PROJECT DESIGN DOCUMENT FORM
FOR CDM PROJECT ACTIVITIES (F-CDM-PDD)
Version 04.1

PROJECT DESIGN DOCUMENT (PDD)

Title of the project activity	SHP Morro Azul CDM Project (JUN1164).
Version number of the PDD	1
Completion date of the PDD	20/08/2012
Project participant(s)	Risaralda Energía S.A.S. E.S.P.
Host Party(ies)	Colombia
Sectoral scope and selected methodology(ies)	I - Energy Industries (renewable/non-renewable sources), Methodology ACM0002
Estimated amount of annual average GHG emission reductions	46,434

SECTION A. Description of project activity
A.1. Purpose and general description of project activity

The project activity consists in the construction of the Small Hydropower Plant Morro Azul with final installed capacity of 19.9 MW.

The SHP Morro Azul is located on the Risaralda River, Cauca River basin, in the municipalities of Belén de Umbria and Anserma – Risaralda and Caldas Departments, Colombia. The SHP will create a new a reservoir with 0.1217 Km2. The plant will be managed by the Risaralda Energía S.A.S. E.S.P., a special purpose society responsible for the power plant construction and operation.

The project activity main purpose is to provide electric power to the National Interconnected System, displacing the thermal generation from fossil fuels present in the system with the generation of renewable energy.

Moreover, it improves the supply of electricity in the country, contributing to its environmental sustainability by increasing the share of renewable energy in relation to total consumption of electricity in Colombia. Thus, the project activity supports the construction of new renewable energy project as environmentally sustainable alternative to generate electric energy.

In regard to the contribution of the project in mitigation of Greenhouse Gas emissions (GHG), the project activity reduces emissions of these gases avoiding thermoelectric plants operation that make use of fossil fuels as energy source. In the absence of the project activity, fossil fuels would be burned in thermoelectric plants connected to the grid to supply the electrical demand of the country. This is considered the baseline scenario (as defined in section B.4) and also the scenario prior to the operation of the hydropower plant. The project activity initiative helps Colombia to meet its goals of promoting sustainable development.

The project activity is also aligned with the specific requirements of the CDM (Clean Development Mechanism) of the host country, because:

- It contributes to environmental sustainability as reduce the use of fossil energy (non-renewable sources). Thus the project contributes to the best use of natural resources and makes use of clean and efficient technologies;
- It enlarges the opportunity for employment in areas where the project is located;
- It contributes to better conditions of the local economy, reducing the amount of pollution released into atmosphere and the associated social costs related to it.

Moreover, the project diversifies the sources of generation of electricity and decentralized energy generation from bringing specific benefits such as:

- Increased reliability, with shorter and less extensive interruptions;
- Fewer demands related to reserve margin;
- Energy of better quality for the region;
- Minor losses in transmission and distribution lines;
- Control energy reactive;
- Mitigation of congestion in transmission and distribution.

A.2. Location of project activity

A.2.1. Host Party(ies)

Colombia

A.2.2. Region/State/Province etc.

Risaralda and Caldas Departments – Central-west Region

A.2.3. City/Town/Community etc.

Belén de Umbria and Anserma cities

A.2.4. Physical/Geographical location

The SHP Morro Azul is located at the Risaralda river, coordinates 5° 11' 20,61''N and. 75° 48'43,63''W , in the Belén de Umbria and Anserma cities, Risaralda and Caldas Departments, central-west, Colombia (5.189058 N and -75.812119 W)

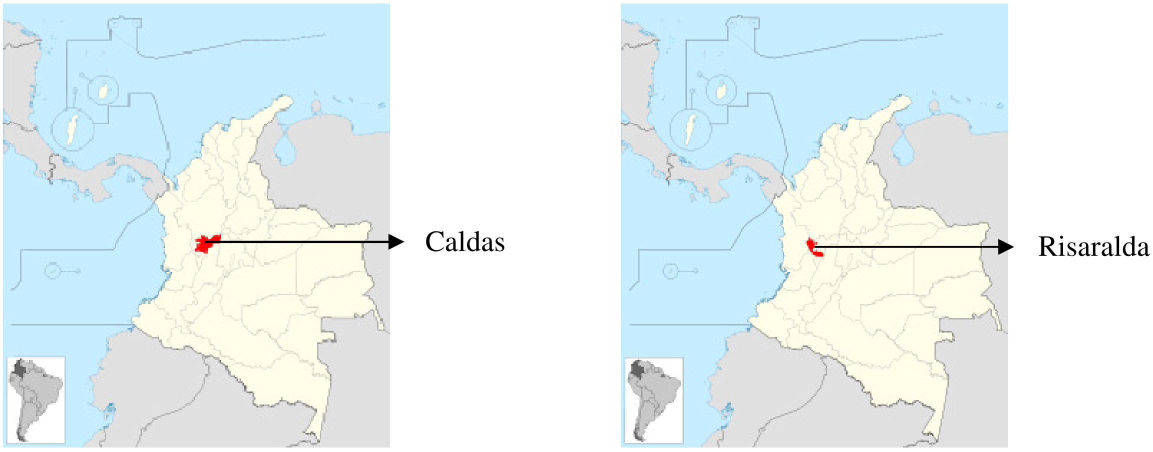

Fig 1: Caldas and Risaralda Departments

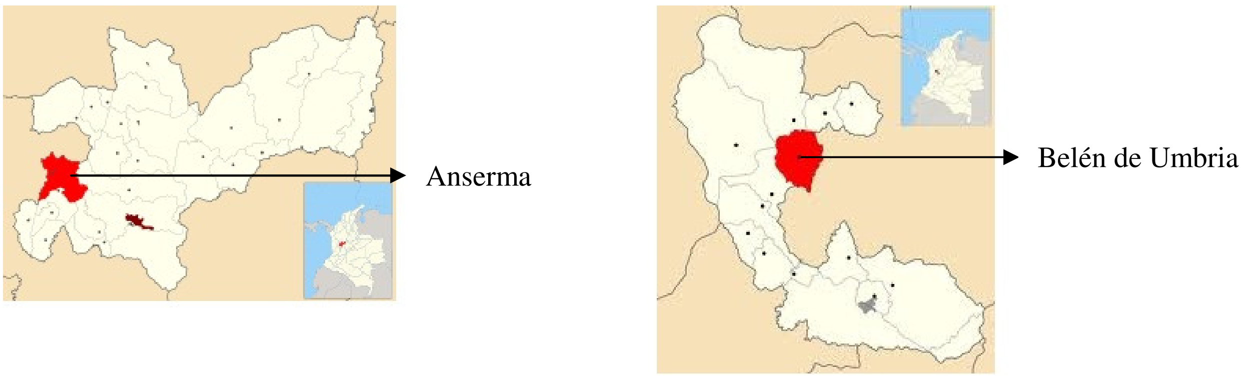

Fig 2: Anserma and Belén de Umbria cities

A.3. Technologies and/or measures

The project activity is a newly built run-of-river hydropower plant.

Prior to implementation of the proposed project, the electricity was generated by the operational power plant matrix that has a strong participation of fossil fuel power plants. Considering the plants linked to

the national grid, the electrical generation using fossil fuel represents about 30.8%[1] of the national generation (according data from December 2011). The project activity reduces GHG emissions avoiding the operation entrance of thermoelectric power plants connected to the grid, that use fossil fuel as energy source. In absence of the project activity, those plants would operate in order to supply the electrical demand of the country. Part of this demand, by now supplied by thermoelectric power plants, will start being supplied by the project activity power plant.

The technology used in the enterprise is the use of hydro energy potential of the Risaralda river for electricity generation by the gravitational energy of the water, which is used to move the turbines and trigger generators that enable the generation of electricity. This is a source of clean and renewable energy that presents low impact on the environment.

The Small Hydropower plant Morro Azul will dispatch generated energy to the National Interconnected Grid through its lift substation (13.8 / 33 KV) located close to the machine house of the plant.

The emissions sources and GHGs involved are CO_2 emissions from electricity generation in fossil fuel fired power plants and emissions of CH_4 from the reservoir of new large hydropower plants less efficient that would be implanted to complement the availability of energy in the country in case of no additional energy input had occurred.

The baseline scenario to the project activity is the same as the scenario existing prior to the start of implementation of the project activity.
The technical characteristics of equipment that will be implemented in the SHP can be seen in table 1:

Table 1: Technical characteristics of main equipment installed at Small Hydroelectric Plant Morro Azul.

Installed Capacity (MW)	19.90
Generators Type	Synchronous
Number of Generators	3
Voltage (KV)	13.8
Turbines Type	Francis
Number of Turbines	3
Spin (rpm)	720
Frequency (Hz)	60
Assured Energy (MWaverage)	14.12
Annual Generation (MWh /year)	123,691
Average Flow (m³/s)	15.27

[1] http://www.xm.com.co/Pages/DescripciondelSistemaElectricoColombiano.aspx - December 2011

A.4. Parties and project participants

Party involved (host) indicates a host Party	Private and/or public entity(ies) project participants (as applicable)	Indicate if the Party involved wishes to be considered as project participant (Yes/No)
Colombia (host)	Risaralda Energía S.A.S. E.S.P. (private entity)	No

A.5. Public funding of project activity

The project activity don´t receives public funding from Parties included in Annex I.

SECTION B. Application of selected approved baseline and monitoring methodology
B.1. Reference of methodology

This project activity applies the following methodology:
ACM0002: *Consolidated baseline methodology for grid-connected electricity generation from renewable sources* - Version 13.0.0 - (valid from 11 May 2012 onwards);

This methodology makes reference to the following approved methodological tools:

- *Tool to calculate the emission factor for an electricity system* - Version 02.2.1 – (valid from 29 September 2011 onwards);
- *Tool for the demonstration and assessment of additionality* - Version 06.0.0 – (valid from 25 November 2011 onwards);
- *Tool to calculate project or leakage CO_2 emissions from fossil fuel combustion* - Version 02 – (valid from 2 August 2008 onwards).

All documents referred above can be obtained at the UNFCCC website, in the link below:
http://cdm.unfccc.int/methodologies/DB/UB3431UT9I5KN2MUL2FGZXZ6CV71LT

B.2. Applicability of methodology

As per UNFCCC`s (United Nations Framework Convention on Climate Change) definitions, the project activity is according the sectoral scope 1 that refers to energy industries (renewable or non renewable sources).

This methodology is applicable to grid-connected renewable power generation project activities that (a) install a new power plant at a site where no renewable power plant was operated prior to the implementation of the project activity (greenfield plant); (b) involve a capacity addition; (c) involve a retrofit of (an) existing plant(s); or (d) involve a replacement of (an) existing plant(s).

In this case is (a) the installation of a new power plants at a site where no renewable power plants was operated prior to the implementation of the project activity (Greenfield plants)

The ACM0002 methodology is applicable to grid-connected renewable power generation project activities under following conditions:

- *The project activity is the installation, capacity addition, retrofit or replacement of a power plant/unit of one of the following types: hydro power plant/unit (either with a run-of-river reservoir or an accumulation reservoir), wind power plant/unit, geothermal power plant/unit, solar power plant/unit, wave power plant/unit or tidal power plant/unit;*

The project activity is the installation of a new hydro power plant/unit.

• *In the case of capacity additions, retrofits or replacements (except for capacity addition projects for which the electricity generation of the existing power plant(s) or unit(s) is not affected): the existing plant 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 addition or retrofit of the plant has been undertaken between the start of this minimum historical reference period and the implementation of the project activity;*
Not applicable to the project activity as it consists of a new hydro power plant.

In case of hydro power plants, at least one of the following conditions must apply:

• *The project activity is implemented in an existing single or multiple reservoirs, with no change in the volume of any of the reservoirs; or*

Not applicable to the project activity.

• *The project activity is implemented in an existing single or multiple reservoirs, where the volume of any of reservoirs is increased and the power density of each reservoir the project activity, as per the definitions given in the Project Emissions section, is greater than 4 W/m2 after the implementation of the project activity; or*

Not applicable to the project activity.

• *The project activity results in new single or multiple reservoirs and the power density of each reservoir the power plant, as per the definitions given in the Project Emissions section, is greater than 4 W/m2 after the implementation of the project activity.*

The project activity results in new reservoir and the power density is above 4W/m2, as described in the calculations in section B.6.

In case of hydro power plants using multiple reservoirs where the power density of any of the reservoirs is lower than 4 W/m2 after the implementation of the project activity all of the following conditions must apply:

• *The power density calculated for the entire project activity using equation 5 is greater than 4 W/m2;*
• *All reservoirs and hydro power plants are located at the same river and were designed together to function as an integrated project1 that collectively constitutes the generation capacity of the combined power plant;*
• *The water flow between the multiple reservoirs is not used by any other hydropower unit which is not a part of the project activity;*
• *The total installed capacity of the power units, which are driven using water from the reservoirs with a power density lower than 4 W/m2, is lower than 15 MW;*
• *The total installed capacity of the power units, which are driven using water from reservoirs with a power density lower than 4 W/m2, is less than 10% of the total installed capacity of the project activity from multiple reservoirs.*

Not applicable to this project activity (not multiple reservoirs)

The methodology is not applicable to the following:

- *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* (not applicable);
- *Biomass fired power plants* (not applicable);
- *Hydro power plants that result in new reservoirs or in the increase in existing reservoirs where the power density of the power plant is less than 4 W/m2* (not applicable).

The small hydro power plant Morro Azul is considered electric generation by renewable source with new single reservoir, which have power densities of 164 W/m^2.
Also, the installed capacity of the plant is 20 MW, greater than 15 MW (as can be verified in table 1), thus the project activity is included in the large scale project category considering the CDM standards.

Therefore, the methodology ACM0002 is applicable to the project activity.

B.3. Project boundary

Source		GHGs	Included?	Justification/Explanation
Baseline scenario	CO_2 emissions from electricity generation in fossil fuel fired power plants that is displaced due to the project activity.	CO_2	Yes	Main emission source.
Baseline scenario	CO_2 emissions from electricity generation in fossil fuel fired power plants that is displaced due to the project activity.	CH_4	No	Minor emission source.
Baseline scenario	CO_2 emissions from electricity generation in fossil fuel fired power plants that is displaced due to the project activity.	N_2O	No	Minor emission source.
Project scenario	For hydro power plants, emissions of CH_4 from the reservoir.	CO_2	No	Minor emission source.
Project scenario	For hydro power plants, emissions of CH_4 from the reservoir.	CH_4	No	Considering that the Power Density of the Small Hydropower Plant Morro Azul is 164 W/m^2, so greater than 10 W/m^2, emissions from the reservoir are considered null.
Project scenario	For hydro power plants, emissions of CH_4 from the reservoir.	N_2O	No	Minor emission source.

The diagram below shows the project boundary, main equipments, monitored parameters and included gases:

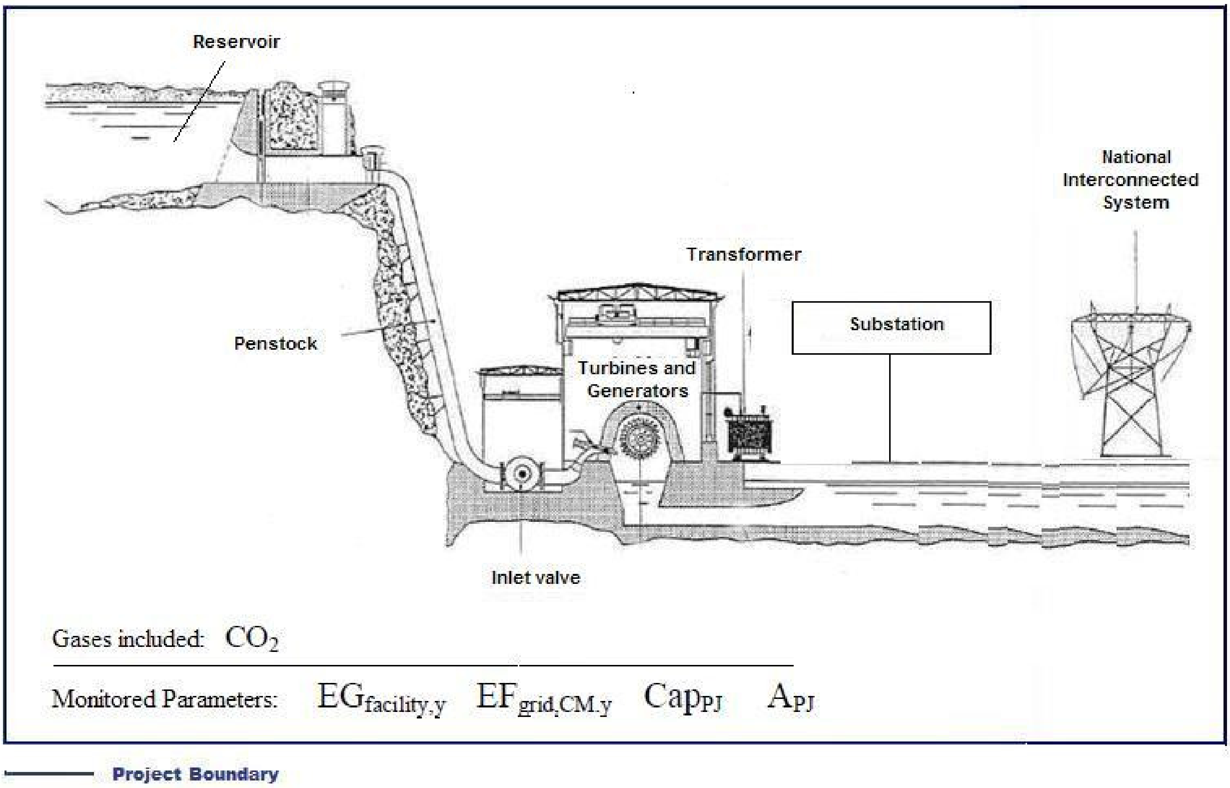

Figure 2: Diagram about project activity boundaries, monitored parameters and included gases.

B.4. Establishment and description of baseline scenario

According to ACM0002, if the project activity is the "installation of a new grid-connected renewable power plant/unit", the baseline scenario is the following:

"*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 generating sources, as reflected in the combined margin (CM) calculations described in the "Tool to calculate the emission factor for an electricity system"*.

The baseline scenario is that the 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 into the grid.

The baseline emissions are the product of electrical energy baseline $EG_{BL,\ y}$ expressed in MWh of electricity produced by the renewable generating unit multiplied by the grid emission factor.

$BE_{y} = EG_{BL,y} * EF_{CO2,grid,y}$

Where:

BE_y =Baseline Emissions in year *y* (t CO2)
$EG_{BL,y}$ = Quantity of net electricity supplied to the grid as a result of the implementation of the CDM project activity in year *y* (MWh)
$EF_{CO_2\,grid\,y}$ = CO2 emission factor of the grid in year *y* (t CO2/MWh)
The Emission Factor can be calculated in a transparent and conservative manner as follows:

(a) A combined margin (CM), consisting of the combination of operating margin (OM) and build margin (BM) according to the procedures described in the "Tool to calculate the Emission Factor for an electricity system".

Thus, from the tool, the emission factor of the grid is $EF_{grid,CM,y}$, which in this case is the same used in the present project activity: $EF_{CO2,grid\,y}$.

Morro Azul small hydroelectric power plant will supply electricity to the Colombian National Grid. In the absence of the project activity, the electricity generated by the SHPs would be supplied from the Colombian National Grid.

B.5. Demonstration of additionality

This item was elaborated based on the latest versions of "ACM0002 - Consolidated baseline methodology for grid connected electricity generation from renewable sources" and of "Tool for the demonstration and assessment of additionality" prevailing the Methodology since this supersede the Tool.

Step 1: Identification of alternatives to the project activity consistent with current laws and Regulations

Sub-step 1a: Define alternatives to the project activity:

Due to the Project is the installation of a new grid connected wind power plant, the baseline scenario, according to the methodology ACM0002 version 13.0.0, is the following:

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 the Tool to calculate the emission factor for an electricity system version 02.2.1.

The selected methodology ACM0002 version 13.0.0 prescribes the baseline scenario, thus alternatives to the Project is not needed to be further identified9 as per paragraph 115 of Clean Development Mechanism Validation and Verification Standard(VVS) version 02.0.

Sub-step 1b: Consistency with mandatory laws and regulations:

The SHP Morro Azul implantation is in compliance with all regulations according to the following entities:

- Gas and Energy Regulatory Comission (CREG – from Spanish *Comisión de Regulación de Energía y Gas*), to regulate all the activities of utility services;
- Mining and Energy Planning Unit (UPME - from Spanish *Unidad de Planeación Minero-Energética*), (UPME), it is a special administrative unit under the Ministry of Mines and Energy,

in charge of comprehensive mining and energy sector planning, created by the Decree 2119 of 1992;

- National Dispatch Center (CND – from Spanish *Centro Nacional de Despacho*), is the agency responsible for planning, supervision and control of the integrated operation of generation resources, transmission interconnection and national grid. It is also responsible for giving instructions to the Regional Dispatch Center to coordinate the maneuvers of the facilities in order to have a safe, reliable and tied to the operating rules and all decisions of the National Operation Council,
- Risaralda Regional Autonomous Corporation (from Spanish *Corporación Autonoma Regional de Risaralda*), supports the implementation of policies, plans, programs and projects on environment and renewable natural resources, and give a full and timely implementation of existing legislation on the readiness, administration, management and use, according to the regulations, standards and guidelines issued by the ENVIRONMENTAL MINISTRY;
- and CDM Executive Board.

Step 2: Investment analysis

The investment analysis shall be performed in order to determine whether the proposed project activity is not:

(a) The most economically or financially attractive; or
(b) Economically or financially feasible, without the revenue from the sale of certified emission reductions (CERs).

For the proposed project activity, the investment analysis determinates if the proposed project activity is not economically/financially feasible without the revenues from the Certified Emission Reductions (CERs).

Sub-step 2a: Determine appropriate analysis method

In order to determine the appropriate analysis method, the following options are available to be used in the additionality analysis:

- Option I - Apply simple cost analysis,
- Option II - Apply investment comparison analysis,
- Option III - Apply benchmark analysis

According to the Tool, if the CDM project activity and the alternatives identified in Step 1 generate financial or economic benefits other than CDM related income, then the investment comparison analysis (Option II) or the benchmark analysis (Option III) shall be used. The benchmark analysis will be applied, because it is the most appropriated for this type of activity in Colombia. Moreover, the Option II shall be applied when there are credible alternative scenarios existed to the project activity. As there are no alternative to compare with the project's indicator (Internal Rate of Return) the Option III shall be applied.

Therefore, the Option III was chosen.

Sub-step 2b: Option III. Apply benchmark analysis

The suitable financial indicator chosen for the proposed project activity is the project's **Internal Rate of Return (IRR)**, because this data is considered adequate for this kind of project and decision context. The

financial indicator most appropriate for this type of project is the Internal Rate of Return (Project's IRR), because it is the compound rate of return annualized effective that can be obtained on invested capital.

The analysis of the financial/economic indicator is based on parameters that are standard in the energy market in Colombia and around the world, considering the specific characteristics of the project type – investments in energy projects.

The benchmark analysis is performed comparing the project's IRR with a benchmark. The established benchmark for this comparison is the Cost of Equity (K_e), extracted from the Weighted Average Costs of Capital (WACC) calculation, in line with the accountable rules generally accepted. The details are described below:

Sub-step 2c: Calculation and comparison of financial indicators

K_e – Cost of Equity

The Weighted Average Costs of Capital considers the weighted costs of equity and third parties capital that any company or sector have.

The sum of return rates required by the creditors (shareholders or third parties) weighted by the participation of each financial agent over the total debt, results the weighted average cost of capital of the companies (WACC). This cost shall be overcome by the project`s return in order to allow the company to honor their commitments and to invest in its growth.

The cost of equity was calculated as the sum of a tax free of risk (US Bonds) plus a Colombian risk premium plus a global risk premium to the equity investment. This methodology of calculation follows the recommendations to the calculation of the equity presented in the "Guidelines on the assessment of financial analysis" published in 62 meeting of the CDM Executive Board (Annex 5).

Cost of Equity calculation

The cost of equity was calculated as follows:

$K_e = GB + PE_g$

Where:

K_e = Cost of equity;
GB = Tax Free of Risk (Rf) + Host country risk premium (ERP)
PE_g = Global Equity risk premium

GB = 5.8% + 3.3%= 9.1%

Rf = Average of return rates of American Bond (T-Bond) corresponding to years 2001 to 2010[2];
ERP (EMBI+ $_{2001\text{–}2010}$) = Average of Colombian Risk Premium, based on data from JP Morgan corresponding to years 2001 to 2010[3];
PE_g = Global Equity Risk Premium provided by Aswath Damodaran[4].

[2] http://pages.stern.nyu.edu/~adamodar/New_Home_Page/datafile/histret.html
[3] http://www.ambito.com/economia/mercados/Riesgo-historico.asp?idpais=4
[4] http://pages.stern.nyu.edu/~adamodar/New_Home_Page/datafile/ctryprem.html

Therefore:

$K_e = 9.1\% + (0.54*8.00)\%$[5] $= 13.42\%$

Considering the exclusion of the inflation rate 3.34%[6], the Project Activity cost of equity is 10.08%[7].

Below, the table 6 summarizes the reference values to the project activity IRR and the equity value used as benchmark.

Table 6: Comparative table between project activity IRR and the project benchmark

Benchmark - Cost of Equity (% year)	IRR Morro Azul (% year)
10.08	6.53

The cash-flow was elaborated for the operational lifetime of the project activity (25 years), getting an Internal Return Rate (IRR) equal 6.53% per year, without revenues of the Certified Emissions Reductions (CERs). With the CERs revenue the Project activity IRR become 6.97 % per year.

As the cash flow of project activity is considered confidential information, this will be integrally presented to the validation entities in a separated worksheet. In the worksheet are also identified all the reference sources to the applied values.

The cash flow has as main input values the following:

Table 7: Main Inputs Values of cash flow

Parameter	SHP Morro Azul
Investment (COP$)	117,060,441.16
Assured Energy (MWaverage)	14.12
Energy Price (COP$/KWh)	109.53
Operation and Maintenance (COP$)	1,999,988.00

The project's IRRs have stayed below of the project proponent`s equity value. The analysis shows that the project is not economically or financially feasible, without the revenue from the sale of certified emission reductions (CERs).

The CERs are highly significant instruments for entrepreneurs in overcoming barriers, improving investment quality and hence stimulating future investments in clean energy generation.

Sub-step 2d: Sensitivity analysis

[5] Risk Premium weighted by the Beta =0.54
[6] http://obiee.banrep.gov.co/analytics/saw.dll?Go&_scid=DgXuT3WszzU
[7] Please, check the worksheet "WACC_SHP_Morro Azul_v1" provided for more details about the calculation performed

To better understand the investment barrier was also performed a **sensitivity analysis** in which were varied the following parameters: (1) Energy Price, (2) Investment, (3) Assured Energy (Plant Load Factor) and (4) Operation and Maintenance costs, in order to check the financial impact of these on the project.

A **Breakeven Point Analysis** was performed in order to discuss the likelihood of occurrence of these scenarios.

The table 8 presents the main results of the analysis.

Table 8: SHP Morro Azul sensitivity analysis.

Parameter	Original Value	Breakeven point	% of deviation
Investment (COP$)	117,060,441.16	81,883,778.59	-30.50
Assured Energy (MWaverage)	14.12	19.16	+35.70
Energy Price (COP$/KWh)	109.53	146.87	+34.10
Operation and Maintenance (COP$)	1,999,988.00	0.00	Not sensible enough

Likelihood of occurrence of scenarios of the breakeven point

To achieve the Breakeven point is not considered feasible due to factors which can be viewed below:

Investment (R$)
Regarding the total investment costs, the input value came from the project proponent budget that is based on the suppliers offers made to the project activity. Also the investment value was informed to other financial entities in order to negotiate a loan.

The sensitivity analysis shows that to reach the benchmark, the investment values should had been 30.50% lower than the previously forecasted. Its breakeven point is R$ 81,883,778.59. Fluctuations of this amplitude are not possible to occur.

Thus, the input values are adequate as well conservative.

Assured Energy (MWaverage)

The Assured Energy is considered adequate because the value come from the "*Hicon Hidric Studies Engineering"* Company studies (a third party company specialized in this kind of studies).

The *Hicon* Company has a body of technical project reviewers who properly analyses generation projects in different sectors in Latin America. The main technical issues that influence the value of Assured Energy, and consequently, the Plant Load Factor, are the historical series of hydrological data of the river, climate conditions, topography, flow regularity, among others. The *Hicon's* technical body is capable to analyze those conditions and issue the plant load factor for the Colombian SHP projects.

And also to led the IRR of the project activity to reach the applied benchmark, the assured energy of the SHP Morro Azul should be 19.12 MWaverage (35.7% greater than the established by Hicon, and almost the plant capacity, so, it is impossible to occur.

Energy Price (R$/MWh)

The energy price value used in the financial calculations is considered adequate because it was published in a very reliable public source, the XM[8] entity website report on September 2011.

The core business of the XM is the electrical sector and is based on the operation of the Colombian National Interconnected System and Energy Management Market in Colombia.

And also the energy price would not reach the readjustment of 34.10% (COP$ 146.97/KWh), as calculated and presented above, since this is an out of market value.

Operational Costs - O&M

As demonstrated in the table 4, this parameter (which comprehends the sum of employees` salaries and maintenance costs) is not sensible to the analysis. Even reducing the parameter to zero, the IRR of project activity (8.20%) would not reach the benchmark.

Conclusion

The project activity has taken in consideration the revenues of CERs sales for the implantation. These financial benefits generated in strong currency (euro or dollar) bring to the project a better security against monetary depreciations.

Facing the explanations, information and evidences provided by the PPs, the project activity IRR is below than the established benchmark (cost of equity), evidencing that project activity is not economically or financially feasible, without the revenue from the sale of certified emission reductions (CERs). The CDM benefits were the key point to go ahead and to implement the project activity, improving its financial attractiveness.

Therefore, the project activity is financially additional.

Step 3: Barrier analysis

Not necessary. As concluded in the sensitivity analysis the project activity is not financially attractive.

Step 4: Common practice analysis

The following stepwise approach clearly demonstrates the project activity not represent the common practice.

The list of power operating in the country is made available by XM and UPME[9].

STEP 1: Calculate applicable output range as +/-50% of the design output or capacity of the proposed project activity.

The projects to be considered in the analyses must have installed power between 9.95 MW (50% below the SHP Morro Azul) and 29.85 MW (50% above of SHP Morro Azul installed capacity, which is 19.90 MW).

8 http://www.xm.com.co
9 http://www.xm.com.co/Pages/DescripciondelSistemaElectricoColombiano.aspx

STEP 2: In the applicable geographical area, identify all plants that deliver the same output or capacity, within the applicable output range calculated in Step 1, as the proposed project activity and have started commercial operation before the start date of the project.

In a conservative approach, was considered the entire host country as a default.

The plants identified in Step 1 deliver the same output within the applicable output range of project activity are presented below[10]:

Table 9: Projects in the Same Output Range as SHP Morro Azul

	Date of commisioned	Project name	Generation type	Pot (MW)
1	17/08/2010	Cogenerador Mayaguez	COG	19,90
2	15/05/2010	Planta Menor San Antonio	HYDRO	19,40
3	01/01/2010	Cogenerador Ingenio Pichichi	COG	27,00
4	01/06/2009	Cogenerador Ingenio Providencia	COG	19,90
5	19/04/2009	COGENERADOR PAPELES NACIONALES SA	COG	12,00
6	19/08/2007	CIMARRON	GAS	17,00
7	19/08/2007	MORRO 2	GAS	17,00
8	23/05/2007	MORRO 1	GAS	19,90
9	23/12/2005	FLORIDA	HYDRO	19,90
10	11/03/2005	TERMOYOPAL 1	GAS	19,00
11	01/01/2005	LA JUNCA	HYDRO	19,40

$N_{all} = 11$

Step 3: Within plants identified in Step 2, identify those that apply technologies different that the technology applied in the proposed project activity.

To the common practice analysis, it was done a survey about the activities which became operational between 2005 (when the CDM become available) to 2011 (before project activity prior consideration), in order to establish a range of projects that can be considered similar to the project activity.

Based on the above premises, were selected power plants with installed capacity between +/- 50% of Morro Azul SHP power (19.90 MW). This resulted in project activities that work in the range between 9.95 and 29.85 MW of installed capacity.

Others project activities registered or under registration in the CDM were not included in the common practice analysis[11].

[10] Were considered the HPPs and SHPs which became operational from 2005 to 2011 excluded the CDM projects. The approach will be explained on Step 3.

[11] The datas public sources utilized were:
UPME – SIEL – Sistema de Información Eléctrico Colombiano:
http://www.siel.gov.co/Inicio/Generaci%C3%B3n/SeguimientoaproyectosdeGeneraci%C3%B3n/tabid/112/Default.aspx?PageContentID=61
UPME – SIMEC – Sistema de Información Minero Energético Colombiano:
http://www.upme.gov.co/generadorconsultas/consulta_ISA.aspx?grupo=G

Considering the explanation above 11 projects became operational, as listed in the Table 9, but 8 of them makes use of different technology (thermal) so different technology than SHP Morro Azul that is a Small hydro power plant.

So we have only 3 other power plants with Hydro technology.

Then, N_{diff}=8

Step 4: Calculate factor $F=1-N_{diff}/N_{all}$ representing the share of plants using technology similar to the technology used in the proposed project activity in all plants that deliver the same output or capacity as the proposed project activity. The proposed project activity is a common practice within a sector in the applicable geographical area if the factor F is greater than 0.2 and $N_{all}-N_{diff}$ is greater than 3.

According the requirements of the version 01.0 of *"Guidelines on Common Practice"*, the factor F that represents "the share of plants using technology similar to the technology used in the proposed project activity in all plants that deliver the same output or capacity as the proposed project activity" must be calculated as follows:

$$N_{all} - N_{diff\,=}\ 11 - 8 = 3$$

In the light of all the explanation provided above and considering the values of factor "F" and "N_{all} - N_{diff}", it is possible to conclude that the implantation of hydropower plants similar to the project activity is not a common practice in Brazil, being therefore eligible to CDM according its requirements.

Table 10: Timeline of SHP Morro Azul implantation events.

Date	Event	Evidence
January 2009	Environmental License Issuance	CARDER Statement Number 59
October 2011	Prior Consideration	Forms to the CDM Executive Board and Colombian DNA
November 2011	CDM validation services start	PDD consultant contracted "e-mail from 09/11/2011"
July2012	Project Activity Starting Date	Project Participant Schedule
August 2014	SHP generation Start	Project Participant Schedule

B.6. Emission reductions
B.6.1. Explanation of methodological choices

The emission reductions of project activity (ER_y) are quantified through the subtraction of project emissions ($PE_{HP,y}$) from baseline emissions (BE_y).

$$ER_y = BE_y - PE_{HP,y}$$

Where:
ER_y = Emission reduction in year y (tCO_2e/year);
BE_y = Baseline emissions in year y (tCO_2e/year);
$PE_{HP,y}$ = Project emission from water reservoirs for hydro power plants in year y (tCO_2e/year)

Project emissions *($PE_{HP,y}$)*

According to the methodology ACM0002 version 12.2.0, for hydro power project activities that result in new reservoirs, project proponents shall account for CH_4 and CO_2 emissions from the reservoir, estimated as follows:

a) If the power density of project (PD) is higher than 4W/m^2 and lower than or equal to 10W/m^2:

$$PE_{HP,y} = \frac{EF_{Res} \cdot TEG_y}{1000}$$

Where;
$PE_{HP,y}$ Emission from water reservoir as tCO_2e/year;
EF_{Res} is the default emission factor for emissions from reservoirs.
TEG_y Total electricity produced by the project activity, including the electricity supplied to the grid and the electricity supplied to internal loads, in year *y* (MWh).

b) If power density of project is greater than 10W/m^2:

$PE_{HP,,y} = 0$.

The power densities of the project activity are calculated as follows:

$$PD = \frac{Cap_{PJ} - Cap_{BL}}{A_{PJ} - A_{BL}}$$

Where:
PD Power density of the project activity, in W/m^2.
Cap_{PJ} Installed capacity of the hydro power plant after the implementation of the project activity (W).
Cap_{BL} Installed capacity of the hydro power plant before the implementation of the project activity (W). For new hydro power plants, this value is zero.
A_{PJ} Area of the reservoir measured in the surface of the water, after the implementation of the project activity, when the reservoir is full (m^2).
A_{BL} Area of the reservoir measured in the surface of the water, before the implementation of the project activity, when the reservoir is full (m^2). For new reservoirs, this value is zero.

To the project activity power plant, $PD = \frac{19,900,000 - 0}{121,700 - 0} = 163$ W/m^2

The power density of the SHP Morro Azul is greater than 10 W/m^2, and then its GHG emissions are considered null.

Baseline Emissions *(BE_y)*

Baseline emissions (BE_y in tCO_2) are the product of the baseline emissions factor ($EF_{grid,CM,y}$ in tCO_2/MWh) multiplied by the electricity supplied by the project activity to the grid ($EG_{PJ,y}$ in MWh), as follows:

$$BE_y = EF_{grid,CM,y} \cdot EG_{PJ,y}$$

Where:
BE_y Baseline emissions in year y (tCO_2e/year);
$EG_{PJ,y}$ 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 (MWh/year);
$EF_{grid,CM,y}$ 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" (tCO_2/MWh).

Calculation of $EG_{PJ,y}$

The project activity is the installation of a new grid-connected renewable power plant/unit at a site where no renewable power plant were operated prior to the implementation of the project activity, thus classified as a Greenfield renewable energy power plants, then:

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

Where:

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

$$EG_{PJ,y} = EG_{Morro\ Azul}$$

$$EG_{PJ,y} = 126,258 \text{ MWh/year}$$

B.6.2. Data and parameters fixed ex ante

Data / Parameter	Cap_{BL}
Unit	W
Description	Installed capacity of the hydro power plant before the implementation of the project activity. For new hydro power plants, this value is zero.
Source of data	Project site.
Value(s) applied	0
Choice of data or Measurement methods and procedures	Not applicable.
Purpose of data	Calculation of the project emissions.
Additional comment	

Data / Parameter	A_{BL}
Unit	m^2
Description	Area of the reservoirs measured in the surface of the water, before the implementation of the project activity, when the reservoir is full (m^2). For new reservoirs, this value is zero.
Source of data	Project site.
Value(s) applied	0
Choice of data or Measurement methods and procedures	Not applicable.
Purpose of data	Calculation of the project emissions.
Additional comment	

Data / Parameter	EF_{res}
Unit	$kgCO_2e/MWh$
Description	Default emission factor for emission from reservoirs.
Source of data	Clean Development Mechanism Executive Board (CDM-EB)
Value(s) applied	90
Choice of data or Measurement methods and procedures	This default emission factor was determined at CDM-EB Meeting 23, held from 22/02/2006 to 24/02/2006.
Purpose of data	Calculation of the project emissions.
Additional comment	Document regarding this emission factor is available at: <http://cdm.unfccc.int/EB/023/eb23_repan5.pdf>

Data / Parameter	$EF_{grid,CM,y}$
Unit	tCO_2e/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	Calculation carried out by the Project Participant in accordance with the "Tool to calculate the emission factor for an electricity system" The emissions factor calculated will consider the parameters presented by the Energy and Mining Planning Unit ("UPME") of the Ministry of Mines and Energy delegated by the Ministry of Environment, Housing and Territorial development ("MAVDT") to carry out such calculation.
Value(s) applied	0.36777
Choice of data or Measurement methods and procedures	The Combined Margin is calculated through a weighted-average formula, considering both the $EF_{grid,OM-DD,y}$ and the $EF_{grid,BM,y}$ and the weights w_{OM} (default 0.5 for the first crediting period and 0.25 for the second and third crediting periods) and w_{BM} (default 0.5 for the first crediting period and 0.75 for the second and third crediting periods).
Purpose of data	Calculation of baseline emissions.
Additional comment	Parameters used for the calculation of the grid's emission factor are presented in Annex 3.

Data / Parameter	$EF_{grid,OM-DD,y}$
Unit	tCO_2e/MWh
Description	CO_2 Operating Margin emission factor of the grid, in a year y
Source of data	Calculation carried out by the Project Participant in accordance with the "Tool to calculate the emission factor for an electricity system" The emissions factor calculated will consider the parameters presented by the Energy and Mining Planning Unit ("UPME") of the Ministry of Mines and Energy delegated by the Ministry of Environment, Housing and Territorial development ("MAVDT") to carry out such calculation.
Value(s) applied	0.54340
Choice of data or Measurement methods and procedures	According procedures established by "Tool to calculate the emission factor for an electricity system".
Purpose of data	Calculation of baseline emissions.
Additional comment	Parameters used for the calculation of the grid's emission factor are presented in Annex 3.

Data / Parameter	$EF_{grid,BM,y}$
Unit	tCO_2e/MWh
Description	CO_2 Build Margin emission factor of the grid, in a year *y*
Source of data	Calculation carried out by the Project Participant in accordance with the "Tool to calculate the emission factor for an electricity system" The emissions factor calculated will consider the parameters presented by the Energy and Mining Planning Unit ("UPME") of the Ministry of Mines and Energy delegated by the Ministry of Environment, Housing and Territorial development ("MAVDT") to carry out such calculation.
Value(s) applied	0.19215
Choice of data or Measurement methods and procedures	According procedures established by "Tool to calculate the emission factor for an electricity system".
Purpose of data	Calculation of baseline emissions.
Additional comment	Parameters used for the calculation of the grid's emission factor are presented in Annex 3.

Data / Parameter	$Cap_{PJ\ –\ Morro\ Azul}$
Unit	W
Description	Installed capacity of the hydro power plant after the implementation of the project activity.
Source of data	Technical studies provided from third party and PP
Value(s) applied	19,900,000
Choice of data or Measurement methods and procedures	Technical specifications on the installed equipments.
Purpose of data	Calculation of project emissions.
Additional comment	

Data / Parameter	$A_{PJ\ –\ Morro\ Azul}$
Unit	m^2
Description	Area of the reservoir measured in the water surface, after the implementation of the project activity, when the reservoir is full.
Source of data	Technical studies provided from third party and/or PP
Value(s) applied	121,700
Choice of data or Measurement methods and procedures	Measured from topographical surveys or satellite pictures.
Purpose of data	
Additional comment	This data is applied for the Power Density calculation.

B.6.3. Ex ante calculation of emission reductions

According to the "**Tool to calculate the emission factor for an electricity system**" the Project participants shall apply the following six steps:

STEP 1. Identify the relevant electricity systems;
STEP 2. Choose whether to include off-grid power plants in the project electricity system (optional);
STEP 3. Select a method to determine the operating margin (OM);
STEP 4. Calculate the operating margin emission factor according to the selected method;
STEP 5. Calculate the build margin (BM) emission factor;
STEP 6. Calculate the combined margin (CM) emissions factor

Step 1: Identify the relevant electricity systems

For determining the electricity emission factors, the relevant project electricity system is the **Colombian National Interconnected System.**

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

Project participants may choose between the following two options to calculate the operating margin and build margin emission factor:

Option I: Only grid power plants are included in the calculation.
Option II: Both grid power plants and off-grid power plants are included in the calculation.

Option I is chosen for the project activity according to the Colombian National Interconnected System and available data to calculate both Operating and Build margin.

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

The calculation of the operating margin emission factor ($EF_{grid,OM,y}$) is based on one of the following methods, which are described under Step 4:

(a) Simple OM; or
(b) Simple adjusted OM; or
(c) Dispatch data analysis OM; or
(d) Average OM.

The OM shall be calculated using the **Simple adjusted method** (b). Since low-cost/must-run resources constitute more than 50% of total grid generation in: 1) average of the five most recent years, or 2) based on long-term averages for hydroelectricity production.
This decision was taken based on the data requirements and the information availability from the official sources, in this case the UPME (Unidad de Planeación Minero Energética – in a free translation "Mining and Energy Planning Unit") and National Dispatch Centre (XM).

For the simple adjusted OM, the emission factor can be calculated using any of the following data vintages:

• *Ex ante* option: If the *ex ante* option is chosen, the emission factor is determined once at the validation stage, thus no monitoring and recalculation of the emissions factor during the crediting period is not required. For grid power plants, use a 3-year generation-weighted average, based on the most recent data available at the time of submission of the CDM-PDD to the DOE for validation. For off-grid power

plants, use a single calendar year within the five most recent calendar years prior to the time of submission of the CDM-PDD for validation.

• *Ex post* option: If the *ex post* option is chosen, the emission factor is determined for the year in which the project activity displaces grid electricity, requiring the emissions factor to be updated annually during monitoring. If the data required calculating the emission factor for year *y* is usually only available later than six months after the end of year y, alternatively the emission factor of the previous year y-1 may be used. If the data is usually only available 18 months after the end of year *y*, the emission factor of the year proceeding the previous year *y*-2 may be used.
The same data vintage (*y*, *y*-1 or *y*-2) should be used throughout all crediting periods.

For this project the ***Ex ante* option** has been chosen in order to use a fixed emission factor (there will be no need monitoring and recalculating the emission factor during the crediting period) given the availability of public information of 3-year generation-weighted average from official sources. Therefore this parameter remains unchangeable over all the crediting period.

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

The simple adjusted OM emission factor ($EF_{grid,OM-adj,y}$) 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, as follows (the Option B is not possible since: a) the necessary data for Option A is available):

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

Where:

$EF_{grid,OM-adj,y}$	= Simple adjusted operating margin CO2 emission factor in year *y* (tCO_2/MWh)
λ_y	= Factor expressing the percentage of time when low-cost/must-run power units are on the margin in year *y*
$EG_{m,y}$	= Net quantity of electricity generated and delivered to the grid by power unit *m* in year *y* (MWh)
$EG_{k,y}$	= Net quantity of electricity generated and delivered to the grid by power unit *k* in year *y* (MWh)
$EF_{EL,m,y}$	= CO_2 emission factor of power unit *m* in year *y* (tCO_2/MWh)
$EF_{EL,k,y}$	= CO_2 emission factor of power unit *k* in year *y* (tCO_2/MWh)
m	= All grid power units serving the grid in year *y* except low-cost/must-run power units
k	= All low-cost/must run grid power units serving the grid in year *y*
y	= The relevant year as per the data vintage chosen in Step 3

$EF_{EL,m,y}$, $EF_{EL,k,y}$, $EG_{m,y}$ and $EG_{k,y}$ should be determined using the same procedures as those for the parameters $EF_{EL,m,y}$ and $EG_{m,y}$ in Option A of the simple OM method.

Determination of $EF_{EL,m,y}$

According to the option A2 of the Tool; the emission factor of each power unit *m* is determined based on the CO_2 emission factor of the fuel type used and the efficiency of the power unit, as follows (the Option A1 is not possible considering the unavailability of the information regarding fuel consumption data of each thermal power plant connected to the grid - this information is not public):

$$EF_{EL,m,y} = \frac{EF_{CO2,m,i,y} \times 3.6}{\eta_{m,y}}$$

Where:

$EF_{EL,m,y}$ = CO_2 emission factor of power unit m in year *y* (tCO_2/MWh)
$EF_{CO2,m,i,y}$ = Average CO_2 emission factor of fuel type *i* used in power unit *m* in year *y* (tCO_2/GJ)
$\eta_{m,y}$ = Average net energy conversion efficiency of power unit *m* in year *y* (ratio)
m = All power units serving the grid in year *y* except low-cost/must-run power units
y = The relevant year as per the data vintage chosen in Step 3.

Where several fuel types are used in a power unit, it has been used the fuel type with the lowest CO2 emission factor for $EF_{CO2,m,i,y}$.

The emission factor of each power unit *k* (low-cost/must run grid power units), $EF_{EL,k}$, is assumed as 0 tCO_2/MWh as a conservative approach.

Selected option to calculate the emission factor of each plant is based on the efficiency of the different power plants in the Colombian power grid.

$$EF_{EL,m,y} = \frac{EF_{CO2,m,i,y} \times 3.6}{\eta_{m,y}} = HR_m \times EF_{CO2,m,j,y}$$

HR_m = Heat Rate, inverse of the efficiency of power unit *m* (MBTU/MWh), (GJ/MWh)
$EF_{CO2,m,i,y}$ = average CO_2 emission factor of fuel type *i*, used in power unit *m*, in year *y* (tCO2/GJ)

Data and calculations for the emission factor of each power unit are included in the Annex 3: Baseline Information.
For cogeneration power plants, according to the option A3, due to only data on electricity generation is available, an emission factor of 0 tCO_2/MWh has been assumed as a simple and conservative approach.

<u>Determination of EG*m,y* and EG*k,y*</u>

For grid power plants, $EG_{m,y}$ and $EG_{k,y}$ should be determined as per the provisions in the monitoring tables. All net electricity imports have been considered low-cost/must-run units *k*.

The parameter λ_y is defined as follows:

$$\lambda_y(\%) = \frac{number\ of\ hours\ low-cost/must-run\ sources\ are\ on\ margin\ in\ year\ y}{8760\ hours\ per\ year}$$

According to the methodology Lambda (λ_y) should be calculated as follows:

Step i) Plot a **load duration curve**. Collect chronological load data (typically in MW) for each hour of the year *y*, and sort the load data from the highest to the lowest MW level. Plot MW against 8760 hours in the year, in descending order.

Step ii) Collect eletricity generation data from each power plant / unit. Calculate the total annual generation (in MWh) from low-cost/must-run power plants / units (i.e. Σk EGk,y).

Step iii) Fill the load duration curve. Plot a horizontal line across the load duration curve such that the area under the curve (MW times hours) equals the total generation (in MWh) from low-cost/must-run power plants / units (i.e. $\Sigma k\ EG_{k,y}$).

Step iv) Determine the "Number of hours for which low-cost/must-run sources are on the margin in year *y*". First, locate the intersection of the horizontal line plotted in Step (iii) and the load duration curve plotted in step (i). The number of hours (out of the total of 8760 hours) to the right of the intersection is the number of hours for which low cost/must-run sources are on the margin. If the lines do not intersect, then one may conclude that low-cost/must-run sources do not appear on the margin and λ_y is equal to zero.

All necessary data to calculate the Operating Margin emission factor are available in official sources such as National Dispatch Centre (XM) and UPME (*Unidad de Planeación Minero Energética*). The information used corresponds to the last available information required to calculate the update of the national emission factor by official sources.

More details about the $\boldsymbol{EF_{grid,OM,y}}$ calculation can be checked in the Annex 3. Below we have the result:

$\boldsymbol{EF_{grid,OM,y} = 0.54340}$

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

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

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

Option 2: For the first crediting period, the build margin emission factor shall be updated annually, *ex post*, including those units built up to the year of registration of the project activity or, if information up to the year of registration is not yet available, including those units built up to the latest year for which information is available. For the second crediting period, the build margin emissions factor shall be calculated *ex ante*, as described in Option 1 above. For the third crediting period, the build margin emission factor calculated for the second crediting period should be used.

For Guática I and Guática II CDM project activity, Build Margin emission factor has been calculated based on the **Option 1**, *ex-ante*.

For the build margin calculation, the sample group of power units *m* used to calculate the build margin consists of either:

(a) Identify the set of five power units, excluding power units registered as CDM project activities, that started to supply electricity to the grid most recently ($SET_{5\text{-units}}$) and determine their annual electricity generation ($AEG_{SET\text{-}5\text{-units}}$, in MWh);
(b) Determine the annual electricity generation of the project electricity system, excluding power units registered as CDM project activities (AEG_{total}, in MWh). Identify the set of power units, excluding power units registered as CDM project activities, that started to supply electricity to the grid most recently and that comprise 20% of AEG_{total} (if 20% falls on part of the generation of a unit, the generation of that unit is fully included in the calculation) ($SET_{\geq 20\%}$) and determine their annual electricity generation ($AEG_{SET\text{-}\geq 20\%}$, in MWh);
(c) From $SET_{5\text{-units}}$ and $SET_{\geq 20\%}$ select the set of power units that comprises the larger annual electricity generation (SET_{sample});
Identify the date when the power units in SET_{sample} started to supply electricity to the grid.
If none of the power units in SET_{sample} started to supply electricity to the grid more than 10 years ago, then use SET_{sample} to calculate the build margin.

The calculation method should be chosen according to the set of power units that comprises the larger annual generation.

The option that corresponds to the highest annual generation will be chosen from the two alternatives: the energy produced by the 5 most modern power stations in Colombia or the most recent power stations generating the 20% of the electricity. If 20% falls on part capacity of a unit, that unit is fully included in the calculation.

The Build Margin emission factor is therefore calculated based on the 20% of the electricity generated, which is larger than the electricity generated by the five most recently built power units.

The build margin emission factor is the generated-weighted average emission factor (tCO_2/MWh) of power units *m* during the most recent year *y* for which electricity generation data is available.

The following formula was used to calculate the build margin emission factor:

$$EF_{grid,BM,y} = \frac{\sum_{i,m} EG_{m,y} . EF_{EL,m,y}}{\sum_{m} EG_{m,y}}$$

Where:

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

The CO_2 emission factor of each power unit *m* ($EF_{EL,m,y}$) should be determined as per the guidance in Step 4 (a) for the simple OM, using options A1, A2 or A3, using for *y* the most recent historical year for which electricity generation data is available, and using for *m* the power units included in the build margin.

More details about the $EF_{grid,BM,y}$ calculation can be checked in the Annex 3. Below we have the result:

$EF_{grid,BM,y}$ **= 0.19215**

Step 6 : Calculate the combined margin emissions factor

The calculation of the combined margin (CM) emission factor ($EF_{grid,CM,y}$) is based on one of the following methods:

(a) Weighted average CM; or
(b) Simplified CM.

For the project activity the method applicable is:

(a) Weighted average CM

The combined margin emissions factor is calculated as follows:

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

Where:

$EF_{grid,BM,y}$	= Build margin CO2 emission factor in year *y* (tCO2/MWh)
$EF_{grid,OM,y}$	= Operating margin CO2 emission factor in year *y* (tCO2/MWh)
w_{OM}	= Weighting of operating margin emissions factor (%)
w_{BM}	= Weighting of build margin emissions factor (%)

Considering that the project activity is based on SHPs, the calculation of the combined margin emissions factor shall use the following default values for w_{OM} and w_{BM}:

w_{OM} = 0.5 and w_{BM} = 0.5 for the first crediting period , and w_{OM} = 0.25 and w_{BM} = 0.75 for the second and third crediting period.

$EF_{grid,CM,y} = 0{,}54340 \times 0{,}5 + 0{,}19215 \times 0{,}5$

$\mathbf{EF_{grid,CM,y} = 0.36777}$ (tCO_2/MWh)

Since:

$$EF_{grid,\ CM,\ y} = EF_{CO2,\ grid,\ y}.$$

The Emission Reductions for this project activity are:

$$ER = BE_y - L_y - PE_y$$

The baseline emissions would be then proportional to the electricity delivered to the grid throughout the project's lifetime. Baseline emissions due to displacement of electricity are calculated by multiplying the electricity baseline emissions factor ($EF_{grid,\ CM,\ y}$) for the electricity generated by the project activity.

$$BE_y = EG_{BL,y} \cdot EF_{CO2,grid,y}$$

The electricity energy generated by the SHP Morro Azul (*$EG_{BL,y}$*) in the year *y* are estimated in 126,258 MWh/year.

So the baseline emissions are:

$$BE_y = 126{,}258 \;.\; 0.36777 = \mathbf{46{,}434\ tCO_2e/year}$$

To this project the leakage aren´t considered, so:

***L_y* = 0**.

As mentioned the (*PE_y*) is zero:

***PE_y* =0**

Thus all this, the Emission Reductions (ER) from the project activity are:

ER = 46,434 – 0 – 0 = 46,434 **tCO_2e/year**

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

Year	Baseline emissions (t CO_2e)	Project emissions (t CO_2e)	Leakage (t CO_2e)	Emission reductions (t CO_2e)
2014 (August)	19,347	0	0	19,347
2015	46,434	0	0	46,434
2016	46,434	0	0	46,434
2017	46,434	0	0	46,434
2018	46,434	0	0	46,434
2019	46,434	0	0	46,434
2020	46,434	0	0	46,434
2021 (July)	27,086	0	0	27,086
Total	325,037	0	0	325,037
Total number of crediting years	7 years, can be renewable for more two periods of 7 years each one.			
Annual average over the crediting period	46,434	0	0	46,434

B.7. Monitoring plan
B.7.1. Data and parameters to be monitored

Data / Parameter	$EG_{Morro\ Azul,y}$
Unit	MWh/year
Description	Quantity of net electricity generation supplied by the project activity to the grid, in year y.
Source of data	Eletricity meters located in the Anserma Substation
Value(s) applied	126,258
Measurement methods and procedures	The net electricity delivered to the grid will be checked through the energy metering.
Monitoring frequency	monthly
QA/QC procedures	The meter must comply with national standards and industrial regulations to ensure the accuracy. The meters must be sealed for safety after calibration.
Purpose of data	Calculation of baseline emissions.
Additional comment	The data will be archived monthly (electronic) should be kept for two years after the end of the crediting period or the last issuance of CERs for this project activity, whichever occurs later

B.7.2. Sampling plan

The datas and parameters monitored in section B.7.1 above are not determined by a sampling approach. The datas are effectively measured.

B.7.3. Other elements of monitoring plan

The monitoring plan for the project activity is based on the CDM methodology **ACM0002** - "***Consolidated baseline methodology for grid-connected electricity generation from renewable sources***", and consists of the monitoring of the electricity generation from the proposed project activity, the surface area of the reservoirs at their full levels, their CO_2 emissions, the installed capacities of the plants and CO_2 emission factors of Brazilian grid.

The process will be carried out in accordance with the requirements from EB on monitoring and verification to ensure that the emission reductions are monitored recorded and reported accurately.
The following are the key items that are considered in the monitoring plan:

i) Monitoring equipment and installation
Given that the emission factor is calculated *ex-ante*, and referring to the Monitoring Methodology ACM0002, the data to be monitored is the electricity supplied to the grid by the hydroelectric project. Electricity supplied to the grid will be monitored according to the Methodology.
The main electricity meter for establishing the electricity delivered to the grid will be installed at the input end of the transmission line (i.e. at the Anserma Substation - that belongs to the Local energy distributor) these electricity meters will be the revenue meter that measures the quantity of electricity that the project will be paid for. Shall be there another 2 pairs of meters located in a panel inside the SHP Power House (to measure the gross generation only).
As these meters provide the main CDM measurement, it will be the key part of the verification process.

All equipment used to monitor the electricity production will be provided by certified entities and calibration certificates up-to-date will be available in future verifications. Records of the meters (type, make, model and calibration documentation) will be retained in the quality control system.

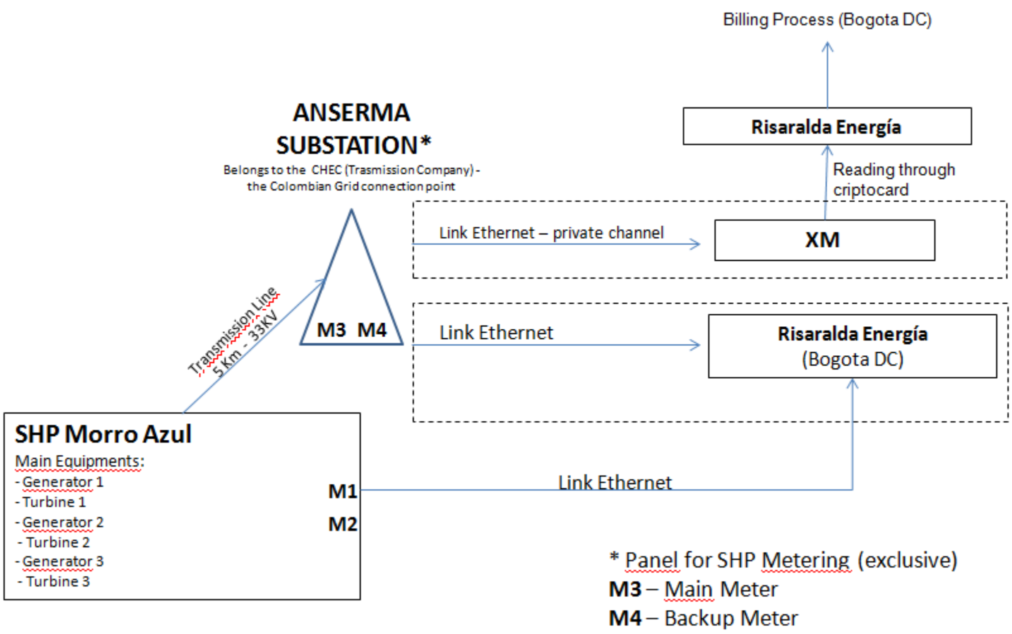

Figure 3: Forecasted Metering Scheme

ii) **Technological elements**
For the readings and reports of generated energy is required to install the measurement equipment at the substation of the power plant or in a place that from the technical point of view is highly recommended, these elements are comprised mainly of current transformers, transformers power and electronic meter, all calibrated by a legally registered entity and approved by regulators.

iii) **Central Reading and reports**
Risaralda Energía shall be responsible for the metering readings trough their own access to the meters registrations and also could access the readings made by the XM's (the communication link between Meters and XM´s shall be done by a private channel with properly security and encrypted).

iv) **Procedure of data recording and archive**

- Electricity will be monitored using a continuous meter and recorded through the main meter.
- Grid Company will confirm the electricity transactions.
- Records of the meter readings will be obtained to reflect the actual data of supplied electricity to the grid.
- Project owner will archive the data electronically until two years after the end of the crediting period.
- Quality assurance and Quality control will be applied: The quality of data generated by this project will be maintained through the development of an overarching monitoring system. This system may include procedures used to double check data, for staff training, meter calibration, accreditation of the facility completing calibration and the adherence to the relevant standards.

v) **Monitoring Management Structure**

An organization structure for monitoring Morro Azul shall be created just before the project start. The project owner will appoint an executive to be responsible for monitoring of all parameters considered in section B.7.1, data acquisition and recording for CDM purposes. The monitoring organization structure includes the persons responsible for the monitoring work, data collection and storage and archiving as well as reporting. A plant Manager is assigned to take charge for supervising measurement and recording works, related to the data collection (meter readings, sale receipts) that will be performed by operational staffs. The CDM manager is responsible for the overall data

SECTION C. Duration and crediting period
C.1. Duration of project activity
C.1.1. Start date of project activity

01/07/2012 –which according to the project activity implementation schedule is the date forecasted to the construction start.

C.1.2. Expected operational lifetime of project activity

30 years – 0 months.

C.2. Crediting period of project activity
C.2.1. Type of crediting period

Renewable crediting period, being:
01/08/2014 until 31/07/2021 the First crediting Period.
01/08/2021 until 31/07/2028 the Second crediting Period.
01/08/2029 until 31/07/2036 the Third crediting Period.

C.2.2. Start date of crediting period

The starting date of the first crediting period of the project activity is 01/08/2014 or in the CDM registration date, whichever occur later.

C.2.3. Length of crediting period

7 years and 0 months renewable for more 2 periods of 7 years and 0 months.

SECTION D. Environmental impacts
D.1. Analysis of environmental impacts

The environmental license was issued by CARDER (from Spanish - *Corporación Autónoma Regional de Risaralda*) in 01/20/2009, this register number is FO-18R-12.
The license is subject to compliance with the obligations contained in the Environmental Management Plan, which is part of the Study Environmental Impact, which are:

- During the construction phase, will be sent reports to CREG about the project status and compliance of the Environmental Management Plan.
- It is necessary guarantee a flow river not less than $4.2 m^3/s$.

- Above the water capture will be installed a limnigrafic station and a system to measure the water derived.
- During the construction and the operation of the project will be adopted action s to avoid the contamination of the aquifers.
- During the execution phase must be fulfilled the rules about loading, unloading, transportation, storage and disposal of debris and excavation and construction materials.
- The investment of the environmental recovery works will be one percent of the total investment of the project.

Besides, all the standards and guidelines about the environment must be obeyed.

D.2. Environmental impact assessment

The project activity include 1 Small Hydro Power plant where the environmental impact is considered not significant when compared with the other generation power plants types (with large flooded area). The Installation Licenses were issued by the Corporación Autónoma Regional de Risaralda (Risaralda Autonomous Regional Corporations - agency responsible for the environmental fiscalization during all the project activity lifetime).

SECTION E. Local stakeholder consultation
E.1. Solicitation of comments from local stakeholders

The project participant has done a presentation to the local stakeholders on 10/08/2012.
With the presentation to the local stakeholders was possible to detail the main aspects of the proposed project activity, for example:

- Project Design and Philosophy;
- Reservoir Area;
- Main negative impacts;
- Main positive impacts;
- Project Owner and the main contact channels;
- Among other issues
-

Additionally was delivered a questioner to be filled by the local stakeholders (13 in the total). The questioner answers can be summarized as follow (the answers were also resumed in topics):

	Yes	**No**
Information presented has easy comprehension?	13	
Sustainable development to the host country?	12	1
GHG reduction	10	3
Can provide negative impacts?	1	12
Can affect the air quality?		13
Contamination Risk?	1	12
Jobs creation?	13	

E.2. Summary of comments received

Due the comments received, it´s important to highlight that to all local stakeholders the information about the project activity was easily comprehension, will create jobs opportunities and doesn´t affect negatively the air quality. Also to all of then the project activity contributes to the sustainable development of the host country or to the project influence area.

To 3 consulted stakeholders was not clear if the project activity could reduce the GHG emissions, so was necessary to clarify the importance of a renewable energy generation inside a country with major generation coming from Large Hydro and Thermal Generation units. To 10 stakeholders consulted the project activity will reduce the GHG emissions.

Due to the contamination risks 12 stakeholders consider that there aren´t contamination impacts coming from the project activity and for 1 of them is it possible to occur contamination but this already was treated inside the project environmental studies.

Due to the negative impacts to 12 stakeholders consulted shouldn't occur negative impacts and only for 1 the impacts can occur, but was clarified that this is not a reason to cancel the project but only to compensate the impacts.

E.3. Report on consideration of comments received

The comments received were treated internally by the project participants; in fact the answers provided by the local stakeholders coming better than expected and also to the PP after the comments received were possible to put efforts on the project construction on a more confident manner than before.

SECTION F. Approval and authorization
Not applicable

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Appendix 1: Contact information of project participants

Organization name	**Risaralda Energía S.A.S. E.S.P.**
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Fax	+57 1 755-7310
E-mail	gdicavalcanti@alupar.com.br
Website	
Contact person	
Title	General Manager
Salutation	Mr.
Last name	Cavalcanti
Middle name	
First name	Guilherme di
Department	
Mobile	
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Personal e-mail	gdicavalcanti@alupar.com.br

Appendix 2: Affirmation regarding public funding

There is no Kyoto Protocol Annex 1 country public fund financing this project activity.

Appendix 3: Applicability of selected methodology

Not used

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

The grid emission factor is determined according to the Tool to calculate the emission factor for an electricity system, as a combined margin emission factor, consisting of the combination of the operating margin and the build margin emission factors. The detailed calculation, as well as all the information used for it, is shown in the spreadsheet prepared by the project developer. The following table summarizes the grid emission factor calculation for ex ante estimation.

	2008	2009	2010	
OM No Low cost/Must run	0,6436	0,6215	0,6022	
OM Low cost/Must run	0,0000	0,0000	0,0000	
Lambda	0,3113	0,0451	0,0203	
$EF_{OM\ Simple\ adjusted;y}$	0,4432	0,5935	0,5899	**TOTAL**
Generation [MWh]	54.112.552	55.641.481	56.572.103	166.326.136,04

$EF_{OM\ Simple\ adjusted\ 10,09,08}$	**0,54340**	tCO2/MWh

$EF_{BM\ 10}$	**0,19215**	tCO2/MWh

EF_{CM} (weight 0.5)	**0,367777**	tCO2/MWh

Appendix 5: Further background information on monitoring plan

ALL RELEVANT INFORMATION IS PROVIDED IN THE SECTION B.7.

Appendix 6: Summary of post registration changes

Not applicable

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History of the document

Version	Date	Nature of revision
04.1	11 April 2012	Editorial revision to change version 02 line in history box from Annex 06 to Annex 06b.
04.0	EB 66 13 March 2012	Revision required to ensure consistency with the “Guidelines for completing the project design document form for CDM project activities” (EB 66, Annex 8).
03	EB 25, Annex 15 26 July 2006	
02	EB 14, Annex 06b 14 June 2004	
01	EB 05, Paragraph 12 03 August 2002	Initial adoption.
Decision Class: Regulatory **Document Type:** Form **Business Function:** Registration		