



**Monitoring report form for CDM project activity
(Version 06.0)**

Complete this form in accordance with the instructions attached at the end of this form.

MONITORING REPORT

Title of the project activity	Sogamoso Hydroelectric Project	
UNFCCC reference number of the project activity	10236	
Version number of the PDD applicable to this monitoring report	Version 08	
Version number of this monitoring report	Version 01	
Completion date of this monitoring report	18/12/2017	
Monitoring period number	First monitoring period	
Duration of this monitoring period	Monitoring period: 15/06/2016 - 14/06/2017	
Monitoring report number for this monitoring report	First Monitoring Report	
Project participants	ISAGEN S.A. E.S.P. PricewaterhouseCoopers Asesores Gerenciales Ltda.	
Host Party	Colombia	
Sectoral scopes	Sectoral scopes 1 : Energy industries (renewable - / nonrenewable sources)	
Applied methodologies and standardized baselines	The ACM0002- version 16.0 "Grid-connected electricity generation from 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
	0 tCO ₂ e	1,141,595 tCO ₂ e ¹
Amount of GHG emission reductions or net anthropogenic GHG removals estimated ex ante for this monitoring period in the PDD	1,386,355 tCO ₂ e/year	

¹ Corresponding to the period evaluated - 365 days

SECTION A. Description of project activity

A.1. General description of project activity

The Sogamoso Hydroelectric Project (hereafter referred to as the "Project") developed by ISAGEN S.A. E.S.P. (hereafter referred to as ISAGEN) is a reservoir based hydropower project located in the Santander Department of the Republic of Colombia (hereafter referred to as the "Host Country") with a maximum total installed capacity of 874.8 MW² comprised of three Francis turbines. The Project utilizes the hydrological resources of the Sogamoso River to generate low emissions electricity for the grid.

The project began its commercial operation in December 1st 2014, contributing to sustainable development of the Host Country, Colombia, specifically in the following aspects:

▪ General Aspects

- The Project launched various investment programs and employment opportunities contributing to the socio-economic development of the nearby municipalities and the Department.
- Through the "Community Information and Participation Program", the Project contributes to the formation of the participative and self-advocating communities.
- The Project matches the criteria and guidelines established by the WCD about policies and corporate expressions of social responsibility.
- The Project contributes to the protection of natural environment of the Sogamoso river basin and the restoration, conservation and protection of the Natural National Park *Serranía de Los Yariguies*³, among other programs.

- **Institutional Strengthening:** This program consists of supporting and strengthening in the provision of services such as health, education, basic sanitation, recreation, security and other aspects, which are direct competence of other government and private entities.

- **Environmental Education:** The Project contributed, during the construction stage, to promote awareness, education and training processes for educational institutions and the population located in the area of influence of the Project, as well as to work's contractors, to establish conscious relationships and proper practices with the environment.

Target groups of this program included 26 educational centers in the area of influence, 18 environmental groups identified in the area, Project's contractors and workers. This program was carried out with *Fundación Natura*. The main activities for this program were:

- i) Support and coordinate activities related to education and environmental management with programs of schools located in the area of influence by strengthening of PRAES (Scholar Environmental Projects, in Spanish)
- ii) Promote through environmental education issues, the development of attitudes, skills and abilities for conservation, protection and proper utilization of natural resources in the communities, by promoting of PROCEDAS (Environmental Education Programs for Citizenships, in Spanish).

- **Improving of health:** Cooperation Agreement signed with the *San Juan de Dios* Hospital in the municipality of *Betulia*, to adequate and equip of the Health Center, located in the area of *Tienda Nueva*.

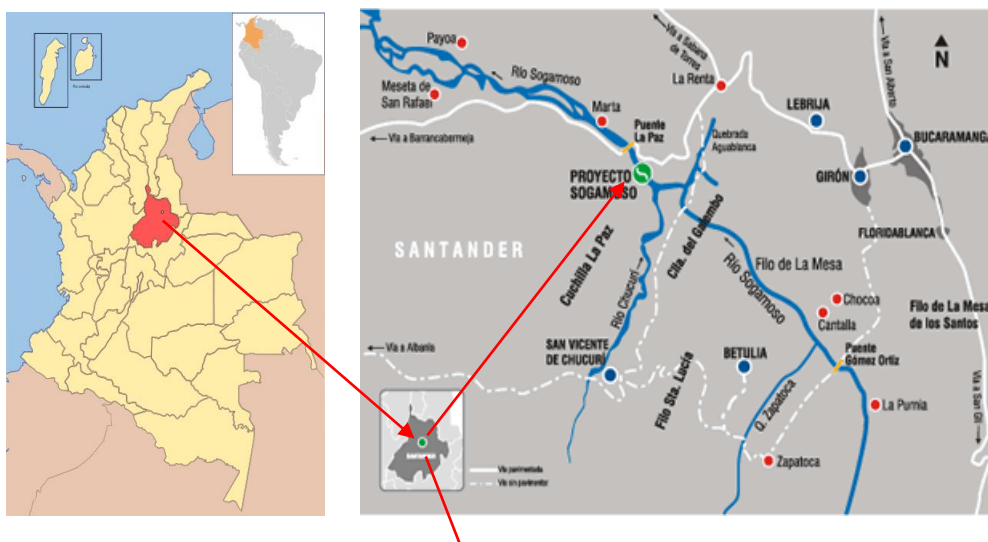
² Installed Capacity

³ *Yariguies* Mountain range is located in the jurisdiction of municipalities of *Betulia*, *Zapatoca*, *Galán*, *El Hato*, *Simacota*, *Chima*, *Contratación*, *Guacamayo*, *Santa Helena*, *Carmen de Chucuri* and *San Vicente de Chucuri*, *Cerro de Armas* in municipality of *Landazuri*; *Cerro de la Paz* and *Cuchilla de Ramos* in the municipality of *Betulia* in the Department of Santander. This program is included in the Investment Plan of 1% approved by the Government.

- **Restitution of roads:** The replacement of some roads and bridges affected by the Project. The roads and bridges were constructed and given to the people for public service in a better condition than they have before building the Project.

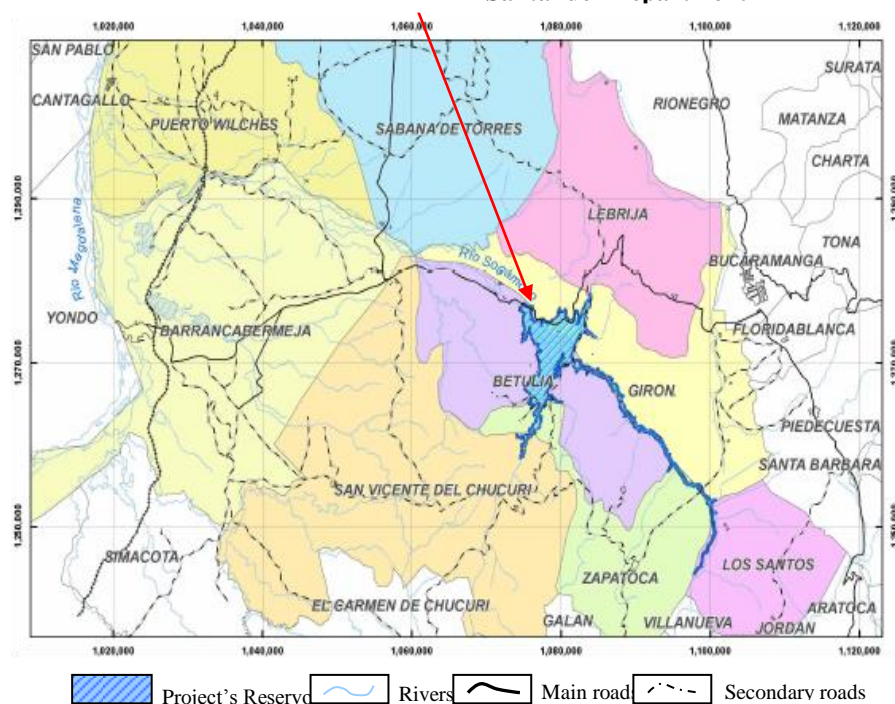
A.2. Location of project activity

The Project is located in the canyon where the Sogamoso River crosses the *La Paz* mountain range, 75 km upstream from the point where the river empties into the *Magdalena* River and 62 km downstream from the confluence of the *Suárez* and *Chicamocha* rivers in the Department of Santander (Colombia). The dam and the reservoir are located into the municipalities of *Girón*, *Betulia*, *Zapatoca*, *Lebrija*, *Los Santos* and *San Vicente de Chucurí*. The Project's coordinates according to Magna Sirgas system are 7° 6' 0.427"N, 73° 24' 26.623"W (See Figure 1).



**Localization of
Santander Department**

**Localization of the Sogamoso Hydroelectric project
in Santander Department**



Project's neighborhood communities

Figure 1. Location project

A.3. Parties and project participants

Parties involved	Project participants	Indicate if the Party involved wishes to be considered as project participant (Yes/No)
ISAGEN S.A E.S.P Republic of Colombia (host)	Project's Owner - Private entity	Yes
PricewaterhouseCoopers Asesores Gerenciales Ltda Republic of Colombia (host)	Consultant - Private entity	Yes

A.4. Reference to applied methodologies and standardized baselines

The ACM0002-version 16.0 “Consolidated baseline methodology for grid-connected electricity generation from renewable sources” large scale, is chosen as the most relevant to the project activity. This methodology, as applied in this project activity, also refers to the approved version of the following Tools: (i) the tool to calculate the emission factor for an electricity system (version 4.0.0)⁴, and (ii) the tool for the demonstration and assessment of additionality (version 7.0.0)⁵.

A.5. Crediting period type and duration

The crediting period is 7 years, type: renewable. From 15/06/2016 to 14/06/2023, (first and last days included). The first monitoring period is from 15/06/2016 - 14/06/2017 (first and last days included).

SECTION B. Implementation of project activity

B.1. Description of implemented project activity

The Project takes advantage of a maximum flow of 630 m³/s distributed in three (3) units of 210 m³/s. The concrete face rock fill dam is 190 m high and 345 m crest length; the crest's level corresponds to 330 meters above sea level. The dam has the spillway on the left side; four gates control the spillway and its discharge channel ends in a ski jump for energy dissipation.

The maximum installed capacity of the Project is 874.8 MW and its registered capacity in the Colombian energy market is 819 MW⁶, which corresponds to the nominal installed capacity that can yield the optimal planned average generation (5,056 GWh per year), according to the technical studies and recommendations made by designer of the Project, INGETEC⁷.

The generation system includes three power units driven by Francis type turbines with a maximum flow of 665 m³/s, and rated flow of 630 m³/s.

According to the last bathymetry study for the Sogamoso reservoir, the total volume is 4,825.04 million of m³, of which 2,756.31 million of m³ corresponds to useful reservoir; flooded area (water mirror) is 6,886 ha, technical parameters that have been reported and approved by the National Operation Council (CNO, in Spanish)⁸.

Each turbine has one three-phase synchronous generator coupled to its axis; the outgoing power from the three generators passes to the three-pole switch-breaker through the isolated phase bar. Next, the power passes to each of the power transformers, which are located in an independent cavern. The power is conducted from the power transformers to the output porch on the surface by power wires.

The power wires make up a set of three-phase circuits at 230 kV, which are connected to the National Transmission System by aerial lines from the output porch on the surface to Sogamoso Substation owned by ISA.

⁴ Website: <https://cdm.unfccc.int/methodologies/DB/EY2CL7RTEHRC9V6YQHLAR6MJ6VEU83>

⁵ Website: <https://cdm.unfccc.int/methodologies/PAmethodologies/tools/am-tool-02-v7.0.pdf>

⁶ CNO Agreement 719, December 21 of 2014

⁷ Power plant's design documentation: INGETEC S.A., Update of tender designs and environmental impact assessment - Sogamoso Hydroelectric Project - Recommendations of installation for the power plant, rev. 1 - June

⁸ CNO Agreement 851, March 03 of 2016

Finally, the power produced in the power plant is delivered to the Grid. The generation works scheme is shown in the following figure.

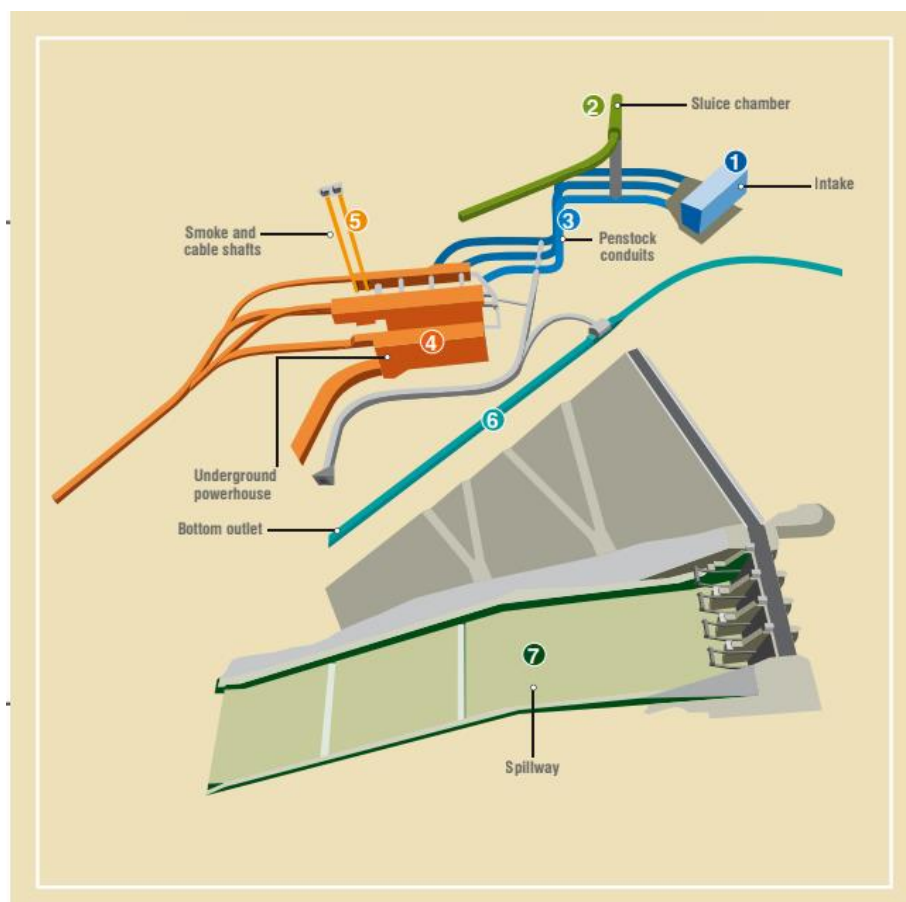


Figure 2. Sogamoso hydroelectric power plant diagram.

The key technical data of the hydro turbines and the generators of the project are listed in Table 1.

Table 1. Technical data of the hydro turbines, generators and electric transformer

Equipment	Specification	Unit	Value
Turbine	Turbine Type	NA	Francis - vertical Axis
	Brand	NA	Andritz Hydro
	Velocity	rpm	163.64
	Flow	m ³ /s	210.00
	Net head	m	145.53
	Rated Power	MW	281.35
	Impeller Diameter	mm	4,450
Generator	Generator type	NA	Synchronous three-phase, vertical axis
	Brand	NA	Toshiba
	Frequency	Hz	60
	Poles Number	Numbers	44
	Voltage	kV	16.5
	Rated Power	MVA	324
	Factor power	NA	0.9

Equipment	Specification	Unit	Value
Electric transformer	Type	NA	Three-phase
	Brand	NA	Siemens
	Series	NA	TP1 – 8657427 TP2 – 8691351 TP3 – 8698533 (Backup) TP4 - 8711761
	Rated Power	MVA	324
	Voltage	kV	230/16.5

The Sogamoso hydroelectric project was constructed between 2009 and 2014. The starting date of the Project was February 4th 2009, with the signature of the contract 46/2985 for the Construction of the Access Roads to the Work Sites of the Project.

On October 2014, main Project construction was completed, and the reservoir was up to the required level to begin Power Plant operation. On November, generator units began testing.

Finally, the Project began its commercial operation stage in December 20, 2014 with an installed capacity of 819 MW.

The power generated and its associated reduced emissions of CO₂ during this monitoring period were 17.65% below the expectations initially proposed in the approved PDD. This variation was due to the operation of the power plant according to the requirements of the National Interconnected Power Grid, the level of the reservoir and the availability of the hydroelectric power plant (for example: the unavailability of Unit 3 due to failures in one of the transformer connection busbar, from August to November 2016).

B.2. Post-registration changes

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

Although during the execution of the activities of the Project no significant changes have arisen in the variables of the Monitoring Plan, it is important to mention some current deviations from the preliminary designs of the Project that are described below:

- Useful capacity delivered to the network electrical was limited to 819 MW (CNO's Agreement 719 of December 21, 2014).
- Net area of the reservoir: For the parameter (A_{PJ}) "Area of the reservoir measured in the surface of the water before the implementation of the project activity" and defined in the monitoring plan of the approved PDD, the preliminary design of the project estimated an area of 7,590 ha with a measurement procedure through satellite images.

This parameter was updated through a bathymetric survey of the reservoir. To guarantee the calculation and correction of latitude, longitude, altitude, heading, inclination, rolling and vertical oscillation, ISAGEN used a high-resolution sonar system capable of taking the bathymetry of the bottom of the water bodies, and an inertial positioning and orientation system (POS) assisted by GNSS (Global Satellite Navigation System).

According to this bathymetric study, conducted in November 30, 2015, the current net area of the reservoir is 6,886 ha. This technical reservoir update was registered in the CNO with a validity of 5 years (The CNO's Agreement 565 of 2012).

B.2.2. Corrections

- According to numeral A.4 of the PDD (Parties and project participants), ISAGEN S.A E.S.P is a mixed entity with public and private capital. However, as of January 13, 2016, ISAGEN S.A E.S.P was acquired by the Canadian investment fund Brookfield Asset Management Inc. (BAM) and its new nature places it as a private company.
- According to the current operational characteristics of the project and the current bathymetry study (CNO's Agreement 565 of 2012), the total reservoir volume is 4,825.04 million m³, with a reservoir area or "mirror area" of 6,886 ha and a useful volume of 2,756.31 million m³.

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

N.A

B.2.4. Inclusion of monitoring plan

N.A

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

N.A

B.2.6. Changes to project design

N.A

SECTION C. Description of monitoring system

The monitoring process is focused on the measurement and control of the variables of energy generated in the hydroelectric power station and the control of the area of the reservoir.

For the case of the monitoring of the electric power generated by the Project, the Monitoring Plan (MP) defines a baseline against which to measure the Project performance in terms of its Greenhouse Gas (GHG) emissions and emission reductions that can be monitored and verified in conformity with the modalities and procedures of the Clean Development Mechanism.

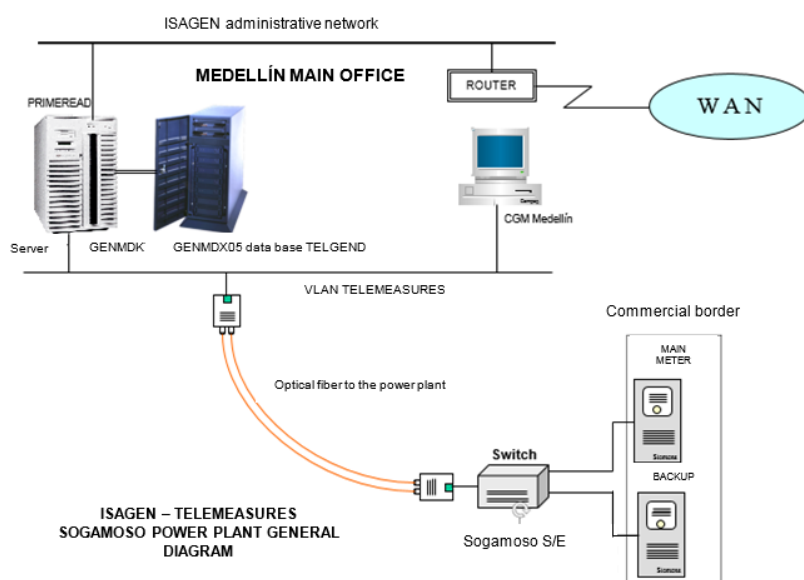


Figure 3. Operational and Management Structure

ISAGEN has incorporated explicitly into its internal procedures a detailed description of the activities related with the adequate management of the CDM monitoring system, that includes the roles and responsibilities associated with those activities (Eg. Internal Procedure 0029).

ISAGEN has formed a multidisciplinary team integrated in the Energy Generation Operations, which is responsible to monitor the parameters, to record and to analyze the data. Since the project will be using an Ex-Ante option for the grid emission factor, the only parameter to monitor for upcoming verifications is the actual power dispatched to the grid. This is relatively simple process, as the Colombian Interconnected System relies on a highly regulated metering setup, which is required for the power payments. ISAGEN saves the data in the internal software (ZSIGEN).

As per the metering, the Project is equipped with multi-function electronic metering devices, which register all information that needs to be monitored, such as exported energy, imported energy, power factor, electric tension, electric flow, etc. It is mandatory to install a backup equipment in addition to the main meter. The metering devices are located at the commercial frontier at the Sogamoso Substation. Before the starting of commercial power exchanges in the wholesale market system, the equipment needs to be duly certified by an authorized entity⁹.

The Energy Generation Operations keeps a periodical maintenance and calibration program according to the codes approved by law, and following recommendations by the equipment providers. Information recorded by the metering equipment is sent every 24 hours to the Commercial Exchange System, operated by the National Dispatch Center (XM). All energy transactions are registered every hour. ISAGEN sends every day, before 8 am, the recorded values of the day before. According to that information, the National Dispatch Center (XM) processes the bills and payments for all transactions performed in the wholesale market. All this information is available to the market agents and to the system control authorities.

The data system at ISAGEN for the project is composed by software and hardware that allows for automatic recording of data collected at the meters. Using a system called PRIMEREAD, all data for outgoing and incoming energy are measured so that net electricity records are kept in files.

⁹ Following Decree 2269 of 1993.

For verification purposes, the data will be easily available at ISAGEN. In addition, historic records of actual energy supplied to the grid are publicly available at the XM website.

SECTION D. Data and parameters

D.1. Data and parameters fixed ex ante

Data/Parameter	$EF_{grid,CM,y}$
Unit	tCO ₂ /MWh
Description	Combined margin CO ₂ emission factor for grid connected power generation in year y calculated using the latest version of the “Tool to calculate the emission factor for an electricity system”
Source of data	Ex-ante calculations
Value(s) applied	0.2742
Choice of data or measurement methods and procedures	As per the “Tool to calculate the emission factor for an electricity system”.
Purpose of data/parameter	Calculation of baseline emissions
Additional comments	As per the “Tool to calculate the emission factor for an electricity system”. This value is calculated ex-ante and will be used throughout the crediting period.

D.2. Data and parameters monitored

(Copy this table for each data or parameter.)

Data/Parameter	$EG_{m,y}$
Unit	MWh
Description	Net quantity of electricity generated and delivered to the grid by power unit m in year y
Measured/calculated/default	Measured. Hourly values. XM monitors continuously the value of this variable. It also keeps records for its customers.
Source of data	Data supplied by ISAGEN for ex-ante calculation, and later by XM for verification purposes. Data supplied by ISAGEN used for ex-ante calculations.
Value(s) of monitored parameter	Net electricity

According to Colombian regulations, the electricity generate from each power plant connected to the Grid will be monitored using metering equipment located at the commercial frontier of every plant, for the Project the XM identification codes are Frt 23459 (Unit 1), Frt 23461 (Unit 2) and Frt 23440 (Unit 3). For the Project, this equipment is located at ISA's Sogamoso Substation 230 kV, located next to the power plant camp. This substation connects the Project to the National Interconnected System. In Colombia, the Measurement Code establishes mandatory high technical standards, procedures to read, to register and to record activities of electricity transactions performed in the Colombian energy market, according to the Resolution 038 of 2014 (Measurement Code) issued by CREG (Energy and Gas Regulation Commission, in Spanish).

Because of the modification of the Measurement Code on May 20, 2014, ISAGEN updated its measurement equipment in order to fulfil the new regulation conditions and standardize all the measurement equipment installed in all the power plants. The measuring equipment located at the Sogamoso Substation has the following characteristics:

Principal Measurement Equipment Unit 1

Type/Brand	SCHNEIDER ELECTRIC
Accuracy class	Active accuracy: 0.2S Reactive accuracy: 2
Serial number	MW-1205A230-01
Calibration frequency	2 years.
First Calibration date	05/09/2014
Validity Period	2014-2015
Calibration Certificate	ME-1409-11448
Last Calibration date	19/09/2016
Validity Period	2016-2018
Calibration Certificate	ME-1609-19630

Backup Measurement Equipment Unit 1

Type/Brand	SCHNEIDER ELECTRIC
Accuracy class	Active accuracy: 0.2S Reactive accuracy: 2
Serial number	MW-1205A231-01
Calibration frequency	2 years
First Calibration date	05/09/2014
Validity Period	2014-2016
Calibration Certificate	ME-1409-11449
Last Calibration date	20/09/2016
Validity Period	2016-2018
Calibration Certificate	ME-1609-19633

Principal Measurement Equipment Unit 2

Type/Brand	SCHNEIDER ELECTRIC
Accuracy class	Active accuracy: 0.2S CI reactive accuracy: 2
Serial number	MW-1205A228-01
Calibration frequency	2 years.
First Calibration date	04/09/2014
Validity Period	2014-2015
Calibration Certificate	ME-1409-11446
Last Calibration date	19/09/2016
Validity Period	2016-2018
Calibration Certificate	ME-1609-19629

Monitoring equipment

Backup Measurement Equipment Unit 2

Type/Brand	SCHNEIDER ELECTRIC
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Monitoring equipment	Backup Measurement Equipment Unit 2	
	Type/Brand	SCHNEIDER ELECTRIC
	Accuracy class	Active accuracy: 0.2S Reactive accuracy: 2
	Serial number	MW-1205A229-01
	Calibration frequency	2 years
	First Calibration date	04/09/2014
	Validity Period	2014-2016
	Calibration Certificate	ME-1409-11447
	Last Calibration date	20/09/2016
	Validity Period	2016-2018
	Calibration Certificate	ME-1609-19632
	Principal Measurement Equipment Unit 3	
	Type/Brand	SCHNEIDER ELECTRIC
	Accuracy class	Active accuracy: 0.2S Reactive accuracy: 2
	Serial number	MW-1205A225-01
	Calibration frequency	2 years.
	First Calibration date	03/09/2014
	Validity Period	2014-2015
	Calibration Certificate	ME-1409-11444
	Last Calibration date	19/09/2016
	Validity Period	2016-2018
	Calibration Certificate	ME-1609-19628
	Backup Measurement Equipment Unit 3	
	Type/Brand	SCHNEIDER ELECTRIC
	Accuracy class	Active accuracy: 0.2S Reactive accuracy: 2
	Serial number	MW-1205A226-01
	Calibration frequency	2 years
	First Calibration date	04/09/2014
	Validity Period	2014-2016
	Calibration Certificate	ME-1409-11445
	Last Calibration date	20/09/2016
	Validity Period	2016-2018
	Calibration Certificate	ME-1609-19631
Measuring/reading/recording frequency	Hourly measurement and monthly recording.	
Calculation method (if applicable)	NA	
QA/QC procedures	All metering devices used to monitor and measure data follow rules that have been summarized in CREG 038 of 2014 Resolution. This Resolution specifies the technical characteristics measurement, telecommunications and back-up equipment to meet installation, testing, certification, operation and maintenance procedures.	
Purpose of data/parameter	This information is required to calculate baseline emissions	
Additional comments	NA	

D.3. Implementation of sampling plan

N.A

SECTION E. Calculation of emission reductions or net anthropogenic removals**E.1. Calculation of baseline emissions or baseline net removals**

The Baseline emissions are calculated according to the Consolidated Baseline Methodology ACM0002 - version 16.0 "Grid-connected electricity generation from renewable sources" as follows:

$$BE_y = EGP_{j,y} * EF_{grid,CM,y}$$

Where:

BE_y = Baseline emissions in year "y" (tCO₂e)

EGP_{j,y} = Quantity of net electricity generation that is produced and fed into the grid as a result of the implementation of the CDM project activity in year y (MWh/yr).

EF_{grid,CM,y} = Combined margin CO₂ emission factor for grid connected power generation in year y calculated using the latest version of the "Tool to calculate the emission factor for an electricity system v.02" (tCO₂e/MWh) in year "y"

Year	Month	Net Electricity Supply to the Grid (kWh)
2016	June	112,993,702
	July	162,283,110
	August	265,851,553
	September	232,824,407
	October	290,670,034
	November	336,080,568
	December	466,129,745
2017	January	385,463,742
	February	401,156,283
	March	280,333,569
	April	417,724,021
	May	569,824,346
	June	242,029,347
TOTAL (kWh)		4,163,364,426

E.2. Calculation of project emissions or actual net removals**Methodology:**

Determine the net annual project electricity output for the period under verification from the XM (the official database of the National Dispatch Center), which can be accessed from the website, <http://informacioninteligente10.xm.com.co>. The output is available in kWh.

- Use the ex-ante combined emission factor calculated in the PDD.

- Multiply the actual electricity output produced by the project by the Combined Emission Factor for the Colombian Interconnected Electricity Grid.
- Total CERs generated by the project for the period are calculated as:

$$ER_y = BE_y - PE_y - L_y$$

Where:

ER_y = Emission reductions in year y (tCO₂e/yr.)

BE_y = Baseline emissions in year y (tCO₂/yr.)

PE_y = Project emissions in year y (tCO₂e/yr.)

PE_y is the project emissions in year y and

L_y refers to leakage in year y as defined in the methodology ACM0002 ver. 16.0 - "Consolidated baseline methodology for grid-connected electricity generation from renewable sources".

According to the PDD, $PE_y = 0$ and $L_y = 0$

E.3. Calculation of leakage emissions

According to the PDD, no leakage emissions are considered. The main emissions potentially giving rise to leakage in the context of electric sector projects are emissions arising due to activities such as power plant construction and upstream emissions from fossil fuel use (e.g. extraction, processing, and transport). These emissions sources were neglected.

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

	Baseline GHG emissions or baseline net GHG removals (tCO ₂ e)	Project GHG emissions or actual net GHG removals (tCO ₂ e)	Leakage GHG emissions (tCO ₂ e)	GHG emission reductions or net anthropogenic GHG removals (tCO ₂ e)		
				Before 01/01/2013	From 01/01/2013	Total amount
Total	1,386,355	1,141,595	0	0	1,141,595	1,141,595

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

Amount achieved during this monitoring period (tCO ₂ e)	Amount estimated ex ante (tCO ₂ e)
1,141,595	1,386,355

E.6. Remarks on increase in achieved emission reductions

The variation between the power generated and its associated reduced emissions of CO₂ is 17.65% below the expectations initially proposed in the approved PDD. This variation is due to the operation of the power plant according to the requirements of the National Interconnected Power Grid, the level of the reservoir and the availability of the hydroelectric power plant (for example: the unavailability of Unit 3 due to failures in one of the transformer connection busbar, from August to November 2016).