MONITORING REPORT

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Contact Information

Project Title	Pichacay Landfill Gas Renewable Energy Project
Version	5.0
Report ID	BTG/1930/MVI/V2021
Date of Issue	25 October 2022
Project ID	1883
Monitoring Period	1 January 2021 to and including 25 August 2021
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1 PROJECT DETAILS

1.1 Summary Description of the Implementation Status of the Project

At the Pichacay landfill municipal solid waste (MSW) from the city of Cuenca in Ecuador is disposed. In the landfill, landfill gas (LFG) (rich in methane (CH_4)) is generated. Prior to the project implementation, generated LFG was directly released into the atmosphere. The project involves the implementation of a LFG collection network with horizontal and vertical wells, a biogas pumping station, an electricity generation infrastructure (encompassing the gradual/phased implementation of 4 engine-generator sets of nameplate installed capacity of 0.85 MWe each), a flare and a power transformer to 22 kV. The project promotes collection and destruction/utilization of LFG with net generated electricity being exported through the electricity grid the project activity is connected to.

The landfill - without any pre-project landfill gas recovery system being available – has been under operation since the year 2001. An Environmental Impact Assessment (EIA) and other needed permissions for LFG extraction and renewable electricity generation were obtained in year 2014. The VCS project activity was constructed and commissioned between years 2014 and 2017 and started commercial operation (with one engine-generator set being under operational status) on 27 July 2017. The second engine-generator was initially expected to start operation around July 2019 but its installation was delayed. This second engine-generator set was finally commissioned from May to mid June 2021. During commissioning the engine-generator was not connected to the grid and any methane destroyed was not measured by an electricity meter. Synchronization and electricity generation tests were performed from 7 – 8 July 2021. The second-engine generator was connected to the grid. The electricity was measured by a rented electricity meter, while the main electricity meter was disconnected (as CENACE will not pay for electricity generated during this test). This resulted in about 5 MWh of electricity produced and sent to the grid. The emissions reductions due to biogas combustion and grid connected electricity production from 7 – 8 July 2021 measured by the rented electricity meter will not be claimed as emission reductions (VCUs) of the project activity. The experimental operation period occurred from 20 July 2021 - 2 August 2021. During experimental operation, the second engine-generator set was operational instead of the first engine-generator, as the project activity did not produce enough biogas yet to run both units simultaneously. The electricity generated was measured by the main electricity meter that also measures the electricity production of the first engine-generator. The emission reductions due to operation of the second engine-generation between 20 July – 2 August are claimed by the project activity The second engine-generator set received its commercial operation declaration by 1 October 2021.

The first 2 installed engine-generator sets the VCS project activity have all licences to be operational until the year 2029. The company wishes to extend operation after this date. Engine-generator set 2 started commercial operation on 1 October 2021. The installation of Engine-generator set 3 is planned to occur in the year 2023; The date of installation of Engine-generator set 4 has not been confirmed yet. Engine-generator sets 3 and 4 are not part of the monitoring period 1 Jan 2021 – 25 Aug 2021 as these engine-generator sets are still in an early stage of implementation work development and no related permits are yet obtained.

Prior to the implementation of the VCS project activity, LFG (rich in CH_4) generated due to anaerobic decomposition of organic share of MSW disposed at the landfill was directly emitted into the atmosphere. The VCS project activity thus promotes collection and destruction/utilization of LFG that would otherwise be directly emitted to the atmosphere, thus promoting real, permanent and measurable reduction of CH_4 emissions. By generating electricity from a renewable energy source, displacement of equivalent amount of electricity that would be otherwise generated in existing grid-connected electricity generation sources (including fossil fuel fired power plants) and addition of new electricity generation sources occurs, thus promoting real and permanent CO_2 emission reductions.

The VCS project activity is located in Santa Ana, city of Cuenca, province of Azuay, in Ecuador.

During the monitoring period from 1 January to 25 August 2021, a total emission reduction of **11,444 tCO_2e** was achieved.

1.2 Sectoral Scope and Project Type

Sectoral scope: 13 & 1, Waste handling and disposal & Energy (renewable/non-renewable)

Project Type -III Other project and Type-I Renewable Energy Project

The project activity is not a grouped project.

1.3 Project Proponent

Organization name	EMAC-BGP ENERGY COMPAÑÍA DE ECONOMÍA MIXTA CEM
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1.4 Other Entities Involved in the Project

Organization name	EMAC EP
Role in the Project	Main Partner of project proponent
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1.5 Project Start Date

The starting date of the VCS project activity is 27 July 2017.

1.6 Project Crediting Period

The project proponent has selected a renewable crediting period of 10 years. The crediting period starts on 27 July 2017 (the project start date) and ends on 26 July 2027.

1.7 Project Location

The VCS project activity is located at Santa Ana, Cuenca, Azuay, Ecuador.

Geographical Coordinates:

Lat = -2.9660411,

Long = -78.9314400

1.8 Title and Reference of Methodology

The following UNFCCC's Clean Development Mechanism (CDM) baseline and monitoring methodologies are applied:

AMS-III.G - Landfill methane recovery (version 10.0).

AMS-I.D – "Grid connected renewable electricity generation" (version 18.0)

AMS-III.G (version 10.0) falls within CDM and VCS Sectoral Sectoral Scopes: 01 and 13 and it is valid from 14 June 2019 onwards. AMS-I.D (version 18.0) falls with CDM and VCS Sectoral Scope: 01, and it is valid from 18 Nov 2014 onwards.

CDM methodological tool(s) and/or other CDM baseline and monitoring methodology(ies) that AMS-III.G refers to (and that are applied for the VCS project activity):

- Tool04: "Emissions from solid waste disposal sites" (version 08.0).

- Tool05: “Baseline, project and/or leakage emissions from electricity consumption and monitoring of electricity generation” (version 03.0)
- AMS-III.H: Methane recovery in wastewater treatment (version 19.0)
- Tool06: "Project emissions from flaring”, (version 02.0.0)
- Tool07: “Tool to calculate the emission factor for an electricity system” (version 05.0)
- Tool 32: “Positive list of technologies” (version 01.0)

1.9 Participation under other GHG Programs

The VCS project activity has not been previously registered under any other GHG program.

1.10 Other Forms of Credit

The VCS project activity is not part of any emission trading program or subject to other binding limits. The VCS project activity has not previously sought or received another form of GHG-related environmental credits.

In year 2012 the PDD of the proposed CDM project “Biogas project at the Municipal landfill of Pichacay, Cuenca” was submitted for public comments, between 01 May 12 – 30 May 12. However, the project never passed the validation stage and has not been registered as CDM project. The project was not rejected.

1.11 Sustainable Development

Numeral 66. Article 27 of the Constitution of the Republic of Ecuador, recognizes and guarantees individuals the right to live in a healthy, ecologically balanced, free from contamination and in harmony with nature. The project strongly contributes towards Sustainable Development.

Locally the project will have its strongest impacts in positive social and environmental benefits. Local emissions of LFG can directly negatively influence the health of the affected inhabitants and additionally leads to the risk of explosions in the surrounding areas within the landfill. Furthermore, emissions of other harmful gases, such as H_2S and odorous compounds are going to be reduced. The VCS project activity improves the living conditions of the direct affected neighborhoods. Furthermore, the VCS project activity has a small but positive impact on employment in the local area as staff is employed to maintain the operation of its infrastructure.

Focusing on national level, the VCS project activity contributes to the generation of renewable energy from non-conventional resources, which is welcomed by CONELEC, as stated in the publication “*Titulo habiliante*”. Moreover, the VCS project activity contributes to the reduction the emission of greenhouse gases. Finally, the project contributes towards Sustainable Ddevelopment in Ecuador by increasing the employment opportunities in the area due to direct or indirect effects of the project realization.

2 SAFEGUARDS

2.1 No Net Harm

LFG is combusted in the project's engine-generator sets with negligible fugitive emissions. Combustion of LFG reduces the risk of fire and improve safety at the landfill. The quality of life of the local community increases because of odor reduction and improved air quality.

Potential negative impacts are noise and dust emissions.

The Environmental management Plan describes measures to avoid, reduce or mitigate potential negative environmental and socio-economic impacts. It contains programs on mitigation, safety, prevention, social participation and community relations, environmental training and monitoring. These programs are developed for the building and operation and maintenance phase of the project. For example, measures are taken for noise and dust control, such as no unnecessary horning, keeping dusty areas wet, etc. Monitoring campaigns on noise, air quality, etc. are foreseen.

The program on social participation foresees in the appointment of an environmental facilitator to the Ministry of Environment, who will be asked to (1) validate the various stakeholders who may be affected by the operation and (2) check the areas of direct and indirect influence described in the Environmental Impact Study and the Environmental Management Plan.

2.2 Local Stakeholder Consultation

Since it concerns a retroactive project, we refer to the local stakeholder consultation conducted during the performance of the Environmental Impact Assessment. This is called the socialisation process, which is documented in a separate report *"Informe de facilitatación, proceso de consulta y participación social del borrador del studio de impacto Ambiental definitive y plan de manejo ambiental del proyecto "generation electrica de biogas (2MW) en el relleno sanitaria Pichacay y linea de transmission asociada"* facilitated by Soc. Jaime Arevalo Ayala.

The procedures or methods used for engaging local stakeholders (e.g., dates of announcements or meetings, periods during which input was sought).

The socialisation process to the population living in the area directly and indirectly impacted by the project, was announced in the following ways:

- on the radio "Spendid Radio City Cuenca during 25th, 26th and 27th November 2013 at 06h00, 12h00 and 18h00.

- In the newspaper El Tiempo of the city of Cuenca in the issue of 21 November 2013.
- Posters in the infocentre located in the Tenure Policy Parroquia Santa Ana in El Chorro longhouse in the longhouse Playa de los Angeles and Mosquera.
- Personal invitation to 47 relevant citizens, such as the governor, fire chief, major, community development representatives, parish priest etc.

The following stakeholder consultation activities were performed:

- Establishment of an information centre at the Tenure Policy parish in Santa Ana, from 21 Nov 2013 – 5 Dec 2013. The info centre was open from 08h00 – 12h00, and 14h00 – 17h00.
- Briefings Saturday 23 November at the community houses of Mosquera (22 persons), Playa de los Angeles (26 persons) and El Chorro (34 persons).
- Public presentation of the draft Environmental Impact Assessment and Environmental Management Plan on Nov 28, 2013, at the Longhouse community of El chorro (more than 44 persons).

The procedures or methods used for documenting the outcomes of the local stakeholder communication.

The outcomes of the local stakeholder consultation is documented in the report "*Informe de facilitatación, proceso de consulta y participación social del borrador del studio de impacto Ambiental definitive y plan de manejo ambiental del proyecto "generation electrica de biogas (2MW) en el relleno sanitaria Pichacay y linea de transmission asociada*", and is input to the Environmental Management Plan. This report is needed to complete the environmental impact assessment. It systematically registers the questions and comments of the local stakeholders and the responses/explanations given by the project owner or his consultant. One chapter is dedicated to identification and solutions formulation of socio-environmental conflicts.

The mechanism for on-going communication with local stakeholders.

The Environmental Management Plan contains a "Social participation and Community Relations Programme" for the building (PRCC 1) and the operation and maintenance (PRCO1 and PRCO2) phase of the project.

PRCC 1 takes care that the people of the parish of Santa Ana, particularly communities Playa de los Angeles and El Chorro, have been informed about the characteristics of the plant, its construction, and possible impacts incurred.

PRCO 1 on community relations has the objective that the project must operate with less social impact by referring to the security of the people that are in the vicinity of the plant. The inhabitants of the area of directly and indirectly influenced by the project should have access to information concerning the environmental management of facilities.

PRCO 2 takes care that the inhabitants directly or indirectly influenced by the project should be granted benefits by the operation of the plant. This is related to the Social Responsibility Agreement for Co-management of the new Landfill (15 December 2011). In this agreement it is established, among others, that Parish Santana and its communities will be beneficiaries of an Environmental Services Fund, which represents 5% of the amounts collected for the concept of the public cleaning fee and garbage collection. It also means that the communities can manage their development in topics such as economic reactivation, health and sanitation, infrastructure; environmental management, among others. Moreover, it covers prevention of environmental pollution, protection of health and safety.

How due account of all and any input received during ongoing communication has been taken? Include details on any updates to the project design or justify why updates are not appropriate.

In the above-described stakeholder consultation activities no signs of conflict or opposition to the project were noticed. The plan to let the population benefit from the activities (see next paragraph) and the avoidance of odours was welcomed. One stakeholder recommended to avoid noise and pollution during construction and operation of the project, issues that are addressed in the Environmental Management Plan. By no CNR-2013-0584-0 Office of December 19, 2013, the corresponding process of social participation related to the EIA was approved. The positive responses from the stakeholder process did not raise the need to update the project design.

2.3 AFOLU-Specific Safeguards

The project is a non-AFOLU project. For non-AFOLU projects, this section is not required.

3 IMPLEMENTATION STATUS

3.1 Implementation Status of the Project Activity

In general, the VCS project activity was under operational status in line with its previously conceived design configuration, except for (1) a maintenance, repair and replacement period for the power transformer, and (2) delayed installation of the second-engine generator set during the monitoring period (1 January 2021 – 25 Aug 2021).

<u>Ad 1. Long maintenance, repair, replacement period for power transformer</u>

In the last week of December 2020, the power transformer (to which the VCS project activity is connected to) suffered several damages due to an internal short circuit. The severity of occurred damages did not allow repair or overhauling of the power transformer, and due to the specific characteristics of the device, the only solution was to install a new unit. The fabrication process, installation and testing of the new power transformer took significant more time than previously expected. Therefore, no electricity was generated by the VCS project activity during the period from 1 Jan 2021 to 19 April 2021.

Ad 2. Delayed Installation of second engine-generator set

As previously outlined in the Joint Project Description and Monitoring Report, the second engine-generator set was previously expected to become operational around July 2019. As explained in the Monitoring Report for the monitoring period from 1 January 2019 to 31 December 2020, due to several reasons, the starting of operations of the second engine-generator set was delayed.

The second engine-generator set was finally commissioned from May to mid June 2021. During commission the engine-generator was not connected to the grid and any methane destroyed was not measured by an electricity meter. Synchronization and electricity generation tests were performed from 7 – 8 July 2021. The second-engine generator was connected to the grid. The electricity was measured by a rented electricity meter, while the main electricity meter was disconnected (as CENACE will not pay for the electricity generated during this test). This resulted in about 5 MWh of electricity produced and sent to the grid. The emissions reductions due to biogas combustion and grid connected electricity production from 7 – 8 July 2021 measured by the rented electricity meter will not be claimed as VCUs of the project activity. The experimental operation period occurred from 20 July 2021 - 2 August 2021. During experimental operation, the second engine-generator set was operational instead of the first engine-generator, as the project activity did not yet produce enough biogas to run both engine-generation units simultaneously. The electricity generated was measured by the main electricity meter that also measures the electricity production of the first engine-generator. This meter is located after the power transformer and does not register whether the electricity if produced by the first or the second unit. As specified in the monitoring (EE_y), the electric efficiency of the engine-generator with the highest electric efficiency has been selected to calculate the methane destruction of both engine-generator sets. The emission reductions due to operation of the second engine-generation between 20 July – 2 August are claimed by the project activity The second engine-generator set received its commercial operation declaration by 1 October 2021.

3.2 Deviations

2.3.1 Methodology Deviations

No methodology deviations have been applied.

2.3.2 Project Description Deviations

As already described in section 3.1 the start of commercial operation of the second engine-generator set for the project's electricity generation infrastructure was initially planned to occur in July 2019. Such installation was delayed until 1 October 2021. This occurred delay in the gradual/phased implementation of the VCS project activity does not represent a deviation and does not impact the applicability of the methodology, additionality or the appropriateness of the baseline scenario.

3.3 Grouped Projects

The project is not a grouped project.

4 DATA AND PARAMETERS

4.1 Data and Parameters Available at Validation

Data / Parameter	η_{PJ}
Data unit	%
Description	Efficiency of the LFG capture system that will be installed in the project activity. It is used for ex ante estimation of emission reduction only. The applicable default value is selected.
Source of data	-
Value applied	50%
Justification of choice of data or description of measurement methods and procedures applied	A default value is selected.
Purpose of Data	Ex ante estimates of baseline emissions
Comments	

Data / Parameter	$\varphi_{default}$
Data unit	-
Description	Default value for the model correction factor to account for model uncertainties
Source of data	-
Value applied	0.75
Justification of choice of data or description of measurement methods and procedures applied	Option 1 of the CDM methodological tool Tool04 is selected, Therefore, a default value for $\varphi_{default}$ is used. For baseline emissions: refer to the table below to identify the appropriate factor based on the application of the tool (A or B) and the climate where the SWDS is located.

	Default values for the model correction factor <table><tr><th></th><th>Humid/wet conditions</th><th>Dry conditions</th></tr><tr><td>Application A</td><td>0.75</td><td>0.75</td></tr><tr><td>Application B</td><td>0.85</td><td>0.80</td></tr></table> As application A is applicable, 0.75 is the value to be applied.
Purpose of Data	Ex ante estimates of baseline emissions
Comments	

Data / Parameter	f_y
Data unit	-
Description	Fraction of methane captured at the SWDS and flared, combusted or used in another manner that prevents the emissions of methane to the atmosphere in year y.
Source of data	-
Value applied	0
Justification of choice of data or description of measurement methods and procedures applied	As this is already accounted for in $F_{CH4,BL,y}$, "f" in the tool is assigned a value of 0
Purpose of Data	Ex ante estimates of baseline emissions
Comments	

Data / Parameter	GWP_{CH4}
Data unit	t CO_2e/t CH_4
Description	Global Warming Potential of methane
Source of data	IPCC
Value applied	28
Justification of choice of data or description of measurement methods and procedures applied	Global warming potential of methane valid for the relevant commitment period.
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	Based on an extensive review of published literature on this subject, including the IPCC 2006 Guidelines for National Greenhouse Gas Inventories
Value applied	0.1
Justification of choice of data or description of measurement methods and procedures applied	Default value
Purpose of Data	Calculation of baseline emissions
Comments	When methane passes through the top-layer, part of it is oxidized by methanotrophic bacteria to produce CO_2. The oxidation factor represents the proportion of methane that is oxidized to CO_2 This should be distinguished from the methane correction factor (MCF) which is to account for the situation that ambient air might intrude into the SWDS and prevent methane from being formed in the upper layer of SWDS

Data / Parameter	F
Data unit	-
Description	Fraction of methane in the SWDS gas (volume fraction)
Source of data	IPCC 2006 Guidelines for National Greenhouse Gas Inventories
Value applied	0.5
Justification of choice of data or description of measurement methods and procedures applied	Default value
Purpose of Data	Ex ante estimates of baseline emissions
Comments	Upon biodegradation, organic material is converted to a mixture of methane and carbon dioxide.

Data / Parameter	$DOC_{f,default}$
Data unit	Weight fraction

Description	Fraction of degradable organic carbon (DOC) that decomposes under the specific conditions occurring in the SWDS for year y
Source of data	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	In case of ex ante estimation of emissions (Application A) following Tool 04 paragraph 4) a default value of DOC_f can be used. $DOC_{f,y}$ = $DOC_{f,\ default}$ = 0.5
Purpose of Data	*Ex ante calculation of baseline emissions*
Comments	This factor reflects the fact that some degradable organic carbon does not degrade, or degrades very slowly, in the SWDS. This default value can only be used for Application A or Application B if the tool is applied to MSW.

Data / Parameter	$MCF_{default}$
Data unit	-
Description	Methane correction factor
Source of data	IPCC 2006 Guidelines for National Greenhouse Gas Inventories
Value applied	1.0
Justification of choice of data or description of measurement methods and procedures applied	In case that the SWDS does not have a water table above the bottom of the SWDS and in case of application A, then select the applicable value from the following: (a) 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) levelling of the waste; (b) 0.5 for semi-aerobic managed solid waste disposal sites. These must have controlled placement of waste and will include all of the following structures for introducing air to the waste layers: (i) permeable cover material; (ii) leachate drainage system; (iii) regulating pondage; and (iv) gas ventilation system; (c) 0.8 for unmanaged solid waste disposal sites – deep. This comprises all SWDS not meeting the criteria of managed SWDS and which have depths of greater than or equal to 5 meters; (d) 0.4 for unmanaged-shallow solid waste disposal sites or stockpiles that are considered SWDS. This comprises all SWDS not meeting the criteria of managed SWDS and which have depths of less than five meters. This includes stockpiles of solid waste that

	are considered SWDS (according to the definition given for a SWDS) Application A is applicable. The landfill of Pichacay is an anaerobic managed solid waste disposal site, as described under (a).
Purpose of Data	Ex ante estimates of baseline emissions
Comments	

Data / Parameter	$W_{j,x}$
Data unit	T
Description	Amount of solid waste type j disposed or prevented from disposal in the SWDS in the year x
Source of data	Several sources: EMAC-EP (2016) Caracterización de los residues sólidos generatos en el Cantón Cuenca, año 2015, informe preparado para la empresa pública municipal de aseo de Cuenca, enero de 2016; estimations from Ing Paul Crespo, head of the final disposal department of EMAC-EP, Hendrik Velthuis BGP Engineering B.V. See section 3.4 of the *Joint Project description & monitoring report PICHACAY LANDFILL GAS RENEWABLE ENERGY PROJECT, version 3.2 of 7 July 2019* under *Determination of Wj,x* including Table 1 to Table 4.
Value applied	See Table 5 (p 33) of the *Joint Project description & monitoring report PICHACAY LANDFILL GAS RENEWABLE ENERGY PROJECT, version 3.2 of 7 July 2019*
Justification of choice of data or description of measurement methods and procedures applied	The characterization of solid waste in Cuenca has been done for three decades. EMAC-EP (2016) is the most recent update and includes historical data on waste composition. More info is provided in section 3.4 of the *Joint Project description & monitoring report PICHACAY LANDFILL GAS RENEWABLE ENERGY PROJECT, version 3.2 of 7 July 2019*.
Purpose of Data	Ex ante estimates of baseline emissions
Comments	The time period in which waste is disposed at the SWDS is from 2001 on. Therefore, x=1 corresponds with the year 2001.

Data / Parameter	DOC_j
Data unit	Weight fraction
Description	Fraction of degradable organic carbon in the waste type j (weight fraction)
Source of data	IPCC 2006 Guidelines for National Greenhouse Gas Inventories (adapted from Volume 5, Tables 2.4 and 2.5)

Value applied	For MSW, the following values for the different waste types j should be applied: **Default values for DOC_j** <table><tr><th>Waste type *j*</th><th>DOC_j (% wet waste)</th></tr><tr><td>Wood and wood products</td><td>43</td></tr><tr><td>Pulp, paper and cardboard (other than sludge)</td><td>40</td></tr><tr><td>Food, food waste, beverages and tobacco (other than sludge)</td><td>15</td></tr><tr><td>Textiles</td><td>24</td></tr><tr><td>Garden, yard and park waste</td><td>20</td></tr><tr><td>Glass, plastic, metal, other inert waste</td><td>0</td></tr></table>
Justification of choice of data or description of measurement methods and procedures applied	The default values are applied.
Purpose of Data	Ex ante estimates of baseline emissions
Comments	The procedure for the ignition loss test is described in BS EN 15169:2007 Characterization of waste. Determination of loss on ignition in waste, sludge and sediments. The percentages listed in table above are based on wet waste basis which are concentrations in the waste as it is delivered to the SWDS. The IPCC Guidelines also specify DOC values on a dry waste basis, which are the concentrations after complete removal of all moist from the waste, which is not believed practical for this situation

Data / Parameter	k_j
Data unit	1/yr
Description	Decay rate for the waste type j
Source of data	IPCC 2006 Guidelines for National Greenhouse Gas Inventories (adapted from Volume 5, Table 3.3)
Value applied	<table><tr><td></td><td>Waste type j</td><td>Value for boreal and temperature (MAT≤20°C). Dry (MAP/PET<1)</td></tr></table>

	<table><tr><td>Slowly degrading</td><td>Pulp, paper, cardboard (other than sludge), textiles</td><td>0.04</td></tr><tr><td></td><td>Wood, wood products and straw</td><td>0.02</td></tr><tr><td>Moderately degrading</td><td>Other (non-food) organic putrescible garden and park waste</td><td>0.05</td></tr><tr><td>Rapidly degrading</td><td>Food, food waste, sewage sludge, beverages and tobacco</td><td>0.06</td></tr></table>
Justification of choice of data or description of measurement methods and procedures applied	MAT = 14.7° C. Therefore, the values belonging to a boreal and temperature (MAT≤20°C) should be applied Source: Sistema de Clasificación Bioclimática Mundial (temperatures) and: Cuenca Climate Guide, meaning that Cuenca has a boreal and temperate climate. MAP = 878 mm/year (source: https://www.weather-atlas.com/en/ecuador/cuenca-climate#rainfall) PET = 1189 mm/year (source: data from weather station Cuenca-Ricauerte obtained from FAO Climwat, processed in FAO Eto calculator. ETo represents the evapotranspiration rate from a reference surface, not short of water. The ETo calculator assesses ETo from meteorological data by means of the FAO Penman-Monteith equation. See http://www.fao.org/land-water/databases-and-software/eto-calculator/en/ and MAP/PET < 1, so values for dry climate are taken
Purpose of Data	Ex ante estimates of baseline emissions
Comments	MAT = Mean Annual Temperature MAP = Mean Annual Precipitation PET = Potential evapotranspiration.

Data / Parameter	$F_{CH4,BL,y}$
Data unit	t CH_4
Description	Methane emissions that would be captured and destroyed to comply with national or local safety requirement or legal regulations in the year y (t CH4).
Source of data	-
Value applied	0
Justification of choice of data or description of measurement methods and procedures applied	In Ecuador there is no law that requires to destroy methane. Before the project no existing LFG capture and destruction system was in place. Hence $F_{CH4,BL,y}$ as per table 3 of ACM0001 “Flaring or use of landfill gas” Case 1 is applicable. In this situation $F_{CH4,BL,y}$=0.
Purpose of Data	Calculation of baseline emissions
Comments	Applicable guidance and procedures from the CDM baseline and monitoring methodology ACM0001 – “Flaring or use of landfill gas” may be followed, as well as taking into account the compliance with the relevant local laws and regulation if such laws and regulations exist

Data / Parameter	$EF_{grid,y}$
Data unit	tCO_2e/MWh
Description	CO_2 emission factor of the grid electricity in year y
Source of data	CENACE (2017), 2017 report, CO_2 emission factor of the National Interconnected System, determined by the Technical Commission for Determination of Greenhouse Gas Emission Factors. See the Joint Project Description and Monitoring Report of the Pichacay Landfill Gas Renewable Energy Project, version 3.2 of 7 July 2019.
Value applied	0.3349
Justification of choice of data or description of measurement methods and procedures applied	Combined margin CO_2 emission factor for grid connected power generation in year y was calculated using the latest version of the “Tool to calculate the emission factor for an electricity system”. For the determination of OM and BM it was chosen to determine these factors ex ante for the whole duration of the first crediting period.
Purpose of Data	Calculation of baseline emissions Calculation of project emissions

Comments	The calculation of $EF_{grid,y}$ using the "Tool to calculate the emission factor for an electricity system" is described in further detail in the Joint Project Description and Monitoring Report of the Pichacay Landfill Gas Renewable Energy Project, version 3.2 of 7 July 2019.

Data / Parameter	$TDL_{j,y}$
Data unit	Fraction
Description	Average technical transmission and distribution losses for providing electricity to source j in year y.
Source of data	CENTROSUR, the electricity distribution company that owns and manages the electric grid
Value applied	5.76%
Justification of choice of data or description of measurement methods and procedures applied	Scenario A of TOOL 05 "Baseline, project and/or leakage emissions from electricity consumption and monitoring of electricity generation" applies. The annual average value based on the most recent data available within the host country was chosen. (See TOOL05, version 03.0, Data / Parameter table 3)
Purpose of Data	Calculation of project emissions
Comments	-

Data / Parameter	$EG_{PJ,facility,2017-2018}$
Data unit	MWh
Description	Quantity of net electricity generation supplied by the project plant/unit to the grid in 2017-2018
Source of data	Electricity meters (ION 7650)
Value applied	2017: 2,776 2018: 5,165
Justification of choice of data or description of measurement methods and procedures applied	Since this is a retroactive project, it is possible to apply measured data for the ex ante determination of the emission reduction from grid displacement electricity.
Purpose of Data	Calculation of baseline emissions
Comments	-

Data / Parameter	$EG_{PJ,facility,2019-2027,estimated}$
Data unit	MWh

Description	Quantity of net electricity generation supplied by the project plant/unit to the grid in year y
Source of data	Estimation from project owner
Value applied	2019: 9,690 2020: 12,920 2021: 12,920 2022: 25,840 2023: 25,840 2024: 25,840 2025: 25,840 2026: 25,840 1 Jan – 26 July 2027: 14,654
Justification of choice of data or description of measurement methods and procedures applied	The project consists of 4 engine-generators (units) that convert landfill gas into electricity. Unit 1 started commercial operation on 27 July 2017; Unit 2 started commercial operation on the 1st of October 2021; engine 3 is expected to start in the last trimester or the first semester of 2023; the installation of Engine 4 has not been planned yet; and are not part of the monitoring period 1 Jan 2019 – 31 Dec 2020. Each engine has a capacity of 1 MW and is expected to generate 0.85 MWh/h during 7,600 hours per year, i.e. 6,460 MWh/engine/year, and 25,840 MWh/year for all 4 engines together. For 2027, a fraction of 207/365 is applied, based on the number of calendar days from 1 Jan – 26 July.
Purpose of Data	Ex ante calculation of baseline emissions
Comments	-

Data / Parameter	NCV_{CH4}
Data unit	MJ/Nm^3
Description	NCV of methane
Source of data	-
Value applied	35.9
Justification of choice of data or description of measurement methods and procedures applied	Default value
Purpose of Data	Calculation of baseline emissions
Comments	

Data / Parameter	D_{CH4}
Data unit	t CH_4/Nm^3 CH_4
Description	Density of methane at the temperature and pressure of the landfill gas in year y
Source of data	ACM0001 version 11
Value applied	0.0007168
Justification of choice of data or description of measurement methods and procedures applied	Because the NCV of methane is reported at normal conditions, the density of methane is also determined at normal conditions. In ACM0001 (version 18.1) reference conditions are defined as 0°C (273.15 K) and 1 atm (101.325 kN/m2, 101.325 kPa). According to ACM0001 (version 11.0) at standard temperature and pressure (0 degree Celsius and 1.013 bar) the density of methane is 0.0007168 tCH_4/m^3CH_4)
Purpose of Data	Calculation of baseline emissions
Comments	AMS-III.G, TOOL04, nor ACM0001 (version 18) provide info on the density of methane under normal conditions. Therefore, a value found in the CDM baseline and monitoring methodology ACM0001 (version 11) was applied.

4.2 Data and Parameters Monitored

Data / Parameter	$EG_{PJ,facility}$
Data unit	MWh
Description	Quantity of net electricity generation supplied by the project plant/unit to the grid in year y
Source of data	Electricity meters (Schneider electric ION 7650 serial numbers MJ-1401A358-04 (main meter) and MJ-1310A536-04 (backup meter).
Description of measurement methods and procedures to be applied	The electricity generated and delivered to the grid is measured continuously and recorded hourly by two ION-7650 meters. The meters are connected to an automatic software – SIMEC, provided by CENACE (technical and economical administrator of the Ecuadorian Electrical System). On a daily basis, SIMEC generates a report automatically, called TPL, with the hourly energy (active, reactive) produced and delivered to the grid. The daily report is double-checked by the Technical Manager of the power plant as well as by CENACE technical specialists. Once the file is approved, it is stored on an online platform – SIMEM. The platform allows viewing and downloading of the stored files, named CON_MED_EXE_20YY-MM-DD.xls. At EBE, the Project Manager groups the data of the respective monitoring period into one excel sheet. All daily reports remain available and can be double checked by the project advisor and verification body.
Frequency of monitoring/recording	Continuous monitoring, hourly measurement and at least monthly recording
Value monitored	2,143.92 MWh See the file *"GHG calculation Pichacay LFG project 1 Jan_25 Aug 2021 v4.xlsx"* for the complete calculation. Daily files CON_MED_EXE_20YY-MM-DD.xls are also available.
Monitoring equipment	Two Schneider Electric ION7650 electricity meters, serial numbers MJ-1401A358-04 (main meter) and MJ-1310A536-04 (backup meter), ANSI C12.16 approved revenue meters; meets ANSI C12.20 class 0.2 accuracy standard. Its accuracy is 0.2% as found in the technical documentation. See *"Technical data sheet ION7650.pdf"*
QA/QC procedures to be applied	The two ION7650 meters are digital and therefore needs no servicing. It is tested for accuracy at the factory and remains accurate for the life of the meter. In contrast, electro-mechanical

	meters need mechanical adjustment before installation and periodic calibration thereafter. Calibration testing is unnecessary for digital meters (See "PowerLogic ION 7550 ION7650 Verifying Accuracy Technical Note 032009.pdf"). Digital meters require 'accuracy' testing, or verification, once after installation to ensure the meter meets required accuracy specifications. Errors observed in the field could be attributed to incorrect connections or instrument transformer ratio settings. This initial testing after installation has taken place on the 5th of October 2017. See "*Electricity export meter calibration certificate 2017.pdf*". Although not necessary from a technical viewpoint, the National Center for Energy Control – CENACE (the institution that controls and regulate the Ecuadorian Electrical Power System) has a legal obligation to perform calibration testing every two years. EBE does not have access to the biannual calibration reports, but can show: (1) the letter with the request of EBE to CENACE to perform the bi-annual calibration test of the electricity meters (Letter with reference EBE-036-21, of 20 May 2021, see "Oficio Referencia EBE-036-21 - CENACE SOLICITUD PRUEBAS MEDIDORES.pdf"); (2) the letter in which CENACE accepts the invitation and proposes the data for the calibration test (Letter with reference CENACE-GDT-2021-0104-O of 26 May 2021, see "CENACE-GDT-2021-0104-O.pdf") and (3) the invoice to prove that this calibration has taken place. (CENACE invoice No. 001-002-000002585 of 8 June 2021, see "CENACE CALIBRATION BILL 2021.pdf". If, for some unexpected reasons the ION meter would fail for this biannual check, CENACE would stop paying for the exported electricity.
Purpose of the data	Calculation of baseline emissions
Calculation method	Reading hourly electricity production and aggregate them for the monitoring period.
Comments	

Data / Parameter	EE_y
Data unit	%
Description	Energy Conversion Efficiency of the project equipment, i.e. Guascor Power Genset type SFGM560.
Source of data	Specification provided by the equipment manufacturer. For engine-generator 1 (model SFGM-560) see specifications provided in offer "Budget reference: "OFV004932-170314-CS-SFGM560-Landfill-BGP Engineers". For engine-generator 2 (model SGE-56SM) see the product information sheet "SGE-56M POWER RATING.pdf"
Description of measurement methods and procedures to be applied	The specification provided by the equipment manufacturer is used as the equipment is designed specifically to utilize biogas as fuel. This is the case. If the specification provides a range of efficiency values, the highest value of the range shall be used for the calculation. The efficiency of nominal load is taken, which is the highest value.
Frequency of monitoring/recording	Once for each engine.
Value monitored	Engine-generator 1: 36.0% Engine-generator 2: 36.1% Highest value of both engines used in the monitoring calculation: 36.1%.
Monitoring equipment	-
QA/QC procedures to be applied	-
Purpose of the data	Calculation of baseline emissions
Calculation method	-
Comments	-

Data / Parameter	$EC_{project,y}$
Data unit	MWh
Description	The quantity of electricity used for the operation of the installed facilities in the year y
Source of data	Monthly electricity bills of the of the local energy distribution company Empresa Elèctrica Regional Centro Sur C.A. (CENACE).
Description of measurement methods and procedures to be applied	They send a monthly bill with detailed specification of the electricity consumed, based on three periods (A: 07h00-18h00; B: 18h00-22h00; C: 22h00-07h00). The monthly electricity bills are kept and stored on paper and as a scanned pdf file. Due to new regulations, since 25 October 2019 the electricity bill is split in two bills: • Energy consumed from the grid in low voltage (220 – 110 V: auxiliary services). • Energy consumed by the genset in mid voltage (22,000 V: substation and 480 V equipment). In case the monthly bills from CENACE are not made available, alternative bills will be downloaded from the *Internal Rent Service of Ecuador (SRI)* system, These alternative bills only contain the costs in USD, but since the tariffs for each period are known, the amount of consumed can be calculated.
Frequency of monitoring/recording	Continuous monitoring, hourly measurement and at least monthly recording
Value monitored	84.36 MWh See separate excel file for monthly values.
Monitoring equipment	Electricity meter class CL200, type A3R model ELSTER ZE3300000L0, serial number 17548507 owned and maintained by the local energy distribution company. The electricity bills show the electricity consumed by the project. The electricity meter is situated in a box outside and locked with a padlock, only accessible by the electricity distribution company. The electricity meter meets ANSI C12.20 accuracy for accuracy class 0.2%. See the technical manual ("A3MeterTM42-2190BUSVersion.pdf").
QA/QC procedures to be applied	The electricity meter is an electronic meter, factory calibrated, and does not require user calibration (See *"A3MeterTM42-*

	2190BUSVersion.pdf"). Moreover, EBE has no access to this meter.
Purpose of the data	Calculation of project emissions
Calculation method	-
Comments	

Data / Parameter	$TDL_{j,y}$
Data unit	Fraction
Description	Average technical transmission and distribution losses for providing electricity to source j in year y.
Source of data	Annual and Multiannual Statistics of the Ecuadorian Electricity Sector 2020, in Spanish: "Estadistica del sector electrico Ecuatoriano, 2020, Agencia de Regulacion y Control de Energia y Recursos Naturales No Renovables See https://www.controlrecursosyenergia.gob.ec/estadisticas-del-sector-electrico-ecuatoriano-buscar/.
Description of measurement methods and procedures to be applied	Scenario A of TOOL 05 "Baseline, project and/or leakage emissions from electricity consumption and monitoring of electricity generation" applies. The annual average value based on the most recent data available within the host country was chosen. (See TOOL05, version 03.0, Data / Parameter table 3) According to "Tool 05 Methodological tool "Baseline, project and/or leakage emissions from electricity consumption and monitoring of electricity generation, Version 03.0" (§7.2, Data / Parameter Table 3)" TDLj,y should be monitored annually. In absence of data from the relevant year, most recent figures are used, but not older than 5 years. The technical distribution losses and the transmission losses as presented in the annual and multiannual statistics of the Ecuadorian electricity sector are reported separately and need to be multiplied to obtain the combined technical transmission and distribution losses ($TDL_{j,y}$). TDLj,y in the following way: $TDL_{j,y} = 1- (DL_{j,y} - 1)*(TL_{j,y} - 1)$ Where, $TDL_{j,y}$ = Average technical transmission and distribution losses for providing electricity to source j in year y

	$DL_{j,y}$ = Average technical distribution losses of the distribution electricity system of Ecuador (%) to the project in year y $TL_{j,y}$ = Average transport losses of the national electricity transport system (SNT) of Ecuador (%) to the project in year y
Frequency of monitoring/recording	Annually
Value monitored	*Estadistica del sector electrico Ecuatoriano* 2020 Table 7, page 14 of this report contains the technical distribution losses of host country Ecuador, being 6.87% in 2020. *Estadistica del sector electrico Ecuatoriano, 2020* Table 100, page 107 contains the transmission losses of the SNT (Systema National de Transmission" *of* host country Ecuador, being 3.32% in 2020. 2020 is the most recent year for which this information is available. Together these losses result in $TDL_{,j,y}$ of 9.96%.
Monitoring equipment	-
QA/QC procedures to be applied	-
Purpose of the data	Calculation of project emissions
Calculation method	-
Comments	-

4.3 Monitoring Plan

The organizational structure, responsibilities and competencies of the personnel that carried out the monitoring activities.

Project owner EBE operates the LFG plant that is part of the project and will measure the required monitoring data related to the project and is qualified to do so.

- The *general manager* of EBE legally represents the project owner. He/she is involved in high level decision making.
- The *supervising Engineer* of the plant in charge of the electrical, electronical and mechanical of the LFG extraction and energy generation plant will be responsible for on-site monitoring data collection. He is qualified to work with the monitoring equipment and preferably speaks English.
- Three *operators* working under the directly supervision of the supervising engineer support the supervising engineer to collect relevant monitoring data.

During the reported monitoring period David González Hidalgo was both the general manager and the supervising engineer of EBE.

BGP Engineers B.V. is responsible for interpretation of the monitoring data, and leakage effects, preparation of the monitoring reports and quality assurance. BGP will provide instructions and training to operators of EBE and operates as the *Project Manager* regarding monitoring in the frame of this VCS project.

Optionally, a *project advisor* is hired to support the project manager with monitoring and quality assurance. For the current monitoring period BTG is appointed as project advisor.

Jilles Nijboer of BGP was the Project Manager during the reported monitoring report and has appointed Martijn Vis of BTG as project advisor to support with monitoring and quality assurance.

The methods used for generating/measuring, recording, storing, aggregating, collating and reporting the data on monitored parameters.

With regards to monitoring AMS-III.G, AMS-I.D provides the following requirements:

1. Flow meters, sampling devices and gas analysers shall be subject to regular maintenance, testing and calibration to ensure accuracy. (AMS-III.G paragraph 27)
2. The quantities and types of biomass and the biomass to fossil fuel ratio (in case of co-fired system) to be used during the crediting period should be explained and documented transparently in the CDM-PDD. For the selection of the baseline scenario, an ex ante estimation of these quantities should be provided (AMS-I.D paragraph 44)
3. The applicable requirements specified in the “General guidelines for SSC CDM methodologies” (e.g. calibration requirements, sampling requirements) are also an integral part of the monitoring guidelines specified below and therefore shall be applied by the project participants (AMS-III.G paragraph 28 & AMS-I.D paragraph 45)

Conform the data and parameters monitored, the monitoring plan foresees in the metering of electricity generated by the engine-gensets ($EG_{PJ,facility}$), the electricity consumed ($EC_{project,y}$) and the efficiency of the engine-genset (EE_y).

The procedures used for handling any internal auditing performed and any non-conformities identified.

The procedures below are related to the activities of the project manager.

The project manager stores and keeps the contracts, fills in data sheets and additional documentation in an orderly way.

The project manager keeps all paper and electronic documents at a safe place during the VCS project period, and longer, if required according to VCS-regulations.

The monitoring data collected from the project owners is processed in the following way:

1. Data is checked on completeness. If the data is not complete, the project manager contacts the supervising engineer by visit, phone, email or fax to ask for additional information.
2. Data is checked on calculation errors. If calculation errors occur, the supervising engineer is contacted by visit, phone, email or fax and asked for clarification, and if necessary additional explanation is given. This type of errors is noted and taken into account in the evaluation of the Monitoring Protocol.
3. If uncertainty exists on the monitoring data, a conservative approach will be applied in the interpretation of this data.
4. Data is entered into the central database, an excel sheet that contains all necessary calculation rules and procedures.
5. Consistency checks are carried out. If significant inconsistencies are observed, the project owner is asked for clarification. The technician of the project owner and project manager will jointly formulate a plausible explanation for the inconsistencies. If this approach does not work, the trouble shooting procedures will be followed.
6. The calculated emission reductions and other relevant information are reported in the monitoring report and offered to the verification body.

The project manager carries out corrective actions as stated in validation and/or verification reports, and/or otherwise as requested by the verification body. If appropriate, the project manager takes care that the project owner implements the corrective actions. The results of corrective actions will be described in the monitoring report of the subsequent period, or will be immediately send to the verification body, depending on its urgency.

The project manager prepares the concept monitoring report and internally checks the report on completeness and quality of data. The concept monitoring report is sent to the project advisor. The project advisor checks the concept monitoring report and the calculations and returns open questions to the project manager. After both project manager and project advisor are fully satisfied with the content of the final monitoring report, the verification body is requested to verify the monitoring report.

If problems occur related to the monitoring of the project performance, for instance data collection, measurement equipment, the data registration form, etc., the project manager will execute the following actions if problems are directly related to the monitoring of projects:

1. The project manager will try to explain and indicate solutions for problems by visit, phone, email or fax.
2. In case of problems that cannot be easily solved, the project manager will contact the project advisor. They will jointly formulate an approach to solve the problem.
3. All disputes that might arise from problems related to monitoring of the project performance will be settled as described in contracts that between project owner, project manager and project advisor.

The implementation of sampling approaches, including target precision levels, sample sizes, sample site locations, stratification, frequency of measurement and QA/QC procedures. Where applicable, demonstrate whether the required confidence level or precision has been met.

Not applicable. For the parameters monitored, no sampling approached need to be applied. These parameters can be just measured and recorded.

5 QUANTIFICATION OF GHG EMISSION REDUCTIONS AND REMOVALS

5.1 Baseline Emissions

Baseline emissions for the VCS project activity are calculated as follows for the considered monitoring period:

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

Where:

Parameter	Unit	Description
BE_y	tCO_ee	Baseline emission for in year y
$BE_{CH4,y}$	tCO_ee	Baseline emission from LFG avoidance that otherwise would be emitted to the atmosphere in absence of the Project in year y (tCO_2e) which is estimated as per AMS-III.G
$BE_{electricity,y}$	tCO_ee	Baseline emission from electricity displacement that otherwise would be provided by grid in year y (tCO_2e) which is estimated as per AMS-I.D

Baseline emission from landfill methane recovery ($BE_{CH4,y}$):

As per AMS-III.G paragraph 22. emission reduction achieved by the VCS project activity is calculated by calculating the amount of methane recovered and destroyed/utilized as follows:

$$\mathrm{ER_{y,calculated}} = (1 - \mathrm{OX}) \times \mathrm{F_{CH4,PJ,y}} \times \mathrm{GWP_{CH4}} - \mathrm{PE_y} - \mathrm{LE_y}$$

Thus, the calculated baseline emissions from landfill methane recovery are

$$\mathrm{BE_{CH4,PJ,y}} = (1 - \mathrm{OX}) \times \mathrm{F_{CH4,PJ,y}} \times \mathrm{GWP_{CH4}}$$

Where:

Parameter	Unit	Description
$BE_{CH4,PJ,y}$	tCO_2e	Baseline emissions achieved by the project in year y.
OX	-	Oxidation factor (reflecting the amount of methane from SWDS that is oxidised in the soil or other material covering the waste) (dimensionless). A default value of 0.1 may be used.
$F_{CH4,PJ,y}$	tCH_4	Methane captured and destroyed/gainfully used by the project activity in the year y
GWP_{CH4}	-	Global Warming Potential for methane (value of 28)

At the project site a flare is installed. However, such flare only becomes operational in case the engine-generator sets of the project's electricity generation infrastructure are not under operational status. Emission reduction achieved due to flaring of LFG is not considered in the context of the determination of achieved emission reductions since no measurement instrument/equipment is installed (e.g. monitoring equipment/instrument) that meets the requirements of TOOL06 and TOOL08. Therefore, during *monitoring*, the baseline and project emissions of the use of the flare also will not be taken into account. ($ER_{flare} = BE_{flare} - PE_{flare} = 0$).

As per paragraph 23 of AMS-III.G, for project activities that utilize the recovered methane for power generation, $F_{CH4,PJ,y}$ can be alternatively directly calculated based on monitoring of the amount of net generated electricity (i.e.,without monitoring methane flow and concentration) as follows:

$$F_{CH4,PJ,y} = \frac{EG_y \times 3{,}600}{NCV_{CH4} \times EE_y} \times D_{CH4}$$

Where:

Parameter	Unit	Description
EG_y	MWh	Electricity generation in year y
3,600	-	Conversion factor (1 MWh = 3,600 MJ)
EE_y	%	Energy Conversion Efficiency of the project equipment
NCV_{CH4}	MJ/Nm^3	NCV of methane
D_{CH4}	$t\ CH_4/Nm^3\ CH_4$	Density of methane

Remark: In AMS-III.G paragraph 23 the $F_{CH4,PJ,y}$ includes GWP_{CH4}. Since GWP_{CH4} is already included in $BE_{y,calculated}$, it has been left out. The resulting baseline emissions of landfill methane recovery are summarised in Table 1.

Table 1: baseline emissions of landfill methane recovery

Period	$EG_{PJ,facility}$	$F_{CH4,PJ}$	$BE_{CH4,y}$
1 January 2021 - 25 August 2021	2,144	427	10,757
Total	2,144		10,757

Baseline emissions from electricity displacement ($BE_{electricity,y}$)

Baseline emissions from electricity generation are calculated as follows:

$$BE_{electricity,y} = EG_{PJ,y} \times EF_{grid,y}$$

Where:

Parameter	Unit	Description
$BE_{electricity,y}$	t CO_2e	Baseline emissions from grid electricity displacement in year y
$EG_{PJ,y}$	MWh	Quantity of net electricity generated and injected into the electricity grid as a result of the implementation of the project activity in year y
$EF_{grid,y}$	tCO_2e/MWh	Combined margin CO_2 emission factor for grid connected power generation in year y (calculated using the latest version of the CDM methodological tool "Tool to calculate the emission factor for an electricity system").

As per paragraph of AMS-I.D, if the project activity is the installation of a greenfield power plant, therefore:

$$EG_{PJ,y} = EG_{PJ,facility,y}$$

Where:

$EG_{PJ,facility,y}$ = Quantity of net electricity generation supplied by the project plant/unit to the grid in year y (MWh)

$EF_{grid,y}$ is ex-ante determined and is fixed during the first crediting period.

The resulting baseline emissions of landfill methane recovery are summarized in *Table 2*. The detailed calculations are presented in GHG calculation spreadsheet "*GHG calculation Pichacay VCS project 1 Jan_25 Aug 2021 v4.xlsx*" which is enclosed to this Monitoring Report.

Table 2: Baseline emissions from electricity generation

Period	$EG_{PJ,facility}$	$EF_{grid,y}$	$BE_{electricity,y}$
1 January 2021 - 25 August 2021	2,144	0.3349	718
Total	2,144		718

5.2 Project Emissions

Project emissions includes two parts, which are calculated as per AMS-III.G and AMS-I.D separately: .

$$PE_y = PE_{CH4,y,} + PE_{electricity,y}$$

Where:

Parameter	Unit	Description
PE_y	tCO_2e	Project emissions in year y
$PE_{CH4,y}$	tCO_2e	Project emissions of landfill methane recovery estimated as per AMS-III.G
$PE_{electricity,y}$	tCO_2e	Project emissions from LFG electricity generation estimated as per AMS-I.D

Project emissions landfill methane recovery

As determined in the "VCS-Joint-Project-Description-Monitoring-Report 7 July 2019 v2.pdf" the project emissions from landfill methane recovery in this project can be described as follows:

$$PE_{CH4,y} = PE_{power,y} + PE_{flare,y}$$

Where:

Parameter	Unit	Description
PE_y	t CO_2e	Project emissions in year y
$PE_{power,y}$	t CO_2e	Emissions from the use of fossil fuel or electricity for the operation of the installed facilities in the year y
$PE_{flare,y}$	t CO_2e	Emissions from flaring or combustion of the landfill gas stream in the year y

At the project site a flare has been installed that is operational in case the engine-generator sets of the project's electricity generation infrastructure are not operational. Emission reductions due to combustion of LFG in the installed flare are not accounted as part of the monitoring of the VCS project activity, since no appropriate measurement equipment/instrument is yet installed (i.e. monitoring equipment/instrument that meets the requirements of CDM methodological tool TOOL06 and TOOL08). Therefore, during the considered *monitoring period,* baseline emissions and project emissions associated with the combustion of LFG in the flare are not taken into account. ($ER_{flare} = BE_{flare} - PE_{flare} = 0$). Consequently, the project emissions due to combustion of LFG by flaring are not taken into account. This is a conservative approach since in reality the flare has destroyed methane part of the year.

Therefore, $PE_{CH4,y} = PE_{power,y}$

Project emissions from consumption of grid-sourced electricity by the VCS project activity are determined as follows:

$$PE_{power,y} = EC_{project,y} \times EF_{grid,y} \times (1 + TDL_{j,y})$$

Where:

Parameter	Unit	Description
$PE_{power,y}$	tCO_2e	Emissions from the use of electricity for the operation of the installed facilities in the year y (t CO_2e)
$EC_{project,y}$	MWh	The quantity of electricity used for the operation of the installed facilities in the year y
$EF_{grid,y}$	tCO_2e/MWh	Combined margin CO_2 emission factor for grid connected power generation in year y calculated using the latest version of the CDM methodological tool “Tool to calculate the emission factor for an electricity system”

$TDL_{j,y}$	Fraction	Average technical transmission and distribution losses for providing electricity to source j in year y

$EF_{grid,y}$ has been determined ex ante and is fixed during the first crediting period.

The most recent available (2020) value of TDLj,y is 9.96%.

The resulting baseline emissions of landfill methane recovery are summarised in Table 3. The detailed calculations are presented as separate annex ("GHG calculation Pichacay VCS project 1 Jan_25 Aug 2021 v4.xlsx) to this monitoring report.

Table 3: Monitored project emissions from the operation of the installed facilities

Period	$EC_{project,y}$	$EF_{grid,y}$	$PE_{power,y}$
1 January 2021 - 25 August 2021	84.36	0.3349	31
Total	84.36		31

Project emissions renewable electricity production

As determined in "VCS-Joint-Project-Description-Monitoring-Report 7 July 2019 v2.pdf" the project emissions from renewable electricity production are zero.

5.3 Leakage

As determined in "VCS-Joint-Project-Description-Monitoring-Report 7 July 2019 v2.pdf" leakage emissions from landfill methane recovery and replacement of grid connected electricity can be set at zero.

5.4 Net GHG Emission Reductions and Removals

The net GHG emission reductions and removals are summarized in the table below. These consist of one vintage:

(1) 1 January 2021 – 25 August 2021

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Year	Baseline emissions or removals (tCO_2e)	Project emissions or removals (tCO_2e)	Leakage emissions (tCO_2e)	Net GHG emission reductions or removals (tCO_2e)
2021*	11,475	31	0	11,444
Total	**11,475**	**31**	**0**	**11,444**

** 1 Jan 2021 – 25 Aug 2021*

Comparison with ex ante emission reduction calculation as found in the Project Description

Table 11 of the “VCS Joint Project Description Monitoring report 7 July 2019 v2.pdf” gives the ex ante emission reduction calculation of the first crediting period. For 1 Jan 2021 – 31 Dec 2021, the following values were calculated:

- Estimated ex ante baseline emissions or removals: 34,142 tCO_2e
- Estimated ex ante project emissions or removals: 4,069 tCO_2e
- Estimated ex ante net GHG reduction or removals: 30,072 tCO_2e.

Since the current monitoring period is from 1 Jan 2021 – 25 Aug 2021, the ex ante baseline, project emissions and net GHG reduction or removals need to be corrected to make a proper comparison with the emission reduction calculation possible. Since the monitoring period of 1 Jan 2021 – 25 August covers 237 days, the ex ante values were multiplied with 237 days /365 days resulting in the following numbers:

- Estimated ex ante baseline emissions or removals: 22,169 tCO_2e
- Estimated ex ante project emissions or removals: 2,642 tCO_2e
- Estimated ex ante net GHG reduction or removals: 19,526 tCO_2e.

The ex ante estimated net GHG reduction of 1 Jan 2021 - 25 Aug 2021 is 8,082 $tCO2$ (~41%) higher than the monitored emission reduction. The main explanatory factors for the difference are (1) a maintenance, repair and replacement period for the power transformer, and (2) delayed installation of the second-engine generator set during the monitoring period, as further explained in section 3.1.