# Project design document form
## (Version 10.1)

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

| BASIC INFORMATION | |
|---|---|
| **Title of the project activity** | Rio Amoyá Run-of-River Hydro Project |
| **Scale of the project activity** | ☒ Large-scale<br>☐ Small-scale |
| **Version number of the PDD** | 09 |
| **Completion date of the PDD** | 10/12/2018 |
| **Project participants** | ISAGEN S.A. ESP |
| **Host Party** | Colombia |
| **Applied methodologies and standardized baselines** | The ACM0002 Large-scale "Consolidated Methodology for Grid-connected electricity generation from renewable sources" version 19.0 |
| **Sectoral scopes linked to the applied methodologies** | Sectoral Scope 1: Energy industries (renewable / nonrenewable sources) |
| **Estimated amount of annual average GHG emission reductions** | 86,131 $tCO_2e$ |

## SECTION A. Description of project activity

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

The Rio Amoyá Run-of-River Hydro Project ("Project"), located in the Municipality of Chaparral in the Departament of Tolima, consists of a greenfield run-of-river power plant with a nominal capacity of 80 MW and an anticipated generation of approximately 513.6 GWh/year, based on the projected generation resulting from engineering studies contracted by ISAGEN S.A. ESP ("ISAGEN") in 1998 and 2005[1]. The power plant will be connected to the national grid through an 18.6 km transmission line. The investment in the power plant includes the mitigation costs associated with construction and operation. The plant started full operation on May 30, 2013 and is expected to result in the reduction of about 1 million $tCO_2e$ by 2019.

The Project is considered not only as a project of electric power generation, but also as an "Environmental Services Project", since it contributes to decrease the global emissions of carbon through the substitution of polluting fuels as a source of electric power generation by the thermoelectric plants connected to the Grid (baseline scenario); and with its multiple benefits and capacity to yield and consolidate economic resources, it contributes to the conservation and protection of the Amoyá River's basin and to the conservation of the páramo ecosystem. About the environmental effects, the Project, thanks to its characteristics of being a run-of-river-intake project with no dam, and the simplicity involving the civil works, had a minimum environmental impact, since it involves no settlement relocation or displacement whatsoever, it has a low effect on the ecosystems in the area of influence and its land requirements are minimal.

The Project contributes to sustainable development of Colombia in the following ways:

1. First, it can show the potential of run-of-river power plants as alternative to other type of power plants, encouraging the construction of run-of-river plants in the Country. These plants produce sustainable development using small resources in different places in the Country.

2. Second, plants of this type contribute to the reduction of polluting particles in the Country, which can else be discharged by thermal power plants.

3. Third, it can develop great knowledge and nationwide experience in the construction of runoff river power plants; also strengthen the national institutional capacities focused to the consolidation of competitive advantages to participate in the international carbon market.

4. Fourth, it can demonstrate the potential value of the environmental services in the region, through the recognition of the role of the natural páramo ecosystem in the generation of electric power and in the production and acquisition of the resources destined to their conservation and protection.

5. Fifth, the local community obtain benefits of different social programs developed by the Project sponsor from a very early stage of its construction, becoming a key element to assure the approval, backup and participation of the community in the project and its complementary activities.

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[1] Back in 1998, INGETEC was hired to evaluate the hydraulic potential of Amoyá and Ambeima rivers, in order to select the best hydropower project, in terms of generating capacity, environmental impact, and costs. This study evaluated a project with a nominal capacity of 78 MW, with an average flow of 17.2 $m^3/s$. A period of 15 years was simulated and the reported average generation level was 516 GWh/yr. To account for potential losses, the team in charge of assessing the projects economic feasibility applied 99% of 516 GWh, which corresponds to 510.7 GWh. Later in 2005, ISAGEN hired another engineering firm, SEDIC, to update and complement INGETEC"s study. Using time series data from hydrological stations, the average flow was now set at 18.4 $m^3/s$, the nominal capacity was increased to 80 MW, and the average generation level was estimated at 513.6 GWh/yr. The latter will be used for the ex-ante estimation of the project emission reductions.

The Project supports the development of an Environmental Program, which aims to promote the conservation of the moorlands (páramo ecosystem in the area of the project), facilitating the ecosystem's ability to regulate water cycle in the surrounding area (páramo ecosystems replenish rivers in the catchment and act as water cycle regulating systems) and to contribute to water supply and power production in the region. Furthermore, the program contributes to the conservation of Páramo Las Hermosas ecosystem. The program also covers a water cycle study and adaptation plan for the páramo.

The Project supports a Social Program that includes: a) Improvement of health, access to potable water, sanitation and health services; b) Improvements to infrastructure c) Access to education; d) Communication activities supporting rural development; e) Community strengthening and sustainable production; and e) Watershed conservation.

The proposed environmental and social programs are additional to what is required by law. These programs complement the mitigation investments included in the capital costs of the power plant. The environmental and social programs will be partially financed with the carbon revenue, with environment program and social program sharing the revenue equally.

## A.2. Location of project activity

### A.2.1. Host Party

Colombia

### A.2.2. Region/State/Province etc.

Tolima, Colombia

### A.2.3. City/Town/Community etc.

Municipality of Chaparral, in the lower range of the Amoyá River Basin

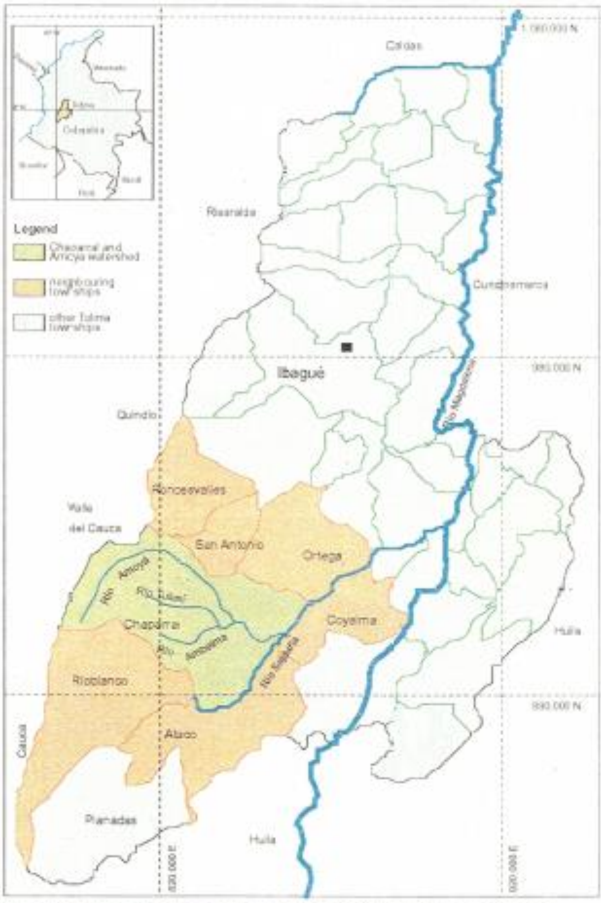
### A.2.4. Physical/Geographical location

The Project is located in the middle section of the Amoyá River Basin in the municipality of Chaparral, Tolima province, Colombia. Chaparral is 262 km from Colombia's capital, Bogota. The Amoyá River receives waters from the Páramo Las Hermosas ecosystem.

The upper reaches of the Amoyá River basin are conformed by a páramo. This high altitude ecosystem is considered of major importance given its great ecological value and the multiple environmental services it provides. Both reasons make the relation with the project of particular relevance. Páramos in the Amoyá area form the largest patch in the Central Cordillera. Out of the páramo total area, 650 $km^2$ are under protection status in the Páramo de Las Hermosas National Park, 27% of which are in the Amoyá river basin.

**Table 1: Project Coordinates**

| | Y | X | Latitude | Longitude |
|---|---|---|---|---|
| Bogotá | **N 1,000,000.000** | **E 1,000,000.000** | | |
| Powerhouse | N 912,781.836 | E 831,653.566 | 3°48'22" | -75°35'35" |
| Intake | N 917,584.603 | E 824,852.432 | 3°50'58" | -75°39'15" |




Map 1. Location of project area: Chaparral and Amoyá river watershed in Tolima province

**Figure 1: Geographical localization of the project activity**

The works are located around the geographical coordinates 75º 40´W and 3º 50´N along the Amoyá River, at elevations between 939 and 1,486 meters above mean sea level.

### A.3. Technologies/measures

The run-of-river plant will use kinetic and potential energy from the waters of the Amoyá River to generate electricity without the need for water storage (i.e. no reservoir is included required). Two turbines and other ancillary facilities are installed underground, along one side of the river, thus minimizing impacts on the landscape. A weir is located at 1,484 m above the sea level. The water will then be conducted through an 8.6 km long intake tunnel, running along the southern side of the river, to reach an underground power house. Most civil works are located underground.

About 151 hectares of land were acquired. Right of way were obtained for the access road and the transmission line. Pelton turbines with vertical axis and a rated capacity of 40 MW each (to efficiently utilize the energy potential of the river) are used to generate power from the kinetic energy of the fast flowing stream and the potential energy between entry and exit points of the tunnel. The state-of-the-art Pelton turbines used in the project have been widely utilized in hydroelectric projects around the world because of their efficiency levels and technical performance.

| Element | Value/description | Unit |
|---|---|---|
| **I. General Specifications** | | |
| Installed Capacity | 80 | MW |
| Load Factor | 73.29 | % |
| Design Flow | 18.4 | $m^3$/sec |
| Hydraulic Head | 520 | meters |
| Annual Generation | 513.6 | GWh |
| Turbine Efficiency | 91.5 | % |

| | | |
|---|---|---|
| Power Generator Efficiency (E100%) | 98.45 | % |
| **II. Diversion Works** | | |
| Diversion structure | Concrete 39W x 5H | meters |
| Intake channel | Concrete, square, 105 m L | meters |
| Settling tank | 3 cells, 86 m L | meters |
| Conduction tunnel | 8,587 m | meters |
| Discharge tunnel | 2,894 m | meters |
| **III. Engine house and turbines** | | |
| Engines house | 12.4 m W, 36.7 m L, 27 m H | meters |
| **IV. Pelton Turbines (2)** | | |
| Vertical axis (2) | 40 | MW |
| Valves (2) | 1.10 m D | meters |
| Synchronic generator (2) | 45.7 | MVA |
| | 13.8 nominal | kV |
| Load bridge | 800 | kN |
| Transformers (2) | 13.8/115 | kV |
| Sub-station | 115 | kV |
| **V. Monitoring equipment (2)** | | |
| There are two bidirectional measurement equipment, one principal and one for backup, located at the Tuluní substation (Chaparral town) with accuracy class CL active accuracy = 0.2S and Cl reactive accuracy = 2. | | |

### A.4. Parties and project participants

| Parties involved | Project participants | Indicate if the Party involved wishes to be considered as project participant (Yes/No) |
|---|---|---|
| The Republic of Colombia (host) | ISAGEN S.A. E.S.P. (private entity) | No |

### A.5. Public funding of project activity

This project does not receive public funding from Parties included in Annex I to the Convention nor Official Development Assistance (ODA) or other sources earmarked for development assistance.

### A.6. History of project activity

1. We Confirm that:
   (a) The proposed CDM project activity is neither registered as a CDM project activity nor included as a component project activity (CPA) in a registered CDM programme of activities (PoA);
   (b) The proposed CDM project activity is not a project activity that has been deregistered.

2. We Declare that the following statement are not true:
   1. The proposed CDM project activity was a CPA that has been excluded from a registered CDM PoA;
   2. A registered CDM project activity or a CPA under a registered CDM PoA whose crediting period has or has not expired (hereinafter referred to as former project) exists in the same geographical location as the proposed CDM project activity.

### A.7. Debundling

Not applicable.

## SECTION B. Application of selected methodologies and standardized baselines

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

The ACM0002 Large-scale “Consolidated Methodology for Grid Connected Electricity Generation from Renewable Sources” (version 19.0) is chosen as the most relevant to the project activity. This

methodology, as applied in this project activity, also refers to the latest approved version of the “Tool to calculate the emission factor for an electricity system” (version 7.0).

The methodological tool “Assessment of the validity of the original/current baseline and update of the baseline at the renewal of the crediting period” (version 03.0.1) was used to determine the validity of the baseline scenario.

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

The methodology ACM0002 was chosen because it applies to grid connected renewable power generation project activities. The detail of the Applicability is presented in Appendix 3.

Also related to the desire of renewing the crediting period, the tool “Assessment of the validity of the original/current baseline and update of the baseline at the renewal of the crediting period” was used to assess the validity of the baseline used at validation of the Project as CDM. The Applicability of the previous mentioned tool is presented in section B.4.

Since it is referenced in the ACM0002, the “Tool to calculate the emission factor for an electricity system” was applied to estimate the Operating Margin (OM), Building Margin (BM) and Combined Margin (CM) to calculate baseline emissions for the Project activity, which supplies electricity to the Colombian Interconnected Grid. The Applicability of the above mentioned Tool is described in the section B.6 and Appendix 4.

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

| | Source | GHG | Included? | Justification/Explanation |
|---|---|---|---|---|
| **Baseline** | $CO_2$ Emissions coming from electricity generation in fossil fuel fired power plants that are displaced due to the project activity | $CO_2$ | Yes | Main emission source. The thermal units in the generation grid produce GHG emissions that are avoided when the Project activity enters the grid replacing the thermal units. |
| | | $CH_4$ | No | Minor emission source |
| | | $N_2O$ | No | Minor emission source |
| **Project activity** | For hydro power plants, emissions of $CH_4$ from the reservoir | $CO_2$ | No | Minor emission source |
| | | $CH_4$ | No | For run-of-river hydro plants emissions of $CH_4$ are not considered. |
| | | $N_2O$ | No | Minor emission source |

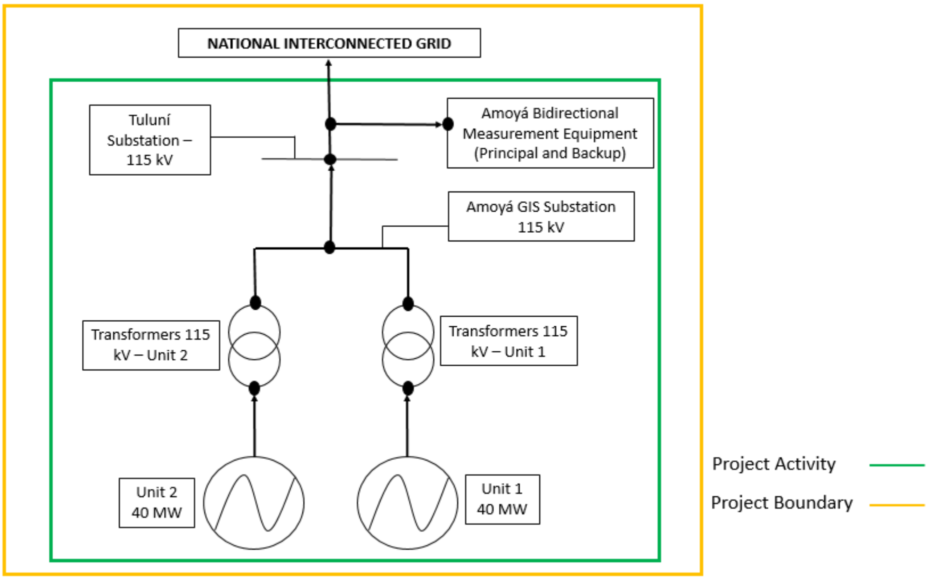



**Figure 2.** Flow diagram of the Project Activity boundary

As referred in ACM0002 the project boundary has to be assessed in terms of the emission sources and spatial extent. The GHG accounted for are shown in the table above.

- Emission sources:

Baseline: For the baseline determination, only $CO_2$ emissions from electricity displaced due to the project are accounted for.

Project: As the project is a run-of-river hydro power Project, it has zero project emissions.

- Project boundary:

The spatial extent of the project boundary includes the project power plant/unit and all power plants/units connected physically to the electricity system[2]. The project is linked to the Colombian national grid through an 18.6 km long transmission line. Therefore, all power plants providing electricity to the Colombian grid system are included in the project boundary.

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

**Identification of the Baseline Scenario**

According to the guidance of the approved methodology ACM0002 "Identification of the baseline scenario", the baseline for the proposed project activity is:

> *"…the project activity is the installation of a Greenfield power plant, the baseline scenario is electricity delivered to the grid by the project activity would have otherwise been generated by the operation of grid-connected power plants and by the addition of new generation sources, as reflected in the combined margin (CM) calculations described in Tool to calculate the emission factor for an electricity system".*

The baseline scenario is the same as the scenario existing prior to the start of the implementation of the project activity: electricity delivered to the Grid by the Project would have otherwise been generated by the operation of Grid-connected power plants and by the addition of new generation sources.

The applicability of the Tool "Assessment of the validity of the original/current baseline and update of the baseline at the renewal of the crediting period", is explained following the correspondent steps mentioned in the Tool, as follows:

***Step 1: Assess the validity of the current baseline for the next crediting period***

***Step 1.1: Assess compliance of the current baseline with relevant mandatory national and/or sectoral policies***

At the time of the Renewal of the Crediting Period, the mandatory national and/or sectoral policies are the same (Laws 142 and 143 of 1994).

During the first crediting period, the Colombian Government issued the Law 1715 of 2014, which desires to promote the development of non-conventional renewable energy sources, but has not change the current baseline.

As the mandatory national and/or sectoral policies are the same for the first and second crediting period, the current baseline is valid.

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[2] On XM website, accessing PARATEC, the following diagrams are found: National Interconnected Grid (http://paratec.xm.com.co/paratec/SitePages/reportemapas.aspx?q=stn) and Power Plants of the Grid (http://paratec.xm.com.co/paratec/SitePages/reportemapas.aspx?q=embalses).

***Step 1.2: Assess the impact of circumstances***

At the time of the Renewal of the Crediting Period, the conditions used to determine the baseline emissions in the previous crediting period are still valid, as the participation of the share of thermoelectric power plants (centrally and non-centrally dispatched) in Colombian Interconnected Grid in 2017 is still relevant (29%, 4,870 MW of 16,778)[3].

As the circumstances are the same for the first and second crediting period, the current baseline is valid.

***Step 1.3: Assess whether the continuation of use of current baseline equipment(s) or an investment is the most likely scenario for the crediting period for which renewal is requested.***

This sub-step was not applied because there were investments in new equipment (new power plants) since the registration of the Project Activity as CDM, so the baseline scenario identified at the validation changed.

***Step 1.4: Assessment of the validity of the data and parameters***

As the emission factors will be used and determined only once (ex-ante) for the second crediting period, the ones used at the registration time should be updated.

***Step 2: Update the current baseline and the data and parameters***

According to step 1.4, the current baseline needs to be updated.

***Step 2.1: Update the current baseline***

As the emission factors of the Colombian Grid has changed from the ones used at registration time, the baseline should be updated, accordingly to Methodology ACM0002 and the Tool to calculate the emission factor for an electricity system, using the most recent information available.

***Step 2.2: Update the data and parameters***

The data and parameters used to calculate the combined margin emission factor of the Grid should be updated.

**<u>Baseline emissions of the proposed project activity were estimated taking into account the following parameters:</u>**

(a) Annual amount of the energy generated by the plant

The total amount of 513.6 GWh of the average electric energy to be generated annually by the Rio Amoyá Run-of-River Hydro Project was taken from the power plant's historic design documentation:

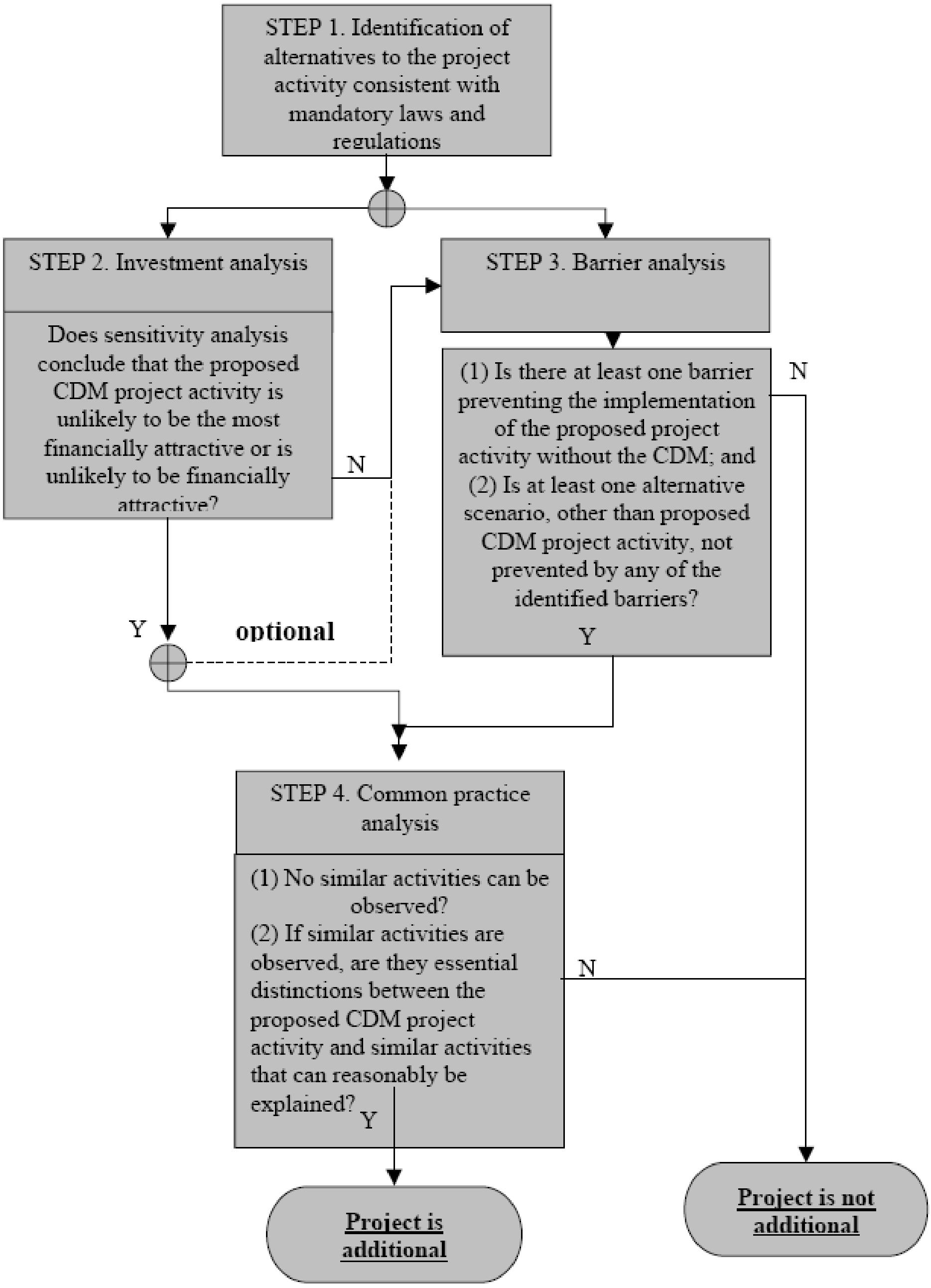
(b) Baseline emission factor for the Colombian electricity Grid.

The baseline combined margin emission factor (equaled to 0.1677 $tCO_2e/MWh$) was calculated according to the "Tool to calculate the emission factor for an electricity system". For details on the calculation please refer to section B.6 and Appendix 4 of the current document.

[3] XM 2017 annual report: http://informesanuales.xm.com.co/2017/SitePages/operacion/Default.aspx

## B.5. Demonstration of additionality

To demonstrate that the project activity is additional and therefore not the baseline scenario, the tool for the demonstration and assessment of additionality, version 05.2 is used. The application of this tool involves the following steps:




### Step 1. Identification of alternatives to the project activity consistent with current laws and regulations

The electric system in Colombia is a competitive sector with national regulations. Although UPME prepares indicative power expansion plans, actual generation and capacity expansion is left to the decisions of the independent power producers.

#### Sub step 1a. Define alternatives to the project activity

The following alternatives are considered realistic and credible.

1. The proposed project activity is undertaken without being registered as a CDM project activity;

2. The system expansion would occur as defined by UPME; that is the electricity will be supplied by a grid produced from another thermal or big hydro unit.

According to the Expansion Plan for the Colombian Electrical Grid 2009-2023, there are registered generation projects for a total additional capacity of 13,545.8 MW, from which 7,685.5 MW correspond to hydropower projects with a capacity of at least 20 MW; 2,884.6 MW of coal power projects; 2,520.5 MW of natural gas fired projects; 305 MW of fuel oil projects; 70.4 MW in hydraulic power projects with a capacity lower than 20 MW; 44.9 MW of co-generation projects; and 20 MW of wind power. In comparison with projects registered in the past, there are new fuel oil projects, and an increase in coal fired operations. The following table depicts the registered projects:

**Table 2. Indicative Expansion Plan for the Colombian electrical grid for the period of 2009-2023**

| PROJECT | TECHNOLOGY | CAPACITY MW | DATE |
|---|---|---|---|
| Termocalendaria | Gas CC | 586 | Nov 12 |
| Termocol | Gas | 210 | Dec 12 |
| Meriléctrica | Gas CC | 103 | Nov 09 |
| Termoflores IV | Gas CC | 160 | Nov 09 |
| GT 23 | Gas CC | 100 | 2012 |
| Termoandina 1 | Gas | 98.5 | 2012 |
| Cimarron repowering | Gas | 38 | 2009 |
| CC Endesa 1 | Gas CC | 400 | 2012 |
| Termo Upar | Gas | 300 | TBD |
| Termolumbi | Gas CC | 300 | TBD |
| Termo Yariguiez | Gas CC | 225 | TBD |
| Termocauca | Coal | 100 | TBD |
| Termobijao | Coal | 460 | 2012 |
| Gecelca 2 | Coal open cycle | 150 | 2012 |
| Gecelca 3 | Coal open cycle | 150 | 2012 |
| Gecelca 4 | Coal open cycle | 100 | 2012 |
| Gecelca 7 | Coal open cycle | 100 | 2012 |
| Termo San Fernando | Coal open cycle | 165 | 2012 |
| Tasajero II | Coal open cycle | 155 | 2012 |
| Termocaribe 1 | Coal pulverized | 350 | 2012 |
| Termozipa 6 | Coal | 154.6 | 2012 |
| Termosuamox | Coal | 300 | 2012 |
| Sinifana 1 | Coal | 175 | 2012 |
| Sinifana 2 | Coal | 175 | 2013 |
| Termocaribe 2 | Coal | 350 | 2015 |
| Gecelca 14 | Fuel Oil | 10 | 2012 |
| Gecelca 15 | Fuel Oil | 50 | 2012 |
| Gecelca 13 | Fuel Oil | 10 | 2012 |
| Termodial 1 | Fuel Oil | 25 | 2010 |
| Termocol | Fuel Oil | 210 | 2008 |
| Porce III | Hydro | 660 | 2010 |
| Amoyá | Hydro | 80 | 2011 |
| Miel II | Hydro | 150 | 2011 |
| Cucuana | Hydro | 48 | 2011 |
| Sogamoso | Hydro | 800 | 2013 |
| El Quimbo | Hydro | 400 | 2013 |
| Porce IV | Hydro | 400 | 2015 |
| Andaqui | Hydro | 687 | 2016 |
| Pescadero Ituango | Hydro | 2400 | 2017 |
| Chapasia | Hydro | 800 | TBD |
| Espiritu Santo | Hydro | 700 | 2018 |
| Bugalagrande | Hydro | 40.5 | TBD |
| Cañaveral | Hydro | 68 | TBD |
| Encimadas | Hydro | 94 | TBD |
| El Doce | Hydro | 360 | 2022 |
| Amaime | Hydro small | 19.9 | Dec 09 |
| Coello 1,2,3 | Hydro small | 3.7 | 2009 |
| Caruquia | Hydro small | 9.5 | Dec 09 |
| Guanaquitas | Hydro small | 9.5 | Jul 09 |

| PROJECT | TECHNOLOGY | CAPACITY MW | DATE |
|---|---|---|---|
| Trasvase Guarino | Hydro small | -- | Jun 10 |
| Barroso | Hydro small | 19.9 | Dec 10 |
| Trasvase Manso | Hydro small | -- | Jan 11 |
| PCH de Neusa | Hydro small | 2.9 | TBD |
| El Popal | Hydro small | 19.9 | Jan 13 |
| Jouktai | Wind | 20 | TBD |
| Cogeneration IPSA | Biomass | 19.9 | Abr 09 |

**Source:** Plan de Expansión de referencia. Generación-transmisión, 2009-2023, República de Colombia, Ministerio de Minas y Energía, published in 2009.

*Sub step 1b. Consistency with mandatory laws and regulations*
All identified alternatives to the project activity are in compliance with mandatory legislation and regulations. Since all available alternatives are realistic and credible to the project participants, the Project is considered additional under Step 1.

**Step 2: Investment analysis**

The purpose of this step is to determine whether the project activity is economically or financially less attractive than Alternative 2 without an additional revenue/funding, possibly from the sale of certified emission reductions (CERs). The investment analysis was conducted in the following steps as specified in the additionality tool and following the "Guidelines on the assessment of investment analysis (Ver3, EB 51):

*Sub-step 2a. Determine appropriate analysis method:*

According to the "Tool for the Demonstration and Assessment of Additionality (Version 05.2)", Option I (simple cost analysis) cannot be used as the project involves revenue generation apart from the revenue from sale of carbon credits. As the alternative to the project activity is the supply of electricity from the grid which is not to be considered an investment, option III (Benchmark analysis) is selected as per the guidance in the investment analysis.

*Sub-step 2b. Option III. Apply benchmark Analysis*

*Identification of a suitable benchmark value*

Under the rules guiding the electric power sector in Colombia individual investors are free to build and operate their power plants as they consider more attractive to their interests (free entry in a competitive market structure). The investment decision is therefore made by each investor based on all the options available incorporating the response of financial institutions in supporting the project activity.

Because there are no restrictions for a project of this type to be developed by an entity other than the project participant, and following the Guidance on the Assessment of Investment Analysis of the Tool for the Demonstration of Additionality, the investment analysis for demonstration of additionality relies on the use of a benchmark based on publicly available data. Because there are no sector specific benchmarks available in the country, the benchmark value for the project is derived from the estimates of the cost of financing i.e. commercial lending rates based on bankers views and private equity investors/funds‟ required return on comparable projects;

The Rio Amoyá Run-of-River Hydro Project which was originally sponsored by a consortium of companies including "Generadora Union", CEMEX, ISAGEN among other investors, sought investment funds through local and international investors and debt through a combination of financial mechanisms.

Project sponsors hired Santander Investments, an international banking group with considerable experience in the financial sector, to serve as the financial advisor with responsibility to (i) conduct project financial analysis by focusing on all realistic scenarios and potential local risks; and, (ii) raise investment funds and debt as required by the project.

In May 2005, after over 18 months of work, Santander Investments informed the project sponsor that they were not able to find interested investors. The investors internal rate of return (IRR) calculated at that time at 9.60% was not high enough to attract investors.

However, considering the flow of revenue from sale of carbon credits based on renegotiated emissions purchased agreement with the World Bank, ISAGEN reevaluated the project and again compared with the hurdle rate which is based on the interest rate charged by the major investor in the sector. Accordingly the benchmark considered is 16.04%, based on interest rates charged by FINDETER in June 2005 for Electricity Generation projects[4].

On the basis of above benchmark, calculation and comparison of financial indicators are carried out in sub-step 2c.

*Sub-step 2c. Calculation and comparison of financial indicators*

1) Basic parameters for calculation of financial indicators

Based on the project proposal, basic parameters considered for calculation of financial indicators are as follows:

| Parameter | Value | Source |
|---|---|---|
| Commercial operations starting year | 2009 | Appraisal Report for Investment Decision[5] / Economic Model |
| Number of years considered in the evaluation | 26 (2005-2030) | Appraisal Report for Investment Decision / Economic Model |
| Annual Electricity Generation | 510.7 GWh/year | INGETEC Hydraulic study [6] |
| Total Investment | 288,691 Million COP[7] (105 Million US$ at 2,749.44 COP/US$) | Appraisal Report for Investment Decision / Economic Model |
| Average Reference Electricity Price (tariff) | 171.08 (COP/kWh) | Energy Planning Unit, Mine and Energy Ministry in the Reference Expansion Plan Generation – Transmission 2004-2018 |
| O&M and Administration costs | 24.96US$/kW/yr. | Appraisal Report for Investment Decision / Economic Model |
| Income tax | 35% | Colombian legislation |
| Depreciation | Civil works: 20 years<br>Equipment: 10 years | Colombian legislation |

All inputs used for the calculations of project IRR were valid and applicable at the time when the assessment of the financial viability of the project was considered (2005)[8].

[4] Source: FINDETER historical interest rates, 2005. FINDETER builds its interest rate based on the interest rate of the deposits at 90 days of the Colombian Treasury (http://www.banrep.gov.co/estad/dsbb/sfin_009.xls), which was 7.18% in June 2005, adding a spread that was 8.860% for loans with a maturity between 8/12 years in June 2005.

[5] Date of the Report: June 2005

[6] Before 2005, ISAGEN initially hired the firm INGETEC to evaluate the hydraulic potential of Amoyá and Ambeima rivers, in order to select the best hydropower project, in terms of generating capacity, environmental impact, and costs. This study evaluated a project with a nominal capacity of 78 MW, with an average flow of 17.2 $m^3$/s. A period of 15 years was simulated and the reported average generation level was 516 GWh/yr. To account for potential losses, the team in charge of assessing the project's economic feasibility applied 99% of 516 GWh, which corresponds to 510.7 GWh. Later again in 2005, ISAGEN hired another engineering firm, SEDIC, to update and complement INGETEC"s study. Using time series data from hydrological stations, the average flow was now set at 18.4 $m^3$/s, the nominal capacity was increased to 80 MW, and the average generation level was estimated at 513.6 GWh/yr.

[7] The total investment costs of the Project with CDM registration is 276,665 Million COP. This difference is due to the reduction on import levies of the equipment for registered CDM Projects in Colombia. However, the project is eligible to claim tax deduction only if the registration has occurred prior to the import of the equipment.

[8] Detail description of the methodology, assumptions and source of the data used for the project financial analysis are available in Spanish.

Results of the financial analysis are shown in the table below. Based on this analysis, the benefits associated with the CDM (i.e., sale of ERs and duties exemption) are not high enough to make the project financially viable. However, as it was stated before, the company used its own internal benchmark to make the decision to go ahead.

The social and environmental benefits of the project for the region have been a strong argument to proceed with project involvement.

**Table 3. Project Internal Rates of Return with and without CDM**

| Scenarios | IRR |
|---|---|
| 1. With Carbon credits[9] and tax exemption | 13.21% |
| 2. Without tax exemptions and without carbon credits | 12.32% |
| Benchmark (FINDETER rate) | 16.04% |

According to the VVM guidelines, the Financial Analysis is referred to the moment of taking the decision of developing the project. In addition, since a later technical study from SEDIC indicated that the annual electricity generation could reach 513.6 GWh/yr., instead of 510.7 GWh/yr. from the INGETEC initial Hydraulic study, it has been also calculated the IRR using the 513.6 GWh/yr., which is just 0.57% higher than the previous estimated value. The IRR using 513.6 GWh/yr. is 13.25% and 12.35%, with and without carbon credits respectively, instead of 13.21% and 12.32%. In both cases the value is still below the benchmark of 16.04%.

<u>*Sub-step 2d: Sensitivity Analysis*</u>

The results of a sensitivity analysis to changes in investment costs and in operation and maintenance cost is presented below.

**Table 4. Sensitivity Analysis of Project IRR without CDM**

| Variable | Base Case (no changes) | Changes of +/- 10% | | Changes of +/- 20% | |
|---|---|---|---|---|---|
| | | + | - | + | - |
| Investment Costs | 12.32% | 11.50% | 13.26% | 10.76% | 14.35% |
| O&M Costs | 12.32% | 11.62% | 13.01% | 10.90% | 13.69% |
| Energy Prices | 12.32% | 19.05% | 4.51% | 25.55% | negative% |

Based on this sensitivity analysis, the project IRR could exceed the relevant benchmark only if energy prices are higher than those used for the analysis (all based on publicly available data). However, in Colombia the merit order dispatch system, and the relatively large share of hydropower, reaching high prices is not a realistic assumption. Also, getting too low an IRR if prices decrease make price risk too high to depend on. The results are similar and below the benchmark value even after accounting the increased generation figures as per the later technical study from SEDIC.

**Step 3. Barrier analysis**

In addition to the investment analysis, barrier analysis is also used to demonstrate that the project is additional. In this step, it is determined that the proposed project activity faces barriers that: a) prevent the implementation of this type of project activity; and b) do not prevent the implementation of at least one of the alternatives.

***Sub step 3a. Identify barriers that would prevent the implementation of type of the proposed project activity***

The following barriers have been identified:

- **Investment barriers**: After considerable effort and a road show that included European and North American capital markets, the project did not achieved financial closure. Out of the total investment cost of the project, 60% was expected to receive debt finance.

[9] Carbon credits value is based on the emission reductions estimated during the decision making process.

However, the projects faced major financial barriers in terms of low returns on equity (9.60%), high upfront need for debt financing and inability of the project revenues to produce the debt-coverage limits required by financiers. Under the BAU scenario, the project lacked ability to attract necessary finances to undertake the project (as informed by the independent financial advisor Santander Investment in May 2005).

The initial sources of financing of the Rio Amoyá Run-of-River Hydro Project are presented below. For simplicity, the sources of finances are divided in "capital investment" and "lending opportunities".

The initial stockholder composition included: (1) 56%, ISAGEN; (2) 5%, Generadora Unión; (3) 5%, civil works contractors; (4) 1%, CEMEX; and (5) 33%, other investors. The project was planned to start in 2008. However, the project was dropped after 18 months of unsuccessful negotiations to secure financial support.

ISAGEN assumed project ownership (100% equity) after assessing the project as an independent sponsor, using its own resources and access to debt, and considering a renegotiated ERPA. The CDM benefits helped improve the project´s IRR for ISAGEN to go ahead with the project. The Government of Colombia controls ISAGEN‟s property, although the company behaves as a private company, where income is generated through energy sales. No subsidies from the government are received or taken into account when considering investment opportunities. Thus, the implementation of the project as a CDM project enables it to overcome investment barriers. It also demonstrates that the project activity is additional.

- **High risk profile of run-of-river hydropower projects**: As the river flow is variable, run-of-river hydropower projects have higher risk than other comparable sources, e.g. reservoir based hydropower, which in the Colombian electricity market brings additional revenue through *reliability charge,* a premium paid for the reliable and ready-to-use power. This reliability charge is paid for the base load that can be offered on a firm basis. In the case of run-of-river projects, the energy supplied on a firm basis is lower than their medium energy and therefore presents higher uncertainties. Renewable energy sources, such as wind farms and run-of-river plants, do not receive extra remuneration for their full amount of energy supplied, as they cannot supply guaranteed energy output to the national system.

***Sub step 3b. Show that the identified barriers would not prevent the implementation of at least one of the alternatives (except the proposed project activity)***

The Colombian power system continues to expand based on individual power producers‟ decisions that find their investment attractive under the rules guiding the sector. It is concluded that other options are open to investors, including ISAGEN, as the Colombian interconnected system continues to expand. Other alternatives – like the installation of a thermal unit or an alternative power plant - would find conditions that enable investors and financiers to obtain financial closure under the existing conditions of availability of hydropower potential, coal and natural gas and the market demand for additional capacity to meet the growing demand.

**Step 4. Common practice analysis**

***Sub-step 4a. Analyze other activities similar to the Rio Amoyá Run-of-River Hydro Project***

Although run-of-river technology is not new in Colombia, its use is not part of the business as usual scenario mainly due to the required high up-front investment capital and relatively low energy prices, which make this type of investments long term return opportunities. Most power generation capacity is added as large hydros (52%) or thermopower (46%), while small hydro projects get to a mere 0.6%. Therefore, the Rio Amoyá Run-of-River Hydro Project is considered additional with respect to investment climate, and access to financing.

***Sub-step 4b. Discussion of similar options that occur***

As shown in Table 1, run-of-river investments in UPME‟s projected power generation expansion plan amount to less than 1% of total generation capacity. Most other new small run-of-river hydropower projects occur supported by CDM.

**As a summary the project demonstrates additionality in the following ways:**

a) Colombia adopted an open, regulated and market oriented energy sector; therefore there is no legal obligation that project has to be built;

b) The run-of-river energy involves relatively high risk compared with fossil fuel forms of energy or even big hydropower involving reservoirs because the river flow is variable and is affected by climate variability. These run-of-river plants do not receive the extra remuneration called *reliability charge,* provided by the national energy regulator as incentive for supplying reliable and ready-to–use energy to the grid so that the national energy demand can be covered. Renewable energy sources, such as wind farms and run-of-river plants do not receive this extra remuneration as they cannot assure a specific amount of energy units to the national system due to the random and uncontrolled nature of their energy source.

c) Several **barriers** individually and collectively increase the risk perception of the investors and financiers. This higher risk perception implies that for the project to be attractive to investors, it must produce higher than normal rate of return on the risk capital and high financial coverage factors for financiers‟ comfort, which combined create a strong **investment barrier**, which prevents it from being part of the capacity expansion plan, namely a limited access to equity and debt in the local and international markets, due to the high risk of investments in Colombia.

d) The financial analysis results show that the business as usual (BAU) scenario presents low returns on equity and low coverage ratios to service debt;

e) The participation of the project in the carbon market improves the leverage (i.e. stakeholder ability to reach financial closure, possibilities of attracting favorable financing conditions, higher return on investment due to the carbon revenue) and increases the project attractiveness to financiers

The project is additional because it generates emission reductions that would not occur otherwise. Considering the significant investment barriers associated with run-of-river power generation in the country, the project sponsor is unlikely to invest in the project in the absence of carbon finance.

<u>Early consideration of CDM</u>

In early 2002, the Project Entity decided to submit a Project Idea Note to the World Bank and after its consideration, a Letter of Intent was signed in September 23, 2002 to develop the project using the Clean Development Mechanism. Further documentary evidence can be made available for verification by the DOE.

The chronology of events of the project activity is presented below:

| Date | Events | Evidences |
|---|---|---|
| April 2002 | Submission of the Project Idea Note (PIN) to the World Bank by the Project Entity (HIDROGER at that moment) | World Bank, 2002 |
| 23 September 2002 | Signature of the Letter of Intent (LOI) between the World Bank and the Project Entity (HIDROGER) | LOI 2002 |
| January 2003 | Project Concept Note approved by the World Bank | World Bank 2003 |
| June 2003 | World Bank environmental safeguards assessment completed | World Bank 2003 |
| 16 July 2003 | Extension of LOI exclusivity period | LOI Extension 2003 |

| Date | Events | Evidences |
|---|---|---|
| November 2003 | World Bank social safeguards assessment completed | World Bank 2003 |
| January 2004 | Santander Investments began analysis on financial closure | |
| 27 April 2004 | Letter of Approval, Colombian DNA | LOA Colombia, 2004 |
| 10 May 2004 | World Bank Project Appraisal Document | World Bank, 2004 |
| 27 May 2004 | ERPA Signed between the World Bank and the Project Entity (HIDROGER) | ERPA 2004 |
| May 2005 | Santander Investment informed that it was not able to find interested investors | ISAGEN, 2005 |
| 8 May 2006 | ISAGEN Executive Board approved the project | ISAGEN, 2006 |
| 8 May 2006 | Novation and ERPA amendment signed with ISAGEN | ERPA amendment, 2006 |
| 18 December 2007 | Memo signed between local authorities and ISAGEN on social benefits for the local communities | ISAGEN, 2007 |
| 21 October 2008 | Change of name of the project by the DNA | LOA Colombia, 2008 |
| 7 May 2008 | Civil works contract signed with Rio Amoyá consortium. CDM Project Starting Date | ISAGEN, 2008 |
| 16 June 2008 | Construction of the project started | |
| 8 May 2009 | World Bank contracted ICONTEC to perform the validation of the project | World Bank, 2009 |
| 8 November 2009 | PDD published for global stakeholder consultation during the period 8 Nov 2009 to 8 Dec 2009 | |
| July 2011 | Expected date of Project commissioning | |

## B.6. Estimation of emission reductions

### B.6.1. Explanation of methodological choices

This section describes the procedures and methodology choices followed as per the approved Consolidated Baseline Methodology for Grid Connected Electricity Generation Projects (ACM0002).

The Methodology ACM0002 is applicable to the project and meets the applicability conditions, specifically, (i) the project involves a new power plant at a site where no renewable power plant was operated prior to the implementation of the project activity (greenfield plant), (ii) the project activity is grid-connected electricity generation from renewable energy sources, and (ii) the geographic and system boundaries for the electricity grid are clearly identified and information on the grid characteristics is available.

The project emissions ($PE_y$) are considered cero, according to equation 1 of Methodology ACM0002, because:

- Emissions due to the use of fossil fuels for the backup generator can be neglected in a renewable energy power generation project activities; $PE_{FF,y} = 0$.
- The project is a hydroelectric power plant, so $PE_{GP,y} = 0$.
- Being a run-of-river hydroelectric power plant there is no reservoir, so $PE_{HP,y} = 0$.

Baseline emissions include only $CO_2$ emissions from electricity generation in fossil fuel fired power plants that are displaced due to the project activity, which are calculated with equation 11 of the Methodology ACM0002. In this equation reference is made to the use of the "Tool to calculate the emission factor for an electricity system", which applied to the project activity, it is obtained that the Operating Margin is calculated using method (b) Simple Adjusted Method, and employing the ex-ante vintage option; the Build Margin is also calculated using the ex-ante Option 1. Further details of the applicability of ACM0002 is presented in Appendix 3.

The applicability of the "Tool to calculate the emission factor for an electricity system", the information used and the details is of the calculations are presented in Appendix 4

For the years 2015 and 2016, the Operating Margin emission factors of the UPME's Resolutions 843 of December 23, 2016 (National Interconnected Grid – SIN 2015 emission factor) and 804 of December 26, 2017 (SIN 2016 emission factor) were used, being these 0,5700 $tCO_2$/MWh and 0,6700 $tCO_2$/MWh respectively. Both Resolutions applied the correspondent version of the "Tool to calculate the emission factor for an electricity system".

For 2017, the data for calculation of the Operating Margin and Build Margin emission factors are collected from official sources such as the Energy and Mines Planning Unit (UPME) and Experts Company Market - XM. XM is in charge of planning, supervision and control of generation and transmission of the national electricity system. XM registers and stores generation data by the hour in a state of the art database that can be fully accessible through the Internet.

No other leakage emissions are considered. The power plant is already operating, so emissions potentially arising due to activities such as power plant construction and upstream emissions from fossil fuel use (e.g. extraction, processing, transport etc.) are neglected.

Concluding, emission reductions related to the Project Activity are the same to the Baseline Emissions, accordingly to the equation 17 of the Methodology ACM0002. The detail of the calculation is presented in section B.6.3.

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

| Data/Parameter | $EG_{m,y}$ and $EG_{k,y}$ |
|---|---|
| Data unit | MWh/yr |
| Description | Net electricity generated and delivered to the grid by power unit *m* or *k* in year *y* |
| Source of data | Data recorded, archived and supplied by XM |
| Value(s) applied | It varies by plant and year. XM keeps records of this variable for its users. |
| Choice of data or measurement methods and procedures | The data are suitable for the calculation of the National grid emission factor following the “Tool to calculate the emission factor for an electricity system”.<br>Simple adjusted OM: once for each crediting period using the most recent three historical years; 2015 - 2017 (*ex ante* option) for the second crediting period.<br>BM: For the second crediting period, Option 1 (*ex ante*) following the guidance included in Step 5. For the third crediting period, the *ex-ante* BM calculation at the start of the second crediting period will be used.<br>The official data are published by XM on their website, there is no need for measurement on each power unit. |
| Purpose of data | Calculation of baseline emissions |
| Additional comment | Not applicable |

| Data/Parameter | $EF_{CO2,i,y}$, $EF_{EL, m, i, y}$, and $EF_{EL, k, i, y}$ |
|---|---|
| Data unit | $tCO_2/TJ$ |
| Description | Emission factor of fossil fuel type i for power plant m or k in year y |
| Source of data | UPME’s Emission Factors of the Colombian National Interconnected Grid – SIN, October 2017. Support document of the Resolution 804 of 2017. |
| Value(s) applied | Fuel oil = 80,570.38<br>Diesel = 74,868.87<br>Coal = 97,257.39<br>Gas =55,100.53<br>Biogas = 84,627.13<br>Bagasse = 62,615.22 |
| Choice of data or measurement methods and procedures | The $CO_2$ emission factor is used to calculate the $CO_2$ emission coefficients of the power plants in the grid. Step necessary to find the baseline emission of the grid according to the “Tool to calculate the emission factor for an electricity system”<br>Simple adjusted OM: Once for each crediting period using the most recent three historical years; 2015 - 2017 (*ex ante* option) for the second crediting period.<br>BM: For the second crediting period, Option 1 (*ex ante*) following the guidance included in Step 5. For the third crediting period, the *ex-ante* BM calculation at the start of the second crediting period will be used. |
| Purpose of data | Calculation of baseline emissions |
| Additional comment | Not applicable |

| **Data/Parameter** | $\eta_{m,y}$ and $\eta_{k,y}$ |
|---|---|
| Data unit | MWh/GJ |
| Description | Average net energy conversion efficiency of power unit *m* or *k* in year *y* |
| Source of data | UPME's Emission Factors of the Colombian National Interconnected Grid – SIN, October 2017. Support document of the Resolution 804 of 2017. |
| Value(s) applied | Diesel = 0,38<br>Coal = 0,31<br>Gas = 0,38<br>Biogas = 0,35<br>Bagasse = 0,30 |
| Choice of data or measurement methods and procedures | Not applicable |
| Purpose of data | Calculation of baseline emissions |
| Additional comment | Not applicable |

| **Data/Parameter** | $\mathbf{EF_{grid,\ CM,y}}$ |
|---|---|
| Data 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 | 0.1677 |
| Choice of data or measurement methods and procedures | As per the "Tool to calculate the emission factor for an electricity system". |
| Purpose of data | Calculation of baseline emissions |
| Additional comment | 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. |

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

#### Baseline emissions

$$BE_y = EG_{PJ,y} \times EF_{grid,CM,y} = 513{,}600\ \frac{MWh}{yr} \times 0.1677\,\frac{tCO_2}{MWh} = 86{,}131\,\frac{tCO_2}{yr}$$

Where:

| | |
|---|---|
| $BE_y$ | Baseline emissions in year y ($tCO_2$/yr) |
| $EG_{PJ,y}$ | 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* that equals to 513,600 MWh/yr. |
| $EF_{grid,CM,y}$ | Combined margin $CO_2$ emission factor for Grid-connected power generation in year *y* calculated using the "Tool to calculate the emission factor for an electricity system" that equals to 0.1677 $tCO_2$/MWh. For details on the calculation see Appendix 4. |

#### Project emissions

The proposed CDM project activity is a run-of-river energy plant and does not give rise to direct GHG emissions since it does not have a reservoir. According to ACM0002 project emission calculations apply only to hydroelectric plants that result in new reservoirs or multiple reservoirs and hydro power project activities that result in the increase of single or multiple existing reservoirs. Since these three cases do not apply to the proposed CDM project activity, a value of zero emissions is assigned to the project emissions, $\mathbf{PE_y = 0}$.

**Leakage**

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 are neglected, $\mathbf{L_y = 0}$.

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

| Year | Baseline emissions ($tCO_2e$) | Project emissions ($tCO_2e$) | Leakage ($tCO_2e$) | Emission reductions ($tCO_2e$) |
|---|---|---|---|---|
| July 1, 2019 – December 31, 2019 | 43,065 | 0 | 0 | 43,065 |
| 2020 | 86,131 | 0 | 0 | 86,131 |
| 2021 | 86,131 | 0 | 0 | 86,131 |
| 2022 | 86,131 | 0 | 0 | 86,131 |
| 2023 | 86,131 | 0 | 0 | 86,131 |
| 2024 | 86,131 | 0 | 0 | 86,131 |
| 2025 | 86,131 | 0 | 0 | 86,131 |
| January 1, 2026 – June 30, 2026 | 43,065 | 0 | 0 | 43,065 |
| **Total** | 602,915 | 0 | 0 | 602,915 |
| **Total number of crediting years** | Seven years per each of the three crediting periods. | | | |
| **Annual average over the crediting period** | 86,131 | 0 | 0 | 86,131 |

## B.7. Monitoring plan

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

| **Data/Parameter** | $\mathbf{EG_{PJ, y}}$ |
|---|---|
| Data unit | MWh/y |
| Description | Quantity of net electricity generation that is produced by the project activity and fed into the grid in year y |
| Source of data | Continuous measurement by equipment installed at the power plant interconnection to the Grid and verified and approved by XM, who publish it on its website. |
| Value(s) applied | 513,600 MWh/year |
| Measurement methods and procedures | Directly measured by the equipment installed at Tuluní interconnection substation, the approved commercial frontier of the Project Activity.<br>The accuracy of the measurement equipment is CL active accuracy = 0.2S and Cl reactive accuracy = 2 and its calibration procedures are established by The Resolution CREG 038 of 2014 and the Internal Normative Document 0545 – Energy Measurement Equipment Calibration (based on the above mentioned Resolution), which state that the equipment must be calibrated every two years.<br>This Resolution also established that the measurement will be conducted and recorded hourly and daily sent to XM, accordingly to the Colombian Measurement Code “Código de Medida”, that establishes mandatory high technical standards, procedures for reading, registering and recording activities of electricity transactions performed in the Colombian energy market.<br>.<br>For further details about measurement methods and procedures see section B.7.3. - Other elements of monitoring plan. |
| Monitoring frequency | Hourly measurement |
| QA/QC procedures | All metering devices used to monitor and measure data follow rules that have been summarized in Resolution 038 of 2014 from CREG, or its modifications. This resolution specifies the technical characteristics measurement, telecommunications and back-up equipment to meet installation, testing, certification, operation and maintenance procedures. |
| Purpose of data | Calculation of baseline emissions |
| Additional comment | Not applicable |

### B.7.2. Sampling plan

Not applicable.

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

The monitoring plan defines procedures to measure emission reductions of greenhouse gases of Rio Amoyá Run-of-River Hydro Project that can be monitored and verified in conformity with the modalities and procedures of the Clean Development Mechanism criteria. The monitoring plan can be updated and/or modified whether changes in Clean Development Mechanism procedures so require.

The monitoring plan will be carried out entirely by ISAGEN with a multidisciplinary team, coordinated by the Energy Generation Operations (*Gerencia de Producción de Energía*) which is responsible to monitor the parameters, to record them and to analyse 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 electricity 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 electricity accountability and payments.

The monitoring plan implements the necessary procedures to measure and to manage Project operations, in order to determine emission reductions in a transparent way and report them to the audit of independent third party verification.

The calculation of annual Project electricity generation is explained below.

**Project electricity generation:** Continuous measurement of net electricity generation supplied by the Project plant to the Grid by means of on-site metering equipment at the interconnected substation where the plant connect to the Grid.

Technical characteristics of measurement systems to be implemented in Rio Amoyá Run-of-River Hydro Project will be in line with the provisions of the Resolution CREG 038 of 2014 or its modifications.

The measurement system will be able to measure the three-phase active energy and three-phase reactive energy by means of:

- Bidirectional electronic meters with double storing, no volatile memory or guaranteed feed, with accuracy class IEC 0.2 as stated by regulation entities according to the voltage and power flow in the power plant.
- Current and voltage transformers located in the approved commercial frontiers.

It is important to mention, that the meters are properly calibrated in Metrology Laboratories properly accredited. Meters are sealed to ensure its calibration; additionally ISAGEN has implemented a verification and re-calibration program of measuring equipment every two (2) years.

The measurement system will be able to receive, record and store data from the measurement devices. Likewise, the measurement system will be able to transmit through the communication system (using corresponding passwords) communication protocols, mistakes detection, and others.

Backup measurement devices will have identical characteristics of main devices which will allow replacing them in case of failure and ensuring this way the measurement and recording continuity.

Obtained and registered data related to the energy measurement process will be transmitted to XM Company, which is in charge of the CND and Colombian Wholesale Electricity Market operations and its commercial administration.

Power transactions are executed every hour. Generation information of every day recorded by the metering equipment is sent to XM Company every 24 hours, usually before 8 am of next day. According to that information provided in the same way by all generators agents, the XM check all information sent by every plant and processes the bills and payments for all transactions done in

the Wholesale Electricity Market. All this information is available to the market agents and to control authorities.

Mentioned above is the current procedure based on the rules and on operating procedures of Wholesale Electricity Market, and may be changed if it is determined by the authorities or entities in charge of administration and control of Wholesale Electricity Market.

Finally, the information related to the electric energy generation of Rio Amoyá Run-of-River Hydro Project will be uploaded and published by XM Company, in the same way for the other power plants of the Grid, by means of database in the XM Company webpage. For confidentiality purposes, the release of information about hourly electricity bid price of plants/units connected to the National Grid is made available with a delay of 3 months.

**Operational and Management Structure for Monitoring Plan**

ISAGEN has a multidisciplinary team, coordinated by the Production Management, who will be responsible for monitoring, recording and analyzing data related to the net electricity generation delivered to the Grid. As it was mentioned below, monitoring and recording data related to the net electricity generation delivered to the Grid is an established process, as the SIN relies on a highly regulated metering setup, which is required to make payments to the generators for electricity delivered by them. This means that for the CDM purposes, ISAGEN will continue with its normal activities for monitoring and recording electricity generation, but Production Management will keep additional copies of the hourly generation records that power plant dispatches to the Grid.

ISAGEN has incorporated to its internal procedures, activities related with the adequate management of the CDM monitoring system, specifying roles and responsibilities of those activities.

The metering system at ISAGEN for the Project is composed by software and hardware called PRIMEREAD that permits automatic recording of data collected at the meters. All data related to two directions power are measured so that net electricity delivered to the Grid are kept in file. For verification purposes, the data will be available at ISAGEN and be consult on transaction ZSIGEN at SAP R/3 with the appropriate authorization. Additionally, ISAGEN will have an electronic workbook, which will consist in a database to compile, specifically for the CDM project, all effectively dispatched electric power. The workbook will aggregate the data in different ways: daily, monthly and annual. The workbook will multiply the aggregate annual electric power by the ex-ante Grid emission factor in order to obtain the annual emission reductions required at verification.

**QA/QC aspects:**

All ISAGEN's operating power plants are part of the Quality Management System under ISO 9001.

Related to specific topics of monitoring plan, QA/QC aspects for taking into account are:

In case of interruptions in the transmission of the generated electric energy data, the operating staff in charge of the plant will make the opportune reading and transmission of generated electric energy data to the CND, according to conditions established by the CREG.

Before starting commercial exchanges in the Wholesale Electricity Market, measurement equipment will be certified by an entity accredited by the Superintendence of Industry and Trade according to the relevant Colombian regulation. ISAGEN will opportunely send the copy of equipment certifications tests to the CND.

Inspection, calibration and certification reports will be filed according to the company policies.

The main equipment contractors will have the responsibility of the theory and practice training of the ISAGEN's staff in order to operate the machinery in an adequate manner. The training will

have a minimum of hours established with the contractor. ISAGEN staff will ensure the professional and technological personnel in the mechanic, electricity, electronics and instrumentation fields.

Other good practice carried out by ISAGEN to ensure the adequate performance of the measurement systems and the generation system is the proper maintenance system executed in the power plants, which will be explained in Appendix 5.

In this way, further details about monitoring plan and QA/QC aspects like maintenance system will be described in Appendix 5.

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

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

07/05/2008

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

The operational lifetime of the Project is estimated as 50 years, as is common for run-of-river projects.

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

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

7 years, renewable.

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

01/07/2019.

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

7 year, renewable.

## SECTION D. Environmental impacts

### D.1. Analysis of environmental impacts

The project will contribute to watershed management and to the preservation of environmental services, sustainability of hydrological cycle from high mountain ecosystems. The conservation of the Rio Amoyá watershed is a major factor influencing the mountain ecosystem, the sustainability of water flow and the agricultural activities in the region.

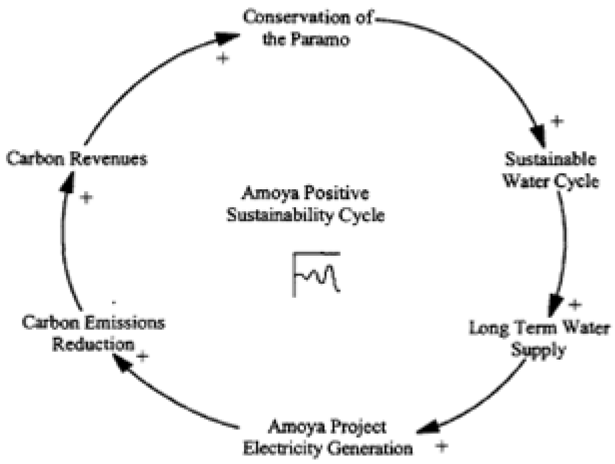



**Figure 2:** Economic and environment relationships of the Rio Amoyá Run-of-River Hydro Project

A detailed environmental impact assessment has been completed. The report concludes that there are no major adverse environmental impacts. The changes in water flow in the Amoyá River over a limited stretch, potential erosion at construction sites and impacts on water quality could be addressed within the Environmental Management Plan during construction and as part of operation and maintenance (O&M) activity. The design flow has been kept at 18.4 $m^3$/s to guarantee a minimum of 1.0 $m^3$/s at all times, and considerably higher 41% of the time. Furthermore, the Environmental Impact Assessment (EIA) shows that the additional flows will add to the river flow starting at 1 km. from the intake point. Measures to control erosion are included in the construction contracts. Water quality in the project area will be improved with the implementation of water resource management and solid waste management measures. Most works will be implemented underground to minimize the environmental footprint of the project.

Environmental Management Plan: The main objective of the environmental management plan is to promote the alignment of the project activities with the environmental and community objectives. The management measures are presented as index cards highlighting the mitigation measures, indicators for monitoring, schedule of execution, people in charge, and resource commitments for tasks. Monitoring programs are designed to verify the implementation of the environmental management measures during construction and operation of the project.

Contingency Plan: A contingency plan has been designed for managing the risks from natural, human and operational hazards. A list of activities to support the implementation of contingency plan has been prepared to address the situations that need to be responded and managed.
Socio-economic impacts: In order to assess the impacts during the construction and the operation a detailed socio-economic analysis was carried out. The diagnosis included assessment of infrastructure, water and sanitation, electrification, transport, communication, land use, health, education, administrative and institutional capacity. The socioeconomic impact assessment shows that the adverse impacts are minor while the positive impacts are substantial.

**CONCERTATION WITH LOCAL COMMUNITIES AND AUTHORITIES:**

In addition to the prevention and mitigation actions for the works related to the construction of the hydropower plant, all of them included in the Environment Management Plan, ISAGEN will undertake the following activities. They have been agreed upon with the local communities close to the project site and local authorities through a Memorandum signed on December 18th 2007 (available upon request):

1. **Basic sanitation:** Installation of family sanitary units and septic wells in the surrounding areas of the *Amoyá* River.
2. **River basin reconstruction and protection**, in the ravines of La *Alcancía, La Virginia, San Jorge y La Arenosa*, in order to Project the remaining forest, avoid deterioration of the environment and improve the conditions of the tributaries and the *Amoyá* River.
3. **Reforestation and maintenance of forests** located in the buffer zone of the *Las Hermosas* National Natural Park. Communal greenhouses will be installed with native species with the aim to recover risk areas and make a sustainable use of natural resources.
4. **Acquisition and management** of lots to protect water springs and improve eroded land in the medium and higher lands of the Amoyá River basin.
5. **Pilot programs for the reforestation mentioned activities.**
6. **Water springs and water sources.** ISAGEN will prepare a water sources inventory, possible uses of them and potential users in the tunnel area, in order to avoid the damaging of water sources.
7. In respect to the social benefits the Project boundary is considered to be area of Las Hermosas. The mayor social investments will be directed to those areas most affected by the hydropower plant.
8. ISAGEN will carry on a construction waste management plan in order to control sediments from the excavations in the Amoyá River and will guarantee the replanting of the zones intervened and the use of organic stratum brought from other excavations within the Project.

9. Considering that the Project is located in an area of high environmental importance, ISAGEN will supersede that no other natural resources are affected by the Project.

Environmental Impacts

The findings of the environmental impact assessment of the Rio Amoyá Run-of-River Hydro Project are summarized below.

**Underground Tunnel**: The construction and operation of the Rio Amoyá Run-of-River Hydro Project does not present major threat to the geological, natural and cultural conditions of the middle valley, where the majority of the socioeconomic activities are clustered. The works are concentrated in the underground tunnels for channeling water flow and the caverns needed for the power plant. The rock in which excavation takes place belongs to the Ibague batholiths, which offers high stability and negligible risk of ex-filtration.

**Roads**: The required access road of 10.8 km is short and 50% of which is an improvement of the existing roads. The temporary access roadway from La Virginia to Window 1 require the displacement of 1 or 2 households that are in the alignment of the roadway; however, during actual construction the need to displace these houses could be avoided, especially considering the ephemeral nature of the infrastructure being built.

**Surface operations:** The quarries and borrow pits needed for concrete mixtures and left over materials of surface and underground excavations are categorized under the surface operations. There are 11 deposits along the roads and have a combined capacity of 1.2 million $m_3$, somewhat larger than the expected volume of excess materials. The environmental management plan includes treatment of the deposits, reclamation of the area and planting of fast growing species to accelerate the land restoration.

**River flow regime:** As a consequence of the project, the natural regime of the Amoyá River may be modified in a short stretch below the weir. As agreed with the environmental authorities, the project design contemplates to maintain a *minimum flow for in-river needs* or *ecological flow.* The installed capacity and mean energy output of the ARPP incorporate this environmental provision.

### D.2. Environmental impact assessment

The environmental impacts of the project are not considered significant. The EIA was completed in accordance with the Colombian law. The corresponding environmental license, and subsequent modifications were awarded by the local (state-wide) environmental authority, Corporación Autónoma Regional del Tolima – CORTOLIMA (Resolutions 1858 of December 16, 1999; 911 of August 28, 2006 and 1662 of July 13, 2009). In addition, CORTOLIMA awarded the Project the environmental license to construct the transmission line that will connect the Project with the National Transmission System (Resolution 2145 of 2009).
The national government has endorsed the project based on the official documentation issued by the Ministry of Environment and Sustainable Development.

## SECTION E. Local stakeholder consultation

### E.1. Modalities for local stakeholder consultation

Comments received from local stakeholders as part of consultation process were compiled in all the phases of the EIA and measures to address them outlined. The project promoters and ISAGEN carried out formal consultations with the local communities and several meetings were held with the government institutions. The consultations with the local community included public hearings and workshops on health and sanitation issues, including the scope of basic agreements for improvements in the access to drinking water and sanitation and health services.

Agreements were sealed in a document signed in December 18, 2007, between representatives of the community, Chaparral's Mayor, Tolima's Governor, Chaparral's spokesman and ISAGEN's General Manager.

### E.2. Summary of comments received

The main concerns of local groups, authorities and communities, expressed in various meetings related to apprehensions due to loss of lands. The project minimized land requirements by designing an underground power facility. In addition, other concerns expressed were:

- Size of the project
- Benefits for the municipal government
- Employment opportunities for local labour
- End-use of the power generated from the project
- Company's management of operations
- Fear of not continuing with the prevailing cropping patterns
- Adverse impact on nearby ecosystems
- Adverse impact on some superficial water sources
- Negative impact on human health
- Potential benefits of project to the community

### E.3. Consideration of comments received

Comments received from local communities and other stakeholders were taken into account and consultations were organized to provide detailed information on the comments. The consultation process involved meetings, workshops, and field visits. The main features of the process were:

- Expectations of the communities and institutions needs were assessed through workshops to enable communities to assess the potential benefits to the community and impacts of the project on environment.
- Meetings and workshops were held in which the proposals of the community were considered, especially for managing the impacts on the ecosystem and socioeconomic aspects pertaining to water resources, health and education.

Agreements were sealed in a document signed in December 18, 2007, between representatives of the community, Chaparral´s Mayor, Tolima´s Governor, Chaparral's spokesman and ISAGEN´s General Manager.

In addition to the activities mentioned in Section D.1., another key project that will address the concerns of the local community is the Education and Culture Project, for which ISAGEN and local communities and authorities have agreed upon the following activities:

- In response to the stakeholders requests ISAGEN has agreed on the preparation of workshops on environmental issues, such as preservation of the ecosystems, based on the specific community requests.
- The project will also support community development, training and capacity building to improve knowledge in collective work and programs, cultural events and establishment of community groups.
- ISAGEN, in partnership with the National Library and as part of the " National Plan for Reading and Libraries" will provide the Chaparral town with a new library which will contain 2,000 books, TV, DVDs, CDs, computers, archiving software and training to librarians.
- ISAGEN will support all schools and high schools in the area of influence of the Project with computer materials and office equipment. ISAGEN will also subsidize college students in the area during the three year construction period and will hand 1,000 school kits for the children up to fifth grade in the Las Hermosas' sector.
- ISAGEN will support with financial resources the preparation of community events, traditional festivities, cultural events and peace-oriented celebrations.

Furthermore, the company will also support the preservation of cultural patrimony and heritage in the region. The Archaeology program will count with the authorization of the Colombian Institute of Anthropology and History-ICANH and will be implemented in order to avoid negative impacts in the patrimony on the region, using modern techniques to detect, analyse and monitor archaeological material. Also, ISAGEN will support the indigenous communities in the area with the anthropological studies requested by them and by supporting them in their recognition quest with the Directorate of Ethnicities of the Ministry of Interior and Justice.

## SECTION F. Approval and authorization

The letter of approval was issued by the Host Party designated national authority (DNA; Ministry of Environment, and Sustainable Development of Colombia) on April 27, 2004.

# Appendix 1. Contact information of project participants

| | |
|---|---|
| **Organization name** | ISAGEN S.A. ESP |
| **Country** | Colombia |
| **Address** | Carrera 30 # 10C – 280, Medellín, Antioquia |
| **Telephone** | +57 (4) 325 6921 |
| **Fax** | +57 (4) 448 8887 |
| **E-mail** | afehrmann@isagen.com.co |
| **Website** | www.isagen.com.co |
| **Contact person** | Mr. Adolfo Fehrmann |

# Appendix 2. Affirmation regarding public funding

No public funding was involved in financing of the proposed project activity.

# Appendix 3. Applicability of methodologies and standardized baselines

The detail of the Applicability of ACM0002 to the Project Activity is presented in the following table:

| Applicability ACM0002 | Applicability to the Project Activity |
|---|---|
| This methodology is applicable to grid-connected renewable energy power generation project activities that:<br>(a) Install a Greenfield power plant;<br>(b) Involve a capacity addition to (an) existing plant(s);<br>(c) Involve a retrofit of (an) existing operating plants/units;<br>(d) Involve a rehabilitation of (an) existing plant(s)/unit(s); or<br>(e) Involve a replacement of (an) existing plant(s)/unit(s). | The Project Activity consists in the installation of a Greenfield power plant at the lower range of the Amoyá River Basin |
| The methodology is applicable under the following conditions:<br>(a) The project activity may include renewable energy power plant/unit of one of the following types: hydro power plant/unit with or without reservoir, wind power plant/unit, geothermal power plant/unit, solar power plant/unit, wave power plant/unit or tidal power plant/unit;<br>(b) In the case of capacity additions, retrofits, rehabilitations or replacements (except for wind, solar, wave or tidal power capacity addition projects) the existing plant/unit started commercial operation prior to the start of a minimum historical reference period of five years, used for the calculation of baseline emissions and defined in the baseline emission section, and no capacity expansion, retrofit, or rehabilitation of the plant/unit has been undertaken between the start of this minimum historical reference period and the implementation of the project activity. | The Project Activity is a hydro power plant without reservoir (run-of-river). |
| In case of hydro power plants, one of the following conditions shall apply:<br>(a) The project activity is implemented in existing single or multiple reservoirs, with no change in the volume of any of the reservoirs; or<br>(b) The project activity is implemented in existing single or multiple reservoirs, where the volume of the reservoir(s) is increased and the power density, calculated using equation (3), is greater than 4 $W/m^2$; or<br>(c) The project activity results in new single or multiple reservoirs and the power density, calculated using | The Project Activity is implemented with no change in the volume of any reservoir, as it is a run-of-river hydropower plant |

| | |
|---|---|
| equation (3), is greater than 4 W/m$^2$; or<br>(d) The project activity is an integrated hydro power project involving multiple reservoirs, where the power density for any of the reservoirs, calculated using equation (3), is lower than or equal to 4 W/m$^2$, all of the following conditions shall apply:<br>(i) The power density calculated using the total installed capacity of the integrated project, as per equation (4), is greater than 4 W/m$^2$;<br>(ii) Water flow between reservoirs is not used by any other hydropower unit which is not a part of the project activity;<br>(iii) Installed capacity of the power plant(s) with power density lower than or equal to 4 W/m$^2$ shall be:<br>a. Lower than or equal to 15 MW; and<br>b. Less than 10 per cent of the total installed capacity of integrated hydro power project. | |
| In the case of integrated hydro power projects, project proponent shall:<br>(a) Demonstrate that water flow from upstream power plants/units spill directly to the downstream reservoir and that collectively constitute to the generation capacity of the integrated hydro power project; or<br>(b) Provide an analysis of the water balance covering the water fed to power units, with all possible combinations of reservoirs and without the construction of reservoirs. The purpose of water balance is to demonstrate the requirement of specific combination of reservoirs constructed under CDM project activity for the optimization of power output. This demonstration has to be carried out in the specific scenario of water availability in different seasons to optimize the water flow at the inlet of power units. Therefore, this water balance will take into account seasonal flows from river, tributaries (if any), and rainfall for minimum five years prior to implementation of CDM project activity. | Not applicable as the Project Activity is not part of an integrated hydro power projects.<br>The Project Activity is the only hydro power plant which uses the flow of the Amoyá River to generate energy. |
| The methodology is not applicable to:<br>(a) Project activities that involve switching from fossil fuels to renewable energy sources at the site of the project activity, since in this case the baseline may be the continued use of fossil fuels at the site;<br>(b) Biomass fired power plants/units. | Not applicable as the Project Activity does not involve switching from fossil fuels to renewable energy sources or it is not a biomass fired power plant. |
| In the case of retrofits, rehabilitations, replacements, or capacity additions, this methodology is only applicable if the most plausible baseline scenario, as a result of the identification of baseline scenario, is “the continuation of the current situation, that is to use the power generation equipment that was already in use prior to the implementation of the project activity and undertaking business as usual maintenance”. | Not applicable as the Project Activity it is not a case of retrofits, rehabilitations, replacements, or capacity additions. |

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

*Applicability of the Tool to calculate the emission factor for an electricity system*

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

The relevant electricity system is the Colombian Interconnected Grid.

Option 2 is selected, because the Colombian Interconnected Grid is managed by XM, as the dispatch center responsible for scheduling and dispatching electricity generated by the Project Activity. This Colombian Grid is connected to Ecuador and Venezuela, however the information required to demonstrate transmission constraints (or not) is not publicly available, so only the Colombian Grid was analyzed.

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

Option I is selected, only grid power plants are included in the calculation.

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

The Simple adjusted OM is selected, to be consistent with the official information (UPME's 2015 and 2016 Emission Factor of the Grid Resolutions) used for the years 2015 and 2016. For 2017 there is no official norm, so the OM was calculated.

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

The simple adjusted OM emission factor ($EF_{grid,OM\text{-}adj,y}$) is a variation of the simple OM, where the power plants/units (including imports) are separated in low-cost/must-run power sources (k) and other power sources (m). As under Option A of the simple OM, it is calculated based on the net electricity generation of each power unit and an emission factor for each power unit. The ex-ante option was selected.

The UPME's Resolutions 843 of December 23, 2016 and 804 of December 26, 2017 were used to provide the $EF_{grid,OM\text{-}adj,2015}$ = 0.5700 $tCO_2$/MWh and $EF_{grid,OM,2016}$ = 0,6700 $tCO_2$/MWh respectively.

The 2017 Operating Margin (OM) was calculated using the equation 10 of the "Tool to calculate the emission factor for an electricity system" and the information downloaded from offical sources (XM[10] and the UPME[11]).

$$EF_{grid,OM-adj,y} = (1-\lambda_y)\times\frac{\sum_m EG_{m,y}\times EF_{EL,m,y}}{\sum_m EG_{m,y}} + \lambda_y\times\frac{\sum_k EG_{k,y}\times EF_{EL,k,y}}{\sum_k EG_{k,y}}$$

The table shown below present the emissions for all power plants connected to the Interconnected National Grid.

| No LCMR | | | | | | | |
|---|---|---|---|---|---|---|---|
| POWER PLANT | FUEL | POWER GENERATION (MWh) | HEAT RATE (MBTU/MWh) | EFFICIENCY (TJ/MWh) | EMISSION FACTOR ($tCO_2$/TJ) | EMISSION FACTOR ($tCO_2$/MWh) | EMISSIONS ($tCO_2$) |
| BARRANQUILLA 3 | Gas | 17.545,5 | 9,6961 | 0,010 | 55,101 | 0,564 | 9.890,0 |
| BARRANQUILLA 4 | Gas | 22.282,7 | 9,9695 | 0,011 | 55,101 | 0,580 | 12.914,3 |
| CARTAGENA 1 | Gas | 8.746,1 | 12,0837 | 0,013 | 55,101 | 0,702 | 6.143,9 |
| CARTAGENA 2 | Gas | 13.297,1 | 11,5167 | 0,012 | 55,101 | 0,670 | 8.902,6 |
| CARTAGENA 3 | Gas | 30.901,2 | 13,8215 | 0,015 | 55,101 | 0,804 | 24.829,1 |
| FLORES 1 | Gas | 434.232,9 | 7,3505 | 0,008 | 55,101 | 0,427 | 185.554,3 |
| FLORES 4B | Gas | 508.139,0 | 6,9107 | 0,007 | 55,101 | 0,402 | 204.143,6 |
| GECELCA 3 | Coal | 1.450,0 | 9,5000 | 0,010 | 97,257 | 0,975 | 1.413,5 |
| GUAJIRA 1 | Gas | 534.329,3 | 9,8000 | 0,010 | 55,101 | 0,570 | 304.415,2 |
| GUAJIRA 2 | Gas | 486.955,9 | 10,2000 | 0,011 | 55,101 | 0,593 | 288.749,4 |

[10] XM Company http://informacioninteligente10.xm.com.co/oferta/Paginas/HistoricoOferta.aspx

[11] UPME's SIAME http://www.siame.gov.co/Inicio/C%C3%A1lculofactordeemisi%C3%B3n/tabid/77/Default.aspx

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| MERILECTRICA 1 | Gas | 4.012,2 | 9,7655 | 0,010 | 55,101 | 0,568 | 2.277,7 |
| PAIPA 1 | Coal | 36.267,8 | 11,9557 | 0,013 | 97,257 | 1,227 | 44.493,3 |
| PAIPA 2 | Coal | 228.114,9 | 10,7918 | 0,011 | 97,257 | 1,107 | 252.607,2 |
| PAIPA 3 | Coal | 136.397,2 | 12,2715 | 0,013 | 97,257 | 1,259 | 171.751,8 |
| PAIPA 4 | Coal | 562.445,5 | 9,5355 | 0,010 | 97,257 | 0,978 | 550.328,5 |
| PROELECTRICA 1 | Gas | 61.073,9 | 7,9420 | 0,008 | 55,101 | 0,462 | 28.197,9 |
| PROELECTRICA 2 | Gas | 51.806,3 | 7,9418 | 0,008 | 55,101 | 0,462 | 23.918,4 |
| TASAJERO 1 | Coal | 329.191,2 | 9,1268 | 0,010 | 97,257 | 0,937 | 308.293,9 |
| TASAJERO 2 | Coal | 327.180,9 | 9,7214 | 0,010 | 97,257 | 0,998 | 326.373,5 |
| TEBSAB | Gas | 3.664.358,9 | 7,2131 | 0,008 | 55,101 | 0,419 | 1.536.566,0 |
| TERMOCANDELARIA 1 | Gas | 29.041,7 | 10,4868 | 0,011 | 55,101 | 0,610 | 17.705,0 |
| TERMOCANDELARIA 2 | Gas | 10.209,3 | 10,4914 | 0,011 | 55,101 | 0,610 | 6.226,7 |
| TERMOCENTRO CC | Gas | 87.474,3 | 7,2683 | 0,008 | 55,101 | 0,423 | 36.961,1 |
| TERMODORADA 1 | Gas | 2.133,4 | 10,5559 | 0,011 | 55,101 | 0,614 | 1.309,2 |
| TERMOEMCALI 1 | Gas | 9.357,4 | 7,4639 | 0,008 | 55,101 | 0,434 | 4.060,2 |
| TERMOSIERRAB | Gas | 15.104,2 | 7,1417 | 0,008 | 55,101 | 0,415 | 6.270,9 |
| TERMOVALLE 1 | Gas | 26.359,0 | 6,9421 | 0,007 | 55,101 | 0,404 | 10.637,8 |
| TERMOYOPAL 2 | Gas | 184.046,1 | 12,0234 | 0,013 | 55,101 | 0,699 | 128.642,7 |
| ZIPAEMG 2 | Coal | 18.617,6 | 11,7207 | 0,012 | 97,257 | 1,203 | 22.391,1 |
| ZIPAEMG 3 | Coal | 23.182,8 | 12,8203 | 0,014 | 97,257 | 1,316 | 30.497,3 |
| ZIPAEMG 4 | Coal | 39.146,6 | 13,6509 | 0,014 | 97,257 | 1,401 | 54.834,5 |
| ZIPAEMG 5 | Coal | 38.024,3 | 12,3226 | 0,013 | 97,257 | 1,264 | 48.079,7 |
| **POWER PLANT** | **FUEL** | **POWER GENERATION (MWh)** | **ηm (MWh/GJ)** | **FUEL EF ($tCO_2/GJ$)** | **CONSTANT** | | **EMISSIONS ($tCO_2$)** |
| AUTOG ARGOS CARTAGENA | Gas | 15.174,6 | 0,38 | 0,055 | 3,6 | | 7.921,2 |
| AUTOG ARGOS TOLUVIEJO | Coal | 6.821,2 | 0,31 | 0,097 | 3,6 | | 7.704,2 |
| AUTOG ARGOS YUMBO | Coal | 2.264,6 | 0,31 | 0,097 | 3,6 | | 2.557,8 |
| AUTOG REFICAR | Gas | 61.711,4 | 0,38 | 0,055 | 3,6 | | 32.213,7 |
| AUTOG UNIBOL | Gas | 6.004,1 | 0,38 | 0,055 | 3,6 | | 3.134,2 |
| COGENERADOR COLTEJER 1 | Coal | 6.521,5 | 0,31 | 0,097 | 3,6 | | 7.365,7 |
| PAPELES NACIONALES | Gas | 2.105,5 | 0,38 | 0,055 | 3,6 | | 1.099,1 |

**LCMR**

| POWER PLANT | FUEL | POWER GENERATION (MWh) | HEAT RATE (MBTU/MWh) | EFFICIENCY (TJ/MWh) | EMISSION FACTOR ($tCO_2/TJ$) | EMISSION FACTOR ($tCO_2/MWh$) | EMISSIONS ($tCO_2$) |
|---|---|---|---|---|---|---|---|
| CIMARRON | Gas | 135.450,7 | 13,500 | 0,014 | 55,101 | 0,785 | 106.303,2 |
| EL MORRO 1 | Gas | 169.408,0 | 12,400 | 0,013 | 55,101 | 0,721 | 122.120,0 |
| EL MORRO 2 | Gas | 158.678,0 | 13,840 | 0,015 | 55,101 | 0,805 | 127.668,6 |
| TERMOYOPAL 1 | Gas | 163.942,2 | 12,706 | 0,013 | 55,101 | 0,739 | 121.093,4 |
| **POWER PLANT** | **FUEL** | **POWER GENERATION (MWh)** | **ηm (MWh/GJ)** | **FUEL EF ($tCO_2/GJ$)** | **CONSTANT** | | **EMISSIONS ($tCO_2$)** |
| AUTOG YAGUARITO | Bagasse | 1.608,9 | 0,30 | 0,063 | 3,6 | | 1.208,9 |
| BIOENERGY | Bagasse | 45.906,2 | 0,30 | 0,063 | 3,6 | | 34.493,2 |
| CENTRAL CASTILLA 1 | Bagasse | 10.469,2 | 0,30 | 0,063 | 3,6 | | 7.866,4 |
| CENTRAL TUMACO 1 | Bagasse | 1,2 | 0,30 | 0,063 | 3,6 | | 0,9 |
| COGENERADOR PROENCA | Bagasse | 130.183,9 | 0,30 | 0,063 | 3,6 | | 97.817,9 |
| COGENERADOR PROENCA II | Bagasse | 1.627,9 | 0,30 | 0,063 | 3,6 | | 1.223,1 |
| DOÑA JUANA | Biogas | 3.993,4 | 0,35 | 0,085 | 3,6 | | 3.476,1 |

| | | | | | | |
|---|---|---|---|---|---|---|
| INCAUCA 1 | Bagasse | 56.697,7 | 0,30 | 0,063 | 3,6 | 42.601,6 |
| INGENIO LA CARMELITA | Bagasse | 0,8 | 0,30 | 0,063 | 3,6 | 0,6 |
| INGENIO MANUELITA | Bagasse | 2.404,5 | 0,30 | 0,063 | 3,6 | 1.806,7 |
| INGENIO PICHICHI 1 | Bagasse | 1.316,8 | 0,30 | 0,063 | 3,6 | 989,4 |
| INGENIO PROVIDENCIA 2 | Bagasse | 118.302,4 | 0,30 | 0,063 | 3,6 | 88.890,4 |
| INGENIO RIOPAILA 1 | Bagasse | 29.283,9 | 0,30 | 0,063 | 3,6 | 22.003,4 |
| INGENIO RISARALDA 1 | Bagasse | 118.262,2 | 0,30 | 0,063 | 3,6 | 88.860,2 |
| INGENIO SAN CARLOS 1 | Bagasse | 6.674,3 | 0,30 | 0,063 | 3,6 | 5.014,9 |
| MAYAGUEZ 1 | Bagasse | 103.968,5 | 0,30 | 0,063 | 3,6 | 78.120,1 |
| PROENCA II | Coal | 867,7 | 0,31 | 0,097 | 4,6 | 1.252,2 |
| PTAR 1 | Gas | 1.772,1 | 0,38 | 0,055 | 3,6 | 925,0 |
| TEQUENDAMA BIOGAS | Biogas | 2.075,3 | 0,35 | 0,085 | 3,6 | 1.806,4 |
| TERMOBOLIVAR 1 | Gas | 3.035,9 | 0,38 | 0,055 | 3,6 | 1.584,7 |
| TERMOMECHERO 5 | Gas | 7.414,7 | 0,38 | 0,055 | 3,6 | 3.870,5 |
| TERMOPIEDRAS | Gas | 283,1 | 0,38 | 0,055 | 3,6 | 147,8 |

The parameter Lambda ($\lambda_y$) was determined using Approach 2 and the equation 11 of the “Tool to calculate the emission factor for an electricity system”. Do to the extent of the information, the detail for Lambda calculation is presented in the annexed spreadsheet *3461 Amoyá - Emission factor_Emissions reductions_nov 30 2018*.

$$\lambda_y(per\ cent) = \frac{Number\ of\ hours\ \text{low} - \text{cost/must} - \text{run}\ are\ on\ the\ margin\ in\ year\ y}{8760\ hours\ per\ year}$$

Lambda = 0.3168

The Operating Margin emission factor that will be applicable for the second crediting period of the Project Activity is $EF_{SIN,OM\text{-}adj,2017}$ = 0.5483 $tCO_2/MWh$.

The details of OM calculation is presented in the annexed spreadsheet *3461 Amoyá - Emission factor_Emissions reductions_nov 30 2018*.

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

The Build Margin Emission factor was calculated *ex ante* Option 1, based on the most recent information available on units already built at the time of submission of the request for renewal of the crediting period.

For this case, after following the proper steps to define the sample group of power units *m*, it was concluded that the power units registered as CDM project activities, starting with power units that started to supply electricity to the grid most recently, until the electricity generation of the new set comprises 20 per cent of the annual electricity generation of the project electricity system, so $SET_{sample\text{-}CDM}$ was used to calculate the build margin.

$AEG_{TOTAL}$ = 59,643,491 MWh
$AEG_{SET\text{-}5\text{-}units}$ = 230,460 MWh
20% of $AEG_{TOTAL}$ = 11,928,698 MWh
$AEG_{SET\text{-}sample\text{-}CDM}$ = 11,946,204 MWh

| | | | Power Generation 2017 | | | GHG Emissions |
|---|---|---|---|---|---|---|
| Date of commissioning | Project name | Generation type | MWh | MWh Accumulated | % | $tCO_2$/2017 |
| 16/12/2017 | TERMOMECHERO 5 | Gas | 78.966,22 | 78.966,22 | 0,13% | 64.121,19 |
| 10/10/2017 | PROENCA II | Coal | 7.170,02 | 86.136,23 | 0,14% | 10.347,59 |

| | | | | | | |
|---|---|---|---|---|---|---|
| 07/10/2017 | LUZMA I | Hydro | 65.607,00 | 151.743,23 | 0,25% | |
| 07/10/2017 | LUZMA II | Hydro | 67.484,52 | 219.227,75 | 0,37% | |
| 29/09/2017 | AUTOG ARGOS EL CAIRO | Hydro | 11.232,41 | 230.460,17 | 0,39% | |
| 03/09/2017 | CELSIA SOLAR YUMBO | Solar | 6.903,81 | 237.363,98 | 0,40% | |
| 30/08/2017 | LAS PALMAS | Hydro | 5.606,25 | 242.970,23 | 0,41% | |
| 20/05/2017 | CANTAYUS | Hydro | 13.016,11 | 255.986,34 | 0,43% | |
| 25/04/2017 | SAN MATIAS | Hydro | 51.361,25 | 307.347,59 | 0,52% | |
| 22/04/2017 | BIOENERGY | Bagasse | 23.934,18 | 331.281,77 | 0,56% | 17.983,73 |
| 19/04/2017 | EL MOLINO | Hydro | 53.262,40 | 384.544,17 | 0,64% | |
| 02/03/2017 | ALEJANDRIA | Hydro | 39.659,82 | 424.204,00 | 0,71% | |
| 02/03/2017 | EL EDÉN | Hydro | 44.319,16 | 468.523,16 | 0,79% | |
| 22/12/2016 | MAGALLO | Hydro | 26.212,41 | 494.735,57 | 0,83% | |
| 10/12/2016 | COELLO | Hydro | 6.484,85 | 501.220,42 | 0,84% | |
| 10/09/2016 | MORRO AZUL | Hydro | 109.990,73 | 611.211,14 | 1,02% | |
| 30/06/2016 | TUNJITA | Hydro | 15.098,61 | 626.309,75 | 1,05% | |
| 25/06/2016 | TEQUENDAMA BIOGAS | Biogas | 2.075,25 | 628.385,00 | 1,05% | 423,39 |
| 20/05/2016 | EL COCUYO | Hydro | 2.202,35 | 630.587,35 | 1,06% | |
| 29/04/2016 | LA FRISOLERA | Hydro | 423,73 | 631.011,08 | 1,06% | |
| 29/04/2016 | DOÑA JUANA | Biogas | 3.993,41 | 635.004,49 | 1,06% | 3.476,07 |
| 27/04/2016 | GUAVIO MENOR | Hydro | 42.276,38 | 677.280,87 | 1,14% | |
| 26/04/2016 | AUTOG REFICAR | Gas | 61.711,44 | 738.992,31 | 1,24% | 32.213,68 |
| 25/04/2016 | PORCE III MENOR | Hydro | 12.651,56 | 751.643,87 | 1,26% | |
| 22/03/2016 | AUTOG YAGUARITO | Bagasse | 1.608,92 | 753.252,78 | 1,26% | 1.208,91 |
| 20/03/2016 | AUTOG ARGOS YUMBO | Coal | 2.264,65 | 755.517,43 | 1,27% | 2.557,79 |
| 20/03/2016 | AUTOG UNIBOL | Gas | 6.004,10 | 761.521,53 | 1,28% | 3.134,17 |
| 17/03/2016 | INGENIO MANUELITA | Bagasse | 2.404,54 | 763.926,07 | 1,28% | 1.806,73 |
| 15/03/2016 | AUTOG ARGOS CARTAGENA | Gas | 15.174,55 | 779.100,62 | 1,31% | 7.921,19 |
| 04/03/2016 | TERMOBOLIVAR 1 | Gas | 3.035,88 | 782.136,50 | 1,31% | 1.584,74 |
| 23/12/2015 | SAN MIGUEL | Hydro | 349.181,40 | 1.131.317,90 | 1,90% | |
| 30/11/2015 | TASAJERO 2 | Coal | 327.180,92 | 1.458.498,83 | 2,45% | 326.373,48 |
| 22/11/2015 | CARLOS LLERAS | Hydro | 457.703,08 | 1.916.201,91 | 3,21% | |
| 16/11/2015 | EL QUIMBO | Hydro | 2.190.095,02 | 4.106.296,93 | 6,88% | |
| 30/09/2015 | PROVIDENCIA | Hydro | 35.266,21 | 4.141.563,13 | 6,94% | |
| 17/09/2015 | GECELCA 3 | Coal | 1.450,01 | 4.143.013,14 | 6,95% | 1.413,49 |
| 29/07/2015 | CUCUANA | Hydro | 265.693,00 | 4.408.706,14 | 7,39% | |
| 30/01/2015 | BAJO TULUA | Hydro | 105.997,74 | 4.514.703,88 | 7,57% | |
| 20/12/2014 | SOGAMOSO | Hydro | 5.438.534,25 | 9.953.238,13 | 16,69% | |
| 17/12/2014 | LAGUNETA | Hydro | 127.109,65 | 10.080.347,78 | 16,90% | |
| 27/11/2014 | LA NAVETA | Hydro | 21.653,31 | 10.102.001,09 | 16,94% | |
| 24/07/2014 | LA REBUSCA | Hydro | 5.134,55 | 10.107.135,64 | 16,95% | |
| 25/06/2014 | SALTO II | Hydro | 213.908,82 | 10.321.044,46 | 17,30% | |
| 29/04/2014 | COGENERADOR PROENCA | Bagasse | 130.183,87 | 10.451.228,33 | 17,52% | 97.817,91 |
| 31/03/2014 | EL POPAL | Hydro | 157.784,33 | 10.609.012,67 | 17,79% | |
| 19/12/2013 | COGENERADOR COLTEJER 1 | Coal | 6.521,54 | 10.615.534,21 | 17,80% | 7.365,70 |
| 10/11/2013 | DARIO VALENCIA SAMPER | Hydro | 871.853,53 | 11.487.387,74 | 19,26% | |
| 24/05/2013 | AMOYA LA ESPERANZA | Hydro | 458.815,83 | 11.946.203,57 | 20,03% | |
| | | | | | | 487.297 |

The build margin emission factor was calculated using equation 15 of the “Tool to calculate the emission factor for an electricity system”.

$$EF_{grid,BM,y} = \frac{\sum_m EG_{m,y} \times EF_{EL,m,y}}{\sum_m EG_{m,y}}$$

The Build Margin emission factor that will be applicable for the second crediting period of the Project Activity is $EF_{SIN,BM,2017}$ = 0.0408t$CO_2$/MWh

The details of BM calculation is presented in the annexed spreadsheet *3461 Amoyá - Emission factor_Emissions reductions_nov 30 2018*.

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

Taking into account that the data to determine OM and BM were available, a weighted average CM method (Option a) was selected, using the equation 16 of the "Tool to calculate the emission factor for an electricity system"

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

Knowing that for the second crediting period of a hydro project activity the $\omega_{OM}$ = 0.25 and $\omega_{BM}$ = 0.75, the Combined Margin emission factor that will be applicable for the second crediting period of the Project Activity is $EF_{SIN,CM,2017}$ = 0.1677 t$CO_2$/MWh.

The details of CM calculation is presented in the annexed spreadsheet *3461 Amoyá - Emission factor_Emissions reductions_nov 30 2018*.

The following table summarizes the findings:

| | 2015 | 2016 | 2017 | TOTAL |
|---|---|---|---|---|
| Power Generation (MWh) | 66.548.474 | 65.935.243 | 66.667.097 | 199.150.814 |
| EF No LCMR | - | - | 0,5871 | |
| EF LCMR | - | - | 0,0164 | |
| Lambda | - | - | 0,3168 | |
| $EF_{grid,OM-adj,y}$ (t$CO_2$/MWh) | 0,5700 | 0,6700 | 0,4063 | |
| $EF_{SIN,OM-adj,2017}$ (t$CO_2$/MWh) | | | **0,5483** | |
| $EF_{SIN,BM,2017}$ (t$CO_2$/MWh) | | | **0,0408** | |
| $EF_{SIN,CM,2017}$ (t$CO_2$/MWh) | | | **0,1677** | |

## Appendix 5. Further background information on monitoring plan

No further background information is used in the development of the monitoring plan.

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

This section is intentionally left blank. For details please refer to section E above.

## Appendix 7. Summary of post-registration changes

The only Post-registration change (PRC-3461-001, approved on 21st September 2016) that the Projects has had included:

- Correction in the transmission line's distance of 18 km to 18.6 km.
- Correction in the number Reported by the synchronous generator of 43.33 MVA to 45.7 MVA.

- Correction regarding the Project Participants: according to the withdrawal registered in the UNFCCC by the International Bank for Reconstruction and Development (IBRD) as Trustee of the Netherlands CDM Facility (NCDMF), who was registered as project participant, decided to withdraw its participation. This change was notified to the UNFCCC on 13/08/2014.
- Correction of the official web site for downloading the recorded generation data for each power plant. The official web site is www.xm.com.co
- Change of the Cross-check description in the monitoring plan.
- Correction in the name National Dispatch Center (CND) by XM.
- Correction of the ex-ante emission reduction calculation due to the delay of the start date of the crediting period (Section B.6.4).
- Change to start date of crediting period from 01/07/2011 to 01/07/2012.