar Es Salaam, Tanzania

## SECTION D. Application of a monitoring methodology and plan

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

This project activity uses the revision to the approved consolidated monitoring methodology ACM0001 version 04 for **"**Consolidated monitoring methodology for landfill gas project activities**".**

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

This methodology is applicable to landfill gas capture project activities, where the baseline scenario is the partial or total atmospheric release of the gas and the project activities include situations such as:
a) The captured gas is flared; or
b) The captured gas is used to produce energy (e.g. electricity/thermal energy), but no emission reductions are claimed for displacing or avoiding energy from other sources; or
c) The captured gas is used to produce energy (e.g. electricity/thermal energy), and emission reductions are claimed for displacing or avoiding energy generation from other sources.

Since one of the project objectives is to flare the captured gas, the project activity includes a) situation. Since there will be electricity production but no emission reductions will be claimed for displacing or avoiding energy from other sources, the project activity would include situation b).

**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 |
|---|---|---|---|---|---|---|---|---|
| | | | | | | | | |
| | | | | | | | | |

This option is not applicable.

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

Not applicable. See section D.2.2.1

**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 |
|---|---|---|---|---|---|---|---|---|
| | | | | | | | | |
| | | | | | | | | |

Not applicable.

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

Not applicable.

**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** | **Data variable** | **Data unit** | **Measured (m), calculated (c) or estimated (e)** | **Recording frequency** | **Proportion of data to be monitored** | **How will the data be archived? (electronic : e / paper : p)** | **For how long is archived data kept?** | **Comment** |
| 1. LFGtotal,y | Total amount of landfill gas captured | $m^3$ | m | Continuously | 100% | Electronic / Paper | During the crediting period and two years after | Measured by a flow meter. Data to be aggregated monthly and yearly. |
| 2. LFGflare,y | Amount of landfill gas flared | $m^3$ | c | Continuously | 100% | Electronic / Paper | During the crediting period and two years after | Measured by a flow meter. Data to be aggregated monthly and yearly. |
| 3. FE | Flare/combustion efficiency, determined by the operation hours (1) and the methane content in the exhaust gas (2) | % | m/c | (1) Continuously (2) quarterly, monthly if unstable Enclosed flares shall be monitored yearly, with the first measurement to be made at the time of installation | n/a | Electronic | During the crediting period and two years after | (1) Continuously monitored by continuous measurement of operation time of flare using a run time meter connected to a flame detector (2) Periodic measurement of methane content of flare exhaust gas. |
| 4. wCH4,y | Methane fraction in the landfill gas | $m^3$ CH4 / $m^3$ LFG | m | Continuously | 100% | Electronic / Paper | During the crediting period and two years after | Preferably measured by continuous gas quality analyzer. |
| 5. T | Temperature of the landfill gas | °C | m | Continuously | 100% | Electronic | During the crediting period and two years after | Measured to determine the density of methane DCH4. |
| 6. P | Pressure of the landfill gas | Pa | m | Continuously | 100% | Electronic | During the crediting period and two years after | Measured to determine the density of methane DCH4. |
| 7. $EL_{IMP}$ | Total amount of electricity imported from the national grid to meet project requirement | MWh | m | Continuously | 100% | Electronic / Paper | During the crediting period and two years after | Required to determine CO2 emissions from use of electricity or other energy carriers to operate the project activity. The records of any electricity imported in the baseline too should be recorded at the start of the project |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 8. $CEF_{electricity,y}$ | Electricity emission factor | $tCO_{2eq}$/MWh | e | At the project start and every time a significant change occurs | 100% | Electronic | During the crediting period and two years after | Required to compute the total $tCO_{2eq}$ produced by the project using the imported electricity from the national grid |
| 9. $ET_y$ | Total amount ef electricity imported from the diesel generator to meet project requirement | MWh | m | Continuously | 100% | Electronic / Paper | During the crediting period and two years after | Required to determine CO2 emissions from use of electricity or other energy carriers to operate the project activity. The records of any electricity imported in the baseline too should be recorded at the start of the project |
| 10. $CEF_{thermal,y}$ | Diesel generator emission factor | $tCO_{2eq}$/MWh | e | At the project start and every time a significant change occurs | 100% | Electronic | During the crediting period and two years after | Required to compute the total $tCO_{2eq}$ produced by the project using the imported electricity from the diesel generator |
| 11. | Regulatory requirements relating to landfill gas projects | Test | n/a | Annually | 100% | Electronic | During the crediting period and two years after | Required for any changes to the adjustment factor (AF) or directly MDreg,y |

As the second phase will start, the quantity of gas used to produce electricity for exportation must be added to $LFG_{electricity,y}$ , so:

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 12. LFGelectricity,y | Amount of landfill gas combusted in power plant for internal consumption and for energy generation | $m^3$ | m | Continuously | 100% | Electronic / Paper | During the crediting period and two years after | Measured by a flow meter. Data to be aggregated monthly and yearly. |
| 13. $EL_{EX,LFG}$ | Total amount of electricity exported out of the project boundary | MWh | m | Continuously | 100% | Electronic / Paper | During the crediting period and two years after | Required to estimate the emission reductions from electricity generation from LFG. |

Also the following data will be collected:

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 14. | Operation of the energy plant | Hours | m | Annually | 100% | Electronic / Paper | During the crediting period and two years after | This is monitored to ensure methane destruction is claimed for methane used in electricity plant when it is operational. |
| 15. | Flare inner temperature | °C | m | Continuously | 100% | Electronic | During the crediting period and two years after | Used to establish when the plant is burning biogas |

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

| Emissions | Significance | Description of formulas |
|---|---|---|
| $CH_4$ not captured by the plant | Significant | Cannot be measured, only estimated. |
| $CO_2$ generated to supply energy to plant | Insignificant | A biogas-fuelled generator will be used to supply power to the plant, so $CO_2$ released during the processing will be zero because it was originally fixed via biomass.<br>The public grid will be used just in case of emergency.<br>$CO_2$ = EF * EA<br>EF = emission factor<br>EA = energy absorbed by the public grid |
| $CO_2$ generated by $CH_4$ flaring | Insignificant | $CO_2$ released during the combustion process was originally fixed via biomass so that the life cycle<br>$CO_2$ emissions is zero. |
| Emissions of $CO_2$ from transport of equipment to the project site | Insignificant | Most of the equipment and materials for the construction will be purchased locally.<br>There will be just one transport of special equipment from Italy to Tanzania.<br>$CO_2$ = NT * ( $CO_{2tr}$ + $CO_{2sh}$ ) = 1.622,5 $tCO_2$ < 1%<br>NT = Number of Transports = 1<br>$CO_{2tr}$ = $CO_2$ generated by truck = $EF_{diesel}$ * KMs = 0,052 $tCO_2$<br>$EF_{diesel}$ = diesel emission factor = 0.26 $kgCO_2$/km<br>KMs = distance harbour in Geneva - the place where equipment is assembled= 200 km<br>$CO_{2sh}$ = $CO_2$ generated by ship = $FC_{ship}$ * $EF_{ship}$ * D = 1.622,4 $tCO_2$<br>$FC_{ship}$ = Fuel Consumption = 33,80 $t_{fuel}$/day<br>$EF_{ship}$ = 3,2 $tCO_2/t_{fuel}$<br>D = days needed by a ship to travel from Italy to Tanzania = 15 |
| Emissions from the venting of biogas (no flaring or electricity generation) | Non-existing | Emissions from the venting of biogas will not occur thanks to the protection against failures provided by an automatic feedback control system. If there is no flaring or incineration, the venting of biogas from the landfill body will be automatically stopped. |

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**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 are associated with landfill gas extraction.

**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 / Version 04

**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.)**

According to ACM0001, the greenhouse gas emission reduction achieved by the project activity during a given year "y" ($ER_y$) is the difference between the amount of methane actually destroyed/combusted during the year ($MD_{project,y}$) and the amount of methane that would have been destroyed/combusted during the year in the absence of the project activity ($MD_{reg,y}$), times the approved Global Warming Potential value for methane ($GWP_{CH4}$), plus the net quantity of electricity exported during the year y ($EL_y$) multiplied by the $CO_2$ emissions intensity of the electricity displaced ($CEF_{electricity,y}$), minus the incremental quantity of fossil fuel required by the project during the year y ($ET_y$) multiplied by the $CO_2$ emissions intensity of the fuel ($CEF_{thermal,y}$).

$$ER_y = (MD_{project,y} - MD_{reg,y}) * GWP_{CH4} + EL_y * CEF_{electricity,y} - ET_y * CEF_{thermal,y}$$

$ER_y$ is measured in tonnes of $CO_2$ equivalents ($tCO_{2e}$), and it's calculated from direct measurement by a flow meter and a CH4 analyzer when the project is operational (see Annex 4). $MD_{project,y}$ and $MD_{reg,y}$ are measured in tonnes of methane ($tCH_4$). The approved Global Warming Potential value for methane ($GWP_{CH4}$) for the first commitment period is 21 $tCO_2e/tCH_4$.
In the case where $MD_{reg,y}$ is not specified by regulatory:

$$MD_{reg,y} = MD_{project,y} * AF$$

As in Tanzania there are no regulatory and we have no contractual requirements, AF is zero and so $MD_{reg,y}$.

The methane destroyed by the project activity ($MD_{project,y}$) during a year is determined by monitoring the quantity of methane actually flared plus the quantity of methane fed to the generator for internal consumption:

$$MD_{project,y} = MD_{flared,y} + MD_{electricity,y}$$

$$MD_{flared,y} = LFG_{flare,y} * w_{CH4,y} * D_{CH4} * FE$$

$$MD_{electricity,y} = LFG_{electricity,y} * w_{CH4,y} * D_{CH4}$$

Where $MD_{flared,y}$ is the quantity of methane destroyed by flaring ($tCH_4$ / year), $LFG_{flare,y}$ is the quantity of landfill gas flared during the year measured in cubic meters ($m^3$), directly measured, $w_{CH4,y}$ is the average methane fraction of the landfill gas as measured during the year and expressed as a fraction (in m³ CH4 / m³ LFG), $D_{CH4}$ is the methane density expressed in tonnes of methane per cubic meter of methane (tCH4/m3CH4) and *FE* is the flare efficiency (the fraction of the methane destroyed). $MD_{electricity,y}$ is the quantity of methane destroyed by generation of electricity ($tCH_4$ / year) and $LFG_{electricity,y}$ is the quantity of landfill gas fed into the electricity generator ($m^3$).

$$EL_y = EL_{EX,LFG} - EL_{IMP}$$

Since in the base project, there will be no exported electricity, $EL_{EX,LFG}=0$.

When the project second phase will take place, an additional amount of electricity will be produced and fed to the national grid but, since option b is chosen, the $EL_{EX,LFG}$ term is zero again. The $EL_y$ and the $ET_y$ terms are the same as above.
So $ER_y$ is calculated as:

$$ER_y = (MD_{project,y} - MD_{reg,y}) * GWP_{CH4}$$

Where $MD_{reg,y}$ and $GWP_{CH4}$ are the same as above. The total amount of methane used to produce electricity has to be added to the amount of methane destroyed. So:

$$MD_{project,y} = MD_{flared,y} + MD_{electricity,y}$$

$$MD_{electricity,y} = LFG_{electricity,y} * w_{CH4,y} * D_{CH4}$$

where $MD_{electricity,y}$ is the quantity of methane destroyed by generation of electricity ($tCH_4$ / year) and $LFG_{electricity,y}$ is the quantity of landfill gas used to produce electricity to supply national grid ($m^3$).

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

| Data | Uncertainty level of data (High/Medium/Low) | Are QA/QC procedures planned for these data? | Explain QA/QC procedures planned for these data, or why such procedures are not necessary. |
|---|---|---|---|
| *3.1. LFGtotal,y* | Low | Yes | Flow meter doesn't require calibration; it should be subject to a regular maintenance and testing regime to ensure accuracy. |
| *3.2. LFGflare,y* | Not applicable | - | In the base project $LFG_{flare,y}$ = $LFG_{total,y}$. In the second part $LFG_{flare,y}$ will be measured separately from $LFG_{total,y}$ |
| *3.3. LFGelectricity,y* | Low | Yes | Flow meter doesn't require calibration; it should be subject to a regular maintenance and testing regime to ensure accuracy. |
| *3.4. LFGthermal,y* | Not applicable | - | No LFG burnt for thermal purpose. |
| *3.5 FE* | Medium | Yes | Regular maintenance of louvers and of the equipment should ensure optimal operation of flares. Flare efficiency should be checked quarterly, with monthly checks if the efficiency shows significant deviations from previous values. |
| *3.6.* WCH4,y | Low | Yes | The gas analyzer should be calibrated through the use of calibration gas according to its protocol, and it'd be subject to a regular maintenance and testing regime 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**

To assure a correct monitoring, the training of the Tanzanian staff will be organized.
Minimum 2 people will be trained:

- general knowledge about the equipment used in the landfill
- reading and recording data
- calibration methodology
- equipment maintenance procedures

- emergency situation (for instance too high oxygen level or electricity breakdown).

Chosen trainees will have a good understanding the processes and installation technology of the landfill gas extraction.
Verification and training start parallel with preliminary works for the installation.

A guidebook about landfill gas extraction and utilization in English will also be available. The guidebook will have:

- operation manual
- drawings
- maintenance instructions
- description of parts of the equipment
- parameters for landfill gas composition, temperature and pressure.

Additionally, the telephone helpdesk will be available with direct connection to Italy, where experts of Biotecnogas s.r.l. can give technical advice.

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

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BIOTECNOGAS Company is not a project participant.

**Annex 4**

## MONITORING PLAN

**Introduction**

Monitoring will be carried out following the procedures set by the Approved Consolidated Methodology ACM0001.
The monitoring methodology is based on direct measurement of the amount of flared $CH_4$ in biogas to determine avoided $CO_{2eq}$.
All the data will be collected continuously automatically by a PLC and then hourly stored in a PC. Also a paper data collection will be performed once a day.
The plant will be supplied by the national grid. In case of national grid failure the plant will use a diesel electricity generator installed in situ.

**Monitoring**

The following data will be monitored:

- Amount of flared biogas ($m^3$), using a turbine flow meter.
- The biogas temperature (°C), using a thermoresistance.
- The biogas pressure (mbar), using a pressure meter.
- Percentage of $CH_4$ in biogas (%), using a gas analyzer.
- Amount of electricity imported from the national grid (MWh), using an electricity meter.
- Amount of electricity imported from the diesel generator (MWh), using an electricity meter.
- The plant working time (hours), using an hours meter.

In addition:

- The flare efficiency will be measured once a year by an accredited entity.
- The electricity emission coefficient will be computed and then applied.
- The diesel generator emission coefficient will be computed and then applied.
- The flare internal temperature will be measured to ensure the plant combustion.

**ERs computation.**

The following formula will be applied to compute the amount of ERs produced by the plant.

$$CO_{2eq} = (M * D * GWP * Qf * FE) – (E_{grid} *COEF_{grid}) – (E_{diesel} * COEF_{diesel})$$

*Where:*
$CO_{2eq}$ *=equivalent tons of* $CO_2$ *[*$tonCO_{2eq}$*]*
*M = biogas methane fraction [Vol.%]*
*D = methane density (constant)* = 0,716 kg/$m^3$
*GWP = methane global warning potential (constant) = 21 tonnes* $CO_{2eq}$*/tonnes* $CH_4$
*Qf = quantity of landfill gas flared [Nm3]*
*FE = Flare efficiency [%]*
$E_{grid}$ *= electricity imported from the national grid [MWh]*
$COEF_{grid}$ *= national grid emission coefficient [*$tonCO_{2eq}$*/MWh]*
$E_{diesel}$ *= electricity imported from the diesel generator [MWh]*
$COEF_{diesel}$ *= diesel generator emission coefficient [*$tonCO_{2eq}$*/MWh]*

**Flow meter**
The biogas quantity will be measured with a flow meter, a counter which counts every 10 $m^3$ of biogas flared.
The biogas quantity will be normalized using its temperature and pressure values. The data will be collected by the PLC and then stored in the PC of the plant.
The flow meter is also provided with a mechanical counter placed over the meter body. Once a day the counter value will be written on a paper document, in order to acquire data in case of PC failure.
To prove the logging procedure and database are correct, the quantity recorded by the flow meter must be higher than the flow quantity logged earlier and lower than the flow quantity logged later.
Flow meter doesn't require calibrations for the first 10 years, according to its specifications.
In case of flow meter failure, it will be exchanged with a spare flow meter as soon as possible.
Despite this quick exchange the plant will operate time without a biogas flow signal.
To determine the flow during this time span, the average flow of the last 7 days will be applied.
The chance of failure of the flow meter is very small.

**Electricity meter**
The plant imported electricity will be measured with two electricity meters, which count every kWh imported. One electricity meter will be used to measure the amount of electricity imported from the national grid while the other one will measure the amount of electricity imported from the diesel generator.
These measures will be collected by the PLC and then stored into the plant PC.
Each electricity meter is also provided with an LCD display which shows the total electricity imported. Once a day those two values will be written on a paper document, in order to acquire data in case of PC failure.
The quantities shown on the displays are true and cannot be altered because the electricity meters are sealed.
To prove that the logging procedure and database are correct, the total imported electricity has to be higher than the total imported electricity logged earlier and lower than the total imported electricity logged later.
In case of electricity meter failure, it will be exchanged with a spare electricity meter as soon as possible.
Despite this quick exchange the plant will operate a short time without measuring the electricity imported. In this case the average daily electricity imported of the last 7 days will be applied.
The chance of failure of the electricity meter is very small.

**$CH_4$ analyzer**
The $CH_4$ content of the biogas will be measured with a gas analyzer.
The $CH_4$ analyzer has to be calibrated according its calibration protocol.
The $CH_4$ content will be collected by the PLC and then stored in the plant PC.
The CH4 analyzer is provided with an LCD display which shows the methane on the oxygen fractions of the biogas. Once a day those two values will be written on a paper document, in order to acquire data in case of PC failure.
In the analyzer calibration protocol, the most important issues for a correct calibration are:
1. The calibration frequency.
2. The quality of the calibration gas.

3. The calibration procedure.
The calibration gases will be purchased from certified gas suppliers.
All the gas tanks used for the calibration will be provided with a quality certificate.
The quality certificate indicates the quality of calibration gas is according to the standard.
In case of analyzer failure, the analyzer will be replaced with a spare analyzer as soon as possible.
Despite this quick exchange, the plant will operate a short time without the biogas $CH_4$ fraction. To determine the biogas $CH_4$ fraction during this time span the average biogas $CH_4$ fraction of the last 7 days will be applied.

**Flare efficiency.**
The flare efficiency will be measured by an accredited entity. The measured efficiency will then be applied for one year. After one year the flare efficiency will be measured again and so on. If no flare efficiency will be measured, the standard conservative value of 90% will be applied.

**Possible failure: No electrical power**
In case of national grid failure, the plant will work using the electricity imported from the diesel generator installed in situ. In case of failure of both national grid and diesel generator, the plant cannot work. The plant blower will stop. Without biogas, the flare will stop too.
The flow-meter will detect no biogas flow and so no ton$CO_{2eq}$ will be measured.
No special actions are possible to avoid this.

**Validation**
The following parameters and items will be checked by an authorized validation agency at the installation once or twice a year.

**Nr. Parameter / item Unit**
1 - Amount of biogas flared
2 - Amount of electricity imported
3 - Biogas $CH_4$ fraction
4 - Calibration procedure $CH_4$ analyzer
5 - Instruments certifications
6 - Log book operating and maintenance
7 - Data collection and storing procedures

All the quantities and procedures outlined in the present Monitoring Plan will be detailed described into the Monitoring Report, which will be submitted to an authorized agency for the validation.