# Project design document form
(Version 11.0)

| BASIC INFORMATION | |
|---|---|
| **Title of the project activity** | Proactiva CGA Iperó Landfill Gas to Energy Project |
| **Scale of the project activity** | ☒ Large-scale<br>☐ Small-scale |
| **Version number of the PDD** | 6.0 |
| **Completion date of the PDD** | 25/05/2021 |
| **Project participants** | Proactiva Meio Ambiente Brasil Ltda.<br>First Climate (Switzerland) AG |
| **Host Party** | Brazil |
| **Applied methodologies and standardized baselines** | ACM0001 – Flaring or use of landfill gas (version 12.0.0) |
| **Sectoral scopes** | 13 – Waste handling and disposal |
| **Estimated amount of annual average GHG emission reductions** | 114,937 $tCO_2e$ |

# SECTION A. Description of project activity

## A.1. Purpose and general description of project activity

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The project activity consists in the capture and combustion of landfill gas to produce electricity. The project is located at CGA Iperó landfill (Central de Gerenciamento Ambiental Iperó), in the State of Sao Paulo, Brazil. The landfill is used for the disposal of municipal solid waste (MSW) and commercial & industrial waste (C&I) from the neighbourhood.

The site is owned and operated by Proactiva Meio Ambiente Brasil Ltda. and started to receive waste in August 2010. The expected lifetime of the landfill is 15 years, i.e. end of operation around 2025. Proactiva Meio Ambiente Brasil Ltda. is the local subsidiary of Proactiva Medio Ambiente S.A., a Spanish company, owned by Veolia Environmental Services (Veolia Propreté) and FCC (50%-50%).

Currently, and in accordance with the local regulations, the site is equipped with vertical, passive wells which vent the landfill gas to the atmosphere. Certain wells generate enough landfill gas to be equipped with manually lit, open burners in order to control odour. The situation prior to the start of the project and the baseline scenario are the same.

The project activity will consist in active methane collection and controlled destruction. The project will be developed following a phased approach.

- The first phase will consist in maximising the landfill gas collection and flaring. During this phase, technical feedback from operations regarding the gas (both quantity and quality) and regarding the stability of the landfill gas collection system will be collected for the second phase.
- The second phase aims at utilizing the landfill gas for the generation of electricity and for the subsequent consumption onsite and export to the Brazilian grid.

The second phase implementation will depend on the technical and economical evaluation of the first phase.

The landfill gas destruction system will include enclosed flares which ensure optimal combustion of the methane. Flares will burn the landfill gas collected during the first phase and then, during the second phase, the landfill gas that exceeds the total capacity of the engine(s) or that is collected during maintenance of the engines will be destroyed in the flares.

The landfill gas will be collected from the existing and future disposal areas of the site.

Environmental Benefits:

Landfill gas contains about 50% of methane. Methane is a greenhouse gas with a Global Warming Potential (GWP) of 21. The project activity, as described, will therefore allow significant reductions of greenhouse gas (GHG) emissions, by decreasing the diffuse/fugitive methane emissions.

In addition, destruction of the collected landfill gas will also enable the destruction of other pollutants such as volatile organic compounds and ammonia.

Even though CGA Iperó is a sanitary landfill, it is not equipped with an active and controlled landfill gas collection system. Therefore, the project will prevent the following risks that result from the lack of regulation upon landfill gas:

- Risk of explosion
- Risk of fire;
- Unpleasant odour nuisances, improving quality of life in the neighbourhood;
- Potential atmospheric pollution, improving health in the neighbourhood;

- Damage to vegetation by asphyxia;

The production of renewable energy contributes to resource conservation and substitutes fossil fuels.

Social benefits:

The project activity will require manpower and therefore generate employment. Jobs shall be created at the stage of the implementation of the project (civil work) as well as at the stage of operation. Since the landfill is young, jobs are expected to be created directly and indirectly for the coming fifteen years.

Landfill gas to energy technology is not common practice in Brazil. By implementing this technology at CGA Iperó Landfill, Proactiva will transfer its expertise and experience with this technology and associated equipments to the local team which will install and operate it. Adequate training programs will be provided to the local staff.

In addition, the employees' training and the implementation of such a project will allow the dissemination of design and operational experience gained at CGA Iperó landfill.

Employment generation and technology transfer will positively impact on the economic development of the local area.

Estimated annual averages and total GHG emission reductions for the chosen crediting period (7 years renewable twice) are the following:

**Table 1 First Crediting Period**

| Year | | Annual estimation of emission reductions in tonne of $CO_2e$ |
|---|---|---|
| 2013 | 4 months | 16,952 |
| 2014 | 12 months | 69,219 |
| 2015 | 12 months | 89,420 |
| 2016 | 12 months | 106,585 |
| 2017 | 12 months | 122,958 |
| 2018 | 12 months | 138,381 |
| 2019 | 12 months | 152,097 |
| 2020 | 8 months | 108,949 |
| Total estimated reductions (tonnes of $CO_2e$) | | 804,561 |
| | | |
| Total number of crediting years | | 7 years |
| Annual average over the crediting period of estimated reductions (tonnes of $CO_2e$) | | 114,937 |

**Table 2 Second Crediting Period**

| Year | | Annual estimation of emission reductions in tonne of $CO_2e$ |
|---|---|---|
| 2020 | 4 months | 54,474 |
| 2021 | 12 months | 172,607 |
| 2022 | 12 months | 180,297 |
| 2023 | 12 months | 186,849 |
| 2024 | 12 months | 192,540 |
| 2025 | 12 months | 197,568 |
| 2026 | 12 months | 170,486 |
| 2027 | 8 months | 90,511 |
| Total estimated reductions (tonnes of $CO_2e$) | | 1,245,332 |
| | | |
| Total number of crediting years | | 7 years |
| Annual average over the crediting period of estimated reductions (tonnes of $CO_2e$) | | 177,905 |

**Table 3 Third Crediting Period**

| Year | | Annual estimation of emission reductions in tonne of $CO_2e$ |
|---|---|---|
| 2027 | 4 months | 45,256 |
| 2028 | 12 months | 110,813 |
| 2029 | 12 months | 92,614 |
| 2030 | 12 months | 79,071 |
| 2031 | 12 months | 68,768 |
| 2032 | 12 months | 60,740 |
| 2033 | 12 months | 54,334 |
| 2034 | 8 months | 31,305 |
| Total estimated reductions (tonnes of $CO_2e$) | | 542,901 |
| | | |
| Total number of crediting years | | 7 years |
| Annual average over the crediting period of estimated reductions (tonnes of $CO_2e$) | | 77,557 |

## A.2. Location of project activity

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CGA Iperó landfill site is located in the municipality of Iperó, about 130 Km from Sao Paulo.


**Figure 1 Detail of the localization of the CGA Iperó landfill (source: http://www.ibge.gov.br)**

The project activity site is located at the border of Sorocaba and Iperó's municipalities, around 10 Km of downtown Sorocaba and 15 km of downtown Iperó. The site can be accessed by Benedito de Paula Leite Junior road, as shown in Figure 2.

The landfill area is delimited by the following GPS coordinates:

- latitude: -23.4284
- longitude: -47.5463

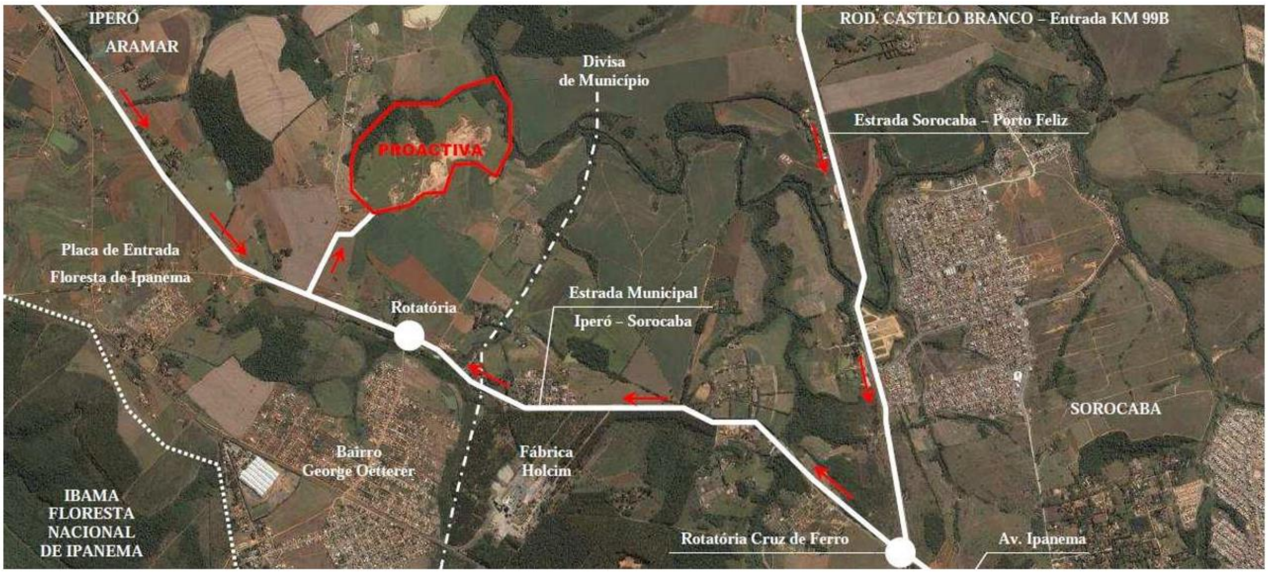


**Figure 2 - CGA Iperó Landfill Location**

## A.3. Technologies/measures

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The scenario prior to the start of the implementation of the project activity is the same as the baseline scenario: Landfill gas that is produced at the initial landfill site is passively vented to the atmosphere via simple passive landfill gas wells. There is no existing landfill gas capture system, no landfill gas is systematically treated or destroyed in the baseline scenario and no equipment for active gas collection or treatment is deployed.

Current practice at the landfill is the installation of vertical wells. A landfill gas sampling campaign was conducted in November 2011 to identify the wells releasing more than 10 $Nm^3$ of landfill gas per hour and that could thus sustain a flame. These wells were then equipped with manually lit burners in order to combust the landfill gas. Though this system enables a natural extraction of the landfill gas, the flaring remains sporadic and linked to the quality and quantity of landfill gas reaching the wellhead. If no CDM project is implemented, the situation will remain this way onsite: passive venting and sporadic flaring.

The scope of the proposed CDM project activity at CGA Iperó landfill comprises the following two phases:

1. The implementation of an active gas collection system, where the landfill gas is conveyed via blowers to an enclosed high efficiency flare for thermal destruction of the landfill gas.
2. The implementation of an energy recovery facility with landfill gas engines that produce electricity which is dispatched to the national electricity grid. This second scope is dependent on landfill gas quality and quantity.

The following table lists the main equipment that will be deployed for the project activity as well as their most important characteristics. A closer description of each equipment is provided in the paragraphs below.

| Equipment | Capacity | Efficiency & load factor (availability) | Average Lifetime |
|---|---|---|---|
| LFG collection system | - | ~85% max. collection efficiency (closed cells) | Project lifetime |
| Blower(s) | 3 units of -150/+100 mbar, running alternately | 95% availability | Project lifetime |
| Flare(s) | 2,000 Nm³/h of biogas<br>3,000 Nm³/h of biogas | ~99% $CH_4$ destruction efficiency<br>95% availability | Project lifetime |
| LFG gas preparation unit | 2 units of 2,000 Nm³/h of biogas, running alternately | ~8,000 running hours/year | Project lifetime |
| LFG engine(s) | 1.426 MW per engine (6 engines estimated based on biogas model) | ~7,446 running hours per year<br>85% availability | 120,000 running hours (including overhaul(s)) |
| Transformer | Transformation 480/23,000 V | ~2.2% electrical losses permanent availability | Project lifetime |

The project activity's objective is to maximize both, capture of landfill gas and energy recovery. The Project Participants estimate that with an optimised, active landfill gas capture system a maximum of 85%[1] of the landfill gas that is produced by the anaerobic degradation of the waste can be collected and conveyed to either a flare or a landfill gas engine. The average capture rate over the project lifetime is estimated at ~74%.

The active landfill gas extraction system will cover the entire site. The site is divided in 5 cells. Each of the cells is designed to protect the soil and groundwater from the infiltration of leachate. This is achieved via the selection of the site (naturally low permeability of the soil), an engineered protection layer of compacted clay and a drainage layer (gravel) with a sufficient gradient and collection pipes to evacuate the leachate from the bottom of the cells and into a retention pool. The waste is placed in dedicated cells and compacted. Once the cells reach their final elevation, a soil cover consisting of clay and topsoil is placed over the completed areas to reduce possible infiltration of rainwater into the landfill.

**<u>Collection System</u>**

- **Vertical wells:**

[1] This is in line with the "Background Information Document for Updating AP42 Section 2.4 for Estimating Emissions from Municipal Solid Waste Landfills" from the US EPA (see: http://www.epa.gov/ttn/chief/ap42/ch02/draft/db02s04.pdf). For the first year of landfilling, a lower capture rate of 50% is assumed as waste is disposed off gradually over the year (Default value of the ACM0001, version 12 methodology).

The site is already equipped with some vertical wells, but these are independent one from another and not connected to a collection system. For the project activity, the vertical wells will be systematically connected to convey the landfill gas to a centralized treatment unit.
Vertical wells are built step by step as the cell is being filled in order to capture the maximum landfill gas possible. They consist of cylindrical wire mesh baskets filled with stones and a central 8" HDPE pipe that is perforated in its lower part. The wells will be sealed at the surface to avoid air inflow.

Additional vertical wells may also be drilled into the landfill once the operated areas reach their final elevation and final cover is applied.

Each well will be equipped with wellheads that enable monitoring of gas flow and quality.

- **Horizontal collection drains:**

This modern technique improves the gas collection by enabling its capture at an earlier stage during operation and prior to cell completion. Horizontal drains will be installed progressively as the cells are being filled, preventing a large amount of gas to be released to the atmosphere.

The drains are surrounded by gravel or other suitable drainage material and will be placed at regular distance as landfilling progresses. The pipes will be made of HDPE to ensure flexibility of the network and resistance to corrosion. Horizontal drains are solely installed for the CDM-project activity.

- **Collection piping:**

There will be three types of collection piping installed for the purpose of the project activity. Connection piping will connect the vertical wells to a manifold which is either connected directly to the main collection pipe or via a secondary pipe. The main collection pipe, surrounding the disposal area of the landfill will convey the landfill gas from the wells to the gas treatment station. The layout of the future systems will be implemented in order to avoid any low points which could disturb or prevent the gas collection (due to condensate blockages). All collection piping is of high-density polyethylene (HDPE).

**<u>Project Activity Station:</u>**

- **Blowers**

Blowers will be installed for efficient landfill gas collection. They will be used to create the required vacuum in the collection network to extract the landfill gas. The number of blowers will be adjusted in function of the quantity of gas to be collected.

- **Landfill gas to energy facility:**

The landfill gas to energy facility will include gas pre-treatment lines, landfill gas engines and all necessary equipment to connect these to the electrical grid. The gas pre-treatment lines will consist in chillers and activated coal filters which clean and dry the gas prior to the combustion in the engines.

Power generation will comprise several engines that are installed as the amount of biogas from the landfill increases. In total and based on the landfill gas model that serves as the basis for this PDD, 6 engines (capacity of 1.426 MW each) are planned to be installed as part of the project activity. The electricity produced will be auto-consumed by the project activity and for other purposes (leachate treatment). It will also be supplied to the grid.

- **Enclosed flares:**

The flares will be installed to burn landfill gas in case the engines are not available (for maintenance or other reasons) and / or if the amount of landfill gas captured exceeds the total capacity of the engines. The project participants plan to install two flares of 2000 Nm³/h and 3000 Nm3/h capacity respectively (the exact capacity will be adapted to the amount of landfill gas collected). The flares will be enclosed and provide a retention time above 0.3 seconds. The flares are designed to ensure a high temperature, above 700°C, and thus a methane destruction rate close to 100%. The flares will be equipped with automatic safety and monitoring controls which avoid the release of unburnt landfill gas to the atmosphere.

**Controls & Instrumentation:**

Extensive instrumentation, monitoring and recording equipment will be installed to monitor landfill gas quality, quantity and combustion efficiency, in accordance with the monitoring plan (see chapter B.7). This instrumentation mainly consists of the following items:

1. Flow meters to measure the normalized landfill gas flow (corrected for pressure and temperature) towards the flare(s) and towards the landfill gas engines. A total flow meter may be installed for safety purposes (redundancy).
2. A gas analyzer to measure the $CH_4$ content of the landfill gas. This gas analyser may additionally measure $CO_2$ and $O_2$ contents.
3. Thermocouples to measure the operating (combustion) and exhaust gas temperature of the flare.
4. A gas analyzer to measure the $CH_4$ and $O_2$ content of the exhaust gas of the flare.
5. Electricity meters to measure electricity consumption from the grid and electricity generation (auto-consumed, consumed for leachate treatment and sold to the grid). Some of these meters may be installed and controlled by the electricity supplier / grid owner.

All equipment (except the electricity meters if they are owned by the supplier) will be connected to a datalogger which continuously registers the monitoring data and safely stores it.

The Project Diagram Scheme available in the Appendix 4 provides the mass and energy balance for the duration of the project activity.

**Provided services:**

The main service provided by CGA Iperó landfill site is the safe disposal of waste collected from the municipality’s inhabitants and commercial customers. The annual quantities of waste are expected to grow in correlation to the population growth and commercial development. Estimation of annual tonnages can be found in section B.6.2 and in the appendix 4 of this PDD. There are currently no local treatment alternatives to the landfill.

Via the project activity CGA Iperó landfill will be able to provide an additional service in that it generates electricity from a renewable power source. This service is a “positive by-product” of the treatment of the collected landfill gas, but does not as such constitute a business objective for the project participants (cf Chapter B.5). The business objective of the project participants is not to become an electricity supplier, but provide safe and environmental friendly waste management services making sure that available resources are used efficiently. In the absence of the project activity (baseline scenario), electricity would therefore be provided by the national grid.

**Transfer of know-how to host parties:**

In implementing the project activity at CGA Iperó landfill, Proactiva Meio Ambiente Brasil Ltda., in partnership with Veolia Propreté and Proactiva Medio Ambiente S.A., transfers its expertise and experience of these systems to the local team and operators. Active landfill gas capture systems, gas flaring and gas recovery for electricity production are not common technologies in Brazil.

Foreign suppliers and international experts from Proactiva Medio Ambiente S.A. will install the systems in collaboration with the local technical team at Iperó who will have to operate the equipment. Thus a transfer of know-how and technical skills will take place and will be reinforced via internal training sessions and/or cooperation with the suppliers.

Local technicians will learn to operate, maintain and extend the active gas capture system, the flaring equipment and in a second step the landfill gas-to-energy equipment so as to guarantee good performance. This includes amongst others, the balancing of the system to optimize the landfill gas flow and $CH_4$ concentration, the maintenance of the pipe works in order to avoid low points and blockages, the connection of new wells, the regulation of the flaring equipment, all operations with regard to the electricity generation and control and management of all site instrumentation and monitoring.

All these tasks will significantly increase the technical skills (mechanics, electricity, electronics, etc.) of the landfill technicians in comparison to the baseline scenario. Once acquired, these skills can then be used to disseminate the technology to other projects within Proactiva Meio Ambiente Brasil Ltda. and Brazil.


**Figure 3 - CGA Iperó Landfill site implementation**

## A.4. Parties and project participants

| Parties involved | Project participants | Indicate if the Party involved wishes to be considered as project participant (Yes/No) |
|---|---|---|
| Brazil (host Party) | Proactiva Meio Ambiente Brasil Ltda. | No |
| Switzerland | First Climate (Swizerland) AG | No. |

## A.5. Public funding of project activity

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The project activity will not benefit from any public funding from Parties included in Annex I of the Kyoto Protocol.

### A.6. History of project activity

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The project activity “Proactiva CGA Iperó Landfill Gas to Energy Project” is registered as under the CDM and it (and/or the infrastructure/components it encompasses) was not previously included as a component project activity (CPA) in a registered CDM programme of activities (PoA). Prior of being registered under the CDM, the project activity (and/or the infrastructure/components it encompasses) did not represent any part or a whole previously registered CDM project activity that had been deregistered. Prior of being registered under the CDM, the project activity (and/or the infrastructure/components it encompasses) were not part of a previous CPA that has been excluded from a previously registered CDM PoA either.

The project activity (and/or the infrastructure/components it encompasses) does not represent or part of a previously registered CDM project activity or a CPA under a previously registered CDM PoA whose crediting period has or has not expired (hereinafter referred to as former project) which existed within the same or other geographical location as the CDM project activity.

### A.7. Debundling

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Not applicable.

## SECTION B. Application of methodologies and standardized baselines

### B.1. References to methodologies and standardized baselines

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The approved methodology that is used is ACM0001: “Flaring or use of landfill gas”, version 12;

The tools used are those referred to by the above mentioned methodology:

- Methodological Tool ”Combined tool to identify the baseline scenario and demonstrate additionality”, version 04.0.0
- Tool to determine project emissions from flaring gases containing methane, version 1
- Tool to calculate baseline, project and/or leakage emissions from electricity consumption, version 1
- Tool to calculate project or leakage $CO_2$ emissions from fossil fuel combustion, version 2
- Methodological Tool ”Emissions from solid waste disposal sites”, version 6.0.1
- Tool to calculate the emission factor for an electricity system, version 2.2.1
- Tool to determine the mass flow of a greenhouse gas in a gaseous stream, version 02.0.0

Hereafter all references to the methodology and the tools will refer to the versions mentioned above.

**B.2. Applicability of methodologies and standardized baselines**

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Methodology ACM0001 is applicable to project activities which:

a) Install a new landfill gas capture system in a new or existing SWDS; or

b) Make an investment into an existing landfill gas capture system to increase the recovery rate or change the use of the captured landfill gas, provided that:

i. The captured landfill gas was only vented or flared and not used prior to the implementation of the project activity; and

ii. In the case of an existing active landfill gas capture system for which the amount of landfill gas cannot be collected separately from the project system after the implementation of the project activity and its efficiency is not impacted on by the project system: historical data on the amount of landfill gas capture and flared is available.

c) Flare the landfill gas and / or use the capture landfill gas in any (combination) of the following ways:

i. Generating electricity;

ii. Generating heat in a boiler, air heater or kiln (brick firing only); and / or

iii. Supplying the landfill gas to consumers through a natural gas distribution network.

d) Do not reduce the amount of organic waste that would be recycled in the absence of the project activity.

The project activity described above consists in turning a passive venting system into an active landfill gas capture and combustion system. The landfill gas will be combusted to generate electricity. The project activity corresponds to the situation b)i. and c)i. mentioned above. It does not reduce the amount of organic waste that would be recycled in the absence of the project activity.

The methodology is only applicable if the application of the procedure to identify the baseline scenario confirms that the most plausible baseline scenario is:

a. Partial or total release of the landfill gas from the SWDS; and

b. In the case that the landfill gas is used in the project activity for generating electricity and / or generating heat in a boiler, air heater or kiln;

i. for electricity generation: that electricity would be generated in the grid or in captive fossil fuel fired power plants; and/ or

ii. For the heat generation: that heat would be generated using fossil fuels in on-site equipment.

a) and b) i. apply. For more details on this part, please refer to section B.4 (description of the baseline scenario) and B.5 (demonstration of additionality of the project activity).

This methodology is not applicable:

a. In combination with other approved methodologies. (…)

b. If the management of the SWDS in the project activity is deliberately changed in order to increase methane generation compared to the situation prior to the implementation of the project activity(…).

No other methodology than ACM0001 is applied.
The project activity consists in improving management of the landfill and enhancing the landfill gas capture for flaring and recovery of the gas from the landfill.

## B.3. Project boundary, sources and greenhouse gases (GHGs)

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| Source | | GHG | Included? | Justification/Explanation |
|---|---|---|---|---|
| Baseline | Emissions from decomposition of waste at the SWDS site | $CH_4$ | Yes | This is the major source of emissions in the baseline. |
| | | $N_2O$ | No | Considered small compared to $CH_4$ emissions from landfill. Exclusion is conservative as per the methodology. |
| | | $CO_2$ | No | The emissions of $CO_2$ resulting from the degradation of organic waste are not accounted since the $CO_2$ is also released under the project activity. |
| | Emissions from electricity generation | $CO_2$ | No | Major emission source if power generation from landfill gas is included in the project activity. |
| | | $CH_4$ | No | Excluded for simplification. This is conservative as per the methodology. |
| | | $N_2O$ | No | Excluded for simplification. This is conservative as per the methodology. |
| | Emissions from heat generation | $CO_2$ | No | There is no heat generation. |
| | | $CH_4$ | No | There is no heat generation. |
| | | $N_2O$ | No | There is no heat generation. |
| | Emissions from the use of natural gas | $CO_2$ | No | There is no use of natural gas. |
| | | $CH_4$ | No | There is no use of natural gas. |
| | | $N_2O$ | No | There is no use of natural gas. |
| Project activity | Emissions from fossil fuel consumption for purposes other than electricity generation or transportation due to the project activity | $CO_2$ | No | The project activity does not include any fuel consumption for other purposes than electricity production. |
| | | $CH_4$ | No | The project activity does not include any fuel consumption for other purposes than electricity production. |
| | | $N_2O$ | No | The project activity does not include any fuel consumption for other purposes than electricity production. |
| | Emissions from electricity consumption due to the project activity | $CO_2$ | Yes | When electricity for the Project activity is not auto-consumed, it should either come from the grid or –if it is installed on-site- from a fossil fuel generator. A fossil fuel generator may be installed on-site as an alternative source of electricity for the project activity. $CO_2$ emissions associated with fossil fuel combustion would therefore be accounted for as project emissions. |
| | | $CH_4$ | No | Excluded for simplification. This emission source is assumed to be very small. |
| | | $N_2O$ | No | Excluded for simplification. This emission source is assumed to be very small. |
| | Emissions from flaring | $CO_2$ | No | Emissions are considered negligible. |
| | | $CH_4$ | Yes | It is an important emission source. |
| | | $N_2O$ | No | Emissions are considered negligible. |
| | Emissions from distribution of LFG using trucks | $CO_2$ | No | There is no distribution of LFG using trucks. |
| | | $CH_4$ | No | There is no distribution of LFG using trucks. |
| | | $N_2O$ | No | There is no distribution of LFG using trucks. |

The flowchart presented below shows the project boundary and the sources of emissions:

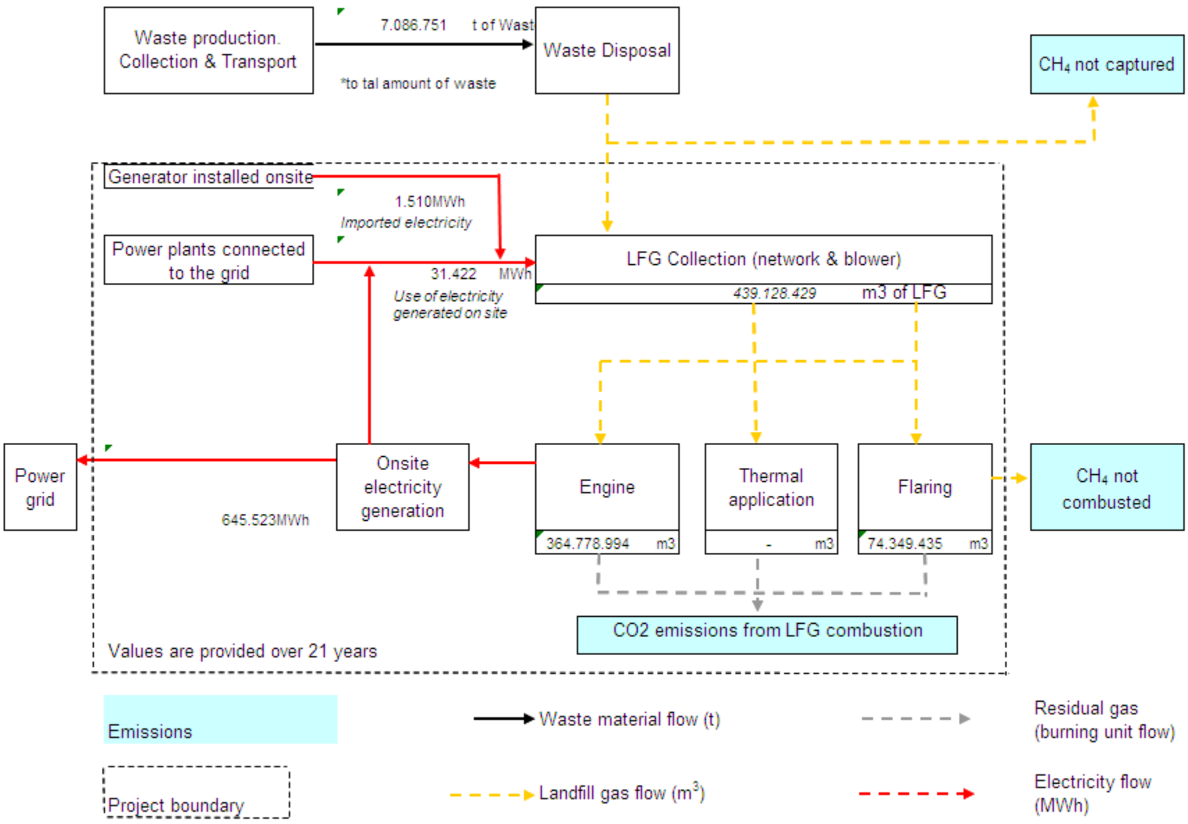


**Figure 4 - Project Boundary**

## B.4. Establishment and description of baseline scenario

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ACM0001 version 12 requires that project participants use the Combined tool to identify the baseline scenario and demonstrate additionality.

The baseline scenario has been identified as per the three first steps of this tool:

- Step 1: Identification of alternative scenarios;
- Step 2: Barrier analysis;
- Step 3: Investment analysis (if applicable);
- Step 4: Common practice analysis.

***Step 1: Identification of alternative scenarios***

This step is used to identify potential alternative scenarios to the proposed CDM project activity baseline scenario.

**Sub-step 1a: Define alternative scenarios to the proposed CDM project activity**

According to the methodology, there are different possible baseline scenarios for landfill gas management and electricity generation. The description of these scenarios is listed below.

The identified alternative scenarios are the scenarios that (a) are available to the project participants, (b) cannot be implemented in parallel to the proposed project activity, and (c) provide outputs or services with comparable quality, properties and application areas as the proposed CDM project activity.

**ALTERNATIVES TO LANDFILL GAS COMPONENT OF THE PROJECT ACTIVITY:**

**LFG1:** The proposed project activity without being registered as a CDM project. This may be an alternative baseline scenario.

**LFG2:** The current situation 'business as usual' of passive venting and sporadic flaring to address safety and odours concerns.
This may be an alternative baseline scenario.

**LFG3:** landfill gas is partially not generated because part of the organic fraction of the solid waste is recycled and not disposed in the SWDS.

Alternatives to the proposed project activity should provide the same output, i.e. deliver goods or services with comparable quality, properties and application areas[2]. The proposed project activity consists in operating a landfill site. Therefore, the treatment of waste in another type of facility does not correspond to an alternative way of operating the landfill site and thus cannot be considered as an alternative.

In addition, a study published by official sources (SNIS[3]) reveals that there are 57 recycling centres in the State of Sao Paulo with a total capacity of 211,806 tonnes per year. This can therefore not be considered as an alternative since the total capacity correspond to less than 50% of annual expected tonnages received at CGA Iperó landfill site.
Therefore, this is not an alternative to the project activity.

**LFG4:** landfill gas is partially not generated because part of the organic fraction of the solid waste is treated aerobically and not disposed in the SWDS.

Alternatives to the proposed project activity should provide the same output, i.e. deliver goods or services with comparable quality, properties and application areas[4]. The proposed project activity consists in operating a landfill site. Therefore, the treatment of waste in another type of facility does not correspond to an alternative way of operating the landfill site and thus cannot be considered as an alternative.

In addition, a study published by official sources (SNIS[5]) reveals that there are 3 composting centres in the State of Sao Paulo with a total capacity of 74,424 tonnes per year. This can

[2] Definition from the annex 8 of the EB 62 report.

[3] Sistema Nacional de Informações sobre Saneamento

[4] Definition from the annex 8 of the EB 62 report.

[5] Sistema Nacional de Informações sobre Saneamento

therefore not be considered as an alternative since the total capacity correspond to less than 25% of annual average expected tonnages received at CGA Iperó landfill site.
Therefore, this is not an alternative to the project activity.

**LFG5:** landfill gas is partially not generated because part of the organic fraction of the solid waste is incinerated and not disposed in the SWDS.

Alternatives to the proposed project activity should provide the same output, i.e. deliver goods or services with comparable quality, properties and application areas[6]. The proposed project activity consists in operating a landfill site. Therefore, the treatment of waste in another type of facility does not correspond to an alternative way of operating the landfill site and thus cannot be considered as an alternative.

In addition, there is no incineration plant in Brazil for municipal solid waste. The only existing units are for hazardous / medical waste.

Therefore, this is not an alternative to the project activity.

**ALTERNATIVES TO POWER GENERATION COMPONENT:**
**E1:** Electricity generation from landfill gas, undertaken without being registered as CDM project activity.

This is an alternative.

**E2:** Electricity generation in existing and/or new on-site or off-site renewable based captive power plant(s).

This is not an alternative because the core activity of Proactiva Meio Ambiente Brasil Ltda. is not to produce electricity – even from renewable sources, but to manage solid waste and SWDS. This scenario does not offer a credible alternative to the proposed project activity, whose electricity production is the output of the landfill site management and is not a sole activity.

The installation of a power generator onsite would only be used to supply the project activity with required electricity when the project itself and the grid are not available. In addition, this will only be a small consumption for internal purposes and would not be considered as an alternative source of electricity at a macro-scall.

Therefore, this is not an alternative to the project activity.

**E3:** Electricity generation in existing and/or new grid-connected power plants. This is the “business as usual” current situation. This is an alternative.

**OTHER ALTERNATIVES:**

**S2:** A third party would install and operate the landfill gas collection and combustion system on site. Landfill operators would not be involved in the landfill gas management.

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[6] Definition from the annex 8 of the EB 62 report.

This is not an alternative because it is not realistic. Proactiva Meio Ambiente Brasil Ltda. owns the landfill site of Iperó and does not intend to contract a third party as this would possibly interfere with the principal activity of the company which is the management of waste.

**S6:** The proposed project activity undertaken, without being registered as a CDM project activity, to be implemented at a later point in time.

This is not an alternative because considering the implementation of the project activity without CERs revenues and to be installed at a later point in time, would mean that there would be more incentives to implement that project later than now. Yet, there are no such signs in Brazil today and no initiative tending to delay the development of the project.

In addition, operations at the landfill site should stop in 2025. After that, the site will be in post-operation and the production of landfill gas will decrease. Any delay in the implementation of the project would contribute to reduce the global revenues for an equivalent investment.

The project does not include heat generation or direct landfill gas supply to a natural gas distribution network. Therefore, no alternatives for such activities have been considered.

**Outcome of sub-step 1a:**
The plausible alternative scenarios identified for the baseline scenario are:

- for landfill gas: LFG1 and LFG2
- for power generation:E1 and E3

**Sub-Step 1b: Consistency with mandatory applicable laws and regulations**

All the alternatives listed in sub-step 1a are in compliance with the applicable laws and regulations of the host country.

***Step 2: Barrier Analysis***

**Sub-Step 2a: Identify barriers that would prevent the implementation of alternative scenarios**

Although landfill-gas-to-energy projects are not common practice in Brazil, the project participants could not identify any barriers that would prevent the implementation of such a project in Brazil. The technology is available and can be imported from other countries. The same applies to the necessary know-how to run the facility – it can be acquired by adequate training of staff.
No investment barriers apply neither. Proactiva Meio Ambiente Brasil Ltda. has the necessary means to implement the project if the financial analysis confirms that it is economically interesting to do so.

No barriers that could prevent the implementation of the alternative scenarios identified in Step 1 have been identified.

**Outcome of Sub-step 2a:** No barrier could be identified.

**Sub-Step 2b:** Eliminate alternative scenarios which are prevented by the identified barriers

The identified alternative scenarios cannot be eliminated through the barrier analysis.

**Outcome of Sub-step 2b:** No alternative scenario could be eliminated.

The remaining scenarios are: LFG1, LFG 2, E1 and E3. Basically, LFG1 + E1 correspond to the project activity (landfill gas and power) without being registered as a CDM. LFG2 + E3 correspond to the “business as usual” situation.

Since more than one scenario is remaining after Step 2 and that the alternatives include the project without CDM, we shall proceed to Step 3 (Investment analysis) to determine which of the remaining alternative scenarios is the baseline scenario.

***Step 3: Investment Analysis***

The objective of this Step 3 is to compare the economic or financial attractiveness of the alternative scenarios remaining after Step 2.

The remaining alternative scenarios can be gathered (LFG1 + E1 and LFG2 + E3) in order to have two plausible scenarios that consist in alternatives for the entire project activity (landfill gas management and power generation). Hereafter, Scenario 1 corresponds to alternatives LFG1 + E1 (project without CDM) and Scenario 2 corresponds to alternatives LFG2 + E3 (business as usual).

The financial indicator used to conduct the financial analysis is the Project Internal Rate of Return (IRR), as recommended by the Combined Tool since one of the remaining alternative scenarios is the “business as usual” scenario, which correspond to current situation and does not require any investment or  expenses to maintain the current situation (such as venting of methane from a landfill).

This step was conducted in accordance with recommendations of the latest version of the “Guidelines on the assessment of investment analysis”.

***<u>Scenario 1 (LFG1 + E1): The proposed project activity without being registered as a CDM project</u>***.

This alternative is to install a gas collection system and connect it to a high capacity vacuum substation, in order to feed the following equipment:

- High efficiencies enclosed flares;
- Landfill gas power generation station including up to 6 engines.

This alternative aims at delivering electricity to the project activity and to the grid.

Investment analysis is conducted here to demonstrate the additionality of the project activity. This analysis was conducted for a period of twenty (20) years which corresponds to the operational lifetime of the project activity, based on landfill operations planning, engines lifetime and expected landfill gas generation. All steps of the investment analysis can be found and reproduced in the

attached excel file. The following is a summary for the reader to understand the approach and values presented.

The installation of the collection, flaring, and landfill-gas-to-energy equipment, requires increased investment as well as increased operation and maintenance costs. The CAPEX will be spread out until the end of the landfill operations, and OPEX will be spent on an annual basis. The main financial elements of this scenario are summarized below:

**Table 6 Main Financial Elements over the analysis period (in USD)[7]**

| | | |
|---|---|---|
| **CAPEX** | Engines | 17,092,063 |
| | Collection Network | 4,911,608 |
| | Gas conditioning | 1,553,894 |
| | Grid connection | 580,000 |
| | Flares | 1,736,921 |
| | Development | 504,297 |
| | **Total** | **26,378,783** |
| **OPEX** | Power Plant | 25,747,069 |
| | Capture & flaring | 6,978,798 |
| | Conditioning | 2,174,222 |
| | Energy Trading costs | 179,723 |
| | Overheads Costs | 4,604,298 |
| | **Total** | **39,684,110** |
| **Revenues** | Electricity Sales | 63,507,558 |
| | Cost savings | 2,310,635 |
| | Residual Value | 844,608 |
| | **Total** | **66,662,801** |

The revenues presented above are estimated with the two following assumptions:

- "Revenues from electricity sales": are determined based on a study realised by a third party to understand the Brazilian electricity market. This study assessed the price of electricity sale to the free market at 101US$ / MWh.
- "Cost savings": the same study assessed that on average, the price of electricity purchased at Iperó landfill is of 161US$ / MWh. Thus it is assumed that for each MWh of electricity that is auto- consumed for purposes other than the project activity itself (i.e. leachate treatment which is outside of the project boundaries), a cost saving of 161-101=60US$ / MWh is achieved.
- Residual Value is what is not depreciated over the assessment period and therefore included back as revenue the last year of the analysis.

As mentioned above, for the purpose of this investment analysis, we have chosen to use the project IRR as financial indicator.

The project IRR was calculated based on the financial elements mentioned above and that can be found in details in the attached excel file. The IRR for Scenario 1 is provided below.

[7] The costs are derived from offers received from manufacturers and standard prices on the Brazilian market.

**Table 7 Project IRR**

| | |
|---|---|
| Scenario 1 (project without CDM) | **-2.27%** |

As per the “Combined tool”, a sensitivity analysis was conducted to assess the variation of the IRR when the key financial parameters vary. These key parameters are defined as those representing more than 20% of the total project costs or more than 20% of the total project revenues. The only costs of the project activity are the investments (CAPEX) and the Operation & Maintenance costs (OPEX). The sole revenues come from the sales of electricity. Therefore, these three parameters have been considered as the three key financial parameters and subject to variation to run the sensitivity analysis.

The PP have chosen to conduct the sensitivity analysis with a +/-20% variation range, to cover a significant range that is not likely to happen to demonstrate that the project IRR is not likely to reach the benchmark.

Investment costs, O&M costs and revenues where therefore altered by + and – 20%. The results of the sensitivity study are summarized below:

| | | + | | - | |
|---|---|---|---|---|---|
| | | **IRR (%)** | **NPV k$US** | **IRR (%)** | **NPV k$US** |
| **Investment** | 20% | -2.96% | -9,601 | -1.66% | -8,911 |
| **Revenue** | 20% | 2.99% | -6,680 | -11.09% | -12,159 |
| **O&M cost** | 20% | -7.33% | -11,117 | 1.45% | -7,445 |

This table can be presented graphically, as shown below:

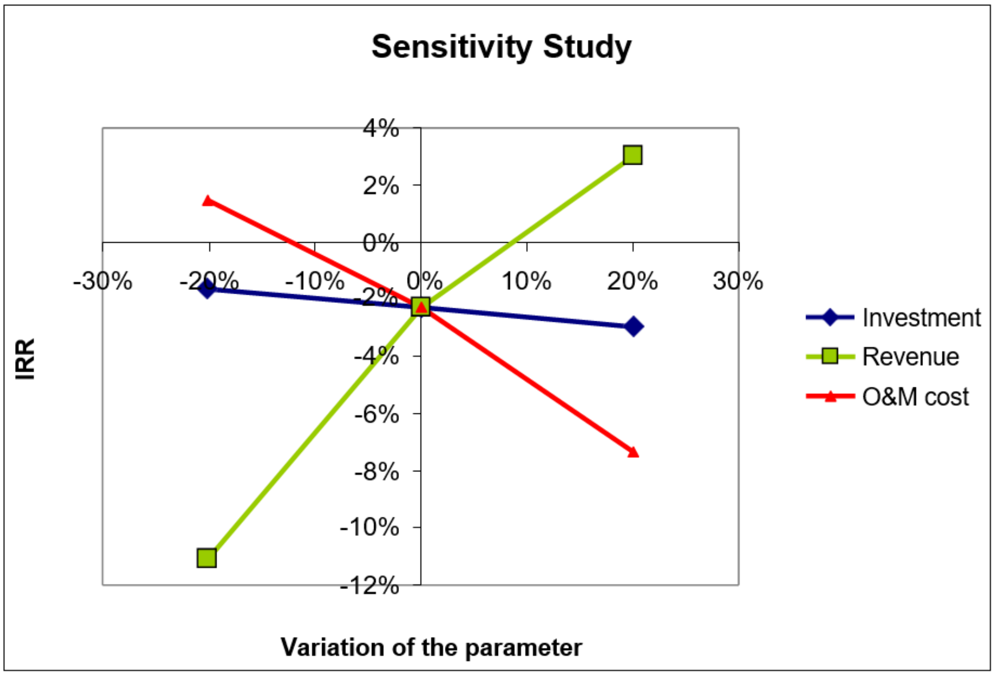

**Figure 5 - Sensitivity Analysis with a +/-20% variation**

The sensitivity analysis shows that the project IRR for Scenario 1 varies from a minimum of -11.09% (revenue variation) to a maximum of 2.99% (revenues increased by +20%).

***<u>Scenario 2 (LFG2 + E3): The current situation 'business as usual'</u>***

Scenario 2 corresponds to a situation where the landfill gas (LFG2) would continue to be passively vented, not requiring additional investments, and where power (E3) would be generated in new / existing plants connected to the grid. For E3, the project participants are not involved since it is not Proactiva Meio Ambiente Brasil Ltda.'s core activity to produce power. Therefore, E3 corresponds to a situation where the project participants would not invest in order to produce electricity.

As per the Combined Tool, for alternative scenarios that correspond to a situation that do not involve any investment costs, operational costs or revenues, the financial indicator to be used to reflect the situation of the scenario is a financial benchmark, since the IRR is used for Scenario 1.

The financial benchmark used was calculated using official figures and references as recommended per the Guidelines and the Combined tool, applying Option a): "the financial benchmark shall be derived from Government bond rates, increased by a suitable risk premium".

Values used to calculate this benchmark are the following:

- Government Bond Rates: NTNB[8] thirteen-year Bond for the Republic of Brazil.

Since the financial analysis is done in real terms, the government Bond rate use for benchmark calculation must be in real terms too. The NTNB Bond is adapted for this situation as it indicates a return rate above official inflation index (IPCA[9]). Among the NTNB maturity time options available, the twenty-three-year NTNB Bond and the thirteen-year NTNB Bond are the ones that better match with the 20-year investment period of the project. As per the Guidelines, the average annual rate for both options was calculated over the last three months prior to submission of PDD for validation (November 2011 to January 2012), from historical data available on the site of Brazilian Treasury[10]:

- Average annual rate for 13-year NTNB Bond: 5.47%
- Average annual rate for 23-year NTNB Bond: 5.52%

For purpose of conservativeness, the lower of the above values was selected (13-year NTNB Bond).

[8] Notas do Tesouro Nacional – Série B / National Treasury Note – Type B

[9] Índice Nacional de Preços ao Consumidor Amplo / National Large Consumer Price Index

[10] http://www.tesouro.fazenda.gov.br/tesouro_direto/download/historico/2011/historicontnb_2011.xls and http://www.tesouro.fazenda.gov.br/tesouro_direto/download/historico/2012/historicontnb_2012.xls, consulted on 21/06/2012

- Risk premium: Independent estimations for 2011 by Stern School of Business (NY University)[11].

Consequently, the IRR benchmark applicable for this scenario is calculated as the combination of the long term rate of the Brazilian debt and the country risk premium.

**Table 8 – IRR benchmark calculation**

| | |
|---|---|
| Government Bond rate | 5.47% |
| Country Risk Premium | 4.82% |
| IRR Benchmark | **10.29%** |

As per the Combined Tool, in order to identify the baseline scenario, we consider that the project IRR to be used for the Baseline Scenario (Scenario 2) is equivalent to the default benchmark. Therefore, the IRR for the Baseline Scenario is 10.29%.

**Outcome of Step 3:**
The ranking of the alternative scenarios, based on the financial indicator is the following:
1. Scenario 2 (10.29%)
2. Scenario 1 (-2.27%)

The ranking of the IRR shows that Scenario 2 is the most financially attractive alternative scenario. In order to confirm this ranking, we have taken into account the results of the sensitivity analysis in the comparison below:

1. Scenario 2 = 10.29%
2. Scenario 1 = 2.99% (+20% Revenues)
3. Scenario 1 = 1.45% (-20% O&M costs)
4. Scenario 1 = -1.66% (-20% Investments)
5. Scenario 1 = -2.27%
6. Scenario 1 = -2.96% (+20% Investments)
7. Scenario 1 = -7.33% (O&M costs increase +20%)
8. Scenario 1 = -11.09% (Revenues decrease -20%)

The sensitivity analysis confirms the result of the investment comparison analysis, i.e. the Scenario 2 is the most financially attractive alternative scenario.

Scenario 2 (LFG2 +E3) is therefore considered as the baseline scenario.

[11] http://pages.stern.nyu.edu/~adamodar/ "The Equity Risk Premium: Determinants, Estimation and Implications: The 2011 Edition", p.54, consulted on 26/12/2011

### B.5. Demonstration of additionality

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As per the Instructions for Completing the Project Design Document Form (version 11.0), since the Combined Tool is used for the identification of the baseline scenario and demonstration of additionality, “the same information need not be replicated in both sections”.

All steps 1 to 3 of the Combined Tool are detailed in section B.4 of this PDD, for further information, please refer to that section of the PDD.

The outcome of the Step 3 (investment analysis) has identified the scenario 2 (business as usual) as the baseline scenario. Therefore, we need to proceed to Step 4 to demonstrate the additionality of the project.

***Step 4: Common Practice Analysis***

The proposed project activity is not a “first of its kind”, then this step is applicable.
The proposed project activity consists in methane destruction and use of “renewable energy”, which are both listed as “measures” in the tool. Therefore, Step 4a applies.

***Step 4 a: The proposed CDM project activity applies measures that are listed in the definition section above***

The four sub-steps 4a (1) to (4) of the Tool have been completed and lead to the following results:
(1) The installed capacity of the project activity is: 6* 1.426MW= 8.556 MW. The +- 50% output range of the project activity based on this installed capacity is: 4,278MW – 12,834 MW.

(2) According to the National Electric Energy Agency (ANEEL) there are 1,548 power plants in Brazil[12]. Among these, 434 biomass power plants[13] and only 19 powered by biogas[14].

Among these 19 power plants, only 1 has the same output range as defined in sub-step 4 a.1 (i.e. 4 to 13 MW). This only power plant is the one of Belo Horizonte, which is a CDM project (registered under number 3464).

Therefore, there is no power plant in Brazil of the same output than the project activity, that has started commercial activities. Thus, $N_{all} = 0$.

(3) Since $N_{all}$ equals to zero, then $N_{diff} = 0$.

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12 http://www.aneel.gov.br/aplicacoes/capacidadebrasil/GeracaoTipoFase.asp?tipo=2&fase=3

13 http://www.aneel.gov.br/aplicacoes/capacidadebrasil/OperacaoGeracaoTipo.asp?tipo=5&ger=Combustivel&principal=Biomassa

14 http://www.aneel.gov.br/aplicacoes/capacidadebrasil/CombustivelListaUsinas.asp?classe=Biomassa&combustivel=19&fase=3

(4) The share of plants using a technology similar to the technology used in the proposed project activity in all plants that deliver the same output or capacity as the proposed project activity is calculated as follows:

$F = 1 - N_{diff}/N_{all}$

$F = 1 – 0/0$

And F cannot be calculated since 0/0 is not calculable.

So F is not defined but $N_{diff}$ - $N_{all}$ is smaller than 3, then the project activity is not considered as common practice.

**Outcome of Step 4:**
The proposed project activity is not regarded as “common practice”, so the proposed project activity is additional.

Identification of the baseline fuel for electricity generation by captive fossil fired power plants and/ or heat generation

The project activity’s baseline does not include any fuel consumption. The existing landfill gas management system is a passive venting system which does not require electricity.

## B.6. Estimation of emission reductions

### B.6.1. Explanation of methodological choices

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**BASELINE EMISSIONS**

Baseline emissions are calculated as follow:

$$BE_y = BE_{CH4,y} + BE_{EC,y} + BE_{HG,y} + BE_{NG,y}$$

**Eq. 1**

Where:

| | | |
|---|---|---|
| $BE_y$ | Baseline Emissions in year y | t $CO_2$e / y |
| $BE_{CH4,y}$ | Baseline Emissions of methane from the SWDS in year y | t $CO_2$e / y |
| $BE_{EC,y}$ | Baseline Emissions associated with electricity generation in year y | t $CO_2$e / y |
| $BE_{HG,y}$ | Baseline Emissions associated with heat generation in year y | t $CO_2$e / y |
| $BE_{NG,y}$ | Baseline Emissions associated with natural gas use in year y | t $CO_2$e / y |

Since the baseline of the project activity does not include any heat generation, and / or natural gas use, the equation (Eq. 1) can be simplified as:

$$BE_y = BE_{CH4,y} + BE_{EC,y}$$

**Eq. 2**

**STEP (A): BASELINE EMISSIONS OF METHANE FROM SWDS ($BE_{CH4,Y}$)**

In order to calculate $BE_{CH4,y}$, we use the Step (A) of the methodology ACM0001, version 12.

$$BE_{CH4,y} = (1 - OX_{top\_layer})(F_{CH4,PJ,y} - F_{CH4,BL,y})GWP_{CH4}$$

**Eq. 3**

Where:

| | | |
|---|---|---|
| $BE_{CH4,y}$ | Baseline Emissions of landfill gas from the SWDS in year y | t $CO_2$e / y |
| $OX_{top\_layer}$ | Fraction of methane in the landfill gas that would be oxidized in the top layer of the SWDS in the baseline | dimensionless |
| $F_{CH4,PJ,y}$ | Amount of methane in the landfill gas which is flared and / or used in the project activity in year y | $tCH_4$ / y |
| $F_{CH4,BL,y}$ | Amount of methane in the landfill gas that would be flared in the baseline in year y | $tCH_4$ / y |
| $GWP_{CH4}$ | Global Warming Potential of $CH_4$ | t $CO_2$e / $tCH_4$ |

***Step A.1. Ex-post determination of $F_{CH4,PJ,y}$***

During the crediting period, $F_{CH4,PJ,y}$ is equivalent to:

$$F_{CH4,PJ,y} = F_{CH4,flared,y} + F_{CH4,EL,y} + F_{CH4,HG,y} + F_{CH4,NG,y}$$

**Eq. 4**

Where:

| | | |
|---|---|---|
| $F_{CH4,flared,y}$ | Amount of methane in the landfill gas which is destroyed by flaring in year y | $tCH_4$ / y |
| $F_{CH4,EL,y}$ | Amount of methane in the landfill gas which is used for electricity generation in year y | $tCH_4$ / y |
| $F_{CH4,HG,y}$ | Amount of methane in the landfill gas which is used for heat generation in year y | $tCH_4$ / y |
| $F_{CH4,NG,y}$ | Amount of methane in the landfill gas which is sent to the natural gas distribution network in year y | $tCH_4$ / y |

Since the project activity includes neither heat generation nor use of landfill gas as natural gas, the equation can be simplified to:

$$F_{CH4,PJ,y} = F_{CH4,flared,y} + F_{CH4,EL,y}$$ **Eq. 5**

a) $F_{CH4,EL,y}$ calculation

$F_{CH4,EL,y}$ is determined using the "Tool to determine the mass flow of a greenhouse gas in a gaseous stream", applying the requirements described below.

According to "Tool to determine the mass flow of a greenhouse gas in a gaseous stream" the following options will be considered for the present project activity:

**Option A**

As per Option A, the mass flow of greenhouse gas *i* (methane) is determined as follows:

$$F_{i,t} = V_{t,db} * v_{i,t,db} * \rho_{i,t}$$ **Eq.6**

With:

$$\rho_{i,t} = \frac{P_t * MM_i}{R_u * T_t}$$ **Eq. 7**

Where:

| | | |
|---|---|---|
| $F_{i,t}$ | kg gas / h | Mass flow of greenhouse gas *i (methane)* in the gaseous stream in time interval *t* |
| $V_{t,db}$ | $m^3$ dry gas / h | Volumetric flow of the gaseous stream in time interval *t* on a dry basis |
| $v_{i,t,db}$ | $m^3$ gas *i* / $m^3$ dry gas | Volumetric fraction of greenhouse gas *i* in the gaseous stream in a time interval *t* on a dry basis |
| $\rho_{i,t}$ | kg gas *i* / $m^3$ gas *i* | Density of greenhouse gas *i* in the gaseous stream in a time interval *t* |
| $P_t$ | Pa | Absolute pressure of the gaseous stream in time interval *t* |
| $MM_i$ | kg / kmol | Molecular mass of greenhouse gas *i* |
| $R_u$ | Pa.$m^3$ / kmol.K | Universal ideal gases constant |
| $T_t$ | K | Temperature of the gaseous stream in time interval *t* |

In the case where the gas temperature would be more than 60°C, we would consider the gas to be wet. Yet, the content measurement would be taken on a dry basis and therefore Option B of the Tool would be applied. As per the Tool, Option B requires to determine absolute humidity. Option 2 of the Tool would therefore be used, assuming that the gaseous stream is saturated as a simplified conservative approach[15].

The saturation absolute humidity ($m_{H2O,t,db,Sat}$) is calculated as per the following equation:

$$m_{H20,t,db,Sat} = \frac{p_{H2O,t,Sat} * MM_{H20}}{(P_t - p_{H2O,t,Sat}) * MM_{t,db}} \qquad \textbf{Eq. 8}$$

Where:

| | | |
|---|---|---|
| $m_{H2O,t,db,Sat}$ | Kg $H_2O$ / kg dry gas | Saturation absolute humidity in time interval *t* on a dry basis |
| $p_{H2O,t,Sat}$ | Pa | Saturation pressure of $H_2O$ at temperature T, in time interval t |
| $T_t$ | K | Temperature of the gaseous stream in time interval *t* |
| $P_t$ | Pa | Absolute pressure of the gaseous stream in time interval *t* |
| $MM_{H20}$ | Kg $H_2O$ / kmol H2O | Molecular mass of $H_2O$ |
| $MM_{t,db}$ | Kg dry gas / kmol dry gas | Molecular mass of the gaseous stream in time interval *t* on a dry basis |

$MM_{t,db}$ is estimated as follows:

$$MM_{t,db} = \sum_k (v_{k,t,db} * MM_k) \qquad \textbf{Eq. 9}$$

15 The tool states that considering the gaseous stream to be saturated is conservative "for the situation that the mass flow of greenhouse gas is underestimated (applicable for calculating baseline emissions)", which is the case here.

Where $v_{k,t,db}$ and $MM_k$ are equivalent, thanks to the simplification allowed by the methodology to the above detailed parameters $v_{i,t,db}$ and $MM_i$.

**Option B**

As per Option B, the mass flow of methane would be determined as follows:

$$V_{t,tb} = V_{t,wb} / (1 + v_{H2O,t,db}) \quad \textbf{Eq. 10}$$

Where:

| | | |
|---|---|---|
| $V_{t,db}$ | $m^3$ dry gas / h | Volumetric flow of the gaseous stream in time interval *t* on a dry basis |
| $V_{t,wb}$ | $m^3$ wet gas / h | Volumetric flow of the gaseous stream in time interval *t* on a wet basis |
| $v_{H2O}$ | $m^3_{H2O}$ / $m^3$ dry gas | Volumetric flow of $H_2O$ in the gaseous stream in time interval *t* on a dry basis |

With:

$$v_{H2O,t,db} = \frac{m_{H2O,t,db} * MM_{t,db}}{MM_{H20}} \quad \textbf{Eq. 11}$$

Where:

| | | |
|---|---|---|
| $v_{H2O,t,db}$ | $m^3_{H2O}$ / $m^3$ dry gas | Volumetric fraction of $H_2O$ in the gaseous stream in time interval *t* on a dry basis |
| $m_{H2O,t,db}$ | Kg $H_2O$ / kg dry gas | Absolute humidity in the gaseous stream in time interval *t* on a dry basis |
| $MM_{H20}$ | Kg $H_2O$ / kmol $H_2O$ | Molecular mass of $H_2O$ |
| $MM_{t,db}$ | Kg dry gas / kmol dry gas | Molecular mass of the gaseous stream in time interval *t* on a dry basis |

$m_{H2O,t,db}$ and $MM_{t,db}$ are determined as per Option 2 of the Tool detailed above.

**Option C**

The mass flow of greenhouse gas *i* ($F_{i,t}$) is determined as follows:

$$F_{i,t} = V_{t,wb,n} * v_{i,t,wb} * \rho_{i,n} \quad \textbf{Eq. 12}$$

with

$$\rho_{i,n} = \frac{P_n * MM_i}{R_u * T_n} \quad \textbf{Eq. 13}$$

Where:

| | |
|---|---|
| $F_{i,t}$ | Mass flow of greenhouse gas *i* in the gaseous stream in time interval *t* (in kg gas/h) |
| $V_{t,wb,n}$ | Volumetric flow of the gaseous stream in time interval *t* on a wet basis at normal conditions (in $m^3$ wet gas/h) |
| $v_{i,t,wb}$ | Volumetric fraction of greenhouse gas *i* in the gaseous stream in time interval *t* on a wet basis (in $m^3$ gas *i*/$m^3$ wet gas) |
| $\rho_{i,n}$ | Density of greenhouse gas *i* in the gaseous stream at normal conditions (in kg gas *i*/$m^3$ wet gas *i*) |
| $P_n$ | Absolute pressure at normal conditions (in Pa) |
| $T_n$ | Temperature at normal conditions (in K) |
| $MM_i$ | Molecular mass of greenhouse gas *i* (in kg/kmol) |
| $R_u$ | Universal ideal gases constant (in Pa.$m^3$/kmol.K) |

The following equation should be used to convert the volumetric flow of the gaseous stream from actual conditions to normal conditions of temperature and pressure:

$$V_{t,wb,n} = V_{t,wb} * (T_n/T_t) * (P_t/P_n) \quad \textbf{Eq. 14}$$

Where:

| | |
|---|---|
| $V_{t,wb,n}$ | Volumetric flow of the gaseous stream in a time interval *t* on a wet basis at normal conditions (in $m^3$ wet gas/h) |
| $V_{t,wb}$ | Volumetric flow of the gaseous stream in time interval *t* on a wet basis (in $m^3$ wet gas/h) |
| $P_t$ | Pressure of the gaseous stream in time interval *t* (in Pa) |
| $T_t$ | Temperature of the gaseous stream in time interval *t* (in K) |
| $P_n$ | Absolute pressure at normal conditions (in Pa) |
| $T_n$ | Temperature at normal conditions (in K) |

The absolute humidity is a parameter required for Options B, thus it will be used only in case Option B is adopted. Option 2 (simplified calculation without measurement of the moisture content)

of the tool is selected for the determination of absolute humidity of the gaseous stream for the project activity:

*Option 2: Simplified calculation without measurement of the moisture content*

This option provides a simple and conservative approach to determine the absolute humidity by assuming the gaseous stream is dry or saturated depending on which is the conservative situation[16].

If it is conservative to assume that the gaseous stream is dry, then $m_{H2O,t,db}$ is assumed to equal 0. If it is conservative to assume that the gaseous stream is saturated, then mH2O,t,db is assumed to equal the saturation absolute humidity ($m_{H2O,t,db,sat}$) and calculated using equation.

$$m_{H2O,t,db,Sat} = \frac{p_{H2O,t,Sat} * MM_{H2O}}{(P_t - p_{H2O,t,Sat}) * MM_{t,db}}$$

**Eq. 15**

Where:

| | |
|---|---|
| $m_{H2O,t,db,sat}$ | Saturation absolute humidity in time interval *t* on a dry basis (kg $H_2O$/kg dry gas) |
| $p_{H20,t,Sat}$ | Saturation pressure of $H_2O$ at temperature Tt in time interval t (Pa) |
| $T_t$ | Temperature of the gaseous stream in time interval *t* (K) |
| $P_t$ | Absolute pressure of the gaseous stream in time interval *t* (Pa) |
| $MM_{H2O}$ | Molecular mass of $H_2O$ (kg $H_2O$/kmol $H_2O$) |
| $MM_{t,db}$ | Molecular mass of the gaseous stream in a time interval *t* on a dry basis (kg dry gas/kmol dry gas) |

Parameter $MM_{t,db}$ is estimated using the following equation.

$$MM_{t,db} = \sum_{k} (v_{k,t,db} * MM_k)$$

**Eq. 16**

Where:

| | |
|---|---|
| $MM_{t,db}$ | Molecular mass of the gaseous stream in time interval *t* on a dry basis (kg dry gas/kmol dry gas) |
| $v_{k,t,db}$ | Volumetric fraction of gas *k* in the gaseous stream in time interval *t* on a dry basis ($m^3$ gas k/$m^3$ dry gas) |
| $MM_k$ | Molecular mass of gas *k (*kg/kmol) |
| K | All gases, except $H_2O$, contained in the gaseous stream (e.g. $N_2$ and $CH_4$,). See available simplification below. |

The determination of the molecular mass of the gaseous stream ($MM_{t,db}$) requires measuring the volumetric fraction of all gases (*k*) in the gaseous stream. However, as a simplification, in the case of the project activity, the volumetric fraction of the methane that is a greenhouse gas and

[16] An assumption that the gaseous stream is saturated is conservative for the situation that the mass flow of greenhouse gas *i* is underestimated (applicable for calculating baseline emissions). Conversely, an assumption that the gas stream is dry is conservative for the situation that the greenhouse gas *i* is overestimated (applicable for calculating project emissions).

considered in the emission reduction calculation in the underlying methodology must be monitored and the difference to 100% may be considered as pure nitrogen. The simplification is not acceptable if it is differently specified in the underlying methodology.

b) $F_{CH4,flared,y}$ calculation:

$$F_{CH4,flared,y} = F_{CH4,sent\_flare,y} - \frac{PE_{flare,y}}{GWP_{CH4}} \quad \textbf{Eq. 17}$$

Where:

| | | |
|---|---|---|
| $F_{CH4,sent\_flare,y}$ | t $CH_4$ / y | Amount of methane in the landfill gas which is sent to the flare in the year y |
| $PE_{flare,y}$ | t $CO_2$e /y | Project emissions from flaring of the residual gas stream in year y |

Where $F_{CH4,sent\_flare,y}$ is calculated as per the "Tool to determine the mass flow of a greenhouse gas in a gaseous stream" by using one of the calculation options adopted for the calculation of $F_{CH4,EL,y}$, therefore please refer to section a) for calculation details.

And where $PE_{flare,y}$ is calculated as per the "Tool to determine project emissions from flaring gases containing methane". It is used to calculate project emissions from the flare(s) due to combustion efficiencies below 100%. The project activity includes enclosed flares. There are two options that can be used to determine the flare efficiency.

We have chosen the option (b): "Continuous monitoring of the methane destruction efficiency of the flare (flare efficiency)".
The tool includes seven (7) steps.

***Step 1: Determination of the mass flow rate of the residual gas that is flared***
This step calculates the residual gas mass flow rate in each hour *h*, based on the volumetric flow rate and the density of the residual gas. The density of the residual gas is determined based on the volumetric fraction of all components in the gas.

$$FM_{RG,h} = \rho_{RG,n,h} * FV_{RG,h} \quad \textbf{Eq. 18}$$

Where:

| | | |
|---|---|---|
| $FM_{RG,h}$ | kg/h | Mass flow rate of the residual gas in hour *h* |
| $\rho_{RG,n,h}$ | kg/m$^3$ | Density of the residual gas at normal conditions in hour *h* |
| $FV_{RG,h}$ | m$^3$/h | Volumetric flow rate of the residual gas in dry basis at normal conditions in the hour *h* |

And:

$$\rho_{RG,n,h} = \frac{P_n}{\frac{R_u}{MM_{RG,h}} * T_n}$$ **Eq. 19**

Where:

| | | |
|---|---|---|
| $\rho_{RG,n,h}$ | kg/m$^3$ | Density of the residual gas at normal conditions in hour *h* |
| $P_n$ | Pa | Atmospheric pressure at normal conditions (101 325) |
| $R_u$ | Pa.m$^3$/kmol.K | Universal ideal gas constant (8 314) |
| $MM_{RG,h}$ | kg/kmol | Molecular mass of the residual gas in hour *h* |
| $T_n$ | K | Temperature at normal conditions (273.15) |

And:

$$MM_{RG,h} = \sum \left( fv_{i,h} * MM_i \right)$$ **Eq. 20**

Where:

| | | |
|---|---|---|
| $MM_{RG,h}$ | kg/kmol | Molecular mass of the residual gas in hour *h* |
| $fv_{i,h}$ | - | Volumetric fraction of component *i* in the residual gas in the hour *h* |
| $MM_i$ | kg/kmol | Molecular mass of residual gas component *i* |
| i | - | As a simplified approach, as per the Tool, we only consider the components $CH_4$ and $O_2$ |

***Step 2: Determination of the mass fraction of carbon, hydrogen, oxygen and nitrogen in the residual gas***

$$fm_{j,h} = \frac{\sum_i fv_{i,h} * AM_j * NA_{j,i}}{MM_{RG,h}}$$ **Eq. 21**

Where:

| | | |
|---|---|---|
| $fm_{j,h}$ | - | Mass fraction of element *j* in the residual gas in hour *h* |
| $fv_{i,h}$ | - | Volumetric fraction of component *i* in the residual gas in the hour *h* |
| $AM_j$ | kg/kmol | Atomic mass of element *j* |
| $NA_{j,i}$ | - | Number of atoms of element *j* in component *i* |
| $MM_{RG,h}$ | kg/kmol | Molecular mass of the residual gas in hour *h* |
| j | | The elements carbon, hydrogen, oxygen and nitrogen |

| | | |
|---|---|---|
| i | | The components $CH_4$, $CO_2$, $O_2$, $N_2$ |

***Step 3: Determination of the volumetric flow rate of the exhaust gas on a dry basis***

This step is applicable since the methane combustion efficiency of the flare is continuously monitored.

$$TV_{n,FG,h} = V_{n,FG,h} * FM_{RG,h}$$ **Eq. 22**

Where:

| | | |
|---|---|---|
| $TV_{n,FG,h}$ | $m^3/h$ | Volumetric flow rate of the exhaust gas in dry basis at normal conditions in hour *h* |
| $V_{n,FG,h}$ | $m^3$/kg residual gas | Volume of the exhaust gas of the flare in dry basis at normal conditions per kg of residual gas in hour *h* |
| $FM_{RG,h}$ | kg residual gas/h | Mass flow rate of the residual gas in the hour *h* |

$$V_{n,FG,h} = V_{n,CO_2,h} + V_{n,O_2,h} + V_{n,N_2,h}$$ **Eq. 23**

Where:

| | | |
|---|---|---|
| $V_{n,FG,h}$ | $m^3$/kg residual gas | Volume of the exhaust gas of the flare in dry basis at normal conditions per kg of residual gas in the hour *h* |
| $V_{n,CO2,h}$ | $m^3$/kg residual gas | Quantity of $CO_2$ volume free in the exhaust gas of the flare at normal conditions per kg of residual gas in the hour *h* |
| $V_{n,N2,h}$ | $m^3$/kg residual gas | Quantity of $N_2$ volume free in the exhaust gas of the flare at normal conditions per kg of residual gas in the hour *h* |
| $V_{n,O2,h}$ | $m^3$/kg residual gas | Quantity of $O_2$ volume free in the exhaust gas of the flare at normal conditions per kg of residual gas in the hour h |

$$V_{n,0_2,h} = n_{0_2,h} * MV_n$$ **Eq. 24**

Where:

| | | |
|---|---|---|
| $V_{n,O2,h}$ | $m^3$/kg residual gas | Quantity of $O_2$ volume free in the exhaust gas of the flare at normal conditions per kg of residual gas in the hour *h* |
| $n_{O2,h}$ | kmol/kg residual gas | Quantity of moles of $O_2$ in the exhaust gas of the flare per kg of residual gas flared in hour *h* |
| $MV_n$ | $m^3$/kmol | Volume of one mole of any ideal gas at normal temperature and pressure (22.4 L/mol) |

$$V_{n,N2,h} = MV_n * \left\{ \frac{fm_{N,h}}{200\,AM_N} + \left( \frac{1 - MF_{O_2}}{MF_{O_2}} \right) * \left[ F_h + n_{O_2,h} \right] \right\}$$ **Eq. 25**

Where:

| | | |
|---|---|---|
| $V_{n,N2,h}$ | $m^3$/kg residual gas | Quantity of $N_2$ volume free in the exhaust gas of the flare at normal conditions per kg of residual gas in the hour *h* |
| $MV_n$ | $m^3$/kmol | Volume of one mole of any ideal gas at normal temperature and pressure (22.4 $m^3$/Kmol) |
| $fm_{N,h}$ | - | Mass fraction of nitrogen in the residual gas in the hour *h* |
| $AM_n$ | kg/kmol | Atomic mass of nitrogen |
| $MF_{O2}$ | - | $O_2$ volumetric fraction of air |
| Fh | kmol/kg residual gas | Stochiometric quantity of moles of $O_2$ required for a complete oxidation of one kg residual gas in hour *h* |
| $n_{O2,h}$ | kmol/kg residual gas | Quantity of moles $O_2$ in the exhaust gas of the flare per kg residual gas flared in hour *h* |

$$V_{nCO2,h} = \frac{fm_{C,h}}{AM_c} * MV$$ **Eq. 26**

Where:

| | | |
|---|---|---|
| $V_{n,CO2,h}$ | $m^3$/kg residual gas | Quantity of $CO_2$ volume free in the exhaust gas of the flare at normal conditions per kg of residual gas in the hour *h* |
| $fm_{C,h}$ | - | Mass fraction of carbon in the residual gas in the hour *h* |
| $AM_C$ | kg/kmol | Atomic mass of carbon |
| $MV_n$ | $m^3$/kmol | Volume of one mole of any ideal gas at normal temperature and pressure (22.4 $m^3$/Kmol) |

$$n_{0_2,h} = \frac{t_{O_2},h}{\left(1 - (t_{O_2} / MF_{O_2})\right)} * \left[ \frac{fm_{C,h}}{AM_C} + \frac{fm_{N,h}}{2AM_N} + \left( \frac{1 - MF_{O_2}}{MF_{O_2}} \right) * F_h \right]$$ **Eq. 27**

Where:

| | | |
|---|---|---|
| $n_{O2,h}$ | kmol/kg residual gas | Quantity of moles of $O_2$ in the exhaust gas of the flare per kg of residual gas flared in hour *h* |
| $t_{O2,h}$ | - | Volumetric fraction of $O_2$ in the exhaust gas in the hour *h* |
| $MF_{O2}$ | - | Volumetric fraction of $O_2$ in the air (0.21) |
| Fh | kmol/kg residual gas | Stochiometric quantity of moles of $O_2$ required for a complete oxidation of one kg of residual gas in hour *h* |

| | | |
|---|---|---|
| $fm_{j,h}$ | - | Mass fraction of element *j* in the residual gas in hour *h* |
| $AM_j$ | kg/kmol | Atomic mass of element *j* |
| j | | The elements carbon (index C) and nitrogen (index N) |

$$F_h = \frac{fm_{C,h}}{AM_C} + \frac{fm_{H,h}}{4AM_H} - \frac{fm_{O,h}}{2AM_O} \quad \textbf{Eq. 28}$$

Where:

| | | |
|---|---|---|
| $F_h$ | kmol $O_2$/kg residual gas | Stochiometric quantity of moles of $O_2$ required for a complete oxidation of one kg residual gas in hour *h* |
| $fm_{j,h}$ | - | Mass fraction of element *j* in the residual gas in hour *h* |
| $AM_j$ | kg/kmol | Atomic mass of element *j* |
| i | | The elements carbon (index C), hydrogen (index H) and oxygen (index O) |

***Step 4: Determination of methane flow rate in the exhaust gas on a dry basis***

This step is applicable since the methane combustion efficiency of the flare is continuously monitored.

$$TM_{FG,h} = \frac{TV_{n,FG,h} * fv_{CH_4,FG,h}}{1000000} \quad \textbf{Eq. 29}$$

With:

| | | |
|---|---|---|
| $TM_{FG,h}$ | kg/h | Mass flow rate of methane in the exhaust gas of the flare in dry basis at normal conditions in the hour *h* |
| $TV_{n,FG,h}$ | $m^3$/h exhaust gas | Volumetric flow rate of the exhaust gas in dry basis at normal conditions in hour *h* |
| $fv_{CH4,FG,h}$ | mg/m3 | Concentration of methane in the exhaust gas of the flare in dry basis at normal conditions in the hour *h* |

***Step 5: Determination of methane mass flow rate in the residual gas on a dry basis***

$$TM_{RG,h} = FV_{RG,h} * fv_{CH_4,RG,h} * \rho_{CH_4,n} \quad \textbf{Eq. 30}$$

With:

| | | |
|---|---|---|
| $TM_{RG,h}$ | kg/h | Mass flow rate of methane in the residual gas in the hour *h* |
| $FV_{RG,h}$ | $m^3$/h | Volumetric flow rate of the residual gas in dry basis at normal conditions in the hour *h* |

| | | |
|---|---|---|
| $fv_{CH4,RG,h}$ | - | Volumetric fraction of methane in the residual gas on dry basis in hour *h* (NB: this corresponds to $fv_{i,RG,h}$ where *i* refers to methane). |
| $\rho_{CH4,n}$ | $kg/m^3$ | Density of methane at normal conditions (0.716) |

***Step 6: Determination of the hourly flare efficiency***

The project activity includes enclosed flare(s) and continuous monitoring of the flare efficiency. Therefore, the flare efficiency in the hour *h* is ($\eta_{flare,h}$) is:

- 0% if the temperature of the exhaust gas of the flare ($T_{flare}$) is below 500°C during more than 20 minutes during the hour *h*.
- Determined as follows in cases where the temperature of the exhaust gas of the flare ($T_{flare}$) is above 500°C for more than 40 minutes during the hour *h*:

$$\eta_{flare,h} = 1 - \frac{TM_{FG,h}}{TM_{RG,h}} \qquad \textbf{Eq. 31}$$

With:

| | | |
|---|---|---|
| $TM_{FG,h}$ | kg/h | Methane mass flow rate in exhaust gas averaged in a period of time t (hour, months or year) |
| $TM_{RG,h}$ | kg/h | Mass flow rate of methane in the residual gas in the hour *h* |

In case the continuous monitoring system is unavailable and / or we lack measurement data, the following default values will be used in accordance with option a) of the Tool to determine project emissions from flaring gases containing methane:

- 0% if the temperature in the exhaust gas of the flare ($T_{flare}$) is below 500 °C for more than 20 minutes during the hour *h*.
- 50%, if the temperature in the exhaust gas of the flare ($T_{flare}$) is above 500 °C for more than 40 minutes during the hour *h,* but the manufacturer's specifications on proper operation of the flare are not met at any point in time during the hour *h*.
- 90%, if the temperature in the exhaust gas of the flare ($T_{flare}$) is above 500 °C for more than 40 minutes during the hour h and the manufacturer's specifications on proper operation of the flare are met continuously during the hour *h*. So far, the manufacturer's recommendations obtained are: retention time > 0.3 sec. and nominal capacity is 2,000 and 3,000 $Nm^3/h$ each.

The manufacturer's specifications on proper operation of the flare refer to the operating temperature and the capacity of the flare. Specifications are not met if the combustion temperature is below the range of temperatures stated by the manufacturer or the volume of methane burnt exceeds the rated capacity of the flare because both negatively impact the combustion efficiency.

***Step 7: Calculation of annual project emissions from flaring***

$$PE_{flare,y} = \sum TM_{RG,h} * (1 - \eta_{flare,h}) * \frac{GWP_{CH4}}{1000}$$ **Eq. 32**

Where

| | | |
|---|---|---|
| $PE_{flare,y}$ | $tCO_2e$ | Project emissions from flaring of the residual gas stream in year y |
| $TM_{RG,h}$ | kg/h | Mass flow rate of methane in the residual gas in the hour h |
| $\eta_{flare,h}$ | - | Flare efficiency in the hour *h* |
| $GWP_{CH4}$ | $tCO_2e/tCH_4$ | Global Warming Potential of methane |

***Step A.1.1: Ex ante estimation of $F_{CH4,PJ,y}$***

To estimate baseline emissions of methane from SWDS, we need an *ex ante* estimation of $F_{CH4,PJ,y}$.
It is determined as follow:

$$F_{CH4,PJ,y} = \eta_{PJ} * BE_{CH4,SWDS,y} / GWP_{CH4}$$ **Eq. 33**

Where:

| | | |
|---|---|---|
| $\eta_{PJ}$ | % | Efficiency of the landfill gas capture system that will be installed in the project activity |
| $BE_{CH4,SWDS,y}$ | $t\ CO_2e$ /y | Amount of methane in the landfill gas that is generated from the SWDS in the baseline scenario in year y |
| $GWP_{CH4}$ | $tCO_2e/tCH_4$ | Global Warming Potential of methane |

$\eta_{PJ}$ is determined based on three assumptions.

- The landfill collection efficiency rate (85%, source US-EPA study)
- The landfill collection efficiency rate the year waste is disposed off (50%, Tool default value)
- The blowers' availability (94%, source: Return of experience at the Tijuquinhas CDM project)

The US-EPA study states that 85% is a reasonable assumption for a newer collection system operated for energy recovery. The objective of the project activity is to capture as much landfill gas as possible to ensure the maximal methane destruction. Since the project activity is established on a new site, the capture system will be built progressively as waste is disposed off to ensure an optimal cover of the site and maximum collection.

Blowers' availability is not taken into account in the 85% efficiency. This parameter is to reflect the network collection efficiency when the landfill gas is effectively actively collected (thanks to the blowers). The blowers' availability is an additional parameter to be taken into account. When blowers are not running, no landfill gas is collected and therefore it decreases the landfill gas

collection efficiency rate. The 94% availability is justified by experience from the Tijuquinhas CDM project, operated and managed by the same PP.

At the same time, the year waste is disposed off, all the landfill gas cannot be properly collected because of the cells management (no final cover, wells progressive construction, etc.). Also, waste is disposed off all year long and therefore the total waste landfill gas generation potential is not effectively generated. It is to reflect this situation that the default value for collection efficiency of the Tool is used the year waste is disposed off.

For the proper calculation of $\eta_{PJ}$ please refer to the excel spreadsheet.

$BE_{CH4,SWDS,y}$ is determined using the methodological tool “Emissions from solid waste disposal sites”.

*$BE_{CH4,SWDS,y}$ Calculation*

We use application A from the Tool: “The CDM project activity mitigates methane emissions from a specific existing SWDS”, and calculate the amount of methane generated on a yearly basis using the following equation:

$$BE_{CH4,SWDS,y} = \varphi_y \cdot (1-f_y) \cdot GWP_{CH4} \cdot (1-OX) \cdot \frac{16}{12} \cdot F \cdot DOC_{f,y} \cdot MCF_y \cdot \sum_{x=1}^{y} \sum_{j} W_{j,x} \cdot DOC_j \cdot e^{-k_j \cdot (y-x)} \cdot (1-e^{-k_j})$$

**Eq. 34**

Where:

| | | |
|---|---|---|
| $BE_{CH4,SWDS,y}$ | t $CO_2$e / y | Baseline methane emissions occuring in year y generated from waste disposal at a SWDS during a time period ending in year y |
| $x$ | - | Year in the time period in which waste disposed at the SWDS, extending from the first year in the time period (x=1) to year y (x=y). As per the methodology, x begins the first year of SWDS operation. |
| $y$ | - | Year of the crediting period for which methane emissions are calculated (y is a consecutive period of 12 months). |
| $DOC_{f,y}$ | Weight fraction | Fraction of Degradable organic carbon (DOC) that decomposes under the specific conditions occurring in the SWDS for year y |
| $W_{j,x}$ | tonnes | Amount of solid waste type *j* disposed or prevented from disposal in the SWDS in the year x |
| $\varphi_y$ | - | Model correction factor to account for model uncertainties for year y |
| $f_y$ | 0 | Fraction of methane captured at the SWDS and flared, combusted or used in another manner that prevents the emissions of methane to the atmosphere in year y. Here $f_y$ = 0 as per the methodology, since is the landfill gas that would have been captured and destroyed is already accounted for in equation 2. |

| | | |
|---|---|---|
| $GWP_{CH4}$ | $tCO_2e/tCH_4$ | Global Warming Potential of methane |
| $OX$ | - | Oxidation factor (reflecting the amount of methane from SWDS that is oxidised in the soil or other material covering the waste) |
| $F$ | - | Fraction of methane in the SWDS gas (volume fraction) |
| $MCF_y$ | - | Methane Correction Factor for year y |
| $DOC_j$ | - | Fraction of degradable organic carbon in the waste type *j* (weight fraction) |
| $k_j$ | 1/ yr | Decay rate for the waste type *j* (1/yr) |
| $j$ | - | Type of residual waste or types of waste in the MSW. As per the methodology, sampling to determine the fractions of different waste types is not necessary because the waste composition can be obtain from previous studies. |

We have chosen to determine the model correction factor ($\varphi_y$) according to Option 2 *Determine* $\varphi_y$ *based on a specific situation of the project activity* of the Methodological Tool.

Where the uncertainty of the determination of methane generation in year y ($v_y$) is calculated as follows:

$$v_y = \sqrt{a^2 + b^2 + c^2 + d^2 + e^2 + g^2} \quad \textbf{Eq. 35}$$

Where:

| Factor | Parameter | Lower Value | Higher Value | Instructions for selecting the factor | Value Used | Justification |
|---|---|---|---|---|---|---|
| a | W | 2% | 10% | Use the lower value if solid waste is weighed using accurate weighbridges. Use the higher value if the amount of waste is estimated. | 2% | Accurate weighbridge is used onsite (used for invoicing). |
| b | $DOC_j$ | 5% | 10% | Use the lower value if DOCj is measured. Use the higher value if default values are used. | 10% | Default values given by the tool are used. |
| c | $DOC_f$ | 5% | 15% | Use the lower value if more than 50% of the waste is rapidly degradable organic material or if the SWDS is located in a tropical climate. | 5% | The SWDS is located in a wet tropical area (see table *k* in B.6.2 justifying the climate) |
| d | F | 0% | 5% | Use the lower value if more than 50% of the waste is rapidly degradable organic material. | 5% | Rapidly degradable material have a high decay rate and include food, foodwaste, |

| | | | | | | |
|---|---|---|---|---|---|---|
| | | | | | | sewerage sludge, beverages and tobacco.<br>These fractions only represent 46.49% of the waste composition used for the project activity, i.e. <50%. |
| e | $MCF_y$ | 0% | 50% | Use the lower value for managed SWDS. For unmanaged SWDS, use the higher value or determine the factor as 2/d (d is depth of the SWDS) | 0% | CGA Iperó is a well managed SWDS : waste is disposed off in cells with a completion planning, compacting, intermediaries and final covers and passive venting of the landfill gas. |
| g | $e^{-k_j \cdot (y-x)} \cdot (1-e^{-k_j})$ | 5% | 20% | The uncertainty values provided express the uncertainty for the exponential term as a whole. Use the lower uncertainty value in the following cases:<br>(i) Application B<br>(ii) Application A: if the SWDS compartments where the project is implemented were closed less than three years ago.<br>In all other cases, use the higher value. | 5% | The site is new (opened in August 2010) and therefore cells were closed less than 3 years ago. Since application A of the tool is applied, we can use the lower value. |

And where $\varphi_y$ is then calculated as:

$$\varphi_y = \frac{1}{(1+v_y)}$$ **Eq. 36**

***Step A.2: Determination of $F_{CH4,BL,y}$***

This step is used to determine the amount of methane that would have been captured and destroyed (by flaring) in the baseline due to requirements, based on four cases identified below.

**Table 1 Cases for determining methane captured and destroyed in the baseline**

| Situation at the start of the Project Activity | Requirements to destroy methane | Existing landfill gas capture system[17] |
|---|---|---|
| Case 1 | No | No |
| Case 2 | Yes | No |
| Case 3 | No | Yes |
| Case 4 | Yes | Yes |

In the case of the Iperó landfill, there is no active landfill gas capture system existing. But the baseline scenario identified (section B.4 and B.5 above), includes a passive venting and sporadic flaring system to meet the requirement to mitigate odours and it is considered in that as a requirement to destroy some methane.
Therefore, Case 2 "*Requirement to destroy methane exists and no existing landfill gas capture system"* is applicable.

In Case 2, $F_{CH4,BL,y} = F_{CH4,BL,R,y}$ **Eq. 37**

The legislation applicable to the project activity does not specify an amount or percentage of landfill gas that should be destroyed, but does require the mitigation of odours. To mitigate odours, the Environmental Agency of the State of Sao Paolo (CETESB) considers the flaring of landfill gas as a good practice.

According to the methodology, a typical destruction rate of 20% should therefore be assumed.

$$F_{CH4,BL,R,y} = 20\% * F_{CH4,PJ,y}$$ **Eq. 38**

According to equation 32, we have:

$$F_{CH4,BL,y} = 20\% * F_{CH4,PJ,y}$$ **Eq. 39**

**STEP (B): BASELINE EMISSIONS ASSOCIATED WITH ELECTRICITY GENERATION ($BE_{EC,Y}$)**

The baseline emissions associated with electricity generation are calculated with the "Tool to calculate baseline, project and / or leakage emissions from electricity consumption".

Electricity source, *k*, corresponds to "the sources of electricity generated identified in the selection of the most plausible baseline scenario". The Baseline scenario is the "business as usual" situation, where electricity is purchased from the national grid. Therefore, Scenario A of the tool is applicable: *electricity consumption from the grid*.

[17] As per the definitions given in the Methodology, "Existing landfill gas capture system" is associated to "an existing active landfill gas capture system (…) that has been in operation in the last calendar year prior to the start of the project activity".

Baseline emissions are calculated as per the following equation:

$$BE_{EC,y} = \sum_{k} EC_{BL,k,y} * EF_{EL,k,y} * (1 + TDL_{k,y})$$ **Eq. 40**

Where:

| | | |
|---|---|---|
| $BE_{EC,y}$ | t $CO_2$e / y | Baseline emissions from electricity consumption |
| $EC_{BL,k,y}$ | MWh / y | Quantity of electricity (equivalent to the net amount of electricity generated using landfill gas in year y) |
| $EF_{EL,k,y}$ | t $CO_2$e / MWh | Emission factor for electricity generation for source *k* in year y |
| $TDL_{k,y}$ | - | Average technical transmission and distribution losses for providing electricity to source k |
| k | - | Sources of electricity consumption in the baseline (national grid) |

All the electricity generated using landfill gas is not sold to the grid, part of it is consumed onsite for the project activity and for the leachate treatment. We assume that in the baseline, the electricity consumed for the project activity would not have been consumed since there would not have been the project implemented. It is therefore conservative to exclude the electricity generated using the landfill gas and consumed by the project activity from the calculation of $EC_{BL,k,y}$.

In addition, the leachate treatment is currently outsourced: leachate are collected from a retention pond and sent to an external waste water treatment plant. Since the treatment is not the same, and in order to be conservative, the PP have decided not to claim CERs for fuel switch for leachate treatment. Therefore, the electricity produced using landfill gas and used for leachate treatment is not considered in the estimation of $EC_{BL,k,y}$ .

$EC_{BL,k,y}$ = Total quantity of electricity generated using landfill gas– electricity consumed for project activity – electricity consumed for leachate treatment

For scenario A, as per Option A1, $EF_{EL,k,y} = EF_{grid,CM,y}$
Where $EF_{grid,CM,y}$ is calculated as per the “Tool to calculate the emission factor for an electricity system”.

*Calculation of $EF_{grid,CM,y}$*

***Step 1: Identify the relevant electricity systems***

In the baseline, electricity consumed is fully generated by power plants off-site connected to the grid.
As per decision of the Brazilian DNA, “any CDM project activity linked to the National Interconnected System (NIS), supplying or using electricity from the grid, and which applies the (…) “Tool to calculate the emission factor for an electricity system” approved by the EB, the single system comprised of the union of SIN subsystems must be adopted as definition of the “Project’s Electricity System”[18].
The project electricity system is therefore the National Interconnected System, hereafter the National Grid.

[18] Resolution n°8, of May 26, 2008

***Step 2: Choose whether to include off-grid power plants in the project electricity system (optional)***

The Brazilian DNA is responsible for the emission factors calculation and does not include the off-grid power plants so far. Option I (only grid connected plants) is applied.

***Step 3: Select a method to determine the operating margin (OM)***

The calculation of the operating margin emission factor ($EF_{grid,OM,y}$) is based on one of the following methods:

a. Simple OM; or
b. Simple Adjusted OM; or
c. Dispatch data analysis OM; or
d. Average OM.

The Brazilian DNA is responsible for calculating the OM and has chosen to apply option c. the dispatch data analysis.
For the dispatch data analysis OM, the year in which the project activity displaced electricity from / to the grid has to be used. Therefore, the emission factor has to be monitored and updated annually.

***Step 4: Calculate the operating margin emission factor according to the selected method***

The dispatch data analysis OM emission factor ($EF_{grid,OM-DD,y}$) is determined based on the grid power units that are actually dispatched at the margin during each hour *h* where the project is displacing grid electricity. This approach is not applicable to historical data and thus, requires annual monitoring of the $EF_{grid,OM-DD,y}$.
The emission factor is calculated as follow:

$$EF_{grid,OM-DD,y} = \frac{\sum_{h} EG_{PJ,h} * EF_{EL,DD,h}}{EG_{PJ,y}} \quad \textbf{Eq. 41}$$

Where:

| | | |
|---|---|---|
| $EF_{grid,OM-DD,y}$ | $tCO_2$ / MWh | Dispatch data analysis operating margin $CO_2$ emission factor in the year y |
| $EG_{PJ,h}$ | MWh | Electricity dispatched by the project activity in hour *h* of year y |
| $EF_{EL,DD,h}$ | $tCO_2$ / MWh | $CO_2$ emission factor for the grid power units in the top of the dispatch order in hour *h* in year y |
| $EG_{PJ,y}$ | MWh | Total electricity displaced by the project activity in year y |
| h | - | Hours in year y in which the project activity is displacing grid electricity |
| y | - | Year in which the project activity is displacing grid electricity |

The Brazilian DNA publishes every year the hourly, daily and monthly average $CO_2$ emission factor ($EF_{EL,DD,h}$)[19].
For ex-ante estimation of Emission reductions, the 2010 data (last available when writing down the PDD) have been used. The $EF_{grid,OM\text{-}DD,y}$ is calculated as an average of the monthly emission factors published by the DNA:

**Table 2 Operational Margin, Monthly average (t $CO_2$e / MWh)**

| | |
|---|---|
| January 2010 | 0.2111 |
| February 2010 | 0.2798 |
| March 2010 | 0.2428 |
| April 2010 | 0.2379 |
| May 2010 | 0.3405 |
| June 2010 | 0.4809 |
| July 2010 | 0.4347 |
| August 2010 | 0.6848 |
| September 2010 | 0.7306 |
| October 2010 | 0.732 |
| November 2010 | 0.7341 |
| December 2010 | 0.6348 |
| **Annual Operating Margin** | **0.4787** |

$EF_{grid,OM\text{-}DD,2010}$ = 0.4787 $tCO_2$ / MWh

***Step 5: Calculate the build margin (BM) emission factor***

In terms of vintage of data, project participants can choose between two options (1 and 2). Option 1 does not require ex-post monitoring however Option 2 does.
The Brazilian DNA is responsible for calculating and publishing the build margin emission factor. As it is revised annually, option 2 applies.

As per Option 2: for the first crediting period, the build margin emission factor shall be updated annually, *ex post*, including those units built up to the year of registration of the project activity or, if information up to the year of registration is not yet available, including those units built up to the latest year for which information is available. For the second crediting period, the build margin emission factor shall be calculated *ex ante*, as described in Option 1. For the third crediting period, the build margin emission factor calculated for the second crediting period should be used.

The build margin emission factor is the generation-weighted average emission factor ($tCO_2$ / MWh) of all power units *m* during the most recent year *y* for which power generation data is available, calculated as follows:

[19] Source : http://www.mct.gov.br/index.php/content/view/307492.html

$$EF_{grid,BM,y} = \frac{\sum_m EG_{m,y} * EF_{EL,m,y}}{\sum_m EG_{m,y}} \qquad \textbf{Eq. 42}$$

Where:

| | | |
|---|---|---|
| $EF_{grid,BM,y}$ | $tCO_2$ / MWh | Build margin $CO_2$ emission factor in year y |
| $EG_{m,y}$ | MWh | Quantity of electricity generated and delivered to the grid by power unit *m* in year y |
| $EF_{EL,m,y}$ | $tCO_2$ / MWh | $CO_2$ emission factor of power unit *m* in year y |
| m | - | Power units included in the build margin |
| y | - | Most recent historical year for which power generation data is available |

$EF_{grid,BM,2010}$ = 0.1404 $tCO_2$ / MWh

***Step 6: Calculate the combined margin emission factor***

As recommended in the Tool, we have calculated the combined margin emission factor as per Option A "weighted average CM", which is the preferred option and calculated as follows:

$$EF_{grid,CM,y} = EF_{grid,OM,y} * w_{OM} + EF_{grid,BM,y} * w_{BM} \qquad \textbf{Eq. 43}$$

Where:

| | | |
|---|---|---|
| $EF_{grid,CM,y}$ | t $CO_2$/MWh | Combined margin $CO_2$ emission factor for the project electricity system in year y |
| $EF_{grid,OM,y}$ | t $CO_2$/MWh | Operating margin $CO_2$ emission factor in year y |
| $EF_{grid,BM,y}$ | t $CO_2$/MWh | Build margin $CO_2$ emission factor in year y |
| $w_{OM}$ | 50% | Weighting of operating margin emission factor |
| $w_{BM}$ | 50% | Weighting of build margin emission factor |

The values used for $w_{OM}$ and $w_{BM}$ are the default values given in the tool, considering that the project activity is neither a wind nor a solar power generation project activity.

$EF_{grid,CM,y}$ = 0.1404 * 50% + 0.4787 * 50%

$EF_{grid,CM,y}$ = **0.3096 t $CO_2$ / MWh**

The Build margin $CO_2$ emission factor and the Operating margin $CO_2$ emission factor will be determined ex-post. Therefore, the Combined margin $CO_2$ emission factor will be determined ex-post.

**PROJECT EMISSIONS ($PE_Y$)**

Project emissions are calculated as follows:

$$PE_y = PE_{EC,y} + PE_{FC,y}$$ **Eq. 44**

Where:

| | | |
|---|---|---|
| $PE_y$ | t $CO_2$e /y | Project Emissions in year y |
| $PE_{EC,y}$ | t $CO_2$ / y | Emissions from consumption of electricity due to the project activity in year y |
| $PE_{FC,y}$ | t $CO_2$ / y | Emissions from consumption of fossil fuels due to the project activity, for purposes other than electricity generation in year y |

The project activity will produce electricity and use part of this electricity for auto-consumption purposes. However, the power plant will not be available 100% of the time. Therefore, a part of the electricity consumed should come from the grid or from an on-site fossil fuel generator. This share of electricity consumption will generate project emissions.
The project activity does not require the use of any fuel apart for an electricity generation purpose.
The project emissions can therefore be calculated as follows:

$$PE_y = PE_{EC,y}$$ **Eq. 45**

*$PE_{EC,y}$ Calculation*

As electricity should either come from the grid or from a fossil fuel generator, Scenario C of the “Tool to calculate baseline, project and / or leakage emissions from electricity consumption” applies. Since the generator will not operate continuously and electricity will be purchased from the grid during the monitored period, case C.III is applied.

Based on the generic approach, project emissions from electricity consumption are:

$$PE_{EC,y} = \sum_j EC_{PJ,j,y} * EF_{EL,j,y} * (1 + TDL_{j,y})$$

**Eq. 46**

Where:

| | | |
|---|---|---|
| $PE_{EC,y}$ | t $CO_2$ / yr | Project emissions from electricity consumption by the project activity in year *y* |
| $EC_{PJ,j,y}$ | MWh | Fraction of electricity consumed by the project activity during year *y* |
| $EF_{EL,y}$ | t$CO_2$/MWh | Emission factor for each source of electricity generation consumed by the project activity. |
| $TDL_{,y}$ | % | Average technical transmission and distribution losses in the grid in year *y* for the voltage level at which electricity is obtained from the grid at the project site. As per the Tool, a default value of 20% is used. |
| j | - | Sources of electricity consumption in the project: collection network & flaring station and conditioning plant. |

The identified sources *j* of electricity consumption in the project activity are the following:

- collection network and flaring station (21 Wh / $m^3$)[20]
- Landfill gas conditioning plant (65 Wh / $m^3$)[21]

$EC_{PJ,j,y}$ is the fraction of electricity consumed by the project activity. Yet, in this project activity, a significant share of the project activity's electricity is supplied by the project itself (landfill gas power plant electricity auto-consumed). This electricity is not taken into account for calculating project emissions.
Therefore, $EC_{PJ,j,y}$ corresponds hereafter to the net quantity of electricity consumed by the two above mentioned sources, i.e. representing the quantity of electricity either purchased from the grid or provided by the generator.
The assumptions used are the following:

- Landfill gas conditioning plant only runs if engines are running, therefore, landfill gas conditioning plant electricity needs are assumed to be 100% auto-consumption;
- Collection network & flaring station electricity needs are estimated to be covered by auto-consumption 85% of the time (engines' availability) when engines are running and the remaining 15% are supplied by the grid or the generator. In case the engines are not running, then 100% of the electricity needs are supplied by the grid or the generator.

Further details on the detailed calculation of the electricity consumption can be found in the excel spreadsheet.

The TDL used for calculating project emissions is 20%.

As Case C.III applies, as a conservative approach, the emission factor used should be the more conservative value between the emission factor of the grid and of the generator.
This approach is used hereafter to determine *ex ante* emissions. During the monitored period, the effective electricity consumption of each source will be duly recorded and the corresponding emission factor will be applied.

Project emissions should be calculated net of the electricity consumed in the baseline. However, the baseline scenario corresponds to a passive flaring system, which does not require any electricity consumption to function.

*Emission Factor of the Grid*
For electricity directly purchased from the grid, the emission factor is the same than the one calculated above for Baseline Emissions ($EF_{grid,CM,y}$), as per Option A1 of the "Tool to calculate baseline, project, and/or leakage emissions from electricity consumption", which states that $EF_{EL,j/k/l,y} = EF_{grid,CM,y}$.

And, $EF_{EL,y} = EF_{grid,CM,y}$ = **0.3096 $tCO_2$ / MWh**

[20] Source: Average data from experience, based on the CDM Project of Tijuquinhas, Brazil (1506) and operated by the same PP.

[21] Source: Conditioning Plant Manufacturer data (Biotecnogas).

*<u>Emission Factor of the Generator</u>*

For the electricity produced by the generator on-site, the emission factor is calculated as per the tool, Option B1, considering that the generator is not a cogeneration set.

$$EF_{EL,j,y} = \frac{\sum_{n}\sum_{i} FC_{n,i,t} * NCV_{i,t} * EF_{CO2,i,t}}{\sum_{n} EG_{n,t}} \quad \textbf{Eq. 47}$$

Where

| | | |
|---|---|---|
| $EF_{EL,j,y}$ | $t\ CO_2$ / MWh | Emission factor for electricity generation for source j in year y |
| $FC_{n,i,t}$ | Mass or volume unit | Quantity of fossil fuel type *i* fired in the captive power plant *n* in time period *t* |
| $NCV_{i,t}$ | GJ / mass or volume unit | Average net calorific value of fossil fuel type *i* used in period *t* |
| $EF_{CO2,i,t}$ | $t\ CO_2$ / GJ | Average $CO_2$ emission factor of fossil fuel type *i* used in the period *t* |
| $EG_{n,t}$ | MWh | Quantity of electricity generated in captive power plant *n* in the time period *t* |
| *i* | - | Fossil fuel types fired in power plant |
| j | - | Sources of electricity consumption |
| n | - | Fossil fuel fired captive power plant installed on site |
| t | - | Time period for which the emission factor for electricity generation is determined |

For the purpose of *ex ante* estimation, we have used the following default values:

| | | |
|---|---|---|
| Fuel Consumption | tonnes | 355 |
| NCV (diesel) | GJ / t | 41.4 |
| EF (diesel) | $tCO_2$ / GJ | 0.0748 |
| Electricity to be produced | MWh | 1,510 |
| EF elec | $tCO_2$ / MWh | 0.7285 |

It results in the comparison of the following two emission factors: 0.3096 t $CO_2$/ MWh (grid) and 0.7226 t $CO_2$/ MWh (generator).
As per the tool, the most conservative value between the two is retained and we will use the fossil fuel captive plant emission factor for project emissions.

Since the EF for the grid will be calculated ex-post, the most conservative value between the fossil fuel EF and the grid EF will be determined ex-post and used to calculate the Project Emissions accordingly.
It means that during the project activity, if the installation of the fossil-fuel generator is delayed in time and up to its installation onsite, the electricity will only come from the landfill gas engines or from the grid. For this period of time, Scenario A “Electricity consumption from the grid” applies.
Option A1 will be applied and the Emission factor calculated above as per the “Tool to calculate the emission factor for an electricity system” for the grid will be used.

### LEAKAGE

No leakage effects are accounted for under this methodology.

### EMISSION REDUCTION

Emission reductions are calculated as follow:

$$ER_y = BE_y - PE_y \quad \textbf{Eq. 48}$$

Where:

| | | |
|---|---|---|
| $ER_y$ | t $CO_2$e / y | Emission reductions in year y |
| $BE_y$ | t $CO_2$e / y | Baseline emissions in year y |
| $PE_y$ | t $CO_2$e / y | Project emissions in year y |

### B.6.2. Data and parameters fixed ex ante

*From the ACM0001 Methodology, version 12*

| **Data/Parameter** | **$OX_{top\_layer}$** |
|---|---|
| Data unit | Dimensionless |
| Description | Fraction of methane that would be oxidized in the top layer of the SWDS in the baseline |
| Source of data | Consistent with how oxidation is accounted for in the methodological tool “Emissions from solid waste disposal sites”, Version 06.0.1” |
| Value(s) applied | 0.1 |
| Choice of data or measurement methods and procedures | Default value as per ACM0001“Flaring or use of landfill gas”, Version 12.0.0 |
| Purpose of data | Calculation of baseline emissions |
| Additional comment | Applicable to Step A |

| **Data/Parameter** | **$GWP_{CH4}$** |
|---|---|
| Data unit | $tCO2e/tCH_4$ |
| Description | Global Warming Potential of methane |
| Source of data | IPCC |
| Value(s) applied | 21 for the first commitment period. Shall be updated according to any future COP/MOP decisions |
| Choice of data or measurement methods and procedures | - |
| Purpose of data | Calculation of baseline emissions |
| Additional comment | |

| **Data/Parameter** | **$NCV_{CH4}$** |
|---|---|
| Data unit | $TJ / tCH_4$ |
| Description | Net calorific value of methane at reference conditions |
| Source of data | Technical literature |
| Value(s) applied | 0.0504 |
| Choice of data or measurement methods and procedures | Data given in the ACM0001 methodology, version 12 |
| Purpose of data | Calculation of baseline emissions |
| Additional comment | |

| **Data/Parameter** | $\eta_{PJ}$ |
|---|---|
| Data unit | Dimensionless |
| Description | Efficiency of the landfill gas capture system that will be installed in the project activity |
| Source of data | Data given in the ACM0001 methodology, version 12 |
| Value(s) applied | Technical specifications of the landfill gas capture system to be installed (50% the year waste is disposed off and 85% the following years). |
| Choice of data or measurement methods and procedures | 50%: default value given in the methodology and applied for the first year when waste is disposed of.<br>85%: value from the study *Turning a Liability into an Asset: A Landfill Gas- to-Energy Project Development Handbook*, US EPA, 1996 |
| Purpose of data | Calculation of baseline emissions |
| Additional comment | |

*From the latest version of the methodological tool "Emissions from Solid waste disposal sites"*

| **Data/Parameter** | **OX** |
|---|---|
| Data unit | - |
| Description | Oxidation factor (reflecting the amount of methane from SWDS that is oxidized in the soil (or other material covering the waste) |
| Source of data | Based on an extensive review of published literature on this subject, including the IPCC 2006 Guidelines for National Greenhouse Gas Inventories |
| Value(s) applied | 0.1 |
| Choice of data or measurement methods and procedures | Data given in the methodological tool "Emissions from Solid waste disposal sites" |
| Purpose of data | Calculation of Baseline Emissions |
| Additional comment | When methane passes through the top-layer, part of it is oxidised by methanotrophic bacteria to produce $CO_2$. The oxidation factor represents the proportion of methane that is oxidised to $CO_2$. This should be distinguished from the methane correction factor (MCF) which is to account for the situation that ambient air might intrude into the SWDS and prevent methane from being formed in the upper layer of SWDS. |

| **Data/Parameter** | **F** |
|---|---|
| Data unit | - |
| Description | Fraction of methane in the SWDS gas (volume fraction) |
| Source of data | IPCC 2006 Guidelines for National Greenhouse Gas Inventories |
| Value(s) applied | 0.5 |
| Choice of data or measurement methods and procedures | Data given in the methodological tool "Emissions from Solid waste disposal sites" |
| Purpose of data | Calculation of Baseline Emissions |

| | |
|---|---|
| Additional comment | Upon biodegradation, organic material is converted to a mixture of methane and carbon dioxide. |

| **Data/Parameter** | **$DOC_{f,defaukt}$** |
|---|---|
| Data unit | Weight fraction |
| Description | Default value for the fraction of Degradable organic carbon (DOC) in MSW that decomposes in the SWDS. |
| Source of data | IPCC 2006 Guidelines for National Greenhouse Gas Inventories |
| Value(s) applied | 0.5 |
| Choice of data or measurement methods and procedures | Data given in the methodological tool “Emissions from Solid waste disposal sites” |
| Purpose of data | Calculation of Baseline Emissions |
| Additional comment | This factor reflects the fact that some degradable organic carbon does not degrade, or degrades very slowly, in the SWDS. This default value can only be used for<br>i) Application A (our case)<br>Application B if the tool is applied to MSW |

| **Data/Parameter** | ***$MCF_{default}$*** |
|---|---|
| Data unit | - |
| Description | Methane Correction Factor |
| Source of data | IPCC 2006 Guidelines for National Greenhouse Gas Inventories |
| Value(s) applied | In case that the SWDS does have a water table above the bottom of the SWDS and in case of application A, then select the applicable value from the following:<br>• 1.0 for anaerobic managed solid waste disposal sites<br>• 0.5 for semi-aerobic managed solid waste disposal sites<br>• 0.8 for unmanaged SWDS – deep<br>• 0.4 for unmanaged-shallow solid waste disposal sites or stockpiles that are considered SWDS<br><br>The value to be applied here is “1”. |
| Choice of data or measurement methods and procedures | The situation onsite corresponds to a situation of anaerobic managed SWDS since the site has controlled placement of waste. They are disposed according to a planning and partial cover is applied everyday preventing fires and water infiltration. |
| Purpose of data | Calculation of Baseline Emissions |
| Additional comment | The MCF accounts for the fact that unmanaged SWDS produce less methane from a given amount of waste than managed SWDS, because a larger fraction of waste decomposes aerobically in the top layers of unmanaged SWDS. In case of a water table above the bottom of the SWDS, a larger proportion of the SWDS is anaerobic and MCF shall be estimated according to equation 12. |

| **Data/Parameter** | ***$DOC_j$*** |
|---|---|
| Data unit | - |
| Description | Fraction of degradable organic carbon in the waste type *j* (weight fraction) |
| Source of data | IPCC 2006 Guidelines for National Greenhouse Gas Inventories (adapted from Volume 5, Tables 2.4 and 2.5) |
| Value(s) applied | For MSW, the following values for the different waste types *j* should be applied: (see table below) |
| Choice of data or measurement methods and procedures | The waste treated onsite are MSW and C&I waste which can be described as a combination of waste types in the table above. There is therefore no need to calculated $DOC_j$. |
| Purpose of data | Calculation of Baseline Emissions |
| Additional comment | The percentages listed above are based on a wet waste basis which are concentrations in the waste as it is delivered to the SWDS. |

| **Waste type *j*** | **DOCj (% wet waste)** |
|---|---|
| Wood & wood products | 43 |
| Pulp, paper and cardboard (other than sludge) | 40 |
| Food, food waste, beverages and tobacco (other than sludge) | 15 |
| Textiles | 24 |
| Garden, yard and park waste | 20 |
| Glass, plastic, metal, other inert waste | 0 |
| Sludge | 5 |
| Rubber & Leather | 39 |

| **Data/Parameter** | ***$K_j$*** |
|---|---|
| Data unit | - |
| Description | Decay rate for the waste type *j* |
| Source of data | IPCC 2006 Guidelines for National Greenhouse Gas Inventories (adapted from Volume 5, Table 3.3) |

<table>
<tr><td rowspan="1">Value(s) applied</td><td>Apply the following default values for the different waste types j<br>Values applied are those for Tropical Wet climate.<br><br>
<table>
<tr><th colspan="2" rowspan="2">Waste type j</th><th colspan="2">Boreal and Temperate (MAT ≤20°C)</th><th colspan="2">Tropical (MAT >20°C)</th></tr>
<tr><td>Dry (MAP/ PET <1)</td><td>Wet (MAP/ PET >1)</td><td>Dry (MAP< 1000mm)</td><td>Wet (MAP> 1000mm)</td></tr>
<tr><td rowspan="2">Slowly degrading</td><td>Pulp, paper, cardboard (other than sludge)</td><td>0.04</td><td>0.06</td><td>0.045</td><td>0.07</td></tr>
<tr><td>Wood, wood products and straw)</td><td>0.02</td><td>0.03</td><td>0.025</td><td>0.035</td></tr>
<tr><td>Moderatly Degrading</td><td>Other (non-food) organic putrescible garden and park waste</td><td>0.05</td><td>0.10</td><td>0.065</td><td>0.17</td></tr>
<tr><td>Rapidly Degrading</td><td>Food, food waste, sewerage sludge, beverages and tobacco</td><td>0.06</td><td>0.185</td><td>0.085</td><td>0.40</td></tr>
</table>
NB: MAT –mean annual temperature, MAP- mean annual precipitation, PET- potential evapotranspiration. MAP/PET is the ratio between the mean annual precipitation and the potential evapotranspiration.<br><br>If a waste type disposed in a SWDS can not clearly be attributed to one of the waste types in the table above, project participants should choose, among the waste types that have similar characteristics, the waste type where the values of DOCj and kj result in a conservative estimate (lowest emissions), or request a revision of/deviation from this methodology.<br>One additional category is considered in the proposed project activity: “rubber & leather”. The lowest decay rate available was attributed to this category, i.e. “Wood & Wood products” default value (0.035). So the decay rate k to be attributed to the category “rubber & leather” chosen is 0.035.<br><br>In the cases of empty fruit bunches (EFB), as their characteristics are similar to garden waste, the parameters values correspondent of garden waste shall be used. In case of sludge from pulp and paper industry, a conservative value of 0.03 shall be used for all precipitation and temperature combinations.</td></tr>
<tr><td>Choice of data or measurement methods and procedures</td><td>Climate at the Iperó landfill site is Wet Tropical with:<br>- average annual rainfall of 1,288.6mm;<br>- average annual temperature of 21.3°C.<br>Source: http://www.cpa.unicamp.br/outras-informacoes/clima_muni_243.html</td></tr>
<tr><td>Purpose of data</td><td>Calculation of Baseline Emissions</td></tr>
<tr><td>Additional comment</td><td>-</td></tr>
</table>

| **Data/Parameter** | **$f_y$** |
|---|---|
| Data unit | - |
| Description | Fraction of methane captured at the SWDS and flared, combusted or used in another manner that prevents the emissions of methane to the atmosphere in year y |
| Source of data | As per the version 12 of the ACM0001 methodology |
| Value(s) applied | 0 |
| Choice of data or measurement methods and procedures | ACM0001 methodology, version 12: "$f_y$ in the tool shall be assigned a value of 0 because the amount of landfill gas that would have been captured and destroyed is already accounted for in equation Eq. 3 of this PDD" (Equation 2 of the methodology). |
| Purpose of data | Calculation of Baseline Emissions |
| Additional comment | |

| **Data/Parameter** | **a, b, c, d, e, f, g** |
|---|---|
| Data unit | % |
| Description | Effect of the uncertainty of different parameters |
| Source of data | Project participants |

| | |
|---|---|
| Value(s) applied | (see table below) |

| Factor | Parameter | Value applied | Justification |
|---|---|---|---|
| a | W | 2% | Accurate weighbridge is used onsite (used for invoicing). |
| b | DOCj | 10% | Default values given by the tool are used. |
| c | DOCf | 5% | The SWDS is located in a wet tropical area (see table *k* in B.6.2 justifying the climate) |
| d | F | 5% | Rapidly degradable material have a high decay rate and include food, foodwaste, sewerage sludge, beverages and tobacco. These fractions only represent 46.49% of the waste composition used for the project activity, i.e. <50%. |
| e | MCFy | 0% | CGA Iperó is a well managed SWDS : waste is disposed off in cells with a completion planning, compacting, intermediaries and final covers and passive venting of the landfill gas. |
| g | $e^{-kj*(y-x)} * (1-e^{-kj})$ | 5% | The site is new (opened in August 2010) and therefore cells were closed less than 3 years ago. Since application A of the tool is applied, we can use the lower value. |

<table>
<tr><td>Choice of data or measurement methods and procedures</td><td>Using the instruction in Table 3 of the Methodological Tool:
<table>
<tr><th>Factor</th><th>Parameter</th><th>Value applied</th></tr>
<tr><td>a</td><td>W</td><td>Lower value as the waste is weighed using accurate wieghbridge.</td></tr>
<tr><td>b</td><td>DOCj</td><td>Higher value since default values are used.</td></tr>
<tr><td>c</td><td>DOCf</td><td>Lower value since the landfill site is located in a tropical climate zone.</td></tr>
<tr><td>d</td><td>F</td><td>Higher value since rapidly degradable organic material do not represent more than 50% of total waste landfilled.</td></tr>
<tr><td>e</td><td>MCFy</td><td>Lower value since the site is a managed site with daily cover, final cover, landfilling cells and planning.</td></tr>
<tr><td>g</td><td>$e^{-kj*(y-x)} * (1-e^{-kj})$</td><td>Lower value for ‘Application A’ is applicable since the SWDS compartments were closed less than 3 years ago.</td></tr>
</table>
</td></tr>
<tr><td>Purpose of data</td><td>Calculation of Baseline Emissions</td></tr>
<tr><td>Additional comment</td><td>Used for determining the model correction factor.</td></tr>
</table>

| **Data/Parameter** | **$W_x$** |
|---|---|
| Data unit | tonnes |
| Description | Total amount of waste disposed in a SWDS in year x |
| Source of data | Measurements by project participants |
| Value(s) applied | *Ex ante* estimations of annual waste inputs (historical data and commercial previsions by local development staff).<br>**Year** / **Annual waste input (tonnes)**:<br>2010: 56,289<br>2011: 251,631<br>2012: 292,172<br>2013: 334,677<br>2014: 379,245<br>2015: 425,942<br>2016: 474,876<br>2017: 504,223<br>2018: 535,196<br>2019: 547,500<br>2020: 547,500<br>2021: 547,500<br>2022: 547,500<br>2023: 547,500<br>2024: 547,500<br>2025: 547,500<br>2026: -<br>2027: -<br>2028: -<br>2029: -<br>2030: -<br>2031: -<br>2032: -<br>2033: -<br>2034: - |
| Choice of data or measurement methods and procedures | Measure on weight basis, using weighbridge. |
| Purpose of data | Continuously, aggregated at least annually |
| Additional comment | |

Nested table (Value(s) applied):

| Year | Annual waste input (tonnes) |
|---|---|
| 2010 | 56,289 |
| 2011 | 251,631 |
| 2012 | 292,172 |
| 2013 | 334,677 |
| 2014 | 379,245 |
| 2015 | 425,942 |
| 2016 | 474,876 |
| 2017 | 504,223 |
| 2018 | 535,196 |
| 2019 | 547,500 |
| 2020 | 547,500 |
| 2021 | 547,500 |
| 2022 | 547,500 |
| 2023 | 547,500 |
| 2024 | 547,500 |
| 2025 | 547,500 |
| 2026 | - |
| 2027 | - |
| 2028 | - |
| 2029 | - |
| 2030 | - |
| 2031 | - |
| 2032 | - |
| 2033 | - |
| 2034 | - |

*From the latest version of the "Tool to determine project emissions from flaring gases containing methane"*

| **Data/Parameter** | **$MM_i$** |
|---|---|
| Data unit | kg/kmol |
| Description | Molecular mass of component i (i = methane, carbon dioxide, Oxygen, hydrogen or nitrogen) |
| Source of data | "Tool to determine project emissions from flaring gases containing methane"<br>"Tool to determine the mass flow of a greenhouse gas in a gaseous stream" |
| Value(s) applied | $MM_{CH4}$ = 16.04 kg/kmol<br>$MM_{CO2}$ = 44.01 kg/kmol<br>$MM_{O2}$ = 32 kg/kmol<br>$MM_{N2}$ = 28.02 kg/kmol |
| Choice of data or measurement methods and procedures | Physical constant |
| Purpose of data | Calculation of Project Emissions |
| Additional comment | Used to determine$F_{CH4,EL,y}$ as per the Tool to determine the mass flow of a greenhouse gas in a gaseous stream and $PE_{flare,y}$ as per the Tool to determine project emissions from flaring gases containing methane |

| **Data/Parameter** | **$AM_j$** |
|---|---|
| Data unit | kg/mol |
| Description | Atomic Mass of element j (j= Carbon or hydrogen, oxygen and nitrogen) |
| Source of data | Mendeleïev table |
| Value(s) applied | $AM_C$ = 12.00 kg/mol<br>$AM_O$ = 16.00 kg/mol<br>$AM_H$ = 1.01 kg/mol<br>$AM_N$ = 14.01 kg/mol |
| Choice of data or measurement methods and procedures | Physical constant |
| Purpose of data | Calculation of Project Emissions |
| Additional comment | |

| **Data/Parameter** | **$P_n$** |
|---|---|
| Data unit | **Pa** |
| Description | Atmospheric pressure at normal conditions |
| Source of data | "Tool to determine project emissions from flaring gases containing methane"<br>"Tool to determine the mass flow of a greenhouse gas in a gaseous stream" |
| Value(s) applied | 101,325 Pa |
| Choice of data or measurement methods and procedures | Physical constant |

| | |
|---|---|
| Purpose of data | Calculation of Project Emissions |
| Additional comment | |

| **Data/Parameter** | **$MM_{H2O}$** |
|---|---|
| Data unit | kg/kmol |
| Description | Molecular mass of water |
| Source of data | Molecular mass of water |
| Value(s) applied | "Tool to determine the mass flow of a greenhouse gas in a gaseous stream" |
| Choice of data or measurement methods and procedures | 18.0152 kg / kmol |
| Purpose of data | Physical constant |
| Additional comment | Calculation of Baseline Emissions |

| **Data/Parameter** | **$R_u$** |
|---|---|
| Data unit | $Pa.m^3/kmol.K$ |
| Description | Universal ideal gas constant |
| Source of data | "Tool to determine project emissions from flaring gases containing methane"<br>"Tool to determine the mass flow of a greenhouse gas in a gaseous stream" |
| Value(s) applied | 8,314.472 $Pa.m^3/kmol.K$ |
| Choice of data or measurement methods and procedures | Physical constant |
| Purpose of data | Calculation of Project Emissions |
| Additional comment | |

| **Data/Parameter** | **$T_n$** |
|---|---|
| Data unit | K |
| Description | Temperature at normal conditions |
| Source of data | "Tool to determine project emissions from flaring gases containing methane"<br>"Tool to determine the mass flow of a greenhouse gas in a gaseous stream" |
| Value(s) applied | 273.15 K |
| Choice of data or measurement methods and procedures | Physical constant |
| Purpose of data | Calculation of Project Emissions |
| Additional comment | |

| Data/Parameter | $MF_{O2}$ |
|---|---|
| Data unit | Dimensionless |
| Description | Oxygen volumetric fraction of air |
| Source of data | “Tool to determine project emissions from flaring gases containing methane” |
| Value(s) applied | $MF_{O2}$ = 0.21 |
| Choice of data or measurement methods and procedures | Physical constant |
| Purpose of data | Calculation of Project Emissions |
| Additional comment | |

| Data/Parameter | $MV_n$ |
|---|---|
| Data unit | $m^3$/kmol |
| Description | Volume of one mole of any ideal gas at normal conditions |
| Source of data | “Tool to determine project emissions from flaring gases containing methane” |
| Value(s) applied | 22.414 $m^3$/kmol |
| Choice of data or measurement methods and procedures | Physical constant |
| Purpose of data | Calculation of Project Emissions |
| Additional comment | |

| Data/Parameter | $\rho_{CH4,n}$ |
|---|---|
| Data unit | - |
| Description | Density of methane gas at normal conditions |
| Source of data | “Tool to determine project emissions from flaring gases containing methane” |
| Value(s) applied | 0.716 kg/$m^3$ |
| Choice of data or measurement methods and procedures | |
| Purpose of data | Calculation of Project Emissions |
| Additional comment | |

*From the latest version of the "Tool to calculate baseline, project and/or leakage emissions from electricity consumption"*

| **Data/Parameter** | **$TDL_{j,y}$ $TDL_{k,y}$** |
|---|---|
| Data unit | Average technical transmission and distribution losses for providing electricity to source *j* or *k* in year y |
| Description | In case of scenario A, choose one of the following options:<br>• Use as default values of 20% for project or leakage electricity consumption sources (*j*)<br>Use as default values of 3% for baseline electricity consumption sources. |
| Source of data | 20% for project emissions and 3% for baseline emissions |
| Value(s) applied | Default values given by the "Tool to calculate baseline, project and/ or leakage emissions from electricity consumption". |
| Choice of data or measurement methods and procedures | Calculation of Baseline Emissions<br>Calculation of Project Emissions |
| Purpose of data | - |
| Additional comment | Average technical transmission and distribution losses for providing electricity to source *j* or *k* in year y |

| **Data/Parameter** | **$w_{BM}$** |
|---|---|
| Data unit | Dimensionless or percentage |
| Description | Weighting of build margin emissions factor |
| Source of data | Default values given in "Tool to calculate the emission factor for an electricity system" (Version 02.2.1) |
| Value(s) applied | 0.5 (50%) for the first crediting period |
| Choice of data or measurement methods and procedures | As mentioned in the "Tool to calculate the emission factor for an alectricity sysyem" (Version 02.2.1): "The following default values should be used for $w_{OM}$ and $w_{BM}$:<br>• Wind and solar power generation project activities: $w_{OM}$ = 0.75 and $w_{BM}$ = 0.25 (owing to their intermittent and non-dispatchable nature) for the first crediting period and for subsequent crediting periods;<br>• All other projects: $w_{OM}$ = 0.5 and $w_{BM}$ = 0.5 for the first crediting period , and $w_{OM}$ = 0.25 and $w_{BM}$ = 0.75 for the second and third crediting period |
| Purpose of data | Calculation of baseline and project emissions |
| Additional comment | |

| **Data/Parameter** | **$w_{OM}$** |
|---|---|
| Data unit | Dimensionless or percentage |
| Description | Weighting of operating margin emissions factor |

| | |
|---|---|
| Source of data | Default values given in "Tool to calculate the emission factor for an alectricity sysyem" (Version 02.2.1) |
| Value(s) applied | 0.5 (50%) for the first crediting period |
| Choice of data or measurement methods and procedures | As mentioned in the "Tool to calculate the emission factor for an electricity system" (Version 02.2.1): "The following default values should be used for $w_{OM}$ and $w_{BM}$:<br>• Wind and solar power generation project activities: $w_{OM}$ = 0.75 and $w_{BM}$ = 0.25 (owing to their intermittent and non-dispatchable nature) for the first crediting period and for subsequent crediting periods;<br>• All other projects: $w_{OM}$ = 0.5 and $w_{BM}$ = 0.5 for the first crediting period , and $w_{OM}$ = 0.25 and $w_{BM}$ = 0.75 for the second and third crediting period |
| Purpose of data | Calculation of baseline and project emissions |
| Additional comment | |

*From the latest version of the "Tool to calculate project or leakage $CO_2$ emissions from fossil fuel combustion"*

| **Data/Parameter** | **$NCV_{i,t}$** |
|---|---|
| Data unit | GJ per mass or volume unit |
| Description | Average net calorific value of fossil fuel type *i* used in the period *t (gas/diesel oil)* |
| Source of data | IPCC 2006 Guidelines on National GHG Inventories |
| Value(s) applied | 41.4 |
| Choice of data or measurement methods and procedures | IPCC default values at the lower limit (more conservative one) of the uncertainty at 95% confidence interval provided in table 1.2 of Chapter 1 of Vol. 2 of the 2006 Guidelines on National GHG Inventories |
| Purpose of data | Calculation of Project Emissions |
| Additional comment | |

| **Data/Parameter** | **$EF_{CO2,i,t}$** |
|---|---|
| Data unit | T $CO_2$ / GJ |
| Description | $CO_2$ emission factor of fossil fuel type *i* used in the period *t* |
| Source of data | IPCC 2006 Guidelines on National GHG Inventories |
| Value(s) applied | 0.0748 |
| Choice of data or measurement methods and procedures | IPCC default values at the upper limit (more conservative one) of the uncertainty at 95% confidence interval as provided in table 1.4 of Chapter 1 of Vol. 2 of the 2006 Guidelines on National GHG Inventories |
| Purpose of data | Calculation of Project Emissions |
| Additional comment | |

### B.6.3. Ex ante calculation of emission reductions

>>

*Please note that all the following equations and calculations refer to the section B.6.1 above.*

All detailed calculations are available in a separated Excel spreadsheet. The formulae suggested by the applicable methodology and tools are complex and involve many different parameters (e.g. Eq. 34). The reader is therefore asked to refer to the Excel spreadsheet in order to verify the formulae that were used and to check the results presented in this chapter.

Emission reductions are calculated as per equation 48

$$ER_y = BE_y - PE_y$$

Where:

| | | |
|---|---|---|
| $ER_y$ | t $CO_2$e / y | Emission reductions in year y |
| $BE_y$ | t $CO_2$e / y | Baseline emissions in year y |
| $PE_y$ | t $CO_2$e / y | Project emissions in year y |

## 1. Baseline Emissions Calculation

### 1.1 Baseline Emissions of methane from SWDS ($BE_{CH4,SWDS}$)

To calculate the baseline emissions we follow the methodology and equations detailed in section B.6.1. First, we need to evaluate the landfill gas production in the landfill (equation 34):

$$BE_{CH4,SWDS,y} = \varphi_y \cdot (1-f_y) \cdot GWP_{CH4} \cdot (1-OX) \cdot \frac{16}{12} \cdot F \cdot DOC_{f,y} \cdot MCF_y \cdot \sum_{x=1}^{y} \sum_{j} W_{j,x} \cdot DOC_j \cdot e^{-k_j \cdot (y-x)} \cdot (1-e^{-k_j})$$

It gives the following values for $BE_{CH4,swds,y}$ over the period:

**Table 3 Methane generated in the SWDS**

| Year | | **Methane generation from the SWDS ($BE_{CH4,swds,y}$)** |
|---|---|---|
| | | $tCO_2e$ / y |
| 2013 | 4 months | 36,696 |
| 2014 | 12 months | 140,306 |
| 2015 | 12 months | 170,432 |
| 2016 | 12 months | 201,025 |
| 2017 | 12 months | 229,051 |
| 2018 | 12 months | 255,621 |
| 2019 | 12 months | 278,317 |
| 2020 | 12 months | 296,360 |
| 2021 | 12 months | 311,068 |
| 2022 | 12 months | 323,342 |
| 2023 | 12 months | 333,807 |
| 2024 | 12 months | 342,897 |
| 2025 | 12 months | 350,915 |
| 2026 | 12 months | 272,332 |
| 2027 | 12 months | 216,771 |
| 2028 | 12 months | 176,918 |
| 2029 | 12 months | 147,840 |
| 2030 | 12 months | 126,200 |
| 2031 | 12 months | 109,739 |
| 2032 | 12 months | 96,920 |
| 2033 | 12 months | 86,695 |
| 2034 | 8 months | 52,230 |
| | | |
| **Total** | **21 years** | **4,555,480** |

$BE_{CH4,swds,y}$ is used to calculate the amount of methane that will be collected in the project activity (equation 33):

$$F_{CH4,PJ,y} = \eta_{PJ} * BE_{CH4,SWDS,y} / GWP_{CH4}$$

The efficiency of the landfill gas capture system that will be installed is estimated to be of 50% the first year waste is landfilled and 85% the following years[22]. The blowers' availability is also considered to calculate the capture rate efficiency. It gives:

**Table 4 Methane captured**

| Year | $F_{CH4,PJ,y}$ ($\eta_{PJ}$ * $BE_{CH4,SWDS,y}$ / GWPCH4) | |
|---|---|---|
| | | $tCH_4$ / y |
| 2013 | 4 months | 1,122 |
| 2014 | 12 months | 4,408 |
| 2015 | 12 months | 5,439 |
| 2016 | 12 months | 6,483 |
| 2017 | 12 months | 7,478 |
| 2018 | 12 months | 8,413 |
| 2019 | 12 months | 9,246 |
| 2020 | 12 months | 9,932 |
| 2021 | 12 months | 10,492 |
| 2022 | 12 months | 10,959 |
| 2023 | 12 months | 11,357 |
| 2024 | 12 months | 11,703 |
| 2025 | 12 months | 12,008 |
| 2026 | 12 months | 10,362 |
| 2027 | 12 months | 8,248 |
| 2028 | 12 months | 6,731 |
| 2029 | 12 months | 5,625 |
| 2030 | 12 months | 4,802 |
| 2031 | 12 months | 4,175 |
| 2032 | 12 months | 3,688 |
| 2033 | 12 months | 3,299 |
| 2034 | 8 months | 1,987 |
| | | |
| **Total** | **21 years** | **157,956** |

[22] Source: USEPA Study: Turning a Liability into an asset, p.28

As detailed in B.6.1, the amount of methane expected to be destroyed in the baseline is equivalent to 20% of the captured gas. As per equation (38) we have:

$$F_{CH4,BL,R,y} = 20\% * F_{CH4,PJ,y}$$

Which gives:

**Table 5 Methane that would be destroyed in the Baseline**

| Year | | $F_{CH4,BL,y}$ ( 20% * $F_{CH4,PJ,y}$ ) |
|---|---|---|
| | | $tCH_4$ / y |
| 2013 | 4 months | 224 |
| 2014 | 12 months | 882 |
| 2015 | 12 months | 1,088 |
| 2016 | 12 months | 1,297 |
| 2017 | 12 months | 1,496 |
| 2018 | 12 months | 1,683 |
| 2019 | 12 months | 1,849 |
| 2020 | 12 months | 1,986 |
| 2021 | 12 months | 2,098 |
| 2022 | 12 months | 2,192 |
| 2023 | 12 months | 2,271 |
| 2024 | 12 months | 2,341 |
| 2025 | 12 months | 2,402 |
| 2026 | 12 months | 2,072 |
| 2027 | 12 months | 1,650 |
| 2028 | 12 months | 1,346 |
| 2029 | 12 months | 1,125 |
| 2030 | 12 months | 960 |
| 2031 | 12 months | 835 |
| 2032 | 12 months | 738 |
| 2033 | 12 months | 660 |
| 2034 | 8 months | 397 |
| | | |
| **Total** | **21 years** | **31,591** |

With these elements, we can calculate the baseline emissions ($BE_{CH4,y}$), as per equation (3):

$$BE_{CH4,y} = (1 - OX_{top\_layer})(F_{CH4,PJ,y} - F_{CH4,BL,y})GWP_{CH4}$$

**Table 6 Baseline Emissions (tonnes of CO2 equivalent)**

| **Baseline Emissions of LFG from the SWDS**<br>**$BE_{CH4,y}$**<br>$(1-OX_{top\_layer})(F_{CH4,PJ} - F_{CH4,BL})GWP$ | | |
|---|---|---|
| Year | Months | tCO2e / y |
| 2013 | 4 months | 16,971 |
| 2014 | 12 months | 66,645 |
| 2015 | 12 months | 82,243 |
| 2016 | 12 months | 98,028 |
| 2017 | 12 months | 113,062 |
| 2018 | 12 months | 127,198 |
| 2019 | 12 months | 139,798 |
| 2020 | 12 months | 150,178 |
| 2021 | 12 months | 158,639 |
| 2022 | 12 months | 165,700 |
| 2023 | 12 months | 171,720 |
| 2024 | 12 months | 176,949 |
| 2025 | 12 months | 181,562 |
| 2026 | 12 months | 156,667 |
| 2027 | 12 months | 124,704 |
| 2028 | 12 months | 101,778 |
| 2029 | 12 months | 85,049 |
| 2030 | 12 months | 72,600 |
| 2031 | 12 months | 63,131 |
| 2032 | 12 months | 55,756 |
| 2033 | 12 months | 49,874 |
| 2034 | 8 months | 30,047 |
| | | |
| **Total** | **21 years** | **2,388,299** |

**1.2 Baseline Emissions associated with electricity generation**

Baseline emissions are calculated as per equation (40) detailed in the above section:

$$BE_{EC,y} = \sum_{k} EC_{BL,k,y} * EF_{EL,k,y} * (1 + TDL_{k,y})$$

The emission factor of the grid is calculated according to equations 36, 37 and 38, with the figures of the Ministry of Sciences and Technologies (Brazilian DNA) for operational margin and build margin. As calculated in section B.6.1, the emission factor for the grid is: 0.3096 t $CO_2$ / MWh.

As mentioned in the methodology, the amount of electricity is equivalent to the total quantity of electricity generated using landfill gas. Yet, hereafter, $BE_{EC,y}$ is calculated based on the quantity of electricity generated using landfill gas, net of the site consumption (project activity consumption and leachate treatment consumption). This approach is conservative. Transmission and distribution losses are of 3% as per the tool (see section B.6.2).

Baseline emissions associated with electricity generation are equivalent to:

**Table 7 Baseline Emissions associated with electricity**

| **Baseline Emissions associated with electricity consumption $BE_{EC,y}$** | | |
|---|---|---|
| Year | Months | tCO2e |
| 2013 | 4 months | - |
| 2014 | 12 months | 2,704 |
| 2015 | 12 months | 7,218 |
| 2016 | 12 months | 8,607 |
| 2017 | 12 months | 9,954 |
| 2018 | 12 months | 11,248 |
| 2019 | 12 months | 12,370 |
| 2020 | 12 months | 13,321 |
| 2021 | 12 months | 14,049 |
| 2022 | 12 months | 14,681 |
| 2023 | 12 months | 15,216 |
| 2024 | 12 months | 15,681 |
| 2025 | 12 months | 16,098 |
| 2026 | 12 months | 13,899 |
| 2027 | 12 months | 11,126 |
| 2028 | 12 months | 9,087 |
| 2029 | 12 months | 7,608 |
| 2030 | 12 months | 6,508 |
| 2031 | 12 months | 5,669 |
| 2032 | 12 months | 5,012 |
| 2033 | 12 months | 4,485 |
| 2034 | 8 months | 1,273 |
| | | |
| **Total** | **21 years** | **205,816** |

Baseline emissions (equation 2), can now be calculated:

$$BE_y = BE_{CH4,y} + BE_{EC,y}$$

**Table 8 Total Baseline Emissions considered for ER calculation**

| **Baseline Emissions**<br>**$BE_y$**<br>**$BE_y = BE_{CH4,y} + BE_{EC,y}$** | | |
|---|---|---|
| Year | Months | tCO2e |
| 2013 | 4 months | 16,971 |
| 2014 | 12 months | 69,349 |
| 2015 | 12 months | 89,461 |
| 2016 | 12 months | 106,635 |
| 2017 | 12 months | 123,016 |
| 2018 | 12 months | 138,446 |
| 2019 | 12 months | 152,168 |
| 2020 | 12 months | 163,499 |
| 2021 | 12 months | 172,687 |
| 2022 | 12 months | 180,381 |
| 2023 | 12 months | 186,937 |
| 2024 | 12 months | 192,630 |
| 2025 | 12 months | 197,660 |
| 2026 | 12 months | 170,566 |
| 2027 | 12 months | 135,830 |
| 2028 | 12 months | 110,864 |
| 2029 | 12 months | 92,658 |
| 2030 | 12 months | 79,109 |
| 2031 | 12 months | 68,800 |
| 2032 | 12 months | 60,768 |
| 2033 | 12 months | 54,359 |
| 2034 | 8 months | 31,320 |
| | | |
| **Total** | **21 years** | **2,594,115** |

**2. Project Emissions**
Project emissions are calculated in section B.6.1. Project emissions would result from the consumption of electricity purchased from the grid and fuel combustion for the production of electricity.
As per equation (Eq. 47) and the following demonstration, we have calculated *ex ante* the Emission factor for the electricity produced by a fossil fuel-fired generator on site: 0.7226 ($tCO_2$ / MWh).
The grid emission factor is: 0.3096 ($tCO_2$ / MWh).

*Ex ante* estimation of Project emissions are calculated with the generator emission factor in order to be conservative. During the crediting period, the amount of electricity consumed from each source will be duly recorded to apply adequate emission factors (especially since the installation of a generator on site is not completely sure).

As explained in section B.6.1 we have:

$$PE_{EC,y} = \sum_j EC_{PJ,j,y} * EF_{EL,j,y} * (1 + TDL_{j,y})$$

Here is an example for 2015. The identified sources of electricity consumption in the project activity are the following:
- collection network and flaring station ( 21 Wh / $m^3$)
- Landfill gas conditioning plant (65 Wh / $m^3$)

The assumptions used are the following:
- Landfill gas conditioning plant only runs if engines are running, therefore, landfill gas conditioning plant electricity needs are assumed to be 100% auto-consumption;
- Collection network & flaring station electricity needs are estimated to be covered by auto-consumption 85% of the time (engines' availability) when engines are running and the remaining 15% are supplied by the grid or the generator. In case the engines are not running, then 100% of the electricity needs are supplied by the grid or the generator.

The TDL used for calculating project emissions is 20%.

With figures, for the year 2015 it gives the following calculation:
Landfill gas collected and sent to flare or engine = 15,193,799 $m^3$
Landfill gas sent to engines = 12,914,729 $m^3$

Electricity needs for project activity = **Erro! Vínculo não válido.** * 21 + **Erro! Vínculo não válido.*** 65
Project activity needs = 1,159 MWh

In 2015, there will be engines installed onsite, therefore we have:
Auto-consumption = **Erro! Vínculo não válido.*** 21 * 85% + **Erro! Vínculo não válido.*** 65 * 100%
Auto-consumption = 1,111 MWh

$EC_{PJ,j,y}$ = Project activity needs – auto-consumption
$EC_{PJ,j,y}$ = 1,159 – 1,111
$EC_{PJ,j,y}$ = 48 MWh

The Project Emissions are therefore calculated based on $EC_{PJ,j,y}$ multiplied by the appropriate emission factor and taking into account the TDL:

$PE_{EC2015}$ = 48 * 0.7285 *(1+20%) = 42 $tCO_2e$

**Table 9 Project Emissions associated with electricity generation from fossil fuel generator**

| **Project Emissions (generator)** | | |
|---|---|---|
| Year | Months | $tCO_2e$ |
| 2013 | 4 months | 19 |
| 2014 | 12 months | 130 |
| 2015 | 12 months | 42 |
| 2016 | 12 months | 50 |
| 2017 | 12 months | 57 |
| 2018 | 12 months | 65 |
| 2019 | 12 months | 71 |
| 2020 | 12 months | 76 |
| 2021 | 12 months | 81 |
| 2022 | 12 months | 84 |
| 2023 | 12 months | 87 |
| 2024 | 12 months | 90 |
| 2025 | 12 months | 92 |
| 2026 | 12 months | 80 |
| 2027 | 12 months | 63 |
| 2028 | 12 months | 52 |
| 2029 | 12 months | 43 |
| 2030 | 12 months | 37 |
| 2031 | 12 months | 32 |
| 2032 | 12 months | 28 |
| 2033 | 12 months | 25 |
| 2034 | 8 months | 15 |
| | | |
| **Total** | **21 years** | **1,321** |

**3. Emission Reductions**

As per equation (48) given in section B.6.1, emission reductions are calculated as:
Emission reductions = Baseline emissions – Project emissions

**Table 10 Project's Emission Reductions (in tonnes of CO2 equivalent)**

| Emission Reductions | | |
|---|---|---|
| Year | Months | $tCO_2e$ |
| 2013 | 4 months | 16,952 |
| 2014 | 12 months | 69,219 |
| 2015 | 12 months | 89,420 |
| 2016 | 12 months | 106,585 |
| 2017 | 12 months | 122,958 |
| 2018 | 12 months | 138,381 |
| 2019 | 12 months | 152,097 |
| 2020 | 12 months | 163,423 |
| 2021 | 12 months | 172,607 |
| 2022 | 12 months | 180,297 |
| 2023 | 12 months | 186,850 |
| 2024 | 12 months | 192,540 |
| 2025 | 12 months | 197,568 |
| 2026 | 12 months | 170,486 |
| 2027 | 12 months | 135,767 |
| 2028 | 12 months | 110,813 |
| 2029 | 12 months | 92,614 |
| 2030 | 12 months | 79,072 |
| 2031 | 12 months | 68,768 |
| 2032 | 12 months | 60,740 |
| 2033 | 12 months | 54,334 |
| 2034 | 8 months | 31,305 |
| | | |
| **Total** | **21 years** | **2,592,794** |

### B.6.4. Summary of ex ante estimates of emission reductions

| Year | Baseline emissions ($t CO_2e$) | Project emissions ($t CO_2e$) | Leakage ($t CO_2e$) | Emission reductions ($t CO_2e$) |
|---|---|---|---|---|
| 2013 | 16,971 | 19 | 0 | 16,952 |
| 2014 | 69,349 | 130 | 0 | 69,219 |
| 2015 | 89,461 | 42 | 0 | 89,420 |
| 2016 | 106,635 | 50 | 0 | 106,585 |
| 2017 | 123,016 | 57 | 0 | 122,958 |
| 2018 | 138,446 | 65 | 0 | 138,381 |
| 2019 | 152,168 | 71 | 0 | 152,097 |
| 2020 | 109,000 | 51 | 0 | 108,949 |
| **Total** | **805,046** | **485** | **0** | **114,937** |
| **Total number of crediting years** | 7 | | | |
| **Annual average over the crediting period** | 115,007 | 69 | 0 | 114,937 |

### B.7. Monitoring plan

### B.7.1. Data and parameters to be monitored

| Data/Parameter | $F_{CH4,BL,R,y}$ |
|---|---|
| Data unit | $tCH_4$ / y |
| Description | Amount of methane in the landfill gas which is flared due to a requirement in year y |
| Source of data | Official Publication of the host country's regulatory requirements relating to landfill gas, contractual requirements, or requirements to address safety and odour concerns.<br>Since no exact figure is given in the above mentioned sources, the ex-ante value used is **20%** as proposed by ACM0001, Step 2A, case 2, eq. 10 |
| Value(s) applied | see table below |
| Measurement methods and procedures | This parameter is not monitored directly, but is 20% of FCH4,PJ,y (cf B.6.1).20% of the quantity of methane effectively destroyed in the project activity is removed as baseline. |
| Monitoring frequency | Annually |
| QA/QC procedures | - |
| Purpose of data | Calculation of Baseline Emissions |
| Additional comment | Applicable to Case 2 of Step A.2 |

| **Year** | | **$F_{CH4,BL,y}$ ( 20% * $F_{CH4,PJ,y}$ ) ($tCH_4$/y)** |
|---|---|---|
| 2013 | 4 months | 224 |
| 2014 | 12 months | 882 |
| 2015 | 12 months | 1,088 |
| 2016 | 12 months | 1,297 |
| 2017 | 12 months | 1,496 |
| 2018 | 12 months | 1,683 |
| 2019 | 12 months | 1,849 |
| 2020 | 12 months | 1,986 |
| 2021 | 12 months | 2,098 |
| 2022 | 12 months | 2,192 |
| 2023 | 12 months | 2,271 |
| 2024 | 12 months | 2,341 |
| 2025 | 12 months | 2,402 |
| 2026 | 12 months | 2,072 |
| 2027 | 12 months | 1,650 |
| 2028 | 12 months | 1,346 |
| 2029 | 12 months | 1,125 |
| 2030 | 12 months | 960 |
| 2031 | 12 months | 835 |
| 2032 | 12 months | 738 |
| 2033 | 12 months | 660 |
| 2034 | 8 months | 397 |
| **Total** | | **31,592** |

| **Data/Parameter** | **Operation of the energy plant (landfill gas engine)** |
|---|---|
| Data unit | Hours |
| Description | Operating hours of the energy plant |
| Source of data | Project participants |
| Value(s) applied | 7446 hours / year (ex-ante), corresponding to 85% availability of the engines (manufacturer's recommendation). |
| Measurement methods and procedures | Each engine is equipped with automatic valves that prevent landfill gas from entering the engine if the engine is shut down, to avoid fugitive emissions. When the engine is shut down, landfill gas is redirected to the flare(s). In addition, each engine is equipped with a separate flow meter.<br>Running hours are therefore determined from the flow meter readings (if there is flow the engine is running).´ |
| Monitoring frequency | Continuously, aggregated annually |
| QA/QC procedures | Engines are equipped with running hour counters. As a crosscheck, the annual running hours can thus be compared with the hours of the counter. |
| Purpose of data | Calculation of Baseline Emissions |
| Additional comment | Applicable to Step A1. This is monitored to ensure methane destruction is claimed for methane used in electricity plant when it is operational. |

*Tool to determine project emissions from flaring gases containing methane*

| **Data/Parameter** | **$fv_{i,h}$ (equivalent to $v_{i,t,db}$ and to $v_{k,t,db}$)** |
|---|---|
| Data unit | $Nm^3$ of $CH_4$ / $Nm^3$ of landfill gas (%) |
| Description | Volumetric fraction of component *i* in the residual dry gas in hour h where *i* = $CH_4$, $CO_2$, $O_2$ |
| Source of data | Continuous gas analyser operating in dry-basis |
| Value(s) applied | $CH_4$ = 50% (ex ante) measured continuously for ER calculations in the project activity |
| Measurement methods and procedures | A gas sample will be taken from the residual gas. This sample will be taken on the same basis (dry/wet) as the measurement of the volumetric flow rate. |
| Monitoring frequency | Continuously. Values to be averaged hourly or at a shorter time interval. Time interval should not be greater than one hour. |
| QA/QC procedures | The gas analyser will be subject to a regular maintenance and calibration in accordance with manufacturer specifications to ensure accuracy. Standard certified gas will be used to compare a zero check and a typical value check. Calibration should include zero verification with an inert gas (e.g. $N_2$) and at least one verification reading with a standard gas (single calibration gas or mixture calibration gas). All calibration gases must have a certificate provided by the manufacturer and must be under their validity period.<br>In case of lack or failure of gas analyser readings, manual measurements will be taken daily using a portable infrared device. |
| Purpose of data | Calculation of Baseline Emissions |

| | |
|---|---|
| Additional comment | As defined within the “Tool to determine project emissions from flaring gases containing methane”, project participants may only measure the CH4 content and consider the remaining part to be $N_2$. |

| **Data/Parameter** | $\mathbf{p_{H20,t,Sat}}$ |
|---|---|
| Data unit | Pa |
| Description | Saturation pressure of $H_20$ at temperature $T_t$ in time interval *t* |
| Source of data | Tool to determine the mass flow of a greenhouse gas in a gaseous stream |
| Value(s) applied | 101,325 Pa |
| Measurement methods and procedures | This parameter is solely a function of the gaseous stream temperature Tt and can be found at reference [1] for a total pressure equal to 101,325 Pa |
| Monitoring frequency | - (as per the Tool) |
| QA/QC procedures | - (as per the Tool) |
| Purpose of data | Calculation of Baseline Emissions |
| Additional comment | [1] Fundamentals of Classical Thermodynamics; Gordon J. Van Wylen, Richard E. Stonntag and Borgnakke; 4° Edition 1994, John Wiley & Sons, Inc. |

| **Data/Parameter** | $\mathbf{t_{O2,h}}$ |
|---|---|
| Data unit | % |
| Description | Volumetric fraction of $O_2$ in the exhaust gas of the flare in hour h |
| Source of data | Continuous gas analyser |
| Value(s) applied | Default flare combustion efficiency used for *ex-ante* calculation is 90% (default value provided by the tool). |
| Measurement methods and procedures | Extractive sampling analysers with water and particulates removal devices will be used. The point of measurement (sampling point) will be in the upper section of the flare (80% of total flare height). Sampling will be conducted with appropriate sampling probes adequate to high temperature level.<br>The accuracy of gas analysers for $O_2$ as applied in exhaust gas measurements is<br>~□1% (% gas). |
| Monitoring frequency | Continuously. Values to be averaged hourly or at a shorter time interval. |
| QA/QC procedures | Analysers will be calibrated according to the manufacturer’s recommendation.<br>A zero check and a typical value check will be performed by comparison with a standard gas.<br>In case of lack or failure of the gas analyser, default values given by the “Tool to determine project emissions from flaring gases containing methane” will be used for flare efficiency:<br>90% if manufacturer’s specifications are met and continuously monitored; 50% if, in a specific hour, any of the parameter are out of the limit of the manufacturer’s specifications. |
| Purpose of data | Calculation of Baseline Emissions |
| Additional comment | - |

| **Data/Parameter** | **$fv_{CH4,FG,h}$** |
|---|---|
| Data unit | $mg/m^3$ (ppmv or % readings) |
| Description | Concentration of methane in the exhaust gas of the flare in dry basis at normal conditions in hour h |
| Source of data | Continuous gas analyser. |
| Value(s) applied | Default flare combustion efficiency used for *ex-ante* calculation is 90% (default value provided by the tool). |
| Measurement methods and procedures | Extractive sampling analysers with water and particulates removal devices. The point of measurement (sampling point) shall be in the upper section of the flare (80% of total flare height). Sampling shall be conducted with sampling probes adequate for high temperature measurements.<br>The accuracy of gas analysers for $CH_4$ as applied in exhaust gas measurements is ~□1% (% gas). |
| Monitoring frequency | Continuously. Values to be averaged hourly or at a shorter time interval. |
| QA/QC procedures | The gas analyser will be subject to a regular maintenance and calibration in accordance with manufacturer specifications to ensure accuracy. A zero check and a typical value check will be performed by comparison with a standard gas.<br><br>In case of lack or failure of the gas analyser, default values given by the "Tool to determine project emissions from flaring gases containing methane" will be used for flare efficiency:<br>90% if manufacturer's specifications are met and continuously monitored; 50% if, in a specific hour, any of the parameter are out of the limit of the manufacturer's specifications. |
| Purpose of data | Calculation of Baseline Emissions |
| Additional comment | Monitoring of this parameter is only applicable in case of enclosed flares and continuous monitoring of the flare efficiency. Measurement instruments may read ppmv or % values. To convert from ppmv to $mg/m^3$, the value shall be multiplied by 0.716. 1% equals 10 000 ppmv. |

| **Data/Parameter** | **$T_{flare}$** |
|---|---|
| Data unit | ° C |
| Description | Temperature in the exhaust gas of the flare |
| Source of data | Temperature measurements by project proponents |
| Value(s) applied | Default flare combustion efficiency used for *ex-ante* calculation is 90% (default value provided by the tool). |
| Measurement methods and procedures | A thermocouple type N will be used. Data will continuously be registered through a data logger. Accuracy for these thermocouples is ~ □2-3%. |
| Monitoring frequency | Continuously monitored and recorded in a datalogger. |
| QA/QC procedures | Thermocouples will be replaced or calibrated as per the manufacturer recommendations at least every year.<br>In case measurements of $T_{flare}$ are temporarily not available, $T_{OP}$ will be used and the average difference of temperatures between $T_{flare}$ and $T_{OP}$ in the previous month will be applied to determine $T_{flare}$. |
| Purpose of data | Calculation of Baseline Emissions |

| | |
|---|---|
| Additional comment | A UV sensor will also provide another indication that the flare burns landfill gas. |

| **Data/Parameter** | **$T_{OP}$** |
|---|---|
| Data unit | ° C |
| Description | Operational (combustion) temperature of the flare |
| Source of data | Thermocouple |
| Value(s) applied | This parameter is necessary to pilot the flare and verify that it is operated in accordance with the manufacturer’s specifications.<br>For ex-ante purposes a default flare efficiency of 90% in accordance with flare manufacturer specifications is used. |
| Measurement methods and procedures | A thermocouple type N (or equivalent, sulphur resistant type K) is used for combustion temperature measurements. Accuracy for these thermocouples is ~ □2-3%. |
| Monitoring frequency | Continuously |
| QA/QC procedures | The thermocouple is replaced or calibrated as per the manufacturer recommendations. |
| Purpose of data | Calculation of Baseline Emissions |
| Additional comment | - A flame detector will provide another indication that the flare is operating and landfill gas is burnt. |

| **Data/Parameter** | **$V_{t,db,flare}$** |
|---|---|
| Data unit | $Nm^3$ /h |
| Description | Volumetric flow of the landfill gas flared on a dry basis |
| Source of data | Flow meters.<br>*Ex ante* values are calculated based on landfill gas model and collection efficiency (see attached excel model) |

| | |
|---|---|
| Value(s) applied | **Year** / / **Quantity of LFG flared ($LFG_{Flare}$) ($m^3$ LFG)**<br>2013 / 4 months / 1,045,112<br>2014 / 12 months / 7,079,489<br>2015 / 12 months / 2,279,070<br>2016 / 12 months / 2,716,475<br>2017 / 12 months / 3,133,083<br>2018 / 12 months / 3,524,807<br>2019 / 12 months / 3,873,970<br>2020 / 12 months / 4,161,618<br>2021 / 12 months / 4,396,084<br>2022 / 12 months / 4,591,762<br>2023 / 12 months / 4,758,590<br>2024 / 12 months / 4,903,488<br>2025 / 12 months / 5,031,320<br>2026 / 12 months / 4,341,441<br>2027 / 12 months / 3,455,700<br>2028 / 12 months / 2,820,384<br>2029 / 12 months / 2,356,827<br>2030 / 12 months / 2,011,851<br>2031 / 12 months / 1,749,427<br>2032 / 12 months / 1,545,067<br>2033 / 12 months / 1,382,065<br>2034 / 8 months / 3,191,805<br>**Total** / / **74,349,435** |
| Measurement methods and procedures | The landfill gas volumetric flow to the flare is measured continuously using a volumetric flow meter or equivalent device. The flow measurement will be normalised to standard conditions using appropriate pressure and temperature readings. Instruments with recordable electronic signal are required.<br>The accuracy of such device is ~ ±1%. |
| Monitoring frequency | Continuous (as per the methodology). Time interval not greater than one hour. |
| QA/QC procedures | Calibration and frequency of calibration is according to manufacturer's specifications.<br>In case the flow meter is temporarily not available, but a total flow meter is installed upstream the engine and flare meters, $V_{t,db,\ flare}$ will be obtained from the difference of the readings from the total flow meter and $V_{t,db,\ engine}$. |
| Purpose of data | Calculation of Baseline emissions |
| Additional comment | To be monitored in case Option A of the methodological tool "Tool to determine the mass flow of a greenhouse gas in a gaseous stream" is selected.<br>In case of several flares, the flow will be measured for each device in accordance with the applicable methodology / tool. |

| **Data/Parameter** | **$V_{t,wb,flare}$** |
|---|---|
| Data unit | $m^3$ wet gas / h |
| Description | Volumetric flow of the landfill gas flared on a wet basis |

<table>
<tr><td>Source of data</td><td>Flow meters.<br>*Ex ante* values are calculated based on landfill gas model and collection efficiency (see attached excel model)</td></tr>
<tr><td>Value(s) applied</td><td>

| **Year** | | Quantity of LFG flared ($LFG_{Flare}$) ($m^3$ LFG) |
|---|---|---|
| 2013 | 4 months | 1,045,112 |
| 2014 | 12 months | 7,079,489 |
| 2015 | 12 months | 2,279,070 |
| 2016 | 12 months | 2,716,475 |
| 2017 | 12 months | 3,133,083 |
| 2018 | 12 months | 3,524,807 |
| 2019 | 12 months | 3,873,970 |
| 2020 | 12 months | 4,161,618 |
| 2021 | 12 months | 4,396,084 |
| 2022 | 12 months | 4,591,762 |
| 2023 | 12 months | 4,758,590 |
| 2024 | 12 months | 4,903,488 |
| 2025 | 12 months | 5,031,320 |
| 2026 | 12 months | 4,341,441 |
| 2027 | 12 months | 3,455,700 |
| 2028 | 12 months | 2,820,384 |
| 2029 | 12 months | 2,356,827 |
| 2030 | 12 months | 2,011,851 |
| 2031 | 12 months | 1,749,427 |
| 2032 | 12 months | 1,545,067 |
| 2033 | 12 months | 1,382,065 |
| 2034 | 8 months | 3,191,805 |
| **Total** | | **74,349,435** |

</td></tr>
<tr><td>Measurement methods and procedures</td><td>The landfill gas flow to the flare is measured continuously using a volumetric flow meter or equivalent device. The flow measurement will always refer to the actual pressure and temperature. Instruments with recordable electronic signal will be used.<br>The accuracy of such device is ~ ±1%.</td></tr>
<tr><td>Monitoring frequency</td><td>Continuous (as per the methodology). Time interval not greater than one hour.</td></tr>
<tr><td>QA/QC procedures</td><td>Calibration and frequency of calibration is according to manufacturer's specifications and will be performed by an independent accredited laboratory against a primary device.<br>In case the flow meter is temporarily not available, but a total flow meter is installed upstream the engine and flare meters, $V_{t,wb}$ will be obtained from the difference of the readings from the total flow meter and $V_{t,db,\ engine}$.</td></tr>
<tr><td>Purpose of data</td><td>Calculation of Baseline emissions</td></tr>
<tr><td>Additional comment</td><td>To be monitored in case Options B or C of the methodological tool "Tool to determine the mass flow of a greenhouse gas in a gaseous stream" is selected.<br>In case of several flares, the flow will be measured for each device in accordance with the applicable methodology / tool.</td></tr>
</table>

| **Data/Parameter** | $V_{t,db,engine}$ |
|---|---|
| Data unit | $Nm^3$ /h |
| Description | Volumetric flow of the landfill gas sent to the engine(s) and used for electricity generation on a dry basis |
| Source of data | Flow meter.<br>*Ex ante* estimation are calculated based on landfill gas model and collection efficiency (see attached excel model) |
| Value(s) applied | (see table below) |

| **Year** | | Quantity of LFG destroyed within the engine ($LFG_{engine,y}$) ($m^3$ LFG) |
|---|---|---|
| 2013 | 4 months | - |
| 2014 | 12 months | 5,232,666 |
| 2015 | 12 months | 12,914,729 |
| 2016 | 12 months | 15,393,359 |
| 2017 | 12 months | 17,754,135 |
| 2018 | 12 months | 19,973,906 |
| 2019 | 12 months | 21,952,498 |
| 2020 | 12 months | 23,582,500 |
| 2021 | 12 months | 24,911,141 |
| 2022 | 12 months | 26,019,985 |
| 2023 | 12 months | 26,965,346 |
| 2024 | 12 months | 27,786,431 |
| 2025 | 12 months | 28,510,815 |
| 2026 | 12 months | 24,601,501 |
| 2027 | 12 months | 19,582,301 |
| 2028 | 12 months | 15,982,177 |
| 2029 | 12 months | 13,355,350 |
| 2030 | 12 months | 11,400,489 |
| 2031 | 12 months | 9,913,420 |
| 2032 | 12 months | 8,755,381 |
| 2033 | 12 months | 7,831,704 |
| 2034 | 8 months | 2,359,160 |
| **Total** | | **364,778,994** |

| | |
|---|---|
| Measurement methods and procedures | The landfill gas flow to the flare is measured continuously using a volumetric flow meter or equivalent device. The flow measurement will be normalized to standard conditions using appropriate pressure and temperature readings.<br>The accuracy of such device is ~ ±1%.<br>In case several engines are installed, the flow will be measured for each device in accordance with the applicable methodology/tool: $V_{t,db,\ engine\ 1,2,3}$. |
| Monitoring frequency | Continuous (as per the methodology). Time interval not greater than one hour. |
| QA/QC procedures | Calibration and frequency of calibration is according to manufacturer's specifications.<br>In case the flow meter is temporarily not available, but a total flow meter is installed upstream the engine and flare meters, $V_{t,db,\ engine}$ will be obtained from the difference of the readings from the total flow meter $V_{t,db,\ flare}$ |

| | |
|---|---|
| Purpose of data | Calculation of Baseline emissions |
| Additional comment | To be monitored in case Option A of the methodological tool “Tool to determine the mass flow of a greenhouse gas in a gaseous stream” is selected. |

| **Data/Parameter** | **$V_{t,wb,engine}$** |
|---|---|
| Data unit | Nm³ /h |
| Description | Volumetric flow of the landfill gas sent to the engine(s) and used for electricity generation on a wet basis |
| Source of data | Flow meter.<br>*Ex ante* estimation are calculated based on landfill gas model and collection efficiency (see attached excel model) |
| Value(s) applied | see table below |

| **Year** | | Quantity of LFG destroyed within the engine ($LFG_{engine,y}$) ($m^3$ LFG) |
|---|---|---|
| 2013 | 4 months | - |
| 2014 | 12 months | 5,232,666 |
| 2015 | 12 months | 12,914,729 |
| 2016 | 12 months | 15,393,359 |
| 2017 | 12 months | 17,754,135 |
| 2018 | 12 months | 19,973,906 |
| 2019 | 12 months | 21,952,498 |
| 2020 | 12 months | 23,582,500 |
| 2021 | 12 months | 24,911,141 |
| 2022 | 12 months | 26,019,985 |
| 2023 | 12 months | 26,965,346 |
| 2024 | 12 months | 27,786,431 |
| 2025 | 12 months | 28,510,815 |
| 2026 | 12 months | 24,601,501 |
| 2027 | 12 months | 19,582,301 |
| 2028 | 12 months | 15,982,177 |
| 2029 | 12 months | 13,355,350 |
| 2030 | 12 months | 11,400,489 |
| 2031 | 12 months | 9,913,420 |
| 2032 | 12 months | 8,755,381 |
| 2033 | 12 months | 7,831,704 |
| 2034 | 8 months | 2,359,160 |
| **Total** | | **364,778,994** |

| | |
|---|---|
| Measurement methods and procedures | The landfill gas flow to the flare is measured continuously using a volumetric flow meter or equivalent device. The flow measurement will be normalized to standard conditions using appropriate pressure and temperature readings.<br>The accuracy of such device is ~ ±1%.<br>In case several engines are installed, the flow will be measured for each device in accordance with the applicable methodology/tool: $V_{t,wb,\ engine\ 1,2,3}$. |

| | |
|---|---|
| Monitoring frequency | Continuous (as per the methodology). Time interval not greater than one hour. |
| QA/QC procedures | Calibration and frequency of calibration is according to manufacturer's specifications.<br>In case the flow meter is temporarily not available, but a total flow meter is installed upstream the engine and flare meters, $V_{t,wb,\ engine}$ will be obtained from the difference of the readings from the total flow meter $V_{t,wb,\ flare}$ |
| Purpose of data | Calculation of Baseline emissions |
| Additional comment | To be monitored in case Options B or C of the methodological tool "Tool to determine the mass flow of a greenhouse gas in a gaseous stream" is selected. |

| **Data/Parameter** | $\mathbf{v_{i,t,wb}}$ |
|---|---|
| Data unit | $m^3CH_4/m^3$ wet gas |
| Description | Volumetric fraction of greenhouse gas methane in a hourly time interval t on a wet basis |
| Source of data | Measurements by project participants using a gas analyzer |
| Value(s) applied | 50% |
| Measurement methods and procedures | Continuous gas analyzer operating in wet-basis. Volumetric flow measurement should always refer to the actual pressure and temperature.<br>Data will be monitored continuously.<br>The accuracy and uncertainty of the monitoring instrument will be in accordance with manufacturer specifications. |
| Monitoring frequency | Continuously (minute basis) |
| QA/QC procedures | Calibration should include zero verification with an inert gas (e.g. $N_2$) and at least one reading verification with a standard gas (single calibration gas or mixture calibration gas). All calibration gases must have a certificate provided by the manufacturer and must be under their validity period.<br>The calibration frequency of this monitoring equipment should be according to the manufacturer's specifications. |
| Purpose of data | Calculation of baseline emissions |
| Additional comment | Under conformance with the "Tool to determine the mass flow of a greenhouse gas in a gaseous stream", the measurement option in the project activity will be as follows:<br>- $v_{i,t,db}$ will be monitored using option A (when LFG temperature is lower than 60ºC, it means dry gas) and B (when LFG temperature is higher than 60ºC, it means wet gas).<br>- $v_{i,t,wb}$ will be monitored using option C |

| **Data/Parameter** | **$v_{i,t,db}$** |
|---|---|
| Data unit | $m^3CH_4/m^3$ dry gas |
| Description | Volumetric fraction of greenhouse gas methane in a hourly time interval t on a dry basis |
| Source of data | Measurements by project participants using a gas analyzer |
| Value(s) applied | 50% |
| Measurement methods and procedures | Continuous gas analyzer operating in dry-basis. Volumetric flow measurement should always refer to the actual pressure and temperature.<br>Data will be monitored continuously, and values will be averaged hourly or a shorter time interval.<br>The accuracy and uncertainty of the monitoring instrument will be in accordance with manufacturer specifications. |
| Monitoring frequency | Continuously (minute basis) |
| QA/QC procedures | Calibration should include zero verification with an inert gas (e.g. $N_2$) and at least one reading verification with a standard gas (single calibration gas or mixture calibration gas). All calibration gases must have a certificate provided by the manufacturer and must be under their validity period.<br>The calibration frequency of this monitoring equipment should be according to the manufacturer's specifications. |
| Purpose of data | Calculation of baseline emissions |
| Additional comment | Under conformance with the "Tool to determine the mass flow of a greenhouse gas in a gaseous stream", the measurement option in the project activity will be as follows:<br>- $v_{i,t,db}$ will be monitored using option A (when LFG temperature is lower than 60ºC, it means dry gas) and B (when LFG temperature is higher than 60ºC, it means wet gas).<br>- $v_{i,t,wb}$ will be monitored using option C |

| **Data/Parameter** | **$T_t$** |
|---|---|
| Data unit | K |
| Description | Temperature of the landfill gas |
| Source of data | Temperature probe (separate or included in flow meters: see above) |
| Value(s) applied | Ex-ante values of temperature are not available. landfill gas volumes are estimated in dry $Nm^3/h$. |
| Measurement methods and procedures | The temperature of the landfill gas is determined either by a separate temperature probe (e.g. PT 100) or by a temperature probe that is integrated into the flow meter. The accuracy of such probe is ~±2°C. |
| Monitoring frequency | Continuous monitoring to ensure the applicability condition (see comment below) |

| | |
|---|---|
| QA/QC procedures | The temperature probe / flow meter will be subject to a regular maintenance and testing regime in accordance with manufacturer specifications. Accuracy will be verified.<br>Default value in case of lack or failure of readings: daily average of the temperature in the previous months. |
| Purpose of data | Calculation of Baseline Emissions |
| Additional comment | If the applicability condition related to the landfill gas temperature being below 60°C is adopted, then this parameter must be monitored continuously to assure the applicability condition is met. |

| **Data/Parameter** | **$P_t$** |
|---|---|
| Data unit | Pa |
| Description | Pressure of the landfill gas in time interval t |
| Source of data | Pressure probe (separate or included in flow meters: see above) |
| Value(s) applied | Ex-ante values for pressure are not available. landfill gas volumes are estimated in dry $Nm^3/h$. |
| Measurement methods and procedures | The pressure of the landfill gas is determined either by a separate pressure probe (e.g. pressure transducers) or by a pressure probe that is integrated into the flow meter. The accuracy of such probe is ~□2 mbar. |
| Monitoring frequency | Continuous monitoring |
| QA/QC procedures | The pressure probe / flow meter will be subject to a regular maintenance and testing regime (monthly calibration) as required by the Tool. Accuracy will be verified.<br>Default value in case of lack or failure of readings: daily average of the pressure in the previous months. |
| Purpose of data | Calculation of Baseline Emissions |
| Additional comment | Provided all parameters are converted to normal conditions during the monitoring process, this parameter may not be needed except for moisture content determination and therefore it should be metered only when performing such measurements. |

<table>
<tr><td>Data/Parameter</td><td>$EG_{m,t}$</td></tr>
<tr><td>Data unit</td><td>MWh</td></tr>
<tr><td>Description</td><td>Quantity of electricity generated in landfill gas engine power plant (m) in the time period t.</td></tr>
<tr><td>Source of data</td><td>Onsite measurements</td></tr>
<tr><td>Value(s) applied</td><td>Ex ante estimated quantities of electricity generated with landfill gas engines are:<br>
<table>
<tr><th>Year</th><th></th><th>Total Quantity of electricity generated by the LFG engine power plant (in MWh)</th></tr>
<tr><td>2013</td><td>4 months</td><td>-</td></tr>
<tr><td>2014</td><td>12 months</td><td>10,278</td></tr>
<tr><td>2015</td><td>12 months</td><td>25,368</td></tr>
<tr><td>2016</td><td>12 months</td><td>30,237</td></tr>
<tr><td>2017</td><td>12 months</td><td>34,874</td></tr>
<tr><td>2018</td><td>12 months</td><td>39,234</td></tr>
<tr><td>2019</td><td>12 months</td><td>43,121</td></tr>
<tr><td>2020</td><td>12 months</td><td>46,322</td></tr>
<tr><td>2021</td><td>12 months</td><td>48,932</td></tr>
<tr><td>2022</td><td>12 months</td><td>51,110</td></tr>
<tr><td>2023</td><td>12 months</td><td>52,967</td></tr>
<tr><td>2024</td><td>12 months</td><td>54,580</td></tr>
<tr><td>2025</td><td>12 months</td><td>56,003</td></tr>
<tr><td>2026</td><td>12 months</td><td>48,324</td></tr>
<tr><td>2027</td><td>12 months</td><td>38,465</td></tr>
<tr><td>2028</td><td>12 months</td><td>31,393</td></tr>
<tr><td>2029</td><td>12 months</td><td>26,233</td></tr>
<tr><td>2030</td><td>12 months</td><td>22,394</td></tr>
<tr><td>2031</td><td>12 months</td><td>19,473</td></tr>
<tr><td>2032</td><td>12 months</td><td>17,198</td></tr>
<tr><td>2033</td><td>12 months</td><td>15,384</td></tr>
<tr><td>2034</td><td>8 months</td><td>6,951</td></tr>
<tr><td>Total</td><td></td><td>718,841</td></tr>
</table></td></tr>
<tr><td>Measurement methods and procedures</td><td>Use electricity meters.<br>Accuracy of the meters is +/-3%.</td></tr>
<tr><td>Monitoring frequency</td><td>Continuously, aggregated at least annually</td></tr>
<tr><td>QA/QC procedures</td><td>Measurement results can be cross-checked with records of sold electricity and records of electricity consumption onsite.<br>The electricity meter will be subject to calibration and maintenance at least annually.</td></tr>
<tr><td>Purpose of data</td><td>Calculation of Project Emissions</td></tr>
<tr><td>Additional comment</td><td>Applicable to calculate project emissions due to consumption of electricity produced by on-site generator</td></tr>
</table>

| **Data/Parameter** | **$EL_{PA,LFG}$** |
|---|---|
| Data unit | MWh |
| Description | Quantity of electricity produced by the LFG engine(s) and consumed by the project activity |
| Source of data | Onsite measurements |
| Value(s) applied | *Ex ante* quantities of electricity to be auto-consumed for the project activity are estimated based on the required volume of electricity and the engine(s)' availability. (see excel model for calculation).<br>The ex-ante values used for auto-consumption are: |
| Measurement methods and procedures | Use electricity meters.<br>Accuracy of the meters is +/-3%. |
| Monitoring frequency | Continuously, aggregated at least annually |
| QA/QC procedures | Total electricity produced less electricity dispatched to the grid and less electricity consumed for leachate treatment.<br>The electricity meter will be subject to calibration and maintenance at least annually |
| Purpose of data | Calculation of Project Emissions |
| Additional comment | Applicable to calculate ex ante project emissions |

| **Year** | | Quantity of electricity autoconsumed (MWh) |
|---|---|---|
| 2013 | 4 months | - |
| 2014 | 12 months | 450 |
| 2015 | 12 months | 1,111 |
| 2016 | 12 months | 1,324 |
| 2017 | 12 months | 1,527 |
| 2018 | 12 months | 1,718 |
| 2019 | 12 months | 1,888 |
| 2020 | 12 months | 2,028 |
| 2021 | 12 months | 2,142 |
| 2022 | 12 months | 2,238 |
| 2023 | 12 months | 2,319 |
| 2024 | 12 months | 2,390 |
| 2025 | 12 months | 2,452 |
| 2026 | 12 months | 2,116 |
| 2027 | 12 months | 1,684 |
| 2028 | 12 months | 1,374 |
| 2029 | 12 months | 1,149 |
| 2030 | 12 months | 980 |
| 2031 | 12 months | 853 |
| 2032 | 12 months | 753 |
| 2033 | 12 months | 674 |
| 2034 | 8 months | 252 |
| **Total** | | **31,422** |

<table>
<tr><td>Data/Parameter</td><td>$FC_{n,i,t}$</td></tr>
<tr><td>Data unit</td><td>L or tonne or $m^3$ / year</td></tr>
<tr><td>Description</td><td>Quantity of fossil fuel type i fired in the captive power plant (generator) n in the time period t</td></tr>
<tr><td>Source of data</td><td>Annual data during the crediting period: onsite measurements</td></tr>
<tr><td>Value(s) applied</td><td>
<table>
<tr><th>Year</th><th></th><th>Fuel consumption for the generator (tonnes)</th></tr>
<tr><td>2013</td><td>4 months</td><td>5</td></tr>
<tr><td>2014</td><td>12 months</td><td>35</td></tr>
<tr><td>2015</td><td>12 months</td><td>11</td></tr>
<tr><td>2016</td><td>12 months</td><td>13</td></tr>
<tr><td>2017</td><td>12 months</td><td>15</td></tr>
<tr><td>2018</td><td>12 months</td><td>17</td></tr>
<tr><td>2019</td><td>12 months</td><td>19</td></tr>
<tr><td>2020</td><td>12 months</td><td>21</td></tr>
<tr><td>2021</td><td>12 months</td><td>22</td></tr>
<tr><td>2022</td><td>12 months</td><td>23</td></tr>
<tr><td>2023</td><td>12 months</td><td>23</td></tr>
<tr><td>2024</td><td>12 months</td><td>24</td></tr>
<tr><td>2025</td><td>12 months</td><td>25</td></tr>
<tr><td>2026</td><td>12 months</td><td>21</td></tr>
<tr><td>2027</td><td>12 months</td><td>17</td></tr>
<tr><td>2028</td><td>12 months</td><td>14</td></tr>
<tr><td>2029</td><td>12 months</td><td>12</td></tr>
<tr><td>2030</td><td>12 months</td><td>10</td></tr>
<tr><td>2031</td><td>12 months</td><td>9</td></tr>
<tr><td>2032</td><td>12 months</td><td>8</td></tr>
<tr><td>2033</td><td>12 months</td><td>7</td></tr>
<tr><td>2034</td><td>8 months</td><td>4</td></tr>
<tr><td>Total</td><td></td><td>355</td></tr>
</table>
</td></tr>
<tr><td>Measurement methods and procedures</td><td>Use weight or volume meters, according to available information.</td></tr>
<tr><td>Monitoring frequency</td><td>At each delivery and aggregated monthly.</td></tr>
<tr><td>QA/QC procedures</td><td>The consistency of metered fuel consumption quantities should be cross-checked with an annual energy balance that is based on purchased quantities and stock changes.<br>In case of lack or failure of the metering, invoices provided by fuel supplier can be used.</td></tr>
<tr><td>Purpose of data</td><td>Calculation of Project Emissions</td></tr>
<tr><td>Additional comment</td><td>Applicable to calculate project emissions due to consumption of electricity produced by on-site generator</td></tr>
</table>

| **Data/Parameter** | **$EG_{n,t}$** |
|---|---|
| Data unit | MWh |
| Description | Quantity of electricity generated in captive power plant (generator) *n* in the time period *t* |
| Source of data | Onsite measurements |
| Value(s) applied | (see table below) |
| Measurement methods and procedures | Use electricity meters.<br>Accuracy of the meters is +/-3%. |
| Monitoring frequency | Continuously, aggregated at least annually |
| QA/QC procedures | A cross-check between the fuel consumption and electricity production will be undertaken to verify the coherent relation between these two parameters. In the case where the electricity meter readings are not available, and therefore $EG_{n,t}$ is not available, the ratio calculated between fuel consumption and electricity generation of the previous period will be used.<br>The electricity meter will be subject to calibration and maintenance at least annually |
| Purpose of data | Calculation of Project Emissions |
| Additional comment | Applicable to calculate project emissions due to consumption of electricity produced by on-site generator |

Value(s) applied:

| **Year** | | Quantity of electricity produced by the generator (MWh) |
|---|---|---|
| 2013 | 4 months | 22 |
| 2014 | 12 months | 149 |
| 2015 | 12 months | 48 |
| 2016 | 12 months | 57 |
| 2017 | 12 months | 66 |
| 2018 | 12 months | 74 |
| 2019 | 12 months | 81 |
| 2020 | 12 months | 87 |
| 2021 | 12 months | 92 |
| 2022 | 12 months | 96 |
| 2023 | 12 months | 100 |
| 2024 | 12 months | 103 |
| 2025 | 12 months | 106 |
| 2026 | 12 months | 91 |
| 2027 | 12 months | 73 |
| 2028 | 12 months | 59 |
| 2029 | 12 months | 49 |
| 2030 | 12 months | 42 |
| 2031 | 12 months | 37 |
| 2032 | 12 months | 32 |
| 2033 | 12 months | 29 |
| 2034 | 8 months | 17 |
| **Total** | | **1,510** |

| **Data/Parameter** | **$EC_{PJ,grid}$** |
|---|---|
| Data unit | MWh |
| Description | Quantity of electricity purchased from the grid for the project activity |
| Source of data | Onsite measurements (meter) |
| Value(s) applied | Ex-ante volume of electricity purchased from the grid for the project activity are null since for the ex-ante calculation of Project Emissions, it was considered that all electricity required for the project activity (in addition to the electricity supplied by the project itself), would be generated by the onsite generator only. This is a conservative approach.<br>The exact volume of electricity consumed from the grid will be monitored during the project activity |
| Measurement methods and procedures | Use electricity meters. |
| Monitoring frequency | Continuously, aggregated at least annually |
| QA/QC procedures | Cross-check measurement results with invoices for purchased electricity where relevant. |
| Purpose of data | Calculation of Project Emissions |
| Additional comment | Applicable to calculate project emissions due to consumption of electricity purchased from the grid. |

| **Data/Parameter** | **$EL_{leachate,LFG}$** |
|---|---|
| Data unit | MWh |
| Description | Quantity of electricity produced onsite by the landfill gas engine(s) and consumed by the leachate treatment. |
| Source of data | Project participant's monitoring (meter) |
| Value(s) applied | (see table below) *Ex ante* quantities of electricity to be consumed by the leachate treatment are estimated based on the required volume of electricity and the site's production. (see excel model for calculation). |
| Measurement methods and procedures | Use electricity meters.<br>Accuracy of the meters is +/-3%. |
| Monitoring frequency | Continuously, aggregated at least annually |
| QA/QC procedures | Total electricity produced less electricity dispatched to the grid and less electricity consumed for the project activity.<br>The electricity meter will be subject to calibration and maintenance at least annually |
| Purpose of data | Calculation of Project Emissions |
| Additional comment | Applicable to calculate ex ante project emissions |

| **Year** | | Quantity of electricity consumed for leachate treatment (MWh) |
|---|---|---|
| 2013 | 4 months | - |
| 2014 | 12 months | 1,349 |
| 2015 | 12 months | 1,619 |
| 2016 | 12 months | 1,917 |
| 2017 | 12 months | 2,127 |
| 2018 | 12 months | 2,237 |
| 2019 | 12 months | 2,434 |
| 2020 | 12 months | 2,513 |
| 2021 | 12 months | 2,728 |
| 2022 | 12 months | 2,828 |
| 2023 | 12 months | 2,923 |
| 2024 | 12 months | 3,010 |
| 2025 | 12 months | 3,062 |
| 2026 | 12 months | 2,616 |
| 2027 | 12 months | 1,884 |
| 2028 | 12 months | 1,518 |
| 2029 | 12 months | 1,222 |
| 2030 | 12 months | 1,000 |
| 2031 | 12 months | 839 |
| 2032 | 12 months | 724 |
| 2033 | 12 months | 642 |
| 2034 | 8 months | 388 |
| **Total** | | **39,580** |

<table>
<tr><th>Data/Parameter</th><th>$ELS_{LFGt}$</th></tr>
<tr><td>Data unit</td><td>MWh</td></tr>
<tr><td>Description</td><td>Quantity of electricity that would be consumed by the baseline electricity consumption source k in year y, or electricity dispatched to the grid by the project activity (both are considered to be equivalent).</td></tr>
<tr><td>Source of data</td><td>Onsite measurements (meters)</td></tr>
<tr><td>Value(s) applied</td><td>
<table>
<tr><th>Year</th><th></th><th>Quantity of electricity supplied to the grid in MWh</th></tr>
<tr><td>2013</td><td>4 months</td><td>-</td></tr>
<tr><td>2014</td><td>12 months</td><td>8,480</td></tr>
<tr><td>2015</td><td>12 months</td><td>22,638</td></tr>
<tr><td>2016</td><td>12 months</td><td>26,996</td></tr>
<tr><td>2017</td><td>12 months</td><td>31,220</td></tr>
<tr><td>2018</td><td>12 months</td><td>35,279</td></tr>
<tr><td>2019</td><td>12 months</td><td>38,799</td></tr>
<tr><td>2020</td><td>12 months</td><td>41,782</td></tr>
<tr><td>2021</td><td>12 months</td><td>44,062</td></tr>
<tr><td>2022</td><td>12 months</td><td>46,045</td></tr>
<tr><td>2023</td><td>12 months</td><td>47,725</td></tr>
<tr><td>2024</td><td>12 months</td><td>49,181</td></tr>
<tr><td>2025</td><td>12 months</td><td>50,489</td></tr>
<tr><td>2026</td><td>12 months</td><td>43,592</td></tr>
<tr><td>2027</td><td>12 months</td><td>34,897</td></tr>
<tr><td>2028</td><td>12 months</td><td>28,500</td></tr>
<tr><td>2029</td><td>12 months</td><td>23,862</td></tr>
<tr><td>2030</td><td>12 months</td><td>20,413</td></tr>
<tr><td>2031</td><td>12 months</td><td>17,781</td></tr>
<tr><td>2032</td><td>12 months</td><td>15,721</td></tr>
<tr><td>2033</td><td>12 months</td><td>14,068</td></tr>
<tr><td>2034</td><td>8 months</td><td>3,993</td></tr>
<tr><td>Total</td><td></td><td>645,523</td></tr>
</table>
</td></tr>
<tr><td>Measurement methods and procedures</td><td>The electricity generated by the project activity and dispatched to the grid is metered using a standard electricity meter that is generally provided / imposed by the grid operator. The project participants rely thus on the measurement and maintenance procedures of the grid operator. Commercial documentation (receipts/invoices) from the grid operator showing the quantity of electricity dispatched will be used as the justification for $ELS_{LFG}$. As the grid operator or client has a commercial interest not to overestimate the quantity of electricity received, this is considered conservative.</td></tr>
<tr><td>Monitoring frequency</td><td>Continuously, aggregated at least annually</td></tr>
<tr><td>QA/QC procedures</td><td>The quantity of electricity dispatched to the grid correspond to the total quantity of electricity produced on site, less the site’s consumption for the project activity and the leachate treatment.</td></tr>
<tr><td>Purpose of data</td><td>Calculation of Project Emissions</td></tr>
<tr><td>Additional comment</td><td></td></tr>
</table>

| **Data/Parameter** | $EF_{grid,BM}$ |
|---|---|
| Data unit | t $CO_2$e / MWh |
| Description | Build Margin $CO_2$ emission factor |
| Source of data | Brazilian DNA<br>(http://www.mct.gov.br/index.php/content/view/327813.html#ancora) |
| Value(s) applied | **0.1404** |
| Measurement methods and procedures | Official data calculated by the Brazilian DNA and published on its Internet website.<br>Applicable to all Brazilian projects. |
| Monitoring frequency | |
| QA/QC procedures | |
| Purpose of data | Calculation of Baseline Emissions<br>Calculation of Project Emissions |
| Additional comment | - |

| **Data/Parameter** | $EF_{grid,OM}$ |
|---|---|
| Data unit | t $CO_2$e / MWh |
| Description | Operating Margin $CO_2$ emission factor |
| Source of data | Brazilian DNA<br>(http://www.mct.gov.br/index.php/content/view/327813.html#ancora) |
| Value(s) applied | **0.4787** |
| Measurement methods and procedures | Official data calculated by the Brazilian DNA and published on its Internet website.<br>Applicable to all Brazilian projects. |
| Monitoring frequency | |
| QA/QC procedures | |
| Purpose of data | Calculation of Baseline Emissions<br>Calculation of Project Emissions |
| Additional comment | |

| **Data/Parameter** | $CEF_{elec,BL,y}$ |
|---|---|
| Data unit | t $CO_2$e / MWh |
| Description | Carbon emission factor of electricity |
| Source of data | Calculated as per the “Tool to calculate the emission factor for an electricity system”, using the latest figures available, provided by the Host Country DNA |
| Value(s) applied | 0.3096 (calculated *ex ante* for the purpose of PDD calculations with 2010 figures) |
| Measurement methods and procedures | The weightings of the operational and build margin are the default values given by the Tool: 0.5 each for the first crediting period.<br>Calculated *ex post* on an annual basis with figures published by the Brazilian DNA, as the $EF_{grid,CM,y}$ |
| Monitoring frequency | |

| | |
|---|---|
| QA/QC procedures | |
| Purpose of data | Calculation of Baseline Emissions<br>Calculation of Project Emissions |
| Additional comment | |

### B.7.2. Sampling plan

>>
Not applicable

### B.7.3. Other elements of monitoring plan

>>
The monitoring equipment, described herein, may be modified to meet operational requirements or system upgrades. Any modification will take into account the monitoring requirements specified in the applied methodology and will be subject to review in the verification process.

**Applied methodology**
ACM0001: Approved Consolidated Methodology “Flaring or use of landfill gas”.

**1. Brief description of the methodology**
The ACM0001 methodology aims at calculating the reduction of methane emissions in Solid Waste Disposal Sites (SWDS) though landfill gas flaring and / or use to generate electricity.

Emission Reductions (ERs) are based on effectively measured amounts of landfill gas that is captured and destroyed in flares and engines, whereas ex ante calculations are based on theoretical calculations and estimated capture rates.

In order to calculate ERs properly, an effective, precise and exhaustive monitoring of varying parameters is needed. The following pages describe this process and how it will be conducted.

As recommended within the “Tool to determine project emissions from flaring gases containing methane” and “Tool to determine the mass flow of a greenhouse gas in a gaseous stream”, all concentrations and gas flows will refer to the same basis (dry / wet).

The data will be analysed on a monthly basis and then aggregated to obtain the yearly emission reductions. The instrumentation will provide series of finite figures.

The methane density will be adjusted according to the pressure and temperature of the landfill gas.

The exported electricity will be monitored through an electricity meter. Similarly, electricity imported from the grid and electricity produced by the fossil fuel-fired generator will be monitored independently.

**2. Data to be collected or used in order to monitor emissions from the project activity and how this data will be archived**

Data collection, use and archive are described in section B.7.1 above. All the elements to be monitored onsite are represented on the P&I diagram below.

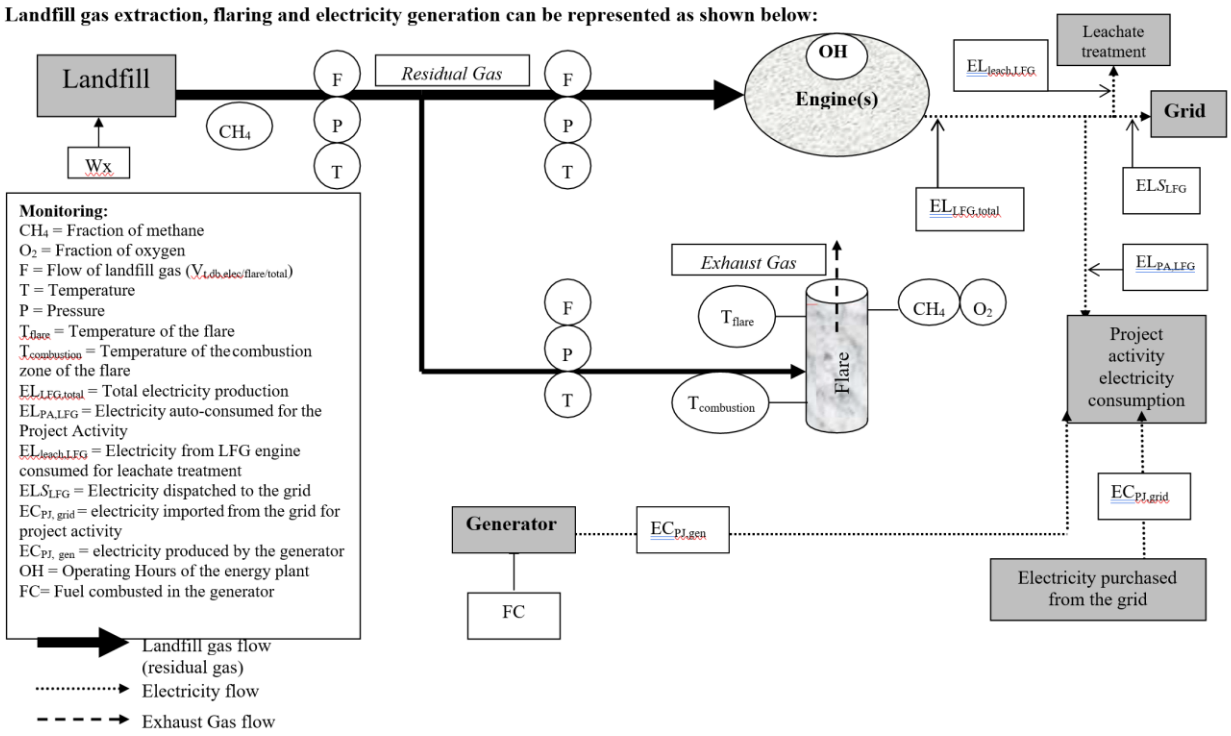


**Figure 5 - P&I diagram to be implemented on site**

### Procedures for record handling:

Most monitoring data will be recorded by an automatic datalogging device (e.g. flare temperature, gas flows, gas concentrations) and the original files will be safely stored without any modifications. A copy will be converted into a spreadsheet using a pre-defined format and then used for ER calculations in the monitoring report.

Electronic data will be stored on-site on a computer hard drive or on a remote server operated by the equipment manufacturer (Internet). Regular data back-ups are performed.

In accordance with CDM procedures, all monitoring data will be kept for two years after the end of the crediting period or the last issuance of CERs for this project activity, whatever occurs the latest.

### Inspection and data analysis:

Daily visual inspection will be carried out by a Landfill Gas Technician. During this visit the Landfill Gas Technician checks the instrumentation and monitoring data such as gas quality, gas flow, vacuum, and flare temperature. He also analyses the data and balances the landfill gas collection system to the adequate suction rate of the landfill in order to maintain a steady gas quality. Periodically, gas quality and vacuum levels are checked at each individual gas well, using a portable meter. This allows maximising gas collection and maintaining the infrastructure.

**Project Management Organization:**
The monitoring, measurement, and reporting will be realized following the organizational structure below:

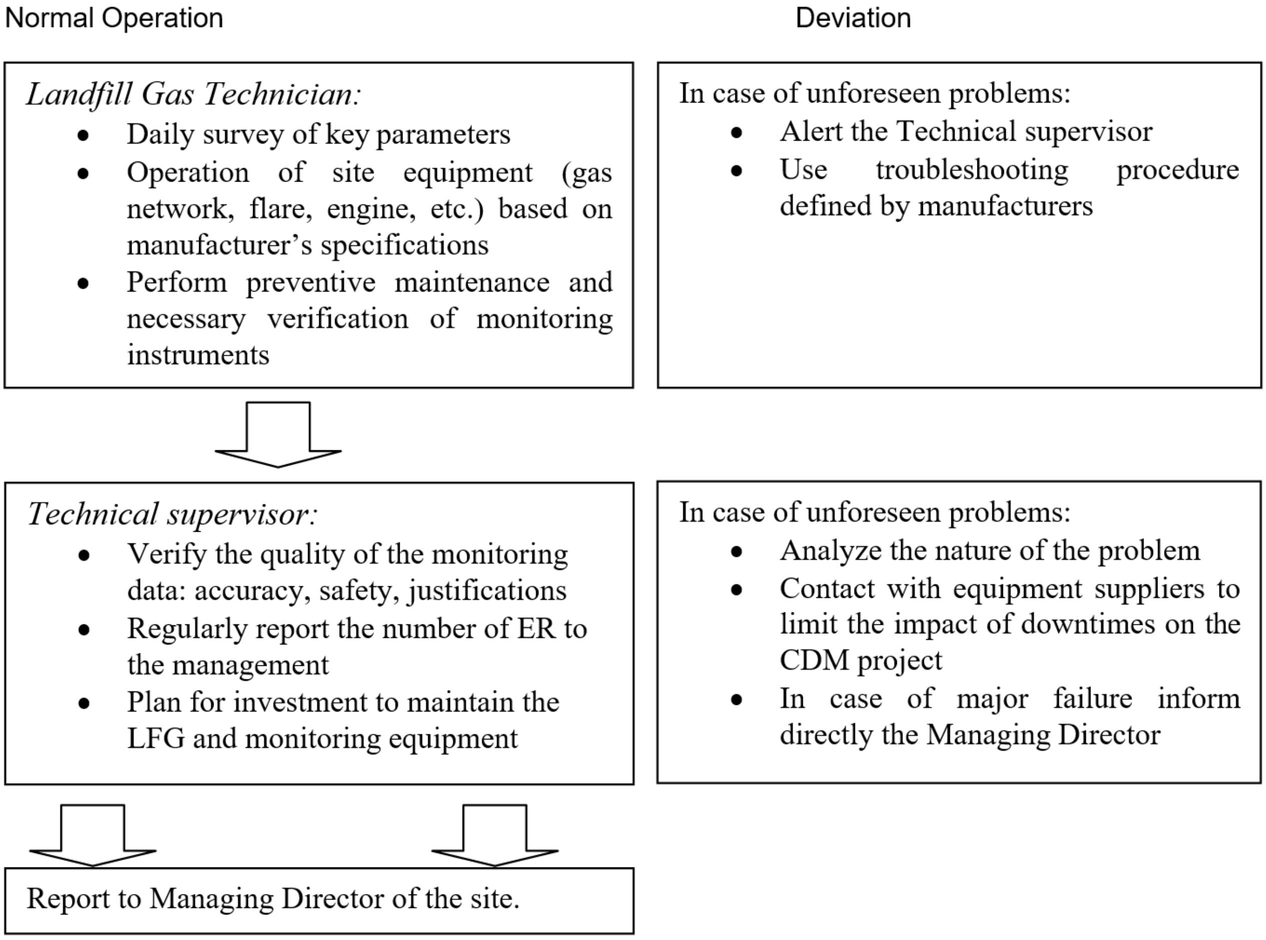


**Figure 6 – Monitoring and reporting organization**

**Training of monitoring personnel**

Employees having responsibilities under the CDM project will be trained adequately. The training will be carried out either internally or externally and will include the following items:
- maintenance of landfill gas collection, flaring and power equipment,
- maintenance and verification of monitoring equipment

**Procedure in case of failure**

If the equipment (flow meter, gas analyser, gauge, etc.) fails, the equipment supplier will be immediately notified. If possible, repairs will be carried out. If the damaged equipment cannot be repaired, it will be replaced by the same or an equivalent unit as soon as possible. In some cases, portable tools will be used in order to carry out daily monitoring of the missing parameter(s) and the data will be recorded manually on paper or in an electronic file.

The previous table specifies the alternative measurement procedures, which will be used in case of a failure of a measuring device.

The flare will be equipped with a telemetry system allowing notifying the landfill gas technician in case the flare is stopped. If a flare is stopped, no landfill gas will be burned and no credits will be claimed during this period.

The engines of the landfill gas power plant will be equipped with a valve system recording if the engine is “On” or “OFF”. If the valve is on “OFF” position, no landfill gas will be directed to that engine, ensuring that the gas going in the engine will be effectively burnt to produce electricity. No credits will be claimed if the valves of the engines are “OFF”.

## SECTION C. Start date, crediting period type and duration

### C.1. Start date of project activity

>>

Start date of the project activity = 01.02.2013
The starting date corresponds to the date when the network civil work will start and when the flare will be ordered to the manufacturer. This will be the case after the project becomes registered as a CDM project.

### C.2. Expected operational lifetime of project activity

>>

21 years and 0 months:
- The landfill site operational lifetime is estimated to last 15 years (2025);
- The site is the property of Proactiva Meio Ambiente Brasil Ltda., therefore, post-operation activities will remain onsite. The project activity can therefore continue. The project activity total duration has been expected for 21 years, which corresponds to the duration of the three crediting periods.
- Also, after 21 years (in 2034), it is expected that there will remain only 1 engine onsite, which would have been installed 13 years before. So all engines will have been properly depreciated over the project activity duration time.

### C.3. Crediting period of project activity

#### C.3.1. Type of crediting period

>>

7-year Renewable crediting period (first crediting period).

#### C.3.2. Start date of crediting period

>>

01/09/2013

#### C.3.3. Duration of crediting period

>>

7 years, 0 months (renewable twice)

## SECTION D. Environmental impacts

### D.1. Analysis of environmental impacts

>>

The project activity consists of:

- The active collection and combustion of landfill gas in a flare, and a landfill gas engine; thereby avoiding passive emissions, reducing the risk of fire and explosion and reducing odours, and trace gases emissions in the neighbourhood.
- The production of renewable electricity for the Brazilian grid, allowing for the reduction of fossil fuels used to produce part of the electricity.
- The project activity will enhance overall landfill management at Proactiva CGA Iperó landfill and reduce global and local environmental impacts that result from the uncontrolled release of landfill gas into the atmosphere. The main environmental concern due to these landfill gas emissions is linked to the content of methane (~50%), which is a greenhouse gas that significantly contributes to global warming.

In addition, emissions of landfill gas can have health and safety implications at a local level:

- Although the majority of landfill gas emissions are quickly diluted in the atmosphere, in confined spaces there is a risk of explosion and/or fire, either within the landfill or outside its boundaries.
- Landfill gas also contains trace components that can cause other local environmental effects such as odour nuisances and tropospheric ozone accumulation (summer smog).
- The project activity will contribute to the mitigation of potential negative environmental impacts of landfill gas emissions by:
- reducing methane emissions by increasing the capture rate and collection efficiency of landfill gas and by implementing landfill gas destruction platform. landfill gas destruction (in engine or in flare) is expected to have a high combustion efficiency, volatile organic compounds and ammonia should be safely eliminated. $CH_4$ burning will turn the remaining gas into $CO_2$.
- diminishing the risk of explosion and potential threat to human health, avoiding the accumulation of landfill gas in the landfill body and its environment via the creation of a dynamic and controlled gas collection system,
- contributing to the production of renewable energy, producing electricity from biogas and thereby decreasing the greenhouse gas emissions from fuels ordinarily used in the production of electricity on the Brazilian grid.

### D.2. Environmental impact assessment

>>

In accordance with the Brazilian and Paulistano legislation, an Environmental Impact Assessment (EIA) prior to any kind of construction was conducted for the implementation of the Proactiva CGA Iperó landfill. Environmental impacts are regularly assessed and controls such as the monitoring of water, air and noise are performed and reported to the responsible authority, the CETESB, Companhia Ambiental do Estado de São Paulo. No significant impact of the activity was identified.

The CETESB has also been informed about the planned project activity. The project participants will comply with all the requirements to get the required licences for landfill gas flaring and electricity production. The application for these licences will be made as soon as project detailed engineering is available. As per demonstration of additionality, such further developments require a lower level of risk concerning CDM registration and will be undertaken later during the registration process.

The CETESB confirmed orally to the PP that no additional EIA is required for the first stage of the proposed project activity. Capture and flaring of the landfill gas is considered as an extension of current landfill site management operations. In addition the EIA initially conducted for the landfill site mentioned the possibility in the future to implement landfill gas capture and flaring. It did not lead to the identification of any specific significant impact.

Regarding the second stage of the project activity, electricity generation using landfill gas, for installed capacity inferior to 10 MW, no additional EIA is required by the CETESB.

The PP will ensure to comply with the regulation and specific requests of the CETESB to obtain in time the licences needed for that stage of the project. If at that time new impacts are identified, the PP will take the necessary measures to mitigate them.

The project activity does not generate environmental impacts that have been considered significant.

# SECTION E. Local stakeholder consultation

## E.1. Modalities for local stakeholder consultation

>>

A public meeting with local stakeholders was held in Iperó on the 26th of January 2012 in order to present the proposed project activity and give room for feedback from interested parties.

Invitations letters to attend the stakeholder meeting and to comment the proposed project were sent to local stakeholders. According to the Resolution 1[23], 4[24] and 7[25] of the Brazilian DNA (CIMGC)[26], the invitation letters were sent at least 15 days before the validation process starts (i.e. publication of the PDD on the UNFCCC website for global stakeholder review). They included the project's name, a Project Idea Note (short summary of the PDD and description of the project) in Portuguese, the Internet address26 where the PDD and the document describing the project's contribution to local sustainable development (known as Annex III) are both available in Portuguese for consultation and / or download. These documents will remain available at this address at least until the registration of the project activity.

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[23] http://www.mct.gov.br/upd_blob/0023/23430.pdf

[24] http://www.mct.gov.br/upd_blob/0011/11780.pdf

[25] http://www.mct.gov.br/upd_blob/0023/23744.pdf

[26] Comissão Interministerial de Mudança Global do Clima / Interministerial Commission on Global Climate Change 26 http://www.proactiva.com.br/mdl-cga-ipero.html

The invitation letters were sent to the following stakeholders:
- City Hall of Iperó Municipality
- City Council of each involved township
- State Environmental Body: CETESB, Companhia Ambiental do Estado de São Paulo
- Municipal Environmental Bodies
- Brazilian NGO Forum and Social Movements for the Environment and Development (FBOMS www.fboms.org.br)
- Community associations whose purpose is directly or indirectly related to the project
- The State Attorney General of the involved state / for the Federal District and Territories
- Federal Attorney General

Among the invited guests, the following attended the public meeting:
- Mr. Zucker Junior, Responsible for Environmental Issues, Municipality of Iperó;
- Mr. Zananiri Cordeiro, Ipanema National Forest Director (IBAMA);
- Mr. Samuel da Silva, President of George Oetterer Neighbourhood Association;
- Mr. Donnini Mancini, Professor at the Sao Paulo State University (UNESP);
- Mr. Martins Siqueira,Executive Secretary of the NGO “Action & Citizenship” (Ação e Cidadania de Iperó);
- Mr. Cesar Fukushima, student at UNESP;
- Mr. Fachini Macluf, student at UNESP.

The stakeholder meeting took place on the 26th January 2012 at 2pm at the Iperó CGA landfill. It consisted first in a presentation of the global context of climate change, global warming and the Kyoto Protocol. In a second part, it went through the details of the particular project activity at Iperó landfill. In a third part, the participants were invited to ask questions or provide comments on the planned activity. Finally, a site visit on the landfill site was organised.

A coupon was attached to the invitation letter for people to provide comments and questions on the project if they could not attend the meeting.

A summary of the stakeholder meeting was prepared and the minutes distributed to all of the participants right afterwards. The pictures below were taken during the presentation and the site visit.

**Figure 7 Participants at the stakeholder meeting**


**Figure 8 Presentation of the project to Participants**

**Figure 9 Participants during the Landfill Site visit**

## E.2. Summary of comments received

>>
Questions and comments during the stakeholder meeting were answered in form of an open debate. A total of six questions were asked by the different guests.

Generally, the project was well perceived by the participants who recognised the positive impacts on the environment and for local communities.

Further information on leachate treatment was demanded and treatment solutions as well as the direct use of landfill gas for evaporation of the leachates were discussed.

Further information on the carbon market and the financial viability of the project in case no electricity would be generated was also sought.

Eventually, questions on the timeframe of the project were asked.

Also, one participant emphasized the fact that this project was benefiting the local environment and that the local community was supporting the project and the company for such initiative.

## E.3. Consideration of comments received

>>
All questions were addressed by providing elements of response during the meeting.

The project boundary does not include the leachate treatment facility. This choice was taken based on the current situation where leachate is sent to an external treatment facility. It was explained to the participants that even though leachate treatment is not part of the project activity, good leachate management is crucial for landfill gas capture and management and is in the interest of the project participants. Furthermore, it was explained that thermal treatment of leachate based on landfill gas is not the preferred option with regard to the projected leachate quantities and treatment cost. Currently; membrane filtration (reverse osmosis using electricity generated by the landfill gas) is the preferred option, but no final decision was taken yet.

Collection and flaring projects already exist and are economically viable with the sole CER revenues. It was pointed out that receiving CERs is tied to the principle of additionality and that these CERs should help to overcome financial barriers that prevent the project, which is the case at Iperó landfill. The average price expected (8 euros / CER) makes the project economically viable. This is also the reason why it is important to have the project registered before the end of 2012 to ensure credit eligibility to, among others, the European Emission Trading System (EU-ETS).

With regard to the duration of the project activity, it was explained that emission reductions are estimated for 21 years and cover 3 possible crediting periods of 7 years. The financial analysis was conducted over 15 years[27]; which corresponds to the projected duration of landfill gas operations at the landfill site.

The questions raised during the stakeholder meeting did not require further action and / or modifications to the project activity and / or PDD.

No written comments were received by regular mail or email from invited guests that could not take part in the stakeholder meeting. Responses will be addressed to all comments received; yet, for practical reasons, only those that will be received before the end of the Public Stakeholder Consultation will be included in the final PDD.

## SECTION F. Approval and authorization

>>

The Brazilian DNA (CIMGC) requires that the project participants submit the PDD as well as the Validation Report for review, prior to delivering the Letter of Approval.
Therefore, the Letter of Approval was not available at the time of submitting the PDD to the validating DOE.

[27] At the time of the stakeholder meeting, the financial analysis had been conducted on 15 years to match with the duration of the landfill operations. Later on during the validation process the financial analysis was conducted on 20 years. To avoid confusion and discrepancy with what stakeholders have been told during the local stakeholder meeting, “15 years” was kept here.

# Appendix 1. Contact information of project participants

| | |
|---|---|
| **Organization name** | Proactiva Meio Ambiente Brasil Ltda. |
| **Country** | Brazil |
| **Address** | Alameda Rio Negro 161 – 5°a. – Alphaville, Barueri, São Paulo |
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| **E-mail** | hahn@proactiva.com.br |
| **Website** | http://www.proactiva.com.br |
| **Contact person** | Régis, Jean, Daniel Hahn |

| | |
|---|---|
| **Organization name** | Proactiva Meio Ambiente Brasil Ltda. |
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| **Website** | http://www.proactiva.com.br |
| **Contact person** | Vincent, Cédric Rebillard |

| | |
|---|---|
| **Organization name** | First Climate (Switzerland) AG |
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| **Address** | Brandschenkestrasse 51, Zurich 8002 Switzerland |
| **Telephone** | +41 44 298 28 00 |
| **Fax** | |
| **E-mail** | focalpoint@firstclimate.com |
| **Website** | www.firstclimate.com |
| **Contact person** | Mr. Urs Broadmann |

## Appendix 2. Affirmation regarding public funding

N.A.

## Appendix 3. Applicability of methodologies and standardized baselines

N.A.

# Appendix 4. Further background information on ex ante calculation of emission reductions

### WASTE INPUT

**Table 11 Waste input at CGA Iperó Landfill**

| Year | Annual waste input (tonnes) |
|---|---|
| 2010 | 56,289 |
| 2011 | 251,631 |
| 2012 | 292,172 |
| 2013 | 334,677 |
| 2014 | 379,245 |
| 2015 | 425,942 |
| 2016 | 474,876 |
| 2017 | 504,223 |
| 2018 | 535,196 |
| 2019 | 547,500 |
| 2020 | 547,500 |
| 2021 | 547,500 |
| 2022 | 547,500 |
| 2023 | 547,500 |
| 2024 | 547,500 |
| 2025 | 547,500 |
| 2026 | - |
| 2027 | - |
| 2028 | - |
| 2029 | - |
| 2030 | - |
| 2031 | - |
| 2032 | - |
| 2033 | - |
| 2034 | - |

Source: weightbridge for historical data and commercial perspectives for future

| **WASTES** | **Value** |
|---|---|
| Wood and wood products | 3.6% |
| Pulp, paper and cardboard (other than sludge) | 11.9% |

| | |
|---|---|
| Food, food waste, beverages and tobacco ( other than sludge) | 44.5% |
| Textiles | 3.1% |
| Garden, yard and park waste | 7.0% |
| Glass, plastic, metal, other inert waste | 27.4% |
| Rubber and leather | 0.6% |
| Sewage slugde | 2.0% |

Sources: Waste composition study for the cities of Sao Paulo, San Bernardo do Campo, Sao José dos Campos and Santo André and a composition study on site to estimate C&I waste composition.

**BENCHMARK:**
Financial benchmark = Country Free Rate + Risk Premium
Country free rate can be associated with Government Bond rate.

$$\text{Brazil's Country Risk Premium} = 2.00\% \left( \frac{17.65\%}{7.32\%} \right) = 4.82\%$$

**Figure 11 Risk Premium calculation. Source: Equity Risk Premiums (ERP): Determinants, Estimation and Implications – The 2011 Edition, Aswath Damodaran**

**CALCULATION OF THE COMBINED MARGIN EMISSION FACTOR FOR THE BRAZILIAN GRID:**

Build Margin: 0.1404 t $CO_2$ / MWh
Operational Margin: 0.4727 t $CO_2$ / MWh

**Combined Margin Emission Factor = 0.1404 * 50% + 0.4727 *50% = 0.3096 t $CO_2$ /MWh**

| BUILD MARGIN | |
|---|---|
| | Average Emission Factor (tCO2/MWh) - **ANNUAL** |
| 2010 | 0.1404 |

| OPERATIONAL MARGIN | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Average Emission Factor (tCO2/MWh) - **MONTHLY** | | | | | | | | | | | |
| 2010 | MONTH | | | | | | | | | | | |
| | January | February | March | April | May | June | July | August | September | October | November | December |
| | 0.2111 | 0.2798 | 0.2428 | 0.2379 | 0.3405 | 0.4809 | 0.4347 | 0.6848 | 0.7306 | 0.7320 | 0.7341 | 0.6348 |

**Figure 1 Build and Operational Margins calculated by the Brazilian DNA (http://www.mct.gov.br/index.php/content/view/327813.html#ancora)**

**1. CASH FLOWS GENERATED BY THE PROJECT**

| | | | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Year | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 |
| | **NET INCOME** | | 0 | -587 | -849 | 58 | 246 | 249 | 418 | 379 | 498 | 584 | 389 | 413 | 458 | 451 | 86 | -529 | -970 | -1,291 | -1,147 | -1,110 | -407 |
| + | Depreciation | | 0 | 209 | 550 | 745 | 763 | 950 | 969 | 1,174 | 1,196 | 1,225 | 1,559 | 1,638 | 1,671 | 1,770 | 1,847 | 1,898 | 1,898 | 1,898 | 1,711 | 1,591 | 1,591 |
| = | **Cash flow from** | **(1)** | **0** | **-378** | **-299** | **803** | **1,008** | **1,199** | **1,387** | **1,552** | **1,693** | **1,809** | **1,948** | **2,051** | **2,129** | **2,221** | **1,932** | **1,369** | **928** | **607** | **565** | **481** | **1,184** |
| - | Capital investment and disposal | **(2)** | 0 | -4,183 | -6,041 | -3,367 | -298 | -3,004 | -279 | -3,010 | -287 | -355 | -3,740 | -698 | -296 | -794 | -536 | -405 | 0 | 0 | -405 | 0 | 0 |
| - | Change in working capital | **(3)** | 0 | 78 | 0 | -229 | -58 | -37 | -55 | -27 | -41 | -30 | -7 | -23 | -20 | -18 | 93 | 116 | 86 | 62 | 6 | 15 | 28 |
| = | **Net cash** | **(1)+(2)+(3)** | **0** | **-4,483** | **-6,339** | **-2,793** | **652** | **-1,842** | **1,053** | **-1,486** | **1,366** | **1,424** | **-1,799** | **1,331** | **1,813** | **1,410** | **1,489** | **1,080** | **1,014** | **670** | **166** | **496** | **1,211** |

**2. NET PRESENT VALUE COMPUTATION**

| *(Figures in kUS$)* | | Total | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Net Present Value at** | **8.0%:** | **-8,614** | 0 | -4,151 | -5,435 | -2,217 | 479 | -1,254 | 663 | -867 | 738 | 712 | -833 | 571 | 720 | 518 | 507 | 341 | 296 | 181 | 42 | 115 | 260 |
| **Net Present Value at** | **10.29%:** | **-9,023** | 0 | -4,065 | -5,211 | -2,082 | 441 | -1,129 | 585 | -748 | 624 | 590 | -676 | 453 | 560 | 395 | 378 | 249 | 212 | 127 | 28 | 77 | 171 |
| **Net Present Value at** | **13.00%:** | **-9,241** | 0 | -3,967 | -4,964 | -1,936 | 400 | -1,000 | 506 | -631 | 514 | 474 | -530 | 347 | 418 | 288 | 269 | 173 | 144 | 84 | 18 | 49 | 105 |

**3. INTERNAL RATE OF RETURN**

| | |
|---|---|
| **Internal Rate of Return:** | **-2.27%** |

**Figure 13 Project Investment analysis and IRR calculation**

## Appendix 5. Further background information on monitoring plan

All the information about the monitoring plan were described in section B.7.1 and B.7.2.

## Appendix 6. Summary report of comments received from local stakeholders

All the information about the comments received from local stakeholders were described in section E.1.

# Appendix 7. Summary of post-registration changes

Revised version of the PDD (version 6.0, dated 05/07/2021) includes the following post-registration changes:

- Corrections in information (that do not affect the project design):
  - Inclusion of references and details about the previously defined ex-ante determined parameters "Weighting of operating margin emissions factor" ($w_{OM}$) and "Weighting of build margin emissions factor" ($w_{BM}$) in Section B.6.2.
  - Consideration in Section B.6.1 of Option C of the methodological tool "Tool to determine the mass flow of a greenhouse gas in a gaseous stream" (version 02.0.0) as one of the alternative approaches for the determination ex-post of stream of methane in collected LFG (in addition to the previously defined Option A and Option B of such tool). Such additional alternative approach is considered by taking into account typical characteristics of both collected LFG (in terms of moisture and temperature) and normally applied related monitoring instruments/equipment (i.e. LFG flow meter and continuous $CH_4$ content gas analyzer)). Related details for the monitoring parameters $V_{t,db}$, $V_{t,wb}$, $v_{i,t,wb}$ and $v_{i,t,db}$ are also adjusted accordingly in Sections B.7.1.

  - Section A.6 (History of the project activity) is completed as required by applicable guidelines for completing the applied latest version of the CDM-PDD form.

  - Previously existent minor typo mistakes were corrected and texts were improved in different sections.

  - Information details for the project participants are updated in the cover (first page), Section A.4 and Appendix 1.

- - - - -

**Document information**

| *Version* | *Date* | *Description* |
|---|---|---|
| 11.0 | 31 May 2019 | Revision to:<br>• Ensure consistency with version 02.0 of the "CDM project standard for project activities" (CDM-EB93-A04-STAN);<br>• Make editorial improvements. |
| 10.1 | 28 June 2017 | Revision to make editorial improvement. |

| *Version* | *Date* | *Description* |
|---|---|---|
| 10.0 | 7 June 2017 | Revision to:<br>• Improve consistency with the “CDM project standard for project activities” and with the PoA-DD and CPA-DD forms;<br>• Make editorial improvement. |
| 09.0 | 24 May 2017 | Revision to:<br>• Ensure consistency with the “CDM project standard for project activities” (CDM-EB93-A04-STAN) (version 01.0);<br>• Incorporate the “Project design document form for small-scale CDM project activities” (CDM-SSC-PDD-FORM);<br>• Make editorial improvement. |
| 08.0 | 22 July 2016 | EB 90, Annex 1<br>Revision to include provisions related to automatically additional project activities. |
| 07.0 | 15 April 2016 | Revision to ensure consistency with the “Standard: Applicability of sectoral scopes” (CDM-EB88-A04-STAN) (version 01.0). |
| 06.0 | 9 March 2015 | Revision to:<br>• Include provisions related to statement on erroneous inclusion of a CPA;<br>• Include provisions related to delayed submission of a monitoring plan;<br>• Provisions related to local stakeholder consultation;<br>• Provisions related to the Host Party;<br>• Make editorial improvement. |
| 05.0 | 25 June 2014 | Revision to:<br>• Include the Attachment: Instructions for filling out the project design document form for CDM project activities (these instructions supersede the "Guidelines for completing the project design document form" (Version 01.0));<br>• Include provisions related to standardized baselines;<br>• Add contact information on a responsible person(s)/ entity(ies) for the application of the methodology (ies) to the project activity in B.7.4 and Appendix 1;<br>• Change the reference number from F-CDM-PDD to CDM-PDD-FORM;<br>• Make editorial improvement. |
| 04.1 | 11 April 2012 | Editorial revision to change version 02 line in history box from Annex 06 to Annex 06b. |
| 04.0 | 13 March 2012 | Revision required to ensure consistency with the “Guidelines for completing the project design document form for CDM project activities” (EB 66, Annex 8). |

| *Version* | *Date* | *Description* |
|---|---|---|
| 03.0 | 26 July 2006 | EB 25, Annex 15 |
| 02.0 | 14 June 2004 | EB 14, Annex 06b |
| 01.0 | 03 August 2002 | EB 05, Paragraph 12<br>Initial adoption. |

Decision Class: Regulatory
Document Type: Form
Business Function: Registration
Keywords: project activities, project design document