Monitoring report form for CDM project activity
(Version 09.0)

MONITORING REPORT			
Title of the project activity	Introduction of the recovery and combustion of methane in the existing sludge treatment system of the Cañaveralejo Wastewater Treatment Plant of EMCALI in Cali, Colombia		
UNFCCC reference number of the project activity	2341		
Version number of the PDD applicable to this monitoring report	07		
Version number of this monitoring report	02.3		
Completion date of this monitoring report	05/10/2021		
Monitoring period number	Second Monitoring Period		
Duration of this monitoring period	01/11/2012 – 31/12/2015		
Monitoring report number for this monitoring period	Not applicable		
Project participants	Empresas Municipales de Cali EMCALI-EICE ESP ALLCOT AG		
Host Party	Colombia		
Applied methodologies and standardized baselines	Methane recovery in wastewater treatment (AMS III.H, Version 09)		
Sectoral scopes	Scope 13: Waste handling and disposal Scope 1: Energy industries (renewable - / non-renewable sources)		
Amount of GHG emission reductions or net anthropogenic GHG removals achieved by the project activity in this monitoring period	Amount achieved before 1 January 2013	Amount achieved from 1 January 2013 until 31 December 2020	Amount achieved from 1 January 2021
	4,779 tCO_2e[1]	142,288 tCO_2e[2]	0
Amount of GHG emission reductions or	186,648 tCO_2e[3]		

[1] Actual GHG emission reductions achieved during the period from November 1, 2012 up to December 31, 2012

[2] Actual GHG emissions reductions achieved from January 1, 2013 up to December 31, 2015

net anthropogenic GHG removals estimated ex ante for this monitoring period in the PDD	

[3] Estimated amount of GHG emission reductions for the current monitoring period (1,156 days) based on average annual estimation of CER's as per the registered PDD

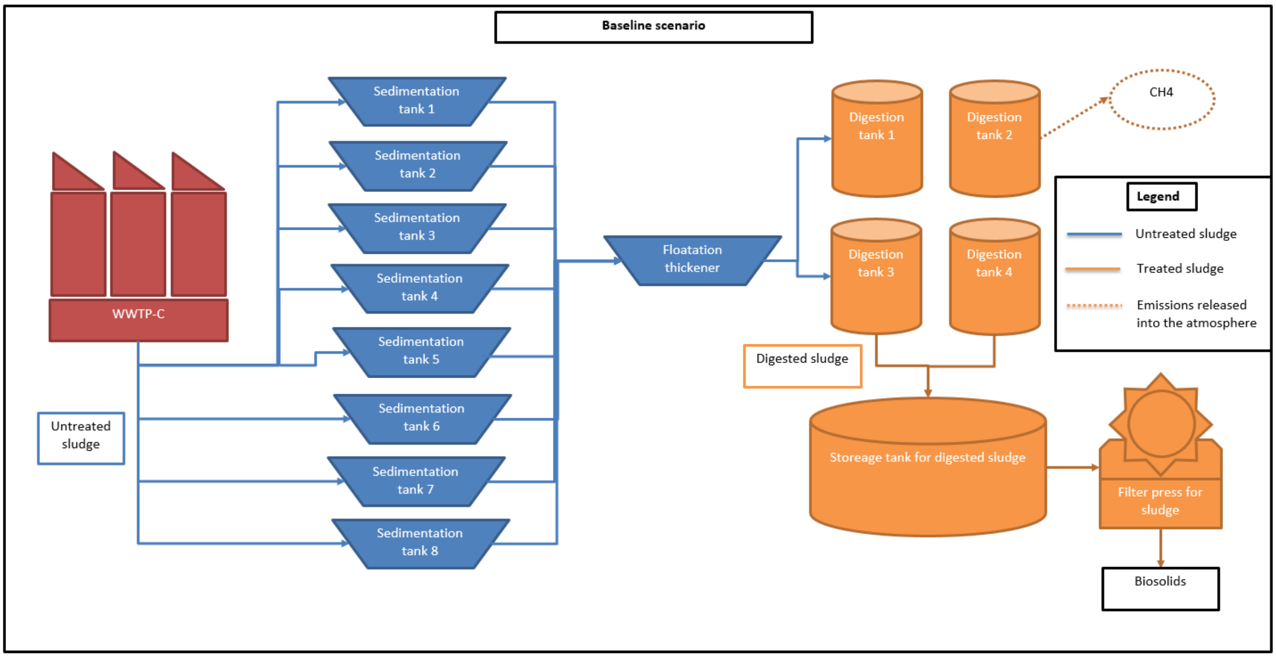
SECTION A. Description of project activity

A.1. General description of project activity

The project activity qualifies as Type III: Other project activities not included in Type I or Type II that result in GHG emission reductions not exceeding 60 KtCO2e per year in any year of the crediting period.

During the primary treatment of the wastewater of Cali, carried out in the WWTP-C, sludge composed of the organic matter susceptible to the decomposition is generated. The sludge is produced in eight sedimentation tanks and next carried into thickener tank. Later on sludge is redirected to four covered anaerobic digestion tanks (digesters) with the purpose of obtaining more stable end-product and eliminating pathogenic microorganisms present in the untreated sludge (see Figure 1). The above mentioned anaerobic digestion, besides stabilizing sludge, generates biogas with high content of methane (between 57% and 64% according to the latest analyses undergone in WWTP-C).

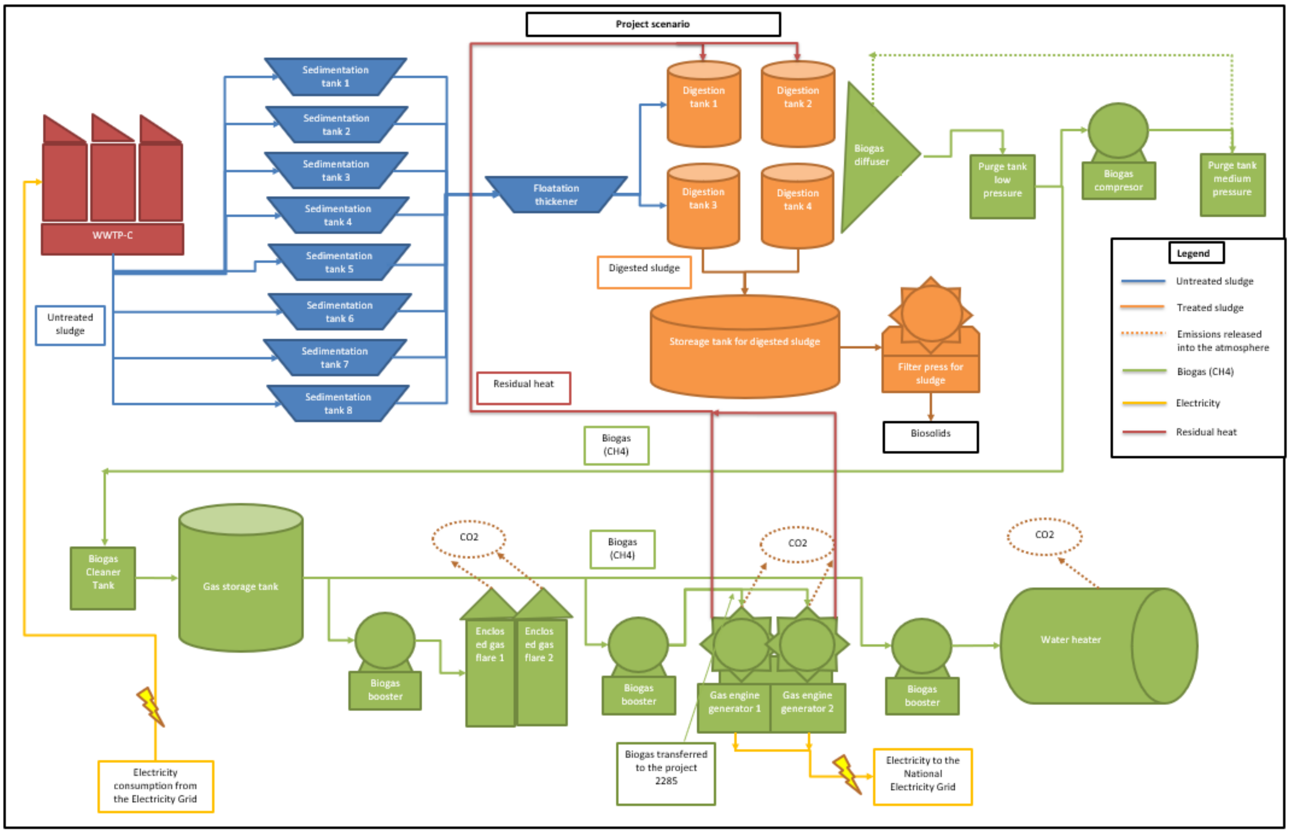
Figure 1: Sludge treatment line –WWTP-C - Baseline Scenario



The baseline scenario is the existing sludge treatment system without methane recovery and combustion.

This project category comprises measures that recover methane from biogenic organic matter in wastewaters by means of Introduction of methane recovery and combustion to an existing sludge treatment system, See figure 2.

Figure 2: Sludge treatment line -WWTP-C Project Scenario

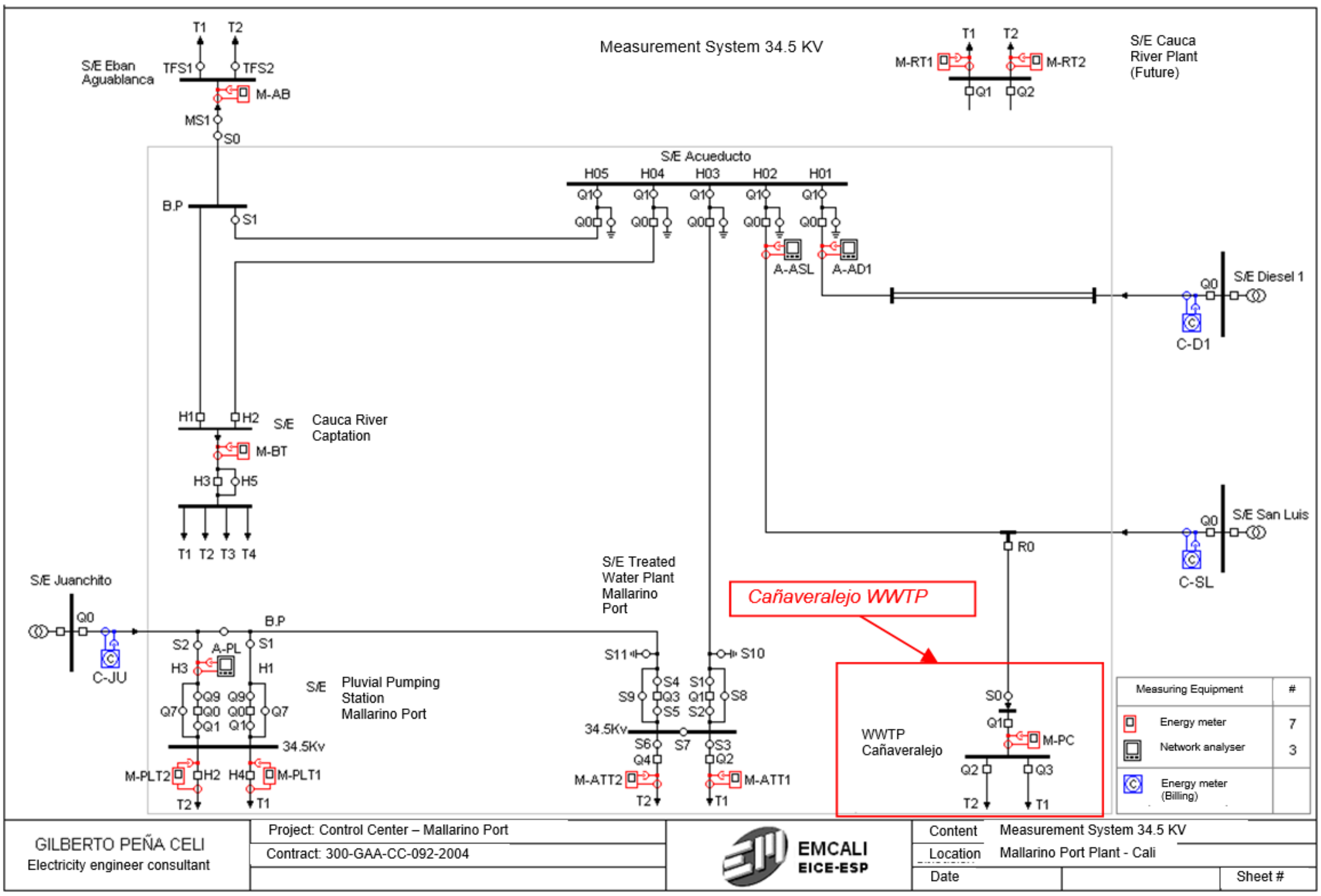


The activity of the proposed Clean Development Mechanism (CDM) small-scale project (further called proposed project) involves the capture and high efficiency combustion of methane, present in biogas generated during the process of treatment of sludge in the Wastewater Treatment Plant – WWTP Cañaveralejo (further called WWTP-C) – located in Cali, Colombia. Methane is burned in the high efficiency internal combustion engine of the electricity generation system. If the engine Generator is unavailable, the methane will be burned in the water heater. Finally, the high efficiency flare is used as the last alternative.

The project is located near to other CDM project activity: *Displacement of the electricity of the national electric grid by the auto-generation of renewable energy in the Cañaveralejo Wastewater Treatment Plant of EMCALI in Cali, Colombia* (Id. 2285). This project activity consists of the displacement of the national grid electricity by the electricity auto-generated by the Wastewater Treatment Plant – WWTP Cañaveralejo (further called WWTP-C). Biogas is produced during the anaerobic digestion of the sludge obtained through the wastewater treatment processes and farther used as fuel in two sets of engine-generators with purpose to generate the electricity for the internal use of the WWTP-C. Both project activities are related since the output of the project 2341 is used for the electricity generation in the project 2285, nevertheless, both projects are separated, independent and monitored and verified in a separated way

Electrical information about the electricity flow, interconnection and measurement points is included in the single line diagram bellow where it is demonstrated that the monitoring of the project 2341 cannot be interfered by the monitoring of the project 2285 since the biogas is transferred from the 2341 to the 2285

Figure 3: Single Line Diagram. Energy flow.



The owner and operator of the proposed project activity is EMPRESAS MUNICIPALES DE CALI EMCALI EICE ESP. The EMCALI mission is to contribute to the well-being and the development of the Cali community through the provision of essentials and complementary public services, committed with the environment and guaranteeing social and economic profitability. Among the services provided by EMCALI are telecommunications, water, electricity and sewer services.

The plant was designed by NITOGOI and constructed by Degremont-Mitsubishi-Conciviles-Norbert Odebrecht, consortium contracted by EMCALI. The WWTP-C is designed to operate with an average flow of 7.6 m^3/s from wastewaters generated by the city of Cali. The construction of WWTP-Cañaveralejo was started on August 10, 1997, and on December 26, 2002, the main project equipment that perform the biogas collection and use started operation (biogas collection system, flares, engines and water heater). The agreement for the installation of the measurement equipment (flowmeters, gas analysers, temperature meters, etc.) was signed on 26/08/2010 and for this reason the expected start date of the CDM project activity was established on 14/09/2010 when the commissioning and operation of the measurement equipment was forecasted. However, the agreement of installation and commissioning of the measurement equipment was finally initiated on 06/10/2010 so, as it is indicated in the previous monitoring report (first monitoring period) the effective operation of the measurement equipment and the availability of the raw data started on 13/01/2011.

The project activity WWTP-Cañaveralejo contributes to the principle "Contribution to the long-term improvement of the social and economic wellbeing of local communities and society in general" due to its commitment to invest in programs of protection of the environment.

The Project was registered on September 15, 2009 with a 10-year fixed crediting period. Emcali requested post-registration changes to the start date of crediting period to UNFCCC, which was approved by the Executive Board of UNFCCC, and accordingly, the start date of crediting period was set forth as of September 14, 2010 until September 13, 2020.

The total emission reductions achieved in the monitored period between 01/11/2012 and 31/12/2015 were 147,067 ton CO_2e.

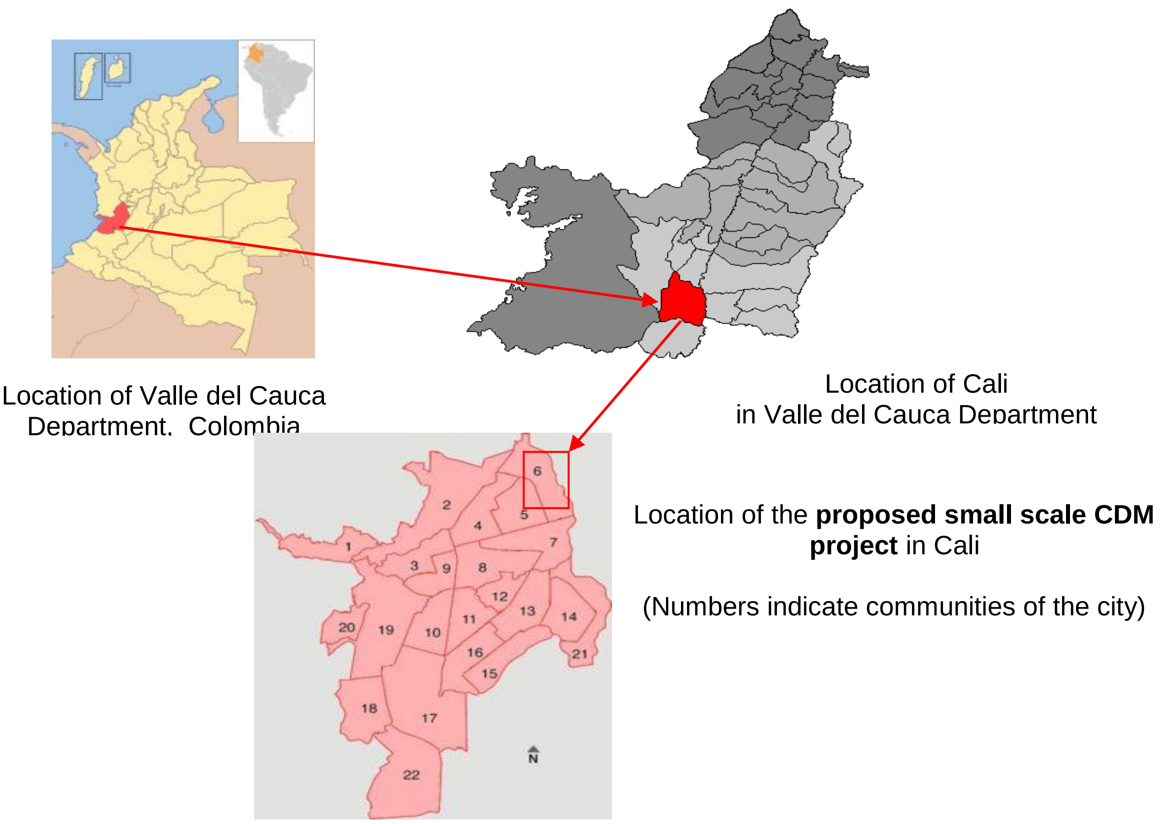
A.2. Location of project activity

The project activity is located in the Wastewater Treatment Plant, Cañaveralejo, (WWTP-C), located in the northeast of Cali in the Department of Valle del Cauca, Republic of Colombia. The Plant has a total area of 22 hectares, at the following geographical coordinates:

3 ° 28 '10.06538 "North, 76 ° 28' 44.03571" West

The WWTP is located 995 meters above sea level. Locally, the WWTP- Cañaveralejo is located in the commune 6 in the Petecuy I neighbourhood of Cali.

Figure 4. Geographical location of the proposed project



Picture 1: Wastewater Treatment Plant (WWTP) – Cañaveralejo, Cali, Colombia

A.3. Parties and project participants

Parties involved	Project participants	Indicate if the Party involved wishes to be considered as project participant (Yes/No)
Colombia	Empresas Municipales de Cali EMCALI EICE ESP (public entity)	No
Switzerland	ALLCOT AG	No

A.4. Reference to applied methodologies and standardized baselines

AMS-III.H.: Methane recovery in wastewater treatment (Version 9.0)[4]

AMS.I.D.: Grid connected renewable electricity generation (Version 13.0)[5]

Tools referenced in this methodology:

- TOOL 03: Tool to calculate project or leakage CO_2 emissions from fossil fuel combustion (Version 02)[6]

[4] https://cdm.unfccc.int/filestorage/C/D/M/CDMWF_AM_743QMM1YKHH15AK2AZAVAIJHRGD5R7/EB38_repan10_AMS_III.H_ver09.pdf?t=eTJ8cXl1ajM3fDB9rUpnM1X9hZ9j5ukXThS-

[5] https://cdm.unfccc.int/filestorage/C/D/M/CDMWF_AM_PHPV5WESACMBTJ2YY54GAJYSIEI3HD/AMS_I.D_rev_ver13.pdf?t=czh8cXl1ajRpfDDNQxLz-h84QemKjHLcifJG

[6] https://cdm.unfccc.int/methodologies/PAmethodologies/tools/am-tool-03-v2.pdf

- TOOL 04: Emissions from solid waste disposal sites (Version 6.0.0)[7]
- TOOL 05: Tool to calculate baseline, project and/or leakage emissions from electricity consumption (Version 01)[8]

A.5. Crediting period type and duration

Type: Fixed

The project participant requested post-registration changes to the start date to UNFCCC, which was accepted by the Executive Board of UNFCCC, and accordingly, the starting date of crediting period was set as of September 14, 2010

Choice of Crediting Period	: Fixed crediting period for 10 years
Crediting Period	: 14/09/2010 - 13/09/2020

SECTION B. Implementation of project activity

B.1. Description of implemented project activity

Recovery and combustion of methane in the project has been implemented as established in the approved Project Design Document (PDD)

All the physical characteristics of the proposed CDM project activity, including the systems of data collection and storage has been carried out in accordance with the registered Project Design Document (PDD).

The project activity involves methane capture and combustion, present in the biogas generated during the sludge treatment process of the Wastewater Treatment Plant of Cañaveralejo.

The technology used for the proposed project is based on the collection of biogas, storage, purification and methane combustion in the electric power generation system.

This project category consists of the capture of biogas produced by organic matter present in generated sludge.

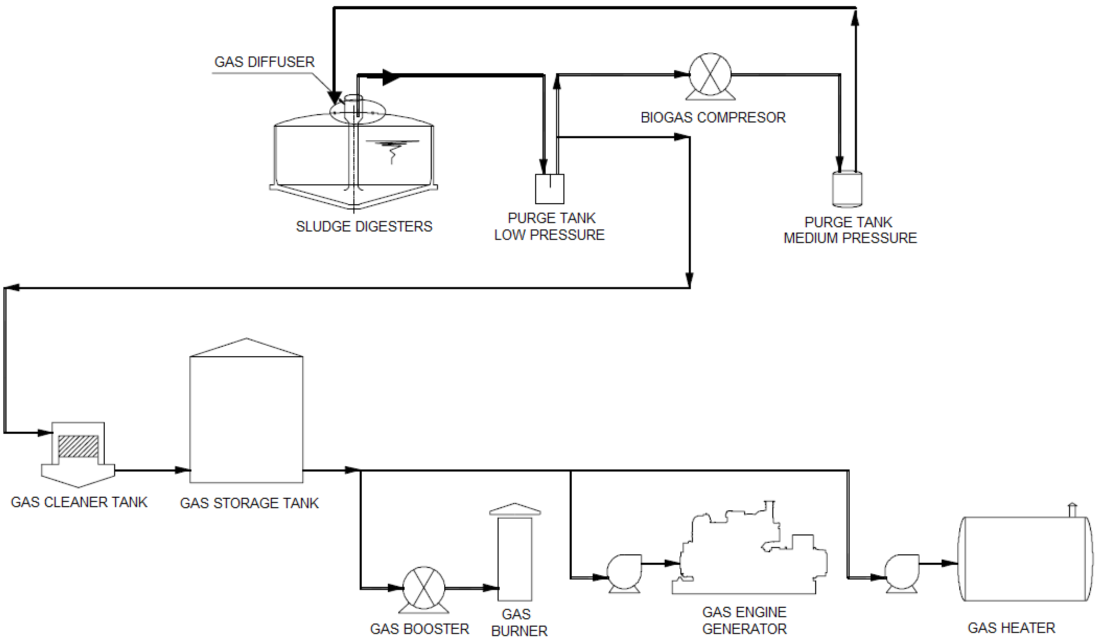
The proposed project activity conforms to the measures that recover methane from biogenic organic matter in wastewaters by means of the “Introduction of methane recovery and combustion to an existing sludge treatment system" according to the option (iii) of the approved methodology Methane Recovery in Wastewater Treatment (AMS III.H, Version 09, Scope 13, Mar 28, 2008).

The recovered methane from the above measure will be utilized for the direct electrical energy generation, conform to the application (a) of the approved methodology Methane Recovery in Wastewater Treatment (AMS III.H, Version 09, Scope 13, Mar 28, 2008).

[7] https://cdm.unfccc.int/methodologies/PAmethodologies/tools/am-tool-04-v6.0.0.pdf

[8] https://cdm.unfccc.int/methodologies/PAmethodologies/tools/am-tool-05-v1.pdf

Figure 5. Methane capture and utilization process



In alternative condition biogas will be combusted in flares and/or water heater. In order to ensure the project adequate implementation and its subsequent operation a multi-facet approach for the sound and safe technology and know-how transfer was introduced. This approach involved careful identification and qualification of appropriate technology/services providers (worldwide acknowledged companies such as Mitsubishi Corporation, Degremont S.A., Waukesha, Leroy Somer and Kayanson), adequate selection of the technology solution, supervision of the complete project installation, the WWTP-C staff training and the development and implementation of a complete Monitoring Plan. As part of this process a technology solution that would be self-sustaining (i.e., highly reliable, low maintenance, and operate with little or no user intervention) had been implemented. Furthermore, the project executer ensures sound and safe application, operation and maintenance of all the equipment implemented in the WWTP-C for the purposes of the CDM project activity and will carefully monitor the data collection, recording processes and environmental and health safety (e.g. the equipment is fit with flame traps, H2S detectors, methane detectors, depressurization valves, flame controls, thermal protection of all the associated engines, fire hazard protection system, etc). Moreover, it will ensure that the staff acquires appropriate expertise and resources to operate the system on an ongoing/continuous basis.

To describe the technology to be implemented within the proposed project activity, the existing technology in the WWTP-C (existing without the project activity) is being explained below.

During the primary treatment of the wastewater of Cali, carried out in the WWTP-C, sludge composed of the organic matter susceptible to the decomposition is generated. The sludge is produced in eight sedimentation tanks and next carried into thickener tank. Later on sludge is redirected to four covered anaerobic digestion tanks (digesters) with the purpose of obtaining more stable end-product and eliminating pathogenic microorganisms present in the untreated sludge (see Figure 1). The above mentioned anaerobic digestion, besides stabilizing sludge, generates biogas with high content of methane (between 57% and 64% according to the latest analyses undergone in WWTP-C).

Description of the technology implemented within the CDM project activity:

The equipment of the technology implemented within the activity of the CDM project for the methane capture and combustion are:

- gas storage tanks
- gas dehumidificator
- gas engine of the electric generator
- biogas flares
- water heater.

The gas captured is being stored in two cylindrical metallic tanks and next conveyed to a gas dehumidificators, later to be burnt in the generators internal combustion engines or, in alternative conditions, in flares and/or water heater. Each generator is a three phase synchronic type devise, which possesses four strokes engines of internal high efficiency combustion and the ability to convey 1,054 kW at 1,200 rpm.

In order to optimize the processes in the Plant, the water from the cooling of the generator's engines is used for the maintenance of the temperature of sludge in the digesters (between 33 to 35°C). This enables to control the optimum thermal conditions for the anaerobic digestion. In case the generation system fails some of the biogas will be redirected and burnt in the water heater which in such case is foreseen to maintain the temperature of sludge in the digesters.

Basic technical specifications of the biogas flare, water heater, dehumidificator, biogas storage tanks and generator's engine (more information available upon a request):

Gas storage tanks

Quantity:	2
Volume:	1,000 m^3
Diameter:	12.451 m
Height:	13 m
Lifetime:	5 years (conform to the estimations of the operating staff of the WWTP-C)

Gas dehumidificator

Quantity:	1
Inlet temperature:	30°C
Relative Humidity:	100%
Flow:	1,000 Nm^3
Pressure abs:	1,033 mbars
Lifetime:	5-7 (conform to the information obtained from the official representative of Degremont in Colombia who installed the equipment in the WWTP-C).

Gas engine generator

Type:	Engine with the gas pre-chamber, 4 strokes, 4 valves
Quantity:	2
Operation:	Automatic with output power and manual switch

Cylinder no.: V-12

Speed: 1,200 rpm aprox.

Fuel consumption: 2,651 Mcal/hr of biogas

Lifetime: 20 years and more (conform to the information obtained from the official representative of Waukesha Engine Dresser in Colombia (PEGSA Ltda)

Enclosed Gas flare

Quantity: 2

Power: 2.2 kW (gas booster)

1.1 kW (ventilator)

Operation: Automatic with the level of biogas in the storage gas tank

Flow: 550m^3/h

Lifetime: 20 years and more (conform to the information of the lifetime of the enclosed flares with similar technical specifications

Water heater:

Type: 3 lines

Quantity: 1

Capacity: 1,200 Mcal/h

Power: 2.5 kW (gas booster)

7.5 kW (ventilator)

Lifetime: 25 years (conform to the information obtained from the producer – Kayanson Engineers).

It is important to emphasize that although the lifetimes of the dehumidificator and biogas storage tanks are foreseen to be shorter than the duration of the CDM project activity, in case it is necessary to replace them within this period, the project proponents will ensure their replacement with the equipment of equal or similar technical and operational specifications. This way it will be ensured that the amount of the emission reductions achieved by the CDM project during the crediting period will not reduce due to the replacement of the existing equipment of the mentioned above project activity.

On the other hand, all the equipment of the project is included within the program of preventive and corrective maintenance which will keep ensuring its proper functioning. Furthermore, at the moment of its reparation or replacement, the time of the installation of the substitute equipment will be reduced to minimum to avoid eventual interference in the continuity of the project activity and the biogas will be combusted in different alternative ways in the flares and/or water heater. Under the alternative operation conditions, when the biogas might be combusted in the flares or in the water heater, the only electricity consumption might occur during the operation of the flares and such will be monitored and subtracted from the total emission reductions achieved by the project activity. There are no diesel generators on site to feed the methane capture neither any other combustion plant (besides the biogas combustion engines of the electric generators).
Main events occurred during the monitoring period are described:

1. Flow rates projected in the PDD's by WWTP-Cañaveralejo Emcali were not actually achieved in the implementation of projects.

2. TSS (total suspended solids) concentration described and projected in the PDD's by Emcali were superior to data obtained due to the rainy season presented during the year 2012 in the Department of Valle del Cauca in Colombia.
3. Fraction of VSS (Volatile Suspended Solids) / TSS (Total Suspended Solids) was lower than projected in the PDD's of Emcali due to the drag of inorganic material presented in the sewage of the city of Cali, Valle del Cauca, Colombia VSS (Volatile Suspended Solids) destruction in the digesters in the WWTP-C was 45% on average, this data was lower than projected in the PDD (50%).
4. The PP lost information from the CDM database due to failures in the SCADA for the period 18/Nov/2015 to 11/Dec/2015.
5. The PP had biogas leaks through the covers of Digesters or Biogas Storage Tanks in the period 12/May/2015 to 08/Sep/2015.
6. The PP had failures in the generators engines in the periods 17/Feb/2015 to 01/Apr/2015, 17/Aug/2015 to 21/Dec/2015.
7. When there is no power generation, the burning of biogas in the heater is started but this equipment only consumes up to a maximum of 250 m^3/h.

B.2. Post-registration changes

B.2.1. Temporary deviations from the registered monitoring plan, applied methodologies, standardized baselines or other methodological regulatory documents

Temporary deviation has been requested between 13/11/2015 until 31/12/2015 as there is not calibration certificate from the meter SN C-7743-S-7719 that measures the parameter $fv_{CH4,H,h}$. For this period, conservatively, all ERs were accounted as zero, in accordance with PS para 231)b)i.

The DOE Verification report is version 1, dated on 18/11/2021

B.2.2. Corrections

(a) Corrections that have been approved by the Board as applicable from the period prior to this monitoring period

Corrections that were approved on 13/12/2019 in the new version of the PDD (version 07) as part of the previous request for issuance (post-registration change PRC-2341-002 – issuance track) of the 1st monitoring report as applicable from the first monitoring period (as per paragraph 232 of the CDM Project standard for project activities) are:

1. Figure 1 was updated, including in the title "baseline scenario", as well as the use of residual heat from electricity generation in the project activity scenario. Thus, the addition of the baseline scheme represented on Figure 1 clarifies the difference between the baseline scenario and the project scenario (Figure 2).
2. New figures (2 and 3) have been included to clarify the technology and boundaries of the project activity.
3. The following sentence: "*basic technical specifications of the biogas flare, water heater, dehumidificator, biogas storage tanks and generator's engine (more information available upon a request)*" has been deleted since it was repetead in Section A.3.
4. Information regarding project participants has been updated in this new version of the PDD to be consistent with the UNFCCC website (inclusion of ALLCOT AG).
5. Section A.7 has been modified to include the use of the Methodological tool: Assessment of debundling for small-scale project activities Version 04.0 instead the Appendix C of the Simplified Modalities and Procedures for Small-Scale CDM Project Activities.
6. Section B.2 has been reinforced including the three applicability conditions of the applied methodology to be consistent with the rest of the document.

7. Project boundaries and sources and gases included and excluded in the calculations have been clarified (Section B.3).
8. Figure 4 has been included to clarify the boundary of the project activity amongst the inclusion of the Biogas alternative use and Energy Consumption of the Grid.
9. Ex post baseline calculations have been clarified in section B.6.1 to be in accordance with paragraph 36 of the applied methodology.
10. The calculation of Project activity emissions from electricity consumption are clarified (in section B.6.1) to be determined as per the procedures described in the latest version of the AMS I.D (Grid connected renewable electricity generation) at the moment of the registration of the project activity (version 13) since the reference to the “Tool to calculate the emission factor of the grid” was not correctly included.
11. A clarification regarding the consideration of Project Emissions has been included in the PDD. Since no new sludge treatment is performed in the project respect to the baseline scenario, the amount of untreated sludge generated ($_{Sy,untreated}$) is the same than in the baseline scenario, therefore, the potential to generate methane are equal in the baseline and the proposed project activity. Therefore, $MEP_{y,s,treatment}$ is considered zero in the ex post calculations. It was included in the PDD only for the ex-ante calculations. This consideration was approved by the Validating DOE during the registration of the project, as it is detailed in the Validation report with reference NO. 2008-BQ-ME-15, and therefore, this is considered only a correction in the reporting.
12. Three monitoring parameters have been detailed in the monitoring plan of the revised PDD to be in accordance with the applied methodology. These parameters were monitored in accordance with the methodology, but, they were not correctly reported in the registered PDD.
    - Flare efficiency (%).
    - Grid electricity consumption in year “y” (MWh).
    - Grid emission factor (tCO2/MWh).

    The operating time of the flares and the water heater are calculated using the values of the temperature, and it is clarified in the respective monitoring parameters (T_{flare1}, T_{flare2}). The operation hours of the water heaters are also calculated using the values of Volumetric flow rate of biogas and volumetric fraction of methane fed into the water heater. And a clarification is also included in the monitoring parameter. It is considered as correction since all of them were considered in the calculations stated in the PDD, but, the tables were not correctly included in the registered version. The process of improve the report of them does not affect the baseline, additionality or design of the project, in accordance with appendix of the CDM Project Standard.

Corrections that were approved in the PRC-2341-001 (approved on 01/07/2015) included the following changes:

- A Numerical notation (comma for thousands and dot for decimals).
- Deleting of specific names, models, brands and equipment’s manufacturers (PP’s confidentiality).
- Correction of the typographical overlaps in the installed capacity1 of the generators (1,054kW instead of 1,045KW and 1,099 kW).
- General editorial and wording corrections.
- Deleting of technical information not required by the methodology or not applicable to the project and considered as unnecessary by the PP (information that could cause confusion to the reader).
- Updating of the description of the SCADA system
- Updating and inclusion of figures and graphs in accordance with the current implementation status.

(b) Corrections that have been approved by the Board as applicable from this monitoring period;

No corrections have been requested and approved by the Board as applicable from this monitoring period.

(c) Corrections that are being submitted with this monitoring report as part of the request for issuance (post-registration change – issuance track) as applicable from this monitoring period.

No corrections are being submitted with this monitoring report as part of the request for issuance (post-registration change – issuance track) as applicable from this monitoring period.

B.2.3. Changes to the start date of the crediting period

No change to the start date of the crediting period is requested.

B.2.4. Inclusion of monitoring plan

Not applicable.

B.2.5. Permanent changes to the registered monitoring plan, or permanent deviation of monitoring from the applied methodologies, standardized baselines, or other methodological regulatory documents

Permanent changes to the registered monitoring plan that were approved in the PRC-2341-001 (approved on 01/07/2015) included the following changes:

- Parameters removed of the monitoring plan:

  - $T_{,H,\, h}$: Temperature of biogas fed into the water heater (°C)

    $T_{G,h}$: Temperature of biogas fed into the engines of the electric . generators (°C).

  - $T_{G,\, h}$: Temperature of biogas flared (°C)

  - $P_{,G,h}$: Pressure of biogas fed into the engines of the electric generators (mbar)

  - $P_{H,\, h}$: Pressure of biogas fed into the water heater (mbar)

  - $P_{,G,h}$: Pressure of biogas flared (mbar)

  Due to the volumetric flow meters deliver results in normal conditions, and these were used for this correction.
  The management and monitoring structure and responsibilities of staff related to CDM project activity has been modified taking into account new changes in the organizational structure of the entity.

B.2.6. Changes to project design

There are no changes to the project design.

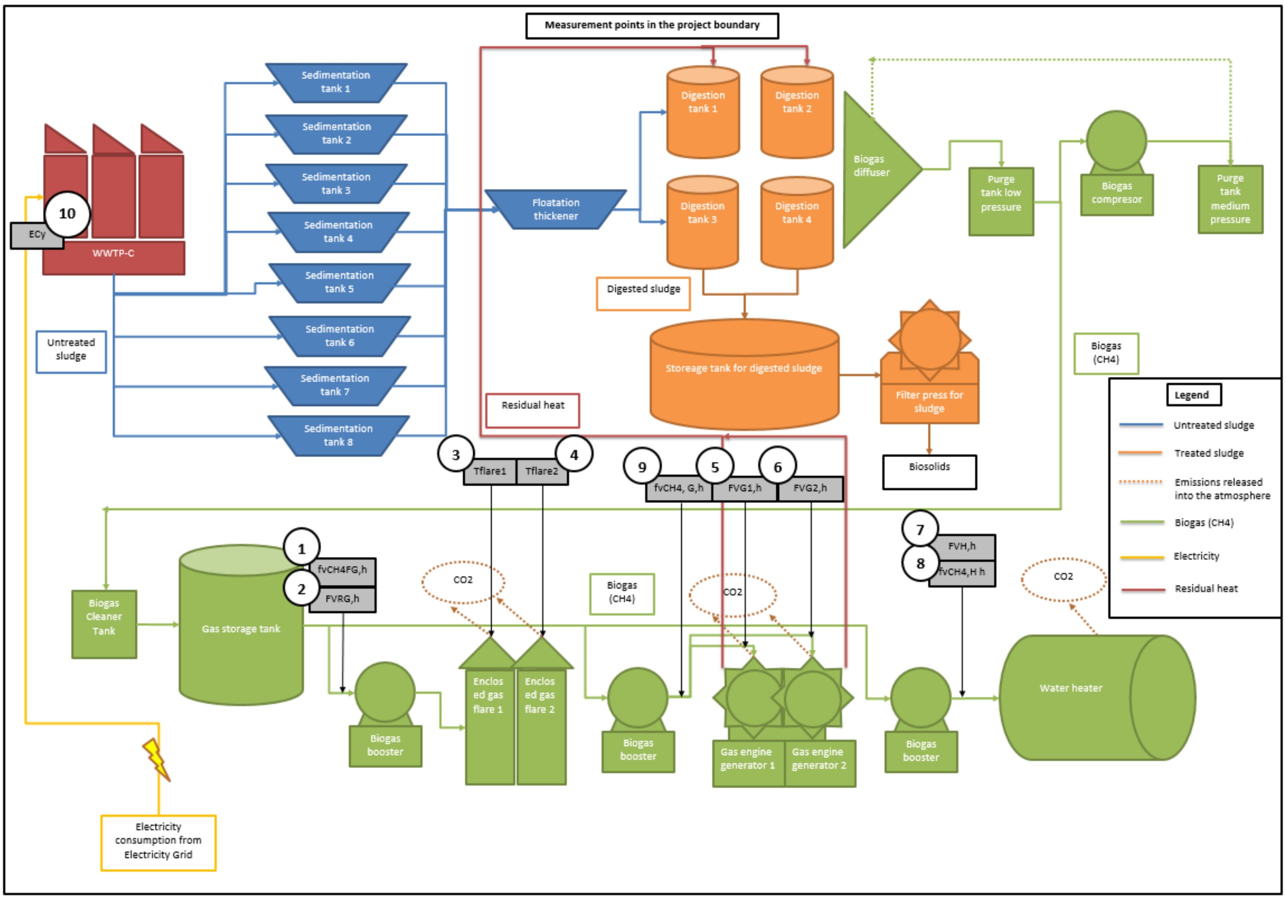
B.2.7. Changes specific to afforestation or reforestation project activity

Not applicable.

SECTION C. Description of monitoring system

The line diagram of the project boundary, showing all relevant monitoring points is the following:

Figure 6: Diagram of control parameters of CDM Project No. 2341 (Recovery and combustion of methane)

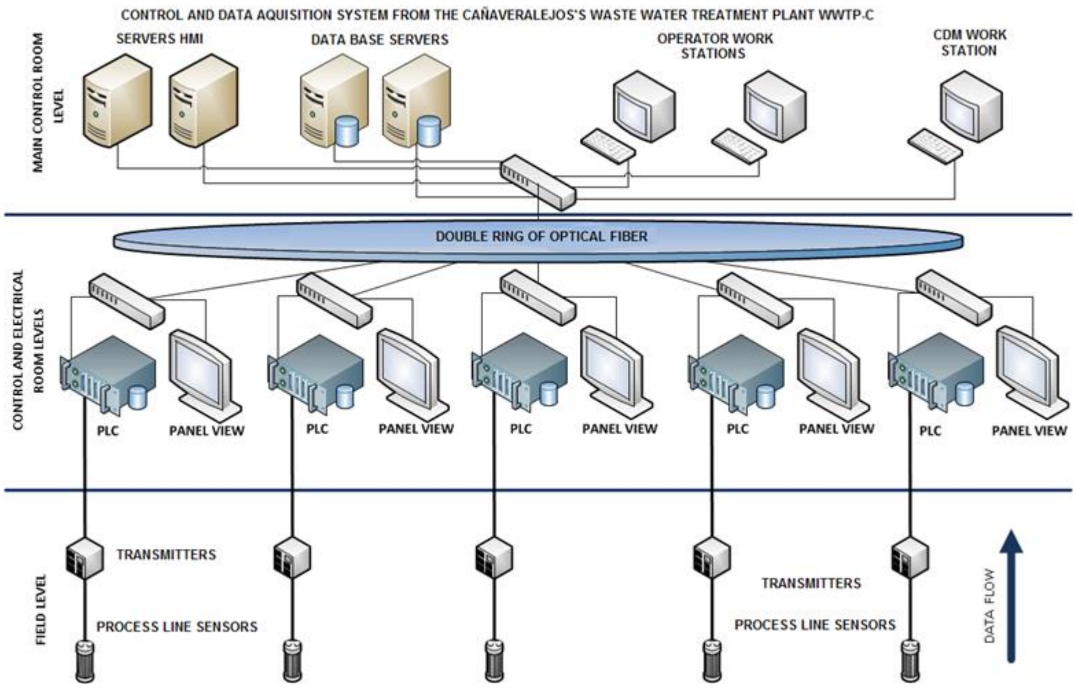


Description Supervisory Control and Data Acquisition – SCADA

SCADA is a set of hardware and software (system) that are intended for the collection of information, usually in real-time in order to provide feedback on a process development under controlled conditions. SCADA is the tool that supports the proper functioning of the system and the WWTP-C process and therefore contributes to generate stable biogas, as well as its capture and combustion.

The SCADA of the Wastewater Treatment Plant of Cañaveralejo (WWTP-C) is formed by the following three levels. (See figure 7):

Figure 7. Data control system of WWPT-Cañaveralejo



a) Field level:

This level constitutes the set of measuring instruments installed in the processing lines, which, by nature, measure different measurement variables. On the other hand, values are sent by wiring to their field installed transmitters. The transmitters have a local display panel of the measure and they are responsible for interpreting the sent values by the sensor and to display the result on the screen, and they also convert digital signals into a voltage signal and analogue signals into electrical current signals from 4 to 20 mA.

b) Level of electrical and control rooms:

This level is made up of 5 electrical control rooms located on 5 strategic divisions of the plant (Water or elevation, Settlers, Digesters, Dehydration and generation) in each electrical and control room there is a Programmable Logic Controller PLC and a View panel or computer control. The PLC receives via a copper cable the signals from the field transmitters. The Signals depending on their digital or analogous nature reach the PLC to input or analogue cards respectively. The PLC's are responsible for converting the voltage or current signals received in its input cards in numerical values of the process variables measured in the field. The interpreted values in the PLC’s are sent to two servers in a HMI (Human Machine Interface) application, through an Ethernet network built on a dual fibre optic ring that runs the plant. Local view panel with an HMI application allow monitoring and control of treatment processes.

c) Level of main control room:

This level is formed by two HMI (Human Machine Interface) application servers (redundantly one of the other) that allow monitoring and equipment control and treatment variables. There are also two database servers (redundantly one of the other) with ORACLE installed. There are computers or workstations located in the control room that comply the specific process operation stations, process and CDM reporting, and the treatment process state visualizer.

The HMI (Human Machine Interface) application included on control servers SCADA is charged of handles stored in servers ORACLE database, in the form of trends, process variables measures at the field level and translated by the PLC in numerical values. These trends keep instantaneous values measured in the field in intervals of 30 seconds, for a period of 3 months. Its main function is to allow the operator and its respective chief, daily take operating decisions.

The workstation is in charge of the CDM projects reports generation, and it has developed a program in Microsoft Excel in order to control its variables which automatically reports averages by hour the instantaneous values stored in a trend form of the monitoring variables that correspond to both CDM projects (2285 and 2341). These average hourly values calculated by the program from the trend data are stored by this, in the CDM report tables which exist on the database servers in the SCADA. The information located in the CDM tables will be stored during the crediting period plus 2 year.

As this project is connected with another activity from the CDM project "Displacement of the electricity of the national electric grid by the auto-generation of renewable energy in the Cañaveralejo Wastewater Treatment Plant (WWTP-C) of EMCALI in Cali, Colombia" (Reference 2285), the measures related to electric engines generators also appear as monitored parameters in the project mentioned above. See Figure 8.

Through the SCADA system, the operation information is collected, stored, processed and controlled.

Table 1. Parameters collected by the SCADA

Parameter		Unit	Frequency of Collection of data
$fV_{CH4G,h}$ $fV_{CH4FG,h}$ $fV_{CH4H,h}$	Volumetric fraction of methane in biogas fed into the engines of the electric generators or combusted in flares and/or water heater	µ V/V	Continuous
$FV_{G,h}$ $FV_{RG,h}$ $FV_{H,h}$	Volumetric flow rate of biogas fed into the engines of the electric generators, flared and/or combusted in water heater	m^3/h	Continuous
T_{flare}	Temperature of the exhaust gas of the flares	°C	Continuous

SCADA Stability and Security Aspects

SCADA stability is offered by having redundancy from the level of electrical and control rooms. From this level redundancy is manifested by the double fibre optic ring which goes through the plant communicating PLC's and workstations so that they work as a system. The panel views installed in each electrical room allow control of the entire plant becoming redundant one of the others.

In the main control room, the redundancy in HMI (Human Machine Interface) servers and redundancy in the database servers. In case one of the servers fails, the other assumes the workload automatically. Once the server resets this fault, it automatically synchronizes again with the one in service and continues its normal operation. This applies to both applications HMI (Human Machine Interface) servers as the database server. Each server has inside an array of RAID 5 Array (HDD) hard drives which also allow replacement of hard drives. Each server has a dual power supply.

As for the security of SCADA the HMI (Human Machine Interface) application can be accessed only by entering specified username and password for each operator. This application offers various levels of access according to user profiles.

User activity in the system is recorded by an event registration. For databases and registered data themselves we must say that the ORACLE database can only be accessed with username and password. The data is written to the database only by the HMI (Human Machine Interface) application automatically and by the Microsoft Excel program. These have an encrypted code in their user name and password that allows them to fulfil their function. Users access to these programs, as mentioned above, by entering a username and password.

Data Flow:

The parameters within the Monitoring Plan of the CDM project are associated with SCADA instruments installed within the operating process WWWTP-C at the field level. Each parameter variables are recorded by the SCADA every 30 seconds in a database called Trends. The values of this database are stored temporarily during the last three months of the process. This is because these are used in order to control the process by evaluating trends. A program in Microsoft Office Excel v.2007, use this temporary database (Trend) and resume / groups corresponding to the monitoring parameters of the project. . This program aggregates the values of the parameters CDM in hourly basis to include them in the excel spreadsheets used for the CDM purposes (ER calculations). The data is stored up to 2 years after the end of the crediting period of the project.

The Data control and CDM operation team is in charge of downloading all the information from this Scada system regarding to the monitoring parameters required by the methodology, the team aggregates and prepares the emission reduction calculations, and make the periodic revision of the information obtained.

Organizational Structure of the monitoring system

The PP has assigned operational team of plant for data monitoring, archiving and analyzing and is reported to Wastewater treatment department chief.

There is an operational and management team which is in charge of the GHG Data Control and CDM Operation, which is also responsible to operate and maintain the wastewater treatment system and implement the monitoring plan. The team is responsible for daily monitoring of the processes in accordance to the quality assurance and control of each parameter as per the monitoring plan.

In addition, a technician responsible in recording the monitored data and report any abnormalities to plant chief on daily basis. The aggregated monitored and recorded data will be stored electronically and in hard copy format up to 2 years after the end of crediting period or the last issuance of CERs, whichever is later. The monitored and recorded data is used and presented to DOE during CERs verification. The wastewater plant chief has reviewed the work performed by the technician and making final reporting to the management of the PP.

The roles and responsibilities performed by the team members are as below:

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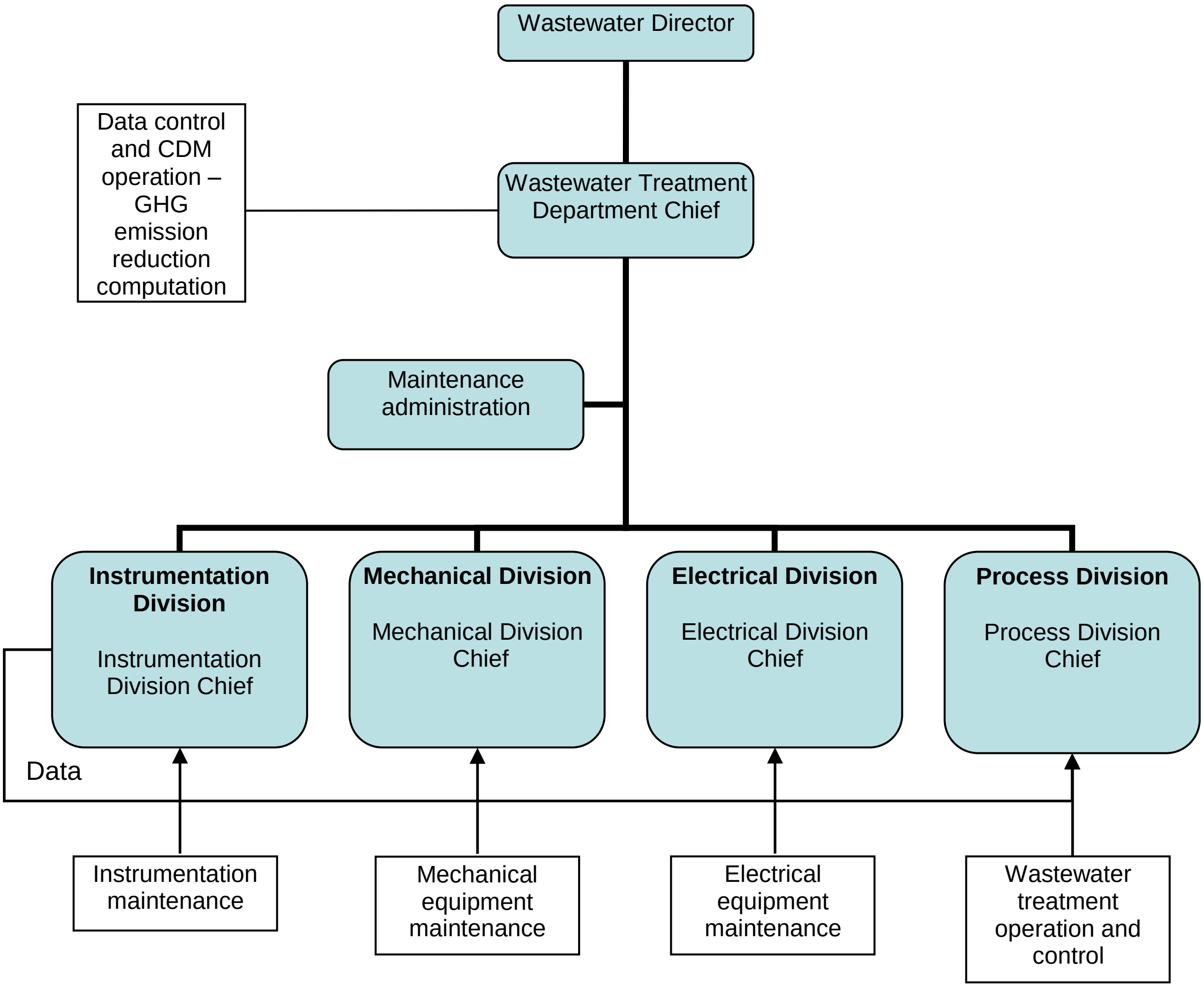
Figure 8. Monitoring Plan Organizational and Management Structure



In order to manage CDM projects WWTP- Cañaveralejo, the direction of the WWTP-C assigned to the Maintenance Management Division as a technical support from control activities, monitoring and results calculation of the CDM project activity.

1. *<u>Direction of WWTP – Cañaveralejo.</u>*

Direction of WWTP- Cañaveralejo is responsible for:

- Administrative direction and monitoring of the CDM projects activities and the monitoring plan of WWTP – Cañaveralejo of EMCALI
- Annual review of performance monitoring plan and approval of changes from the monitoring plan in case they are required.
- Approval of the annual calculations of GHG reductions made by the Maintenance Management Division.
- Review and confirm the raw data collected, aggregated and emission reduction calculations done by the technician.
- Assist the technician during verification.

- Responsible for revision of the reporting of the plant Estimated emission reductions during the monitoring period and the outcome of the verification and status of issuance of CER.

2. *Instrumentation Division.*

Instrumentation division is responsible for:

- Maintenance of control and instrumentation equipment of the WWTP-C, including the maintenance of the Supervisory Control and Data Acquisition - SCADA,
- Preparation of the annual program of preventive and corrective maintenance of the WWTP-C instruments
- Preparation of a weekly schedule of preventive and corrective maintenance of the WWTP-C instruments
- Review and approval of work orders by the Chief of instrumentation Division
- Archives of work orders for a period of 10 +2 years in instrumentation office.
- Supervision and control of the operation of the data servers, as well as monitoring and supervision of the maintenance activities SCADA hired through an outsourced service.
- Provide the GHG data control and CDM operation team with the required data for the monitoring of the GHG reductions.

3. *Process Division*.

The process division is responsible for the following activities:

- Preparation of monthly reports of the results of the plant operations.
- Operate and control the process of the Wastewater treatment.
- With regard to the CDM management projects WWTP-Cañaveralejo, the WWTP-C direction assigned to the Maintenance Management Division as support and technical support in activities control, monitoring and calculations results of the CDM project activity.
- Provide the GHG data control and CDM operation team with the required data for the monitoring of the GHG reductions.

4. *Maintenance Management Division*.

The Maintenance Management Division is responsible for:

- Computation of GHG emissions reduction of the two CDM projects and presentation to the WWTP-C direction for approval.
- Storage and control of computation and the results of GHG emission reductions of CDM projects in the servers' database from the control system located in the control room of the WWTP-C for a period of 10 + 2 years on magnetic media.
- Control and monitoring of statistical techniques and management trends applied to the variables of the monitoring plan of the two CDM projects.
- Provide the GHG data control and CDM operation team with the required data for the monitoring of the GHG reductions.

5. *Mechanical Division.*

The Mechanical Division is responsible for the following:

- General maintenance of mechanical equipment of WWTP-Cañaveralejo.
- Preparation of the annual program of WWTP-C mechanical equipment maintenance.
- Preparation of a weekly schedule of WWTP-C mechanical equipment maintenance.
- Review and approval of work orders by the mechanical division chief and subsequent delivery of orders to the maintenance management division.
- Archives of work orders for a period of 10 +2 years in instrumentation office.
- Provide the GHG data control and CDM operation team with the required data for the monitoring of the GHG reductions.

6. *Electrical Division.*

Electrical division is responsible for the following:

- General maintenance of the plant electrical equipment (preventive, corrective and predictive).
- Generators operation and maintenance.
- Preparation of the annual WWTP-C program electrical equipment maintenance.
- Preparation of a weekly schedule of the WWTP-C electrical equipment maintenance.
- Review and approval of work orders by the Electrical division chief and subsequent delivery of maintenance orders of maintenance management division.
- Archives of work orders for a period of 10 +2 years in the electrical division office.
- Provide the GHG data control and CDM operation team with the required data for the monitoring of the GHG reductions.

GHG Data Control and CDM Operation

The operational and management team is in charge of GHG data collection from the rest of the departments. Also, they are responsible for:

- Collect the data on the various monitoring parameters from the rest of Divisions as per the monitoring plan.
- Report to the plant chief if there any abnormalities
- Use defined protocols and routine procedures, with good, professional data entry, extraction and reporting will be encouraged to maximize transparency of data archiving
- Data aggregation and emission reduction calculations
- Data for various parameters aggregated and used in emission reduction calculations.
- Coordinate with the DOE during verification

Procedure of WWTP- Cañaveralejo staff training

The WWTP-C staff training method according with the operation, maintenance, calibration and project equipment monitoring activity is as follows:

Suppliers, who provide equipment, instruments and systems to WWTP-C, have to adapt staff training to the WWTP-C technical staff according to the operation and / or maintenance.

The training is considered appropriate when the trained staff show the sufficient skills to operate the equipment.

Quality Assurance and Quality Control.

Quality is assured through the calibration and verification of the measurement equipment. All monitoring equipment is calibrated according to the manufacturer's suggestions. The frequency of calibration is carried out according to the manufacturer's instruction, therefore the calibration activity and / or verification of each monitoring equipment ensures that the equipment operates at the indicated level of accuracy.Project proponent will take responsibility for the quality assurance and quality control for recording, maintaining and archiving all the data by appointing consultants and/or technical support team to carry out the system analysis, equipment calibration and overall maintenance on a regular basis throughout the crediting period. PP has provided necessary training on data monitoring and recording to all the staff personnel involved in the monitoring process, in order to improve the efficiency of their work.

Emergency procedure

PP has implement an Emergency Procedure in the plant to handle an emergency situation in the plant, and measures to be taken to ensure that there is no unintended methane leakage from the system. All the plant operators have been familiarized on the procedure.

With respect to the emergency procedures, EMCALI has installed a backup PLC, which captures the information each 5 minutes and aggregates hourly, sending this information to the EMCALI´s control center, located 3 km far from the plant. Hence, in case of any emergency, the information on ERs is easily and reliably recovered and stored. During the on-site visit, the DOE reviewed the abovementioned PLC, and found it properly maintained and operative.

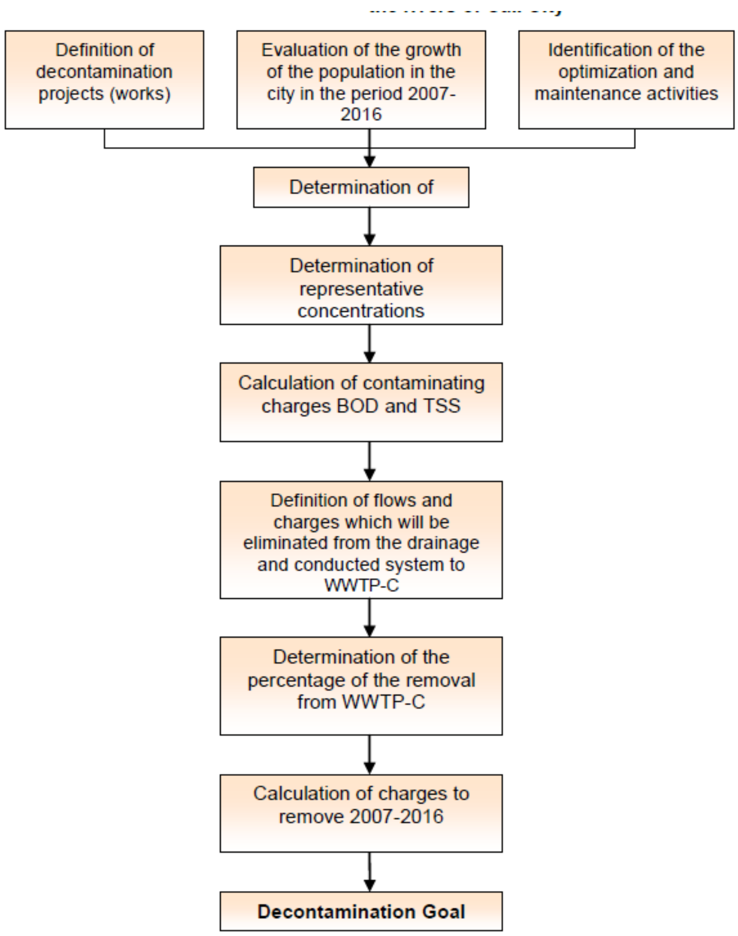
Uncertainty in data

Some uncertainties may result due to malfunction of meters, calibration issues and wrong data collection (gaps in manual log sheets, human errors by plant operators). The operator is expected to put best efforts to prevent such errors; however regular internal audits shall rectify any such uncertainty in the monitored data.

SECTION D. Data and parameters

D.1. Data and parameters fixed ex ante

Data/Parameter	**Qy**
Unit	m^3/year
Description	The flow of influent wastewater to the WWTP-C in year “y” of a crediting period
Source of data	Estimations of the Planning Department of EMCALI
Value(s) applied	<table><tr><th>Year</th><th>Estimation of the flow of influent wastewater to PTAR-C (m^3/year)</th></tr><tr><td>2008</td><td>140,781,960</td></tr><tr><td>2009</td><td>186,111,596</td></tr><tr><td>2010</td><td>189,109,408</td></tr><tr><td>2011</td><td>191,180,062</td></tr><tr><td>2012</td><td>203,233,121</td></tr><tr><td>2013</td><td>206,323,649</td></tr><tr><td>2014</td><td>208,487,019</td></tr><tr><td>2015</td><td>208,796,072</td></tr><tr><td>2016</td><td>209,723,230</td></tr><tr><td>2017</td><td>210,248,620</td></tr><tr><td>2018</td><td>211,052,157</td></tr></table>
Choice of data or measurement methods and procedures	EMCALI, based on the extensive study of the Planning Department of EMCALI “Sanitation and wastewater management plan for the years 2007-2016”, foresees the increase of influent wastewater to the WWTP-C as the function of three following components: definition of the decontamination projects, evaluation of the growth of Cali in the following years and the identification of the optimization and maintenance activities in the city. It needs to be emphasized that the increase of wastewater inflow is **NOT** due to the activity of the proposed CDM project but due to the three components already mentioned above inherent to the development of the city of Cali. EMCALI realized a diagnostic of the sewer system of the city. Main wastewater streams were identified and the causes with possible solutions were evaluated. Some of the solutions are oriented into the optimization of the grids, having in mind that this action would reduce wastewater that due to false functioning is conducted to canals and rivers; other works are connected to the implementation of the sanitary collectors that will block and redirect wastewaters to the WWTP-C that currently are disposed by some of the sectors in an inadequate way; in other cases a necessity for the optimization of the separation and improvement structures of the sewer maintenance system of the city was identified. For a better understanding of the methodology applied, a graph below presents the steps taken for the calculation of the Decontamination Goal. To project the population of Cali the information of the Administrative Department of Planning DAP-97 was taken into account, having in mind that DANE (the Administrative Department of the Municipal Planning) only registered the population in year 2005 without further projections. On the other hand, Registry 2005 presented the number of habitants for the city of Cali similar to the numbers projected by DAP- 97, which allows deducing that the projections would proceed with the same tendency. For the ex-ante calculations of the baseline and the project activity emissions more conservative scenery for the growth of the population, decontamination projects and the optimization and maintenance activities was adopted, i.e., 25 percent in 2008 and 2 percent uncertainty level for years 2009-2018 in comparison with the initial projection presented by EMCALI[26]. This higher uncertainty level of 25% for the year 2008 was adopted due to the unexpected delay in the planned by EMCALI for this year maintenance and expansion of the sewer system grid. These works are delayed in function of other constructions being developed in Cali by the municipality (for example, the constructions of massive transportation system for Cali – MIO by acronyms in Spanish). It is foreseen that this delay resulting in the lower wastewater inflow to the WWTP-C will extend only over the year 2008 and therefore, the following years would continue with the 2% uncertainty level.

Choice of data or measurement methods and procedures	The result of these calculations is available upon the request. At the moment of the preparation of the present document, no other policies, plans, strategies or regulations are known to present risks to the calculation of the baseline emissions and therefore no higher uncertainty level to the one already included in the estimation of the amount of the inflow wastewater (25% in 2008 and 2% in the rest of the years of the crediting period) was included in the calculation. **Figure 5: Flow graph for the calculation of the decontamination goal of the rivers of Cali City** 
Purpose of data/parameter	Calculation of ex ante emissions reductions
Additional comments	The calculation of the GHG emission reduction will be based on the direct measurement of the amount of methane captured and used as fuel in the engine of the electric generator or burned as emergency in the flares or water heater. Once the project is implemented, this parameter will not be necessary for the calculation.

Data/Parameter	**TSS**
Unit	g/m^3
Description	Average concentration of total suspended solids (TSS) present in the influent wastewater entering the WWTP-C.
Source of data	Average of measurements made by the WWTP-C´s laboratory during the last three years of the WWTP-C operation (2004, 2005 and 2006). Data are stored in the Process Area.
Value(s) applied	184
Choice of data or measurement methods and procedures	The WWTP-C´s Laboratory takes a daily hourly samples comprised by influent wastewater in quotas proportional to the flow volume entering the WWTP-C. The total suspended solids (TSS) are determined by means of the gravimetric technique aforementioned in the Standard Methods for the Examination of Water and Wastewater, Edition 20, as per Methodology 2540D; for dry conditions between 103-105C. Data of the TSS analysis are daily introduced by the Laboratory stuff (Administrative Analyst) into the form “Tab.1 Parámetros fisicoquímicos I agua cruda”. The data are next revised and “published” in intranet by the Laboratory Chief (Professional of the Supporting Process). Data with the analysis are archived for 10 years in paper copy in folder no. 5 “*Informes Análisis Línea de Agua WWTP-C*” for each year. The Process Area has direct access to the data already “published” in intranet and is able to process them. The Process Area prepares every month, semester and year reports of the functioning of the Plant. Based on these data from the last 3 years (2004, 2005, 2006) the average concentration of TSS in influent wastewater entering the WWTP-C was calculated. Detailed calculation is available upon the request.
Purpose of data/parameter	Calculation of emission reduction
Additional comments	The calculation of the GHG emission reduction will be based on the direct measurement of the amount of methane captured and used as fuel in the engine of the electric generator or burned as alternative in the flares or water heater. Once the project is implemented, this parameter will not be necessary for the calculation.

Data/Parameter	**$\mu_{removal}$ TSS**
Unit	Fraction
Description	Average efficiency of the removal of TSS in the WWTP-C
Source of data	Average of measurements made by the WWTP-C´s laboratory during the last three years of the WWTP-C operation (2004, 2005 and 2006). Data are stored in the Process Area.
Value(s) applied	0.6
Choice of data or measurement methods and procedures	TSS removal efficiency depends on the sedimentation tanks operation. It is possible to apply this efficiency to calculate the sludge produced which afterwards is taken to the anaerobic digesters. The average sedimentation tanks efficiency varied in years 2006 and 2007 between 63 and 67% (efficiency of the TSS removal). For the purposes of the calculation of the amount of sludge - lower, more conservative value was adopted.
Purpose of data/ parameter	Calculation of emissions reduction
Additional comments	The calculation of the GHG emission reduction will be based on the direct measurement of the amount of methane captured and used as fuel in the engine of the electric generator or burned as alternative in the flares or water heater. Once the project is implemented, this parameter will not be necessary for the calculation.

Data/Parameter	**%DM**
Unit	Percentage
Description	Percentage of dry matter from untreated sludge generated from the WWTP-C sedimentation tanks.
Source of data	Average of measurements made by the WWTP-C´s laboratory. Data is stored in the Process Area.
Value(s) applied	1.21
Choice of data or measurement methods and procedures	According to the Methodology AMS III.H, Version 09, Scope 13, Mar 28, 2008, the default value for the fraction of degradable organic content of non-treated sludge ($DOC_{y,s,untreated}$) is 0.05. Such value relates to domestic sludge in wet basis, considering 10% of dry matter. Due to the fact that dry matter from non-treated sludge at the WWTP-C is substantially different from the value reported by the Methodology, the value was amended. Section B.4 shows details of the calculation, and Appendix 3 Baseline information, shows the monthly average data for 2006 and 2007 of the content of total solids (TS) in non-treated sludge. The WWTP-C laboratory takes specific samples twice a day from the sludge flowing out from each sediment tanks. The total suspended solid (TSS) is determined by means of the gravimetric technique as per Methodology 2540H for solids and semisolids as per the Standard Methods for the Examination of Water and Wastewater. Data of the TSS analysis are daily introduced by the Laboratory stuff (Administrative Analyst) into the form "*Tab.1 Parámetros fisicoquímicos agua cruda*". The data are next revised and "published" in intranet by the Laboratory Chief (Professional of the Supporting Process). Data of the analysis are archived for 10 years in paper copy in folder no. 5 "Informes Análisis Línea de Agua WWTP-C" for each year. The Process Area has direct access to the data already "published" in intranet and is able to process them. The Process Area prepares monthly, semester and yearly reports of the functioning of the plant. Based on the most recent data of the years 2006 and 2007 of the Plant's operation, the average concentration of TSS in influent wastewater entering WWTP-C was calculated.
Purpose of data/parameter	Calculation of emissions reduction
Additional comments	The calculation of the GHG emission reduction will be based on the direct measurement of the amount of methane captured and used as fuel in the engine of the electric generator or burned as emergency in the flares or water heater. Once the project is implemented, this parameter will not be necessary for the calculation.

Data/Parameter	GWP_{CH4}
Unit	tCO_2/tCH_4
Description	Methane Global-Warming Potential
Source of data	Climate Change mitigation Climate Change 2014 – WGR Report AR5 -IPCC
Value(s) applied	21 for the first commitment period 25 for the second commitment period
Choice of data or measurement methods and procedures	Calculation of baseline emission and project emission
Purpose of data/parameter	Calculation of baseline emission and project emission
Additional comments	--

Data/Parameter	D_{CH4}
Unit	kg/Nm3
Description	Methane Density
Source of data	Tool to determine project emissions from flaring gases containing methane Refer to UNFCCC Annex 13 Defined in the methodological tool EB-68 Annex 15 CDM UNFCCC – Table 2006 IPCC Guidelines for National Greenhouse Gas Inventories
Value(s) applied	0.716
Choice of data or measurement methods and procedures	--
Purpose of data/parameter	Calculation of baseline emission and Project emission
Additional comments	--

D.2. Data and parameters monitored

Data / Parameter	$fv_{CH4FG,h}$
Unit	μV/V
Description	Volumetric fraction of methane in biogas fed into flares
Measured/ Calculated / Default	Measured
Source of data	Continuous flow meter. The measurement location is shown in Figure 5. Measurement Point 1
Value(s) of monitored parameter	Average value for this Monitoring Period: **63.12%** See data table – spreadsheets for more information

Monitoring equipment	**Equipment 1:** Infrared methane concentration meter Beacon 110, Serial B110-11Z004, Sensor 65-1011RK CH4 Serial 7551 Calibration frequency: Annual (According to the suggestion made by the manufacturer) Precision: ± 5%, reading ± 2% complete scale Date of installation: 27/06/2012 Calibration records:

Date of calibration	Certificate´s code	Company Certificate	Next due calibration
Calibration 1: 08/12/2011	N.A	RKI	07/12/2012
Calibration 2: 01/06/2012	1661	HIGIELECTRONIX LTDA	31/05/2013
Calibration 3: 22/10/2012	2013	HIGIELECTRONIX LTDA	21/10/2013
Calibration 4: 24/07/2013	3198	HIGIELECTRONIX LTDA	23/07/2014
Calibration 5: 29/04/2014	HX-CC-MG-1878	HIGIELECTRONIX LTDA	28/04/2015
Calibration 6: 14/05/2015	HX-CC-MG-3269	HIGIELECTRONIX LTDA	13/05/2016

Equipment 2:

Infrared methane concentration meter

Beacon 110, Serial M2A49903

Calibration frequency: Annual (According to the suggestion made by the manufacturer)

Precision: ± 5%, reading ± 2% complete scale

Date of installation: 29/04/2015

Calibration records:

Date of calibration	Certificate´s code	Company Certificate	Next due calibration
Calibration 1: 13/11/2014	HX-CC-MG-2471	HIGIELECTRONIX LTDA	12/11/2015

<table>
<tr><td></td><td><u>Equipment 3:</u>
Infrared methane concentration meter
Beacon 110, Serial HX-MGF-001
<u>Calibration frequency:</u> Annual (According to the suggestion made by the manufacturer)
<u>Precision:</u> ± 5%, reading ± 2% complete scale
<u>Date of installation:</u> 10/12/2015
<u>Calibration records:</u>
<table>
<tr><th>Date of calibration</th><th>Certificate´s code</th><th>Company Certificate</th><th>Next due calibration</th></tr>
<tr><td>Calibration 1: 04/12/2015</td><td>HX-CC-MG-4154</td><td>HIGIELECTRONIX LTDA</td><td>03/12/2016</td></tr>
</table></td></tr>
<tr><td>Measuring/
Reading/
Recording frequency</td><td>Continuously Monitored, hourly recording</td></tr>
<tr><td>Calculation method (if applicable)</td><td>Not applicable</td></tr>
<tr><td>QA/QC procedures</td><td>Quality Assurance: given by the equipment manufacturer. The data is stored digitally in the SCADA. The meter is operated and calibrated according to the manufacturer’s specifications
Calibration: The instrument is calibrated according to manufacturer’s recommendations within one year
Preventive Maintenance: - Routine maintenance will be made to the instrument.
Meter general technical specifications:
Precision: ± 5% reading ± 2% complete scale
Due to calibration delay in the measurement equipment Serial 7551, during the period 29/04/2015 - 13/05/2015 the maximum error of the equipment was applied as discount factor (5%) in accordance with paragraph 366 of the CDM Validation and verification standard.</td></tr>
<tr><td>Purpose of data/parameter</td><td>Calculation of baseline emissions</td></tr>
<tr><td>Additional comments</td><td>Recording Frequency: Continuously.
Data record: Electronic for crediting period + 2 years</td></tr>
</table>

Data / Parameter	$FV_{RG,h}$:
Unit	Nm^3/h
Description	Volumetric flow rate of biogas fed into flares
Measured/ Calculated / Default	Measured
Source of data	Continuous flow meter. The measurement location is shown in Figure 5. Measurement Point 2.
Value(s) of monitored parameter	Total amount of biogas fed into flares during this Monitoring Period: **4,199,498.86 m^3** See data table – spreadsheets for more information.
Monitoring equipment	**Equipment 1:** Endres+Hauser Thermal dispersion mass flow meter Serial Number D907E202000 Calibration frequency: Every 5 years (According to the suggestion made by the manufacturer). Precision: ± 1% of reading, ± 0.5% of complete scale Date of installation: 08/01/2011 Calibration records: Cal. Certificate: 1000122896, issued by Endress+Hauser Dated on: 18/10/2010, valid until: 17/10/2015 **Equipment 2:** Endres+Hauser Thermal dispersion mass flow meter Serial Number F6103A02000 Calibration frequency: Every 5 years (According to the suggestion made by the manufacturer). Precision: ± 1% of reading, ± 0.5% of complete scale Date of installation: 14/07/2015 Calibration records: Cal. Certificate: 100192497, issued by HIGIELECTRONIX LTDA Dated on: 27/06/2012, valid until: 26/06/2017
Measuring/ Reading/ Recording frequency	Continuously monitored and hourly accumulated recording
Calculation method (if applicable)	Not applicable

QA/QC procedures	**Quality Guarantee:** given by the equipment manufacturer. **Calibration:** The instrument is calibrated according to manufacturer's recommendations within five (5) years **Preventive Maintenance:** Routine maintenance will be made to the instrument. **Meter general technical specifications**: Precision: ± 1% reading + 0.5% at complete scale standard precision
Purpose of data/parameter	Calculation of baseline emissions
Additional comments	Recording Frequency: Continuously. Data record: Electronic for crediting period + 2 years

Data / Parameter	T_{flare1}
Unit	°C
Description	Temperature in the exhaust gas of the flares to determine combustion efficiency in flare 1
Measured/ Calculated / Default	Measured
Source of data	Continuous flow meter. Continuous temperature measurement meter by Thermocouple type K The measurement location is shown in Figure 6. Measurement Point 3
Value(s) of monitored parameter	Average value for this Monitoring Period: **652.79 ºC** See data table – spreadsheets for more information.

<table>
<tr><td>Monitoring equipment</td><td>

Equipment 1

Thermocouple Type K

Serial D9002214168

Calibration Frequency: Annual (According to the suggestion made by the manufacturer)

Precision Range: ± 0.75%

Date of installation: 08/01/2011

Calibration records:

- 1st Calibration certificate: TC10-HBA3CDSXCA200, issued by Endress + Hauser

  Dated on 30/09/2010, valid until 29/09/2011
- 2nd Calibration certificate: 1182-C, issued by Metrologic Colombia S.A.S

  Dated on 17/08/2011, valid until 16/08/2012
- 3rd Calibration certificate: 2191-C, issued by Metrologic Colombia S.A.S

  Dated on 19/09/2012, valid until 18/09/2013

Equipment 2

Endres+Hauser Thermocouple Type K

Serial F4004114168

Calibration Frequency: Annual (According to the suggestion made by the manufacturer)

Precision Range: ± 0.75%

Date of installation: 19/09/2013

Calibration records:

Date of calibration	Certificate´s code	Company Certificate	Next due calibration
Calibration 1: 13/07/2012	CA12833	SAYTEC COLOMBIA	12/07/2013
Calibration 2: 19/09/2013	CA-13153	SAYTEC COLOMBIA	18/09/2014
Calibration 3: 31/07/2014	CA-14246	SAYTEC COLOMBIA	30/07/2015
Calibration 4: 04/08/2015	CA-15380	SAYTEC COLOMBIA	03/08/2016

</td></tr>
<tr><td>Measuring/
Reading/
Recording frequency</td><td>Continuously monitored and hourly recording</td></tr>
<tr><td>Calculation method
(if applicable)</td><td>Not applicable</td></tr>
</table>

QA/QC procedures	**Quality Guarantee:** given by the equipment manufacturer. **Calibration:** The instrument is calibrated according to manufacturer's recommendations, every year **Preventive Maintenance:** Routine maintenance will be made to the instrument. **Meter general technical specifications**: Precision: ± 0.75 °C Temperature Ranges: -40°C to 1,200 °C Recording Frequency: Continuously The thermocouple measures the temperature of the exhaust gas flow in the flare. A temperature higher than 500 °C indicates a significant amount of gas still flaring and that the flare is still operating. Due to calibration delay in the measurement equipment F4004114168, during the period 31/07/2015 - 03/08/2015 the maximum error of the equipment was applied as discount factor (0.75%) in accordance with paragraph 366 of the CDM Validation and verification standard.
Purpose of data/parameter	This parameter is used to determine the efficiency in reducing methane in the flares.
Additional comments	Recording Frequency: Continuously. Data record: Electronic for crediting period + 2 years

Data / Parameter	T_{flare2}
Unit	°C
Description	Temperature in the exhaust gas of the flare required to determine the combustion efficiency in flare 2
Measured/ Calculated / Default	Measured
Source of data	Continuous temperature measurement meter by Thermocouple type K. The measurement location is shown in Figure 6. Measurement Point 4
Value(s) of monitored parameter	Average value for this Monitoring Period: **647.74 ºC** See data table – spreadsheets for more information.

Monitoring equipment	**<u>Equipment 1:</u>** Endres+Hauser Thermocouple Type K Serial number D9002314168 Calibration Frequency: Annual (According to the suggestion made by the manufacturer) Precision Range: ± 0.75% Date of installation: 08/01/2011 Calibration records: • 1st Calibration certificate: 2192-C, issued by Metrologic Colombia S.A.S Dated on 19/09/2012, valid until 18/09/2013 • 2nd Calibration certificate: CA 13154, issued by SAYTEC COLOMBIA , Dated on 19/09/2013, valid until 18/09/2014 • 3rd Calibration certificate: CA-15268, issued by SAYTEC COLOMBIA , Dated on 01/06/2015, valid until 31/05/2016
Measuring/ Reading/ Recording frequency	Continuously monitored and daily recording
Calculation method (if applicable)	Not applicable
QA/QC procedures	**Quality Guarantee:** given by the equipment manufacturer. **Calibration:** The instrument is calibrated according to manufacturer's recommendations every year, **Preventive Maintenance:** Routine maintenance will be made to the instrument. **Meter general technical specifications**: Precision: ± 0.75 °C Temperature Ranges: -40°C to 1,200 °C Recording Frequency: Continuously The thermocouple measures the temperature of the exhaust gas flow in the flare. A temperature higher than 500 °C indicates a significant amount of gas still flaring and that the flare is still operating. Due to calibration delay in the measurement equipment D9002314168, during the period 19/09/2014 - 31/05/2015 the maximum error of the instrument used to measure the data (0.75%) is applied in accordance with paragraph 366 of the CDM Validation and verification standard since the calibration was delayed.
Purpose of data/parameter	This parameter is used to determine the efficiency in reducing methane in the flares.
Additional comments	Recording Frequency: Continuously. Data record: Electronic for crediting period + 2 years

Data / Parameter	$FV_{G1,h}$:
Unit	Nm³/h
Description	Volumetric flow rate of biogas fed into the electric generator engine 1
Measured/ Calculated / Default	Measured
Source of data	Volumetric Flow Meter principle of thermal dispersion with continuous measurement. The measurement location is shown in Figure 6. Measurement Point 5.
Value(s) of monitored parameter	Total amount of biogas fed into engine 1 during this Monitoring Period: **0 m³** See data table – spreadsheets for more information.
Monitoring equipment	**Equipment 1** Thermal dispersion mass flow Series Number D907E302000 Calibration Frequency: Every 5 years (According to the suggestion made by the manufacturer) Instrument Accuracy: ± 1% of reading, ± 0.5% of complete scale Date of installation: 08/01/2011 Calibration records: Calibration certificate 1000122896, issued by Endress + Hauser Dated on 18/10/2010, valid until 17/10/2015 **Equipment 2** Thermal dispersion mass flow Series Number F6103B02000 Calibration Frequency: Every 5 years (According to the suggestion made by the manufacturer) Instrument Accuracy: ± 1% of reading, ± 0.5% of complete scale Date of installation: 21/01/2013 Calibration records: Calibration certificate 1000192497, issued by Endress + Hauser Dated on 26-06-2012, valid until 25/06/2017
Measuring/ Reading/ Recording frequency	Continuously monitored and hourly accumulated recording
Calculation method (if applicable)	Not applicable

QA/QC procedures	**Quality Guarantee:** given by the equipment manufacturer. **Calibration:** every 5 years, time specified by the manufacturer for this equipment The instrument is calibrated according to manufacturer's recommendations within five (5) years **Preventive Maintenance:** Routine maintenance will be made to the instrument. **Meter general technical specifications**: Precision: ± 1% reading + 0.5% at complete scale standard precision
Purpose of data/parameter	Calculation of baseline emissions
Additional comments	Recording Frequency: Continuously. Data record: Electronic for crediting period + 2 years

Data / Parameter	$FV_{G2,h}$:
Unit	Nm^3/h
Description	Volumetric flow rate of biogas fed into the electric generator engine 2
Measured/ Calculated / Default	Measured
Source of data	Volumetric Meter principle of thermal dispersion with continuous measurement. The measurement location is shown in Figure 5. Measurement Point 6
Value(s) of monitored parameter	Total amount of biogas fed into engine 2 during this Monitoring Period: **7,725,991.18 m^3** See data table – spreadsheets for more information.

Monitoring equipment	**Equipment 1** Endres+Hauser Thermal dispersion mass fllow meter Series Number E3136B02000 Calibration Frequency: Every 5 years (According to the suggestion made by the manufacturer) Instrument Accuracy: ± 1% of reading, ± 0.5% of complete scale Installation date: 07/07/2011 Calibration records: Calibration certificate 1000136626, issued by Endress + Hauser Dated on 14/04/2011, valid until 13/04/2016 **Equipment 2** Endres+Hauser Thermal dispersion mass fllow meter Series Number D907E302000 Calibration Frequency: Every 5 years (According to the suggestion made by the manufacturer) Instrument Accuracy: ± 1% of reading, ± 0.5% of complete scale Installation date: 21/01/2013 Calibration records: Calibration certificate 1000122896, issued by Endress + Hauser Dated on 18/10/2010, valid until 17/10/2015 **Equipment 3** Endres+Hauser Thermal dispersion mass fllow meter Series Number E3136B02000 Calibration Frequency: Every 5 years (According to the suggestion made by the manufacturer) Instrument Accuracy: ± 1% of reading, ± 0.5% of complete scale Installation date: 03/08/2015 Calibration records: Calibration certificate 1000136626, issued by Endress + Hauser Dated on 14/04/2011, valid until 13/04/2016
Measuring/ Reading/ Recording frequency	Continuously monitored and hourly accumulated recording
Calculation method (if applicable)	Not applicable

QA/QC procedures	**Quality Guarantee:** given by the equipment manufacturer. **Calibration:** every 5 years, time specified by the manufacturer for this equipment The instrument is calibrated according to manufacturer's recommendations within five (5) years **Preventive Maintenance:** Routine maintenance will be made to the instrument. **Meter general technical specifications**: Precision: ± 1% reading + 0.5% at complete scale standard precision
Purpose of data/parameter	Calculation of baseline emissions
Additional comments	Recording Frequency: Continuously. Data record: Electronic for crediting period + 2 years

Data / Parameter	$FV_{H,h}$
Unit	Nm^3/h
Description	Volumetric flow rate of biogas fed into the water heater
Measured/ Calculated / Default	Measured
Source of data	Volumetric Flow Meter principle of thermal dispersion with continuous measurement. The measurement location is shown in Figure 6. Measurement Point 7
Value(s) of monitored parameter	Total amount of biogas fed into water heater during this Monitoring Period: **2,244,206.76 m^3** See data table – spreadsheets for more information.
Monitoring equipment	Endres+Hauser Thermal dispersion mass fllow meter Series Number F2037B02000 Calibration Frequency: Every 5 years (According to the suggestion made by the manufacturer) Instrument Accuracy: ± 1% of reading, ± 0.5% of complete scale Installation date: 18/05/2012 Calibration records: Calibration certificate 1000172915, issued by Endress + Hauser Dated on 07/02/2012, valid until 06/02/2017
Measuring/ Reading/ Recording frequency	Continuously monitored and hourly accumulated recording
Calculation method (if applicable)	Not applicable

QA/QC procedures	**Quality assurance:** Given by the equipment manufacturer. Additionally, the monitoring of the flow meter is automatically computerized and supported by special software. The monitoring data are saved digitally in SCADA (Control and Acquisition Data System) **Quality control:** -**Calibration:** The instrument is calibrated regularly in accordance with the manufacturer's recommendations no later than five (5) years. - **Maintenance:** Routine maintenance of the instrument is performed. - The WWTP-C will undertake the statistical control of each parameter monitored and used for the calculation of the GHG emission reductions of a given CDM project.
Purpose of data/parameter	Calculation of baseline emissions
Additional comments	Recording Frequency: Continuously. Data record: Electronic for crediting period + 2 years

Data / Parameter	$fv_{CH4,H\ h}$
Unit	μV/V
Description	Volumetric fraction of methane in biogas combusted in water heater
Measured/ Calculated / Default	Measured
Source of data	Continuous measuring meter with infrared. The measurement location is shown in Figure 5. Measurement Point 8
Value(s) of monitored parameter	Average value for this Monitoring Period: **63.63%** See data table – spreadsheets for more information.

Monitoring equipment	**Equipment 1 (Portable)** Sewerin Multitec 540 (portable) Infrared methane concentration meter Serial Number: 06611000335 Calibration frequency: as suggested by the manufacturer (every year). Precision Range: ± 5% reading, ± 2% at complete scale. Operation period: 27/06/2012 until 28/08/2012 Calibration records: Cal. Certificate SRCC11-148, Issued by Revicol Ltda Dated on 18/11/2011, valid until 17/11/2012 **Equipment 2** RKI Infrared Beacon B110 methane concentration meter Serial Number: B110-128015 Calibration frequency: as suggested by the manufacturer (every year). Precision Range: ± 5% reading, ± 2% at complete scale. Date of installation: 28/08/2012 Calibration records: Cal. Certificate 72-2110RK-02, Issued by RKI Instruments Dated on 17/08/2012, valid until 16/08/2013 **Equipment 3** RKI Infrared Beacon B110 methane concentration meter Serial Number: C-7743-S-7719 Calibration frequency: as suggested by the manufacturer (every year). Precision Range: ± 5% reading, ± 2% at complete scale. Date of installation: 20/11/2014 Calibration records: Cal. Certificate HX-CC-MG-2588, Issued by RKI Instruments Dated on 13/11/2014, valid until 12/11/2015
Measuring/ Reading/ Recording frequency	Continuously monitored and hourly accumulated recording
Calculation method (if applicable)	Not applicable

QA/QC procedures	**Quality assurance:** Given by the equipment manufacturer. Additionally, the monitoring of the flow meter is automatically computerized and supported by special software. The monitoring data are saved digitally in SCADA (Control and Acquisition Data System) **Quality control:** **-Calibration:** The instrument is calibrated regularly in accordance with the manufacturer's recommendations within one (1) year. **- Maintenance:** Routine maintenance of the instrument is performed. - the WWTP-C will undertake the statistical control of each parameter monitored and used for the calculation of the GHG emission reductions of a given CDM project. Due to calibration delay in the measurement equipment B110-128015, during the period 17/08/2013 – 19/11/2014 the maximum error of the instrument used to measure the data (5%) is applied in accordance with paragraph 366 of the CDM Validation and verification standard since the calibration was delayed. Measurement equipment C-7743-S-7719 was replaced on 26/01/2016 and it has a calibration delay from 13/11/2015 to 31/12/2015 (end date of this second MP). Therefore, it is not possible to check whether the error found would be higher than the maximum permissible error. Following the most conservative approach available, the ERs generated during this gap period has been accounted as 0 tCO_2.
Purpose of data/parameter	Calculation of baseline emissions
Additional comments	Recording Frequency: Continuously. Data record: Electronic for crediting period + 2 years

Data / Parameter	$fv_{CH4,G\ h}$
Unit	μV/V
Description	Volumetric fraction of methane in biogas combusted into the electric generator engine
Measured/ Calculated / Default	Measured
Source of data	Continuous measuring meter with infrared. The measurement location is shown in Figure 5. Measurement Point 9
Value(s) of monitored parameter	Average value for this Monitoring Period: **62.26 %** See data table – spreadsheets for more information.

Monitoring equipment	**Equipment 1** ATI Infrared D12-IR-3-1-1 methane concentration meter Serial Number C10-IR-501 Calibration frequency: Annual (as suggested by the manufacturer). Precision Range: ± 5% read ± 2% full scale Date of installation: 07/04/2011 Calibration records: • Calibration certificate 84319 issued by Analytical Technology Inc Dated on 15/02/2011, valid until 14/02/2012 • Calibration certificate 17092013 issued by PROGEN S.A Dated on 17/09/2013, valid until 16/09/2014 • Calibration certificate 14-028 issued by PROGEN S.A Dated on 23/04/2015, valid until 22/04/2016
Measuring/ Reading/ Recording frequency	Continuously monitored and hourly average recorded
Calculation method (if applicable)	Not applicable
QA/QC procedures	**Quality assurance:** Given by the equipment manufacturer. Additionally, the monitoring of the flow meter is automatically computerized and supported by special software. The monitoring data are saved digitally in SCADA (Control and Acquisition Data System) **Quality control:** **-Calibration:** The instrument is calibrated regularly in accordance with the manufacturer's recommendations. **- Maintenance:** Routine maintenance of the instrument is performed. - The WWTP-C will undertake the statistical control of each parameter monitored and used for the calculation of the GHG emission reductions of a given CDM project Due to calibration delay in the measurement equipment C10-IR-501, during the period 01/11/2012 - 17/09/2013 the maximum error of the instrument used to measure the data (5%) is applied in accordance with paragraph 366 of the CDM Validation and verification standard since the calibration was delayed. Due to calibration delay in the measurement equipment C10-IR-501, during the period 17/09/2014 - 22/04/2015 the maximum error of the instrument used to measure the data (5%) is applied in accordance with paragraph 366 of the CDM Validation and verification standard since the calibration was delayed.
Purpose of data/parameter	Calculation of baseline emissions
Additional comments	Recording Frequency: Continuously. Data record: Electronic for crediting period + 2 years

Data / Parameter	η_{flare}
Unit	%
Description	Flare Efficiency
Measured/ Calculated / Default	Continuously calculated
Source of data	Continuously calculated from the temperature of the flares
Value(s) of monitored parameter	Average value for this Monitoring Period: **90%** See data table – spreadsheets for more information.
Monitoring equipment	Not applicable
Measuring/ Reading/ Recording frequency	Continuously monitored and hourly recording

Calculation method (if applicable)	One of the two following options shall be used to determine the efficiency of the flaring process in an enclosed flare: (a) To adopt a 90% default value, or (b) To perform a continuous monitoring of the efficiency. According to the methodological “Tool to determine project emissions from flaring gases containing methane”, in case of enclosed flares and use of the default value for the flare efficiency (90%), the flare efficiency in the hour h ($\eta_{flare,h}$) is: • 0% if the temperature in the exhaust gas of the flare (T_{flare}) is below 500°C for more than 20 minutes during the hour h • 50% if the temperature in the exhaust gas of the flare (T_{flare}) is above 500°C for more than 40 minutes during the hour h, but the manufacturer’s specifications on proper operation of the flare (biogas flow higher than the minimum flow of 110 Nm^3/h and methane fraction higher than the minimum value of 20%) are not met at any point in the time during the hour h • 90% if the temperature in the exhaust gas of the flare (T_{flare}) is above 500°C for more than 40 minutes during the hour h and the manufacturer’s specifications on proper operation of the flare (biogas flow higher than the minimum flow of 110 Nm^3/h and methane fraction higher than the minimum value of 20%) are met continuously during the hour h. The manufacturer´s specifications of proper operation of the flare (biogas flow higher than the minimum flow of 110 Nm^3/h and methane fraction higher than the minimum value of 20%) have been determined using the technical specifications of the equipment provided by the project owner and the “Guidance on Landfill Gas Flaring” (www.environment-agency.gov.uk). As the flare system used by the project is manufactured in UK according to the technical specifications, this type of flare must follow the technical guidelines and recommendations stablished by the Environmental Agency of UK. The minimum biogas flow has been conservatively determined using the maximum biogas flow as per manufacturer specifications (550 Nm^3/h) and the guidelines from the UK Environmental Agency for Landfill Gas Flaring. This guideline establishes the turn-down ratio (ratio of minimum gas flow to maximum gas flow under which satisfactory operating conditions will be maintained) in 5:1 or 4:1 so in the case of the flare system used in this project is 110 Nm^3/h, using the turn-down ratio of 5:1 as the most used in the sector. In the case of the methane content in the biogas, the guideline stablishes a range of methane concentrations of around 20–60% by volume for a flare operating under good and safe combustion conditions so the value of 20% for methane concentration has been selected as the minimum value for optimal combustion conditions.
QA/QC procedures	Not applicable
Purpose of data/parameter	Calculation of baseline emissions
Additional comments	Recording Frequency: hourly. Data record: Electronic for crediting period + 2 years

Data/Parameter	**ECy**
Unit	MWh
Description	Grid electricity consumption in year "y"
Measured/calculated/ default	Calculated
Source of data	Monitoring consists of metering the number of hours of operating of the equipment that consumes electricity: flare 1, flare 2 and water heater.
Value(s) of monitored parameter	Total quantity of electricity consumed by the project activity during this monitoring period: **146 MWh**
Monitoring equipment	Not applicable. The calculation to determine the electricity consumption is based on the monitoring performed by the Thermocouple type K in the case of the flares operation and the Endres+Hauser Thermal dispersion mass flow meter in the case of water heater operation.
Measuring/reading/recording frequency	Continuously monitored and hourly recording
Calculation method (if applicable)	The method to determine the operation of the operational hours of the flare 1 and flare 2 that consumes electricity would be: • $Op_{flare1\ and\ 2}$=0 when temperature in the exhaust gas of the flares required to determine the combustion efficiency in flare 1 and 2 is below 500ºC. • $Op_{flare1\ and\ 2}$=1 when temperature in the exhaust gas of the flares required to determine the combustion efficiency in flare 1 and 2 is higher than 500ºC The method to determine the operation of the operational hours of the water heater that consumes electricity would be: • $Op_{water\ heater}$=0 when the volumetric flow of biogas fed into the water heater is zero. • $Op_{water\ heater}$=1 when the volumetric flow of biogas fed into the water heater is above zero. Once determined the operational hours of the equipment, the nameplate capacity of the equipment is multiplied by the operational hours to determine the electricity consumption.
QA/QC procedures	Not applicable
Purpose of data/parameter	Calculation of project emissions from electricity consumption in the year y (t CO2e)
Additional comments	In order to be conservative it will be considered that the flares and the water heater will be operating using 100% electricity from the national grid. This approach is conservative since the internal electricity is produced with biogas, thus, emission factor of zero.

Data/Parameter	EF
Unit	tCO_2/MWh
Description	Grid emission factor
Measured/calculated/ default	Calculated
Source of data	Grid emission factor of the National interconnected System calculated in accordance with AMS.I.D or using data published by UPME (Energy and Mining Unit of Colombia) for the relevant year.
Value(s) of monitored parameter	Year 2012: **0.13853 tCO_2/MWh** Year 2013: **0.21038 tCO_2/MWh** Year 2014: **0.21944 tCO_2/MWh** Year 2015: **0.24422 tCO_2/MWh**
Monitoring equipment	Not applicable
Measuring/reading/recording frequency	The value will be calculated for the year in which the electricity consumption occurs.

Calculation method (if applicable)	Calculated as the weighted average in accordance with the applied methodology AMS-I.D
QA/QC procedures	Not applicable
Purpose of data/parameter	Calculation of project emissions in case that electricity consumption is produced in the plant.
Additional comments	Data record: Electronic for crediting period + 2 years

D.3. Implementation of sampling plan

Not applicable

SECTION E. Calculation of emission reductions or net anthropogenic removals

E.1. Calculation of baseline emissions or baseline net removals

In accordance with the approved monitoring methodology AMS III.H Methane recovery in wastewater treatment (Version 09, Scope 13, Mar 28, 2008), and approved PDD baseline emissions consist of:

$BE_h = MEP_{h,s,treatment} * GWP_{CH4}$

Where:

$MEP_{h,s,treatment}$: Methane emission potential of the sludge treatment system in hour “h”

On PDD the theoretical method employed to **estimated** the future production methane was:

$MEP_{h,s,treatment} = S_{h,untreated} * DOC_{h,s,untreated} * DOC_F * F * 16/12 * MCF_{s,treatment}$

However, according to the paragraph 34 of the methodology AMS III.H Methane recovery in wastewater treatment (Version 09), for the cases of (ii) introduction of anaerobic sludge treatment with methane recovery and combustion to untreated sludge; (iii) and (iv) introduction of methane recovery and combustion unit to an existing anaerobic wastewater or sludge treatment system, and (vi) introduction of a sequential stage of wastewater treatment with methane recovery and combustion to an existing wastewater treatment, the calculation of emission reductions shall be based on the amount of methane recovered and fuelled or flared, that is monitored ex-post. In the case of the project activity, it consists of the introduction of methane recovery and combustion to an existing sludge treatment system (iii). In this case, as per paragraph 36 of the methodology AMS III.H (Version 09), the amount of methane recovered, fuelled, flared or utilized (electricity and heat generation) shall be monitored ex-post, using continuous flow meters and the fraction of methane in the gas should be measured with a continuous analyser. Additionally, according to paragraph 38 of the methodology AMS III.H (Version 09), regular maintenance should ensure optimal operation of flares. The flare efficiency, defined as the fraction of time in which the gas is combusted in the flare, multiplied by the efficiency of the flaring process, shall be monitored.

Thus, for the **real** calculation during MP, the parameter $MEP_{h,s,treatment}$ is calculated according to the following formula based on monitoring parameters:

$MEP_{h,s,treatment} = (FV_{RG,h}*fv_{CH4,FG,h} + FV_{H,h}* fv_{CH4,H,h} + (FV_{G1,h}+FV_{G2,h}) * fv_{CH4,G,h}) * D_{CH4}$

Therefore, the final formula for the MR is:

$BE_h = (FV_{RG,h} * fv_{CH4,FG,h} * \eta_{flare}) + FV_{H,h} * fv_{CH4,H,h} + (FV_{G1,h} + FV_{G2,h}) * fv_{CH4,G,h}) * D_{CH4} * GWP_{CH4}$

$fv_{CH4,FG,h}$: Average volumetric fraction of methane in biogas (µV/V) combusted in flares (µV/V)

$FV_{RG,h}$: Volumetric biogas flow rate carried for combustion in the flare (m^3/h)

η_{flare}: Flare efficiency (%). Both flare efficiencies, for flare 1 and flare 2, are considered in the calculation of η_{flare} depending on if only one flare is in operation (flare 1 or flare 2 efficiency is considered only) or both flares are in operation (the minimum value of efficiency is considered between flare 1 and flare 2 in order to be conservative if both values are different to 0%, for example if Flare 1 efficiency is 50% and flare 2 efficiency is 90%, 50% value is multiplied, if both flares are in operation and both flares have the same flare efficiency, the common efficiency value is used).Thus, in the case Flare 1 is in operation only, flare 1 efficiency is multiplied (0%, 50% or 90%), in the case Flare 2 is in operation only, flare 2 efficiency is multiplied (0%, 50% or 90%) in the case of both flares are in operation (flare 1 and flare 2), if the efficiency of both flares is the same, the value used for flare efficiency is the common value of both (0%, 50% or 90%), if both flares in operation have efficiencies different to 0% and are not the same, the minimum efficiency between both is used (50% or 90%). If both flares efficiencies are 0% or both flares are in operation, the value used is 0.

T_{flare} Temperature in the exhaust gas of the flares (K/°C)

$FV_{G,h}$: Volumetric biogas flow rate carried to the engines of the electric generators (m^3/h)

$FV_{H,h}$ Volumetric biogas flow rate carried for combustion in water heater (m3/h)

$fv_{CH4,H,h}$: Average volumetric fraction of methane in biogas combusted in water heater (µV/V).

$fv_{CH4,G,h}$: Average volumetric fraction of methane in biogas fed into the engines of the electric generators (µV/V)

D_{CH4} Methane Density (kg/Nm^3)

GWP_{CH4} Methane Global Warming Potential

For example, in 23/02/2013 at 19:00 PM, in the baseline the data reported is the following:

Paramater	Unit	Value
(1) Volumetric fraction of methane in biogas fed into flares (fvCH4,FG,h)	**µ V/V**	60.00
(2) Volumetric flow rate of biogas fed into flares (FVRG,h)	**m^3/h**	991.27
Operation of flare 1 (Op,flare1)	**0-1**	1 (In operation)
Operation of flare 2 (Op,flare2)	**0-1**	1 (In operation)

Temperature in the exhaust gas of the flare required to determine the combustion efficiency in flare 1 (Tflare1)	**°C**	657.38
Temperature in the exhaust gas of the flare required to determine the combustion efficiency in flare 2 (Tflare2)	**°C**	654.74
Flare 1 efficiency (η_{flare},flare1)	**%**	90
Flare 2 efficiency (η_{flare},flare2)	**%**	90
(7) Volumetric flow rate of biogas fed into the water heater (FVH,h)	**m^3/h**	0.00
(11) Volumetric fraction of methane in biogas combusted in water heater (fvCH4,H,h)	**μ V/V**	60.00
(12) Volumetric fraction of methane in biogas fed into the electric generator engine (fvCH4,G,h)	**μ V/V**	58.90
(5) Volumetric flow rate of biogas fed into the electric generator engine 1 (FVG1,h)	**m^3/h**	0.00
(6) Volumetric flow rate of biogas fed into the electric generator engine 2 (FVG2,h)	**m^3/h**	0.00
Baseline Emissions (BE)	tCO_2e	9.582

In the example indicated above, both flares (flare 1 and flare 2) are in operation to attend the biogas flow and in both flares the “temperature in the exhaust gas of the flare required to determine the combustion efficiency” are higher than 500ºC (tool condition). Additionally, the manufacturer conditions are met as biogas flow is higher than 110 Nm^3/h (minimum biogas flow as per technical recommendations of the equipment), and methane concentration is higher than 20% (minimum methane concentration as per technical recommendations of the equipment). Thus, according the “Tool to determine project emissions from flaring gases containing methane”, the value used for flare efficiency is 90%.

The flow meter used in the project measure instantaneous flow in m^3/h. The SCADA (Data Control and Acquisition System) of the WWTP-C records the data every 30 seconds and calculates the flow passed in those 30 seconds and accumulates it at the time. That is, the SCADA performs the hour calculation (the total volume of biogas that circulates during every complete hour, in m^3), which is the data used in the ER Calculation spreadsheet to calculate the emissions reductions.

The actual baseline emissions for the reporting period is **147,098 tCO_2.**

E.2. Calculation of project emissions or actual net removals

In accordance with the approved monitoring methodology AMS III.H Methane recovery in wastewater treatment (Version 09, Scope 13, March 28, 2008), project activity emissions consist of:

$$PE_h = PE_{h,power} + PE_{h,ww,treated} + PE_{h,s,final} + PE_{h,fugitive} + PE_{h,dissolved} + PE_{h,upgrading} + PE_{h,leakage,pipeline}$$

Where:

PE_h	Project activity emissions in the hour "h" (tCO2e)
$PE_{h,power}$	Emissions from electricity from the grid in the hour "h"
$PE_{y,ww,treated}$	Emissions from degradable organic carbon in treated wastewater in the hour "h"
$PE_{h,s,final}$	Emissions from anaerobic decay of the final sludge produced in the hour "h"
$PE_{h,fugitive}$	Emissions from methane release in capture and utilization/combustion/flare systems in the hour "h"
$PE_{h,dissolved}$	Emissions from dissolved methane in treated wastewater in the hour "h"
$PE_{h,upgrading}$	Emission related to the upgrading and compression of biogas in the hour "h"
$PE_{h,leakage,pipeline}$	Emission due to the physical leakage from the dedicated piped network in the hour "h"

Relevant to the proposed project activity is the following formula:

$$PE_h = PE_{h,power} + PE_{h,fugitive}$$

The reasons for leaving out other formula components are:

$PE_{h,ww,treated}$	Introduction of a recovery and combustion to an existing sludge treatment system does not changes the amount of methane produced per unit of COD removed. Having the aforementioned in mind, the content of degradable organic carbon in treated wastewater is expected to be the same in the baseline as in the project activity and therefore, this term is not relevant for further calculations.
$PE_{h,s,final}$	Introduction of a recovery and combustion to an existing sludge treatment system does not changes the amount of methane produced per unit of COD removed. Having the aforementioned in mind, the amount and characteristics of the sludge produced in the baseline scenario will not change in the proposed project activity and therefore, this term is not relevant for further calculations.
$PE_{h,dissolved}$	Introduction of a recovery and combustion to an existing sludge treatment system does not changes the amount of methane produced per unit of COD removed. Having the aforementioned in mind, the amount and characteristics of methane dissolved in treated wastewater in the baseline scenario will not change in the proposed project activity and therefore, this term is not relevant for further calculations.

$PE_{h,upgrading}$ The recovered methane is not upgraded for bottling, therefore, this term is neglected.

$PE_{h,leakage,pipeline}$ There are no emission due to the physical leakage from the dedicated piped network for transport of upgraded biogas to the end users in the proposed project activity, therefore, this term is not relevant for further calculations

$$\mathbf{PE_{h,fugitive} = PE_{y,fugitive,ww} + PE_{y,fugitive,s}}$$

Where:

$PE_{h,fugitive,ww}$ Fugitive emissions through capture and utilization/combustion/flare inefficiencies in the anaerobic wastewater treatment in year "y" (tCO2e)

$PE_{h,fugitive,s}$ Fugitive emissions through capture and utilization/combustion/flare inefficiencies in the anaerobic sludge treatment in year "y" (tCO2e) .

As the recovery and combustion will be introduced only to an existing anaerobic sludge treatment system, the emissions will be associated only to the fugitive emissions from the capture and utilization/combustion/flare inefficiencies in this system. There will be no change in the anaerobic wastewater treatment between the baseline and the proposed project activity, therefore, $PE_{y,fugive,ww}$= 0.

The project emissions could be produced only due to the capture and combustion efficiency of the methane recovery system in the sludge treatment.

Nevertheless, this project emissions ($PE_{fugitive,y}$)should be taken into consideration in case that the project activity implies any change in the sludge treatment, which it will not the case. The amount of untreated sludge generated ($S_{y,untreated}$) will be the same than in the baseline scenario, therefore, the potential to generate methane are equal in the baseline and the proposed project activity. For this reason, $MEP_{y,s,treatment}$ is considered zero in the ex post calculations, and therefore, $\mathbf{PE_{y,fugitive,s}}$ is also zero

Therefore, the project emissions in this monitoring period will be due to only the electricity consumption for the project purposes:

$PEh = PE_{h,power}$

$PE_{h,power}$ Emissions from the electricity consumption for the project purposes (electricity consumption for the operation of the flares and water heaters[9]) in the hour "h"

$PE_{h,power} = EC_h * EF_h$

EC_h Grid electricity consumption for the operation of the flares in the hour "h"

EF_h Emission factor for grid electricity in the hour "h"

Grid electricity consumption for the operation of the flares in year "y" will be determined by the measurement of the operation hours of the flares multiplied by the nameplate (installed capacity) of the flare 3.3 kW per each (2.2 kW - gas booster + 1.1 kW – ventilator, according to the technical specification of the equipment). The operational time of the flares will be registered in SCADA, Control and Acquisition Data System for 10+2 years beginning from the start of the project operation – see above the description of the system. Grid electricity consumption for the operation of the water heater in year "y" will be determined by the measurement of the operation hours of the water heater multiplied by the nameplate (installed capacity) of the water heater 10.0 kW (2.5 kW - gas booster + 7.5 kW – ventilator, according to the technical specification of the equipment). The

[9] During this monitoring period the water heaters were not operating using electricity from the grid

operational time of the water heater will be registered in SCADA, Control and Acquisition Data System for 10+2 years beginning from the start of the project operation – see above the description of the system.

For example, in 23/02/2013 at 19:00 PM, in the power consumption project emissions the data reported is the following:

Runtime of flares (Flare1 + Falre2)	**h**	1 / 1
Runtime of heater	**h**	0
Electricity consumption	**KWh**	0.00660
Emission Factor	**tonCO_2/MWh**	0.21038
$PE_{h,power}$	**tonCO_2e**	0.001

Finally, the project emissions are:

$PE_{h,power}$	**tCO_2e**	0.001
Project Emissions (PE)	**tCO_2e**	0.001

Emission factor for the grid electricity is calculated in accordance with the methodology AMS-I.D version 13.0. Option b of the methodology is used, and the grid emission calculation is made as the weighted average emissions (in t CO_2/MWh) of the current generation mix. The data of the year in which project consumption occurs must be used.

Under this option, emission factor is calculated based on the net electricity generation of each power unit and an emission factor for each power unit, as follows:

$$EF = (\Sigma_m EG_{m,y} \times EF_{EL,m,y}) / \Sigma_m EG_{m,y}$$

Where:

EF = Grid emisión factor (tCO_2/MWh)

$EG_{m,y}$ = Net quantity of electricity generated and delivered to the grid by power unit m in year y (MWh)

$EF_{EL,m,y}$ = CO2 emission factor of power unit m in year y (t CO_2/MWh)

m = All power units serving the grid in year y including low-cost/must-run power units

y = The relevant year in which project electricity consumption occurs

In accordance with these calculations, the grid emission factor for the second monitoring period:

	FUEL	kWh	EF (tCO_2/MWh)	tCO_2
TERM	COAL	2,492,621,149	1.0745	2,678,290
	GAS	9,210,959,008	0.5871	5,407,960
	QUEROSENE	450,489	0.8873	400
	COMBUSTOLEO	87,022,341	0.9655	84,022
	ACPM	115,805,262	1.0745	124,431
COGENERATION	BAGASSE	343,857,170	0	0
	GAS	2,789,764	0.5871	1,638
HYDRO	WATER	47,581,709,764	0	0
WIND	WIND	54,854,711	0	0
TOTAL		**59,890,069,658**		8,296,742
GRID EMISSION FACTOR 2012 (tCO_2/MWh)			0.13853	

	FUEL	kWh	EF (tCO_2/MWh)	tCO_2
TERM	COAL	5,526,164,244	1.0745	5,937,794
	GAS	11,541,402,246	0.5871	6,776,216
	QUEROSENE	2,761,489	0.8873	2,450
	COMBUSTOLEO	127,069,325	0.9655	122,688
	ACPM	225,249,826	1.0745	242,028
	JET-A1	1,541,049	1.0615	1,636
COGENERATION	BAGASSE	348,988,035	0	0
	GAS	1,842,423	0.5871	1,082
	COAL	1,153,905	1.0745	1,240
HYDRO	WATER	44,362,790,073	0	0
WIND	WIND	57,624,803	0	0
TOTAL		**62,196,587,420**		13,085,134
GRID EMISSION FACTOR 2013 (tCO_2/MWh)			0.21038	

	FUEL	kWh	EF (tCO_2/MWh)	tCO_2
TERM	COAL	5,630,233,663	1.0745	6,049,616
	GAS	13,007,259,087	0.5871	7,636,853
	JET -A1	8,569,062	1.0615	9,096
	MIX GAS - JET A1	104,392,969	0.8243	86,054
	QUEROSENE	132,610	0.8873	118
	COMBUSTOLEO	112,809,054	0.9655	108,920
	ACPM	180,245,116	1.0745	193,671
COGENERATION	BAGASSE	441,706,783	0	0
	GAS	1,326,318	0.5871	779
	COAL	28,986,535	1.0745	31,146
HYDRO	WATER	44,741,963,398	0	0

WIND	WIND	70,230,298	0	0
TOTAL		**64,327,854,891**		14,116,252
GRID EMISSION FACTOR 2014 (tCO_2/MWh)			0.21944	

	FUEL	kWh	EF (tCO_2/MWh)	tCO_2
TERM	COAL	6,244,982,941	1.0745	6,710,156
	GAS	13,448,743,295	0.5871	7,896,058
	QUEROSENE	44,720,532	0.8873	39,679
	COMBUSTOLEO	490,707,472	0.9655	473,789
	ACPM	1,042,852,750	1.0745	1,120,532
COGENERATION	BAGASSE	513,852,624	0	0
	GAS	1,785,985	0.5871	1,049
	COAL	10,548,517	1.0745	11,334
HYDRO	WATER	44,681,902,367	0	0
WIND	WIND	68,377,448	0	0
TOTAL		**66,548,473,931**		16,252,598
GRID EMISSION FACTOR 2015 (tCO_2/MWh)			0.24422	

E.3. Calculation of leakage emissions

Given that technology used does not imply equipment transferred from another activity, and existing equipment is not transferred to another activity, no leakage must be considered in accordance with applied methodology.

E.4. Calculation of emission reductions or net anthropogenic removals

	Baseline GHG emissions or baseline net GHG removals (t CO_2e)	Project GHG emissions or actual net GHG removals (t CO_2e)	Leakage GHG emissions (t CO_2e)	GHG emission reductions or net anthropogenic GHG removals (t CO_2e)			
				Before 01/01/2013	From 01/01/2013 until 31/12/2020	From 01/01/2021	Total amount
Total	147,098	31	-	4,779	142,288	0	147,067

E.5. Comparison of emission reductions or net anthropogenic removals achieved with estimates in the registered PDD

Amount achieved during this monitoring period (t CO_2e)	Amount estimated ex ante for this monitoring period in the PDD (t CO_2e)
147,067	186,648

The monitoring period from 01/11/2012 to 31/12/2015 (1,156 days) is *ex-ante* calculated in accordance with the registered PDD.

Total number of days of the 2nd monitoring period:

61 days (01/11/2012 – 31/12/2012) + 365 days (01/01/2013-31/12/2013) + 365 days from (01/01/2014 - 31/12/2014) + + 365 days from (01/01/2015 -31/12/2015) = 1,156 days

E.5.1. Explanation of calculation of "amount estimated ex ante for this monitoring period in the PDD"

Below is the table used for the calculation of the amount estimated ex ante for this monitoring period in the PDD. These calculations can be found in the Excel spreadsheet used for the ERs calculations *("(041021) ER Calc_2341_01-11-2012_31-12-2015")*.

Item		Actual values achieved during this monitoring period	Values estimated in ex-ante calculation of registered PDD
Year 2012	*From*	01/11/2012	01/01/2012
	To	31/12/2012	31/12/2012
	Days	61	365
	Emission reductions or GHG removals by sinks (t CO_2e)	4,779	57,693
	tCO2e/day	**78.40**	**158.06**
Year 2013	*From*	01/01/2013	01/01/2013
	To	31/12/2013	31/12/2013
	Days	365	365
	Emission reductions or GHG removals by sinks (t CO_2e)	41,729	58,570
	tCO2e/day	**114.34**	**160.47**
Year 2014	*From*	01/01/2014	01/01/2014
	To	31/12/2014	31/12/2014
	Days	365	365
	Emission reductions or GHG removals by sinks (t CO_2e)	59,980	59,184
	tCO2e/day	**164.35**	**162.15**
Year 2015	*From*	01/01/2015	01/01/2015
	To	31/12/2015	31/12/2015
	Days	365	365

	Emission reductions or GHG removals by sinks (t CO_2e)	40,579	59,272
	tCO2e/day	**111.23**	**162.46**

E.6. Remarks on increase in achieved emission reductions

The amount of ERs estimated ex ante as per PDD was 186,648 t CO_2e, compared with the 147,067 t CO_2e obtained during this monitoring period. Therefore, there is an issuance success of 79% compared with the PDD values.

E.7. Remarks on scale of small-scale project activity

As per the applied methodology "*Methane recovery in wastewater treatment. Version 9.0*", measures are limited to those that result in aggregate emission reductions of less than or equal to 60 kt CO_2 equivalent annually from all type III components of the project activity.

As can be seen in section E.5.1, the actual net Emission Reductions achieved annually during this second Monitoring Period (and the annual ERs estimated ex-ante as per PDD for this Monitoring Period) are in all the cases bellow the maximum limit indicated by the methodology:

ERs estimated ex-ante for the year 2012 **Actual net ERs achieved during the period 01/11/2012 – 31/12/2012**	57,693 tCO_2eq 4,779 tCO_2eq
ERs estimated ex-ante for the year 2013 **Actual net ERs achieved during 2013**	58,570 tCO_2eq 41,729 tCO_2eq
ERs estimated ex-ante for the year 2014 **Actual net ERs achieved during 2014**	59,184 tCO_2eq 59,980 tCO_2eq
ERs estimated ex-ante for the year 2015 **Actual net ERs achieved during 2015**	59,272 tCO_2eq 40,579 tCO_2eq

This demonstrates that the combined scale of the activities belonging to the same small-scale project type (Type III) remains under the limit of that type every year during the first monitoring period, and no cap of the GHG emission reductions is needed.

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Document information

Version	Date	Description
09.0	8 October 2021	Revision to: • Ensure consistency with version 03.0 of the “CDM project standard for project activities” (CDM-EB93-A04-STAN).
08.0	6 April 2021	Revision to: Reflect the “Clarification: Regulatory requirements under temporary measures for post-2020 cases” (CDM-EB109-A01-CLAR).
07.0	31 May 2019	Revision to: • Ensure consistency with version 02.0 of the “CDM project standard for project activities” (CDM-EB93-A04-STAN); • Add a section on remarks on the observance of the scale limit of small-scale project activity during the crediting period; • Add "changes specific to afforestation or reforestation project activity" as a possible post-registration changes; • Clarify the reporting of net anthropogenic GHG removals for A/R project activities between two commitment periods; • Make editorial improvements.
06.0	7 June 2017	Revision to: • Ensure consistency with version 01.0 of the “CDM project standard for project activities” (CDM-EB93-A04-STAN); • Make editorial improvements.
05.1	4 May 2015	Editorial revision to correct version numbering.
05.0	1 April 2015	Revisions to: • Include provisions related to delayed submission of a monitoring plan; • Provisions related to the Host Party; • Remove reference to programme of activities; • Overall editorial improvement.
04.0	25 June 2014	Revisions to: • Include the Attachment: Instructions for filling out the monitoring report form (these instructions supersede the "Guideline: Completing the monitoring report form" (Version 04.0)); • Include provisions related to standardized baselines; • Add contact information on a responsible person(s)/ entity(ies) for completing the CDM-MR-FORM in A.6 and Appendix 1; • Change the reference number from *F-CDM-MR* to *CDM-MR-FORM*; • Editorial improvement.
03.2	5 November 2013	Editorial revision to correct table in page 1.

Version	*Date*	*Description*
03.1	2 January 2013	Editorial revision to correct table in section E.5.
03.0	3 December 2012	Revision required to introduce a provision on reporting actual emission reductions or net GHG removals by sinks for the period up to 31 December 2012 and the period from 1 January 2013 onwards (EB 70, Annex 11).
02.0	13 March 2012	Revision required to ensure consistency with the "Guidelines for completing the monitoring report form" (EB 66, Annex 20).
01.0	28 May 2010	EB 54, Annex 34. Initial adoption.

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