ECOPARQUE SERGIPE LANDFILL GAS PROJECT

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1 PROJECT DETAILS

1.1 Summary Description of the Project

The proposed VCS project activity titled “EcoParque Sergipe Landfill Gas Project” encompasses the promotion at the Ecoparque Sergipe landfill site of destruction and/or utilization and/or supply to consumer(s) of landfill gas (LFG) (rich in methane) through collection LFG and its destruction in high temperature enclosed flare(s), utilization as gaseous fuel in set of engine-generator sets of an electricity generation infrastructure (with final total combined nameplate installed capacity of 7.13 MW) and supply of upgraded[1] LFG to consumer(s) with two LFG processing and supply infrastructure of combined installed capacity of 2,500 Nm^3/h each resulting in a total combined capacity of 5,000 Nm^3/h.

As per its design configuration, combustion of collected LFG occurs in the following methane destruction device(s):

- Set of 1 high temperature enclosed flare(s), while the number of flares may be increased or reduced in the future;
- Set of 5 engine generator sets of an electricity generation infrastructure (in which collected LFG is utilized as gaseous fuel for electricity generation), that can have different power arrangements;
- One or several modular LFG upgrading and supply infrastructure with total combined LFG upgrading and supplying installed capacity of 5,000 Nm^3/h[2]. Upgraded LFG is to be supplied to consumer(s) through natural gas distribution network and/or dedicated pipeline[3].

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[1] In order to meet applicable related technical and commercial requirements for the supply of LFG to consumer(s), collected LFG suffers further treatment (upgrading) prior of being delivered to external consumer(s) as part of the proposed VCS project activity (e.g. removal of CO_2 and N_2 content and contaminants/impurities present in collected LFG, thus resulting in a gas with improved CH_4 content and reduced level of contaminants and impurities).

[2] The project’s may be implemented under a gradual/phased implementation schedule depending on procurement and construction aspects and circumstances.

[3] Share of upgraded LFG may eventually be supplied to the project’s electricity generation infrastructure (in order to be used as gaseous fuel for electricity generation as part of the proposed VCS project activity).

LFG (which is rich in methane (CH_4) has been historically generated at the Ecoparque Sergipe landfill as a result of anaerobic decomposition of municipal solid waste (MSW) disposed in this solid waste disposal site (SWDS).

By promoting effective and efficient collection and destruction/utilization/supply of LFG at the Ecoparque Sergipe landfill, the proposed VCS project activity thus aims to promote real, permanent and measurable greenhouse gas (GHG) emission reductions. It is assumed that, in the absence of the proposed VCS project activity (baseline scenario), LFG (rich in methane) would otherwise be directly emitted into the atmosphere (not destroyed/utilized/supplied). The proposed VCS project activity thus promote mitigation of CH_4 emissions. Furthermore, while electricity generation using LFG as gaseous fuel by the project's electricity generation infrastructure promotes displacement of equivalent amount of electricity that would be otherwise generated by existent power generation facility (including fossil fuel fired power plants) and addition of new power generation sources within the National Electricity Grid of Brazil. Thus, the proposed VCS project activity promotes CO_2 emission reductions associated with generation of electricity using non-conventional renewable energy source. Moreover, the supply of upgraded LFG to consumer(s) promote displacement of fossil fuel (i.e. natural gas) that would be otherwise consumed by the consumer(s) to which upgraded LFG is supplied. Thus, the proposed VCS project activity promotes additional CO_2 emission reductions associated with supply of upgraded LFG to consumer(s) (displacing consumption of fossil fuel)[4].

The Ecoparque Sergipe landfill is a well-managed landfill site located in the municipality of Rosário do Catete in Sergipe State (North-eastern region of Brazil). The landfill started its operations in year 2012. This landfill site has been operated by the host country project proponent Orizon Valorização de Resíduos S.A.

The pre-project-implementation scenario represents LFG generated at the Ecoparque Sergipe landfill (with high content of CH_4) being freely directly emitted into the atmosphere through the surfaces of the landfill and pre-project existent LFG venting drains (without any treatment, collection, continuous combustion or control and with no promotion of destruction/utilization/supply of LFG).

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[4] The following condition is applicable as per the applied CDM baseline and monitoring methodology ACM0001 (version 19.0):

> *"In the case of LFG supplied to the end-user(s) through natural gas distribution network, trucks or the dedicated pipeline, the baseline scenario is assumed to be displacement of natural gas."*

GHG emission reductions to be achieved by the VCS project activity:

By promoting permanent and real mitigations of CH_4 and CO_2, the proposed VCS project activity is expected to promote total combined GHG emission reductions of 2,729,366 tCO_2e during its 1st 7-year crediting period[5]. This value is equivalent to average annual GHG emission reductions of 389,909 tCO_2e/year.

1.2 Sectoral Scope and Project Type

The sectoral scopes applicable to the proposed VCS project activity are the following:

- 1. Energy (renewable/non-renewable)
- 13. Waste handling and disposal.

1.3 Project Eligibility

While both the sectoral scopes 1 (Energy (renewable/non-renewable)) and 13 (Waste handling and disposal) are listed as valid sectoral scopes under VCS, the applied CDM baseline and monitoring methodology ACM0001 (version 19.0) is valid/applicable for project activities under such scopes.

1.4 Project Design

☒ The project includes a single location or installation only

☐ The project includes multiple locations or project activity instances, but is not being developed as a grouped project

☐ The project is a grouped project

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[5] Under conformance with applicable VCS rules, the 1st 7-year crediting period for the proposed VCS project activity may be renewed to additional two 7-year crediting periods.

1.5 Project Proponent

Organization name	Orizon Valorização de Resíduos S.A.
Contact person	Mr. Dalton Canelhas
Title	Operational Director
Address	Av. das Nações Unidas, 12.901 8º andar | Torre Oeste Cidade Monções, São Paulo – SP, Brazil - 04578-000
Telephone	+55 (11) 5103 5300
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1.6 Other Entities Involved in the Project

Organization name	UniCarbo – Energia e Biogás Ltda.
Role in the project	General carbon technical & commercial consulting and advisory services
Contact person	Mr. Nuno Barbosa
Title	Managing Director
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Telephone	+55 (11) 98596 0950
Email	nuno@unicarbo.com.br

1.7 Ownership

The entity Orizon Valorização de Resíduos S.A. has all proof of evidence of ownership for both the Ecoparque Sergipe landfill and the proposed VCS project activity, including the following ones:

- Orizon Valorização de Resíduos S.A.
- Declaration by the Board on the operation of the Ecoparque Sergipe Landfill
- Declaration by the Board on the implementation of the VCS project activity “ECOPARQUE SERGIPE LANDFILL GAS PROJECT”

1.8 Project Start Date

The proposed VCS project activity is expected to start its operations by February/2023.

1.9 Project Crediting Period

The 1st 7-year crediting period for the proposed VCS project activity starts on 01/02/2023 and ends on 31/01/2030.

1.10 Project Scale and Estimated GHG Emission Reductions or Removals

The estimated annual GHG emission reductions/removals of the project are:

☐ <20,000 tCO_2e/year

☐ 20,000 – 100,000 tCO_2e/year

☒ 100,001 – 1,000,000 tCO_2e/year

☐ >1,000,000 tCO_2e/year

Project Scale	
Project	
Large project	X

Year	Estimated GHG emission reductions or removals (tCO_2e)
2023	322,216
2024	365,358
2025	377,931
2026	389,920
2027	401,419
2028	412,495
2029	423,203
2030	36,824
Total estimated ERs	2,729,366

Total number of crediting years	7
Average annual ERs	389,909

1.11 Description of the Project Activity

Pre-project-implementation situation at the Ecoparque Sergipe landfill:

Municipal Solid Waste (MSW) disposal at the Ecoparque Sergipe landfill has regularly occurred since year 2012. The pre-project-implementation situation (situation prior to the implementation of the proposed VCS project activity) at the Ecoparque Sergipe landfill represents the non-existence of appropriate equipment/infrastructure and/or practice dedicated to promote effective LFG management (LFG collection and destruction/utilization) at this particular landfill site, with LFG being directly vented through the surface of the landfill and through pre-project-implementation available set of rudimentary and conventional LFG venting drains available across the landfill. Thus, the pre-project-implementation situation at the Ecoparque Sergipe landfill represents the existence of a set of conventional and to some extent rudimentary passive LFG venting drains being made available in the landfill's permanent MSW disposal area in order to allow LFG existent in the landfill to be vented (in order to avoid significant accumulation of LFG in the inner section of the landfill and thus reducing the risk of fire and explosions (safety concerns)). This solution represents the existence of a solution for management of LFG at the Ecoparque Sergipe landfill which is under conformance with applicable requirements[6], but not appropriate and environmental/climate friendly.

It is assumed that in the baseline scenario (absence of the proposed VCS project activity) appropriate infrastructure for promoting effective and efficient LFG collection and destruction would remain being inexistent at the Ecoparque Sergipe landfill along its lifetime.

The baseline scenario for emissions of methane (CH_4) at the Ecoparque Sergipe landfill thus represents the continuation of the pre-project-implementation practice (generated LFG being vented (directly emitted into the atmosphere) through the surface of the landfill and trough existent rudimentary and conventional LFG venting drains).

The baseline scenario for emissions of methane in the landfill site is therefore identical to the scenario existing prior to the implementation of the proposed VCS project activity (pre-project-implementation scenario).

The previously conceived overall design, operation and management plan of the Ecoparque Sergipe landfill is not expected to be compromised or changed as a result of the implementation of the proposed VCS project activity. While no practice to increase methane generation has ever occurred at the Ecoparque Sergipe landfill, none of such practice (to increase methane generation) is expected to occur after the implementation of the proposed

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[6] Currently (July/2022) there are still no legal municipal, state or national requirements in the city of Rosário do Catete, Sergipe State nor in the country of Brazil (respectively) that establish any requirement or guidance in terms of LFG management in new or existing landfills or waste dumpsites.

VCS project activity either. As required by the applied baseline and monitoring methodology ACM0001 (version 19.0), the occurrence or planning of any kind of change in the management of the Ecoparque Sergipe landfill during the time period to be encompassed by operation of the proposed VCS project activity is to be reported and is to be justified by referring to applicable technical or regulatory specifications.

Technology and measures encompassed by the project design:

Employed technology encompasses implementation of appropriate LFG collection, LFG flaring, electricity generation infrastructure fueled by LFG as well as infrastructure for supply of upgraded LFG to consumer(s) (through natural gas distribution network and/or dedicated pipeline) at the Ecoparque Sergipe landfill.

Infrastructure to be implemented as part of the proposed VCS project activity encompasses the following:

- an active LFG collection system composed by LFG collection wells;
- LFG transportation pipeline network;
- Set of 1 high temperature enclosed flare(s);
- Set of 5 engine-generator sets and remaining ancillary devices of the project’s electricity generation infrastructure;
- A modular LFG upgrading and supply infrastructure with combined infrastructure of combined installed capacity of 5,000 Nm^3/h[7] [8].

The implementation and operation of the proposed VCS project activity will allow methane contained in the LFG to be efficiently destroyed/utilized though controlled combustion and/or through supply to consumer(s), thus avoiding emissions of methane into the atmosphere and, due to that, promoting real and permanent GHG emission reductions.

Furthermore, additional GHG emission reductions are promoted through:

- Generation of electricity through the utilization of LFG as a renewable energy source (with generated electricity displacing equivalent amount of electricity that would be otherwise generated in existent grid-connected electricity generation sources (including fossil fuel fired power generation sources) and addition of new power generation sources within the National Electricity Grid of Brazil)

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[7] The project’s may be implemented under a gradual/phased implementation schedule depending on procurement and construction aspects and circumstances.

[8] While the way upgraded LFG will be supplied to consumer(s) is yet to be defined (it depends on yet to be addressed commercial and technical aspects), the design for the proposed VCS project activity currently considers the supply of upgraded LFG to consumer(s) through one of the following options (or even eventual combination of options):

i) Supplying the LFG to consumers through a natural gas distribution network;

ii) Supplying the LFG to consumers through a dedicated pipeline;

While options (i) and (ii) are all covered by the applied methodological approaches of the applied CDM baseline and monitoring methodology ACM0001 (version 19.0) + applicable CDM methodological tools, this VCS PD considers the above-summarized 2 options in the particular context of project design description as well as the applied approaches for determining baseline emissions and project emissions.

- Supplying of upgraded LFG to consumer(s) (with supplied upgraded LFG displacing fossil fuel (i.e. natural gas) that would be otherwise utilized for meeting consumer(s)'s energy demand).

The project system is to be equipped with all needed monitoring system to ensure that all required monitoring related measurements are performed under full conformance with requirements established by the applied CDM baseline and monitoring methodology ACM0001 (version 19.0) and applicable CDM methodological tools. Monitoring activities will include continuous measurement of LFG flow to the flare(s) and/or engine-generator sets and/or infrastructure for promoting upgrading and supply of LFG to consumer(s), continuous monitoring of methane content in collected LFG, continuous monitoring of operational conditions/status of the flare(s) and/or engine-generator sets combusting LFG (project's methane destruction devices) and/or infrastructure for promoting upgrading and supply of LFG to consumer(s). The amount of electricity generated as well as consumption of electricity by the proposed VCS project activity will also be measured. Finally, measurements and monitoring required for the determination of project emissions associated to the supply of upgraded LFG to consumer(s) (e.g. through natural gas distribution network and/or dedicated pipeline) will also be performed under conformance with the applied CDM baseline and monitoring methodology ACM0001 (version 19.0) and/or applicable CDM methodological tools.

In summary, the project technology is environmentally safe and sound.

Project's infrastructure:

LFG flaring equipment:

The design and construction for the proposed VCS project activity encompass the following characteristics/technology that aim to promote efficient and controlled combustion of collected LFG through flaring:

- Combustion of LFG under controlled, safe and efficient (with very low CH_4 fugitive emissions) conditions are guaranteed by the utilization of high temperature enclosed flare(s).
- Use of best practice safety devices for the flare(s) (such as flame detector(s) and slam shut valve(s)).
- Continuous measurement of temperature of the exhaust gas of each individual flare (with continuous monitoring of the flare status (with every minute recording of the status signal of flame detector(s)) being available.

While the applied CDM baseline and monitoring methodology ACM0001 (version 19.0) and applicable CDM methodological tool requires ex-post monitoring whether flaring equipment combusting LFG operates under compliance with operational requirements and/or recommendations as set by equipment (flare manufacturer), the main operational characteristics and specifications of the high temperature enclosed flares currently installed as part of the project activity[9] [10] are defined as follows:

LFG combustion flaring equipment	Characteristics/specifications
Flare 1	Manufacturer: Biotecnogás srl Model: 5000HT Min. LFG flaring capacity (for continuous operation): Flow rate of 1,000 Nm^3/h Max. LFG flaring capacity (for continuous operation): Flow rate of 5,000 Nm^3/h Min. CH_4 destruction efficiency: 99.5% Required min. temperature of the exhaust gas of the flare (to ensure LFG destruction

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[9] The currently considered number of flares may to be installed as part of the proposed VCS project activity (1 high temperature enclosed flare) represent the only equipment combusting LFG installed as part of the project activity for which compliance with applicable operational specifications/requirements (as established by equipment manufacturer) should be monitored as per applicable guidance of the CDM baseline and monitoring methodology ACM0001 (version 19.0) and applicable CDM methodological tool.

[10] The project proponent Orizon Valorização de Resíduos S.A. acknowledges that more (or even less) than one high temperature enclosed flare may be eventually temporarily or permanently in place as part of the project activity in order to fully accommodate previously projected potential amount of LFG to be collected and projected increase in the amount of LFG. This is in accordance to the project design conceptualization (which considers gradual installation of additional flare(s) and other equipment (e.g. centrifugal blower(s)) within the project lifetime in order to eventually address forecasted increase in LFG collection to be flared as part of the proposed VCS project activity.

Besides the flares and the engine-generator sets, this VCS PD does not include detailed specifications and maintenance requirements for other equipment which are part of the project activity (e.g. centrifugal blower(s), CH_4 content gas analyzer unit, LFG pressure and temperature sensors, thermocouple(s) (for measuring temperature of the exhaust gas of the flare(s)), infrastructure for upgrading and supplying LFG to consumer(s), etc.). While, differently than the case of the high temperature enclosed flares, compliance of specific maintenance requirements and specifications for such additional equipment of the project's LFG collection and destruction/utilization infrastructure are not required to be monitored through dedicated monitoring parameters, it is important to note that such equipment may be eventually changed during the project's lifetime (due to eventual malfunction, maintenance schedules, calibration events, etc.). The non-inclusion of specification and maintenance details of such additional equipment in the VCS PD is in accordance with applicable VCS and/or CDM rules and requirements (incl. requirements of the CDM baseline and monitoring methodology ACM0001 (version 19.0) and applicable guidelines for completing the VCS PD for a proposed VCS project activity). Details about such additional ancillary equipment (incl. monitoring instruments/equipment) will be later made available in Monitoring Reports to be completed for regular monitoring periods for the proposed VCS project activity upon its registration.

	under high CH_4 destruction efficiency): 850 °C Required max. temperature of the exhaust gas of the flare (to ensure LFG destruction under high CH_4 destruction efficiency): 1,200 °C Required frequency for inspection service (incl. inspection in the conditions of the flare's isolation ceramics revetment material): every year

Source: Equipment technical declarations made available by Biotecnogás srl.

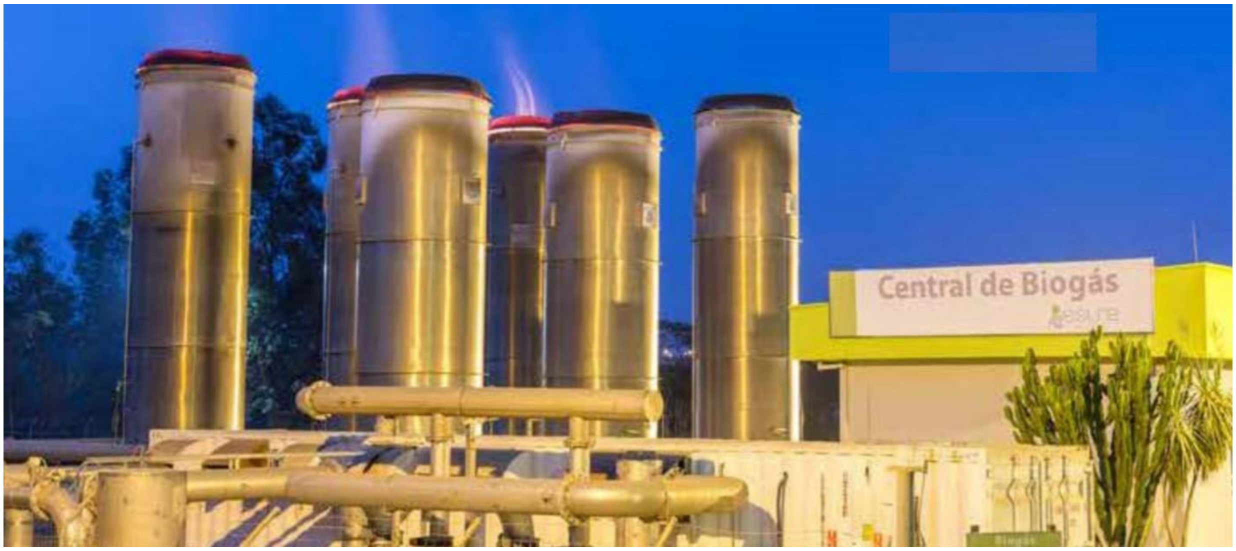

Figure 1 – View of high temperature enclosed flares similar to the one to be installed as part of the proposed VCS project activity.

Source: Orizon Valorização de Resíduos S.A.

Electricity generation infrastructure:

As part of the proposed VCS project activity, collected LFG will be utilized as gaseous fuel for electricity generation in a set of 5 engine-generators fully powered by LFG that represents the major components of the project's electricity generation infrastructure.

The state-of-the-art engine-generator manufactured in Austria by GE Jenbacher GmbH & Co OHG, or equivalent, has individual nameplate power generation capacity of about 1.4 MW.

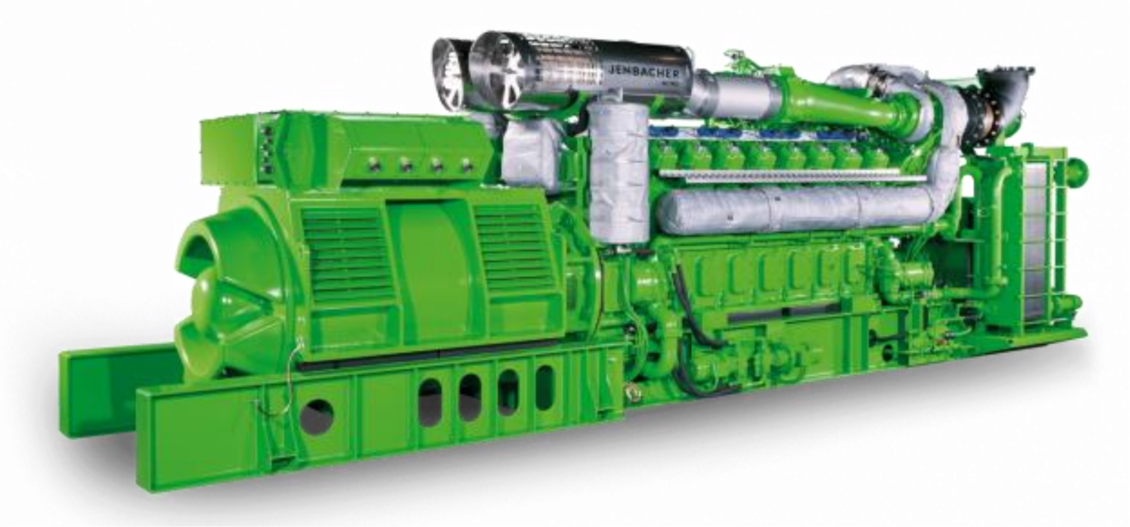

Figure 2: View of an engine-generator set Type 4, G-420 series engine-generator set manufactured by GE Jenbacher GmbH & Co OHG

Source: GE Jenbacher GmbH

The GE Jenbacher lean-burn engine-generator sets fuelled by LFG have CH_4 destruction efficiency in the range of 99.5%[11]. The engine-generator sets are to be assembled under a container-based modular power generation package set design. Each container includes ancillary equipment (cooling fan, coolant radiator, control & safety systems, etc.).

Infrastructure for the supply of upgraded LFG to consumer(s):

As part of the proposed VCS project activity, collected LFG will be upgraded and supplied to consumer(s) through the installation and operation of a modular LFG upgrading and supplying infrastructure. In order to meet applicable related technical and commercial requirements for upgraded LFG, collected LFG suffers further treatment (upgrading) prior of being delivered to external consumer(s) (e.g. removal of CO_2 and N_2 content present in collected LFG) thus resulting in a gas with improved CH_4 content and reduced level of contaminants and impurities. Upgraded LFG may eventually be supplied to the project's electricity generation infrastructure in order to be alternatively used as gaseous fuel for electricity generation as part of the proposed VCS project activity.

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[11] Source: Publicly available declaration from GE Power & Water Jenbacher Gas Engines – USA. Available online: https://www.linquip.com/device/8945/gas-engine-generator-set-j420

The total combined nameplate LFG processing capacity of the project's modular LFG upgrading and supplying infrastructure is 5,000 Nm^3/h[12].

Figure 3: View of modular infrastructure for upgrading and supplying LFG to consumer(s) similar to the one to be installed as part of the proposed VCS project activity

Source: Greenlane Biogas

Consumption of electricity by the project activity:

As per the project design, electricity demand for the proposed VCS project activity is to be met by consumption of grid-sourced electricity, by electricity sourced by the project's electricity generation infrastructure and/or by backup captive off-grid electricity generator (fuelled by diesel).

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[12] While the way upgraded LFG will be supplied to consumer(s) is yet to be defined (it depends on yet to be addressed commercial and technical aspects), the design for the proposed VCS project activity currently considers the supply of upgraded LFG to consumer(s) through one of the following options (or even eventual combination of options):

i) Supplying the LFG to consumers through a natural gas distribution network;

ii) Supplying the LFG to consumers through a dedicated pipeline;

While options (i) and (ii) are all covered by the applied methodological approaches of the applied CDM baseline and monitoring methodology ACM0001 (version 19.0) + applicable CDM methodological tools, this VCS PD considers the above-summarized 2 options in the particular context of project design description as well as the applied approaches for determining baseline emissions and project emissions.

The backup electricity generator is expected to be activated automatically (through automatic switching control) whenever supply of grid-sourced electricity to the project activity is interrupted. An automatic switching control will not allow the backup electricity generator being connected to the electricity grid. Thus, under no circumstance the project's electricity demand can be met simultaneously by grid-sourced electricity and by backup electricity generator (fuelled by diesel).

In summary, the project's electricity demand can technically be met by one of the following sources/approaches:

- Imports of grid-sourced electricity, or
- Electricity sourced by the project's electricity generation infrastructure,
- Electricity sourced by a yet to be installed backup captive off-grid electricity generator (fuelled by diesel) (expected to occur only during temporary planned or unplanned circumstances when supply of grid-sourced electricity is temporarily interrupted).

Expected lifetime for the proposed VCS project activity:

The expected operational lifetime for the project's LFG collection and destruction/utilization infrastructure is at least 25 years. However, related equipment and infrastructure lifetime may even exceed 25 years if required service and maintenance is performed correctly and in case the project activity is always operated as per recommendation and requirements set by manufacturers/suppliers of included equipment/instruments.

Technology transfer:

While the project's high temperature enclosed flare(s), engine-generator sets and some of the monitoring instruments may be imported equipment/instruments, the proposed VCS project activity is expected to also use domestically manufactured components (equipment, instruments, etc.). While all currently existent LFG collection and destruction/utilization initiatives under operation in landfills located in Brazil were implemented (or are currently being implemented/validated) as project-based initiatives under the GHG emission reduction schemes/standards (e.g. CDM, VCS, and/or under other GHG abatement schemes/standards), such project activities indeed involve transfer of technology and improvements in practices for LFG management to the host-country Brazil.

No change in the design and operational conditions of the Ecoparque Sergipe landfill:

Design and operational aspects of the Ecoparque Sergipe landfill are not expected to be change during the operational lifetime of the proposed VCS project activity. The Ecoparque Sergipe landfill is expected to still being operated with the application of the same and previously applied MSW landfilling technics and procedures.

The Ecoparque Sergipe landfill was designed and has been operated under conformance with its related design, construction, operational and management specifications and requirements (as detailed and specified in environmental permits and licenses applicable for this particular landfill site). Applied design and operational pattern represents the best available practices for landfill construction and operation in Brazil.

The whole management and operation plan of the Ecoparque Sergipe landfill has been approved and has been regularly monitored by the competent environmental authority of Sergipe State.

The Ecoparque Sergipe landfill is regarded as a very well-designed and very well-managed landfill. As established by the valid environmental and operational permits, disposed MSW is constantly covered and levelled with the use of heavy equipment (excavators, compacting equipment, etc.). Furthermore, safety requirements are defined and addressed as part of the operation of the landfill by using a preventative approach.

1.12 Project Location

Physical/Geographical location of the proposed VCS project activity:

The landfill hosting the proposed VCS project activity is the is the Ecoparque Sergipe landfill, which is located aside the margins of the Governador Mário Covas highway, 212, Rosário do Catete – SE.

The project's geographical coordinates are as follows:

- Latitude: 10°41'50.6"S or -10.6973
- Longitude: 37°02'49.1"W or -37.0469

1.13 Conditions Prior to Project Initiation

While the baseline scenario for methane emissions, generation of electricity and consumption of fuel by consumer(s) for the proposed VCS project activity represents the pre-project-implementation situation at the Ecoparque Sergipe landfill in terms of management and utilization of LFG, electricity generation occurring in existent electricity generation sources within the National Electricity Grid of Brazil and consumption of natural gas by consumer(s) respectively, the stepwise identification of the baseline scenario for the proposed VCS project activity (under conformance with the applied CDM baseline and monitoring methodology ACM0001 (version 19.0) and applicable CDM methodological tools) is presented in Section 0 (Baseline Scenario).

1.14 Compliance with Laws, Statutes and Other Regulatory Frameworks

The stepwise identification of the baseline scenario for the proposed VCS project activity (under conformance with the applied CDM baseline and monitoring methodology ACM0001 (version 19.0) and applicable CDM methodological tools) includes identification and demonstration of compliance of the proposed VCS project activity with all and any eventually existent and applicable local, regional and national regulations, laws. The stepwise identification of the baseline scenario for the proposed VCS project activity is presented in Section 0 (Baseline Scenario).

1.15 Participation under Other GHG Programs

1.15.1 Projects Registered (or seeking registration) under Other GHG Program(s)

The proposed VCS project activity was not previously registered and did not seek registration under any other GHG program.

1.15.2 Projects Rejected by Other GHG Programs

While the proposed VCS project activity did not seek previous registration under any other GHG program, it was thus not previously rejected by any other GHG program.

1.16 Other Forms of Credit

1.16.1 Emissions Trading Programs and Other Binding Limits

Does the project reduce GHG emissions from activities that are included in an emissions trading program or any other mechanism that includes GHG allowance trading?

☐ Yes ☒ No

The proposed VCS project activity does not aim to reduces GHG emissions from activities that are currently included in an emissions trading program or any other mechanism that includes GHG allowance trading as there are currently none of such program and/or mechanism in the host-country Brazil. Thus, upon conformance with currently valid and applicable climate change regulations in Brazil, GHG emission reductions generated by the proposed VCS project activity are not expected to be used for compliance under such programs and/or mechanisms[13] [14].

1.16.2 Other Forms of Environmental Credit

Has the project sought or received another form of GHG-related credit, including renewable energy certificates?

☐ Yes ☒ No

The proposed VCS project activity has not (and is not expected to) sought or received another form of GHG-related environmental credit, including renewable energy certificates (RECs).

1.17 Sustainable Development Contributions

Environmental and climate change positive aspects of the proposed VCS project activity and contribution of the proposed VCS project activity towards Sustainable Development locally and in the whole country Brazil:

While methane is a powerful greenhouse gas (GHG), the pre-project-implementation situation of emission of LFG into the atmosphere contributes to climate change. Collection and destruction/utilization of LFG will promote real and permanent abatement of GHG emissions at the Ecoparque Sergipe landfill. Furthermore, by promoting electricity generation through the utilization of LFG as a renewable energy source, the proposed VCS project activity also promotes displacement of electricity that would be otherwise generated by existent grid-connected electricity generation sources (including fossil fuel fired power generation sources) and addition of new power generation sources along the baseline scenario. In addition, by promoting supply of upgraded LFG to consumer(s) (through natural gas distribution network and/or dedicated pipeline), the proposed VCS project activity also promotes displacement of fossil fuel (e.g. natural gas) that would be otherwise consumed by such consumer(s) along the baseline scenario. Moreover, the supply of upgraded LFG to consumer(s) displaces consumption of fossil fuel natural gas that would otherwise occur.

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[13] In case Voluntary Carbon Units (VCUs) to be issued as a result of the operation of the proposed VCS project activity are to be used in the context of Paris Agreement Article 6 mechanisms and international Paris related programs (such as CORSIA), it will be opportunely demonstrated that such VCUs meet any and all relevant requirements established under such mechanisms and programs. That will include any requirement relating to double counting and corresponding adjustments. Thus, if applicable, the project proponent Orizon Valorização de Resíduos S.A. will demonstrate adherence to such requirements by applying the relevant VCU label to their VCUs in the Verra Registry.

[14] In case GHG emission reductions from the proposed VCS project activity be in the future included in an emissions trading program and/or any other mechanism that includes GHG allowance trading, in line with currently applicable VCS rules and procedures, appropriate evidence will be provided by the project proponent Orizon Valorização de Resíduos S.A. that the GHG emission reductions generated by the proposed VCS project activity have not and will not be otherwise counted or used under such program or mechanism. As established by applicable VCS rules, such evidence may include:

(a) a letter from the program operator, designated national authority or other relevant regulatory authority that emissions allowances (or other GHG credits used in the program) equivalent to the reductions generated by the proposed VCS project activity have been cancelled from the program or national cap, as applicable.

(b) evidence of the purchase and cancellation of GHG allowances equivalent to the GHG emissions reductions or removals generated by the proposed VCS project activity related to the program or national cap.

(c) evidence from the program operator, designated national authority or other relevant regulatory authority stating that the specific GHG emission reductions generated by the proposed VCS project activity are not within the scope of the program or national cap.

Besides climate change mitigation, the project activity provides other important local environmental benefits: LFG contains trace amounts of volatile organic compounds, which are regarded as local air pollutants. Capturing of LFG using an active forced collection system and its destruction/utilization by combustion thus also promote reduction of emission of local pollutants.

The proposed VCS project activity also provides the following additional important local environmental and social benefits:

- Destruction of other air pollutants, such as hydrogen sulphide, that is present in trace quantities in LFG.
- Improved LFG management at the Ecoparque Sergipe landfill promotes reduction of risks of occurrence of fire and explosion at the landfill as well as reduction of odour.
- Promotion of local job opportunities.

Once it reaches its operational status, the proposed VCS project activity will be able to be used as a technological demonstration initiative in terms of appropriate and environment-friendlier management of LFG as part of operation of a landfill, generation of electricity by using non-conventional renewable energy source and/or supply of gaseous energy source to consumer(s). It is the intention of the project proponent Orizon Valorização de Resíduos S.A. to eventually establishing cooperation agreements with local NGOs, academia and community in order to demonstrate and promote this type of project in other landfills in Brazil.

In summary, the proposed VCS project activity contributes towards Sustainable Development in Brazil.

1.18 Additional Information Relevant to the Project

Leakage Management

While the proposed VCS project activity promotes collection (recovery) of LFG and its destruction/utilization/supply, there is no sources of leakage to be considered. Furthermore, as per the applied CDM baseline and monitoring methodology ACM0001 (version 19.0), no leakage effects (i.e. leakage sources and leakage emissions) are to be considered by project activities applying this methodology.

Commercially Sensitive Information

Not applicable. There is no commercially sensitive information to be excluded from the public version of this VCS PD.

Further Information

Not applicable. There is no additional relevant legislative, technical, economic, sectoral, social, environmental, geographic, site-specific and/or temporal information that may have a bearing on the eligibility of the project, the net GHG emission reductions or the quantification of net GHG emission reductions for the proposed VCS project activity.

2 SAFEGUARDS

2.1 No Net Harm

In accordance with applicable Brazilian environmental regulations, it is the responsibility of the environmental agency of the State (province) to approve the overall environmental aspects for initiatives in landfills in the context of applicable environmental licensing procedure for such initiatives. The environmental authority in Sergipe State is Administração Estadual do Meio Ambiente (ADEMA). In Brazil, in the particular case of environmental licensing for construction and operation of landfills, normally, the implementation of an initiative promoting forced extraction of LFG and its destruction/utilization may not require any dedicated or separated additional environmental licensing procedure (including development and approval of an Environmental Impact Assessment (EIA)).

In general, the expected environmental aspects for the proposed VCS project activity are positive (with minor negative environmental impacts) and they can be summarized as follows:

- The project will have a positive influence on the local environment by promoting the destruction of gases like H_2S and derivatives of methane, mercaptans and other chemical compounds that result in bad odors and sanitary risks in the neighbouring populations: such as diseases and asthma due to the air pollution.
- Efficient collection and destruction of LFG will reduce risks of explosion in the landfill site. Indeed, in the presence of a specific proportion of oxygen, the methane contained in the landfill gas can become explosive. Due to that, the proposed VCS project activity will be operated with continuous monitoring and control of the oxygen content of collected LFG which is sent to the project's methane destruction devices, thus continuously controlling the risk of explosions.
- The operation of enclosed high temperature flares can generate noise and vibration in case of operational problems. As part of the operation of the project activity, it will be ensured that the installed flare(s) always operate in accordance with the operational requirements and conditions as established by the equipment manufacturer. That will minimize the occurrence of noise and vibration that could negatively affect working staff of the landfill and people living in the surrounding areas.

2.2 Local Stakeholder Consultation

The Project owner collected comments by local stakeholders on the project activity. Survey questionnaires were distributed to relevant personnel of the landfill site, local villagers and government officials by the Project owner on 15/07/2022. The survey questionnaire was designed to assess the project impacts on the local environment and social economic development. The structure of the survey respondents is listed in Table 2-1 below.

In general, local stakeholders are supportive of the project construction. The survey shows that a majority of local stakeholders think the Project will help improve the life of local people and promote local economic development without much adverse environmental impact. The survey shows that almost all of the stakeholders are supportive to the proposed project, believing that the Project will provide more employment opportunities, help local economic development, and increase local power supply.

Therefore, the implementation of the Project is regarded as beneficial by most of the local stakeholders.

Local Stakeholder Consultation during the project implementation stage: Communications with local stakeholders are being carried out at periodic intervals. Key implementation schedules or changes of the project will be communicated to the local authority, who will inform the neighbourhood committee and the local residents, the comments and suggestions from residents will be collected by the local authority meanwhile. And the local government agencies and competent authorities will conduct spot checks on the implementation of the project from time to time and give suggestions on the involved rectification problems. In line with VCS requirements all the processes have been implemented to receive comments from local stakeholders as well as communicate with them at periodic intervals.

2.3 Environmental Impact

Not applicable.

2.4 Public Comments

No public comments were received.

2.5 AFOLU-Specific Safeguards

Not applicable. The proposed VCS project activity is not an AFOLU project.

3 APPLICATION OF METHODOLOGY

3.1 Title and Reference of Methodology

While the Clean Development Mechanism (CDM) is a GHG program approved by VCS, the following CDM baseline and monitoring methodology is applied:

- Consolidated baseline and monitoring CDM methodology ACM0001 - "Flaring or use of landfill gas" (version 19.0)

  (https://cdm.unfccc.int/methodologies/DB/JPYB4DYQUXQPZLBDVPHA87479EMY9M)

The following CDM methodological tools are also applied:

- Emissions from solid waste disposal sites (version 08.0) (https://cdm.unfccc.int/methodologies/PAmethodologies/tools/am-tool-04-v8.0.pdf)

- Baseline, project and/or leakage emissions from electricity consumption and monitoring of electricity generation (version 03.0) (https://cdm.unfccc.int/methodologies/PAmethodologies/tools/am-tool-05-v3.0.pdf)

- Project emissions from flaring (version 04.0) (https://cdm.unfccc.int/methodologies/PAmethodologies/tools/am-tool-06-v4.0.pdf)

- Tool to determine the mass flow of a greenhouse gas in a gaseous stream (version 03.0) (https://cdm.unfccc.int/methodologies/PAmethodologies/tools/am-tool-08-v3.0.pdf)

- Tool to calculate the emission factor for an electricity system (version 07.0) (https://cdm.unfccc.int/methodologies/PAmethodologies/tools/am-tool-07-v7.0.pdf/history_view)

- Combined tool to identify the baseline scenario and demonstrate additionality (version 07.0) (https://cdm.unfccc.int/methodologies/PAmethodologies/tools/am-tool-02-v7.0.pdf)

- Common practice (version 03.1) (https://cdm.unfccc.int/methodologies/PAmethodologies/tools/am-tool-24-v1.pdf)

- "Project and leakage emissions from the transportation of freight" (version 01.1) (https://cdm.unfccc.int/methodologies/PAmethodologies/tools/am-tool-12-v1.1.0.pdf)

- "Tool to calculate project or leakage CO_2 emissions from fossil fuel" (version 03.0) (https://cdm.unfccc.int/methodologies/PAmethodologies/tools/am-tool-03-v3.pdf)

3.2 Applicability of Methodology

The approved baseline and monitoring methodology ACM0001 (version 19.0) is applied.

In addition, the CDM methodological tools listed in Section 3.1 (which are referred by this CDM baseline and monitoring methodology or by one of the applied CDM methodological tools) are also applied. Demonstration applicability conditions for ACM0001 (version 19.0) and for all methodological tools referred in Section 3.1 are included in the tables below:

Applicability Condition of CDM baseline and monitoring methodology ACM0001 – "Flaring or use of landfill gas" (version 19.0)	**Justification**
"The methodology is applicable under the following conditions: *(a) Install a new LFG capture system in an existing or new (Greenfield) SWDS where no LFG capture system was or would have been installed prior to the implementation of the project activity; or* *(b) Make an investment into an existing LFG capture system to increase the recovery rate or change the use of the captured LFG, provided that:* *(i) The captured LFG was vented or flared and not used prior to the implementation of the project activity; and* *(ii) In the case of an existing active LFG capture system for which the amount of LFG 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 LFG capture and flared is available;* *(c) Flare the LFG and/or use the captured LFG in any (combination) of the following ways:* *(i) Generating electricity;* *(ii) Generating heat in a boiler, air heater or kiln (brick firing only) or glass melting furnace; and/or*	The project design encompasses the installation of an active (forced) LFG capture system in an existing SWDS partially where no LFG capture system was previously installed with utilization, as part of the proposed VCS project activity, of collected LFG for electricity generation and with collected LFG being upgraded and supplied to consumer(s) (through natural gas distribution network and/or dedicated pipeline) also being encompassed by the proposed VCS project activity. In this sense, condition (a) of the quoted applicability criteria is met. It is important to note that, under the pre-project-implementation situation, there is no active/forced LFG capture system that has been in operation with LFG generated in the Ecoparque Sergipe landfill being directly vented into the atmosphere through the surface of the landfill and by existent rudimentary and conventional LFG venting drains (with no regular combustion of LFG occurring in such drains). The project design encompasses collection of LFG and its destruction/utilization through combustion in the high temperature enclosed flare(s), utilization of LFG as gaseous fuel for electricity generation in the engine-generator sets of the project's electricity generation infrastructure and supply of upgraded LFG to consumer(s) (through natural gas distribution network and/or dedicated pipeline). Thus, the

(iii) Supplying the LFG to consumers through a natural gas distribution network; *(iv) Supplying compressed/liquefied LFG to consumers using trucks;* *(v) Supplying the LFG to consumers through a dedicated pipeline;* *(d) Do not reduce the amount of organic waste that would be recycled in the absence of the project activity.”*	project activity fully fulfills condition (c-i), (c-iii) and (c-v). As a result of the implementation of the proposed VCS project activity, no quantitative, qualitative, procedural or regulatory change are expected to occur in terms of MSW management activities and policies valid for the Ecoparque Sergipe landfill and/or applicable in any other potential waste treatment or disposal facility under the area of influence of this landfill (that would be promoted or triggered by the proposed VCS project activity) in comparison with what would occur in the absence of the proposed VCS project activity (baseline scenario). It is crucial to note that, mainly by taking into consideration the nature of the proposed VCS project activity and aspects related to recycling of organic fraction of MSW in the region of landfill and in the rest of Brazil, the implementation of the proposed VCS project activity per se is not expected to promote or trigger any quantitative change in waste disposal activities undertaken at the Ecoparque Sergipe landfill. Furthermore, no quantitative or qualitative changes in terms of waste management practices are expected to be promoted or triggered in any other existent or potential waste disposal or waste treatment facility (located or to be located in the region of influence of the Ecoparque Sergipe landfill) as a direct outcome or consequence of the implementation and operation of the proposed VCS project activity. Thus, the mere implementation of the proposed VCS project activity and its operation are not expect to promote or trigger any reduction (or prevention) in the amount of

	organic type of MSW (or any other type of solid waste) that would eventually be recycled and/or reused in the region of influence of the Ecoparque Sergipe landfill (e.g. no prevention by the proposed VCS project activity of the implementation or and non-promotion of any reduction of activity in an eventually existent or hypothetical waste composting facility that would promote reuse/recycling of waste in the region (for example)). As demonstrated in the applicable construction, design and operational requirements valid for the Ecoparque Sergipe landfill, this landfill is not expected to include any activity or initiative promoting recycling or reuse of organic fraction of waste disposed at this landfill (i.e. such as implementation of a large scale waste sorting or waste composting facility for example). Without any relevant organic waste recycling activity or initiative being under operation within the limits of the Ecoparque Sergipe landfill, it is thus clearly not expected that the implementation of the project activity could per se eventually reduce organic waste recycling activities in the Ecoparque Sergipe landfill. It is imperative to note that design, construction and operational aspects for the Ecoparque Sergipe landfill were previously defined in accordance with the commercial agreements that the project proponent and landfill owner Orizon Valorização de Resíduos S.A. currently holds and is expected to hold in the position of the current operator and owner of the Ecoparque Sergipe landfill and as regional waste management company (service provider) providing MSW disposal services.

	Furthermore, it is also crucial to take into account that currently there is not even any existent or planned large-scale MSW sorting, recycling or utilization facility for organic fraction of MSW (e.g. a large-scale waste composting plant) with comparable size/capacity and located in the region of influence of the Ecoparque Sergipe landfill either. As a matter of fact, recycling and reuse of organic fraction of MSW is still not being a common practice in the whole country of Brazil. In this sense, the implementation the proposed VCS project activity per se does not represent any perverse incentive or driver for the promotion of any supposed quantitative or qualitative reduction or prevention of waste recycling related activities (or initiatives for any type of organic fraction of solid waste or solid residues) that would occur in the region of influence of this landfill[15] in the absence of

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[15] As per the Brazilian Federal Law 12.305/10 (passed in year 2010), waste recycling is defined as a process of transformation of waste material and residues through promotion of changes in their physical, chemical or biological properties in order to allow and promote use/utilization of such materials as raw material or even as new products. Although waste recycling is being regarded in the national sector directives for waste management as a priority goal in the whole country, solid waste recycling initiatives in Brazil are still being quite limited (especially in the case of organic fraction of MSW) mainly due to economic restrictions. As outlined in the publication "*Panorama dos Resíduos Sólidos no Brasil – 2020*" (tittle translated into English language as "*Outlook of Solid Waste Sector in Brazil – year 2020"* and available online at: https://abrelpe.org.br/panorama-2020/), solid waste recycling initiatives in Brazil have encompassed mainly the following by-products/waste types with higher economic value:

- aluminum (mainly beverage aluminum cans),
- pre-separated/sorted clean (not contaminated) paper,
- pre-separated/sorted (not contaminated) plastic material (mainly PET beverage bottles),
- glass material.

The "*Panorama dos Resíduos Sólidos no Brasil*" is a publication annually published by the Associação Brasileira de Empresas de Limpeza Pública e Resíduos Especiais – ABRELPE (translated into English language as "Brazilian Association for Municipal Solid Waste and Special Waste") and has represented one of the most credible annual outlook and statistics source for the solid waste management in the country. The most recent Greenhouse Gases Emissions National Inventory (published by the Brazilian Ministry of Technology and Science in 2010 and available online at: http://www.mct.gov.br/upd_blob/0213/213909.pdf) also confirms that non-conventional MSW treatment alternatives (such as composting of organic fraction of MSW and waste incineration) are not meaningful practices in Brazil (including the region where the project activity is implemented).

In fact, in year 2012 the Brazilian Ministry of City Infrastructure (through its National Secretary of Sanitation) has published the year 2017 edition of a very comprehensive and detailed sectoral analysis/diagnostic about the whole MSW sector in Brazil: the publication "*Diagnóstico do Manejo de Resíduos Sólidos Urbanos – 2017*" (tittle translated into English language as "Diagnostics of Urban Solid Waste Management - 2017" and available online at: http://www.snis.gov.br/diagnostico-residuos-solidos/diagnostico-rs-2017). Like the Report "*Panorama dos Resíduos Sólidos no Brasil – 2020*", this Government official publication also includes relevant and detailed statistics for MSW management for the main municipalities, States and regions in Brazil. Available statistics includes prevailing practices in terms of waste management practices (collection, disposal and re-use/recycle).

In the particular case of the region under potential influence of the Orizon Valorização de Resíduos S.A. (cities from which generated MSW is disposed at the landfill), all solid waste materials (organic or inert) to be eventually/potentially recycled (very small share of collected MSW) are normally previously sorted (under very limited percentiles) in the waste generation sources (prior to be mixed with other types of MSW to be disposed in landfills or waste dump sites in the region).

In the particular case of recycling of organic fraction of waste material to be disposed in landfills or dump sites, the current *status quo* is also expected to be the prevailing situation valid in the future: paper waste streams (mixed with other MSW types), food residues, textile, wood waste etc. when ready to be disposed in landfills/dump sites or already disposed in a particular landfills or dump sites) are not even regarded as recyclable material (and thus not even accounted in the available statistics for recyclable material).

Under the category "*organic MSW fraction*" only clean (not contaminated) and previously appropriately sorted pulp/paper/cardboard waste materials have actually been regarded as recyclable material as per both available statistics and available recycling practices. Besides some particular inert waste materials with attractive commercial value (e.g. aluminum packaging material (e.g. cans), some types of clean plastic material and some types of glass), no other waste materials have been normally collected from stream of MSW to be disposed in landfills in order to be eventually recycled in the region where the project activity is implemented and/or even transported to be recycled in other region. This has also been the typical waste recycling scenario in other regions of Brazil.

Thus, in the particular case of the Orizon Valorização de Resíduos S.A., both under the baseline and project scenarios (with or without the implementation of the project activity), no organic fraction of solid waste stream that has been directed to this particular landfill would be expected to be collected and directed to any type of recycling facility (e.g. composting facility) after or prior its disposal at the landfill site. This situation is expected to remain being the practice in the future. In fact, as established by related construction and design documents for the Orizon Valorização de Resíduos S.A., no waste pickers or waste sorting teams have ever operated in the landfill area. No composting plant for organic waste (or any other type of alternative management for MSW organic content) was ever implemented or is expected to be implemented in the area in the future either.

All of the above-summarized facts and aspects confirms that no relevant sorting and collection of recyclable organic material from MSW already disposed in the Orizon Valorização de Resíduos S.A. are expected to occur regardless of the implementation of the proposed VCS project activity (under both baseline and project scenarios). Thus, recycling or alternative reuse/utilization of organic fraction from waste already disposed in the landfill are not expected to occur either (regardless of the implementation of the proposed VCS project activity).

In summary, based on information and data included in the "*Diagnóstico do Manejo de Resíduos Sólidos Urbanos – 2017*"; information and data available in the "*Panorama dos Resíduos Sólidos no Brasil – 2020*" and also based on common practice for waste collection, currently existing very limited and not relevant recycling initiatives in the region of the project activity and even in other regions in Brazil, and by also taking into account the particular situation at the region of the project site, the following assertions are valid for potential of recycling of organic fraction of MSW in the region of influence of the Orizon Valorização de Resíduos S.A.:

- The current MSW management practice in Brazil (and its trend for the future) represents disposal of collected MSW in existing and new landfills (and still existing open dump sites). This practice currently represents almost all undertaken management for all stream of MSW which is actually collected (in mass basis); with very reduced share of collected MSW in Brazil being currently treated under non-conventional methods such as waste incineration (0.03%) and composting (0.11%) (in mass basis as per data of year 2019 (data organized and published in year 2021)).
- It is important to note that in all regions in Brazil with existing MSW disposal activities using landfilling techniques (in existing landfill or existing dump sites) significant quality improvements in terms of MSW disposal services and techniques are still being required especially for cases where solid waste is disposed in existing not-well-managed landfill or dump sites. Such required improvements include construction of better-designed landfills, use of more appropriated technics for waste compacting and covering, etc. In this particular sense, the landfill represents a very well designed and very well managed landfill. The main barrier for improving MSW management in Brazil is still being lack of capital and investment capacity from municipalities to face high associated costs for implementing environmentally friendly MSW management operations. Under the region of influence of the landfill, organic fraction of solid waste material that is collected as MSW has been historically disposed by applying landfilling techniques.
- In all geographical regions in Brazil, relative very low share of previously sorted pulp/paper/cardboard (clean and not contaminated) waste materials have been used as recycling material in the region. Materials under such conditions are termed in the available statistics as “dry recyclable material” and are normally not mixed with MSW stream to be sent to landfills or dump sites. It is important to note that the initiatives and businesses involving recycling of previously sorted dry pulp/paper/cardboard materials (clean and not contaminated materials) have their particular dynamics and characteristics and with not so detailed statistics in some cases. However, under no circumstance such activities are to be affected or even influenced by change, improvements or aspects related to MSW disposal activities employing good landfilling technics (for example: in most of the well managed landfills in Brazil, the landfill is implemented in a closed and controlled area without waste pickers collecting waste from the landfill as a way or living). By taking into consideration the dynamics of initiatives promoting recycling of paper material, it is correct to assume that, differently than for MSW disposal activities; policies, planning and practices related to MSW collection and sorting could indeed under a certain limit play a role such initiatives.
- By merely promoting efficient collection and destruction/utilization of LFG in a landfill (where LFG is generated due to anaerobic degradation of organic fraction of MSW which is to be disposed in the landfill under the framework of contracts for MSW disposal signed with municipalities in the region), the implementation of the project activity and its continuous operation *per-se* clearly are not expected to represent any driver or incentive for promoting any change in the MSW management situation in the region where it is implemented (including waste recycling practices or initiatives for organic content of MSW to be disposed in landfills or dump sites).

By taking into account (i) the institutional and regulatory framework for the public service of MSW management; (ii) the dynamics of MSW sector in the region where the project activity is to be implemented and in Brazil, and (iii) magnitude of average costs for existing MSW management options (which could be regarded as alternatives to disposal of MSW in landfills (e.g employment of MSW composting techniques)), (iv) the available related statistics, the following aspects are also to be noted:

- it is clear that promotion or even disincentive of recycling of organic fraction of MSW are not waste policy aspects that would be under any influence or willingness of the project proponents Orizon Valorização de Resíduos S.A. (as the current owner and operator of the Ecoparque Sergipe landfill). Aspects and actions related to promotion of any increase or even reduction of recycling of organic fraction of waste (and/or recycling of any other type of solid waste material) in the region where the project activity is to be implemented, are to be seen as dependent in a last instance on public service policies (including policies, laws, regulations and programmes) to be set by competent governmental authorities (under a regional and national level) and by practitioners of recycling. In Brazil, the administrations of municipalities are responsible for addressing all MSW management services.

	the proposed VCS project activity at the Ecoparque Sergipe landfill. The same is actually also applicable for recycling of inert waste material. Furthermore, regardless of the non-existence of any MSW recycling or utilization facility with comparable capacity that could eventually somehow compete with the Ecoparque Sergipe landfill as disposal site for organic fraction of MSW waste, aspects and actions related to promotion of recycling or utilization of organic fraction of solid waste are to be seen as fully dependent on regional and/or national public service policies in the case of Brazil (including policies, laws, regulations and programmes) and such aspects and actions are to be defined/triggered by competent governmental authorities (under a

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Furthermore, there are federal directives and laws to be considered by Municipalities for the implementation and operation of their local waste management policies. This is the case in the geographical region of the project site. Waste collection and disposal services are normally performed by the municipality and/or are performed by private companies hired and paid by one or more municipalities (under contractual commercial agreements for provision of public service on behalf of such municipality (ies)) for the provision of MSW collection and/or MSW disposal services by completely following directives and requirements established by the municipalities in signed contracts. In this context, both under the baseline and project scenarios (with or without the implementation of the project activity), the project proponent Orizon Valorização de Resíduos S.A. is not under a position to design or plan the implementation of any initiative promoting recycling or use of organic waste (e.g. operation of a solid waste composting plant) at the Orizon Valorização de Resíduos S.A. or at other location in the region.

- The implementation and operation of the project-based VCS initiative promoting collection of LFG and its destruction/utilization at the Orizon Valorização de Resíduos S.A. *per se* would not trigger any change in the regional policies and practices for MSW management in the region or outside its region of influence either. As further discussed in Sections 3.4 and 3.7, so far, there is still no legal restriction neither requirement for LFG gas collection and its destruction using high temperature enclosed flares and/or its utilization in any other combustion or supply device in Brazil. Moreover, there is still no legal restriction neither requirement for passive venting of LFG or its combustion in conventional LFG destruction systems either. There is no applicable regulation/law that deals with LFG management in Brazil. Thus, the implementation (and operation) of more appropriate and environmentally safe management of LFG at the Orizon Valorização de Resíduos S.A. (as part of the proposed VCS project activity) does not represent a driver or incentive to promote incremental disposal of organic waste stream at this landfill thus displacing or preventing such waste stream from being treated under an existent or potential (hypothetical) MSW recycling/utilization facilities (e.g. a hypothetical waste composting plant) instead.

In summary, by taking into consideration the nature of project activity and all facts/aspects and information above presented, the project activity clearly does not pose any risk or potential to promote any relative decrease of the amount of organic fraction of MSW that would be otherwise recycled or utilized or prevention of any mean of waste recycling or utilization.

	regional and national level) and/or to be eventually implemented/operated by practitioners of waste recycling. In Brazil, the administrations of municipalities typically are the entities responsible for all MSW management services. In this context, waste management companies such as Orizon Valorização de Resíduos S.A. normally acts as service providers, providing MSW collection and disposal services as per directives and contractual requirements set by the municipalities from which generated MSW are to be managed (collected and disposed). In this sense, in the position of a MSW management company operating a LFG collection and destruction initiative in the landfill it operates and owns, Orizon Valorização de Resíduos S.A. is not under a position to trigger, establish or promote any reduction or prevention of organic waste recycling in the region where it operates. Finally, the implementation of the proposed VCS project activity has not represented (and it is not expected to represent) any incentive or driver for involved municipalities, any other public entity or any other relevant recycling practitioner for the promotion of changes in policies and practices related to recycling of inert or organic solid waste in the region of influence of the Ecoparque Sergipe landfill (or even beyond such region). As outlined in Sections 3.4 and 3.7, so far, there are still no legal restrictions or requirements for LFG gas collection and its destruction using high temperature enclosed flare(s) and/or utilization or supply of LFG using any other device/equipment in Brazil. Moreover, there are still no legal restrictions neither requirement for venting and/or combustion of LFG in conventional passive

	LFG destruction systems either (where combustion of small and not defined share of generated LFG through use of conventional passive LFG venting/combustion drains is identified as the baseline scenario for the project activity). There are no applicable regulations that deal with LFG management in Brazil at all. Thus, the implementation of more appropriate and environmentally safe management of LFG at the Ecoparque Sergipe landfill (as a direct outcome of the implementation of the proposed VCS project activity) per se does not represent any driver or incentive to dispose incremental amount of MSW in the Ecoparque Sergipe landfill (when compared to the situation that would occur in the absence of the proposed VCS project activity) either. In this sense, under no circumstance, the project activity per se potentially is expected to promote any displacement of volumes of organic waste stream from treatment/utilization being performed in an existent or hypothetical MSW recycling/utilization facilities (e.g. a MSW composting plant for example) in order to be disposed at the Ecoparque Sergipe landfill as a direct result of the implementation of the project activity. Therefore condition (d) is also satisfied.
"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) Atmospheric release of LFG or capture of LFG and destruction through flaring to comply with regulations or contractual requirements, to address safety and odour concerns, or for other reasons; and* *(b) In the case that the LFG is used in the project activity for generating*	As further demonstrated in Section 3.4, the most plausible baseline scenario for methane emissions at the Ecoparque Sergipe landfill is the release (direct emission) of LFG from the SWDS directly into the atmosphere and through pre-project passive LFG venting drains (with no share of generated LFG being destroyed). The application of the procedure to identify the baseline scenario thus falls into (a). While the project design does encompass utilization of LFG as gaseous fuel for

electricity and/or generating heat in a boiler, air heater, glass melting furnace or kiln; In the case of LFG supplied to the end-user(s) through natural gas distribution network, trucks or the dedicated pipeline, the baseline scenario is assumed to be displacement of natural gas. *(i) For electricity generation: that electricity would be generated in the grid or in captive fossil fuel fired power plants; and/or* *(ii) For heat generation: that heat would be generated using fossil fuels in equipment located within the project boundary."* *(c) In the case of LFG supplied to the end-user(s) through natural gas distribution network, trucks or the dedicated pipeline, the baseline scenario is assumed to be displacement of natural gas.* *(d) In the case of LFG from a Greenfield SWDS, the identified baseline scenario is atmospheric release of the LFG or capture of LFG in a managed SWDS and destruction through flaring to comply with regulations or contractual requirements, to address safety and odour concerns, or for other reasons."*	electricity generation and/or supply of LFG to the end-user(s) through natural gas distribution network and/or dedicated pipeline, (b-i) and (c) are thus also applicable. While the Ecoparque Sergipe landfill does not represent a Greenfield SWDS, (d) is not applicable.
"This methodology is not applicable: *(a) In combination with other approved methodologies. For instance, ACM0001 cannot be used to claim emission reductions for the displacement of fossil fuels in a kiln or glass melting furnace, where the purpose of the CDM project activity is to implement energy efficiency measures at a kiln or glass melting furnace;*	Neither option (a) and/or (b) occur. The only GHG emission reductions claimed by the project activity are due to destruction of methane through combustion and CO_2 emission reductions associated with displacement of electricity generated in grid and displacement of natural gas (by electricity generated as part of the proposed VCS project activity and supply of upgraded LFG to consumer(s) respectively).

(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.”	After the implementation of the proposed VCS project activity, the landfill operator is expected to continue with MSW disposal activities at the Ecoparque Sergipe landfill as per its normal and previously planned/defined operation conditions and practices. MSW disposal practices and management at the Ecoparque Sergipe landfill are not expected to change after the implementation and starting of operations of the proposed VCS project activity[16]. The quoted applicability condition is thus satisfactory met.

Regarding the applied CDM methodological tools, the table below summarizes how the proposed VCS project activity meets their applicability conditions:

CDM methodological tool	Version	Applicability conditions	Comments
“Project emissions from flaring”	04.0	*“This tool provides procedures to calculate project emissions from flaring of a residual gas, where the component with the highest concentration is methane. The source of the residual gas is biogenic (e.g. landfill gas or biogas from wastewater treatment) or coal mine methane. (…)*	As part of the proposed VCS project activity, collected LFG (whose component with the highest concentration is methane) is combusted the project’s methane destruction devices and supplied to consumer(s). The CDM baseline and monitoring methodology ACM0001 (version 19.0) requires that, as part of the determination of baseline emissions,

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[16] The operation of the Orizon Valorização de Resíduos S.A. in terms of disposal of MSW (practices of waste disposal, covering, levelling, compacting, leachate management, etc.) is not expected to change after the implementation and starting of operations of the proposed VCS project activity. Thus, there is no valid action promoting increase in methane generation (like e.g. through addition of liquids, pre-treating waste, changing the shape of the landfill) that would be triggered or promoted by the implementation of the proposed VCS project activity at the Orizon Valorização de Resíduos S.A. (when compared to the situation prior to its implementation).

		This tool provides procedures to calculate project emissions from flaring of a residual gas. The tool is applicable to enclosed or open flares and project participants should document in the CDM-PDD the type of flare used in the project activity. *This tool is applicable to the flaring of flammable greenhouse gases where:* *(a) Methane is the component with the highest concentration in the flammable residual gas; and* *(b) The source of the residual gas is coal mine methane or a gas from a biogenic source (e.g. biogas, landfill gas or wastewater treatment gas).* *The tool is not applicable to the use of auxiliary fuels and therefore the residual gas must have sufficient flammable gas present to sustain combustion. For the case of an enclosed flare, there shall be operating specifications provided by the manufacturer of the flare.* *This methodological tool refers to the latest approved version of "TOOL08: Tool to determine the mass flow*	project emissions from flaring are to be determined. LFG is a flammable gas generated from the anaerobic decomposition of organic waste material disposed in the Ecoparque Sergipe landfill. LFG is thus a gas from a biogenic source. Methane is the component with the highest concentration in LFG. No auxiliary fuel is required to make the flammability of LFG sufficiently enough to be combusted in the project's methane destruction devices and/or devices from consumer(s) (to which upgraded LFG will be supplied as part of the proposed VCS project activity). As demonstrated below, the applicability conditions for the CDM methodological tool "Tool to determine the mass flow of a greenhouse gas in a gaseous stream" are sufficiently met. Thus, the quoted applicability conditions defined in the CDM methodological tool are sufficiently met.

		of a greenhouse gas in a gaseous stream".	
"Tool to determine the mass flow of a greenhouse gas in a gaseous stream"	03.0	*"Typical applications of this tool are methodologies where the flow and composition of residual or flared gases or exhaust gases are measured for the determination of baseline or project emissions, which is the case of the present project activity"*	As established by the applied CDM baseline and monitoring methodology ACM0001 (version 19.0), this tool is applied as per the methodology for determining the mass flow of CH_4 which is sent to the project's methane destruction devices (flare(s), engine-generator sets) and supplied to consumer(s). The applicability condition of the CDM methodological tool is thus met.
"Baseline, project and/or leakage emissions from electricity consumption and monitoring of electricity generation"	03.0	*"This tool provides procedures to estimate the baseline, project and/or leakage emissions associated with the consumption of electricity, and procedures to monitor the amount of electricity generated by the project power plant.* *(…)* *If emissions are calculated for electricity consumption, the tool is only applicable if one out of the following three scenarios applies to the sources of electricity consumption:* (a) *Scenario A: Electricity consumption from the grid. The*	As established by the CDM baseline and monitoring methodology ACM0001 (version 19.0), consumption of electricity by the proposed VCS project activity is to be accounted as project emissions. Furthermore, net electricity generated by the proposed VCS project activity is to be accounted for the determination of baseline emissions. Electricity demand of the proposed VCS project activity is expected to be met through imports of grid-sourced electricity, electricity sourced by the project's electricity generation infrastructure or electricity sourced by

		electricity is purchased from the grid only, and either no captive power plant(s) is/are installed at the site of electricity consumption or, if any captive power plant exists on site, it is either not operating or it is not physically able to provide electricity to the electricity consumer; *(b) Scenario B: Electricity consumption from (an) off-grid fossil fuel fired captive power plant(s). One or more fossil fuel fired captive power plants are installed at the site of the electricity consumer and supply the consumer with electricity. The captive power plant(s) is/are not connected to the electricity grid; or* *(c) Scenario C: Electricity consumption from the grid and (a) fossil fuel fired captive power plant(s). One or more fossil fuel fired captive power plants operate at the site of the electricity consumer. The*	backup captive off-grid electricity generator (fueled by diesel). Thus, Scenario C of the tool is applicable. In summary, the quoted applicability criteria defined in the CDM methodological tool are sufficiently met.

		captive power plant(s) can provide electricity to the electricity consumer. The captive power plant(s) is/are also connected to the electricity grid. Hence, the electricity consumer can be provided with electricity from the captive power plant(s) and the grid."	
"Emissions from solid waste disposal sites"	08.0	*"This tool provides procedures to calculate baseline, project or leakage emissions of methane from solid waste disposed or prevented from disposal at a solid waste disposal site (SWDS)."* *"The tool can be used to determine emissions for the following types of applications:* *(a) Application A: The CDM project activity mitigates methane emissions from a specific existing SWDS. Methane emissions are mitigated by capturing and flaring or combusting the methane (e.g. "ACM0001: Flaring or use of landfill gas"). The methane is generated from waste disposed in*	The proposed VCS project activity mitigates methane emissions from a landfill. The applicability of the CDM methodological tool is thus met. Application A in the CDM methodological tool is selected and applied in the context of calculations of ex-ante estimates of emission reductions to be achieved by the proposed VCS project activity as established by the applied CDM baseline and monitoring methodology ACM0001 (version 19.0). Thus, the quoted applicability criteria defined in the CDM methodological tool is sufficiently met.

		the past, including prior to the start of the CDM project activity. In these cases, the tool is only applied for an ex ante estimation of emissions in the project design document (CDM-PDD). The emissions will then be monitored during the crediting period using the applicable approaches in the relevant methodologies (e.g. measuring the amount of methane captured from the SWDS); *(b) Application B: The CDM project activity avoids or involves the disposal of waste at a SWDS. An example of this application of the tool is ACM0022, in which municipal solid waste (MSW) is treated with an alternative option, such as composting or anaerobic digestion, and is then prevented from being disposed of in a SWDS. The methane is generated from waste disposed or avoided from disposal during the crediting period. In*	

		these cases, the tool can be applied for both ex ante and ex post estimation of emissions. These project activities may apply the simplified approach detailed in 0 when calculating baseline emissions."	
"Tool to calculate the emission factor for an electricity system"	07.0	*This methodological tool determines the CO_2 emission factor for the displacement of electricity generated by power plants in an electricity system, by calculating the "combined margin" emission factor (CM) of the electricity system.* *(…)* *The CM is the result of a weighted average of two emission factors pertaining to the electricity system: the "operating margin" (OM) and the "build margin" (BM). The operating margin is the emission factor that refers to the group of existing power plants whose current electricity generation would be affected by the proposed CDM project activity. The build margin is the emission factor that refers to the*	Project emissions due to the consumption of grid-sourced electricity by the proposed VCS project activity and baseline emissions for electricity generation are both determined by applying applicable guidance of the CDM methodological tool "Baseline, project and/or leakage emissions from electricity consumption and monitoring of electricity generation" (of which the applied CDM baseline and monitoring methodology ACM0001 version 19.0 refers to). The CDM methodological tool "Tool to calculate the emission factor for an electric system" is referred to in the CDM methodological tool "Baseline, project and/or leakage emissions from electricity consumption and monitoring of electricity generation" for the purpose of calculating project

		group of prospective power plants whose construction and future operation would be affected by the proposed CDM project activity. *(…)* *This tool may be applied to estimate the OM, BM and/or CM when calculating baseline emissions for a project activity that substitutes grid electricity that is where a project activity supplies electricity to a grid or a project activity that results in savings of electricity that would have been provided by the grid (e.g. demand-side energy efficiency projects).* *(…)* *In case of CDM projects the tool is not applicable if the project electricity system is located partially or totally in an Annex I country."*	emissions in case where a project activity consumes electricity from the grid. The CO_2 emission factor for the electricity grid which sources electricity to the proposed CDM project activity is determined as the combined margin CO_2 emission factor[17]. The electricity grid (to which the project activity is connected to) is not located partially or totally in an Annex I country. The relevant applicability conditions of the CDM methodological tool are thus fully met.
"Combined tool to identify the baseline scenario and demonstrate additionality"	07.0	"*This tool is only applicable to methodologies for which the potential alternative scenarios to the*	As established by the applied CDM baseline and monitoring methodology ACM0001 (version 19.0), the CDM methodological tool "Combined tool to

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[17] The DNA of Brazil has regularly calculated and reported values for the CO_2 emission factor of the National Electricity Grid of Brazil. Such values are reported as being determined/calculated through application of the CDM methodological tool "Tool to calculate the emission factor for an electricity system" (version 07.0 and previous versions).

		proposed project activity available to project participants cannot be implemented in parallel to the proposed project activity" *(…)* *For example, in the following situations a methodology could refer to this tool:* - *For an energy efficiency CDM project where the identified potential alternative scenarios are: (a) retrofit of an existing equipment, or (b) replacement of the existing equipment by new equipment, or (c) the continued use of the existing equipment without any retrofits;* - *For a CDM project activity related to the destruction of a greenhouse gas in one site where the identified potential alternative scenarios are: (a) installation of a thermal destruction unit, or (b) installation of a catalytic destruction system, or (c) no abatement of the greenhouse gas.* *In these cases, the project proponents could*	identify the baseline scenario and demonstrate additionality" is to applied as per the methodology for the identification of the baseline scenario as well as the assessment and demonstration of the additionality for the proposed VCS project activity. The proposed VCS project activity encompasses destruction/utilization of a greenhouse gas in one site where one of the identified potential alternative scenarios is no abatement of the greenhouse gas. The identification of the baseline scenario for the proposed VCS project activity as well as its assessment and demonstration of additionality are performed by applying the stepwise procedure of ACM0001 (version 19.0) which refers to the CDM methodological tool in question. The applicability condition of the CDM methodological tool is thus met.

		not implement the three alternatives in parallel but they could only implement one of them.” However, the tool is, for example, not applicable in the following situation: the CDM project activity is the installation of a Greenfield facility that provides a product to a market (i.e. electricity, cement, etc.) where the output could be provided by other existing facilities or new facilities that could be implemented in parallel with the CDM project activity.”	

3.3 Project Boundary

The boundary for the proposed VCS project activity includes the landfill site where LFG (rich in methane) is captured and destroyed/utilized. The electricity grid to which the proposed VCS project activity is connected to is the National Electricity Grid of Brazil. Under conformance with applicable guidance from the applied CDM baseline and monitoring methodology ACM0001 (version 19.0), the table below provides a summary of the delineation of greenhouse gases (GHG) and sources included and excluded from the project boundary:

Source		Gas	Included?	Justification/Explanation
Baseline	Emissions from decomposition of waste at the SWDS site.	CO_2	No	CO_2 emissions from decomposition of organic waste are not accounted since the CO_2 is also released under the project activity.
		CH_4	Yes	The major source of GHG emissions in the baseline
		N_2O	No	N_2O emissions are very small when compared to CH_4 emissions from SWDS (in tCO_2e). This is conservative.

Source		Gas	Included?	Justification/Explanation
		Other	No	No emissions from GHG other than CH_4 are considered in the context of determination of baseline emissions from waste decomposition at the SWDS site.
	Emissions from electricity generation	CO_2	Yes	Major emission source.
		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.
		Other	No	No emissions from GHG other than CO_2 are considered in the context of determination of baseline emissions from electricity generation by the proposed VCS project activity
	Emissions from LFG delivered to consumer(s) through dedicated pipeline	CO_2	Yes	Excluded for simplification. This emission source is assumed to be very small.
		CH_4	No	Major emission source.
		N_2O	No	Excluded for simplification. This emission source is assumed to be very small.
		Other	No	No emissions from GHG other than CO_2 are considered in the context of determination of baseline emissions from LFG delivered to consumer(s) through dedicated pipeline by the proposed VCS project activity
Project	Emissions from the use of natural gas	CO_2	No	Excluded for simplification. This is conservative
		CH_4	No	Major emission source since supply of LFG to consumer(s) (through a natural gas distribution network and/or dedicated pipeline) is included in the proposed VCS project activity
		N_2O	No	Excluded for simplification. This is conservative
		Other	No	No emissions from GHG other than CH_4 are considered in the context of determination of baseline emissions from the use of natural gas.
	Emissions from	CO_2	Yes	May be an important/material emission source.

Source		Gas	Included?	Justification/Explanation
	consumption of grid-sourced electricity by the proposed VCS project activity	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.
		Other	No	No emissions from GHG other than CO_2 are considered in the context of determination of project emissions from consumption of grid-sourced electricity by the proposed VCS project activity
	Emissions from consumption of electricity sourced by the backup captive off-grid electricity generator (fuelled by diesel)	CO_2	Yes	May be an important emission source.
		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.
		Other	No	No emissions from GHG other than CO_2 are considered in the context of determination of project emissions from consumption of electricity sourced by the backup captive off-grid electricity generator (fuelled by diesel)
	Emissions from distribution of LFG through dedicated pipelines	CO_2	Yes	May be an important/material emission source.
		CH_4	Yes	May be an important/material emission source.
		N_2O	No	Emissions are considered negligible.
		Other	No	No emissions from GHG other than CO_2 are considered in the context of determination of project emissions for the supply of upgraded LFG to consumer(s) through dedicated pipeline (if applicable).

The schematic flow diagram below summarizes the project boundary and delineates the proposed VCS project activity (equipment, parameters to be monitored, and GHG included in the project boundary):

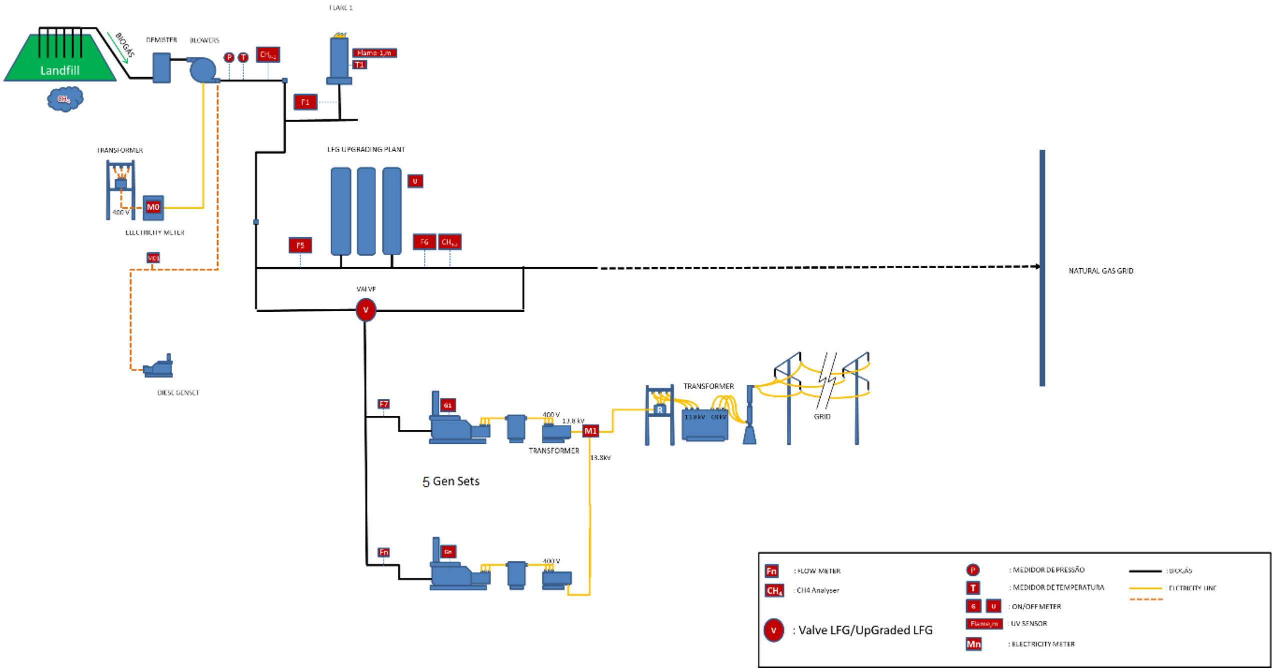
FLARE 1
BIOGÁS
Landfill
CH_4
DEMISTER
BLOWERS
P
T
$CH_{4,1}$
Flame-1,m
T1
F1
TRANSFORMER
400 V
M0
ELECTRICITY METER
LFG UPGRADING PLANT
U
F5
F6
$CH_{4,2}$
MD1
DIESE GENSET
VALVE
V
NATURAL GAS GRID
F7
G1
400 V
13.8 kV
M1
TRANSFORMER
13.8kV
TRANSFORMER
R
13.8kV
69kV
GRID
5 Gen Sets
Fn
Gn
400 V
Fn : FLOW METER
CH_4 : CH4 Analyser
V : Valve LFG/UpGraded LFG
P : MEDIDOR DE PRESSÃO
T : MEDIDOR DE TEMPERATURA
G U : ON/OFF METER
Flame,m : UV SENSOR
Mn : ELECTRICITY METER
: BIOGÁS
: ELCTRICITY LINE

Figure 2 - Diagram summarizing the project boundary and delineating the proposed VCS project activity (equipment, parameters to be monitored, and GHG included in the project boundary)

3.4 Baseline Scenario

According to the methodology ACM0001 – Flaring or use of landfill gas version 19.0, the project participants may either apply the simplified procedures (as described in section 5.3.1 of the referred methodology) or the "Combined tool to identify the baseline scenario and demonstrate additionality" (as described in section 5.3.2 of the same methodology).

The project participants decided to use the simplified procedures for this project activity.

In this case, the project participants applied the methodological tool "Tool 32: Positive lists of technology". Among the technologies listed in the referred methodological tool, the following is applicable to this project activity:

> *"Landfill gas recovery and its gainful use*
>
> *11. The project activities and PoAs at new or existing landfills (greenfield or brownfield) are deemed automatically additional, if it is demonstrated that prior to the implementation of the project activities and PoAs the landfill gas (LFG) was only vented and/or flared (in the case of brownfield projects) or would have been only vented and/or flared (in the case of greenfield projects) but not utilized for energy generation, and that under the project activities and PoAs any of the following conditions are met:*
>
> *(a) The LFG is used to generate electricity in one or several power plants with a total nameplate capacity that equals or is below 10 MW;*

> *(b) The LFG is used to generate heat for internal or external consumption;*
>
> *(c) The LFG is flared."*

Applying to the proposed project activity:

- Prior to the project implementation, the LFG was only vented and there was no LFG energy generation on-site;
- The proposed project activity consists in LFG flaring and electricity generation with capacity below 10MW.

Thus, the proposed project activity meets the "Tool 32: Positive lists of technology" applicability criteria and the project activity automatically additional.

3.5 Additionality

Additionality analysis will be presented at a later stage.

3.6 Methodology Deviations

Not applicable. There are no methodology deviations.

3.7 Baseline Emissions

While, in accordance with the applied CDM baseline and monitoring methodology ACM0001 (version 19.0) and applicable CDM methodological tools, emission reductions (ER_y) to be achieved by the proposed VCS project activity are determined (in tCO_2e) as the difference between baseline emissions (BE_y) and project emissions (PE_y)[18], this section presents the CDM methodological approach for the determination of BE_y:

Determination of Baseline Emissions (BE_y):

As per ACM0001 (version 19.0), baseline emissions (BE_y) for a project activity promoting LFG collection and destruction/utilization are generally determined according to equation (1) and comprises the following potential generic emission sources:

(a) Baseline methane emissions from the SWDS[19] in the absence of the project activity

(b) Baseline emissions for electricity generation using fossil fuels or supplied by the grid in the absence of the project activity

(c) Baseline emission for heat generation using fossil fuels in the absence of the project activity

(d) Baseline emissions for natural gas use from existing natural gas network in the absence of the project activity

---

[18] $ER_y = BE_y - PE_y$

Where:

ERy	Emission reductions in year y (in tCO_2e/yr)
BE_y	Baseline emissions in year *y* (in tCO_2e/yr)
PE_y	Project emissions in year *y* (in tCO_2e/yr)

[19] As established by the CDM methodological tool “Emissions from solid waste disposal sites” (version 08.0), “SWDS” refers to Solid Waste Disposal Site.

$$BE_y = BE_{CH4,y} + BE_{EC,y} + BE_{HG,y} + BE_{NG,y} \quad \textbf{(1)}$$

Where:

BE_y	Baseline emissions in year *y* (in tCO_2e/yr)
$BE_{CH4,y}$	Baseline emissions of methane from the SWDS in year *y* (in tCO_2e/yr)
$BE_{EC,y}$	Baseline emissions associated with electricity generation in year *y* (in tCO_2e/yr)
$BE_{HG,y}$	Baseline emissions associated with heat generation in year *y* (in tCO_2e/yr)
$BE_{NG,y}$	Baseline emissions associated with natural gas use in year *y* (in tCO_2e/yr)

While the proposed VCS project activity promotes mitigation of CH_4 emissions, $BE_{CH4,y}$ is thus applicable in the context of the determination of baseline emissions. While Electricity generation using LFG as gaseous fuel is considered/regarded as an additional GHG abatement/mitigation measure for the project activity, $BE_{EC,y}$ is thus applicable in the context of the determination of baseline emissions for the proposed VCS project activity. In addition, while LFG to be collected by the project activity is expected to be upgraded and supplied to consumer(s), $BE_{NG,y}$ is thus also applicable in the context of the determination of baseline emissions for the proposed VCS project activity. While as per the project design, no collected LFG is currently expected to be used as gaseous fuel for heat generation purposes, $BE_{HG,y}$ is thus not applicable in the context of the determination of baseline emissions for the proposed VCS project activity.

Thus, the determination approach for baseline emissions is summarized as follows:

$$BE_y = BE_{CH4,y} + BE_{EC,y} + BE_{NG,y} \quad (2)$$

Determination of baseline emissions of methane from the SWDS ($BE_{CH4,y}$):

Baseline emissions of methane from the SWDS ($BE_{CH4,y}$) is calculated in conformance with the applied CDM baseline and monitoring methodology ACM0001 (version 19.0) + applicable CDM methodological tools respectively by following the approaches presented below, where the determination of $BE_{CH4,y}$ is based on the amount of methane that is actually captured and combusted and supplied to consumer(s) as a result of the implementation and operation of the proposed VCS project activity and also by taking in account the amount of methane that would be captured and destroyed in the landfill in the absence of the project activity (baseline scenario). In addition, the effect of methane oxidation (that is assumed as existing in the baseline scenario, but not in the project scenario) is also taken into account as also required by ACM0001 (version 19.0)[20].

$$BE_{CH4,y} = \left(\left(1 - OX_{top\_layer}\right) * F_{CH4,PJ,y} - F_{CH4,BL,y}\right) * GWP_{CH4} \quad \textbf{(3)}$$

Where:

OX_{top_layer}	Fraction of methane in the LFG that would be oxidized in the top layer of the SWDS in the baseline scenario (dimensionless)
$F_{CH4,PJ,y}$	Amount of methane which is destroyed by the project activity through combustion of collected LFG in project's methane destruction devices in year *y* (in tCH_4/yr)
$F_{CH4,BL,y}$	Amount of methane that would be destroyed through flaring of LFG in the baseline scenario (absence of project activity) in year *y* (in tCH_4/yr)
GWP_{CH4}	Global warming potential of CH_4 (in tCO_2e/tCH_4)

Ex post determination of $F_{CH4,PJ,y}$:

As per the applied CDM baseline and monitoring methodology ACM0001 (version 19.0), the amount of methane which is destroyed by the proposed VCS project activity is to be generically ex-post determined as the sum of quantities of methane destroyed through combustion of collected LFG in flare(s), power plant(s), boiler(s), air heater(s), glass melting furnace(s), kiln(s) (methane destruction devices) and/or by supply of collected LFG to consumer(s) through natural gas distribution network based on ex-post measurements, as follows:

$$F_{CH4,PJ,y} = F_{CH4,flared,y} + F_{CH4,EL,y} + F_{CH4,HG,y} + F_{CH4,NG,y} \quad \textbf{(4)}$$

Where:

---

[20] As established by the applied CDM baseline and monitoring methodology ACM0001 (version 19.0), the ex-ante determined parameter $OX_{top\text{-}layer}$ is the fraction of the methane that would be oxidized in the top layer of the considered SWDS (i.e. the Orizon Valorização de Resíduos S.A.) in the absence of the proposed VCS project activity (baseline scenario). As per ACM0001 (version 19.0), it is assumed that for a typical landfill hosting a LFG collection and destruction and/or utilization project activity, this effect is reduced since part of LFG which is captured does not pass through the top layer of the considered SWDS. This oxidation effect is also accounted for in the CDM methodological tool "Emissions from solid waste disposal sites" (version 08.0). In addition to this effect, the installation of a LFG capture system under the proposed VCS project activity may result in the suction of additional air into the considered SWDS. In some cases, such as project activities where the LFG collection is based on high suction pressure, the suction effort may decrease the amount of methane that is generated in the landfill under the project scenario. However, in most circumstances where the LFG is captured and used this effect was considered to be very small, as the operators of landfills have, in most cases, an incentive to maintain a high methane concentration in the LFG. For this reason, this effect is neglected as a conservative assumption.

$F_{CH4,flared,y}$	Amount of methane which is destroyed through combustion of collected LFG in the flare(s) in year *y* (in tCH_4).
$F_{CH4,EL,y}$	Amount of methane which is destroyed through combustion of collected LFG in the internal combustion gas engines in year *y* (in tCH_4).
$F_{CH4,HG,y}$	Amount of methane which is destroyed through combustion of collected LFG in heat generation device(s) in year *y* (in tCH_4/yr). The project design currently does not encompass combustion of collected LFG in heat generation device(s). Thus, $F_{CH4,HG,y}$ is assumed as null (zero).
$F_{CH4,NG,y}$	Amount of methane which is destroyed by supply of collected LFG to consumer(s) through natural gas distribution network in year *y* (in tCH_4/yr).

In summary, the amount of methane which is destroyed by the project activity through combustion of collected LFG in project's methane destruction devices will be ex-post determined as follows:

$$F_{CH4,PJ,y} = F_{CH4,flared,y} + F_{CH4,EL,y} + F_{CH4,NG,y} \quad \textbf{(5)}$$

Determination of the amount of methane which is destroyed through combustion of collected LFG in the flare(s) ($F_{CH4,flared,y}$)

$F_{CH4,flared,y}$ is determined as the difference between the amount of methane supplied to the flare(s) and any methane emissions from the flare(s), as follows:

$F_{CH4,flared,y}$ is determined as the difference between the amount of methane supplied to each individual flare and methane emissions from the flare in question, as follows:

$$F_{CH4,flared,y} = F_{CH4,sent\_flare,y} - \frac{PE_{flare,y}}{GWP_{CH4}} \quad \textbf{(6)}$$

Where:

$F_{CH4,flared,y}$	Amount of methane which is destroyed through combustion of collected LFG in the flares in year *y* (in tCH_4/yr)
$F_{CH4,sent\_flare,y}$	Amount of methane in collected LFG which is sent to the flare(s) in year *y* (in tCH_4/yr)
$PE_{flare,y}$	Project emissions from flaring of the residual gas stream in year *y* (in tCO_2e/yr)
GWP_{CH4}	Global warming potential of CH_4 (in tCO_2e/tCH_4)

For each individual high temperature enclosed flare, $F_{CH4,sent\_flare,y}$ is determined by following applicable guidance of the CDM methodological tool "Tool to determine the mass flow of a greenhouse gas in a gaseous stream" (version 03.0). As per the ACM0001 (version 19.0), the following requirements apply for the determination of $F_{CH4,sent\_flare,y}$:

- The gaseous stream that shall be considered in the application of the CDM methodological tool is the stream of collected LFG which is sent for combustion in the flare(s)
- CH_4 is the greenhouse gas for which the mass flow is determined
- The simplification offered for calculating the molecular mass of the gaseous stream is valid (equations 3 or 17 in the CDM methodological tool)
- The mass flow should be calculated at least on an hourly basis for each hour *h* in year *y*

Determination of the amount of methane in collected LFG which is used for electricity generation ($F_{CH4,EL,y}$)[21]*:*

$F_{CH4,EL,y}$ is determined directly using applicable guidance of the CDM methodological tool "Tool to determine the mass flow of a greenhouse gas in a gaseous stream" (version 03.0), by applying the following requirements defined in ACM0001 (version 19.0):

- The gaseous stream the CDM methodological tool shall be applied to is the stream of collected LFG which is sent to each engine-generator set of the electricity generation facility.
- CH_4 is the greenhouse gas for which the mass flow is determined.
- The simplification offered for calculating the molecular mass of the gaseous stream is valid (equations 3 or 17 in the tool).
- The mass flow should be calculated on a hourly basis for each hour *h* in year *y.*
- The mass flow calculated for hour *h* is 0 if the engine-generator set is not working in hour *h* ($Op_{j,h}$ = equipment not working), the accumulated hourly values are then summed to a yearly unit basis.

Applicable guidance of the CDM methodological tool "Tool to determine the mass flow of a greenhouse gas in a gaseous stream" (version 03.0) will be applied ex-post to determine

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[21] $F_{CH4,EL,y}$ is determined for each stream of collected LFG which is sent to each engine-generator sets of the project's electricity generation infrastructure, by using applicable guidance of the CDM methodological tool "Tool to determine the mass flow of a greenhouse gas in a gaseous stream" (version 03.0) and by applying requirements defined in ACM0001 (version 15.0).

$F_{CH4,sent\_flare,y}$, $F_{CH4,EL,y}$ and $F_{CH4,NG,y}$ [22] by using one of the options A, B, C or D. The selection of the determination option will depend on project conditions and/or monitoring equipment/instruments to be installed as part of the proposed VCS project activity.

Use of Option A, B, C or D for the determination of $F_{CH4,sent\_flare,y}$, $F_{CH4,EL,y}$ and $F_{CH4,NG,y}$:

As established by the CDM methodological tool "Tool to determine the mass flow of a greenhouse gas in a gaseous stream" (version 03.0), depending on the project conditions, one of the following measurement options will be chosen and the following formulas applied for the determination of $F_{i,t}$ [23]:

Option	**Flow of gaseous stream**	**Volumetric fraction**
A	Volume flow dry basis	Dry or wet basis[24]
B	Volume flow wet basis	Dry basis
C	Volume flow wet basis	Wet basis
D	Mass flow dry basis	Dry or wet basis

Option A:

Flow measurement on a dry basis is not doable for a wet gaseous stream. Therefore, it is necessary to demonstrate that the gaseous stream is dry to use this option. There are two ways to do this:

- Measure the moisture content of the gaseous stream ($C_{H2O,t,db,n}$) and demonstrate that this is less or equal to 0.05 kg H_2O/m^3 dry gas; or
- Demonstrate that the temperature of the gaseous stream (T_t) is less than 60ºC (333.15 K) at the flow measurement point.

If it cannot be demonstrated that the gaseous stream is dry, then the flow measurement should be assumed to be on a wet basis and the corresponding option from the table above should be applied instead.

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[22] As per the CDM methodological tool "Tool to determine the mass flow of a greenhouse gas in a gaseous stream" (version 03.0), the mass flow of greenhouse gas in a gaseous stream (which in the particular case of the proposed VCS project activity are the amount of methane in collected LFG which is sent to the flares ($F_{CH4,sent\_flare,y}$), to the engine-generator sets ($F_{CH4,EL,y}$) and supplied to consumer(s) ($F_{CH4,NG,y}$) is actually represented as $F_{i,t}$.

[23] The selection of option A, B, C or D will occur on an ex-post basis depending on the type and/or specifications of monitoring equipment installed and under operation as part of the proposed VCS project activity.

[24] Flow measurement on a dry basis is not feasible at reasonable costs for a wet gaseous stream, so there will be no difference in the readings for volumetric fraction in wet basis analyzers and dry basis analyzers and both types can be used indistinctly for calculation Options A and D.

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

$$F_{i,t} = V_{t,db} * v_{i,t,db} * \rho_{i,t} \quad \textbf{(7)}$$

with

$$\rho_{i,t} = \frac{P_t * MM_i}{R_u * T_t} \quad \textbf{(8)}$$

Where:

$F_{i,t}$	Mass flow of greenhouse gas *i* in the gaseous stream in time interval *t* (in kg gas/h)
$V_{t,db}$,	Volumetric flow of the gaseous stream in time interval *t* on a dry basis at normal conditions (in m³ dry gas/h)
$v_{i,t,db}$	Volumetric fraction of greenhouse gas *i* in the gaseous stream in time interval *t* on a dry basis (in m³ gas *i*/m³ dry gas)
$\rho_{i,t}$	Density of greenhouse gas *i* in the gaseous stream (in kg gas *i*/m³ gas *i*)
P_t	Absolute pressure of the gaseous stream in time interval *t* (in Pa)
MM_i	Molecular mass of greenhouse gas *i* (in kg/kmol)
R_u	Universal ideal gases constant (in Pa.m^3/kmol.K)
T_t	Temperature of the gaseous stream in time interval *t* (in K)

Option B:

The mass flow of greenhouse gas *i* ($F_{i,t}$) is determined using equations (7) and (8). The volumetric flow of the gaseous stream in time interval *t* on a dry basis ($V_{t,db}$) is determined by converting the measured volumetric flow from wet basis to dry basis as follows:

$$V_{t,db} = V_{t,wb} / (1 + v_{H2O,t,db}) \quad \textbf{(9)}$$

Where:

$V_{t,db}$	Volumetric flow of the gaseous stream in time interval *t* on a dry basis (in m^3 dry 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)

$v_{H2O,t,db}$ Volumetric fraction of H_2O in the gaseous stream in time interval *t* on a dry basis (in m^3 H_2O/m^3 dry gas)

The volumetric fraction of H_2O in time interval *t* on a dry basis ($v_{H2O,t,db}$) is estimated according to the following equation:

$$v_{H2O,t,db} = \frac{m_{H2O,t,db} * MM_{t,db}}{MM_{H2O}} \quad \textbf{(10)}$$

Where:

$v_{H2O,t,db}$ Volumetric fraction of H_2O in the gaseous stream in time interval *t* on a dry basis (in m^3 H_2O/m^3 dry gas)

$m_{H2O,t,db}$ Absolute humidity in the gaseous stream in time interval *t* on a dry basis (in kg H_2O/kg dry gas)

$MM_{t,db}$ Molecular mass of the gaseous stream in time interval *t* on a dry basis (kg dry gas/kmol dry gas)

MM_{H2O} Molecular mass of H_2O (in kg H_2O/kmol H_2O)

In case this Option is selected, the absolute humidity of the gaseous stream ($m_{H2O,t,db}$) will be determined using Option 2 specified below under "*Determination of the absolute humidity of the gaseous stream*" and the molecular mass of the gaseous stream ($MM_{t,db}$) will be determined using the following equation:

$$MM_{t,db} = \sum_{k} (v_{k,t,db} * MM_k) \quad \textbf{(11)}$$

Where:

$v_{k,t,db}$ Volumetric fraction of gas *k* in the gaseous stream in time interval *t* on a dry basis (in 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, CO_2, O_2, CO, H_2, CH_4, N_2O, NO, NO_2, SO_2, SF_6 and PFCs). See 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, the volumetric fraction of only the gases *k* that are greenhouse gases and are 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.

Option C:

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

$$F_{i,t} = V_{t,wb,n} * v_{i,t,wb} * \rho_{i,n} \tag{12}$$

with

$$\rho_{i,n} = \frac{P_n * MM_i}{R_u * T_n} \tag{13}$$

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 m³ 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 m³ gas *i*/m³ wet gas)
$\rho_{i,n}$	Density of greenhouse gas *i* in the gaseous stream at normal conditions (in kg gas *i*/m³ 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:

$$V_{t,wb,n} = V_{t,wb} * (T_n / T_t) * (P_t / P_n) \tag{14}$$

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)

Option D:

Flow measurement on a dry basis is not doable for a wet gaseous stream. Therefore, it is necessary to demonstrate that the gaseous stream is dry to use this option. There are two ways to do this:

- Measure the moisture content of the gaseous stream ($C_{H2O,t,db,n}$) and demonstrate that this is less or equal to 0.05 kg H_2O/m^3 dry gas; or
- Demonstrate that the temperature of the gaseous stream (T_t) is less than 60ºC (333.15 K) at the flow measurement point.

If it cannot be demonstrated that the gaseous stream is dry, then the flow measurement should be assumed to be on a wet basis and the corresponding option from the above table should be applied instead.

The mass flow of greenhouse gas *i* ($F_{i,t}$) is determined using equations (7) and (8). The volumetric flow of the gaseous stream in time interval *t* on a dry basis ($V_{t,db}$) is determined by converting the mass flow of the gaseous stream to a volumetric flow as follows:

$$V_{t,db} = M_{t,db} / \rho_{t,db} \qquad \textbf{(15)}$$

Where:

$V_{t,db}$	Volumetric flow of the gaseous stream in time interval *t* on a dry basis (in m^3 dry gas/h)
$M_{t,db}$	Mass flow of the gaseous stream in time interval *t* on a dry basis (in kg/h)
$\rho_{t,db}$	Density of the gaseous stream in time interval *t* on a dry basis (in kg dry gas/m^3 dry gas)

The density of the gaseous stream ($\rho_{t,db}$) should be determined as follows:

$$\rho_{t,db} = \frac{P_t * MM_{t,db}}{R_u * T_t} \qquad \textbf{(16)}$$

Where:

$\rho_{t,db}$ Density of the gaseous stream in a time interval *t* on a dry basis (in kg dry gas/m^3 dry gas)

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)

$MM_{t,db}$ Molecular mass of the gaseous stream in a time interval *t* on a dry basis (in kg dry gas/kmol dry gas). The molecular mass of the gaseous stream ($MM_{t,db}$) is estimated by using equation (11).

Determination of the absolute humidity of the gaseous stream

The absolute humidity is as parameter required for Options B and E only, thus it will be used only in case Option B is adopted (as Option E is not selected as a measurement option for the project activity). Option 2 of the tool is selected 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. 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 $m_{H2O,t,db}$ is assumed to equal the saturation absolute humidity ($m_{H2O,t,db,sat}$) and calculated using equation (7).

$$m_{H_2O,t,db,SAT} = \frac{p_{H2O,t,Sat} * MM_{H2O}}{(P_t - p_{H2O,t,Sat}) * MM_{t,db}} \qquad \textbf{(17)}$$

Where:

$m_{H2O,t,db,sat}$ Saturation absolute humidity in time interval *t* on a dry basis (in kg H_2O/kg dry gas)

$p_{H20,t,sat}$ Saturation pressure of H_2O at temperature T_t in time interval *t* (in Pa)

T_t	Temperature of the gaseous stream in time interval *t* (in K)
P_t	Absolute pressure of the gaseous stream in time interval *t* (in Pa)
MM_{H2O}	Molecular mass of H_2O (in kg H_2O/kmol H_2O)
$MM_{t,db}$	Molecular mass of the gaseous stream in a time interval *t* on a dry basis (in kg dry gas/kmol dry gas). $MM_{t,db}$ is estimated by using equation (11).

Determination of $PE_{flare,y}$ (required for the determination of $F_{CH4,flared,y}$):

As established by the applied CDM baseline and monitoring methodology ACM0001 (version 19.0), $PE_{flare,y}$ is determined by following applicable guidance of the CDM methodological tool “Project emissions from flaring” (version 04.0). Since share of collected LFG is expected to be combusted (by flaring) in high temperature enclosed flare(s) as a result of the operation of the proposed VCS project activity, $PE_{flare,y}$ is thus calculated as the sum of the related emissions for each individual flare (where project emissions from flaring from each one of the flares, if applicable, are calculated separately (as established by the CDM methodological tool)).

For each individual flare, the calculation procedure in the referred methodological tool is applied to determine project emissions from flaring the residual gas ($PE_{flare,y}$) based on the flare efficiency ($\eta_{flare,m}$) and the mass flow of methane to the flare in question ($F_{CH4,RG,m}$). The flare efficiency is determined for each minute *m* of year *y* based either on monitored data or default values.

Calculation procedure for the determination of project emissions from flaring is applied as follows under a stepwise approach:

Step 1: Determination of the methane mass flow of the residual gas

Step 2: Determination of the flare efficiency

Step 3: Calculation of project emissions from flaring

Step 1: Determination of the methane mass flow in the residual gas:

The CDM methodological tool “Tool to determine the mass flow of a greenhouse gas in a gaseous stream” (version 03.0) shall be used to determine (in kg) the mass flow of methane in the residual gaseous stream in the minute *m*: $F_{CH4,m}$.

The following requirements apply for the determination of the mass flow of methane in the gaseous stream in minute *m*:

- The CDM methodological tool “Tool to determine the mass flow of a greenhouse gas in a gaseous stream” (version 03.0) shall be applied to the residual gas
- The flow of the gaseous stream shall be measured continuously
- CH_4 is the greenhouse gas *i* for which the mass flow should be determined
- The simplification offered for calculating the molecular mass of the gaseous stream is valid (equations 3 and 17 in the tool)
- The time interval *t* for which mass flow should be calculated is every minute *m*.

$F_{CH4,m}$ which is measured as the mass flow during minute *m*, shall then be used to determine the mass of methane (in kilograms) fed to the flare in question in the minute *m* ($F_{CH4,RG,m}$). $F_{CH4,m}$ shall be determined on a dry basis.

Step 2: Determination of flare efficiency:

As required by the applied CDM baseline and monitoring methodology ACM0001 (version 19.0), the flare efficiency value is to be determined for each installed flare. Also, as per ACM0001 (version 19.0), flare efficiency represents the combustion efficiency of LFG in the flare in terms of CH_4 by considering *inter alia* the time and condition that the flare in question is operating.

For determining the combustion efficiency for the enclosed flare in question, the selected option of the CDM methodological tool “Project emissions from flaring” (version 04.0) are (i) the option to apply a default efficiency value or (ii) determining the flare efficiency based on monitored data (based on applicable measurements and calculations).

The time each of the project’s high temperature enclosed flare has operated is determined by monitoring the flame combustion status/condition by using a flame detector and, for the case of the high temperature enclosed flare(s) to be installed as part of the proposed VCS project activity, the monitoring requirements related to operational requirements/conditions (as provided by the manufacturer’s specifications for operating conditions) shall be met in addition to the confirmation of flare status/condition.

In the case of the proposed VCS project activity, the flare efficiency for each minute *m* ($\eta_{flare,m}$) will be, as a priority, determined by following applicable guidance as per Option B.1 of the CDM methodological tool “Project emissions from flaring” (version 04.0), where the flare efficiency will be determined on the basis of the performance of at least biannual basis related measurements. In case at least biannual related measurements are not available for a particular monitoring period, applicable guidance as per Option A (application of default values) of the CDM methodological tool “Project emissions from flaring” (version 04.0) will be used as an alternative.

Both options are summarized below:

Option A: Apply default value for flare efficiency.

Option B: Measure the flare efficiency.

Option A: Application of default value:

For each one of the high temperature enclosed flares to be installed as part of the project activity, the flare efficiency for each minute *m* ($\eta_{flare,m}$) is 90% when the following two operational conditions/requirements are simultaneously met (in order to demonstrate that the flare is operating as per the recommendations and requirements set by the equipment manufacturer for the minute *m* in question):

1. The temperature of the exhaust gases of the flare (monitoring parameter $T_{EG.m}$) and the flow rate of LFG to the flare (monitoring parameter $F_{RG,m}$) are both within the manufacturer's specification/requirements for the flare (monitoring parameter $SPEC_{flare}$) in minute *m;*
2. Flame is detected in the flare in minute *m* (monitoring parameter $Flame_m$).

If for the minute *m*, conditions (1) and/or (2) are not met, $\eta_{flare,m}$ is set as 0% for the minute in question. Furthermore, as also established by the CDM methodological tool "Project emissions from flaring" (version 04.0), for enclosed flares that are defined as low height flares, the flare efficiency shall be adjusted, as a conservative approach, by subtracting 10 percentile points. For example, the default value applied shall be 80%, rather than 90%.

Option B: Measured flare efficiency:

For each one of the high temperature enclosed flares which are to be part of the proposed VCS project activity, the flare efficiency in the minute *m* is determined as a value which is calculated based on performed related measurements ($\eta_{flare,m} = \eta_{flare,calc,m}$) when the following two conditions are simultaneously met (in order to demonstrate that the flare is operating):

1. The temperature of the exhaust gas of the flare (monitoring parameter $T_{EG.m}$) and the flow rate of LFG to the flare (monitoring parameter $F_{RG,m}$) are within the manufacturer's specification for the flare ($SPEC_{flare}$) in minute *m*;
2. Flame is detected in the flare in minute *m* (monitoring parameter $Flame_m$).

Otherwise $\eta_{flare,m}$ is set as 0%.

By applying Option B.1, where the measurement is performed by an accredited independent third-party entity (e.g. an independent inspection/analysis service company) on a biannual basis, the following calculation formula is applied:

Option B.1: Biannual measurement of the flare efficiency:

The calculated flare efficiency $\eta_{flare,calc,m}$ is determined as the average of at least two measurements of the flare efficiency made in year *y* ($\eta_{flare,calc,y}$), adjusted by an uncertainty factor of 5 percentile points as follows:

$$\eta_{flare,calc,y} = 1 - \frac{1}{2}\sum_{t=1}^{2}\left(\frac{F_{CH4,EG,t}}{F_{CH4,RG,t}}\right) - 0.05 \qquad \textbf{(18)}$$

Where:

$\eta_{flare,calc,y}$	Flare efficiency in the year *y*
$F_{CH4,EG,t}$	Mass flow of methane in the exhaust gas of the flare on a dry basis at reference conditions in the time period *t* (in kg)
$F_{CH4,RG,t}$	Mass flow of methane in the residual gas on a dry basis at reference conditions in the time period *t* (in kg)
t	The two time periods in year y during which the flare efficiency is measured, each a minimum of one hour and separated by at least six months[25]

Note: $F_{CH4,EG,t}$ is measured for each individual flare according to an appropriate national or international standard. $F_{CH4,RG,t}$ is calculated for each flare according to Step 1[26], and consists of the sum of methane flow in the minutes *m* that makes up the time period *t*.

Option B.2: Measurement of flare efficiency in each minute

The flare efficiency in the minute m is a measured value ($\eta_{flare,m} = \eta_{flare,calc,m}$) when the following three conditions are met to demonstrate that the flare is operating:

(1) The temperature of the flare ($T_{EG.m}$) and the flow rate of the residual gas to the flare ($F_{RG,m}$) is within the manufacturer's specification for the flare ($SPEC_{flare}$) in minute *m*;

(2) The flame is detected in minute *m* ($Flame_m$); and

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[25] As also established by the CDM methodological tool "Project emissions from flaring" (version 04.0), if the monitoring period for the VCS project activity is shorter than one year, the measurement should be at least twice in a monitoring period and in a maximum timeframe of six months between each measurement.

[26] As per Step 1 $F_{CH4,RG,t}$ is equal to the sum of methane flow values ($F_{CH4,sent\_flare,y}$) in the minutes *m* that make up the time period *t*.

Otherwise $\eta_{flare,m}$ is 0%.

The flare efficiency ($\eta_{flare,calc,m}$) is determined based on monitoring the methane content in the exhaust gas, the residual gas, and the air used in the combustion process during the minute *m* in year *y*. In case this Option is adopted, the flare efficiency for minute m will be calculate by following the provisions of the methodological tool "Project emissions from flaring" (version 04.0) as follows:

$$\eta_{flare,calc,m} = 1 - \frac{F_{CH4,EG,m}}{F_{CH4,RG,m}} \quad \textbf{(19)}$$

Where:

$\eta_{flare,calc,m}$	Flare efficiency in the minute *m*
$F_{CH4,EG,m}$	Mass flow of methane in the exhaust gas of the flare on a dry basis at reference conditions in the minute *m* (in kg)
$F_{CH4,RG,m}$	Mass flow of methane in the residual gas on a dry basis at reference conditions in the minute *m* (in kg)

Step 2.1: Determine the methane mass flow in the exhaust gas on a dry basis

The mass flow of methane in the exhaust gas is determined based on the volumetric flow of the exhaust gas and the measured concentration of methane in the exhaust gas, as follows:

$$F_{CH4,EG,m} = V_{EG,m} \times fc_{CH4,EG,m} \times 10^{-6} \quad \textbf{(20)}$$

Where:

$V_{EG,m}$	Mass flow of methane in the exhaust gas of the flare on a dry basis at reference conditions in the minute *m* (in kg)
$fc_{CH4,EG,m}$	Concentration of methane in the exhaust gas of the flare on a dry basis at reference conditions in minute *m* (in mg/m^3)

Step 2.2: Determine the volumetric flow of the exhaust gas ($V_{EG,m}$)

Determine the average volume flow of the exhaust gas in minute *m* based on a stoichiometric calculation of the combustion process. This depends on the chemical composition of the residual gas, the amount of air supplied to combust it and the composition of the exhaust gas. It is calculated as follows:

$$V_{EG,m} = Q_{EG,m} \times M_{RG,m} \tag{21}$$

Where:

$Q_{EG,m}$	Volume of the exhaust gas on a dry basis at reference conditions per kilogram of residual gas on a dry basis at reference conditions in minute *m* (in m^3 exhaust gas/kg residual gas)
$M_{RG,m}$	Mass flow of the residual gas on a dry basis at reference conditions in the minute *m* (in kg)

Step 2.3: Determine the mass flow of the residual gas ($M_{RG,m}$)

The project proponent may select to monitor the mass flow of the residual gas in minute *m* directly (see monitored parameter $M_{RG,m}$) or, according to the procedure given in this step, calculate $M_{RG,m}$ based on the volumetric flow 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.

$$M_{RG,m} = \rho_{RG,ref,m} \times V_{RG,m} \tag{22}$$

Where:

$P_{RG,ref,m}$	Density of the residual gas at reference conditions in minute *m* (in kg/m^3)
$V_{RG,m}$	Volumetric flow of the residual gas on a dry basis at reference conditions in the minute *m* (in m^3)

And

$$\rho_{RG,ref,m} = \frac{P_{ref}}{\frac{R_u}{MM_{RG,m}} \times T_{ref}} \tag{23}$$

Where:

P_{ref}	Atmospheric pressure at reference conditions (in Pa)
R_u	(universal ideal gas constant (in Pa.m^3/kmol.K)
$MM_{RG,m}$	Molecular mass of the residual gas in minute *m* (kg/kmol)
T_{ref}	Temperature at reference conditions (K)

Use the equation below to calculate $MM_{RG,m}$. When applying this equation, the project proponent may choose to either a) use the measured volumetric fraction of each component *i* of the residual gas, or b) as a simplification, measure the volumetric fraction of methane and consider the difference to 100% as being nitrogen (N_2). The same equation applies, irrespective of which option is selected.

$$MM_{RG,m} = \sum_{t} \left(v_{i,RG,m} \times MM_i \right) \tag{24}$$

Where:

MM_i	molecular mass of residual gas in minute *m* (in kg/kmol)
$V_{t,RG,m}$	Volumetric fraction of component *i* in the residual gas on a dry basis at reference conditions in the hour *h*
i	Components of the residual gas. If Option (a) is selected to measure the volumetric fraction, then I = CH_4, CO, CO_2, O_2, H_2, H_2S, NH_3, N_2 or if Option (b) is selected then i = CH_4 and N_2.

Step 2.4: Determine the volume of the exhaust gas on a dry basis at reference conditions per kilogram of residual gas ($Q_{EG,m}$)

$Q_{ECO2,EG,m}$ shall be determined as follows:

$$Q_{EG,m} = Q_{CO2,EG,m} + Q_{O_2,EG,m} + Q_{N_2,EG,m} \tag{25}$$

$Q_{ECO2,EG,m}$	Volume of the exhaust gas on a dry basis per kg of residual gas on a dry basis at reference conditions in the minute *m* (m^3/kg residual gas)
$Q_{CO2,EG,m}$	Quantity of CO_2 volume in the exhaust gas per kg of residual gas on a dry basis at reference conditions in the minute *m* (m^3/kg residual gas)

$Q_{N2,EG,m}$	Quantity of N_2 volume in the exhaust gas per kg of residual gas on a dry basis at reference conditions in the minute *m* (m^3/kg residual gas)
$Q_{O2,EG,m}$	Quantity of O_2 volume in the exhaust gas per kg of residual gas on a dry basis at reference conditions in the minute *m* (m^3/kg residual gas)

with

$$Q_{O_2,EG,m} = n_{O2,EG,m} \times VM_{ref} \quad \textbf{(26)}$$

Where:

$n_{O2,EG,m}$	Quantity of O_2 (moles) in the exhaust gas per kg of residual gas flared on a dry basis at reference conditions in minute *m* (kmol/kg residual gas)
VM_{ref}	Volume of one mole of any ideal gas at reference temperature and pressure (m^3/kmol)

$$Q_{N_2,EG,m} = VM_{ref} \times \left\{ \frac{MF_{N,RG,m}}{2 \times AM_N} + \left(\frac{1 - v_{O2,air}}{v_{O2,air}} \right) \times \left[F_{O2,RG,m} + n_{O2,EG,m} \right] \right\} \quad \textbf{(27)}$$

Where:

$MF_{N,RG,m}$	Mass fraction of nitrogen in the residual gas in the minute *m*
AM_N	Atomic mass of nitrogen (kg/kmol)
$v_{O2,air}$	Volumetric fraction of O_2 in air
$F_{O2,RG,m}$	Stochiometric quantity of moles of O_2 required for a complete oxidation of one kg residual gas in minute *m* (kmol/kg residual gas)

$$Q_{CO2,EG,m} = \frac{MF_{C,RG,m}}{AM_C} \times VM_{ref} \quad \textbf{(28)}$$

Where:

$MF_{C,RG,m}$	Mass fraction of carbon in the residual gas in the minute m
AM_C	Atomic mass of carbon (kg/kmol)
VM_{ref}	Volume of one mole of any ideal gas at reference temperature and pressure (m^3/kmol)

$$n_{O2,EG,m} = \frac{v_{O2,EG,m}}{\left(1-\left(v_{O2,EG,m} / v_{O2,air}\right)\right)} \times \left[\frac{MF_{C,RG,m}}{AM_{c}} + \frac{MF_{N,RG,m}}{2 \times AM} + \left(\frac{1-v_{O2,air}}{v_{O2,air}}\right) \times F_{O2,RG,m}\right]$$

(29)

Where:

$v_{O2,EG,m}$	Volumetric fraction of O_2 in the exhaust gas on a dry basis at reference conditions in the minute *m*
$MF_{C,RG,m}$	Mass fraction of carbon in the residual gas in the minute m
$MF_{N,RG,m}$	Mass fraction of nitrogen in the residual gas in the minute m
AM_N	Atomic mass of nitrogen (kg/kmol)

$$F_{O2<RG,m} = \frac{MF_{C,RG,m}}{AM_{C}} + \frac{MF_{H,RG,m}}{4AM_{H}} - \frac{MF_{O,RG,m}}{2AM_{O}} \qquad \textbf{(30)}$$

Where:

$MF_{O,RG,m}$	Mass fraction of oxygen in the residual gas in the minute m
AM_O	Atomic mass of oxygen (kg/kmol)
$MF_{H,RG,m}$	Mass fraction of hydrogen in the residual gas in the minute m
AM_H	Atomic mass of hydrogen (kg/kmol)

Determine the mass fractions of carbon, hydrogen, oxygen and nitrogen in the residual gas, using the volumetric fraction of component *i* in the residual gas and applying the equation below. In applying this equation, the project proponent may choose to either a) use the measured volumetric fraction of each component *i* of the residual gas, or (b) as a simplification, measure the volumetric fraction of methane and consider the difference to 100% as being nitrogen (N_2). The same equation applies, irrespective of which option is selected.

$$MF_{j,RG,m} = \frac{\sum_{i} v_{i,RG,m} \times AM_{j} \times NA_{j,i}}{MM_{RG,m}} \qquad \textbf{(31)}$$

Where:

$MF_{j,RG,m}$ Mass fraction of element *j* in the residual gas in the minute *m*

$v_{i,RG,m}$	Volumetric fraction of component *i* in the residual gas on a dry basis in the minute *m*
AM_j	Atomic mass of element *j* (kg/kmol)
$NA_{j,i}$	Number of atoms of element *j* in component *i*
$MM_{RG,m}$	Molecular mass of the residual gas in minute m (kg/kmol)
j	Elements C, O, H and N
i	Component of residual gas. If Option (a) is selected to measure the volumetric fraction, then *i* = CH_4, CO, CO_2, O_2, H_2, H_2S, NH_3, N_2 or if Option (b) is selected then *i* = CH_4 and N_2

As also established by the methodological tool "Project emissions from flaring" (version 04.0), for enclosed flares that are defined as low height flares, determined every-minute the flare efficiency values shall be adjusted, as a conservative approach, by subtracting 10 percentile points.

Step 3: Calculation of project emissions from flaring:

For each individual flare, project emissions from flaring are calculated as the sum of emissions for each minute *m* in year *y*, based on the methane mass flow in the residual gas ($F_{CH4,RG,m}$) and the flare efficiency ($\eta_{flare,m}$), as follows:

$$PE_{flare,y} = GWP_{CH4} * \sum_{m=1}^{525,600} F_{CH4,RG,m} * \left(1-\eta_{flare,m}\right) * 10^{-3} \quad \textbf{(32)}$$

Where:

$PE_{flare,y}$	Project emissions from flaring of the residual gas in year *y* (in tCO_{2e})
GWP_{CH4}	Global warming potential of methane valid for the commitment period (in tCO_2e/tCH_4)
$F_{CH4,RG,m}$	Mass flow of methane in the residual gas in the minute *m* (in kg)
$\eta_{flare,m}$	Flare efficiency in minute *m*

Ex-ante estimation of $F_{CH4,PJ,y}$

Ex-ante estimates of $F_{CH4,PJ,y}$ is required to estimate methane baseline emissions from the Ecoparque Sergipe landfill in the context of annual estimates the emission reductions to be achieved by the proposed VCS project activity.

As established by the applied CDM baseline and monitoring methodology ACM0001 (version 19.0), $F_{CH4,PJ,y}$ is estimated as follows:

$$F_{CH4,PJ,y} = \eta_{PJ} * BE_{CH4,SWDS,y} / GWP_{CH4} \quad \textbf{(33)}$$

Where:

$BE_{CH4,SWDS,y}$	Amount of methane in the LFG that is generated from the SWDS in the baseline scenario in year *y* (in tCO_2e)
η_{PJ}	Efficiency of the LFG capture system that will be installed as part of the proposed VCS project activity
GWP_{CH4}	Global warming potential of CH_4 (in tCO_2e/tCH_4)

$BE_{CH4,SWDS,y}$ is determined by applying applicable guidance of the CDM methodological tool “Emissions from solid waste disposal sites” (version 08.0). The following guidance is to be taken into account when applying the tool:

- f_y as per the CDM methodological tool shall be assigned a value of 0 because the amount of LFG that would have been captured and destroyed is already accounted for when applying the CDM baseline and monitoring methodology ACM0001 (version 19.0);
- In the tool, *x* begins with the year that the SWDS started receiving wastes (e.g. the first year of SWDS operation); and
- Sampling to determine the fractions of different waste types is not necessary because the waste composition can be obtained from previous studies.

Thus, for the *ex-ante* estimation of the amount of methane which is destroyed by the proposed VCS project activity through combustion of collected LFG in project’s methane destruction devices + supply of upgraded LFG to consumer(s) ($F_{CH4,PJ,y}$) during each year y, the calculation of $BE_{CH4,SWDS,y}$ is given by the following formulae:

$$BE_{CH4,SWDS,y} = \varphi_y * (1 - f_y) * GWP_{CH4} * (1 - OX) * \frac{16}{12} * F * DOC_{f,y} * MCF_y * \sum_{x=1}^{y} \sum_{j} W_{j,x} * DOC_j * e^{-k_j \cdot (y-x)} * \left(1 - e^{-k_j}\right) \quad \textbf{(34)}$$

Where:

$BE_{CH4,SWDS,y}$	Baseline methane emissions occurring in year *y* generated from waste disposal at a SWDS during a time period ending in year *y* (in tCO_2e / yr)
x	Years in the time period in which waste is disposed at the SWDS, extending from the first year in the time period (*x* = 1) to year *y* (*x* = *y*)
y	Year of the crediting period for which methane emissions are calculated (*y* is a consecutive period of 12 months)

$DOC_{f,y}$	Fraction of degradable organic carbon (DOC) that decomposes under the specific conditions occurring in the SWDS for year *y* (weight fraction)
$W_{j,x}$	Amount of solid waste type *j* disposed or prevented from disposal in the SWDS in the year *x* (t)
φ_y	Model correction factor to account for model uncertainties for year *y*. The value (as per Option 2 of applicable guidance in the CDM methodological tool) is selected. Thus, $\varphi_y = 0.75$
f_y	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*. f_y in the CDM methodological tool “Emission from solid waste disposal sites” shall be assigned a value of 0 because the amount of LFG that would have been captured and destroyed is already accounted for when applying the CDM baseline and monitoring methodology ACM0001 (version 19.0). While as per the CDM methodological tool “Emissions from solid waste disposal sites” (version 08.0), f_y is presented as a parameter to be monitored ex-post; by considering the related methodological approach of ACM0001 (version 19.0) and assigned value for f_y, this parameter will thus not be monitored ex-post.
GWP_{CH4}	Global Warming Potential of methane
OX	Oxidation factor (reflecting the amount of methane from SWDS that is oxidized 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	Decay rate for the waste type *j* (1 / yr)
j	Type of residual waste or types of waste in the MSW

The value and source of information for each of the variables above are given in Section 4.1. It is important to note that the approach to take into account characteristics of the disposed waste (used as inputs for the ex-ante estimation) are the ones recommended by IPCC. Due to that, no sampling of waste is necessary. This is in accordance with both the CDM methodological tool “Emissions from solid waste disposal sites” (version 08.0) and the CDM baseline and monitoring methodology ACM0001 (version 19.0). While the design of the proposed VCS project activity is limited to the promotion of collection and destruction/utilization/supply of LFG at the Ecoparque Sergipe (without promoting any change in the management and operation of this particular landfill), the project activity thus does not prevent any solid waste from being disposed at the landfill.

The determination of $BE_{CH4,SWDS,y}$ in the context of the calculation of ex-ante estimations of emission reductions to be achieved by the proposed VCS project activity is included in Section 3.8. An emission reduction calculation spreadsheet which includes all related calculations for figures presented in Section 3.8 is enclosed to this VCS PD.

Determination of $F_{CH4,BL,y}$

As required by the applied CDM baseline and monitoring methodology ACM0001 (version 19.0), this section represents the application of the stepwise procedure for the determination of the amount of methane that would have been captured and destroyed in the baseline scenario (absence of the proposed VCS project activity) at the Ecoparque Sergipe landfill due to eventually applicable regulatory or contractual requirements and/or to address eventually existent applicable safety and odors concerns (which are collectively referred to as "*requirement*" under this step).

The four cases summarized in the table below are distinguished in ACM0001 (version 19.0). As also required by ACM0001 (version 19.0), the appropriate case for the particular baseline context of the proposed VCS project activity is identified and justified below.

Possible cases for determining methane captured and destroyed in the baseline as per ACM0001 (version 19.0)

Situation at the start of the project activity	Requirement to destroy methane	Existing LFG capture and destruction system
Case 1	No	No
Case 2	Yes	No
Case 3	No	Yes
Case 4	Yes	Yes

Requirement to destroy methane:

Non-existence of regional, national regulatory or contractual requirements related to LFG management in the region of the project site and/or in Brazil:

Currently there is no legal obligation to promote any kind of capture and/or combustion/destruction/utilization/supply of LFG at the Ecoparque Sergipe landfill [27].

Furthermore, this situation is currently not realistically expected to be changed during the time period to be encompassed by the 1st 7-year crediting period of the project VCS activity. It is important to note that there has been no contractual requirement set by any official (governmental) or private party establishing/requiring collected LFG to be destroyed through combustion.

Existence of non-regulatory and non-contractual requirements to destroy methane due to safety and odor concerns:

In the particular case of the Ecoparque Sergipe landfill, there is no requirement to destroy methane due to non-regulatory requirements (i.e. due to technical and/or operational requirements as due to safety and odor concerns). As per the project design and licensing requirements applicable in the particular context of the Ecoparque Sergipe landfill, no LFG is required to be combusted in available LFG venting drains in order to address any kind of odors or safety concerns. The practice of direct venting of LFG through existing LFG venting drains (with no combustion) has been regarded as enough to prevent dangerous accumulation of LFG in the inner section of the landfill. While as per the methodological approach of the applied CDM baseline and monitoring methodology ACM0001 (version 19.0) applicable for determination of $F_{CH4,BL,y}$, any combustion of LFG in order to address any kind of safety and/or odour concerns would be regarded as an existing requirement to destroy methane, It is thus assumed that, in the particular case of the Ecoparque Sergipe landfill, there is no non-regulatory requirement to destroy methane either.

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[27] In July/2022, there was no legal requirement for LFG gas collection and its destruction using active or passive high temperature enclosed flares in Brazil. Moreover, there was still no legal restriction neither requirement for passive venting of LFG or its combustion in conventional LFG destruction systems. Actually, there is still no applicable regulation that deals with LFG management in Brazil. The National Policy on Waste Management (passed in year 2010) does not deal with LFG management either.

Some facts about the Brazilian National Policy on Waste Management:

After years of studies and negotiations, the Brazilian Regulation of the National Policy on Waste Management, established by Decree No. 7,404/10 (the Decree), was published on 02/08/2010 and entered into force on 23/12/2010. This decree regulates the National Policy on Waste Management (PNRS), established by Federal Law No. 12,305/10 (the LPNRS), and creates the Steering Committee for the Implementation of Reverse Logistics Systems (Steering Committee) and the PNRS Interministerial Committee. This Brazilian Regulation of the National Policy on Waste Management does not establish any requirement, obligation, guidelines or recommendation related to LFG management at landfills in Brazil. The following is outlined by the law and regulation specialized firm “Tauil & Chequer Advogados“ in an article published in year 2011 of which content remains being valid:

> *“(...) The Regulation of the National Policy on Waste Management, established by Decree No. 7,404/10 (the Decree), was published on December 23, 2010. In force since its publication, the Decree regulates the National Policy on Waste Management (PNRS), established by Federal Law No. 12,305/10 (the LPNRS), and creates the Steering Committee for the Implementation of Reverse Logistics Systems (Steering Committee) and the PNRS Interministerial Committee. The main purpose of the PNRS Interministerial Committee is to support the PNRS structuring and implementation, in order to enable the accomplishment of the provisions and goals set forth by the LPNRS. The Steering Committee has the basic function of guiding the implementation of reverse logistics. Among the instruments regulated by the Decree are the Reverse Logistics Systems, the Waste Management Plans (PGRS) and the National Registry for Hazardous Waste Operators. The Decree lists three specific instruments for the implementation and operation of the reverse logistic systems: (i) sectorial agreements, executed between public authorities and the industry; (ii) regulations, issued by the executive branch; and (iii) commitment agreements—which are to be adopted in the absence of sectorial agreements and regulations and when specific circumstances require more restrictive obligations—to be approved by the competent environmental agency. Regarding the obligation to prepare a PGRS, which should be required within environmental permitting proceedings, the Decree mentions the possibility of jointly submitting the PGRS under specific conditions and in cases where activities are conducted in the same condominium, municipality, micro-region or metropolitan/urban areas. Additionally, the Decree establishes that small companies that generate household waste, as provided for by article 30 of the LPNRS, are not required to submit a PGRS. Regarding the National Registry for Hazardous Waste Operators, which must be integrated to the already existing Federal Technical Registry of IBAMA, the Decree establishes a registration obligation for companies that manipulate or operate hazardous waste. The Decree also describes those who are considered generators or operators of hazardous waste, establishing several requirements for their authorization or permitting. These include the preparation of hazardous waste management plan, the demonstration of technical and economic capacity and the obtaining of civil liability insurance for environmental damages.”* [SIC]

Paper is available online: http://www.tauilchequer.com.br/publications/detailprint.aspx?publication=1179

By taking such assumptions into account, the following is thus valid/applicable for the Ecoparque Sergipe landfill in the absence of the proposed VCS project activity (baseline scenario) in the context of the application of related methodological guidance of ACM0001 (version 19.0):

- Requirement to destroy methane: NO

By taking this assumption into account, thus, Case 2 and Case 4 (which are options/cases associated to existence of requirement to destroy methane in the absence of the proposed VCS project activity) are directly regarded as not applicable for the determination of $F_{CH4,BL,y}$ in the particular case of the proposed VCS project activity (in the particular contexts of both its identification of baseline scenario and determination of baseline emissions).

Thus, the remaining possibly valid alternatives (cases) (after the analysis of existence of non-regulatory and/or non-contractual requirements to destroy methane due to safety and/or odour concerns) are thus Case 1 and Case 3.

Non-Existence of LFG capture and destruction system at the Ecoparque Sergipe landfill:

By taking into account the definitions of "*LFG capture system*" and "*existing LFG capture system*" as per ACM0001 (version 19.0) [28], it is thus assumed that there has been no LFG capture system at the Ecoparque Sergipe landfill since its starting of operations. While combustion of LFG has not occurred at the landfill, no destruction of methane has thus occurred. Therefore, it is assumed that there has been no LFG capture and destruction system at the Ecoparque Sergipe landfill.

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[28] As per the applied CDM baseline and monitoring methodology ACM0001 (version 19.0), "*LFG capture system*" is defined as follows:

> "*A system to capture LFG. The system may be passive, active or a combination of both active and passive components. Passive systems capture LFG by means of natural pressure, concentration, and density gradients. Active systems use mechanical equipment to capture LFG by providing pressure gradients. Captured LFG can be vented, flared or used.*"

As per ACM0001 (version 19.0), "*existing LFG capture system*" is defined as follows:

> "*An existing active LFG capture system is a system that has been in operation in the last calendar year prior to the start of the operation of the project activity.*"

It is also reasonable to assume that, no LFG capture and destruction system is to be implemented in the absence of the proposed VCS project (baseline scenario) at the Ecoparque Sergipe landfill. As per the design of this landfill site, in the absence of the implementation and starting of operations of the project activity, the currently existent set of pre-project-implementation LFG venting drains would kept being available on site and LFG would kept being vented (freely emitted into the atmosphere through the surface of the landfill and through these LFG venting drains (with no combustion occurring).

The pre-project-implementation venting drains are not conceived for combustion of LFG. Freely LFG venting through the LFG venting drains has occurred as there is no legal requirement to destroy methane in the Ecoparque Sergipe landfill and the operator of this landfill site does not have any incentive or requirement to install passive conventional LFG flares (combusting LFG) instead of conventional LFG venting drains. Venting of LFG through conventional LFG venting drains and through the landfill surface has been a practice in several others landfills and dump sites in Brazil and other countries in Latin America for cases where there have been no requirements for destruction of LFG.

By taking the above-presented facts and assumptions into account, the following is thus valid/applicable for the Ecoparque Sergipe landfill in the absence of the proposed VCS project activity (baseline scenario) in the context of the application of related methodological guidance of ACM0001 (version 19.0):

- Existing LFG capture and destruction system: NO

Therefore, Case 3 (which is an option/case associated to existence of LFG capture and destruction in the absence of the proposed VCS project activity) is regarded as a not applicable case for the determination of $F_{CH4,BL,y}$ in the context of both identification of baseline scenario and determination of baseline emissions for the proposed VCS project activity.

Thus, the only remaining possibly valid alternative (case) (after the analysis of Existence of LFG capture and destruction system at the Ecoparque Sergipe landfill) is Case 1.

In summary, the following is thus valid in the context of the application of the stepwise procedure for the determination of $F_{CH4,BL,y}$ for the project activity during its 1st crediting period:

- Requirement to destroy methane = NO
- Existing LFG capture and destruction system = NO

By taking into account the outcome of the above presented analysis, the following methodological approach is thus valid for the determination of $F_{CH4,BL,y}$:

Application of methodological guidance valid for Case 1:

Under Case 1 of the methodological guidance for the determination of $F_{CH4,BL,y}$, the following is applicable as per ACM0001 (version 19.0):

$F_{CH4,BL,y} = 0$ **(35)**

Baseline emissions associated with electricity generation ($BE_{EC,y}$)

As established by the applied CDM baseline and monitoring methodology ACM0001 (version 19.0), baseline emissions associated with electricity generation in year *y* ($BE_{EC,y}$) shall be calculated by applying applicable guidance of the CDM methodological tool “Baseline, project and/or leakage emissions from electricity consumption and monitoring of electricity generation” (version 03.0). When applying this CDM methodological tool the following is to be considered:

- The electricity sources *k* in the tool correspond to the sources of electricity generated identified in the selection of the most plausible baseline scenario; and
- $EC_{BL,k,y}$ in the tool is equivalent to the net amount of electricity generated using LFG in year *y*.

The CDM methodological tool “Baseline, project and/or leakage emissions from electricity consumption and monitoring of electricity generation” (version 03.0) also declares the following:

> *“In the generic approach, project, baseline and leakage emissions from consumption of electricity are calculated based on the quantity of electricity consumed, an emission factor for electricity generation and a factor to account for transmission losses (…)”*

Specifically for baseline emissions the following equation is applicable:

$$BE_{EC,y} = \sum_{j} EC_{BL,k,y} * EF_{EL,k,y} * (1 + TDL_{k,y}) \quad \textbf{(36)}$$

Where:

$BE_{EC,y}$	Baseline emissions associated with electricity generation (in tCO_2/yr).
$EC_{BL,k,y}$	Net amount of electricity generated using LFG in year *y* (in MWh)
$EF_{EL,k,,y}$	Emission factor for electricity generation for source *k* in year *y* (in tCO_2/MWh) $EF_{EL,j/k/l,y}$ represents the combined margin (CM) emission factor for the electricity grid to which the project activity is connected to ($EF_{grid,CM,y} = EF_{EL,grid,y}$).
$TDL_{k,y}$	Average technical transmission and distribution losses for providing electricity to source *k* in year *y*

k	Sources of electricity generated identified in the selection of the most plausible baseline scenario

By following the above-quoted applicable guidance of the CDM methodological tool "Baseline, project and/or leakage emissions from electricity consumption and monitoring of electricity generation" (version 03.0), baseline emissions for electricity generation by the project activity ($BE_{EC,y}$), are determined as follows:

$$BE_{EC,grid,y} = EC_{BL,y} * EF_{EL,grid,y} * (1 + TDL_{grid,y}) \tag{36.1}$$

Where:

$EC_{PJ,grid,y}$	Net amount of electricity generated using LFG in year y (in MWh).
$EF_{EL,grid,y}$	Emission factor for grid sourced electricity in year y (in tCO_2/MWh). $EF_{EL,grid,y}$ is determined as the combined margin (CM) emission factor ($EF_{grid,CM,y}$).
$TDL_{grid,y}$	Average technical transmission and distribution losses for providing electricity to the grid and/or for grid sourced electricity consumed by the VCS project activity

Determination of combined margin (CM) emission factor ($EF_{grid,CM,y} = EF_{EL,grid,y}$):

Option A.1 of the CDM methodological tool "Baseline, project and/or leakage emissions from electricity consumption and monitoring of electricity generation" (version 03.0) is selected for determining $EF_{EL,k,,y}$. Thus, according to the selected option, the following is applicable:

> *"Calculate the combined margin emission factor of the applicable electricity system, using the procedures in the latest approved version of the "Tool to calculate the emission factor for an electricity system" ($EF_{EL,j/k/l,y} = EF_{grid,CM,y}$)."*

The CDM methodological tool "Tool to calculate the emission factor for an electric system" (version 07.0) indicates that the emission factor of the electricity grid to which the project activity is to be connected is determined by the following 6-step approach:

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

Combined margin CO_2 emissions factor is calculated in accordance with the "Tool to calculate the emission factor for an electricity system" (version 07.0). This methodological tool determines the CO_2 emission factor for the displacement of electricity generated by grid-connected power plants, by calculating the combined margin emission factor ($EF_{CM,y}$) of the electricity system. As per the "Tool to calculate the emission factor for an electricity system" (version 07.0), $EF_{CM,y}$ is determined as a weighted average of two CO_2 emission factors pertaining to the electricity system: the CO_2 operating margin emission factor ($EF_{OM,y}$) and the build margin emission factor ($EF_{BM,y}$). The operating margin emission factor refers to the group of existing power plants whose current electricity generation would be potentially affected by the proposed CDM project activity. The build margin emission factor refers to the group of prospective power plants whose construction and future operation would be potentially affected by the proposed CDM project activity.

The applicable procedures of “Tool to calculate the emission factor for an electricity system” (version 04.0) tool are described in the following steps:

- Step 1. Identify the relevant electricity systems:

For determining the electricity emission factors, a project electricity system is defined by the spatial extent of the power plants that are physically connected through transmission and distribution lines to the project activity and that can be dispatched without significant transmission constraints. The spatial extent of the project boundary includes the project site which is connected to the National Electricity Grid of Brazil which is named National Interconnected System (*Sistema Interligado Nacional – SIN*).

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

Option I of the tool is chosen which is to include only grid power plants in the calculation.

- 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.

Any above method can be utilized. However, the simple OM method (option a) can only be used if low-cost/must-run resources constitute less than 50% of total grid generation in: 1) average of the five most recent years, or 2) based on long-term averages for hydroelectricity production. This is not the case for the project electricity system being considered. Since the simple adjusted OM (option b) emission factor is a variation of the simple OM, where the power plants/units (including imports) are separated in low-cost/must-run power sources and other power sources, this is also not applicable to this project activity. For the similar reason, the option (d), average OM emission factor is not eligible for this project, since it is calculated as the average emission rate of all power plants serving the grid, using the methodological guidance for the simple OM, but including in all equations also low-cost/must-run power plants. Therefore, for the OM calculation method, the option (c) dispatch data analysis is referred, since the Ministry of Science, Technology and Innovation of Brazil has been updated and published annually the information for power units[29].

For the dispatch data analysis OM, the year in which the project activity displaces grid electricity and the emission factor updating annually during monitoring is utilized.

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

In order to determine the combined margin emission factor, the dispatch data analysis method has been selected among four options proposed in the methodology, since it is publicly available in Brazil.

The dispatch data analysis OM emission factor ($EF_{grid,OM\text{-}DDy}$) 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 $EF_{grid,OM\text{-}DDy.}$, as the MCTI have been done.

The operating margin emission factor is calculated as follows:

$$EF_{grid,OM\text{-}DDy} = \frac{\sum EG_{PJ,h} \cdot EF_{EL,DD,h}}{EG_{PJ,y}} \quad \textbf{(37)}$$

Where:

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

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[29] The Ministry of Science, Technology and Innovation have been calculating the CO_2 emission factor according to the methodology tool “Tool to calculate the emission factor for an electricity system” (version 2.2.0), approved by the CDM Executive Board. The CO_2 emission factor was obtained in the Brazilian DNA website. Source of data used: Tool to calculate the emission factor for an electricity system (version 2.2.0 and more recent versions): The actual value has been calculated by Ministry of Science, Technology and Innovation (MCTI), Brazilian Designated National Authority (DNA). The Emission Factor will be monitored through ex-post calculation, following the latest version of Tool to calculate the emission factor for an electricity system. The Brazilian DNA calculated the value based on the Tool. The Combined Margin is calculated through a weighted-average formula, considering both the $EF_{grid,OM\text{-}DD,y}$ and the $EF_{grid,BM,y}$ and the weights w_{OM} and w_{BM} (default values of 0.50 and 0.50, respectively).

Y	Year in which the project activity is displacing grid electricity

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

In terms of vintage of data, project participants can choose between one of the following two options:

Option 1: *For the first crediting period, calculate the build margin emission factor ex ante based on the most recent information available on units already built for sample group m at the time of CDM-PDD submission to the DOE for validation. For the second crediting period, the build margin emission factor should be updated based on the most recent information available on units already built at the time of submission of the request for renewal of the crediting period to the DOE. For the third crediting period, the build margin emission factor calculated for the second crediting period should be used. This option does not require monitoring the emission factor during the crediting period.*

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 emissions factor shall be calculated ex ante, as described in Option 1 above. For the third crediting period, the build margin emission factor calculated for the second crediting period should be used.*

Option 1 is selected for the 1st 7-year crediting period of the project activity.

The build margin emissions factor is the generation-weighted average emission factor (in tCO_2/MWh) of all power units m during the most recent year *y* for which power generation data is available. The DNA of Brazil has regularly published an official value for $EF_{grid,BM,y}$ [30]. The latest published value (applicable for year 2020) is thus the value for the ex-ante selected parameter $EF_{grid,BM,y}$ and is calculated as follows:

$$EF_{grid,BM,y} = \frac{\sum EG_{m,y} \cdot EF_{EL,m,y}}{\sum EG_{m,y}} \quad \textbf{(38)}$$

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[30] Details about the determination of values for the CO_2 emission factor for the national electricity grid of Brazil by the DNA of Brazil are made available online in the website of the DNA of Brazil:

https://antigo.mctic.gov.br/mctic/opencms/ciencia/SEPED/clima/textogeral/emissao_despacho.html

Where:

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

- Step 6. Calculate the combined margin (CM) emissions factor

The combined margin emissions factor is calculated as follows:

$$EF_{grid,CM,y} = EF_{grid,OM,y} * w_{OM} + EF_{grid,BM,y} * w_{BM} \tag{39}$$

Where:

$EF_{grid,BM,y}$	Build margin CO_2 emission factor in year *y* (tCO_2/MWh)
$EF_{grid,OM,y}$	Operating margin CO_2 emission factor in year *y* (tCO_2/MWh)
w_{OM}	Weighting of operating margin emissions factor (%)
w_{BM}	Weighting of build margin emissions factor (%)

The values for w_{OM} and w_{BM} are ex-ante selected as per applicable guidance of the "Tool to calculate the emission factor for an electric system", which includes the following as a requirement:

"The following default values should be used for w_{OM} and w_{BM}:

(a) 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;

(b) 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,6 unless otherwise specified in the approved methodology which refers to this tool."

While values for the parameters $EF_{grid,BM,y}$, w_{OM} and w_{BM} (which are applicable for the whole 1st 7-year crediting period) are selected ex-ante, annual values for $EF_{grid,OM,y}$ within the credting period will be determined ex-post as required by the "Tool to calculate the emission factor for an electric system”. Thus, during the 1st 7-year crediting period, the combined margin CO_2 emission factor will be calculated and updated annually.

Baseline emissions associated with heat generation ($BE_{HG,y}$)

As the proposed VCS project activity does not encompass any utilization of collected LFG for heat generation (in boiler, air heater, glass melting furnace(s) and/or kiln), baseline emissions associated with heat generation in year y ($BE_{HG,y}$) are not considered. In summary, this step is not applicable.

Baseline emissions associated with natural gas use ($BE_{NG,y}$)

Baseline emissions associated with natural gas use ($BE_{NG,y}$) is calculated in conformance with the applied CDM baseline and monitoring methodology ACM0001 (version 19.0) + applicable CDM methodological tools respectively by following the approaches presented below, where the determination of $BE_{NG,y}$ is based on the amount of landfill gas that is actually captured and sent to the natural gas network or dedicated pipeline or in the trucks as a result of the implementation and operation of the proposed VCS project activity. Thus, $BE_{NG,y}$ is calculated as follows:

$$BE_{NG,y} = 0.0504 * F_{CH4,NG,y} * EF_{CO2,NG,y} \tag{40}$$

Where:

$BE_{NG,y}$	Baseline emissions associated with natural gas use in year y (t CO_2e/yr)
$F_{CH4,NG,y}$	Amount of methane in the LFG which is sent to the natural gas distribution network or dedicated pipeline or to the trucks in year y (tCH_4/yr)
$EF_{CO2,NG,y}$	Average CO2 emission factor of natural gas in the natural gas network or dedicated pipeline or in the trucks in year y (tCO_2e/TJ)

In which $EF_{CO2,NG,y}$ is calculated as per guidelines provided by the “Tool to calculate project or leakage CO_2 emissions from fossil fuel combustion” (version 03.0). The following approaches can be used:

Option A: The CO_2 emission coefficient $COEF_{i,y}$ is calculated based on the chemical composition of the fossil fuel type i, using the following approach:

If $FC_{i,j,y}$ is measured in a mass unit:

$$COEF_{i,y} = w_{C,i,y} \times 44/12 \quad \textbf{(41)}$$

If $FC_{i,j,y}$ is measured in a volume unit:

$$COEF_{i,y} = w_{C,i,y} \times \rho_{i,y} \times 44/12 \quad \textbf{(42)}$$

Where:

$COEF_{i,y}$ = CO_2 emission coefficient of fuel type i (tCO_2/mass or volume unit);

$w_{C,i,y}$ = Weighted average mass fraction of carbon in fuel type i in year y (tC/mass unit of the fuel);

$\rho_{i,y}$ = Weighted average density of fuel type i in year y (mass unit/volume unit of the fuel);

i = Fuel types combusted in process j during the year y.

Option B: The CO_2 emission coefficient $COEF_{i,y}$ is calculated based on net calorific value and CO_2 emission factor of the fuel type i, as follows:

$$COEF_{i,y} = NCV_{i,y} \times EF_{CO2,i,y} \quad \textbf{(43)}$$

Where:

$NCV_{i,y}$ = Weighted average net calorific value of the fuel type i in year y (GJ/mass or volume unit);

$EF_{CO2,i,y}$ = Weighted average CO2 emission factor of fuel type i in year y (tCO_2/GJ).

Monitoring of the management of the landfill:

As required by the applied CDM baseline and monitoring methodology ACM0001 (version 19.0), the design and operational conditions of the Ecoparque Sergipe landfill site will be annually monitored on the basis of different sources, including inter alia:

- Original design of the landfill;
- Technical specifications for the management of the landfill;
- Applicable local or national regulations

The original operational design of the Ecoparque Sergipe landfill site should be confirmed not to be modified in order to ensure that no practice to deliberately or intentionally increase methane generation at the landfill have been occurring during the period, when compared to the landfill management and operation condition prior to the implementation of the proposed VCS project activity. As required by the applied CDM baseline and monitoring methodology ACM0001 (version 19.0), any change in the management of the landfill after the implementation of the proposed VCS project activity should be justified by referring to technical or regulatory specifications and impacts of such changes in the determination of baseline emissions should in this case be taken into account appropriately. Such monitoring requirement will be used for the determination/confirmation of baseline emissions and/or confirmation of the project's implementation as described in the VCS PD (in terms of operation and management conditions of the landfill from which LFG is destroyed/combusted/supplied to consumer(s)). Further related monitoring details are included in Sections 4.2 and 4.3 (under parameter "Management of SWDS").

3.8 Project Emissions

While, in accordance with the applied CDM baseline and monitoring methodology ACM0001 (version 19.0) and applicable CDM methodological tools, emission reductions (ER_y) to be achieved by the proposed VCS project activity are determined (in tCO_2e) as the difference between baseline emissions (BE_y) and project emissions (PE_y), this section presents the methodological approach for the determination of PE_y:

Determination of Project Emissions (PE_y):

As established by ACM0001 (version 19.0), project emissions (PE_y) for a proposed VCS project activity promoting LFG collection and destruction/utilization are to be generically calculated (in tCO_2/year) as follows:

$$PE_y = PE_{EC,y} + PE_{FC,y} + PE_{DT,y} + PE_{SP,y} \quad \textbf{(44)}$$

Where:

PE_y	Project emissions in year *y* (in tCO_2/yr)
$PE_{EC,y}$	Emissions from consumption of electricity due to the project activity in year *y* (in tCO_2/yr)
$PE_{FC,y}$	Emissions from consumption of fossil fuels due to the project activity, for purpose other than electricity generation, in year *y* (in tCO_2/yr)
$PE_{DT,y}$	Emissions from the distribution of compressed/liquefied LFG using trucks, in year y (in tCO_2/yr)

$PE_{SP,y}$	Emissions from the supply of LFG to consumers through a dedicated pipeline, in year y (tCO_2/yr)

In the particular case of the project activity, while grid-sourced electricity and electricity generated by the backup captive off-grid electricity generators (fuelled by diesel) are sources of electricity to be consumed by the project activity, related project emissions ($PE_{EC,y}$) are thus being determined ex-post. Furthermore, while the proposed VCS project activity encompasses distribution of LFG to consumer(s) through dedicated pipeline, related project emissions ($PE_{SP,y}$) are to be determined ex-post. Moreover, compressed/liquefied upgraded LFG by using trucks, there are no project emissions from the distribution of compressed/liquefied LFG using trucks to also be determined ex-post, thus $PE_{DT,y} = 0$; since no fossil fuel is to be consumed by the proposed VCS project activity for purpose other than electricity generation, there will be no related project emissions ($PE_{FC,y} = 0$)

Thus, the following is applicable for the particular case of the proposed VCS project activity:

$$PE_y = PE_{EC,y} + PE_{SP,y} \qquad \textbf{(44.1)}$$

Determination of project emissions due to consumption of electricity by the proposed VCS project activity ($PE_{EC,y}$):

In the particular case of the project activity, while grid-sourced electricity and electricity generated by the backup captive off-grid electricity generators (fuelled by diesel) are sources of electricity to be consumed by the project activity, $PE_{EC,y}$ is determined as follows:

$$PE_{EC,y} = PE_{EC,grid,y} + PE_{EC,captive,y} \qquad \textbf{(45)}$$

Where:

$PE_{EC,grid,y}$	Project emissions from consumption of grid electricity due to the project activity in year *y* (in tCO_2/yr)
$PE_{EC,captive,y}$	Project emissions from consumption of electricity generated by a captive off-grid electricity generator fueled by fossil fuel (diesel) in year *y* (in tCO_2/yr)

$PE_{EC,grid,y}$ and $PE_{EC,captive,y}$ are calculated according to the following approaches:

As required by the applied CDM baseline and monitoring methodology ACM0001 (version 19.0), $PE_{EC,y}$ shall be calculated by applying the methodological approach established by the CDM methodological tool "Baseline, project and/or leakage emissions from electricity consumption and monitoring of electricity generation" (version 03.0).

While the project activity fits under "Scenario C *(Electricity consumption from the grid and (a) fossil fuel fired captive power plant(s))* of this methodological tool, the following is also established by the tool:

> *"In the generic approach, project, baseline and leakage emissions from consumption of electricity are calculated based on the quantity of electricity consumed, an emission factor for electricity generation and a factor to account for transmission losses (…)"* [31]

ACM0001 (version 19.0) establishes the *following* when applying this methodological tool:

> *"$EC_{PJ,k,y}$[32] in the tool is equivalent to the amount of electricity consumed by the project activity in year y ($EC_{PJ,y}$)."*
>
> *"If in the baseline a proportion of LFG is destroyed ($F_{CH4,BL,y}$ > 0), then the electricity consumption in the tool ($EC_{PJ,j,y}$) should refer to the net quantity of electricity consumption (i.e. the increase due to the project activity). The determination of the amount of electricity consumed in the baseline shall be transparently documented in the CDM-PDD."*[33]

In the particular case of the proposed VCS project activity, electricity sources *j* in the tool corresponds to the sources of electricity consumed due to the project activity:

(i) grid-sourced electricity and

(ii) electricity generated by the backup captive off-grid electricity generator (fuelled by diesel)

Electricity from sources (i) and (ii) are expected to be consumed for the operation of the proposed VCS project activity. No sources of electricity other than (i) and (ii) are expected to be used to meet the project's electricity demand.

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[31] The project's electricity demand is to be met by one of the following sources/approaches:

- Imports of grid-sourced electricity.
- Electricity sourced by the project's electricity generation infrastructure
- Electricity sourced by the backup captive off-grid electricity generator (fuelled by diesel) (expected to occur only during temporary planned or unplanned circumstances when supply of grid-sourced electricity is also interrupted).

[32] As per the CDM methodological tool "Baseline, project and/or leakage emissions from electricity consumption and monitoring of electricity generation" (version 03.0), $EC_{PJ,j,y}$ is the quantity of electricity consumed by the project electricity consumption source *j* in year *y*.

[33] In the particular case of the proposed VCS project activity, the CDM-PDD is to be understood as this VCS PD.

In the particular case of the proposed VCS project activity, although LFG is destroyed in the baseline scenario ($F_{CH4,BL,y} > 0$), while the no electricity has been previously used in the pre-project-implementation (baseline scenarios) for collecting and destroying LFG, the determination of the amount of electricity consumed in the baseline scenario (absence of the project activity) is thus not applicable/considered. In summary, according to the CDM methodological tool "Baseline, project and/or leakage emissions from electricity consumption and monitoring of electricity generation" (version 03.0), project emissions due to electricity consumption by the project activity ($PE_{EC,y}$) are generically calculated as follows:

$$PE_{EC,y} = \sum EC_{PJ,j,y} * EF_{EL,j,y} * (1 + TDL_{j,y}) \qquad \textbf{(46)}$$

Where:

$EC_{PJ,j,y}$	Quantity of electricity consumed by the project electricity consumption source *j* in year y (in MWh).
$EF_{EL,j,y}$	CO_2 emission factor for electricity generation for source j in year y (in tCO_2/MWh).
$TDL_{j,y}$	Average technical transmission and distribution losses for providing electricity to source *j* in year *y*

Project emissions due to the consumption of grid-sourced electricity by the project activity ($PE_{EC,grid,y}$):

By following applicable guidance of the CDM methodological tool "Baseline, project and/or leakage emissions from electricity consumption and monitoring of electricity generation" (version 03.0) valid for Scenario C (Electricity consumption from the grid and (a) fossil fuel fired captive power plant(s)); project emissions due to consumption of grid-sourced electricity by the project activity ($PE_{EC,grid,y}$) are determined as follows:

$$PE_{EC,grid,y} = EC_{PJ,grid,y} * EF_{EL,grid,y} * (1 + TDL_{grid,y}) \qquad \textbf{(47)}$$

Where:

$EC_{PJ,grid,y}$	Quantity of grid-sourced electricity consumed by the project activity in year y. As detailed in Sections 4.2 and 4.3, values for $EC_{PJ,grid,y}$ will be measured and monitored ex-post in MWh as per the provisions of the CDM methodological tool "Baseline, project and/or leakage emissions from electricity consumption and monitoring of electricity generation" (version 03.0).

$TDL_{grid,y}$	Average technical transmission and distribution losses for providing electricity to the grid and/or for grid sourced electricity consumed by the project activity. As detailed in Sections 4.2 and 4.3, the value for $TDL_{grid,y}$ applicable for import of grid-sourced electricity will be determined ex-post as per the provisions of the CDM methodological tool “Baseline, project and/or leakage emissions from electricity consumption and monitoring of electricity generation” (version 03.0).
$EF_{EL,grid,y}$	CO_2 emission factor for grid-sourced electricity in year y (in tCO_2/MWh). $EF_{EL,grid,y}$ is determined ex-post by following applicable guidance of the CDM methodological tool “Tool to calculate baseline, project and/or leakage emissions from electricity consumption” as follows: *“Where case C.III has been identified, as a conservative simple approach, the emission factor for electricity generation should be the more conservative value between the emission factor determined as per guidance for scenario A and B respectively. This means that the more conservative value should be chosen between a) the result of applying either option A1 or A2 and b) the result of applying either option B1 or B2.”* *“Where case C.I has been identified, the guidance for scenario A (…) should be applied (use option A1 or option A2).”* The above-quoted options of the CDM methodological tool (Options A.1 or A.2.) may thus be analyzed ex-post for the determination of $EF_{EL,grid,y}$ as follows:

Option A.1: $EF_{EL,grid,y}$ is calculated ex-post as the combined margin (CM) emission factor ($EF_{grid,CM,y}$) as per applicable guidance of the CDM methodological tool “Tool to calculate the emission factor for an electricity system” (version 07.0) by following the approach summarized in this Section under “*Approach for determination of combined margin (CM) emission factor ($EF_{grid,CM,y} = EF_{EL,grid,y}$)”.*

Option A.2: $EF_{EL,grid,y}$ is directly determined as 1.3 tCO_2/MWh (applicable conservative default value of the CDM methodological tool “Tool to calculate baseline, project and/or leakage emissions from electricity consumption” (version 03.0)).

Project emissions due to the consumption of electricity sourced by backup captive off-grid electricity generator (fuelled by diesel) ($PE_{EC,captive,y}$):

By following applicable guidance of the CDM methodological tool “Baseline, project and/or leakage emissions from electricity consumption and monitoring of electricity generation” (version 03.0); project emissions from the consumption of electricity generated by the backup captive off-grid electricity generator (fuelled by diesel) are to be calculated as follows:

$$PE_{EC,captive,y} = EC_{PJ,captive,y} * EF_{EL,captive,\ y} * (1 + TDL_{captive,y}) \quad \textbf{(48)}$$

Where:

$EC_{PJ,captive,y}$	Amount of electricity sourced by the backup captive off-grid electricity generator (fuelled by diesel) and consumed by the project activity. As detailed in Sections 4.2 and 4.3, values for $EC_{captive,y}$ will be measured and monitored ex-post (in MWh) as per the provisions of the CDM methodological tool "Baseline, project and/or leakage emissions from electricity consumption and monitoring of electricity generation" (version 03.0)".
$TDL_{captive,y}$	Average technical transmission and distribution losses for electricity sourced by the captive electricity generator. As detailed in Sections 4.2 and 4.3, the value for $TDL_{captive,y}$ will be determined ex-post as per the provisions of the CDM methodological tool "Baseline, project and/or leakage emissions from electricity consumption and monitoring of electricity generation" (version 03.0).
$EF_{EL,captive,y}$	CO_2 emission factor for electricity sourced by the captive off-grid electricity generator (in tCO_2/MWh). Like in the case of $EF_{EL,grid,y,}$ $EF_{EL,captive,y}$ is directly determined, by following applicable guidance of the CDM methodological tool "Baseline, project and/or leakage emissions from electricity consumption and monitoring of electricity generation" (version 03.0), as 1.3 tCO_2/MWh (applicable conservative default value of the CDM methodological tool).

Determination of project emissions due to supply of LFG to consumer(s) through a dedicated pipeline *by the proposed VCS project activity* ($PE_{SP,y}$)*:*

In the particular case of the project activity, while landfill gas is expect to be supplied through dedicated pipeline to the consumer, this is a source of project emissions by the project activity, $PE_{SP,y}$ is determined as follows:

$$PE_{SP,y} = 0.0504 \text{ x } DEFT_{SP,y} \text{ x } F_{CH4,NG,y} \quad \textbf{(49)}$$

Where:

$PE_{SP,y}$	Project emissions from the supply of LFG to consumers due to physical leakage from the dedicated pipeline, in year y (tCO_2/yr)

$DEFT_{SP,y}$	Default emission factor for the supply of LFG to consumers due to physical leakage through the dedicated pipeline (tCO_2e/TJ). Which is based on the Appendix, Table 1, page 19 (Natural gas distribution) of the Tool "Upstream leakage emissions associated with fossil fuel use" (version 2) and is determined as 2.2 tCO_2e/TJ.
$F_{CH4,NG,y}$	Amount of methane in the LFG which is sent to the consumer through a dedicated pipeline in year y (tCH_4/yr)

3.9 Leakage

Not applicable as per CDM baseline and monitoring methodology ACM0001 (version 19.0).

3.10 Net GHG Emission Reductions and Removals

While emission reductions to be achieved by the proposed VCS project activity (ER_y) are determined as the difference between baseline emissions (BE_y) and project emissions (PE_y)[34], the following relevant equations and conditions are applied for the ex-ante estimation of emission reductions to be achieved by the proposed VCS project activity during the period:

Determination of ex-ante estimates for baseline emissions (BE_y):

While the proposed VCS project activity encompasses (i) methane destruction (as its most quantitatively relevant unique GHG abatement measure), (ii) displacement of grid-sourced electricity (by electricity generated by the project's electricity generation infrastructure) and (iii) displacement of consumption of natural gas (by the supply of upgraded LFG to consumer(s)); by following the applicable methodological approaches and taking into account assumptions + ex-ante determined values for applicable monitoring parameters (as presented in Sections 3.7 and 4.1 respectively), baseline emissions (BE_y) are thus determined as follows:

$$BE_y = BE_{CH4,y} + BE_{EL,y} + BE_{NG,Y}$$

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[34] $ER_y = BE_y - PE_y$

Where:

ERy	Emission reductions in year y (in tCO_2e/yr)
BE_y	Baseline emissions in year *y* (in tCO_2e/yr)
PE_y	Project emissions in year *y* (in tCO_2e/yr)

Where:

$BE_{CH4,y}$	Baseline emissions of methane from the SWDS in year y (tCO_2e/yr)
$BE_{EC,y}$	Baseline emissions for electricity generation (tCO_2/yr)
$BE_{NG,y}$	Baseline emissions associated with natural gas use in year *y* (in tCO_2e/yr)

Determination of $BE_{CH4,y}$:

$BE_{CH4,y}$ is estimated as follows:

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

Where:

OX_{top_layer}	Fraction of methane that would be oxidized in the top layer of the SWDS in the baseline. OX_{top_layer} is ex-ante determined as 0.1. Further details about the ex-ante value determination for OX_{top_layer} are made available in Section 4.1.
$F_{CH4,BL,y}$	Amount of methane that would have been captured and destroyed in the baseline scenario (absence of the CDM project activity). As outlined in Section 3.7, $F_{CH4,BL,y} = 0$
GWP_{CH4}	Global warming potential of CH_4 ($tCO_2e/t\ CH_4$). GWP_{CH4} is ex-ante determined as 28. Further details about the ex-ante value determination for GWP_{CH4} are made available in Section 4.1.
$F_{CH4,PJ,y}$	Amount of methane in the LFG which is combusted in the project's methane destruction devices and/or supplied to consumer(s) in year y (tCH_4/yr). In the particular context of the ex-ante estimation of emission reductions to be achieved by the proposed VCS project activity, as established by the applied CDM baseline and monitoring methodology ACM0001 (version 19.0), $F_{CH4,PJ,y}$ is determined (in $tCH_4/year$) as follows:

Determination of ex-ante estimations of $F_{CH4,PJ,y}$:

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

Where:

η_{PJ}	Efficiency of the LFG capture system that will be installed as part of the proposed VCS project activity. η_{PJ} is ex-ante determined as 0.99. Further details about the ex-ante value determination for η_{PJ} are made available in Section 4.1.

GWP_{CH4}	Global warming potential of CH_4 ($tCO_2e/t\ CH_4$). GWP_{CH4} is ex-ante determined as 28. Further details about the ex-ante value determination for GWP_{CH4} are made available in Section 4.1.
$BE_{CH4,SWDS,y}$	Amount of methane in the LFG that is generated from the SWDS in the baseline scenario in year *y* (in tCO_2e/yr). $BE_{CH4,SWDS,y}$ is estimated as follows:

$$BE_{CH4,SWDS,y} = \varphi_y * (1 - f_y) * GWP_{CH4} * (1 - OX) * \frac{16}{12} * F * DOC_f * MCF * \sum_{x=1}^{y} \sum_{j} W_{j,x} * DOC_j * e^{-k(y-x)} * (1 - e^{-kj})$$

For the determination of estimates of $BE_{CH4,SWDS,y}$, the ex-ante determined values for all parameters in the formulae above as well as historical and forecasts of MSW disposal at the Ecoparque Sergipe landfill are applied. Details about such ex-ante determined parameters are made available in Section 4.1.

Determination of $BE_{EC,y}$:

$BE_{EC,y}$ is determined as follows:

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

Where:

$EC_{BL,y}$	Net amount of electricity generated using LFG in year *y* (in MWh). In the particular context of ex-ante estimates of emission reductions to be achieved by the proposed VCS project activity, is estimated as 49,967 MWh/yr.
$TDL_{grid,y}$	Average technical transmission and distribution losses for providing electricity to the grid and/or for grid sourced electricity consumed by the project activity. In the particular context of ex-ante estimates of emission reductions to be achieved by the proposed VCS project activity, $TDL_{,grid,y}$ is ex-ante estimated as being 3% ($TDL_{grid,export,y}$). Selected value represents the applicable conservative default value as per the CDM methodological tool "Baseline, project and/or leakage emissions from electricity consumption and monitoring of electricity generation" (version 03.0).
$EF_{EL,grid,y}$	CO_2 emission factor for grid-sourced electricity in year y (in tCO_2/MWh). In the particular context of ex-ante estimates of emission reductions to be achieved by the proposed VCS project activity , $EF_{EL,grid,y}$ is estimated as per guidance for scenario A.1 of the the CDM methodological tool "Baseline, project and/or leakage emissions from electricity consumption and

monitoring of electricity generation" (version 03.0). The following is applicable:

By following procedure and guidance described in Section 3.7, the combined margin CO_2 emission factor ($EF_{grid,CM,y}$) for the elecricity grid of Brazil (SIN grid) is estimated as follows:

$EF_{grid,CM,y} = w_{OM} * EF_{grid,OM,y} + w_{BM} * EF_{grid,BM,y}$

Where:

w_{OM}	Weighting of operating margin emissions factor. w_{OM} is ex-ante determined as 50% (0.50). See Section 4.1 for further details.
w_{BM}	Weighting of build margin emissions factor. w_{BM} is ex-ante determined as 50% (0.50). See Section 4.1 for further details.
$EF_{grid,BM,y}$	Build margin CO_2 emission factor in year y. In the particular context of ex-ante estimates of emission reductions to be achieved by the proposed VCS project activity, $EF_{grid,BM,y}$ is ex-ante estimated as 0.0979 tCO_2/MWh. Selected value represents the annual average value applicable for year 2020 (as determined and published by the DNA of Brazil). Thus, in the particular case of the proposed VCS project activity, $EF_{grid,BM,y} = EF_{grid,BM,2020}$[35].
$EF_{grid,OM,y}$	Operating margin CO_2 emission factor in year *y* (in tCO_2/MWh). In the particular case of the project activity, $EF_{grid,OM,y} = EF_{grid,OM\text{-}DD,y}$. *Operational Margin CO_2 emission factor (dispatch analysis calculation method ($EF_{grid,OM\text{-}DD,y}$):* In the particular context of ex-ante estimations of emission reductions to be achieved by the proposed VCS project activity, the adopted value for $EF_{grid,OM\text{-}DD,y}$ is the value published by the DNA of as being the calculated value which is valid for year 2021 (the latest year for which values are available at the time of the completion of the this PDD):

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[35] Details about the determination of the CO_2 Emission Factors for the national electricity grid of Brazil (according to the CDM methodological tool: "Tool to calculate the emission factor for an electricity system (version 07.0 and previous versions) are made available online:

https://antigo.mctic.gov.br/mctic/opencms/ciencia/SEPED/clima/textogeral/emissao_despacho.htm

Operating Margin Emission Factor of Brazilian Integrated Electric System for year 2021 (dispatch analysis calculation method)

Operating Margin Emission Factor, year 2021 CO_2 Emission Factor (tCO_2/MWh)											
Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
0.6001	0.6023	0.5657	0.5522	0.5909	0.5940	0.5824	0.6214	0.6351	0.6236	0.6331	0.5815

The average value of $EF_{grid,OM\text{-}DD,2021}$ is thus calculated as 0.5985 tCO_2/MWh. Values of $EF_{grid,OM\text{-}DD,2021}$ are determined and reported by the DNA of Brazil. Further details are available online at the website of the DNA of Brazil.

$EF_{grid,CM,y}$ is thus calculated as follows:

$EF_{grid,CM,y} = w_{OM} * EF_{grid,OM,y} + w_{BM} * EF_{grid,BM,y} = 0.50 * 0.5985 + 0.50 * 0.0979 = 0.3482$ tCO_2/MWh (where related calculations are summarized in the emission reduction calculation spreadsheet enclosed to this VCS PD).

It is important to note that, as a simplification (only in the particular context of the ex-ante estimation of project emissions to be promoted by the proposed VCS project activity, it is assumed that the calculated combined margin grid emission factor ($EF_{grid,CM,y}$) (based on the value of $EF_{grid,OM\text{-}DD,2021}$ (valid for year 2021) and the value of $EF_{grid,BM,2020}$) is used for the determination of ex-ante estimates of emission reductions for all years encompassed by the 1st 7-year crediting period of the proposed VCS project activity (regardless of the fact that annual values for $EF_{grid,OM,y}$ and $EF_{grid,BM,y}$ are to be ex-post determined every year, thus potentially later affecting the value to be calculated for $EF_{grid,CM,y}$ for each individual year encompassed by the crediting period. This simplification is anyway under conformance with applicable VCS rules[36].

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[36] In the context of ex-ante estimations of project emissions due to consumption of grid electricity by the proposed VCS project activity, it is reasonable to consider as a simplification that significant changes in the average and marginal CO_2 intensity for electricity generated at the national electricity grid of Brazil are not expected to occur during the 1st 7-year crediting period of the project activity due to the following reason:

Information related to the determination of the combined margin CO_2 emission factor for the national electricity grid of Brazil is made available in the website/web portal of the DNA of Brazil[37].

Determination of $BE_{NG,y}$:

$BE_{NG,y}$ is determined as follows:

$BE_{NG,y} = 0.0504 * F_{CH4,NG,y} * EF_{CO2,NG}$

Where:

$F_{CH4,NG,y}$	Amount of methane in the LFG which is associated with natural gas use in year y (tCH_4/yr). In the particular context of the ex-ante estimation of emission reductions to be achieved by the proposed VCS project activity, as established by the applied CDM baseline and monitoring methodology ACM0001 (version 19.0).
$EF_{CO2,NG}$	CO_2 emission factor of natural gas in year y which is ex-ante estimated as 58.3 tCO_2/TJ.

An emission reduction calculation spreadsheet is enclosed to this VCS PD. This calculation spreadsheet includes all required related calculations for the

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- As per official domestic electricity generation related information published by the Brazilian Government, "*The system keeps the predominance of renewable and non-greenhouse gases emitting sources, amounting up to 80% of total capacity. The need of additional power capacity to cope with net peak load appears from 2022 onwards, totaling about 13,200 MW in 2027, which could be provided by storage technologies or flexible thermal power plants*". (https://www.epe.gov.br/en/press-room/news/pde-2027-the-ten-year-energy-expansion-plan-2027).

  Thus, no significant/relevant changes in the average and marginal CO_2 intensity of electricity generation in Brazil is expected to occur by considering the high predominance of use of renewable energy sources for the generation of grid sourced electricity in Brazil in recent years.
- Although the project participant acknowledges that, in the particular case of Brazil, calculated annual values for the CO_2 Combined Margin emission factor for the National Electricity Grid of Brazil is somehow heavy influenced by unpredictable aspects such as rain patterns, level of dams in large hydropower plants, capacity factors for non-conventional renewable energy generation facilities (e.g. wind and biomass power plants, etc.), the above-quoted information represents, under a certain limit, a credible reasons for assuming a fixed value for $EF_{grid,CM}$ in the context of the ex-ante estimations of emission reductions to be achieved by the project activity during its 1st 7-year crediting period.
- Regardless of the assumption of a fixed value for $EF_{grid,CM}$ in the context of the ex-ante estimations of emission reductions to be achieved by the project activity during the 1st 7-year crediting period (only in the context of ex-ante estimation of emission reductions), as highlighted in Section 3.7, the CO_2 combined emission factor for the national electricity grid of Brazil will be annually calculated ex-post.
- The ex-ante estimated values for annual project emissions due to consumption of grid electricity represent (in nominal terms) a very low fraction of estimated total annual emission reductions to be achieved by the project activity.

[37] Calculation of CO_2 emission factor for the National Electricity Grid of Brazil: Data source is available online:

https://antigo.mctic.gov.br/mctic/opencms/ciencia/SEPED/clima/textogeral/emissao_despacho.html ex-ante estimation of $BE_{CH4,y}$, $BE_{EC,y}$ and $BE_{NG,y}$ for the 1st 7-year crediting period of the proposed VCS PD.

The ex-ante estimation of $BE_y = BE_{CH4,y} + BE_{EC,y}\ BE_{NG,y}$ is thus summarized as follows:

Year	Estimation of $BE_{CH4,y}$ (tCO_2e)	Estimation of $BE_{EC,y}$ (tCO_2e)	Estimation of $BE_{NG,y}$ (tCO_2e)	Estimation of baseline emissions (tCO_2e)
	$BE_{CH4,y}$	$BE_{EC,y}$	$BE_{NG,y}$	$BE_y = BE_{CH4,y} + BE_{EC,y} + BE_{NG,y}$
2023	294,433	16,399	12,909	323,741
2024	333,730	17,921	15,470	367,121
2025	345,062	17,921	16,759	379,742
2026	355,868	17,921	17,989	391,778
2027	366,232	17,921	19,168	403,321
2028	376,215	17,921	20,305	414,440
2029	385,867	17,921	21,403	425,190
2030	33,567	1,522	1,908	36,997
Total	**2,490,974**	**125,447**	**125,911**	**2,742,330**

Note: All values applicable for years 2023 and 2030 are valid for the fractions of these years which are encompassed by the 1st 7-year renewable crediting period: from 01/02/2023 to 31/12/2023 and from 01/01/2030 to 31/01/2030 respectively.

Determination of ex-ante estimations for project emissions (PE_y):

As outlined in Section 3.7, project emissions to be considered in the context of the determination of emission reductions to be achieved by the project activity are those due to the consumption of grid-sourced electricity and due to supply of LFG to consumer(s) through a dedicated pipeline. The related ex-ante estimations of the corresponding project emissions are determined as follows:

$PE_y = PE_{EC,y} + PE_{SP,y}$

Determination of ex-ante estimations of project emissions due to consumption of electricity by the project activity ($PE_{EC,grid,y}$):

By following the applicable methodological approaches and assumptions + ex-ante determined values presented in Section 3.7 and 4.1 respectively, $PE_{EC,grid,y}$ is determined as follows:

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

Where:

$PE_{EC,grid,y}$	Project emissions due to consumption of grid sourced electricity by the project activity in year *y* (in tCO_2/yr).
$EC_{PJ,grid,y}$	Quantity of grid sourced electricity consumed by the project activity in year *y* (in MWh). $EC_{PJ,grid,y}$ is estimated as being 2,820 MWh per year. Further details are included in Section 4.2. This value is assumed based on the expected nominal power output for the main electrical equipment to be installed as part of the project activity under its final configuration (e.g installed centrifugal blowers + ancilary equipement) and also by assuming that such equipment will work continuously (24 hours a day) under full power during the whole 1st 7-year crediting period of the project activity[38].
$TDL_{grid,y}$	Average technical transmission and/or distribution losses for grid sourced electricity consumed by the project activity in year *y.* For the particular case of estimates of $PE_{EC,grid,y}$, $TDL_{,grid,y}$ is selected as 20%. Further details are included in Section 4.2.
$EF_{EL,grid,y}$	CO_2 emission factor for grid-sourced electricity in year y (in tCO_2/MWh).

Determination of project emissions due to supply of LFG to consumer(s) through a dedicated pipeline *by the proposed VCS project activity ($PE_{SP,y}$):*

In the particular case of the project activity, while landfill gas is expect to be supplied through dedicated pipeline to the consumer, this is a source of project emissions by the project activity, $PE_{SP,y}$ is determined as follows:

$$PE_{SP,y} = 0.0504 \text{ x } DEFT_{SP,y} \text{ x } F_{CH4,NG,y} \tag{44}$$

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[38] It is important to note that additional power consuming equipment (e.g. additional centrifugal blowers) may be eventually installed as part of the project activity in order to accommodate projected increment in the quantity of LFG to be collected and destroyed by the project activity. In this sense, the conservative approach hereby assumed for estimating $EC_{PJ,grid,y}$ during the 1st 7-year crediting period of the project activity (equipment continuously operating under full power) is appropriate (and under a certain level incorporates an increase in grid electricity consumption by the project activity that may occur).

Where:

$PE_{SP,y}$	Project emissions from the supply of LFG to consumers due to physical leakage from the dedicated pipeline, in year y (tCO_2/yr)
$DEFT_{SP,y}$	Default emission factor for the supply of LFG to consumers due to physical leakage through the dedicated pipeline (tCO_2e/TJ). Which is based on the Appendix, Table 1, page 19 (Natural gas distribution) of the Tool “Upstream leakage emissions associated with fossil fuel use” (version 2) and is determined as 2.2 tCO_2e/TJ.
$F_{CH4,NG,y}$	Amount of methane in the LFG which is sent to the consumer through a dedicated pipeline in year y (tCH_4/yr)

In summary, ex-ante estimations of total project emissions for the project activity during its 1st 7-year crediting period are thus summarized as follows:

PE_y	Electricity consumed from the grid (MWh)	Electricity supplied by backup captive off-grid electricity generator (fuelled by diesel) [3] (MWh)	Project emissions due to electricity consumption (tCO_2e)	Project emissions due to supply of LFG through a dedicated pipeline (tCO_2e)	Total Project emissions promoted the project activity - PEy (tCO_2e)
Year	$EC_{PJ,grid,y}$	$EC_{PJ,captive,y}$	$PE_{EC,y} = (EC_{PJ,grid,y} * EF_{EL,grid,y} * (1+TDL_{grid,import,y})) + (EC_{PJ,captive,y} * EF_{EL,captive,y} * (1 + TDL_{captive,y}))$	$PE_{SP,y} = 0.0504 \times DEFT_{SP,y} \times F_{CH4,NG,y}$	$PE_y = PE_{EC,y}$
	(MWh)	(MWh)	(tCO_2)	(tCO_2)	(tCO_2)
2023	2,580	0	1,078	446	1,525
2024	2,820	0	1,178	584	1,763
2025	2,820	0	1,178	632	1,811
2026	2,820	0	1,178	679	1,858
2027	2,820	0	1,178	723	1,902
2028	2,820	0	1,178	766	1,945
2029	2,820	0	1,178	808	1,987
2030	240	0	100	72	173
Total	**19,740**	**0**	**8,249**	**4,711**	**12,964**

Note: All values applicable for years 2023 and 2030 are valid for the fractions of these years which are encompassed by the 1st 7-year renewable crediting period: from 01/02/2023 to 31/12/2023 and from 01/01/2030 to 31/01/2030 respectively.

Summarized ex-ante estimations of emission reductions (ER_y):

By taking into account the above summarized values for baseline and project emissions, the ex-ante estimations of the emission reductions for the project activity along its 1st 7-year crediting period are summarized as follows:

ER_y	Emission reductions (tCO_2e)
Year	$ER_y = BE_y - PE_y$
	(tCO_2e)
2023	322,216
2024	365,358
2025	377,931
2026	389,920
2027	401,419
2028	412,495
2029	423,203
2030	36,824
Total	**2,729,366**

Note: All values applicable for years 2023 and 2030 are valid for the fractions of these years which are encompassed by the 1st 7-year renewable crediting period: from 01/02/2023 to 31/12/2023 and from 01/01/2030 to 31/01/2030 respectively.

Details about all ex-ante determined parameters which are used for the ex-ante estimations of emissions reductions are included in the previous section. An emission reduction calculation spreadsheet with all related calculations for the ex-ante estimations of emission reductions to be achieved by the project activity during its 1st crediting period is enclosed to this PDD.

Year	Estimated baseline emissions or removals (tCO_2e)	Estimated project emissions or removals (tCO_2e)	Estimated leakage emissions (tCO_2e)	Estimated net GHG emission reductions or removals (tCO_2e)
2023	323,741	1,525	0	322,216
2024	367,121	1,763	0	365,358
2025	379,742	1,811	0	377,931
2026	391,778	1,858	0	389,920
2027	403,321	1,902	0	401,419
2028	414,440	1,945	0	412,495
2029	425,190	1,987	0	423,203
2030	36,997	173	0	36,824
Total	**2,742,330**	**12,964**	**0**	**2,729,366**

4 MONITORING

4.1 Data and Parameters Available at Validation

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 CDM methodological tool “Emissions from solid waste disposal sites” (version 08.0)
Value applied	0.1
Justification of choice of data or description of measurement methods and procedures applied	Default value as per the applied CDM baseline and monitoring methodology ACM0001 - “Flaring or use of landfill gas” (version 19.0)

Purpose of Data	Calculation of baseline emissions
Comments	-

Data / Parameter	**GWP_{CH4}**
Data unit	tCO_2e/tCH_4
Description	Global warming potential of CH_4
Source of data	Table 1 in Box 3.2 - Greenhouse Gas Metrics and Mitigation Pathways of the 5th Assessment Report of the Intergovernmental Panel on Climate Change, based on the effects of greenhouse gases over a 100-year time horizon. Available at: https://archive.ipcc.ch/pdf/assessment-report/ar5/syr/SYR_AR5_FINAL_full_wcover.pdf The applied values are also in accordance with the currently applicable guidelines from VCS for the selection and application of the global warming potential to proposed VCS project activities.
Value applied	28
Justification of choice of data or description of measurement methods and procedures applied	-
Purpose of Data	Calculation of baseline emissions.
Comments	-

Data / Parameter	η_{PJ}
Data unit	Dimensionless
Description	Efficiency of the LFG capture system that will be installed in the proposed VCS project activity

Source of data	Value obtained from technical literature
Value applied	0.99
Justification of choice of data or description of measurement methods and procedures applied	Technical literature-based value[39] (with design and operational characteristics/aspects of the Ecoparque Sergipe landfill and the currently considered construction (design, planned layout) and operational characteristics for the implementation of project's LFG collection network being taken into consideration[40]).
Purpose of Data	Calculation of baseline emissions
Comments	Selected value can also be represented as percentage, since 0.99 = 99.00%

Data / Parameter	R_u
Data unit	Pa.m^3/kmol.K
Description	Universal ideal gases constant

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[39] The technical paper "*Measuring landfill gas collection efficiency using surface methane concentration*" (which was published by Raymond L. Huitric and Dung Kong, from the Solid Waste Management Department of the Los Angeles County Sanitation Districts), states the following regarding LFG collection efficiency for a well-managed LFG collection system:

> *"Measuring landfill gas collection efficiency is important for gauging emission control effectiveness and energy recovery opportunities. Though researched for years, practical measures of collection efficiency are lacking. Instead, a default efficiency of 75% based on surveys of industry estimates is commonly used, for example, by the United States Environmental Protection Agency (US EPA). Though few, actual emission measurements indicate substantially higher efficiencies ranging from 85 to 98%."*

This document also mentions *"(…) landfill gas collection efficiencies should routinely reach 100%."*

Practical results, shown on table 4 of the study: Weighted average collection efficiency, show a collection efficiency of 92.8 to 96.1% on well-engineered landfills with vacuum systems to extract LFG.

The paper "*Measuring landfill gas collection efficiency using surface methane concentration*" is available online: https://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.498.2784&rep=rep1&type=pdf

[40] Assumptions for the expected LFG collection efficiency of the project activity are based on the definition of the general construction aspects (considered design and planned layout) as well as operational characteristics for the implementation of the project's LFG collection network. Such assumed efficiency for LFG collection is derived by taking into consideration the experience and expertise of the project proponent Orizon Valorização de Resíduos S.A. in implementation and operation of LFG collection and destruction/utilization project-based initiatives in different landfill sites in Brazil.

Source of data	Default value as per the CDM methodological tool “Tool to determine the mass flow of a greenhouse gas in a gaseous stream” (version 03.0)
Value applied	8,314
Justification of choice of data or description of measurement methods and procedures applied	-
Purpose of Data	Calculation of baseline emissions.
Comments	**-**

<table>
<tr><td>Data / Parameter</td><td>$\mathbf{MM_i}$</td></tr>
<tr><td>Data unit</td><td>kg/kmol</td></tr>
<tr><td>Description</td><td>Molecular mass of greenhouse gas i</td></tr>
<tr><td>Source of data</td><td>Default value as per the CDM methodological tool “Tool to determine the mass flow of a greenhouse gas in a gaseous stream” (version 03.0)</td></tr>
<tr><td>Value applied</td><td>The following values of molecular mass are applicable for CH_4 (the only GHG which is considered):
<table>
<tr><th>Compound</th><th>Structure</th><th>Molecular mass (kg/kmol)</th></tr>
<tr><td>Methane</td><td>CH_4</td><td>16.04</td></tr>
</table></td></tr>
<tr><td>Justification of choice of data or description of measurement methods and procedures applied</td><td>-</td></tr>
<tr><td>Purpose of Data</td><td>Calculation of baseline emissions.</td></tr>
<tr><td>Comments</td><td>-</td></tr>
</table>

Data / Parameter	**MM_k**
Data unit	kg/kmol
Description	Molecular mass of gas *k*
Source of data	Default value as per the CDM methodological tool “Tool to determine the mass flow of a greenhouse gas in a gaseous stream” (version 03.0)
Value applied	For considered gases *k* that are greenhouse gases (GHGs), the values below are applied for MM_k. As per the CDM methodological tool “Tool to determine the mass flow of a greenhouse gas in a gaseous stream” (version 03.0) the following is applicable for the particular case of the project activity: *“The determination of the molecular mass of the gaseous stream ($MM_{t,db}$) requires measuring the volumetric fraction of all gases (k) in the considered gaseous stream. However, as a simplification, only the volumetric fraction of gases k that are greenhouse gases and are 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.”* ACM0001 (version 19.0) does not include any restriction to such simplification. Thus, only the volumetric fraction of gases that are greenhouse gases and are considered in related calculations (CH_4 in the particular case of the proposed VCS project activity) and the difference to 100% is just considered as pure nitrogen. <table><tr><th>Compound</th><th>Structure</th><th>Molecular mass (kg/kmol)</th></tr><tr><td>Nitrogen</td><td>N_2</td><td>28.01</td></tr></table>
Justification of choice of data or description of measurement methods and procedures applied	-
Purpose of Data	Calculation of baseline emissions
Comments	-

Data / Parameter	MM_{H2O}
Data unit	kg/kmol
Description	Molecular mass of water
Source of data	Default value as per the CDM methodological tool “Tool to determine the mass flow of a greenhouse gas in a gaseous stream” (version 03.0)
Value applied	18.0152
Justification of choice of data or description of measurement methods and procedures applied	-
Purpose of Data	Calculation of baseline emissions
Comments	-

Data / Parameter	P_n
Data unit	Pa
Description	Total pressure at normal conditions
Source of data	Default value as per the CDM methodological tool “Tool to determine the mass flow of a greenhouse gas in a gaseous stream” (version 03.0)
Value applied	101,325
Justification of choice of data or description of measurement methods and procedures applied	-
Purpose of Data	Calculation of baseline emissions
Comments	-

Data / Parameter	**T_n**
Data unit	K
Description	Temperature at normal conditions
Source of data	Default value as per the CDM methodological tool “Tool to determine the mass flow of a greenhouse gas in a gaseous stream” (version 03.0)
Value applied	273.15
Justification of choice of data or description of measurement methods and procedures applied	-
Purpose of Data	Calculation of baseline emissions
Comments	-

Data / Parameter	**φ**
Data unit	-
Description	Default value for the model correction factor to account for model uncertainties
Source of data	Default value applicable for determination of baseline emissions as per the CDM methodological tool “Emissions from solid waste disposal sites” (version 08.0). Value applicable for humid/wet conditions as per Application A is selected (based on the climate conditions valid for the location of the project activity). Source for weather condition data: http://www.bbc.com/weather
Value applied	0.75
Justification of choice of data or description of measurement methods and procedures applied	Determined based on default value of table 3 of the referred CDM methodological tool as per Option 1, Application A (value applicable for humid/wet conditions).
Purpose of Data	Calculation of baseline emissions

Comments	-

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	Applicable default value as per the CDM methodological tool "Emissions from solid waste disposal sites" (version 08.0)
Value applied	0.1
Justification of choice of data or description of measurement methods and procedures applied	-
Purpose of Data	Calculation of baseline emissions
Comments	-

Data / Parameter	**F**
Data unit	-
Description	Fraction of methane in the SWDS gas (volume fraction)
Source of data	Applicable default value as per the CDM methodological tool “Emissions from solid waste disposal sites” (version 08.0)
Value applied	0.5
Justification of choice of data or description of measurement methods and procedures applied	This factor reflects the fact that some degradable organic carbon does not degrade, or degrades very slowly, under anaerobic conditions in the considered SWDS. A default value of 0.5 is recommended by IPCC.
Purpose of Data	Calculation of baseline emissions
Comments	-

Data / Parameter	$\mathbf{DOC_{f,default}}$
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	Applicable default value as per the CDM methodological tool “Emissions from solid waste disposal sites” (version 08.0), which refers to applicable value as per IPCC 2006 Guidelines for National Greenhouse Gas Inventories.
Value applied	0.5
Justification of choice of data or description of measurement methods and procedures applied	This factor reflects the fact that some degradable organic carbon does not degrade, or degrades very slowly, in the SWDS. The default value was applied as per Application A of the CDM methodological tool “Emissions from solid waste disposal sites” (version 08.0): “*The CDM project activity mitigates methane emissions from a specific existing SWDS*”

	[41].
Purpose of Data	Calculation of baseline emissions
Comments	Application A of the CDM methodological tool “Emissions from solid waste disposal sites” (version 08.0) is the applicable case of the proposed VCS project activity.

Data / Parameter	**$MCF_{default}$**
Data unit	-
Description	Methane correction factor
Source of data	Value is sourced by the CDM methodological tool “Emissions from solid waste disposal sites” (version 08.0), that refers to IPCC 2006 Guidelines for National Greenhouse Gas Inventories.
Value applied	1.0
Justification of choice of data or description of measurement methods and procedures applied	Value is selected as per Application A of the CDM methodological tool, under the following conditions: “*1.0: for anaerobic managed solid waste disposal sites. These must have controlled placement of waste (i.e., waste directed to specific deposition areas, a degree of control of scavenging and a degree of control of fires) and will include at least one of the following: (i) cover material; (ii) mechanical compacting; or (iii) leveling of the waste”* The day-to-day MSW disposal activities at the Ecoparque Sergipe landfill encompasses utilization of appropriate MSW landfilling practices (covering, leveling and mechanical compacting of disposed material, etc.) as part of the operation of this landfill. The Ecoparque Sergipe landfill is regarded as a well-managed landfill site.
Purpose of Data	Calculation of baseline emissions

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[41] In the particular case of the proposed VCS project activity, the statement is to be interpreted as follows:

“The proposed VCS project activity mitigates methane emissions from a specific existing SWDS”, where the existing SWDS is the Orizon Valorização de Resíduos S.A..

Comments	-

Data / Parameter	**DOC_j**
Data unit	-
Description	Fraction of degradable organic carbon in the waste type *j* (weight fraction)
Source of data	Values are selected as per applicable guidance of the CDM methodological tool "Emissions from solid waste disposal sites" (version 08.0), that refers to IPCC 2006 Guidelines for National Greenhouse Gas Inventories, (adapted from Volume 5, Tables 2.4 and 2.5).
Value applied	See table below
Justification of choice of data or description of measurement methods and procedures applied	The selected values are based on wet waste basis (moisture concentrations in the waste streams as waste is delivered to the SWDS). The IPCC 2006 Guidelines also specifies DOC values on a dry waste basis, which refers to the moisture concentrations after complete removal of all moisture from the waste. However, this selection is not practical for the situation/practice at the Ecoparque Sergipe landfill.
Purpose of Data	Calculation of baseline emissions
Comments	-

Waste type *j*	**DOC_j (% wet waste)**
Wood and 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

<table>
<tr><td>Data / Parameter</td><td>k_j</td></tr>
<tr><td>Data unit</td><td>1/yr</td></tr>
<tr><td>Description</td><td>Decay rate for the waste type j</td></tr>
<tr><td>Source of data</td><td>Values are selected as per applicable guidance of the CDM methodological tool “Emissions from solid waste disposal sites” (version 08.0). The CDM methodological tool refers to values as per IPCC 2006 Guidelines for National Greenhouse Gas Inventories (adapted from Volume 5, Table 3.3).</td></tr>
<tr><td>Value applied</td><td>
<table>
<tr><th>Degradation speed</th><th>Waste type</th><th>k_j</th></tr>
<tr><td rowspan="2">Slowly degrading</td><td>Wood, wood products, rubber and leather</td><td>0.035</td></tr>
<tr><td>Pulp, paper and cardboard (other than sludge), textiles</td><td>0.07</td></tr>
<tr><td>Moderately
Degrading</td><td>other (non-food) organic putrescible
Garden, yard and park waste</td><td>0.17</td></tr>
<tr><td>Rapidly degrading</td><td>Food, food waste, sewage sludge, beverages and tobacco</td><td>0.4</td></tr>
</table>
</td></tr>
<tr><td>Justification of choice of data or description of measurement methods and procedures applied</td><td>Parameters are selected in accordance to the climate zone valid for the project site:
Mean Annual Temperature (MAT) = 25.4 °C
Mean Annual Precipitation (MAP) = 1,040 mm – (wet climate).
Aridity index (MAP/PET) = 5
Source of data for mean annual temperature (MAT), mean annual precipitation (MAP) and aridity index:
https://pt.climate-data.org/search/?q=ros%C3%A1rio+do+catete
https://www.researchgate.net/figure/The-Global-Aridity-Index-Global-Aridity-ET0-and-Global-Reference-Evapotranspiration_fig1_346315859</td></tr>
<tr><td>Purpose of Data</td><td>Calculation of baseline emissions</td></tr>
</table>

Comments	-

Data / Parameter	**W_j**
Data unit	-
Description	Weight fraction of the waste type *j*
Source of data	Values are selected as per applicable guidance of IPCC 2006 Guidelines for National Greenhouse Gas, Volume 5, Chapter 2, tables 2.3-2.5, MSW composition regional default values for South-America.
Value applied	see table below
Justification of choice of data or description of measurement methods and procedures applied	-
Purpose of Data	Calculation of baseline emissions
Comments	No composition analysis for MSW disposed at the Ecoparque Sergipe landfill is currently available.

Waste type *j*	**W_j** (% wet waste)
Wood and wood products	4.7
Pulp, paper and cardboard (other than sludge)	17.1
Food, food waste, beverages and tobacco (other than sludge)	44.9
Textiles	2.6
Garden, yard and park waste	0
Glass, plastic, metal, other inert waste	30.7

Data / Parameter	**$SPEC_{flare}$**

<table>
<tr><td>Data unit</td><td>Temperature - °C
Flow rate or heat flux – kg/h or Nm^3/h
Maintenance schedule - number of days</td></tr>
<tr><td>Description</td><td>Manufacturer’s flare specifications for temperature, flow rate and maintenance schedule</td></tr>
<tr><td>Source of data</td><td>Flare manufacturer data (for the single flare currently expected to be installed as part of the project activity)</td></tr>
<tr><td>Value applied</td><td>
<table>
<tr><th>$SPEC_{flare, Flare}$</th><th>Min.</th><th>Max.</th></tr>
<tr><td>Operational LFG flow (for continuous operation):</td><td>1,000 Nm^3/h</td><td>5,000Nm^3/h</td></tr>
<tr><td>Required temperature of the exhaust gas of the flare (to ensure LFG destruction (combustion) under high CH_4 destruction efficiency):</td><td>850 °C</td><td>1,200 °C</td></tr>
<tr><td>Required minimum frequency for inspection and maintenance service (incl. inspection in the conditions of the flare isolation ceramics revetment material):</td><td colspan="2">Min. every year</td></tr>
<tr><td>Required/recommended minimum frequency for replacement of the flare isolation ceramics revetment material:</td><td colspan="2">After 10 years of regular and appropriate operation</td></tr>
</table>
</td></tr>
<tr><td>Justification of choice of data or description of measurement methods and procedures applied</td><td>As established by the CDM methodological tool “Project emissions from flaring” (version 04.0), the flares’ specifications and operational + maintenance requirements (as set/recommended by the equipment manufacturer) are</td></tr>
</table>

	documented and considered for the ex-ante determination of applicable values for the parameter $SPEC_{flare}$. Ex-ante selected data will be compared against monitored data related to the operation of the flares along the project's lifetime, including: a) Minimum and maximum monitoring records for data regarding inlet LFG flow rate (b) Minimum and maximum monitoring records for data of temperature in the exhaust gas of each individual high temperature enclosed flare; and (c) Duration in days of time periods between maintenance events for each individual high temperature enclosed flare.
Purpose of Data	Calculation of baseline emissions
Comments	All flare specification and operation details/requirements are based on information provided by the manufacturer of equipment currently expected to be installed as part of the proposed VCS project activity. Data is used as a reference for later ex-post determination of values of flare efficiency ($\eta_{flare,m}$) for the high temperature enclosed flares in the context of determination of baseline emissions.

Data / Parameter	$EF_{EL,grid,y}$
Data unit	tCO_2/MWh
Description	CO_2 emission factor for grid-sourced electricity in year *y*
Source of data	Applicable conservative default values as per the CDM methodological tool "Baseline, project and/or leakage emissions from electricity consumption and monitoring of electricity generation" (version 03.0) (by following option A.2 of the underlying methodological tool).
Value applied	1.3 (for project emissions) 0.3482 (for baseline emissions)
Justification of choice of data or description of	Data is determined as per applicable guidance of the CDM methodological tool "Baseline, project and/or leakage emissions

measurement methods and procedures applied	from electricity consumption and monitoring of electricity generation" (version 03.0).
Purpose of Data	Calculation of baseline emissions and project emissions
Comments	The ex-ante determined default value for $EF_{EL,grid,y}$ is to be used for the determination of - Baseline emissions for electricity generation ($BE_{EC,y}$) - Project emissions due to the consumption of electricity by the project activity ($PE_{EC,y}$) While applying option A.2 as per Scenario C.III of the CDM methodological tool "Baseline, project and/or leakage emissions from electricity consumption and monitoring of electricity generation".

Data / Parameter	$\mathbf{EF_{EL,captive,y}}$
Data unit	tCO_2/MWh
Description	CO_2 emission factor for electricity sourced by the captive off-grid electricity generators
Source of data	Applicable default as per the CDM methodological tool "Baseline, project and/or leakage emissions from electricity consumption and monitoring of electricity generation" (version 03.0) (by following option B2 of the underlying methodological tool).
Value applied	1.3
Justification of choice of data or description of measurement methods and procedures applied	Data is determined as per applicable guidance of the CDM methodological tool "Baseline, project and/or leakage emissions from electricity consumption and monitoring of electricity generation" (version 03.0).
Purpose of Data	Calculation of project emissions (due to the consumption of electricity by the project activity).
Comments	The ex-ante determined default value for $EF_{EL,captive,y}$ is to be used for the determination of project emissions due to the consumption of electricity by the project activity ($PE_{EC,y}$) while applying option B.2 as per the CDM methodological tool

	"Baseline, project and/or leakage emissions from electricity consumption and monitoring of electricity generation".

Data / Parameter	w_{BM}
Data unit	%
Description	Weighting of build margin emissions factor
Source of data	Applicable default value as per the CDM methodological tool "Tool to calculate the emission factor for an electricity system" (version 07.0)
Value applied	0.50 (50%) during the 1st 7-year crediting period
Justification of choice of data or description of measurement methods and procedures applied	The applicable value for the 1st crediting period of a VCS project activity as per the CDM methodological tool "Tool to calculate the emission factor for an electricity system" (version 07.0) is selected.
Purpose of Data	Calculation of project emissions and baseline emissions.
Comments	-

Data / Parameter	w_{OM}
Data unit	%
Description	Weighting of operating margin emissions factor
Source of data	Applicable default value as per the CDM methodological tool "Tool to calculate the emission factor for an electricity system" (version 07.0)
Value applied	0.50 (50%) during the 1st 7-year crediting period
Justification of choice of data or description of measurement methods and procedures applied	The applicable value for the 1st crediting period of a VCS project activity as per the CDM methodological tool "Tool to calculate the emission factor for an electricity system" (version 07.0) is selected.
Purpose of Data	Data is used for determination of project emissions due to the consumption of electricity by the project activity.

Comments	Calculation of project emissions and baseline emissions.

4.2 Data and Parameters Monitored

Data / Parameter	**Management of SWDS**
Data unit	Dimensionless
Description	Management of the SWDS
Source of data	Monitoring performed by the project participants and/or appointed 3rd party. The design and operational conditions of the solid waste disposal site (SWDS) (Ecoparque Sergipe landfill) will be annually monitored on the basis of different sources, including *inter alia*: - Original construction and operational design of the landfill - Technical specifications and requirements for the management of the landfill - Applicable local or national regulations dealing with management and operation of existing landfills Any occurred or planned relevant change in terms of management of the landfill will be reported and justified.
Description of measurement methods and procedures to be applied	Original construction and operational design of the Ecoparque Sergipe landfill should be confirmed as not being modified along the project's operational lifetime. This is to ensure that no practice aiming to increase methane generation in the landfill occurs after the implementation of the proposed VCS project activity. As required by the applied CDM baseline and monitoring methodology ACM0001 (version 19.0), any change in the management of the Ecoparque Sergipe landfill after the implementation of the proposed VCS project activity should be justified by referring to technical or regulatory specifications.
Frequency of monitoring/recording	Annually

Value applied	No estimated value is required for the determination of ex-ante estimation of emission reduction to be achieved by the proposed VCS project activity. Baseline emissions of methane from the SWDS ($BE_{CH4,y}$) are ex-ante estimated by estimating the amount of methane which is destroyed by the project activity through combustion of collected LFG in the project's flare(s) and/or engine-generator sets (methane destruction device(s)) and/or supply of upgraded LFG to consumer(s) in year *y* ($F_{CH4,PJ,y} = F_{CH4,flared,y} + F_{CH4,EL,y} + F_{CH4,NG,y}$) as a function of ex-ante estimated values for efficiency of the LFG capture system to be installed as part of the proposed VCS project activity (η_{PJ}) as well as ex-ante estimations for the amount of methane in the LFG that is generated from the SWDS in the baseline scenario in year *y* ($BE_{CH4,SWDS,y}$) by applying applicable guidance of the CDM methodological tool "Emissions from solid waste disposal sites" (version 08.0) and considering aspects/characteristics of the landfill.
Monitoring equipment	No equipment/instrument is expected to be used to monitor the data/parameter.
QA/QC procedures to be applied	Not applicable.
Purpose of data	Calculation of baseline emissions
Calculation method	-
Comments	-

Data / Parameter	**$V_{t,wb,j}$**
Data unit	m³ wet gas/h
Description	Volumetric flow of LFG stream in time interval *t* on a wet basis for *j* (where *j* is the LFG delivery pipeline to each flare and/or to each engine-generator set and/or to the LFG delivery pipeline for the project's infrastructure for the supply of upgraded LFG to consumer(s)).
Source of data	Measurements/monitoring performed by the project proponent. Measured as part of the operation of the proposed VCS project activity by applying appropriate LFG flow meters.
Description of measurement methods and procedures to be applied	Volumetric flow measurement of collected LFG should always refer to the actual LFG absolute pressure and LFG temperature. Use of measuring instrument/equipment with recordable electronic signal (analogical or digital) is assumed.
Frequency of monitoring/recording	Continuous measurements will be recorded and reported with an every-minute frequency.
Value applied	No estimated value is required for the determination of ex-ante estimation of emission reduction to be achieved by the proposed VCS project activity. Baseline emissions of methane from the SWDS ($BE_{CH4,y}$) are ex-ante estimated by estimating the amount of methane which is destroyed by the project activity through combustion of collected LFG in the project's flare(s) and/or engine-generator sets (methane destruction device(s)) and/or supply of upgraded LFG to consumer(s) in year *y* ($F_{CH4,PJ,y} = F_{CH4,flared,y} + F_{CH4,EL,y} + F_{CH4,NG,y}$) as a function of ex-ante estimated values for efficiency of the LFG capture system to be installed as part of the proposed VCS project activity (η_{PJ}) as well as ex-ante estimations for the amount of methane in the LFG that is generated from the SWDS in the baseline scenario in year *y* ($BE_{CH4,SWDS,y}$) by applying applicable guidance of the CDM methodological tool "Emissions from solid waste disposal sites" (version 08.0) and considering aspects/characteristics of the landfill.
Monitoring equipment	Measurements/monitoring performed by the project proponent.

	Measured as part of the operation of the proposed VCS project activity by applying appropriate LFG flow meters.
QA/QC procedures to be applied	Periodic calibration events for the LFG flow meters will be performed by using a reference primary device provided by a third party independent accredited calibration laboratory. Calibration events will be performed in a frequency as per instrument specifications and/or instrument manufacturer's recommendations. Monitoring equipment/instrument(s) will be subject to a regular maintenance and testing regime in accordance to appropriate national / international standards/requirements and/or best practice. Spare instrument(s) may be kept.
Purpose of data	Calculation of baseline emissions
Calculation method	-
Comments	This parameter will be monitored in case Options B or C of the "Tool to determine the mass flow of a greenhouse gas in a gaseous stream" (version 03.0) are applied for the determination of $F_{CH4,flared,y}$ and/or $F_{CH4,EL,y}$ and/or $F_{CH4,NG,y}$.

Data / Parameter	$V_{t,db,j}$
Data unit	m³ dry gas/h
Description	Volumetric flow of LFG stream in time interval *t* on a dry basis for *j* (where *j* is the LFG delivery pipeline to each flare and/or to each engine-generator set and/or to the LFG delivery pipeline for the project's infrastructure for the supply of upgraded LFG to consumer(s)).
Source of data	Measurements/monitoring performed by the project proponent. Measured as part of the operation of the proposed VCS project activity by applying appropriate LFG flow meters.
Description of measurement methods and procedures to be applied	Volumetric flow measurement of collected LFG should always refer to the actual LFG absolute pressure and LFG temperature. Use of measuring instrument/equipment with recordable electronic signal (analogical or digital) is assumed.
Frequency of monitoring/recording	Continuous measurements will be recorded and reported with an every-minute frequency.
Value applied	No estimated value is required for the determination of ex-ante estimation of emission reduction to be achieved by the proposed VCS project activity. Baseline emissions of methane from the SWDS ($BE_{CH4,y}$) are ex-ante estimated by estimating the amount of methane which is destroyed by the project activity through combustion of collected LFG in the project's flare(s) and/or engine-generator sets (methane destruction device(s)) and/or supply of upgraded LFG to consumer(s) in year *y* ($F_{CH4,PJ,y} = F_{CH4,flared,y} + F_{CH4,EL,y} + F_{CH4,NG,y}$) as a function of ex-ante estimated values for efficiency of the LFG capture system to be installed as part of the proposed VCS project activity (η_{PJ}) as well as ex-ante estimations for the amount of methane in the LFG that is generated from the SWDS in the baseline scenario in year *y* ($BE_{CH4,SWDS,y}$) by applying applicable guidance of the CDM methodological tool "Emissions from solid waste disposal sites" (version 08.0) and considering aspects/characteristics of the landfill.

Monitoring equipment	Measurements/monitoring performed by the project proponent. Measured as part of the operation of the proposed VCS project activity by applying appropriate LFG flow meters.
QA/QC procedures to be applied	Periodic calibration events for the LFG flow meters will be performed by using a reference primary device provided by a third party independent accredited calibration laboratory. Calibration events will be performed in a frequency as per instrument specifications and/or instrument manufacturer's recommendations. Monitoring equipment/instrument(s) will be subject to a regular maintenance and testing regime in accordance to appropriate national / international standards/requirements and/or best practice. Spare instrument(s) may be kept.
Purpose of data	Calculation of baseline emissions
Calculation method	-
Comments	This parameter will be monitored in case Option A of the CDM methodological tool "Tool to determine the mass flow of a greenhouse gas in a gaseous stream" (version 03.0) is applied for the determination of $F_{CH4,flared,y}$ and/or $F_{CH4,EL,y}$ and/or $F_{CH4,NG,y}$.

Data / Parameter	$v_{CH4,t,db,j}$
Data unit	$m^3 CH_4/m^3$ dry gas
Description	Volumetric fraction of CH_4 in the collected LFG in time interval *t* on a dry basis for *j* (where *j* is the LFG delivery pipeline to each flare and/or to each engine-generator set and/or to the LFG delivery pipeline for the project's infrastructure for the supply of upgraded LFG to consumer(s)).
Source of data	Measurements/monitoring performed by the project participants. Measured as part of the operation of the project activity by applying an appropriate continuous CH_4 content gas analyzer.

Description of measurement methods and procedures to be applied	Measurements to be performed by appropriate continuous gas analyzer(s) operating in dry-basis. Volumetric flow measurement should always refer to the actual pressure and temperature. Use of measuring instrument/equipment with recordable electronic signal (analogical or digital) is assumed.
Frequency of monitoring/recording	Continuous measurements will be recorded and reported with an every-minute frequency.
Value applied	No estimated value is required for the determination of ex-ante estimation of emission reduction to be achieved by the proposed VCS project activity. Baseline emissions of methane from the SWDS ($BE_{CH4,y}$) are ex-ante estimated by estimating the amount of methane which is destroyed by the project activity through combustion of collected LFG in the project's flare(s) and/or engine-generator sets (methane destruction device(s)) and/or supply of upgraded LFG to consumer(s) in year *y* ($F_{CH4,PJ,y} = F_{CH4,flared,y} + F_{CH4,EL,y} + F_{CH4,NG,y}$) as a function of ex-ante estimated values for efficiency of the LFG capture system to be installed as part of the proposed VCS project activity (η_{PJ}) as well as ex-ante estimations for the amount of methane in the LFG that is generated from the SWDS in the baseline scenario in year *y* ($BE_{CH4,SWDS,y}$) by applying applicable guidance of the CDM methodological tool "Emissions from solid waste disposal sites" (version 08.0) and considering aspects/characteristics of the landfill.
Monitoring equipment	Measurements/monitoring performed by the project participants. Measured as part of the operation of the project activity by applying an appropriate continuous CH_4 content gas analyzer.
QA/QC procedures to be applied	Periodic calibration events in the continuous CH_4 content gas analyzer(s) will be performed by utilization of calibration span gas with certified CH_4 content (for span checking/adjustment). Utilization of an inert calibration gas (e.g. N_2) will also occur (for span checking/adjustment). All calibration gases (span

	gases) must have a certificate provided by the gas supplier and must be under their validity period. Periodic calibration events will be performed in a frequency as per instrument specifications and/or instrument manufacturer's recommendations. Monitoring equipment/instrument(s) will be subject to a regular maintenance and testing regime in accordance to appropriate national / international standards/requirements and/or best practice. Spare instrument(s) may be kept.
Purpose of data	Calculation of baseline emissions
Calculation method	-
Comments	This parameter will be monitored in case Option B of the "Tool to determine the mass flow of a greenhouse gas in a gaseous stream" (version 03.0) is applied for the determination of $F_{CH4,flared,y}$ and/or $F_{CH4,EL,y}$ and/or $F_{CH4,NG,y.}$ This parameter may be monitored in case Options A or D of the CDM methodological "Tool to determine the mass flow of a greenhouse gas in a gaseous stream" (version 03.0) are applied instead.

Data / Parameter	$\mathbf{v_{CH4,t,wb,j}}$
Data unit	m^3CH_4/m^3 dry gas
Description	Volumetric fraction of CH_4 in the collected LFG in time interval *t* on a wet basis for *j* (where *j* is the LFG delivery pipeline to each flare and/or to each engine-generator set and/or to the LFG delivery pipeline for the project's infrastructure for the supply of upgraded LFG to consumer(s)).
Source of data	Measurements/monitoring performed by the project participants. Measured as part of the operation of the project activity by applying an appropriate continuous CH_4 content gas analyzer.

Description of measurement methods and procedures to be applied	Measurements to be performed by appropriate continuous gas analyzer(s) operating in wet-basis. Volumetric flow measurement should always refer to the actual pressure and temperature. Use of measuring instrument/equipment with recordable electronic signal (analogical or digital) is assumed.
Frequency of monitoring/recording	Continuous measurements will be recorded and reported with an every-minute frequency.
Value applied	No estimated value is required for the determination of ex-ante estimation of emission reduction to be achieved by the proposed VCS project activity. Baseline emissions of methane from the SWDS ($BE_{CH4,y}$) are ex-ante estimated by estimating the amount of methane which is destroyed by the project activity through combustion of collected LFG in the project's flare(s) and/or engine-generator sets (methane destruction device(s)) and/or supply of upgraded LFG to consumer(s) in year *y* ($F_{CH4,PJ,y} = F_{CH4,flared,y} + F_{CH4,EL,y} + F_{CH4,NG,y}$) as a function of ex-ante estimated values for efficiency of the LFG capture system to be installed as part of the proposed VCS project activity (η_{PJ}) as well as ex-ante estimations for the amount of methane in the LFG that is generated from the SWDS in the baseline scenario in year *y* ($BE_{CH4,SWDS,y}$) by applying applicable guidance of the CDM methodological tool "Emissions from solid waste disposal sites" (version 08.0) and considering aspects/characteristics of the landfill.
Monitoring equipment	Measurements/monitoring performed by the project participants. Measured as part of the operation of the project activity by applying an appropriate continuous CH_4 content gas analyzer.
QA/QC procedures to be applied	Periodic calibration events in the continuous CH_4 content gas analyzer(s) will be performed by utilization of calibration span gas with certified CH_4 content (for span checking/adjustment). Utilization of an inert calibration gas (e.g. N_2) will also occur (for span checking/adjustment). All calibration gases (span

	gases) must have a certificate provided by the gas supplier and must be under their validity period. Periodic calibration events will be performed in a frequency as per instrument specifications and/or instrument manufacturer's recommendations. Monitoring equipment/instrument(s) will be subject to a regular maintenance and testing regime in accordance to appropriate national / international standards/requirements and/or best practice. Spare instrument(s) may be kept.
Purpose of data	Calculation of baseline emissions
Calculation method	-
Comments	This parameter will be monitored in case Option C of the "Tool to determine the mass flow of a greenhouse gas in a gaseous stream" (version 03.0) is applied for the determination of $F_{CH4,flared,y}$ and/or $F_{CH4,EL,y}$ and/or $F_{CH4,NG,y}$. This parameter may be monitored in case Options A or D of the CDM methodological "Tool to determine the mass flow of a greenhouse gas in a gaseous stream" (version 03.0) are applied instead.

Data / Parameter	$\mathbf{M_{t,db,j}}$
Data unit	kg/h
Description	Mass flow of the LFG stream in time interval *t* on dry basis for *j* (where *j* is the LFG delivery pipeline to each flare and/or to each engine-generator set and/or to the LFG delivery pipeline for the project's infrastructure for the supply of upgraded LFG to consumer(s))
Source of data	Measurements/monitoring performed by the project proponent.

	Measured as part of the operation of the proposed VCS project activity by applying appropriate LFG mass flow meters.
Description of measurement methods and procedures to be applied	Continuous measurements to be performed by applying appropriate mass flow meter operating in dry-basis. Mass flow measurement should always refer to the actual pressure and temperature (calculated based on the wet basis flow measurement plus water concentration measurement). Instruments with recordable electronic signal (analogical or digital) are required.
Frequency of monitoring/recording	Continuous measurements will be recorded and reported with an every-minute frequency.
Value applied	No estimated value is required for the determination of ex-ante estimation of emission reduction to be achieved by the proposed VCS project activity. Baseline emissions of methane from the SWDS ($BE_{CH4,y}$) are ex-ante estimated by estimating the amount of methane which is destroyed by the project activity through combustion of collected LFG in the project's flare(s) and/or engine-generator sets (methane destruction device(s)) and/or supply of upgraded LFG to consumer(s) in year *y* ($F_{CH4,PJ,y} = F_{CH4,flared,y} + F_{CH4,EL,y} + F_{CH4,NG,y}$) as a function of ex-ante estimated values for efficiency of the LFG capture system to be installed as part of the proposed VCS project activity (η_{PJ}) as well as ex-ante estimations for the amount of methane in the LFG that is generated from the SWDS in the baseline scenario in year *y* ($BE_{CH4,SWDS,y}$) by applying applicable guidance of the CDM methodological tool "Emissions from solid waste disposal sites" (version 08.0) and considering aspects/characteristics of the landfill.
Monitoring equipment	Measurements/monitoring performed by the project proponent. Measured as part of the operation of the proposed VCS project activity by applying appropriate LFG mass flow meters.
QA/QC procedures to be applied	Periodic calibration events for the LFG mass flow meters will be performed by using a reference primary device provided by a third party independent accredited calibration laboratory. Calibration events will be performed in a frequency as per

	instrument specifications and/or instrument manufacturer's recommendations. Monitoring equipment/instrument(s) will be subject to a regular maintenance and testing regime in accordance to appropriate national / international standards/requirements and/or best practice. Spare instrument(s) may be kept.
Purpose of data	Calculation of baseline emissions
Calculation method	-
Comments	This parameter will be monitored in case Option D of the CDM methodological tool "Tool to determine the mass flow of a greenhouse gas in a gaseous stream" (version 03.0) is applied for the determination of $F_{CH4,flared,y}$ and/or $F_{CH4,EL,y}$ and/or $F_{CH4,NG,y}$.

Data / Parameter	$\mathbf{T_t}$
Data unit	K[42]
Description	Temperature of the LFG stream in time interval *t*
Source of data	Measurements/monitoring performed by the project proponent. Measured as part of the operation of the proposed VCS project activity by applying appropriate LFG temperature sensor(s).
Description of measurement methods and procedures to be applied	Measured to determine the density of methane ρ_{CH4}. No separate monitoring of LFG temperature is necessary when using LFG flow meters that automatically measure temperature and pressure, expressing LFG volumes in normalized cubic meters (by considering standard temperature and pressure (STP) conditions). Instruments with recordable electronic signal (analogical or digital) are required.
Frequency of monitoring/recording	Continuous measurements will be recorded and reported with an every-minute frequency.

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[42] Measurements for T_t may be recorded and reported in °C. Under such circumstance, recorded/reported data in °C will be converted to Kelvin (K) (in order to also being recorded/reported in K).

Value applied	No estimated value is required for the determination of ex-ante estimation of emission reduction to be achieved by the proposed VCS project activity. Baseline emissions of methane from the SWDS ($BE_{CH4,y}$) are ex-ante estimated by estimating the amount of methane which is destroyed by the project activity through combustion of collected LFG in the project's flare(s) and/or engine-generator sets (methane destruction device(s)) and/or supply of upgraded LFG to consumer(s) in year *y* ($F_{CH4,PJ,y} = F_{CH4,flared,y} + F_{CH4,EL,y} + F_{CH4,NG,y}$) as a function of ex-ante estimated values for efficiency of the LFG capture system to be installed as part of the proposed VCS project activity (η_{PJ}) as well as ex-ante estimations for the amount of methane in the LFG that is generated from the SWDS in the baseline scenario in year *y* ($BE_{CH4,SWDS,y}$) by applying applicable guidance of the CDM methodological tool "Emissions from solid waste disposal sites" (version 08.0) and considering aspects/characteristics of the landfill.
Monitoring equipment	Measurements/monitoring performed by the project proponent. Measured as part of the operation of the proposed VCS project activity by applying appropriate LFG temperature sensor(s). Instruments with recordable electronic signal (analogical or digital) are required.
QA/QC procedures to be applied	Periodic calibration events for the LFG temperature sensor(s) will be performed by using a reference primary device provided by a third party independent accredited calibration laboratory. Calibration events will be performed in a frequency as per instrument specifications and/or instrument manufacturer's recommendations. Monitoring equipment/instrument(s) will be subject to a regular maintenance and testing regime in accordance to appropriate national / international standards/requirements and/or best practice. Spare instrument(s) may be kept.
Purpose of data	Calculation of baseline emissions
Calculation method	-

Comments	In case of measurements for the applicable LFG flow parameter are automatically converted and recorded in normalized cubic meters (by considering standard temperature and pressure (STP) conditions), monitoring of this parameter may not be required except if the applicability condition related to the gaseous stream flow temperature being below 60ºC is adopted. Under this circumstance, this parameter shall be monitored continuously to assure the applicability condition is indeed met.

Data / Parameter	$\mathbf{P_t}$
Data unit	Pa[43]
Description	Pressure of the LFG stream in time interval *t*
Source of data	Measurements/monitoring performed by the project proponent. Measured as part of the operation of the proposed VCS project activity by applying appropriate LFG pressure sensor(s).
Description of measurement methods and procedures to be applied	Measured to determine the density of methane ρ_{CH4}. No separate monitoring of LFG pressure is necessary when using LFG flow meters that automatically measure temperature and pressure, expressing LFG volumes in normalized cubic meters (by considering standard temperature and pressure (STP) conditions). Instruments with recordable electronic signal (analogical or digital) are required.
Frequency of monitoring/recording	Continuous measurements will be recorded and reported with an every-minute frequency.

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[43] Depending on installed measurement instrument, measurements for P_t may be recorded and reported in mbar. Under such circumstance, recorded/reported data in mbar will be converted into Pascal (Pa) (in order to be also recorded and reported in Pa).

Value applied	No estimated value is required for the determination of ex-ante estimation of emission reduction to be achieved by the proposed VCS project activity. Baseline emissions of methane from the SWDS ($BE_{CH4,y}$) are ex-ante estimated by estimating the amount of methane which is destroyed by the project activity through combustion of collected LFG in the project's flare(s) and/or engine-generator sets (methane destruction device(s)) and/or supply of upgraded LFG to consumer(s) in year *y* ($F_{CH4,PJ,y} = F_{CH4,flared,y} + F_{CH4,EL,y} + F_{CH4,NG,y}$) as a function of ex-ante estimated values for efficiency of the LFG capture system to be installed as part of the proposed VCS project activity (η_{PJ}) as well as ex-ante estimations for the amount of methane in the LFG that is generated from the SWDS in the baseline scenario in year *y* ($BE_{CH4,SWDS,y}$) by applying applicable guidance of the CDM methodological tool "Emissions from solid waste disposal sites" (version 08.0) and considering aspects/characteristics of the landfill.
Monitoring equipment	Measurements/monitoring performed by the project proponent. Measured as part of the operation of the proposed VCS project activity by applying appropriate LFG pressure sensor(s). Instruments with recordable electronic signal (analogical or digital) are required.
QA/QC procedures to be applied	Periodic calibration events for the LFG pressure sensor(s) will be performed by using a reference primary device provided by a third party independent accredited calibration laboratory. Calibration events will be performed in a frequency as per instrument specifications and/or instrument manufacturer's recommendations. Monitoring equipment/instrument(s) will be subject to a regular maintenance and testing regime in accordance to appropriate national / international standards/requirements and/or best practice. Spare instrument(s) may be kept.
Purpose of data	Calculation of baseline emissions
Calculation method	-

Comments	In case of measurements for the applicable LFG flow parameter are automatically converted and recorded in normalized cubic meters (by considering standard temperature and pressure (STP) conditions), monitoring of this parameter may not be required.

Data / Parameter	$F_{CH4,EG,t}$
Data unit	kg
Description	Mass flow of methane in the exhaust gas of the flare on a dry basis at reference conditions in the time period *t*
Source of data	Measurements undertaken by a third-party accredited entity for each operational flare.
Description of measurement methods and procedures to be applied	Measure the mass flow of methane in the exhaust gas of each operational flare according to an appropriate national or international standard (such as the UK's Technical Guidance LFTGN05 or a similar standard). The time period *t* over which the mass flow is measured must be at least one hour. The average flow rate to the flare during the time period *t* must be greater than the average flow rate observed for the previous six months.
Frequency of monitoring/recording	Biannual
Value applied	No estimated value is required for the determination of ex-ante estimation of emission reduction to be achieved by the proposed VCS project activity. Baseline emissions of methane from the SWDS ($BE_{CH4,y}$) are ex-ante estimated by estimating the amount of methane which is destroyed by the project activity through combustion of collected LFG in the project's flare(s) and/or engine-generator sets (methane destruction device(s)) and/or supply of upgraded LFG to consumer(s) in year *y* ($F_{CH4,PJ,y} = F_{CH4,flared,y} + F_{CH4,EL,y} + F_{CH4,NG,y}$) as a function of ex-ante estimated values for efficiency of the LFG capture system to be installed as part of the proposed VCS project activity (η_{PJ}) as well as ex-ante estimations for the amount of methane in the LFG that is

	generated from the SWDS in the baseline scenario in year *y* ($BE_{CH4,SWDS,y}$) by applying applicable guidance of the CDM methodological tool “Emissions from solid waste disposal sites” (version 08.0) and considering aspects/characteristics of the landfill.
Monitoring equipment	Measure the mass flow of methane in the exhaust gas of each operational flare according to an appropriate national or international standard (such as the UK's Technical Guidance LFTGN05 or a similar standard) with appropriate equipment being used by 3rd-party inspection service company.
QA/QC procedures to be applied	QA/QC procedures are to be applied by the entity responsible for performing the related measurements as per requirements of the applied standard.
Purpose of data	Calculation of baseline emissions[44]
Calculation method	-
Comments	Monitoring of this parameter is required in the case of enclosed flares and if the project participants select Option B.1 to determine flare efficiency.

Data / Parameter	$p_{H20,t,Sat}$
Data unit	Pa
Description	Saturation pressure of H_2O at temperature T_t in time interval *t*
Source of data	Data as per the literature “*Fundamentals of Classical Thermodynamics*”; Authors: Gordon J. Van Wylen, Richard E. Sonntag and Borgnakke; 4º Edition 1994. Published by John Wiley & Sons, Inc.

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[44] It is relevant to note that, as shown in Section 4.1, as per the applied methodological approach, monitoring records of $F_{CH4,EG,t}$ are used for the determination of project emissions from flaring ($PE_{flare,y}$), of which are accounted for the determination of baseline emissions (and not used for the determination of project emissions despite of being termed as “project emissions” from flaring).

Description of measurement methods and procedures to be applied	This parameter is solely a function of the LFG stream temperature T_t and can be found at above-referenced literature for a total pressure equal to 101,325 Pa.
Frequency of monitoring/recording	-
Value applied	No estimated value is required for the determination of ex-ante estimation of emission reduction to be achieved by the proposed VCS project activity. Baseline emissions of methane from the SWDS ($BE_{CH4,y}$) are ex-ante estimated by estimating the amount of methane which is destroyed by the project activity through combustion of collected LFG in the project's flare(s) and/or engine-generator sets (methane destruction device(s)) and/or supply of upgraded LFG to consumer(s) in year *y* ($F_{CH4,PJ,y} = F_{CH4,flared,y} + F_{CH4,EL,y} + F_{CH4,NG,y}$) as a function of ex-ante estimated values for efficiency of the LFG capture system to be installed as part of the proposed VCS project activity (η_{PJ}) as well as ex-ante estimations for the amount of methane in the LFG that is generated from the SWDS in the baseline scenario in year *y* ($BE_{CH4,SWDS,y}$) by applying applicable guidance of the CDM methodological tool "Emissions from solid waste disposal sites" (version 08.0) and considering aspects/characteristics of the landfill.
Monitoring equipment	-
QA/QC procedures to be applied	-
Purpose of data	Calculation of baseline emissions
Calculation method	-
Comments	-

Data / Parameter	$v_{i,RG,m}$
Data unit	-
Description	Volumetric fraction of component *i* in the residual gas on a dry basis in the minute m where *i* = CH_4, CO, CO_2, O_2, H_2, H_2S, NH_4, N_2

Source of data	Measurements/monitoring performed by the project proponent. Measured as part of the operation of the proposed VCS project activity by applying appropriate gas analyzer (s).
Description of measurement methods and procedures to be applied	Continuous measurements to be performed by applying appropriate gas analyzer.
Frequency of monitoring/recording	Continuous measurements will be recorded and reported with an every-minute frequency.
Value applied	No estimated value is required for the determination of ex-ante estimation of emission reduction to be achieved by the proposed VCS project activity. Baseline emissions of methane from the SWDS ($BE_{CH4,y}$) are ex-ante estimated by estimating the amount of methane which is destroyed by the project activity through combustion of collected LFG in the project's flare(s) and/or engine-generator sets (methane destruction device(s)) and/or supply of upgraded LFG to consumer(s) in year *y* ($F_{CH4,PJ,y} = F_{CH4,flared,y} + F_{CH4,EL,y} + F_{CH4,NG,y}$) as a function of ex-ante estimated values for efficiency of the LFG capture system to be installed as part of the proposed VCS project activity (η_{PJ}) as well as ex-ante estimations for the amount of methane in the LFG that is generated from the SWDS in the baseline scenario in year *y* ($BE_{CH4,SWDS,y}$) by applying applicable guidance of the CDM methodological tool "Emissions from solid waste disposal sites" (version 08.0) and considering aspects/characteristics of the landfill.
Monitoring equipment	To be performed by applying appropriate gas analyzer.
QA/QC procedures to be applied	Periodic calibration events in the continuous CH_4 content gas analyzer(s) will be performed by utilization of calibration span gas with certified CH_4 content (for span checking/adjustment). Utilization of an inert calibration gas (e.g. N_2) will also occur (for span checking/adjustment). All calibration gases (span

	gases) must have a certificate provided by the gas supplier and must be under their validity period. Periodic calibration events will be performed in a frequency as per instrument specifications and/or instrument manufacturer's recommendations. Monitoring equipment/instrument(s) will be subject to a regular maintenance and testing regime in accordance to appropriate national / international standards/requirements and/or best practice. Spare instrument(s) may be kept.
Purpose of data	Calculation of baseline emissions
Calculation method	-
Comments	This parameter will be monitored in case Option B.2 of the "Project emissions from flaring" (version 04.0) is applied for the determination of flare efficiency ($\eta_{flare,m} = \eta_{flare,calc,m}$).

Data / Parameter	**$V_{RG,m}$**
Data unit	m^3
Description	Volumetric flow of the residual gas on a dry basis at reference conditions in the minute m
Source of data	Measurements by project participants using an appropriate flow meter
Description of measurement methods and procedures to be applied	Instruments with recordable electronic signal (analogical or digital)
Frequency of monitoring/recording	Continuous measurements will be recorded and reported with an every-minute frequency.
Value applied	No estimated value is required for the determination of ex-ante estimation of emission reduction to be achieved by the proposed VCS project activity. Baseline emissions of methane from the SWDS ($BE_{CH4,y}$) are ex-ante estimated by estimating the amount of methane which is destroyed by the project activity through combustion of

	collected LFG in the project's flare(s) and/or engine-generator sets (methane destruction device(s)) and/or supply of upgraded LFG to consumer(s) in year y ($F_{CH4,PJ,y} = F_{CH4,flared,y} + F_{CH4,EL,y} + F_{CH4,NG,y}$) as a function of ex-ante estimated values for efficiency of the LFG capture system to be installed as part of the proposed VCS project activity (η_{PJ}) as well as ex-ante estimations for the amount of methane in the LFG that is generated from the SWDS in the baseline scenario in year y ($BE_{CH4,SWDS,y}$) by applying applicable guidance of the CDM methodological tool "Emissions from solid waste disposal sites" (version 08.0) and considering aspects/characteristics of the landfill.
Monitoring equipment	Measurements by project participants using an appropriate flow meter
QA/QC procedures to be applied	Flow meters are to be periodically calibrated according to the manufacturer's recommendation
Purpose of data	Calculation of baseline emissions
Calculation method	Not applicable
Comments	This parameter will be monitored in case Option B.2 of the "Project emissions from flaring" (version 04.0) is applied for the determination of flare efficiency ($\eta_{flare,m} = \eta_{flare,calc,m}$).

Data / Parameter	$M_{RG,m}$
Data unit	kg
Description	Mass flow of the residual gas on a dry basis at reference conditions in the minute m
Source of data	Measurements performed by the project participant using an appropriate continuous mass flow meter(s)
Description of measurement methods and procedures to be applied	Instruments with recordable electronic signal (analogical or digital)
Frequency of monitoring/recording	Continuous measurements will be recorded and reported with an every-minute frequency.

Value applied	No estimated value is required for the determination of ex-ante estimation of emission reduction to be achieved by the proposed VCS project activity. Baseline emissions of methane from the SWDS ($BE_{CH4,y}$) are ex-ante estimated by estimating the amount of methane which is destroyed by the project activity through combustion of collected LFG in the project's flare(s) and/or engine-generator sets (methane destruction device(s)) and/or supply of upgraded LFG to consumer(s) in year y ($F_{CH4,PJ,y} = F_{CH4,flared,y} + F_{CH4,EL,y} + F_{CH4,NG,y}$) as a function of ex-ante estimated values for efficiency of the LFG capture system to be installed as part of the proposed VCS project activity (η_{PJ}) as well as ex-ante estimations for the amount of methane in the LFG that is generated from the SWDS in the baseline scenario in year y ($BE_{CH4,SWDS,y}$) by applying applicable guidance of the CDM methodological tool "Emissions from solid waste disposal sites" (version 08.0) and considering aspects/characteristics of the landfill.
Monitoring equipment	Measurements performed by the project participant using an appropriate continuous mass flow meter(s)
QA/QC procedures to be applied	Flowmeters must be periodically calibrated according to the manufacturer's recommendation
Purpose of data	Calculation of baseline emissions
Calculation method	Not applicable
Comments	This parameter will be monitored in case Option B.2 of the "Project emissions from flaring" (version 04.0) is applied for the determination of flare efficiency ($\eta_{flare,m} = \eta_{flare,calc,m}$).

Data / Parameter	$v_{O2,EG,m}$
Data unit	-
Description	Volumetric fraction of O_2 in the exhaust gas on a dry basis at reference conditions in the minute m
Source of data	Measurements/monitoring performed by the project proponent.

	Measured as part of the operation of the proposed VCS project activity by applying appropriate gas analyzer (s).
Description of measurement methods and procedures to be applied	Continuous measurements to be performed by applying appropriate gas analyzer.
Frequency of monitoring/recording	Continuous measurements will be recorded and reported with an every-minute frequency.
Value applied	No estimated value is required for the determination of ex-ante estimation of emission reduction to be achieved by the proposed VCS project activity. Baseline emissions of methane from the SWDS ($BE_{CH4,y}$) are ex-ante estimated by estimating the amount of methane which is destroyed by the project activity through combustion of collected LFG in the project's flare(s) and/or engine-generator sets (methane destruction device(s)) and/or supply of upgraded LFG to consumer(s) in year y ($F_{CH4,PJ,y} = F_{CH4,flared,y} + F_{CH4,EL,y} + F_{CH4,NG,y}$) as a function of ex-ante estimated values for efficiency of the LFG capture system to be installed as part of the proposed VCS project activity (η_{PJ}) as well as ex-ante estimations for the amount of methane in the LFG that is generated from the SWDS in the baseline scenario in year y ($BE_{CH4,SWDS,y}$) by applying applicable guidance of the CDM methodological tool "Emissions from solid waste disposal sites" (version 08.0) and considering aspects/characteristics of the landfill.
Monitoring equipment	To be performed by applying appropriate gas analyzer.
QA/QC procedures to be applied	Periodic calibration events in the continuous CH_4 content gas analyzer(s) will be performed by utilization of calibration span gas with certified CH_4 content (for span checking/adjustment). Utilization of an inert calibration gas (e.g. N_2) will also occur (for span checking/adjustment). All calibration gases (span

	gases) must have a certificate provided by the gas supplier and must be under their validity period. Periodic calibration events will be performed in a frequency as per instrument specifications and/or instrument manufacturer's recommendations. Monitoring equipment/instrument(s) will be subject to a regular maintenance and testing regime in accordance to appropriate national / international standards/requirements and/or best practice. Spare instrument(s) may be kept.
Purpose of data	Calculation of baseline emissions
Calculation method	-
Comments	This parameter will be monitored in case Option B.2 of the "Project emissions from flaring" (version 04.0) is applied for the determination of flare efficiency ($\eta_{flare,m} = \eta_{flare,calc,m}$).

Data / Parameter	$\mathbf{fc_{CH4,EG,m}}$
Data unit	mg/m^3
Description	Concentration of methane in the exhaust gas of the flare on a dry basis at reference conditions in the minute m
Source of data	Measurements/monitoring performed by the project proponent. Measured as part of the operation of the proposed VCS project activity by applying appropriate gas analyzer (s).
Description of measurement methods and procedures to be applied	Continuous measurements to be performed by applying appropriate gas analyzer.
Frequency of monitoring/recording	Continuous measurements will be recorded and reported with an every-minute frequency.

Value applied	No estimated value is required for the determination of ex-ante estimation of emission reduction to be achieved by the proposed VCS project activity. Baseline emissions of methane from the SWDS ($BE_{CH4,y}$) are ex-ante estimated by estimating the amount of methane which is destroyed by the project activity through combustion of collected LFG in the project's flare(s) and/or engine-generator sets (methane destruction device(s)) and/or supply of upgraded LFG to consumer(s) in year y ($F_{CH4,PJ,y} = F_{CH4,flared,y} + F_{CH4,EL,y} + F_{CH4,NG,y}$) as a function of ex-ante estimated values for efficiency of the LFG capture system to be installed as part of the proposed VCS project activity (η_{PJ}) as well as ex-ante estimations for the amount of methane in the LFG that is generated from the SWDS in the baseline scenario in year y ($BE_{CH4,SWDS,y}$) by applying applicable guidance of the CDM methodological tool "Emissions from solid waste disposal sites" (version 08.0) and considering aspects/characteristics of the landfill.
Monitoring equipment	To be performed by applying appropriate gas analyzer.
QA/QC procedures to be applied	Periodic calibration events in the continuous CH_4 content gas analyzer(s) will be performed by utilization of calibration span gas with certified CH_4 content (for span checking/adjustment). Utilization of an inert calibration gas (e.g. N_2) will also occur (for span checking/adjustment). All calibration gases (span gases) must have a certificate provided by the gas supplier and must be under their validity period. Periodic calibration events will be performed in a frequency as per instrument specifications and/or instrument manufacturer's recommendations. Monitoring equipment/instrument(s) will be subject to a regular maintenance and testing regime in accordance to appropriate national / international standards/requirements and/or best practice. Spare instrument(s) may be kept.
Purpose of data	Calculation of baseline emissions
Calculation method	-

Comments	This parameter will be monitored in case Option B.2 of the “Project emissions from flaring” (version 04.0) is applied for the determination of flare efficiency ($\eta_{flare,m} = \eta_{flare,calc,m}$).

Data / Parameter	**$T_{EG,m}$**
Data unit	ºC
Description	Temperature in the exhaust gas of the enclosed flare in minute *m*
Source of data	Measurements performed for each operational flare by the project participants
Description of measurement methods and procedures to be applied	Measure the temperature of the exhaust gas of each operational high temperature enclosed flare by appropriate temperature measurement equipment (e.g. thermocouples). Measurements outside the operational temperature specified/recommended by the manufacturer may indicate that one or more flares is/are not functioning correctly and may require maintenance. Flare manufacturers must provide suitable monitoring ports for the monitoring of the temperature of the exhaust gas of the flare. These would normally be expected to be in the middle third of the flare. Where more than one measurement port for temperature of the exhaust gas of the flare is fitted to the flare, the flare manufacturer must provide written instructions detailing the conditions under which each location shall be used and the port most suitable for monitoring the operation of the flare according to manufacturer’s specifications for temperature[45].
Frequency of monitoring/recording	Continuous measurements will be recorded and reported with a least every minute frequency.

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[45] In the particular case of the high temperature enclosed flare(s) to be installed as part of the proposed VCS project activity, only one individual measuring instrument (e.g. thermocouple) may be located in the upper section of the flare. Anyway, in case flare(s) to be installed as part of the proposed VCS project activity has/have more than one measurement port (for temperature of the exhaust gas of the flare), the requirement applicable for flare with more than one measurement port for temperature of the exhaust gas will thus be considered.

Value applied	No estimated value is required for the determination of ex-ante estimation of emission reduction to be achieved by the proposed VCS project activity. Baseline emissions of methane from the SWDS ($BE_{CH4,y}$) are ex-ante estimated by estimating the amount of methane which is destroyed by the project activity through combustion of collected LFG in the project's flare(s) and/or engine-generator sets (methane destruction device(s)) and/or supply of upgraded LFG to consumer(s) in year *y* ($F_{CH4,PJ,y} = F_{CH4,flared,y} + F_{CH4,EL,y} + F_{CH4,NG,y}$) as a function of ex-ante estimated values for efficiency of the LFG capture system to be installed as part of the proposed VCS project activity (η_{PJ}) as well as ex-ante estimations for the amount of methane in the LFG that is generated from the SWDS in the baseline scenario in year *y* ($BE_{CH4,SWDS,y}$) by applying applicable guidance of the CDM methodological tool "Emissions from solid waste disposal sites" (version 08.0) and considering aspects/characteristics of the landfill.
Monitoring equipment	Measurements/monitoring performed by the project proponent. Measured as part of the operation of the proposed VCS project activity by applying appropriate thermocouples.
QA/QC procedures to be applied	Temperature measurement equipment should be replaced or calibrated in accordance with their maintenance schedule. Periodic calibration events will be performed in the instruments by a third party independent accredited calibration laboratory in a frequency as per instrument specifications and/or instrument manufacturer's recommendations. Monitoring equipment/instrument(s) will be subject to a regular maintenance and testing regime in accordance to appropriate national / international standards/requirements and/or best practice. Spare instrument(s) may be kept.
Purpose of data	Calculation of baseline emissions
Calculation method	-

Comments	Unexpected changes such as a sudden increase/drop in temperature can occur for different reasons. As part of the monitoring procedure, these events will be noted in the site records along with any corrective action that was implemented to correct the issue. Measurements are required to determine if manufacturer's flare specifications for operating temperature are met.

Data / Parameter	**$Flame_m$**
Data unit	Flame status "*on*" or flame status "*off*"
Description	Flame detection of flare in the minute *m*
Source of data	Measurements/monitoring for each operational flare performed by the project participants. Whenever, flame is detected in the flare, flame status "*on*" is attributed. Whenever, flame is not detected in the flare, flame status "*off*" is attributed.
Description of measurement methods and procedures to be applied	Measure for each operational flare using a fixed installation optical flame detector: Ultraviolet detector or Infra-red or both.
Frequency of monitoring/recording	Once per minute.
Value applied	No estimated value is required for the determination of ex-ante estimation of emission reduction to be achieved by the proposed VCS project activity. Baseline emissions of methane from the SWDS ($BE_{CH4,y}$) are ex-ante estimated by estimating the amount of methane which is destroyed by the project activity through combustion of collected LFG in the project's flare(s) and/or engine-generator sets (methane destruction device(s)) and/or supply of upgraded LFG to consumer(s) in year *y* ($F_{CH4,PJ,y} = F_{CH4,flared,y} + F_{CH4,EL,y} + F_{CH4,NG,y}$) as a function of ex-ante estimated values for efficiency of the LFG capture system to be installed as part of the proposed VCS project activity (η_{PJ}) as well as ex-ante estimations for the amount of methane in the LFG that is generated from the SWDS in the baseline scenario in year *y* ($BE_{CH4,SWDS,y}$) by applying applicable guidance of the CDM methodological tool "Emissions from solid waste disposal sites"

	(version 08.0) and considering aspects/characteristics of the landfill.
Monitoring equipment	Measure for each operational flare using a fixed installation optical flame detector: Ultraviolet detector or Infra-red or both.
QA/QC procedures to be applied	Equipment shall be maintained and calibrated in accordance with manufacturer's recommendations.
Purpose of data	Calculation of baseline emissions
Calculation method	-
Comments	Applicable to the flare(s). The condition will be regularly monitored for each individual high temperature enclosed flare. Periodic calibration events will be performed in the instruments by a third party independent accredited calibration laboratory in a frequency as per instrument specifications and/or instrument manufacturer's recommendations. Monitoring equipment/instrument(s) will be subject to a regular maintenance and testing regime in accordance to appropriate national / international standards/requirements and/or best practice. Spare instrument(s) may be kept.

Data / Parameter	**Maintenance$_y$**
Data unit	Calendar dates
Description	Maintenance events completed in year *y* as monitored by the project participants.
Source of data	Measurements/monitoring performed by the project participants.
Description of measurement methods and procedures to be applied	Record the date that maintenance events were completed in year *y*. Records of maintenance logs must include all aspects of the maintenance including the details of the person(s) undertaking the work, parts replaced, or needing to be replaced, source of replacement parts, serial numbers and calibration certificates.

Frequency of monitoring/recording	Annual
Value applied	No estimated value is required for the determination of ex-ante estimation of emission reduction to be achieved by the proposed VCS project activity. Baseline emissions of methane from the SWDS ($BE_{CH4,y}$) are ex-ante estimated by estimating the amount of methane which is destroyed by the project activity through combustion of collected LFG in the project's flare(s) and/or engine-generator sets (methane destruction device(s)) and/or supply of upgraded LFG to consumer(s) in year *y* ($F_{CH4,PJ,y} = F_{CH4,flared,y} + F_{CH4,EL,y} + F_{CH4,NG,y}$) as a function of ex-ante estimated values for efficiency of the LFG capture system to be installed as part of the proposed VCS project activity (η_{PJ}) as well as ex-ante estimations for the amount of methane in the LFG that is generated from the SWDS in the baseline scenario in year *y* ($BE_{CH4,SWDS,y}$) by applying applicable guidance of the CDM methodological tool "Emissions from solid waste disposal sites" (version 08.0) and considering aspects/characteristics of the landfill.
Monitoring equipment	-
QA/QC procedures to be applied	Records must be kept in a maintenance log for two years beyond the life of the flare.
Purpose of data	Calculation of baseline emissions
Calculation method	-
Comments	These dates are required so that they can be compared to the maintenance schedule to check that maintenance events were completed within the minimum time between maintenance events specified by the manufacturer ($SPEC_{flare}$).

Data / Parameter	**$EC_{PJ,grid,y}$**
Data unit	MWh
Description	Amount of grid electricity consumed by the project activity during the year *y*

Source of data	Measured as part of the operation of the project activity by applying appropriate electricity meter(s).
Description of measurement methods and procedures to be applied	Authorized electricity meter(s) may be used. Measurement records will be cross-checked against available electricity consumption receipts/invoices (e.g. issued by the local electricity distribution company, if applicable). The parameter $EC_{PJ,y}$ is equivalent to the parameter $EG_{EC,y}$ as indicated in the CDM baseline and monitoring methodology ACM0001 (version 19.0).
Frequency of monitoring/recording	Continuous measurements will be aggregated automatically. Accumulated measurement records will be reported at least once a month.
Value applied	It is estimated that the proposed VCS project activity will consume 2,820 MWh of grid-sourced electricity per year. In the context of the ex-ante estimation of emission reductions to be achieved by the proposed VCS project activity, it is considered that the project's electricity demand will be met entirely by imports of grid-sourced electricity.
Monitoring equipment	Authorized electricity meter(s) may be used. Measurement records will be cross-checked against available electricity consumption receipts/invoices (e.g. issued by the local electricity distribution company, if applicable).
QA/QC procedures to be applied	Periodic calibration events will be performed in a frequency as per instrument specifications and/or instrument manufacturer's recommendations. Monitoring equipment/instrument(s) will be subject to a regular maintenance and testing regime in accordance to appropriate national / international standards/requirements and/or best practice. Spare instrument(s) may be kept.
Purpose of data	Calculation of project emissions
Calculation method	-
Comments	The value considered in the context of the ex-ante estimation of emission reductions was selected based on the probable

	nameplate power output for the centrifugal blowers to be installed as part of the proposed VCS project activity. Centrifugal blowers are the most electricity intensive equipment to be installed as part of the proposed VCS project activity. Also, as a conservative assumption, it is considered that the proposed VCS project activity will operate 24 hours a day along its lifetime. Measurement records will be cross-checked against available receipts/invoices/reports for imports and/or purchase of grid-sourced electricity.

Data / Parameter	**$EC_{BL,y}$**
Data unit	MWh
Description	Amount of electricity generated using LFG by the project activity in year *y*
Source of data	Measured as part of the operation of the project activity by applying appropriate electricity meter(s).
Description of measurement methods and procedures to be applied	Authorized electricity meter(s) may be used. The parameter $EC_{BL,y}$ is equivalent to the parameter $EG_{PJ,y}$ as indicated in ACM0001 (version 19.0). Measurement records will be cross-checked against available electricity sales receipts/invoices issued by the local electricity commercialization/distribution company.
Frequency of monitoring/recording	Continuous measurements will be aggregated automatically. Accumulated measurement records will be reported at least once a month.
Value applied	It is estimated that the proposed VCS project activity will generate 49,967 MWh electricity per year.
Monitoring equipment	Authorized electricity meter(s) may be used.
QA/QC procedures to be applied	Periodic calibration events will be performed in a frequency as per instrument specifications and/or instrument manufacturer's recommendations. Monitoring equipment/instrument(s) will be subject to a regular maintenance and testing regime in accordance to appropriate

	national / international standards/requirements and/or best practice. Spare instrument(s) may be kept. Measurement records will be cross-checked against available electricity sales receipts/invoices issued by the local electricity commercialization/distribution company.
Purpose of data	Calculation of baseline emissions
Calculation method	-
Comments	-

Data / Parameter	**$EC_{PJ,captive,y}$**
Data unit	MWh
Description	Quantity of electricity generated in captive diesel backup generator during the year y
Source of data	Measured as part of the operation of the project activity by applying appropriate electricity meter(s).
Description of measurement methods and procedures to be applied	Appropriate electricity meter(s) is/are to be used.
Frequency of monitoring/recording	Measurements will be aggregated manually or automatically. Accumulated measurement records will be reported at with at least every-month frequency.
Value applied	No estimated value is required for the determination of ex-ante estimation of emission reduction to be achieved by the proposed VCS project activity as it is assumed, in this particular context, that all electricity demand of the proposed VCS project activity will be met by imports of grid-sourced electricity.
Monitoring equipment	Appropriate electricity meter(s) is/are to be used.

QA/QC procedures to be applied	Periodic calibration events will be performed in a frequency as per instrument specifications and/or instrument manufacturer's recommendations. Monitoring equipment/instrument(s) will be subject to a regular maintenance and testing regime in accordance to appropriate national / international standards/requirements and/or best practice. Spare instrument(s) may be kept.
Purpose of data	Calculation of project emissions
Calculation method	-
Comments	Backup captive off-grid backup electricity generator (fuelled by diesel) is expected to be used only for emergency purposes. Thus, in the context of ex-ante estimates of emission reductions to be achieved by the project activity, there is no estimated amount of electricity to be generated this generator and/or amount of fossil fuel diesel to be consumed by the generators either. Project emissions due to the consumption of electricity sourced by these generators are thus estimated as zero (null) in the context of ex-ante estimates of emission reductions to be achieved by the project activity. However, related project emissions will be determined ex-post along the crediting period and will be accounted for the determination of emission reductions.

Data / Parameter	**$EF_{grid,OM,y}$ = $EF_{grid,OM-DD,y}$**
Data unit	tCO_2/MWh
Description	Operation margin CO_2 emission factor in year *y* = Dispatch data analysis operating margin CO_2 emission factor in year *y*.
Source of data	Data will be determined as per applicable guidance for dispatch data analysis operating margin CO_2 emission factor as per Option A.1 of the CDM methodological tool "Tool to calculate the emission factor for an electricity system" (version 07.0).

Description of measurement methods and procedures to be applied	Data will be determined as per applicable guidance for dispatch data analysis operating margin CO_2 emission factor as per applicable guidance of the CDM methodological tool "Tool to calculate the emission factor for an electricity system" (version 07.0).
Frequency of monitoring/recording	Yearly
Value applied	0.5985 The selected value considered for all years encompassed by the 7-year crediting period of the proposed VCS project activity in the context of the ex-ante estimation of emission reductions represents the value calculated by the DNA of Brazil and valid for year 2021 (the most recent annual value available). Data is made available online: https://antigo.mctic.gov.br/mctic/opencms/ciencia/SEPED/clima/textogeral/emissao_despacho.html
Monitoring equipment	-
QA/QC procedures to be applied	-
Purpose of data	Calculation of baseline emissions and project emissions
Calculation method	-
Comments	

Data / Parameter	**$TDL_{grid,y}$**
Data unit	-
Description	Average technical transmission and distribution losses for providing electricity to the grid and/or for grid sourced electricity consumed by the project activity
Source of data	Use of recent, accurate and reliable data available within the host country or selection of applicable default values as per Option A of the CDM methodological tool "Baseline, project and/or leakage emissions from electricity consumption and monitoring of electricity generation" (version 03.0) or use of

	recent, accurate and reliable data available within the host country.
Description of measurement methods and procedures to be applied	The CDM methodological tool “Baseline, project and/or leakage emissions from electricity consumption and monitoring of electricity generation” (version 03.0) defines, as alternative, default value of 20% for project consumption sources (applicable for determination of project emissions due to consumption of grid-sourced electricity by the proposed VCS project activity) and default value of 3% for baseline electricity consumption sources (applicable for the determination of baseline emissions for electricity generation by the proposed VCS project activity). The selection of these default values is under conformance with applicable guidance of the CDM baseline and monitoring methodology ACM0001 (version 19.0). While transmission and distribution sources applicable for both grid-sourced electricity to be consumed by the proposed VCS project activity and for electricity generation by the proposed VCS project activity (equivalent to electricity consumption of baseline electricity consumption sources when applying the underlaying tool) do not fit under Scenario B and/or Scenario C (case II) of the such tool, the selected 20% value for $TDL_{grid,import,y}$ and 3% values for $TDL_{grid,export,y}$ are thus under conformance with applicable guidance of the CDM methodological tool. The selection of 20% value for $TDL_{grid,import,y}$ and 3% value for $TDL_{grid,export,y}$ meets applicable guidance for Scenarios A and C (cases I and III) of the CDM methodological tool “Baseline, project and/or leakage emissions from electricity consumption and monitoring of electricity generation” (version 03.0) (whichever of these scenarios are applicable for the particular case of the proposed VCS project activity). It is relevant to note that as per the project design, the amount of electricity to be consumed by the proposed VCS project activity (project electricity consumption sources) to which scenario C of the CDM methodological tool “Baseline, project and/or leakage emissions from electricity consumption and monitoring of electricity generation” (version 03.0) refers is

	smaller than the so-called electricity consumption of baseline electricity consumption sources ($EC_{BL,k,y}$) as per such methodological tool (where $EC_{BL,k,y}$ in the tool is equivalent to the net amount of electricity generated using LFG in year y ($EG_{PJ,y}$) as defined by ACM0001 (version 19.0)). In summary, the proposed VCS project activity generates more electricity than it requires for its operation, with the largest amount of generated electricity being exported through the electricity grid the proposed VCS project activity is connected to. Under these particular conditions, also considering the 3% default value for electricity imported by the project activity (through the electricity grid the project activity is connected to) in thesis would represent an acceptable alternative. However, as a conservative approach, the generic 20% default value of the CDM methodological tool "Baseline, project and/or leakage emissions from electricity consumption and monitoring of electricity generation" (version 03.0) applicable for project consumption sources is selected. This approach results in higher project emissions, thus reducing emission reductions to be achieved by the proposed VCS project activity accordingly.
Frequency of monitoring/recording	Annually. In the absence of data from the relevant year, most recent figures should be used, but not older than 5 years.
Value applied	3% (for generated electricity exported through the electricity grid the project activity is connected to ($TDL_{grid,export,y}$)) 20% (for electricity imported by the project activity through the electricity grid the project activity is connected to ($TDL_{grid,import,y}$))
Monitoring equipment	-
QA/QC procedures to be applied	-
Purpose of data	Calculation of baseline emissions and project emissions.
Calculation method	-
Comments	-

Data / Parameter	$TDL_{captive,y}$
Data unit	-
Description	Average technical transmission and distribution losses for electricity sourced by the captive electricity generator
Source of data	Selection of applicable default values as per the CDM methodological tool "Baseline, project and/or leakage emissions from electricity consumption and monitoring of electricity generation" (version 03.0)
Description of measurement methods and procedures to be applied	-
Frequency of monitoring/recording	Annually
Value applied	1.3
Monitoring equipment	-
QA/QC procedures to be applied	-
Purpose of data	Calculation of project emissions
Calculation method	-
Comments	-

Data / Parameter	$Op_{j,h}$
Data unit	-
Description	Operation of the equipment that consumes LFG (engine-generator sets of the electricity generation infrastructure)
Source of data	Measured as part of the operation of the project activity.
Description of measurement methods and procedures to be applied	For each equipment unit j using the LFG monitor that the plant is operating in hour h by the monitoring any one or more of the following three parameters: (a) Temperature. Determine the location for temperature measurements and minimum operational temperature based

	on manufacturer's specifications of the burning equipment. Document and justify the location and minimum threshold in the PDD; (b) Flame. Flame detection system is used to ensure that the equipment is in operation; (c) Products generated. Monitor the generation of steam for the case of boilers and air-heaters and glass for the case of glass melting furnances. This option is not applicable to brick kilns. $Op_{j,h}$ = 0 when: (a) One of more temperature measurements are missing or below the minimum threshold in hour h (instantaneous measurements are made at least every minute); (b) Flame is not detected continuously in hour h (instantaneous measurements are made at least every minute); (c) No products are generated in the hour h. Otherwise, $OP_{j,h}$ = 1
Frequency of monitoring/recording	Hourly.
Value applied	No estimated value is required for the determination of ex-ante estimation of emission reduction to be achieved by the proposed VCS project activity. Baseline emissions of methane from the SWDS ($BE_{CH4,y}$) are ex-ante estimated by estimating the amount of methane which is destroyed by the project activity through combustion of collected LFG in the project's flare(s) and/or engine-generator sets (methane destruction device(s)) and/or supply of upgraded LFG to consumer(s) in year *y* ($F_{CH4,PJ,y} = F_{CH4,flared,y} + F_{CH4,EL,y} + F_{CH4,NG,y}$) as a function of ex-ante estimated values for efficiency of the LFG capture system to be installed as part of the proposed VCS project activity (η_{PJ}) as well as ex-ante estimations for the amount of methane in the LFG that is generated from the SWDS in the baseline scenario in year *y* ($BE_{CH4,SWDS,y}$) by applying applicable guidance of the CDM methodological tool "Emissions from solid waste disposal sites"

	(version 08.0) and considering aspects/characteristics of the landfill.
Monitoring equipment	-
QA/QC procedures to be applied	-
Purpose of data	Calculation of baseline emissions
Calculation method	-
Comments	In the particular case of the proposed VCS project activity the only equipment/infrastructure that promotes utilization of LFG are the engine-generator sets of the electricity generation infrastructure and the infrastructure for upgrading and supplying LFG to consumer(s).

Data / Parameter	**Status of biogas destruction device(s)**
Data unit	-
Description	Operational status of biogas destruction device(s)
Source of data	Not applicable.
Description of measurement methods and procedures to be applied	Monitoring and documenting may be undertaken through monitoring of the operation status of the flare(s), engine-generators set of the project's electricity generation infrastructure and the infrastructure for upgrading and supplying LFG to consumer(s) in order to demonstrate the actual destruction/supply of methane in such installed biogas destruction device(s). Emission reductions will not accrue for periods in which the underlying destruction device(s).
Frequency of monitoring/recording	Continuous measurements will be recorded and reported with a least every minute frequency.
Value applied	Not applicable. No estimated value is required for the determination of ex-ante estimation of emission reduction to be achieved by the proposed VCS project activity. Baseline emissions of methane from the SWDS ($BE_{CH4,y}$) are ex-ante estimated by estimating the amount of methane which

	is destroyed by the project activity through combustion of collected LFG in the project's flare(s) and/or engine-generator sets (methane destruction device(s)) and/or supply of upgraded LFG to consumer(s) in year *y* ($F_{CH4,PJ,y} = F_{CH4,flared,y} + F_{CH4,EL,y} + F_{CH4,NG,y}$) as a function of ex-ante estimated values for efficiency of the LFG capture system to be installed as part of the proposed VCS project activity (η_{PJ}) as well as ex-ante estimations for the amount of methane in the LFG that is generated from the SWDS in the baseline scenario in year *y* ($BE_{CH4,SWDS,y}$) by applying applicable guidance of the CDM methodological tool "Emissions from solid waste disposal sites" (version 08.0) and considering aspects/characteristics of the landfill.
Monitoring equipment	-
QA/QC procedures to be applied	Not applicable.
Purpose of data	Calculation of baseline emissions
Calculation method	-
Comments	Monitoring records for the monitoring parameter "Flame detection of flare in the minute *m*" ($Flame_m$) may be considered for the case of the flare(s). Monitoring the operational status of the engine-generator sets by embedded electronics of the sets may also be considered.

Data / Parameter	**$FC_{j,y}$**
Data unit	Mass or volume unit per year (e.g. ton/yr or m^3 /yr)
Description	Quantity of fuel type i combusted in process j during the year y
Source of data	Onsite measurements
Description of measurement methods and procedures to be applied	Depending on the calculation option applied by the project participant, either an appropriate mass or volume meter will be used.

Frequency of monitoring/recording	Continuously
Value applied	Not applicable
Monitoring equipment	Depending on the calculation option applied by the project participant, either an appropriate mass or volume meter will be used.
QA/QC procedures to be applied	Measured fuel consumption quantities will be cross-checked with an annual energy balance that is based on purchased quantities and stock changes.
Purpose of data	Calculation of project and/or leakage emissions
Calculation method	Not applicable
Comments	-

<table>
<tr><td>Data / Parameter</td><td>$w_{C,i,y}$</td></tr>
<tr><td>Data unit</td><td>tC/mass unit of the fuel</td></tr>
<tr><td>Description</td><td>Weighted average mass fraction of carbon in fuel type i in year y</td></tr>
<tr><td>Source of data</td><td><table>
<tr><th>Data source</th><th>Conditions for using the data source</th></tr>
<tr><td>a) Values provided by the fuel supplier in invoices</td><td>Preferred source</td></tr>
<tr><td>b) Measurements by the project participants</td><td>If (a) is not available</td></tr>
</table></td></tr>
<tr><td>Description of measurement methods and procedures to be applied</td><td>Measurements will be undertaken in line with national or international fuel standards</td></tr>
<tr><td>Frequency of monitoring/recording</td><td>Each fuel delivery, from which weighted average annual values should be calculated</td></tr>
</table>

Value applied	Not applicable
Monitoring equipment	Not applicable
QA/QC procedures to be applied	Obtained values under (a) and (b) will be verified if they are within the uncertainty range of the product of the IPCC default values as provided in Table 1.2 and Table 1.3, Vol. 2 of the 2006 IPCC Guidelines
Purpose of data	Calculation of project and/or leakage emissions
Calculation method	Not applicable
Comments	-

<table>
<tr><td>Data / Parameter</td><td>$\rho_{i,y}$</td></tr>
<tr><td>Data unit</td><td>Mass unit/volume unit</td></tr>
<tr><td>Description</td><td>Weighted average density of fuel type i in year y</td></tr>
<tr><td>Source of data</td><td>
<table>
<tr><th>Data source</th><th>Conditions for using the data source</th></tr>
<tr><td>a) Values provided by the fuel supplier in invoices</td><td>Preferred source</td></tr>
<tr><td>b) Measurements by the project participants</td><td>If (a) is not available</td></tr>
<tr><td>c) Regional or national default values</td><td>If (a) is not available (only applicable with liquid fuels)</td></tr>
</table>
</td></tr>
<tr><td>Description of measurement methods and procedures to be applied</td><td>Measurements will be undertaken in line with national or international fuel standards</td></tr>
<tr><td>Frequency of monitoring/recording</td><td>Each fuel delivery, from which weighted average annual values should be calculated</td></tr>
<tr><td>Value applied</td><td>Not applicable</td></tr>
<tr><td>Monitoring equipment</td><td>Not applicable</td></tr>
</table>

QA/QC procedures to be applied	Not applicable
Purpose of data	Calculation of project and/or leakage emissions
Calculation method	Not applicable
Comments	Applicable where Option A is chose for determination of $PE_{TR,y}$ is used and where $FC_{i.j.y}$ is measured in a volume unit. Preferably the same data source should be used for $w_{C,i,y}$ and $\rho_{i,y}$

<table>
<tr><td>Data / Parameter</td><td>$NCV_{i,y}$</td></tr>
<tr><td>Data unit</td><td>GJ per mass or volume unit (e.g. GJ/m³, GJ/ton)</td></tr>
<tr><td>Description</td><td>Weighted average net calorific value of fuel type i in year y</td></tr>
<tr><td>Source of data</td><td>
<table>
<tr><th>Data source</th><th>Conditions for using the data source</th></tr>
<tr><td>a) Values provided by the fuel supplier in invoices</td><td>Preferred source</td></tr>
<tr><td>b) Measurements by the project participants</td><td>If (a) is not available</td></tr>
<tr><td>c) Regional or national default values</td><td>If (a) is not available (only applicable with liquid fuels)</td></tr>
<tr><td>d) IPCC default values at the upper limit of the uncertainty at a 95% confidence interval as provided in Table 1.2 of Chapter 1 of Vol. 2 (Energy) of the 2006 IPCC Guidelines on National GHG Inventories</td><td>If (a) is not available</td></tr>
</table>
</td></tr>
</table>

Description of measurement methods and procedures to be applied	Measurements will be undertaken in line with national or international fuel standards (if (a) of (b) are applicable)

Frequency of monitoring/recording	For (a) and (b): The NCV it will be obtained for each fuel delivery, from which weighted average annual values should be calculated.
	For (c): Review appropriateness of the values annually.
	For (d): Any future revision of the IPCC Guidelines should be taken into account

Value applied	Not applicable
Monitoring equipment	Not applicable
QA/QC procedures to be applied	Obtained values under (a), (b) and (c) will be verified if they are within the uncertainty range of the product of the IPCC default values as provided in Table 1.2, Vol. 2 of the 2006 IPCC Guidelines
Purpose of data	Calculation of project and/or leakage emissions
Calculation method	Not applicable
Comments	Applicable where Option B is used for determination of $PE_{TR,y}$

Data / Parameter	**$EF_{CO2,i,y}$**
Data unit	tCO2/GJ
Description	Weighted average CO2 emission factor of fuel type i in year y
Source of data	IPCC default values as provided in table 1.4 of Chapter1 of Vol. 2 (Energy) of the 2006 IPCC Guidelines on National GHG Inventories
Description of measurement methods and procedures to be applied	Not applicable
Frequency of monitoring/recording	Any future revision of the IPCC Guidelines should be taken into account

Value applied	58.3
Monitoring equipment	Not applicable
QA/QC procedures to be applied	Not applicable
Purpose of data	Calculation of baseline, project and/or leakage emissions
Calculation method	Not applicable
Comments	-

4.3 Monitoring Plan

General monitoring:

The following instruments/equipment will be used to monitor required data along the lifetime of the proposed VCS project activity (depending on the applied measurement options and calculation approaches - to be chosen ex-post)[46]:

Instrument or Source of data	Measurement option		Data monitored	
Appropriate volumetric or mass flow meter(s) (one individual LFG flow meter for each operational high temperature enclosed flare and/or each operational engine-generator set with separated measurement data	A	Volume flow – dry basis; Volumetric fraction dry or wet basis	**$V_{t,db,j}$**	Volumetric flow of LFG stream *j* in time interval *t* on a dry basis (in m^3 dry gas/h). *j* = LFG delivery pipeline to each operative high temperature enclosed flare and/or each operative engine-generator set (i.e. each installed methane destruction device)

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[46] Measurement options defined in the CDM methodological tool “Tool to determine the mass flow of a greenhouse gas in a gaseous stream” (version 03.0) when referring to “*Adequate volumetric or mass flow meter(s)*” and defined in the CDM methodological tool “Project emissions from flaring” (version 04.0) in other cases. Different measurement options are indeed defined in the CDM methodological tool “Tool to determine the mass flow of a greenhouse gas in a gaseous stream” (version 03.0) when referring to “Adequate volumetric or mass flow meter (s)”. The applicable guidance of the CDM methodological tool “Project emissions from flaring” (version 04.0) also refers to different measurement and calculation options.

being recorded and reported for each one of these methane destruction devices)	B	Volume flow – wet basis; Volumetric fraction dry basis	$\mathbf{V}_{\mathbf{t,wb,j}}$	Volumetric flow of LFG stream *j* in time interval *t* on a wet basis (in m^3 dry gas/h). *j* = LFG delivery pipeline to each operative high temperature enclosed flare and/or each operative engine-generator set (i.e. each installed methane destruction device)
	C	Volume flow – wet basis; Volumetric fraction wet basis	$\mathbf{V}_{\mathbf{t,wb,j}}$	Volumetric flow of LFG stream *j* in time interval *t* on a wet basis (in m^3 wet gas/h). *j* = LFG delivery pipeline to each operative high temperature enclosed flare and/or each operative engine-generator set (i.e. each installed methane destruction device)
	D	Mass flow – dry basis; Volumetric fraction dry or wet basis	$\mathbf{M}_{\mathbf{t,db,j}}$	Mass flow of LFG stream *j* in time interval *t* on a dry basis (in kg/h). *j* = LFG delivery pipeline to each operative high temperature enclosed flare and/or each operative engine-generator set (i.e. each installed methane destruction device)
Continuous CH_4 content gas analyser unit	-		$\mathbf{V}_{\mathbf{CH4,t,db/wb,j}}$	Volumetric fraction of methane on the LFG stream directed to the flares and/or to the internal combustion gas engines in a time

			interval *t* on a dry or wet basis (in m^3 CH_4/m^3 dry or wet gas)
LFG pressure sensor	-	**P_t**	Pressure of the LFG stream directed to the flare(s) and/or to each operative engine-generator set in time interval *t* (in Pa or mbar) Note: P_t may not be monitored when using LFG flow meters that automatically consider and measures LFG temperature and LFG pressure, thus expressing LFG volumetric or mass flows in normalized units
LFG temperature sensor	-	**T_t**	Temperature of the LFG stream directed to the flares and/or to each operative engine-generator set in time interval t (in K or ºC) Note: T_t may not be monitored when using LFG flow meters that automatically consider and measures LFG temperature and LFG pressure, thus expressing LFG volumetric or mass flows in normalized units.
Not based on measurements. Monitoring	-	**$p_{H20,t,Sat}$**	Saturation pressure of H_2O at temperature T_t in time interval t.

performed in the context of operation/monitoring for the project activity (based on calculations)			This parameter is solely a function of the LFG stream temperature T_t and can be found at referenced literature.
Electricity meters	-	**$EC_{PJ,y}$**	Amount of grid electricity consumed by the project activity in year y (in MWh)
		$EC_{PJ,captive,y}$	Quantity of electricity generated by / consumed from captive diesel backup generator during the year y (in MWh)
		$EC_{BL,y}$	Amount of electricity generated using LFG by the project activity in year *y* (in MWh)
Not based on measurements. Monitoring performed in the context of operation/monitoring for the project activity (based on calculations)	-	**$EF_{grid,OM,y}$ = $EF_{grid,OM-DD,y}$**	Operation margin CO_2 emission factor in year y = Dispatch data analysis operating margin CO_2 emission factor in year y. (in tCO_2/MWh). Data will be determined as per applicable guidance for dispatch data analysis operating margin CO_2 emission factor of the methodological tool “Tool to calculate the emission factor for an electricity system” (version 07.0).
Not based on measurements performed in the context of	-	**Management of SWDS**	Management of SWDS The design and operational conditions

operation/monitoring for the project activity			of the landfill will be annually monitored on the basis of different sources, including inter alia: - Original design of the landfill; - Technical specifications for the management of the landfill; - Applicable local or national regulations
Meter or equipment electronics.	-	**Op$_{j,h}$**	Operation of the equipment that consumes LFG (engine-generators sets). For each engine-generator set *j* combusting LFG, it will be continuously monitored whether the equipment is operating in hour h by monitoring any one the following sub-parameters/conditions: - Amount of electricity generated in hour h - Operational status of the engine-generator set during each hour h.
Measurements undertaken by a third-party accredited entity	B.1	**F$_{CH4,EG,t}$**	Mass flow of methane in the exhaust gas of the flare on a dry basis at reference conditions in the time period t (kg).

			For each one of the installed high temperature enclosed flare(s), it will be measured the mass flow of methane in the exhaust gas according to an appropriate national or international standard (e.g. UKs Technical Guidance LFTGN05). The time period *t* over which the mass flow is measured must be at least one hour. The average flow rate to the flare during the time period *t* must be greater than the average flow rate observed for the previous six months. Monitoring of this parameter is only required in the case the project participants select Option B.1 to determine the efficiency values for the high temperature enclosed flares.
Appropriate Gas analyzer(s) (one individual gas analyzer for each high temperature enclosed flare)	**Option B.2**	$\mathbf{v_{i,RG,m}}$	Volumetric fraction of component *i* in the residual gas on a dry basis in the minute m where *i* = CH_4, CO, CO_2, O_2, H_2, H_2S, NH_4, N_2 (As a simplified approach, the project proponent may only measure the content

			CH_4, CO and CO_2 of the residual gas and consider the remaining part as N_2) Monitoring of this parameter is only applicable in case of enclosed flares and continuous monitoring of the flare efficiency
Appropriate volumetric or mass flow meter(s) (one individual LFG flow meter for each high temperature enclosed flare)	**Option B.2**	$v_{RG,m}$	Volumetric flow of the residual gas on a dry basis at reference conditions in the minute m Monitoring of this parameter is only applicable in case of enclosed flares and continuous monitoring of the flare efficiency
Appropriate volumetric or mass flow meter(s) (one individual LFG flow meter for each high temperature enclosed flare)	**Option B.2**	$M_{RG,m}$	Mass flow of the residual gas on a dry basis at reference conditions in the minute *m* Monitoring of this parameter is only applicable in case of enclosed flares and continuous monitoring of the flare efficiency
Appropriate Gas analyzer(s) (one individual gas analyzer for each high temperature enclosed flare)	**Option B.2**	$v_{O2,EG,m}$	Volumetric fraction of O_2 in the exhaust gas on a dry basis at reference conditions in the minute *m* Monitoring of this parameter is only applicable in case of enclosed flares and continuous monitoring of the flare efficiency.
Concentration of methane in the	**Option B.2**	$fc_{CH4,EG,m}$	Concentration of methane in the exhaust gas of the flare on a dry

exhaust gas of the flare on a dry basis at reference conditions in the minute m			basis at reference conditions in the minute *m* Monitoring of this parameter is only applicable in case of enclosed flares and continuous monitoring of the flare efficiency
Thermocouples	A or B.1	$T_{EG,m}$	Temperature in the exhaust gas of the enclosed flare in minute m (ºC) For each one of the installed high temperature enclosed flare(s), it will be continuously measured the temperature of the exhaust gas through use of appropriate temperature measurement instrument (e.g. thermocouples). Measurements outside the operational temperature specified by the flare manufacturer may indicate that the flare is not functioning correctly and may require maintenance or repair work. For each flare, the temperature of the exhaust gas in each flare has to be measured in a suitable monitoring port. In high temperature enclosed

			flares, monitoring ports are normally expected to be located within the middle third of the flare. In case more than one temperature port is fitted to the high temperature enclosed flare, the flare manufacturer must provide written instructions detailing the conditions under which each location shall be used and the port most suitable for monitoring the operation of the flare according to manufacturer's specifications for temperature of exhaust gas. The high temperature enclosed flare currently installed as part of the project activity only have one monitoring port for temperature of the exhaust gas. Measurements are required to determine if manufacturer's flare specifications for operating temperature are met.
Optical flame detector (using ultra violet or infra-red technology or both	A or B.1	**$\mathbf{Flame_m}$**	Flame detection of flare in the minute m (Flame "on" or Flame "off"). For each installed high temperature enclosed flare(s), continuous monitoring of flame

			detection through use of appropriate installation (e.g. optical flame detector (using ultra violet or infra-red technology or both).
Records from the project participants gathered as part of the operation of the project activity.	B.1	**Maintenance$_y$**	Maintenance events completed in year y (Calendar dates) for the high temperature enclosed flare(s) combusting LFG. For the high temperature enclosed flare(s), record the date when maintenance events are performed in year *y*. Records of maintenance logs will include all aspects of the maintenance including the details of the person(s) undertaking the work, parts replaced/repaired, or needing to be replaced, source of replacement parts, serial numbers and related calibration certificates.
Not based on measurements	Calculated or application of default value	**TDL$_{grid,y}$ / TDL$_{captive,y}$**	Use of recent, accurate and reliable data available within the host country or selection of the applicable default value as per the methodological tool “Baseline, project and/or leakage emissions from electricity consumption

				and monitoring of electricity generation” (version 03.0).
Project participants	-		**Status of biogas destruction device**	Operational status of biogas destruction device. The same procedures as adopted for monitoring parameter $Flame_m$ (in the case of the flare(s)) and for parameter $Op_{j,h}$ (in the case of engine-generator sets). For installed high temperature enclosed flare(s), continuous monitoring of flame detection through use of appropriate installation (e.g. optical flame detector (using ultra violet or infrared technology or both). For installed engine-generators sets, continuous monitoring of operational status signal in each engine
Mass or volume meter	-		$\mathbf{FC_{i,j,y}}$	Quantity of fuel type *i* combusted in process j during the year *y*
Project participants	A	Monitoring fuel consumption	$\mathbf{w_{C,i,y}}$	Weighted average mass fraction of carbon in fuel type i in year y
Project participants	A	Monitoring fuel consumption	$\boldsymbol{\rho_{i,y}}$	Weighted average density of fuel type i in year y

Default value	B	Using conservative default values	**$NCV_{i,y}$**	Weighted average net calorific value of fuel type i in year y
Default value	B	Using conservative default values	**$EF_{CO2,i,y}$**	Weighted average CO2 emission factor of fuel type i in year y

During the lifetime of the proposed VCS project activity, all continuously measured LFG related parameters as well as measurements related to the exhaust gas of the flare(s) (temperature in the exhaust gas of the flare(s)) and parameters related to flare operational conditions of the flare(s) and/or engine-generator set(s) and/or infrastructure promoting upgrading and supply of LFG to consumer(s) (i.e. status of the methane destruction device(s)) will all be recorded electronically via an appropriate data logger / data acquisition system (to be located within the site boundary).

The data logger / data acquisition system will have the capability to record all data in a safe and reliable manner (thus ensuring the required data reliability and validity). Data recording and reporting frequency for these parameters will be at least every minute.

Records of electricity generated by the proposed VCS project activity as well as records of electricity consumed by the proposed VCS project activity will also be recorded electronically via an appropriate data logger / data control / data acquisition system (to be located within the site boundary). Data from invoices of commercialization of generated electricity and consumption of grid-sourced electricity (issued by local electricity transmission/commercialization company and/or electricity purchaser) may also be used as cross-checking. Monitoring related to supply of upgraded LFG to consumer(s) will also be performed, if applicable (by *inter alia* considering data and details from invoices of commercialization of upgraded LFG).

By the use of appropriate software application, recorded monitoring data will be regularly retrieved, aggregated and reported in order to be considered in the context of calculations of emission reduction achieved by the proposed VCS project activity.

Monitoring records available in the data logger / data acquisition system might be regularly retrieved remotely by modem or directly on site. If automatic data logging by the logger / data acquisition system fails, measurement data might be recorded manually (whenever it is possible). If data is not properly recorded or cannot be retrieved, no emissions reductions will be claimed for the period encompassing such data recording/reporting failure or conservative emission reduction determination measure will be applied, if applicable.

All monitoring data will be recorded and backed-up in a central database. As per the applicable monitoring procedure, data records will be summarized into emission reduction calculations prior to each periodic VCS verification. All data recorded by the data logger /

data acquisition system will be made available to the Validation and Verification Body (VVB) responsible for each periodic verification. This will ensure that data integrity and reliability for related monitoring data.

Procedures for handling non-conformances with the validated monitoring plan will also be in place.

As per the monitoring procedure to be adopted by the project proponent Orizon Valorização de Resíduos S.A., access to monitoring data will be restricted and controlled. All monitoring records will be kept archived until at least two years after the end of the crediting period or at least two years after the last issuance of VCU's for the proposed VCS project activity, whichever occurs later.

It will be the responsibility of the appointed monitoring team manager to ensure that all monitoring data is properly measured and recorded as part of operation of the project activity.

Technical specifications for monitoring instruments/equipment (e.g. manufacturer, model, serial numbers, accuracy, etc.) will be detailed in the Monitoring Reports for each periodic verification.

Maintenance and calibration for monitoring instruments/equipment and project's equipment/components in general:

During the lifetime of the proposed VCS project activity, all maintenance service and routines will include all preventive and corrective actions necessary for ensuring good functioning of all project related equipment, such as:

- Visual control of the equipment state and real-time check of displayed parameters,
- Cleaning up the equipment and the sensors,
- Lubrication and greasing,
- Replacement or overhauling of defective parts (including regular welding service in the HDPE pipelines and manifolds, testing and replacement of components from the engine-generator sets, etc.).
- Calibration events in monitoring instruments/equipment will be periodically and appropriately performed as per applicable frequency, procedures and methods established or recommended by instrument/ equipment manufacturer, applicable national/international standards and/or best practice, as available.

General malfunction of equipment: if monitoring instruments/equipment or project's equipment/components present failure or malfunction, applicable repair or replacement actions will be carried out. Spare units for some of the monitoring instruments/equipment may be kept on site.

Project's operational and management structure:

An appropriate project's operational and management structure will be made available as part of the operation of the proposed VCS project activity during its lifetime.

The project's operational and management structure will rely on trained staff with responsibilities clearly defined. All collaborators and employees involved with operation of project and/or monitoring will be trained internally and/or externally. Training efforts may include *inter alia*:

a) General competence development about LFG generation and collection.

b) Review of equipment operational principles and captors.

c) Maintenance and calibration requirements for project's related equipment.

d) Procedures for monitoring data gathering and handling.

e) Emergency and safety procedures.

f) General competence development about methane destruction through combustion of LFG in high temperature enclosed flare.

g) General competence development about utilization of LFG as gaseous fuel for electricity generation

h) General competence development about upgrading of LFG and its supply to consumer(s) (through natural gas distribution network and/or dedicated pipeline).

The monitoring plan will be implemented and operationalized during the lifetime of the proposed VCS project activity by reflecting the best practice in terms of monitoring efforts for LFG collection and destruction/utilization project-based initiatives under VCS.

Monitoring of the management of the landfill:

As required by the applied CDM baseline and monitoring methodology ACM0001 (version 19.0), the design and operational conditions of the Ecoparque Sergipe landfill will be monitored along the lifetime of the proposed VCS project activity on the basis of different sources, including *inter alia*:

- Original design of the landfill;
- Technical specifications for the management of the Ecoparque Sergipe landfill;
- Applicable local or national regulations

During the lifetime of the proposed VCS project activity, original operational design of the landfill should be confirmed not to be modified in order to ensure that no practice to increase methane generation at the landfill have been occurring, when compared to the landfill management and operation condition prior to implementation of the project activity. As required by the applied CDM baseline and monitoring methodology ACM0001 (version 19.0), any change in the management of the landfill after the implementation of the proposed VCS project activity should be justified by referring to technical or regulatory specifications and impacts of such changes in the determination of baseline emissions should in this case be taken into account appropriately. Such monitoring requirement will be used for the determination/confirmation of baseline emissions and/or confirmation of the project's implementation as described in the VCS PD (in terms of operation and management conditions of the landfill from which LFG is combusted). Further monitoring details are included in Section 4.2 (under parameter "Management of SWDS").