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

PROJECT DESIGN DOCUMENT (PDD)

Title of the project activity	***La Vuelta and La Herradura Hydroelectric Project***
Version number of the PDD	Version 7 -12 February 2014
Completion date of the PDD	
Project participant(s)	Empresas Públicas de Medellín E.S.P. (private) Electric Power Development Co. Ltd and MGM Carbon Portfolio S.a.r.l.
Host Party(ies)	Empresas Públicas de Medellín E.S.P. (private)
Sectoral scope and selected methodology(ies)	Sectoral scope 1: “Energy Industries – Renewable Sources”. Baseline methodology ACM0002/version 06 “*Consolidated baseline methodology for grid-connected electricity generation from renewable sources*”.
Estimated amount of annual average GHG emission reductions	68,795 tCO2/year

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

- **Purpose:**

The purpose of the project activity is to build a hydroelectric power plant, with a total installed nameplate capacity of 33.48 MW, in order to take advantage of the capacity of La Herradura River, by means of two subprojects in a chain (La Vuelta and La Herradura). The proposed subprojects were not strictly built to cover the expected increase in electricity demand but to add efficiency to the electricity system as a whole, to improve electricity service in the west of Antioquia Department, and to contribute to the regional sustainable development, while reducing CO2 emissions.

- ✓ **Project Description:**

The use of La Herradura River begins in the upper part of the basin at the La Vuelta subproject. The mean flow is 12.3 m3/s with a 112 m fall for an installed nameplate turbine capacity of 12.4 MW. La Herradura subproject is located 5 km downstream (on the same river). The mean flow is 14.0 m3/s with a fall of approximately 220 m, for an installed nameplate turbine capacity of 21.08 MW..

- ✓ **Brief history of the project:**

Several studies for the utilization of La Herradura River basin were conducted between 1965 and 1997. The first study, commissioned by the Cooperative of Municipalities of Antioquia for a minihydro plant at La Vuelta, was executed by Gutiérrez and Montoya Civil Engineers. In 1994, the Medellín Integral S.A. firm carried out technical and economic feasibility studies of La Herradura for the former Electrificadora de Antioquia, today Antioquia Energy Company (EADE S.A.E.S.P.). Between 1995 and 1997 various environmental and design studies for both projects were also undertaken. These studies defined the basic outline of effective use for these subprojects, which remain valid today. Finally, during 2001, Empresas Públicas de Medellín E.S.P. (EE.PP.M) conducted an internal review of the technical and environmental documentation of the subprojects, with the purpose of project optimization, as well as analyzing the economic and financial viability for their construction, and considering the possibilities of reducing financial risks through project formulation as CDM.

- **Sustainable development considerations:**

a. Economic

The project generates revenue for the municipalities from economic transfer within the framework of Law 99/93. This amount could be about 200,000 US$/year during the project life. These resources are available to the municipalities for the implementation of Municipal Development Plans, especially in basic sanitation and environmental protection programs.

The Urabá region, influenced directly by the development of the project, is the only area of the Department that is connected to the Caribbean sea. This region includes export-oriented activities. In this region the exploitation of banana plantations (one of the main export items) is developed at industrial and commercial levels. Additionally, there is a potential development for meat industry which is favored with a better quality of power supply. The project improves electricity service in the region.

Electricity service for the northwest of Antioquia Department is provided by a two-link transmission system (Figure 1):

- Transmission line of 115 kV with a total length of 230 km, reinforced with a series compensation system in Apartadó substation, making it possible to increase its transportation and stability capacity.
- Transmission line of 230 kV with 49 km between Urrá and Urabá substations, connecting to Antioquia Department through Caucasia substation.

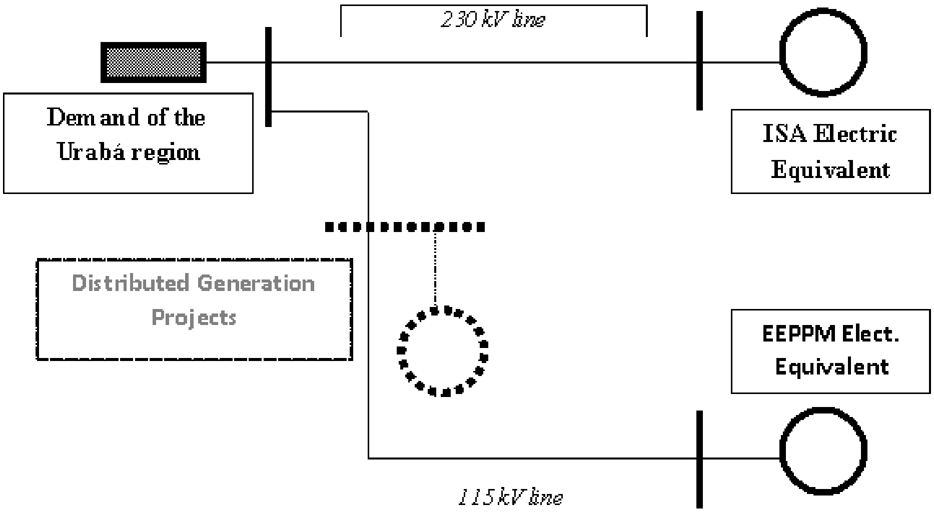


Figure 1: Electricity transmission system in the Antioquia Department

The current average demand of Urabá region is of about 50 MW, which is covered through Urrá-Urabá lines of 230 kV and West-Apartadó of 115 kV. Frequent guerrilla attacks to the 230 kV line leaves it out of order, limiting energy supply to the Urabá region since the 115 kV line it is not designed to transport 50 MW.

The project is in line with "distributed generation" concept, especially because it favours the development of new small productive activities in rural areas.

b. Environmental

The project provides clean energy and reduces CO2 emissions in Colombia.

The direct on-site emissions from the project are the emissions related to the production of electricity. Hydropower is a clean energy source that is emissions free, and there are no GHG emissions that are directly related to the use of hydropower for electricity production. Subsequently, the direct emissions for the project are considered zero.

Moreover, run-of-river plants have no regulating reservoirs so that environmental impacts are minimal and under control through a periodic monitoring plan.

c. Social

The project contributes to job creation during the construction period and also during operation (about 1,000 direct and indirect employments). Also, the projects contributes to regional development through institutional strengthening, with the goal that municipalities manage their own development projects, as well as providing new access roads for villages in the region. Likewise, through the construction of roads providing better connection among the municipalities of Abriaquí, Frontino, and Cañasgordas, people living in the project area would gain access to basic health services, education, and trading of local agricultural produce. Potential expansion and replicability are also possible.

d. National Sustainable Development Criteria

The Colombian government, through the Colombian Office for Climate Change Mitigation (OCMCC), has elaborated sustainable development criteria for CDM projects. The project can be reviewed in the context of a draft version of these criteria.

In that sense, it can be stated that the project complies with the applicable sectoral legal framework and has completed the environmental impact assessment and received the environmental licenses, it has the corresponding authorization to be developed, and it respects community interests and rights. The project is in line with national policies and programs by promoting the use of renewable energy sources (Law 697/2001). It also contributes to improving long-term social and economic conditions of the local community, as stated above. Additionally, the project implements clean technology contributing to the cleaner production criterion. Specifically, the main concerns are summarized as follows:

Review of sustainable development criteria proposed by OCMCC (June 2003)

1. Commitment with sectoral regulations (property rights, rights over natural resources, certificates, licenses, environmental impact studies, rights of local communities according to Art. 330 of National Constitution, Law 21/1991, Law 99/1993, and Decree 1320/1998).

A copy of property rights, environmental licenses, rights over natural resources, environmental impact studies and documentation related to local community opinion assessment are available for the validation stage (see Annex 5). Section D of this PDD also includes a summary of the main aspects and conclusions regarding environmental impact studies.

2. Contribution and compatibility with government policies (local, regional, and national planning, programs, and projects).

The project is in line with criteria for the generation capacity expansion plan of the national electricity system, general environmental policies and energy policies of the country. A summary of related legislation is included in Annex 5.

3. Contribution to improvements in social and economic conditions of local community (institutional agreements, employment generation, capacity building, local market development, impact on the trade balance, consideration of social needs).

Actions dealing with local communities' needs have been considered as part of the Environmental Management Plan of the project activity (see additional information in Annex 5).

4. Cleaner production implementation (minimization of negative environmental impacts, technology transfer).

Hydroelectricity is a clean technology, which helps to avoiding air polluting emissions coming from fossil fuel-fired power plants.

A more detailed description about environmental, social and economic contributions of the project is presented in Annex 5.

A.2. Location of project activity
A.2.1. Host Party(ies)
>>Republic of Colombia

A.2.2. Region/State/Province etc.

>>Antioquia Department

A.2.3. City/Town/Community etc.

>>Cañasgordas, Frontino, and Abriaquí Municipalities

A.2.4. Physical/Geographical location

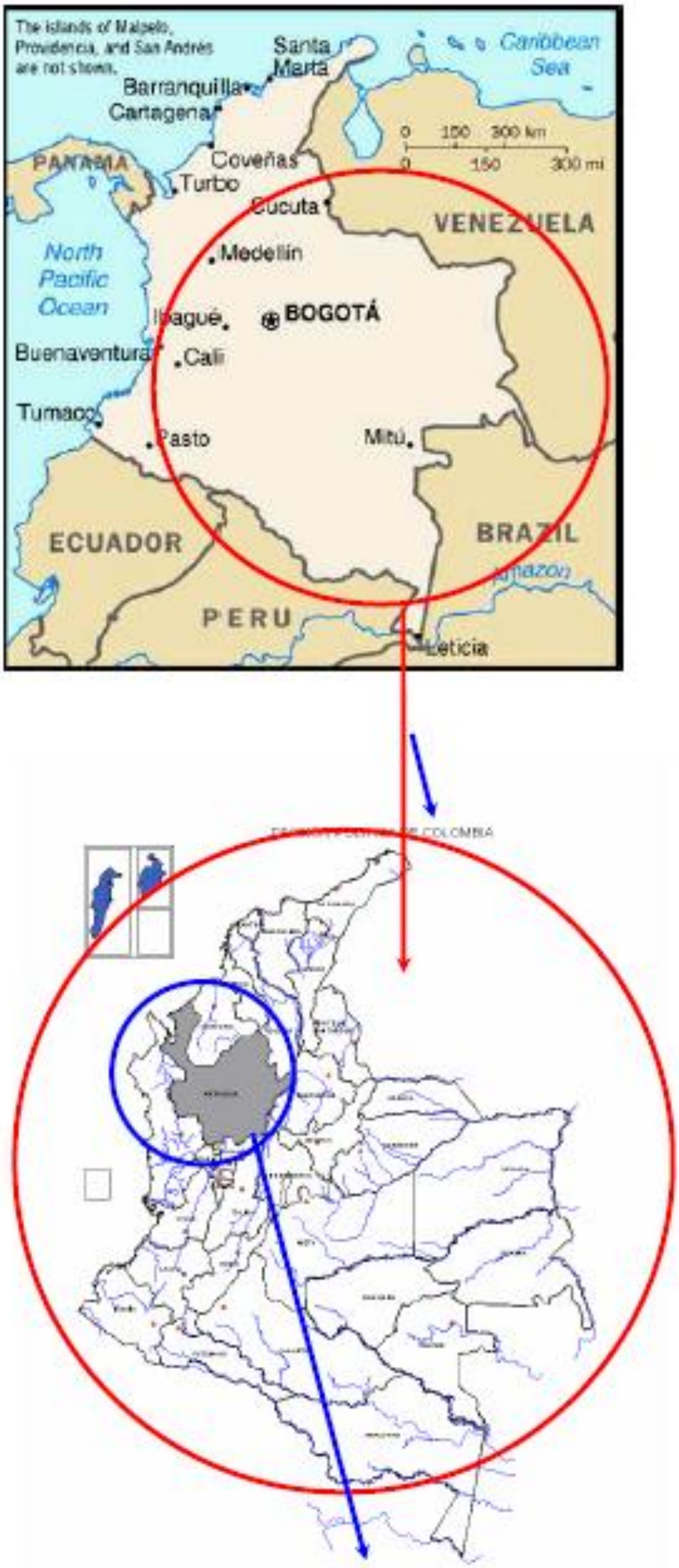
>>The Republic of Colombia is located in Northern South America bordering the Caribbean Sea, between Panamá and Venezuela and bordering the North Pacific Ocean, between Ecuador and Panamá. The project is located in the north-western area of Antioquia Department, using water from La Herradura River, under the jurisdiction of Cañasgordas, Frontino and Abriaquí municipalities, although the whole of Urabá Antioqueño can be considered as regional area of influence, which goes from Santa Fé de Antioquia to Arboletes. In this zone of approximately 230 km2, important municipalities, such as Dabeiba, Mutatá, Chigorodó, Apartadó, and Turbo are located (See Fig. 2).

La Herradura Sub-Project

La Herradura subproject takes place on La Herradura River, starting from an existing topographic fall between that river and the Cañasgordas River. Both rivers later join to form the Sucio River basin, a tributary to the Atrato River. The hydrographic basin area of La Herradura River is 320 km2, which contributes to a mean flow of 14 m3/s at catchment point. The construction is located in Frontino and Cañasgordas jurisdictions.

La Vuelta Sub-Project

La Vuelta subproject takes place in the upper and middle La Herradura River basin, up to the fork at the Nancuí gulch, at 1,595 m elevation, covering all Abriaquí municipality and the limits coincide with the dividing basin and to a lesser extent with Frontino municipality. The hydrographic basin area of La Herradura River is 286 km2, which contributes to a mean flow of 12.3 m3/s at catchment point.


The islands of Malpelo, Providencia, and San Andrés are not shown.
Santa Marta
Barranquilla
Cartagena
Caribbean Sea
Coveñas
PANAMA
Turbo
Cucuta
VENEZUELA
North Pacific Ocean
Medellín
Ibagué
BOGOTÁ
Buenaventura
Cali
Tumaco
Pasto
Mitú
ECUADOR
BRAZIL
PERU
Leticia
0 150 300 km
0 150 300 mi

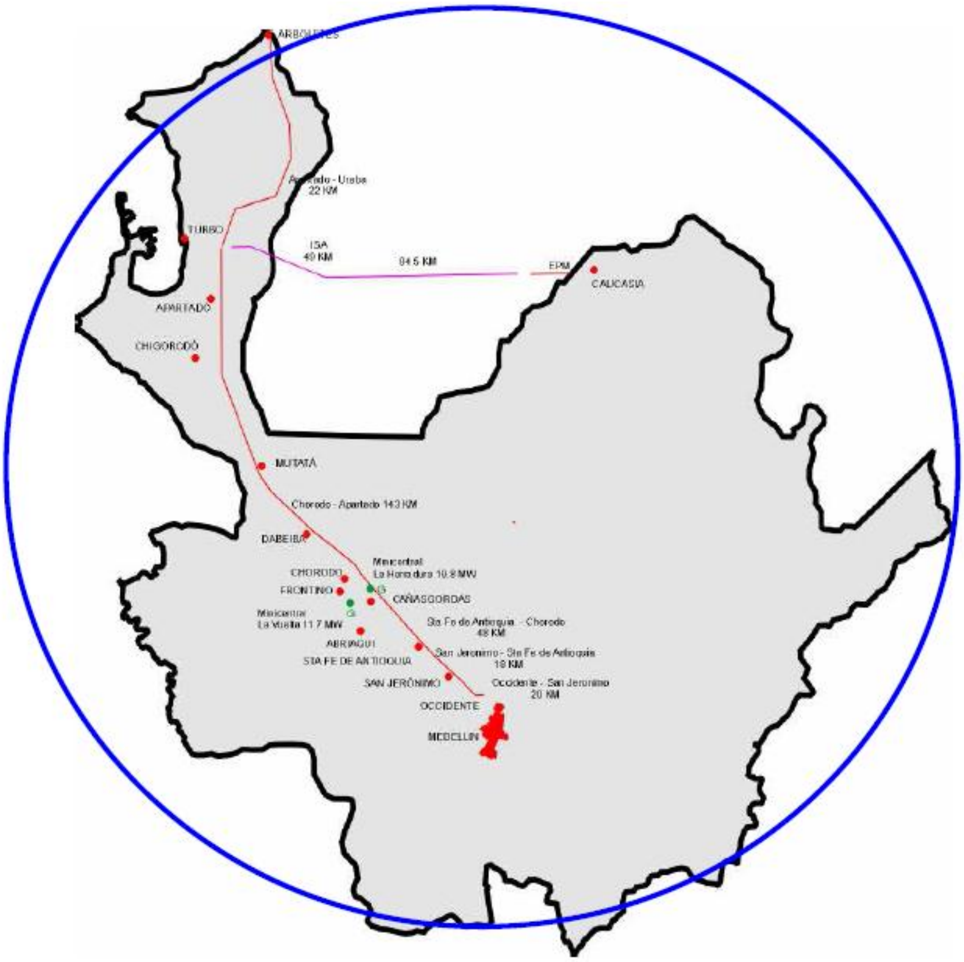


Figure 2. Colombia (above) and Antioquia Department (below)
Geographic coordinates: Approx. 6ºN, 76ºW
Source: http://www.eia.gov/cia/publications/factbook/geos/co.html
Green points represent La Vuelta and La Herradura power plants locations

A.3. Technologies and/or measures

>>**La Vuelta Sub-Project**

The main components of the sub-project consist of:

- Works to divert the stream flow and remove sand.
- A spillway with a capacity of 1,687 m3/s.
- Box coulvert conduction, free flow tunnel and penstock.
- A power house on the surface with a generating unit equipped with a Francis turbine.
- Main substation next to the power house.
- Connection to the electric system of EADE S.A. E.S.P. with the purpose of not saturating the 44 kV

Frontino-Cañasgordas power line.

Power plant characteristics	
Installed capacity	12.4 MW
Plant nominal flow	12 m3/s
Load tank normal level	1,590.80 m above sea level

Discharge normal level	1,473.80 m above sea level
Installation elevation in turbine belt wheel	1,470.80 m above sea level
Normal gross head (1,590.80 – 1,473.80)	117 m
Net design head	112.90 m

Hydraulic turbine	
Type	Francis, horizontal axis
Number of units	1
Nameplate capacity (without losses)	12,4 00kW*
Rotation speed	514.28 min-1
Nominal submergence	(1,473.80 – 1,470.80) 3 m
Nominal flow	11.97 m3/s (approx.)
Design net head	112.90 m
Minimum efficiency (100% opening)	2.4%
Generator	
Type	Synchronic with horizontal axis
Number of units	1
Nominal power output	14,000 kVA
Nominal tension	13.8 kV
Nominal frequency	60 Hz
Power factor (cosine ø)	0.85 (lagging)
Synchronic speed	514.28 min-1

* The turbine capacity value differs slightly from the first registered PDD (Version 6 – 06 September 2006), see explanation and justification in Appendix 6 of this PDD

La Herradura Sub-Project

The main components of the sub-project consist of:

- Works to divert stream flow and remove sand.
- Vertical reception well emptying its waters to conduction.
- Pressurized 1,534 m tunnel, which receives the water from the vertical well.
- Pressurized pipes as last tract of the flow system.
- A power house on the left riverbank of the Cañasgordas River with two Francis turbines within.
- Discharge channel to the Cañasgordas River and substation located on the north side of the power house.

Power plant characteristics	
Installed capacity	21.08 MW
Central nominal flow	10.0 m3/s
Load tank normal level	1184.5 m above sea level
Discharge normal level	940 m above sea level
Installation elevation of turbine belt wheel	937.5 m above sea level
Normal gross head	244.5 m
Design net head	230.6 m
Hydraulic Turbine	
Type	Francis, horizontal axis
Number of units	2
Nameplate capacity (without losses)	10,540 kW*
Rotation speed	900 min-1
Nominal submergence (940.0 – 937.5)	2.5 m
Total nominal flow (two turbines)	10.0 m3/s (approx.)
Design net head	230.6 m

Minimum efficiency (100% opening)	92.4%
Admission valves (spherical type)	0.9 m nominal day

* The turbine capacity value differs slightly from the first registered PDD (Version 6 – 06 September 2006), see explanation and justification further below in Appendix 6 of this PDD

Taking into account the selected equipment, it was decided to assign two generating units to the power plant. Each turbine is equipped with a pressure relief valve synchronized with the closing of blades so as to limit spiral chamber internal pressure at gross leap 115%.

Turbine Regulator: programmable digital type with electronic head operated from central or by remote control from another control center. It also has an electro-hydraulic system for normal operations of synchronization, charge and discharge.

Generator	
Type	synchronic, horizontal axis
Number of units	2
Nominal power output	12.0 MVA
Nominal tension	13.8 kV
Nominal frequency	60 Hz
Power factor (cosine ø)	0.85 (in delay)
Synchronic speed	900 min-1

Transformers: It has been decided the use of an outdoors transformer for the two generators, with a capacity of 24 MVA: three-phase, with primary nominal voltage of 13.8 kV and secondary of 44 kV and 60 Hz, oil-cooled under normal conditions and by forced air under operating conditions at continual maximum capacity.

Mechanical auxiliary equipments: Oil in bolsters is cooled in a dry type tower, the oil circuit is closed and the pumps are directly propelled by the unit axis. For the drainage of the spiral chamber, the relief valve discharge pit, the draft duct and infiltrated water and power house floors drainage, there is a system with submergible vertical pumps installed in the drainage pit to conduct water to the discharge channel.

Electric auxiliary equipments: A 480 kV-13.8 kV transformer is used as normal feed, fed from any of the two generators as main source. It has a diesel electric generator of 480 V and 60 Hz emergency system.

Each generation unit has a control center and a 480 V distribution board so that maintenance and selection processes in auxiliary services operations are independent. There is a surveillance system and water level control in the load tank. Therefore, the central is interconnected, so as to secure accurate load tank operation hydraulic conditions.

Turbine specifications: The turbines are Francis reaction turbines, with a martensitic stainless steel welded impeller, with spiral chamber and welded draft pipe from soothed carbon steel sheets, of thin austenitic grain size.

A Francis turbine is a type of hydraulic reactor turbine where the flow exits the turbine blades in radial direction. Francis turbine is common in power generation facilities and is used in applications where high flow rates are available at medium hydraulic head (e.g. Niagara Falls). Water enters the turbine through a casing and is directed to the blades by wicket gates. The low momentum water then exits the turbine through a draft tube.

Francis turbines can be assembled both vertically and horizontally. Figure 3 shows a Francis turbine where water can enter freely through the whole circumference and through the outer ring of the guide vanes. These guide vanes can be adjusted so the amount of incoming water may be controlled. Francis

turbines are highly efficient and versatile turbines (inflow-impulse type in the first stage and outflow-axial reaction type in the second stage).

Francis turbines are the most widely used among water turbines. Figure 3 shows a typical configuration of a Francis turbine.

Figure 3 shows a typical configuration of a Francis turbine.

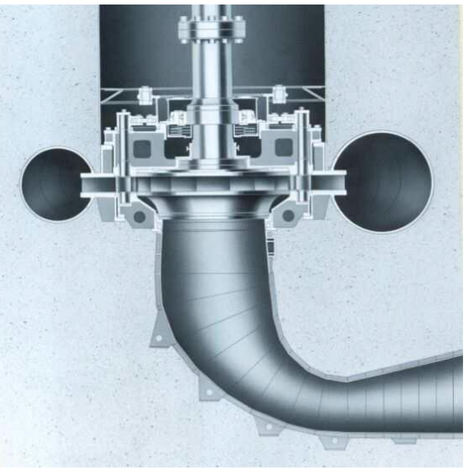


Figure 3: Francis Turbine Spiral Cased Horizontal Shaft - typical arrangement

The technology involved is well-known and hundreds of similar projects exist all over the world. It is widely recognized as an environmentally sound and safe technology.

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)	Empresas Públicas de Medellín E.S.P. (private)	No
Japan (Annex I)	Electric Power Development Co. Ltd.	No
Switzerland	MGM Carbon Portfolio S.a.r.l.	No

Project sponsors' capability for implementing the project (e.g. credentials):

From 1955 and up to 1997, Empresas Públicas de Medellín E.S.P. (EE.PP.M) was a decentralized municipal entity providing diverse public services (e.g. energy, water supply, sewage) to the Antioquia Department including the Valle de Aburrá region and other municipalities such as Bello, Copacabana, Girardota, Barbosa, Itaguí, Envigado, Sabaneta, La Estrella, and Caldas.

Since 1998 and considering both the Agreement 69 of 1997 issued by the Medellín Council and the Law 142 of 1994, EE.PP.M was modified to become an Industrial and Commercial State Enterprise with the specific objective of providing sustainable services and enhancing community progress.

Effectively, EE.PP.M has 48 years of experience building and operating infrastructure as well as providing public services to the 2,500,000 inhabitants of the region including sewerage, wastewater transport, and treatment, electricity, gas distribution, and telecommunications.

In the power sector, EE.PP.M has built the hydroelectric capacity base of the Antioquia Department (e.g. Guadalupe I, II, III, and IV, Mocorongo, Playas, Niquía, La Tasajera, and Porce II hydroelectric power plants). EE.PP.M also owns the only hydro plant in the country able to store water from one year to the next (Guatapé plant with the Peñol dam). The company has also diversified its portfolio of power generation assets, finishing in 1998 the construction of La Sierra gas-based thermal power plant of 300 MW capacity, where a combined cycle project with additional 166 MW was later developed. This project started commercial operations on January 27, 2001. As of 2004, EE.PP.M was building La Vuelta and La Herradura hydro plants and Jepirachi wind farm of 19.5 MW, the first project to be carried out in the country with this technology. Jepirachi project belongs to the PCF portfolio (the Emission Reduction Purchase Agreement was signed in December 2002) and is also the first project in Colombia to be implemented within the CDM framework.

Moreover, since 1998, EE.PP.M provides natural gas distribution service in 10 municipalities of the Valle

de Aburrá Region.

The EE.PP.M power generating business has a total installed capacity of 2,573 MW and generates an average of 9,100 GWh per year.

At present, EE.PP.M is planning medium- to long-term capacity additions to its portfolio of power generation projects, considering the CDM learning-by-doing process, experience, positioning, and revenues, and thus also considering the construction and operation of Porce III hydro plant (660 MW).

In terms of the company’s financial status, the 2003 EE.PP.M investments reached a total of about 630 million USD with a balanced debt of 33% and equity of 2.8 billion USD.

EE.PP.M has a solid capital and a sustainable and transparent financial balance, which is built on sales and that, has never needed external contributions or governmental fund transfers. Decision-making regarding investments, expansion, and the operation of the diversified portfolio of EE.PP.M’s assets are exclusively conducted by internal administrative bodies, the Board of Directors and the director manager.

Finally, EE.PP.M has received several national and international awards for its economic, financial, and social performance. In particular, EE.PP.M was receiver of the national award “Premio Portafolio a la Empresa del Siglo XX”, which is given by a board of experts composed by academia, industrial and banking sectors of Colombia.

A.5. Public funding of project activity

>>No public funding, including official development assistance, is involved in financing this project activity. The only funds involved are those handled by the project sponsor EE.PP.M.

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

>>According to the Colombian energy matrix, the type of data available, and the CDM activity itself, the proposed project is developed using the approved consolidated baseline methodology ACM0002/version

06 "*Consolidated baseline methodology for grid-connected electricity generation from renewable sources*".

Project additionality is analyzed using the "*Tool for demonstration and assessment of additionality*" proposed by the CDM Executive Board.

B.2. Applicability of methodology

>>The approved consolidated methodology ACM0002/version 06 is applicable to grid-connected renewable power generation project activities.

The proposed project activity meets all applicability conditions required by the methodology, as follows:

1) The project involves an electricity capacity addition from a run-of-river hydro power plant.
2) The project does not involve switching from fossil fuels to renewable energy at the site of the project activity.
3) The geographic and system boundaries for the Interconnected Colombian System grid can be clearly identified and information on the characteristics of the grid is available.

La Vuelta and la Herradura Hydroelectric Project belongs to the Interconnected Colombian System, which is a hydrothermal electricity system. The Colombian electricity system, in which power plants operate, is dominated by hydro plants and to a lesser extent by thermal plants (approx. 65.6% hydro and 34.4% thermal of installed capacity of centrally dispatched plants, and 75.19% hydro and 24.81% thermal —80.63% natural gas and 19.37% coal— in terms of energy generation in 2001).

Power plants are dispatched according to their generation costs, the least-cost plants enter first, while the plant dispatched later to cover the demand sets the marginal price of electricity.

Hydropower plants enter the system declaring the opportunity price of their water resources (water storage is a common business strategy, which many times leads to hydro plants to be at the dispatch margin), taking into consideration hydrological conditions. (Note that in some Latin American power systems hydro plants are always dispatched in the base load since those plants do not declare generation costs and only thermal plants compete for entering into the electricity delivery.)

Thus, La Vuelta and La Herradura plants displace grid electricity that would otherwise be supplied and generated by the current operation and expansion of the grid, mainly with fossil fuel-fired plants at the margin. As such, the generation of the interconnected national grid, as a whole, results in lower CO2 emissions than those that would occur if the proposed project was not implemented.

The emission reductions achieved by the project activity are the difference between baseline emissions and project emissions, including emissions due to leakage.

For this kind of renewable energy project activities, there are not project emissions, and the main emissions potentially giving rise to leakage are emissions arising due to activities such as power plant construction, fuel handling, and land inundation. However, project participants do not need to consider these emission sources as leakage in applying this methodology.

Thus, only baseline emissions are considered in the calculation of emission reductions.

In accordance to the methodology ACM0002/version 06, following project implementation, baseline emissions will be calculated applying the combined margin emission factor, consisting of the combination of the operating margin (OM) and the build margin (BM) emission factors.

According to the data available for the Colombian electricity sector, the methodological choice selected to calculate the OM is the Dispatch Data Analysis (DDA), Option C of the methodology. The DDA provides an accurate and actual expression of the emission sources that would be displaced by the proposed CDM project activity. Additionally, Option 2 of the methodology is selected for the BM calculation.

According to methodology ACM0002/version 06, the spatial extent of the project boundary includes the project site and all power plants connected physically to the electricity system that the CDM project power plant is connected to, which corresponds to the national interconnected grid.

Sufficient information exists to demonstrate that La Vuelta and La Herradura project is not common practice in Colombia. There is also sufficient information to document in a transparent and conservative manner the additionality analysis, as well as the GHG baseline estimation prior to project implementation.

The National Dispatch Center (CND), which coordinates the Wholesale Electricity Market (MEM) and operates the National Interconnected System (SIN) of Colombia, provides all the dispatch data required to calculate the emission factors and the Energy and Mining Planning Unit (UPME) of the Ministry of Energy and Mines provides key parameters to perform calculations.

According to the methodology, the key data used to determine the baseline scenario is given in the following table.

Table 3: Key data

Parameters	**Data sources**
Oxidation factor of fuel *i*	IPCC guidelines
CO_2 emissions factor of fuel *i*	IPCC guidelines
Variables	**Data sources**
Electricity generated by La Vuelta and La Herradura hydroelectric plants	EE.PP.M
Plant dispatch order of the grid	CND
Electricity generated by each power plant of the Colombian SIN	CND
Specific consumption of power plant for the fuel *i*	CND and UPME
Heat rate of power plant for the fuel *i*	CND and UPME
Net Calorific Value of fuel *i*	Plant management or IPCC guidelines

This kind of plants are considered as plants without dams,[1] since the dams are very small and they are obviously needed to permit water access and avoid air penetration into the tunnels. In the case of La Vuelta and La Herradura plants there are only thin water films over flooded areas of 6,181 m2 (La Vuelta) and 3,194 m2 (La Herradura). The vegetation in these areas (backwater along the river-bed) corresponds to very small portions of grass since it was removed during digging works.

The thresholds (EB23 Annex 5) are:

LV: 11.7 MW/6,181 m2 = 1,893 W/m2

LH: 19.8 MW/3,194 m2 = 6,199 W/m2

These values are greater than 10 W/m2. Thus, no methane emissions are considered since project emissions from the reservoir may be neglected according to EB 23 Annex 5.

[1] Moreover, plants that can storage water for ten days are considered as plants without dams.

B.3. Project boundary

Source		GHGs	Included?	Justification/Explanation
Baseline scenario	Fossil fuel-fired power plants	CO_2	Yes	Following the guidelines of ACM0002, the baseline will consider only CO2 emissions from electricity generation from fossil-fuelfired power plants that are displaced by the CDM project activity.
		CH_4	No	As in ACM0002/v06
		N_2O	No	As in ACM0002/v06
Project scenario		CO_2	No	As in ACM0002/v06
		CH_4	No	See below
		N_2O	No	As in ACM0002/v06

As stated in methodology ACM0002/version 06, methane project emissions shall be accounted for from New Hydroelectric power projects with reservoirs only if power density is greater than 4 W/m2 and less than or equal to 10 W/m2. If power density is greater than 10 W/m2 then project emissions are equal to zero.

Regarding La Vuelta and La Herradura Hydroelectric Project, power density for LV is 1,893 W/m2 and for LH is 6,199 W/m2. As both are greater than 10 W/m2, thus, no project emissions will be accounted for in the emission reductions calculation for the proposed project activity.

B.4. Establishment and description of baseline scenario

>> Following the guidelines of ACM0002/version 06, the baseline will consider only CO2 emissions from electricity generation in fossil-fuel-fired power plants that are displaced by the CDM project activity.

The spatial extent of the project boundary includes the project site (La Vuelta and La Herradura power plants) and all power plants connected physically to the electricity system that the CDM project power plant is connected to, as shown in Figure 4.

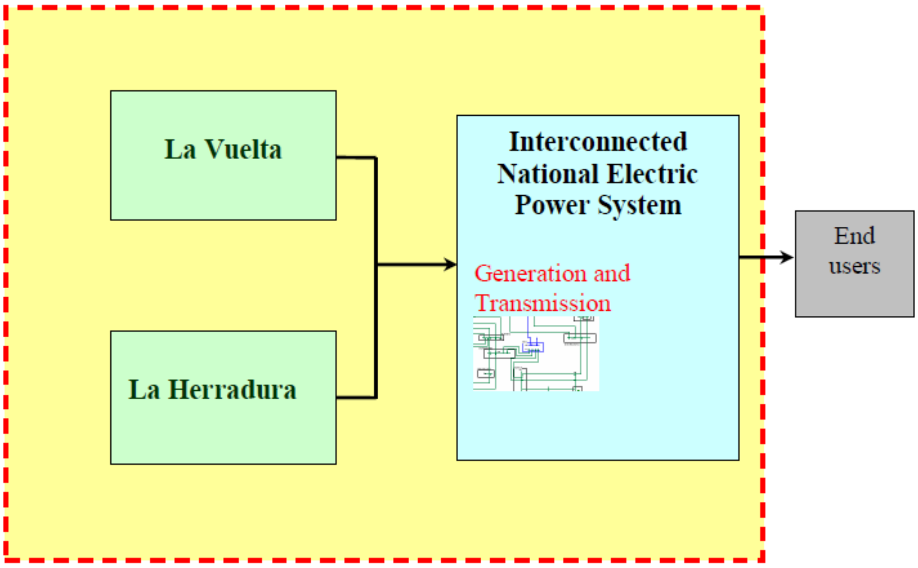


Figure 4: Project boundary (red line represents the project boundary)

B.5. Demonstration of additionality

>>As mentioned above, project additionality is analyzed using the latest version of the "*Tool for the demonstration and assessment of additionality*."

Step 0. Preliminary screening based on the starting date of the project activity

EE.PP.M is a leading company in Colombia, which has adopted an internal environmental strategy to deal with its main business activities and new investments. It is also one of the pioneer enterprises in considering CDM as a part of its decision-making process.[2]

Since people working for the World Bank —looking for projects to be presented to the Prototype Carbon Fund (PCF) — contacted EE.PP.M and suggested the possibility of developing CDM project activities,[3] EE.PP.M has paid a great attention to the novel Clean Development Mechanism.[4] They were also involved in contacting experts in order to closely follow CDM consolidation and to be kept apprised of the status of current negotiations in this issue. Their first successful experience was the presentation of the Jepirachi Carbon Offset Project[5] (19.5 MW Wind Power Plant in Alta Guajira, Colombia, 2002) to the PCF (the Emission Reduction Purchase Agreement was signed in December 2002).

Aware of the potentiality that the CDM offered, EE.PP.M submitted a letter to the Colombian Ministry of Environment, in September 2001, expressing the intention of exploring the possibility to develop a joint GHG mitigation project activity with two run-of-river hydro plants in La Herradura River basin. After that EE.PP.M reached a collaboration agreement with MGM International to identify and develop CDM project activities in a wider framework.[6]

The proposed project activity is a consequence of those facts and circumstantial meetings, which contributed to the EE.PP.M decision to reconsider the project among their possibilities, also taking into account that a contact with a potential buyer (Electric Power Development Corporation, of Japan) was already established thanks to the above mentioned agreement.

This project was conceived many years ago, but it was just after CDM acquired a real body when EE.PP.M reconsidered the project, giving it a high priority among its investment opportunities.

La Herradura basin has been studied for electric generation purposes since 1965. Between 1994 and 1997, technical and economic feasibility studies as well as environmental and design studies were undertaken. The mentioned studies defined the outline of effective use of the two subprojects. During 2001 E.PP.M. conducted internal reviews of the technical and environmental documents and studies. The economic and financial viability analysis concluded that financial risks could be reduced through CER revenues if the project was registered as a CDM. Thus, in the absence of project registration as a CDM, EE.PP.M. would not have made any other project or they would have waited and looked for another CDM project in the future.

[2] Three of the "official" Colombian projects were developed by EE.PP.M (Jepirachi Windpower Project, Río Amoya Hydroelectric Project, and La Vuelta and La Herradura Hydroelectric Project).

[3] On that occasion EE.PP.M started working with two projects, the Jepirachi Carbon Offset Project and the previously low-priority —and almost already disregarded— project of La Vuelta and La Herradura.

[4] Take into account that by that time CER prices scenarios were highly optimistic, around US$ 20 per tonne of CO_2e.

[5] Jepirachi Carbon Offset Project (19.5 MW Wind Power Plant in Alta Guajira, Colombia), Baseline Assessment, the Prototype Carbon Fund, May 2002. The information can be found in www.prototypecarbonfund.org.

[6] In particular, EE.PP.M has dispatched to MGM Buenos Aires office a person from the Planning and Energy Sub-Manager Department in order to support work on the PDD and also to further knowledge in this new and evolving concept. The company has also devoted a person of this Department to work in the project baseline determination.

However, none of these projects were done due to the same kind of barriers La Vuelta and La Herradura faced at that time. Those barriers could be overcome thanks to CDM (a possibility that EE.PP.M has seriously considered as shown by the three CDM projects submitted). Taking into account the social and economic uncertainties of developing countries, CDM registration is a certain opportunity to overcome this kind of barriers, also contributing to sustainable development.

It is worth recognizing that, when evaluating the implementation of La Vuelta and La Herradura Hydroelectric project, CDM is envisaged not only by its revenues and the added value given by carbon credits but also by other monetarily non quantifiable qualities, such as:

- Positioning of EE.PP.M in an emergent market through the early participation in a learning-by doing process
- Gaining public image and recognition through national and international certifications along the assessment process (the whole project cycle)
- Contributing to sustainability and improving social conditions in a scantly developed rural region, among other non-material aspects.

Therefore, EE.PP.M started the development of the PDD and related documents with active involvement and close collaboration with MGM International and not only hiring consultants to develop the studies, which is the business-as-usual in these kind of projects.

Finally, in October 2004 and December 2004, La Herradura and La Vuelta started operating.

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

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

The alternatives identified are the following:

1. Continuation of the current capacity addition trend
2. Implementation of the project without CDM assistance
3. No implementation of any project

Regarding the first alternative, it can be clearly seen that the current trend involves capacity addition using thermal power generation technologies.

Since the 1994 power sector reform in Colombia (Law 142 on public services and Law 143 on electricity), capacity additions have been performed by both the public and the private sector. Table 4 shows that independent power producers have privileged gas-based thermal generation. Most of the thermal plants were constructed due to the incentive created by the new electricity market. The only hydro project added in this period, the 405 MW Porce II owned by EE.PP.M, began its construction in 1992prior to the power sector reform. (EE.PP.M is public sector, but it is highly focused on financial performance to the point that it is the most profitable company in Colombia.[7])

[7] See for example the Colombian journal "Semana," July 7, 2003; http://www.semana.com.

Table 1: Capacity additions, 1995-2001 (values in MW)[8]

Type of generation	Private	Public	Total	%
Hydro		405	405	10
Coal	165	150	315	8
Natural gas	2,415	755	3,170	81
Total	2,580	1,310	3,890	
% by investor	66	34		

Public companies only contributed to 34% of the expansion; therefore the largest portion was in charge of independent producers. Over 80% of the 1995-2001 capacity addition was natural gas and only 10% was hydro. All the latter were by the public sector. Coal power plants added up to 8% of the total, evenly divided among private and public sectors.

This electricity market behavior —favoring thermal power plants over hydroelectric projects— has indeed been the experience in all countries —both industrial and developing— where the power sector was deregulated in the 90s.

Independent power producers have diminished their investment rate lately. While capacity additions exceeded 700 MW in 1995 and 1996, they were less than 200 MW in 2001. Guerrilla attacks on the transmission network are partly responsible for this outcome.

The long interconnection lines required for hydroelectric generation have been highly exposed to guerrilla attacks. This leads to prioritize the installation of power plants close to the largest consumption centers; again favoring thermal power plants.

There are also other factors such as the important increase in natural gas prices in 1999 and some regulatory uncertainties on capacity charge values.

Colombia's important fuel reserves and the need to guarantee electricity supply through a more balanced mix between thermal and hydroelectric generation[9] have supported the trend towards thermal power generation. (Currently, Colombian reserves are equivalent to 34 years of natural gas production and more than 150 years of coal production.)

Sub-step 1b. Enforcement of applicable laws and regulations

All alternatives identified above are in line with all the legal and regulatory requirements of Colombia.

Taking into account the current capacity addition trend, all projects that may be considered (including EE.PP.M. portfolio) are included in the Colombian National Expansion Plan. For this reason, it is assumed that any possible project that starts operations will comply with all the legal and regulatory requirements of Colombia. Moreover, as it was mention in Step 0 of this PDD, the proposed CDM project is operating since the end of 2004.

Step 2. Investment analysis

Sub-step 2a. Determine appropriate analysis method

[8] Source: Reference Expansion Plan 2002-2011, UPME, Bogotá, Oct. 2002.

[9] Moreover, global climate change now produces more abrupt variations in hydrological cycles, altering water availability and thus hydroelectric generation in an unpredictable way.

An analysis of alternative cost options in terms of investment requirements, NPV and IRR (if corresponds), comparing the proposed project against potential projects by the project developer or other IPP is a way to demonstrate additionality. Then the option chosen is Option II "Investment Comparison Analysis."

Sub-step 2b. – Option II. Apply investment comparison analysis

This analysis is presented for the options handled by EE.PP.M while deciding to go ahead with the proposed project activity under the CDM and also comparing their options with the most attractive options for other IPP.

This analysis also demonstrates that La Vuelta and La Herradura Hydroelectric Project was not a prioritized project of EE.PP.M, but that this project became a priority project due to the anticipated CDM benefits.

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

This sub-step is presented together with **Sub-step 2d**: **Sensitivity analysis.**

The most attractive options at the time La Vuelta and La Herradura was decided were those related to thermal generation. Table 5 shows a financial analysis.

Table 2: Economic indicators for thermal plants

Power Plant	Capacity (MW)	Investment (US$ million, Dec. 1996)	NPV (US$ million, energy price = 33 US$/MWh)	IRR (%)
Simple cycle	300	154	12.6	10.36
Combined cycle	150	113	135.9	19.92

In 2001 EE.PP.M assessed the potential to develop a CDM project in order to contribute to global warming mitigation through an evolving mechanism. EE.PP.M decided to promote a relatively low investment cost option with an excellent sustainable development contribution. The project itself was not financially viable but CDM benefits were considered as a key factor that helped support the decisionmaking process, leading to the formulation of the proposed project under the CDM.

By carrying out an NPV analysis of the project, it is obvious that the project could not be developed due to its financial unattractiveness. The required investment is US$ 38.7 million and NPV is negative (−9.1 million US$) without CER revenues, applying a discount rate of 7.86% (WACC).

If carbon credits are considered in the analysis the project's NPV turns positive at approximately US$ 12 per tonne of CO2e (for example, at 20 US$/tCO2e, the NPV is US$ 6.4 million and the IRR is 9.1%). In conclusion, and from a financial point of view, the project could only be carried out if CER revenues are considered in order to surmount the economic hurdles of the project.

Furthermore, if light variations (±10%) of the discount rate (WACC) used for the project's NPV analysis are applied, NPV still shows negative results, which confirm the robustness of the financial analysis and the trustworthiness of the conclusions derived from it, *i.e.*, that the project could not be carried out without including CER revenues.

Other alternatives (belonging to EE.PP.M. project portfolio) were directly excluded due to huge investment and very negative NPV values.

Besides financial barriers, the project has an important social content contributing to sustainable development, thus providing a motivation to implement it. But it was not a competitive option due to disappointing sectoral circumstances. It is understandable that the company would have waited for another opportunity in the future when sectoral conditions were more appropriate. It was when EE.PP.M realized the valuable opportunity that CDM represents; this played a role speeding up the decision to go on with the project. And what could be better than beginning with a small renewable energy project, reducing also transaction relative costs.

Step 3. Barrier analysis

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

The barriers identified are the following:

Barrier due to prevailing practice: hydro plants were not the actual and current practice in the electricity market despite the fact that the national system was highly based on hydroelectricity in the past. In recent years deregulation has strongly favored more economically attractive options based on thermal energy. Moreover, run-of-river power plants (with Francis turbines) have a very low technological penetration in Colombia.

Sectoral barrier: there were also regulatory uncertainties on capacity charge values, circumstances related to fuel availability and prices, security of the interconnected system which could not be based so strongly on hydroelectricity due to hydrological uncertainties (moreover affected by the consequences of climate change).

Social and institutional barrier: *guerrilla* attacks on transmission towers mainly affected hydro plants because they are located in rural areas where such attacks were more common.

Political and investment barrier: in addition to the arguments provided in the investment analysis presented above, Colombia was undergoing difficult times, which made also difficult for that project developers to attract investors or get financing from banks.

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 current capacity addition trend, basically fossil-fuel-fired power generation plants, has several advantages against a run-of-river project, as explained as follows:

Barrier due to prevailing practice: as thermal plants are considered the current capacity addition trend, the barrier due to prevailing practice would not affect the decision of constructing another fossil-fuel-fired power plant.

Sectoral barrier: thermal power generation plants do not depend on hydrological conditions. On any circumstance, if there is enough fuel to fire the power plant and according to its efficiency and spot price, the thermal plant will run and generate electricity to be sold. Moreover, a run-of-river lacks of a dam, increasing the dependency on hydrological conditions.

Social and institutional barrier: thermal power plants may be located either in a rural or urban area, as they do not depend on hydrological and topographic conditions. Taking this argument into account, a thermal power plant may be located in the energy requirement area, eliminating the transmission tower attacks risk.

Political and investment barrier: as showed in the investment analysis, thermal power plants have more attractive and convenient IRRs than hydroelectric power plants. Because of this reason, investors would prefer to construct a thermal power plant than a run-of-river one. Moreover, the capacity addition trend, usually follows this investment trend.

Although the best alternative for investors is to construct a thermal power plant, the continuation of this capacity addition trend was not a possibility considered by EE.PP.M., since the main objective of the proposed project activity was related to provide clean energy to the west of Antioquia Department, improving the electricity service and contributing to regional development, which is in line with the environmental and social politics of the company.

It is clear that the first alternative identified (current capacity addition trend) is not the best option to contribute to sustainable development, as well as to climate change mitigation.

The need of local sources of generation and the fact that Colombia has 34-year of natural gas reserves and 150-year of coal reserves (if the capacity addition trend continues, it may lead to fuel switching from natural gas to coal, increasing GHG emissions), show that the thermal generation expansion trend would have been continued by other IPPs (situation that might contribute to accelerate climate change and its environmental and social negative consequences).

It is also clear that none of the projects of EE.PP.M portfolio would have been developed since they were quite unviable. This alternative does not face any barrier or risk to the company and it is considered the most plausible scenario that would occur in the absence of CDM incentives.

La Vuelta and La Herradura project is the least investment cost option with the best sustainable development contribution among all projects considered by EE.PP.M. But it was not a competitive option due to the disappointing sectoral circumstances. Thus, it is clearly demonstrated that, in the absence of CDM registration, EE.PP.M. would not have carried out any project.

Step 4. Common practice analysis

As stated above, the Colombian power sector is dominated by hydroelectric generation power plants. However, since 1994's electric sector reform, the capacity addition trend reflects that the thermal generation has been favored. Therefore, the thermal generation dominated the capacity additions since 1994. The only hydropower plant added since the reform, and previous to the consideration of La Vuelta and La Herradura project implementation, was one of 405 MW whose construction started in 1992, previous to the reform. Furthermore, when EE.PP.M. decided to implement La Vuelta and La Herradura project, there were just a few run-of-river hydropower plants in Colombia.

As of September 2005, Colombia had only 6 run-of-river power plants, of which one of them was out of order due to a terrorist attack. The table below provides the list of Colombia's run-of-river power plants.

Table 3: run-of-river power plant as of September 2005

Power plant name	Status
Esmeralda	Operating
Insula	Operating
San Francisco	Operating
Florida II	Operating
Río Mayo	Operating
Calderas	Out of order

Therefore, the proposed CDM activity is not a common practice in Colombia.

Step 5. Impact of CDM registration

As it is demonstrated through all the steps analyzed above, the only way to implement the proposed project activity was by overcoming all the stated barriers and by decreasing the associated risks to this kind of project.

La Vuelta and La Herradura subprojects were put on hold until conversations with relevant CDM actors influenced on the project sponsor's point of view —focusing again on run-of-river hydro plants in spite of barriers and political conditions and based on the incentive of getting a new source of income. Those facts contributed to renewing project development, in line with the environmental and social politics of EE.PP.M.

The CDM potential of the subprojects was a crucial incentive for EE.PP.M to consider the opportunity of developing the project activity for registration under the CDM based on the CER revenues and the **contribution to the sustainable development in Colombia**. Otherwise (without CER incentive), La Vuelta and La Herradura hydroelectric project would have never became a reality.

Another important aspect of the project registration as a CDM project is that the implementation of the project brings technology transfer to a developing country that otherwise would have continued generating electricity with non-renewable sources. The CDM registration may have a replication effect, attracting investors and, in consequence, bringing last generation technology to the country.

Moreover, the project implementation generates CO2 emission reductions, contributing to GHG atmospheric concentration stabilization.

For all the arguments exposed above, it is clear that the CDM registration was a critical, if not the most important, fact that was taken into account when deciding to implement the proposed project activity.

All the steps of the "*Tool for the demonstration and assessment of additionality*" were strictly followed, resulting in the demonstration that the proposed CDM project activity is additional.

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

Estimate of GHG emissions by sources:

There are no project emissions.

Estimated leakage

Project participants do not need to consider leakage in applying this methodology.

Estimated anthropogenic emissions by sources of greenhouse gases of the baseline

The baseline emissions corresponding to the year *y* will be calculated applying the combined margin concept, expressed as follows:

$$BE_{sp,y}(tonCO2 / yr) = EF\ (tonCO_2 / MWh) \cdot EG_{spy}\ (MWh / yr) \qquad (1)$$

Where EG_y is the project generation (comprising "La Vuelta" subproject and "La Herradura" subproject) and EF_y, is the grid emission factor calculated
as the weighted average of the Operating Margin emission factor (EF_{OMy}) and the Build Margin emission factor (EF_{BMy}), as follows:

$$EF_y\ (tonCO_2 / MWh) = w_{OM} \cdot EF_{OM},_y\ (tonCO_2 / MWh) + w_{BM} \cdot EF_{BM,y}\ (tonCO_2 / MWh) \qquad (2)$$

The relative weights, w_{OM} and w_{BM}, are assumed to be equal to 0.5, according to the default value provided by the methodology.

Operating Margin (OM)
According to the data available for the Colombian electricity sector, the methodological choice selected to calculate the OM is the Dispatch Data Analysis (DDA), Option C of the methodology. The DDA provides an accurate and real expression of the emission sources that would be displaced by the proposed CDM project activity.

The operating margin will be calculated in an hourly basis for each day of the year, for the set of power plants in the top 10% of grid system dispatch
order during the hour *h*.

$$EF_{OM\_DispathDaa,y}(tonCO_2/MWh) = \frac{E_{OM,y}(tonCO_2)}{EG_y(MWh)} \quad (3)$$

where EG_y is the generation of the project in year *y*, and $E_{OM,y}$ are the emissions associated with the operating margin calculated as,

$$E_{OM\_DispathDaa,y}(tonCO_2) = \sum_h EG_h(MWh) \bullet EF_{DD,h}(tonCO_2/MWh) \quad (4)$$

where EGh is the generation of the project in each hour *h* and $EFDD,h$ is the hourly generation-weighted average emissions per unit of energy of the set of power plants (*n*) in the top 10% of grid system dispatch order during hour *h*.

$EFDD,h$ is calculated on an hourly basis as the fuel consumed by the generation power plant in the hour *h* (informed by the dispatch data center, CND), times the emission factor of the fuel, divided by the electricity generation of the corresponding generation device in the hour *h*. The CND will provide the hourly generation of every power plant, including La Vuelta and La Herradura. The fuel consumed may be calculated as the product between the electricity generation of the plant and its associated specific consumption. Thus, the hourly generation-weighted average emissions per unit of energy are calculated as follows

$$EF_{DDh}(tonCO_2/MWh) = \frac{\sum_{i,n}\left[F_{i,n,h}(kton)\cdot COEF_{i,n}(tonCO_2/kton)\right]}{\sum_n GEN_{n,h}(MWh)} \quad (5)$$

where Fi,n,h is the quantity of fuel *i* consumed by plant *n* in the hour *h*, $COEFi,n$ is the CO2 emission coefficient of fuel *i*, and $GEN\ n,h$ is the electricity generation of plant *n* in the hour *h*.

The quantity of fuel consumed by each plant is calculated as follows:

$$F_{i,n,h}(kton) = GEN_{i,n,h}(MWh)\cdot SC_{i,n}(kton/MWh) \quad (6)$$

where $GEN\ i\ n,h$ is the electricity generation of plant *n* consuming fuel *i* in the hour *h* and SCi,n is the specific consumption of power plant *n* consuming fuel *i* (mass or volume converted to kton). This

approach is used since no official data are available for hourly fuel consumption of thermal power plants serving the system.

Additionally, the emission coefficient of each fuel is calculated as follows:

$$COEF_{i,n}(tCO_2 / kton) = NCV_i(TJ / Kton) \cdot EF_{CO_2}(tonCO_2 / TJ) \cdot OXID_i \tag{7}$$

where *NCVi* is the net calorific value of the fuel *i*, *OXIDi* is the oxidation factor of the fuel *i*, and *EFCO2,i* is the CO2 emission factor per unit of energy of the fuel *i*.

As the CND provides the specific consumption (*SC*) or the heat rate (*HR*) for each power plant, equations 5, 6, and 7, are simplified to:

$$EF_{DD,h}(tCO_2 / MWh) = \frac{\sum_{n,i} SC_{i,n}(kton / MWh) \cdot COEF_{i,n}(tonCO_2 / kton) \cdot GEN_{i,n,h}(MWh)}{\sum_{n} GEN_{n,h}(MWh)} \tag{8}$$

if specific consumptions are provided, or

$$EF_{DDh}(tCO_2 / MWh) = \frac{\sum_{n,i} HR_{i,n}(TJ / MWh) \cdot COEF_{i,n}(tonCO_2 / TJ) \cdot GEN_{i,n,h}(MWh)}{\sum_{n} GEN_{n,h}(MWh)} \tag{9}$$

if heat rates are provided.

In the case of Equation 9, *COEFi,n* is determined by the following equation:

$$COEF_{i,n}(tCO_2 / TJ) = EF_{CO_2}(tonCO_2 / TJ) \cdot OXID_i \tag{10}$$

Build Margin (BM)

Option 2 of the methodology ACM0002/version 06 is selected for the BM calculation.

For the first crediting period, the BM emission factor will be updated annually *ex-post* for the year in which actual project generation and associated emissions reductions occur. For subsequent crediting periods, it will be calculated *ex-ante*, based on the most recent information available on plants already built for sample group *m*. The sample group *m* consists of either:

- The five power plants that have been built most recently, or
- The power plants capacity additions in the electricity system that comprise 20% of the system generation (in MWh) and that have been built most recently.

From these two options, the sample group that comprises the larger annual generation will be used.

Power plant capacity additions registered as CDM project activities will be excluded from the sample group *m*.

Taking into account the considerations mentioned above, the BM will be calculated as a generation-weighted average emission factor of a sample of power plants *m*, as follows:

$$EF_{BM,y}(tonCO_2 / MWh) = \frac{\sum_{i,m}\left[F_{i,m,y}(kton) \cdot COEF_{i,m}(tonCO_2 / kton)\right]}{\sum_{m} GEN_{m,y}(MWh)} \quad (11)$$

where $F_{i,m,y}$, $COEF_{i,m}$, and $GEN_{m,y}$ are analogous to the variables described above for OM calculation for plants *m*.

B.6.2. Data and parameters fixed ex ante

(Copy this table for each piece of data and parameter.)

Data / Parameter	EF_y
Unit	$tonCO_2 / MWh$
Description	Colombian grid emission factor
Source of data	Combined margin emission factor in accordance to the methodology ACM0002/version 06:
Value(s) applied	0.4128 tonCO2/MWh
Choice of data or Measurement methods and procedures	$EF_y\ (tonCO_2 / MWh) = w_{OM} \cdot EF_{OM,y}\ (tonCO_2 / MWh) + w_{BM} \cdot EF_{BM,y}\ (tonCO_2 / MWh)$ where *EFOMy* is the operating margin emission factor estimated from dispatch data corresponding to the first seven months of 2005, which also includes information on exports and imports to the national grid, and *EFBMy* is the build margin emission factor estimated from official data on power plant generation provided by UPME for the year 2004.
Purpose of data	Estimate baseline emissions
Additional comment	

B.6.3. Ex ante calculation of emission reductions

For each subproject, baseline emissions corresponding to the year *y* are obtained through the Equation 1, as follows:

$$BE_{sp,y}(tonCO2 / yr) = EF\ (tonCO_2 / MWh) \cdot EG_{spy}\ (MWh / yr) \quad (1)$$

where *BEspy* are the baseline emissions for the subproject, *EF* is the Colombian grid emission factor, and *EGspy* is the subproject electricity generation.

To estimate baseline emissions, the grid emission factor is determined as a combined margin emission factor, in accordance to the methodology ACM0002/version 06.

Thus, the grid emission factor is estimated as follows:

$$EF_y\ (tonCO_2 / MWh) = w_{OM} \cdot EF_{OM,y}\ (tonCO_2 / MWh) + w_{BM} \cdot EF_{BM,y}\ (tonCO_2 / MWh) \quad (2)$$

The relative weights, w_{OM} and w_{BM}, are assumed to be equal to 0.5, according to the default value provided by the methodology.

where *EFOMy* is the operating margin emission factor estimated from dispatch data corresponding to the first seven months of 2005 (see CM emission factor.xls, Spreadsheet OM), which also includes information on exports and imports to the national grid (see CM emission factor.xls, Spreadsheet Exp-Imp), and *EFBMy* is the build margin emission factor estimated from official data on power plant generation provided by UPME for the year 2004 (see CM emission factor.xls, Spreadsheet BM).

The emission factors considered are the following:

EFOMy = 0.5476 tonCO2/MWh

EFBMy = 0.2780 tonCO2/MWh

The relative weights, *wOM* and *wBM*, are assumed to be equal to 0.5, according to the default value provided by the methodology.

Thus, the grid emission factor results to be:

EFy = 0.4128 tonCO2/MWh[10]

This value is used in the *ex ante* estimation of baseline emissions for each year of the crediting period. However, it is important to note that the emission factor of the grid strongly depends on hydrological conditions and thus, it should be corrected in an accurate calculation following project implementation. Then, following ACM0002/version 06, option (c) *Dispatch Data Analysis OM* of Step 1 [Calculate the Operating Margin emission factor(s) (*EFOM,y*)] and Option 2 of Step 2 [Calculate the Build Margin emission factor (*EFBM,y*)], the grid emission factor will be calculated and updated annually *ex post* for the year in which actual project generation and associated emission reductions occur. For subsequent crediting periods, *EFBM,y* will be calculated ex ante, as described in Option 1 of Step 2, based on the most recent information available on plants already built for sample group *m* at the time of baseline revision.

Additionally, the subproject electricity generation is also estimated from actual data corresponding to the first seven months of 2005. The corresponding values were taken from CM emission factor.xls (Spreadsheet OM).

GENLV,y = 31,258 MWh (1 January to 31 July 2005)

GENLH,y = 65,539 MWh (1 January to 31 July 2005)

In order to estimate the annual generation, the 7-month values were extrapolated to the entire year (this is only an approximation).

GENLV,y = 31,258 MWh x 365/212 = 53,817 MWh/yr

GENLH,y = 65,539 MWh x 365/212 = 112,839 MWh/yr

[10] This value can be compared to the one established by the government of Colombia. According to Res. 18-1401 of the Colombian Ministry of Energy and Mines, the Colombian emission factor was set as 0.477 tonCO$_2$/MWh, according to the use of the combined margin approach proposed for small-scale project activities.

Finally, baseline emissions for La Vuelta and La Herradura subprojects are (see file CM emission factor.xls, Spreadsheet CM):

BELV,y = 22,215 tonCO2/yr

BELH,y = 46,580 tonCO2/yr

The total estimated baseline emissions are obtained as follows:

$$BE_y\ (tonCO_2\ /\ yr) = BE_{LV,y}\ (tonCO_2\ /\ yr) + BE_{LH,y}\ (tonCO_2\ /\ yr) \qquad (14)$$

Thus, total estimated baseline emissions corresponding to La Vuelta and La Herradura Hydroelectric

Project result to be:

BEy = **68,795 tonCO2/yr**

The estimated emission reductions are obtained through the Equation 12, as follows:

$$ER_y\ (tonCO_2\ /\ yr) = BE_y\ (tonCO_2\ /\ yr) - PE_y\ (tonCO_2\ /\ yr) - L_y\ (tonCO_2\ /\ yr) \qquad (12)$$

Where *ERy* are the emission reductions during the year *y*, *PE y* are the project emissions during the year *y*, and *L y* is the leakage during the year *y*.

Considering that there are neither project emissions nor leakage considered for the proposed project activity, the emission reductions are:

$$ER_y\ (tonCO_2\ /\ yr) = BE_y\ (tonCO_2\ /\ yr) \qquad (13)$$

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 ($t\ CO_2e$)
2005	68,795	0	0	68,795
2006	68,795	0	0	68,795
2007	68,795	0	0	68,795
2008	68,795	0	0	68,795
2009	68,795	0	0	68,795
2010	68,795	0	0	68,795
2011	68,795	0	0	68,795
Total	481,566	0	0	481,566
Total number of crediting years	7			
Annual average over the crediting period	68,795	0	0	68,795

B.7. Monitoring plan

B.7.1. Data and parameters to be monitored

(Copy this table for each piece of data and parameter.)

Data / Parameter	*EG*
Unit	*MWh*
Description	*Electricity generated by La Vuelta and La Herradura hydroelectric plants*
Source of data	*EE.PP.M*
Value(s) applied	$GEN_{LV,y}$ = 53,817 MWh/yr $GEN_{LH,y}$= 112,839 MWh/yr
Measurement methods and procedures	Measured
Monitoring frequency	*Hourly measurements and monthly recording*
QA/QC procedures	*QA/QC procedures are those requested by the electricity regulation entity.*
Purpose of data	*Calculation of baseline emissions*
Additional comment	*Hourly data will be monitored.*
Data / Parameter	*Plant dispatch order of the grid*
Unit	-
Description	-
Source of data	*CND*
Value(s) applied	
Measurement methods and procedures	Measured
Monitoring frequency	*yearly*
QA/QC procedures	
Purpose of data	*Calculation of baseline emissions*
Additional comment	*This data will be used to determine in an hourly basis, the 10% marginal plants to be considered in the OM emission factor calculation.*

Data / Parameter	*n*
Unit	-
Description	*Identification of the power plants for the OM*
Source of data	*EE.PP.M*
Value(s) applied	
Measurement methods and procedures	Estimated
Monitoring frequency	*yearly*
QA/QC procedures	
Purpose of data	*Calculation of baseline emissions*
Additional comment	*Identification of plants to calculate OM emission factor.*

Data / Parameter	*m*
Unit	-
Description	*Identification of the power plants for the BM*
Source of data	*EE.PP.M*
Value(s) applied	
Measurement methods and procedures	*Estimated*
Monitoring frequency	*yearly*
QA/QC procedures	
Purpose of data	*Calculation of baseline emissions*
Additional comment	*Identification of plants to calculate BM emission factor.*

Data / Parameter	*GEN*
Unit	*MWh*
Description	*Electricity generated by each power plant (n or m) of the Colombian SIN*
Source of data	*CND*
Value(s) applied	
Measurement methods and procedures	*Measured*
Monitoring frequency	*yearly*
QA/QC procedures	*These data will be directly used for calculation of emissions reductions. QA/QC procedures are those requested by the electricity regulation entity.*
Purpose of data	*Calculation of baseline emissions*
Additional comment	*Hourly data will be monitored.*

Data / Parameter	*SCi*
Unit	*tonne fuel/MWh*
Description	*Specific consumption of power plant for the fuel i*
Source of data	*CND*
Value(s) applied	
Measurement methods and procedures	*Measured*
Monitoring frequency	*yearly*
QA/QC procedures	*These data will be updated when it is necessary. Information cross-check shall be used to assure and control quality, taken into account, e.g., annual fuel consumption published by UPME.*
Purpose of data	*Calculation of baseline emissions*
Additional comment	*These data will be updated when it is necessary.*

Data / Parameter	*HRi*
Unit	*TJ/MWh*
Description	*Heat rate of power plant for the fuel i*
Source of data	*CND*
Value(s) applied	
Measurement methods and procedures	*Measured*
Monitoring frequency	*yearly*
QA/QC procedures	*These data will be updated when it is necessary. Information cross-check shall be used to assure and control quality, taken into account, e.g., annual fuel consumption published by UPME.*
Purpose of data	*Calculation of baseline emissions*
Additional comment	*These data will be updated when it is necessary.*

Data / Parameter	*NCVi*
Unit	*TJ/ ktonne fuel*
Description	*Net Calorific Value of fuel i consumed in each power plant*
Source of data	*Plant management or IPCC guidelines*
Value(s) applied	
Measurement methods and procedures	*Measured*
Monitoring frequency	*yearly*
QA/QC procedures	*These data will be updated when it is necessary. Information cross-check shall be used to assure and control quality.*
Purpose of data	
Additional comment	*These data will be updated when it is necessary*

Data / Parameter	*COEFi*
Unit	*tCO2 per kton or GJ*
Description	*Emission coefficient of each fuel i*
Source of data	*EE.PP.M*
Value(s) applied	
Measurement methods and procedures	*Calculated*
Monitoring frequency	*yearly*
QA/QC procedures	
Purpose of data	*Calculation of baseline emissions*
Additional comment	*It will be calculated as shown in Section B.6.1*

Data / Parameter	*Fi*
Unit	*tonne*
Description	*Quantity of fuel i consumed by each power plant*
Source of data	*EE.PP.M*
Value(s) applied	
Measurement methods and procedures	*Calculated*
Monitoring frequency	*yearly*
QA/QC procedures	
Purpose of data	*Calculation of baseline emissions*
Additional comment	*It will be calculated from official heat rates as shown in Section B.6.1*

Data / Parameter	*EFOM*
Unit	*tCO2/MWh*
Description	*Operating Margin emission factor of the grid*
Source of data	*EE.PP.M*
Value(s) applied	
Measurement methods and procedures	*Calculated*
Monitoring frequency	*yearly*
QA/QC procedures	
Purpose of data	*Calculation of baseline emissions*
Additional comment	*It will be calculated as shown in Section B.6.1*

Data / Parameter	*Build Margin emission factor of the grid (EFBM)*
Unit	*tCO2/MWh*
Description	
Source of data	*EE.PP.M*
Value(s) applied	
Measurement methods and procedures	*Calculated*
Monitoring frequency	*yearly*
QA/QC procedures	
Purpose of data	*Calculation of baseline emissions*
Additional comment	*It will be calculated as shown in Section B.6.1*

Data / Parameter	*EF*
Unit	*tCO2/MWh*
Description	*Emission factor of the grid*
Source of data	*EE.PP.M*
Value(s) applied	
Measurement methods and procedures	*Calculated*
Monitoring frequency	*yearly*
QA/QC procedures	
Purpose of data	*Calculation of baseline emissions*
Additional comment	*It will be calculated as shown in Section B.6.1*

Data / Parameter	*Electricity imports to the electricity system*
Unit	*MWh*
Description	
Source of data	*CND*
Value(s) applied	
Measurement methods and procedures	*Calculated*
Monitoring frequency	*yearly*
QA/QC procedures	
Purpose of data	*Calculation of baseline emissions*
Additional comment	*The corresponding emission factor will be considered 0.*

B.7.2. Sampling plan

There is no sampling involved in the monitoring of the proposed project activity.

B.7.3. Other elements of monitoring plan

>>**Description of the operational and management structure that the project operator will implement in order to monitor emission reductions and any leakage effects, generated by the project activity.**

EE.PP.M has many years with proven experience in the electricity market and carries out conventional procedures to give continuity to control and auditing tasks in order to guarantee verifiable output information and to supply high quality data that can be straightforwardly replicated by a third party. The procedures are externally audited by auditing firms and validated by the Colombian regulation entity.

Calibration of energy equipments follows national standards, according to the calibration instructive specified in Colombian norm NTC 4,856 for electricity metering devices, designed to establish the routine essays to be performed on energy meters in order to do initial and periodic verification of meters operation. The methodology and procedures are applied to alternating current active energy meters manufactured according to NTC 2,288, 2,147, and 4,052 standards, and to reactive energy meters manufactured according to NTC 2,148 and 4,569 standards. EE.PP.M has adopted its own procedure based on the Colombian technical norm NTC-ISO-IEC 17,025 and NTC 4,856, under the so-called “Instructive to perform on-site electricity meter proofs with a pattern metering device” (DIS-EM-LE-IN-009-01). Similar procedures apply to all thermal plants in Colombia.

The power plants La Vuelta and La Herradura are located in the Metropolitan Area under the "Subgerencia Operación" of the "Gerencia Generación Energía," in charge of the operation and maintenance of the power plants. Operation procedures are ruled by the same norms used by EE.PP.M for their power plants, including several department of the company involved in the different tasks (Planning, Environment, Transactions, Operation, etc.).

Monitoring procedures can be implemented on site or remote, using tele-measurement technology. The "Equipo de Medida" (Measurement Team) is in charge of measurements. This team sends the information on daily generation to the "Centro de Control Tasajera," (Tasajera Control Centre) which receives all the information of the power plants ascribed to the Metropolitan Area. From this centre the power plants dispatch is executed. It informs to the "Centro de Control Generación," (Generation Control Centre) also called "Subestación Colombia," (Colombia Substation) located in Medellín. This centre elaborates a Monthly Operation Report with the data collected from the whole set of power plants operated by EE.PP.M in the Metropolitan Area. The centre is connected to the "Centro de Control de Generación Nacional," (National Generation Control Centre) which is charge of power plants operation.

SECTION C. Duration and crediting period

C.1. Duration of project activity

C.1.1. Start date of project activity

>> The starting date is defined in this project as the date in which construction began:

01/02/2002

After estimating potential carbon offsets the project developer has decided to acquire the land and construct and improve roads in February 2002 and November 2002 for La Vuelta, respectively, and April 2002 and March 2003 for La Herradura, respectively.

Before the onset of project construction phase, it was necessary to carry out pre-construction activities, as an essential requirement for the fulfillment of the scheme, such as:

- Technical improvement and revision of projects.
- Creation of specifications for the leasing of homologation designs, execution of missing designs and work supervision.
- Additional financial and economic evaluations.
- Revision of current environmental licenses.
- Negotiations for the financing of projects.
- Preliminary negotiations with municipality authorities and local communities.

Tables 7 and 8 show the construction schedule for each plant

Table 7: La Vuelta project scheme

Tasks	Start	End
premises acquisition	01-Oct-01	27-Feb-02
road construction and fitting	15-Apr-02	02-Nov-02
derivation works	09-Jun-02	30-Jun-03
power house	01-Sep-02	31-Oct-03
conduction: civil works, tunnel	08-Aug-02	31-Oct-03
electromechanical equipments supply	15-Jun-03	31-Oct-03
electromechanical equipments assembly	15-Jun-03	14-Jun-04

pipelines supply	15-Jan-03	10-Aug-03
pipelines assembly	01-Jun-03	30-Sep-03

Table 8: La Herradura project scheme

Tasks	Start	End
premises acquisition	01-Nov-01	04-Apr-02
roads construction and fitting	22-Apr-02	14-Mar-03
derivation works	01-Mar-03	27-Dec-03
power house	01-May-03	14-Sep-03
conduction: civil works, tunnel	21-Aug-02	04-Dec-03
electromechanical equipments supply	15-Jun-03	31-Oct-03
transportation and assembly of electromechanical equipments	15-Jun-03	30-Aug-04
pipelines supply	27-Feb-03	24-Oct-03
pipelines assembly	15-Jun-03	31-Oct-03

C.1.2. Expected operational lifetime of project activity

>> 50 years

C.2. Crediting period of project activity

C.2.1. Type of crediting period

>> Renewable crediting period

C.2.2. Start date of crediting period

>> Start of operation of La Vuelta: 18 December 2004

Start of operation of La Herradura: 8 October 2004

Emission reductions will be accounted since: 01/01/2005

C.2.3. Length of crediting period

7 years

SECTION D. Environmental impacts

D.1. Analysis of environmental impacts

>> EE.PP.M has commissioned “Integral Ingenieros Consultores” to perform the environmental impact studies for La Vuelta and La Herradura project, complying with a requirement settled by the Colombian government for hydroelectric works. The specific documentation can be found mainly in two reports:

- “Desarrollo Hidroeléctrico del Río Herradura: Proyecto La Herradura, Estudio de Impacto Ambiental, Informe Final” (December 1996, Medellín) by Integral Ingenieros Consultores for Empresa Antioqueña de Energía (EADE).

- “Desarrollo Hidroeléctrico del Río Herradura: Proyecto La Vuelta, Estudio de Impacto Ambiental, Informe Final” (August 1996, Medellín) by Integral Ingenieros Consultores for Empresa Antioqueña de Energía (EADE).

Information regarding the Environmental Management Plan Follow-up is included in Annex 5.

D.2. Environmental impact assessment

>> Considering its historical commitment to environment care recently ratified with the approval of the environmental policy of Empresas Públicas de Medellín E.S.P., in order to incorporate the environmental variable to the development of all its project works or activities, during 1996, environmental impact studies for each one of the projects[11] were carried out, taking into account the following general criteria:

- Maximum security, as much for the stability of the works as for the area in which they are located.
- Rational use of the hydraulic resource from the environmental, technical and economic point of view.
- Best use of available fall, causing the smallest possible impact on the landscape.
- Minimum environmental impact due to construction and operation of the project.

These studies determined that the areas where the projects are located are highly mountainous, with steep slopes, formed mostly by sedimentary and igneous rocks in active process of erosion. These are highly exploited areas, where the natural terrestrial ecosystems were turned into farming activities for subsistence and paddocks for extensive cattle raising. This has drastically changed the diversity and abundance of the wild and native flora and fauna, although some species in danger of extinction that have survived will not be in danger because of the projects. Such modifications could be made due to the absence of naturally protected ecosystems, although in the upper part of the basin, the National natural Park "Las Orquídeas", which will not be affected by the project, can be found.

As regards water quality, it has been determined that even when most streams are polluted especially due to coliforms, the macro-invertebrates in streams are clean-water indicators, with low occurrence and diversity. The areas of the projects do not have wetlands ecosystems that can be affected.

The use of natural resources between local communities and projects did cause neither conflicts nor relevant displacement of anthropogenic activities. On the contrary, there have been benefits or positive impacts such as generation of local employment during construction stage, generation of economic resources for the three municipalities of the area of influence on law transfers for energy sales (3% of gross sales), the payment of industry and trade taxes and property tax. Likewise, energy efficiency due to the optimization of the regional electric system will be improved, and the generation supplied by the localization of small generation centrals near consumption centers such as Urabá region will be favored. Additionally, the project will provide works of infrastructure to the region, mainly roads, favoring local development and access to basic health and education services, and trading of agricultural products.

In the project area, there are no native or black communities, but only rural communities. Since there are no regulation reservoirs associated to the projects, massive population moving will not take place. Only three dwellings will be moved, mainly for security reasons, since they are located on the edge of the new roads slopes. These families will be relocated within the same lands, keeping their own place, therefore minimizing completely the uprooting effect.

In the archaeology studies a few remains were mentioned (depressions and hillocks, dwelling sites and interments) and it was necessary to perform more detailed archaeology surveying studies to define the importance and the type of intervention to be implemented during the construction phase.

[11] Empresa Antioqueña de Energía, Integral Ingenieros Consultores, La Vuelta Hydroelectric Project Environmental Iimpact Study, August 1996. Empresa Antioqueña de Energía, Integral Ingenieros Consultores, La Herradura Hydroelectric Project Environmental Impact Study, December 1996.

In agreement with this highly exploited environment and the projects' characteristics (small centrals, no reservoirs, etc.), it was concluded that no significant environmental impacts that are unacceptable or that would make the project unfeasible will be generated. The following are the most relevant impacts:

- Reduction of water flows in two sections of La Herradura River due to diversion of flows to power house penstock; affecting the water ecosystem and the quality of the landscape (these two natural elements do not hold relevant connotations).
- Increase of water flows in a sector of Cañasgordas River (approx. 8.5 km) due to La Herradura plant discharge, generating graduation and bed undercut processes.
- Air contamination through noise and dust for the grinding plant operation, the mixing of concrete and the increase in the transportation of machinery, materials and equipment.

Environmental management plans comprising procedures for the management of impacts, monitoring and follow-up programs and contingency plans were proposed in order to guarantee the implementation of the project in the framework of sustainable development and according to evaluation results. The costs of these plans have been duly included in the costs of the project.

According to the information obtained from Environmental Impact Studies, the Compañía Antioqueña de Energía (EADE), initial owner of the project, arranged the environmental licenses with Urabá Environmental Corporation for Sustainable Development (Corpourabá), environmental authority in the region, granting them through Resolutions Nº 194197, October 27, 1997 and 159397, August 21, 1997, which were given, later on, to Empresas Públicas de Medellín E.S.P., through Resolutions 702 and 402 of January 8, 2002. The environmental requirements demanded by Colombian legislation for this type of project are, therefore, being fulfilled.

Finally, the characteristics and dimensions of the project, together with the environmental characteristics of the region where it is being developed, generate low scale impacts successfully managed or compensated. This can be demonstrated since the environmental authority has granted them the environmental license for its development. Positive impacts for the region are generated with the construction and functioning of the project, as previously mentioned, especially from the social point of view, emphasizing the transfers payment to the municipalities and Corpourabá, estimated in US$ 200,000/year during the project lifetime.

The environmental and social performance of the project is controlled by the Follow-up of the Environmental Management Plan. The main parameters under periodic monitoring are:

Environmental parameters:

- Water quality: using the Languelier index, considering pH, alkalinity, hardness and dissolved solids as the main parameters. The analysis follows standard international procedures (AWWA, APHA and WPSF).
- Superficial water quality during the construction phase. The quality of superficial water of La Herradura River is monitored according to international NFS quality river index, considering pH, turbidity NTU, temperature, solids, dissolved oxygen, biochemical oxygen demand, nitrates, phosphates, and coliforms as main parameters. The analysis follows standard international procedures (AWWA, APHA and WPSF). Nine measuring stations were placed on La Herradura and Cañasgordas rivers.
- Air quality: the main air pollutant considered is particulate matter (PM), monitored through 24 hours sampling during 8 days every six months in two sites located close to the triturating plant and concrete blending. The output is going to be expressed in daily averages, in order to ensure the compliment of Decree 02/1982 of the Ministry of Health (PM levels must be lower than 400 $\mu g/m^3$ at 25ºC and 760 mmHg). The equipment to be used for suspended PM sampling is HIVOL, standardized by the US Environmental Protection Agency.

Regarding social issues these topics are under control:

- Protection of the archeological heritage: devoted to recover pre-Hispanic cultural material that can be affected by removal works and excavations. An archeologist is controlling the procedures.
- Contingency plan: based on a contingency prevention program to give assistance in emergencies and take corrective actions under unforeseeable facts. An emergency brigade is destined to provide attention with the participation of the trained local community. The team is trained to be ready to activate a series of preventing measures and controlling procedures to mitigate unforeseeable events derived from the construction, anthropogenic actions, and external agents.
- In order to be able to give an immediate response, the team must be prepared to predict dangerous situations, perform risk analysis, recommend preventing norms, design alarming system to detect the beginning and follow the evolution of an emergency, prepare corrective action procedures, and coordinate infrastructure and human resources to attend the emergency. Three groups were created each one attending a previously identified set of potential contingencies of each construction phase. Social contingencies, associated to labor situations, are also included in the plan in order to quickly inform to the corresponding authorities.
- Training, education and outreach programs: a social management plan is implemented in order to provide capacity building to the local community and follow its grade of involvement in the project activity. A set of surveys is developed each three months.
- Social indicators (employment generation, satisfaction level, economic growth of the regional economy) are also periodically registered.

A detailed description of these issues is beyond the scope of the current PDD and it is left to be inspected by the operational entity in charge of the project verification. The complete information can be found in "Desarrollo Hidroeléctrico del Río Herradura: Proyecto La Herradura, Estudio de Impacto Ambiental, Informe Final" (December 1996, Medellín) by Integral Ingenieros Consultores for Empresa Antioqueña de Energía (EADE) and "Desarrollo Hidroeléctrico del Río Herradura: Proyecto La Vuelta, Estudio de Impacto Ambiental, Informe Final" (August 1996, Medellín) by Integral Ingenieros Consultores for Empresa Antioqueña de Energía (EADE).

SECTION E. Local stakeholder consultation

E.1. Solicitation of comments from local stakeholders

>> The process followed to collect stakeholders' comments was a consultation through a survey for the evaluation of the environmental performance of La Vuelta and La Herradura Hydroelectric Project.

The following set of questions was sent to local stakeholders, during May and June, 2003:

1. Do you believe that the socio-economic situation of the region will improve due to the implementation of "La Vuelta and La Herradura" hydro project?
2. Is the implementation of the project able to improve the environmental situation in the region?
3. How does the development of the project affect you (positively or negatively) or on your environment?
4. Would you recommend private companies or authorities to develop projects of this nature?
5. Do you think "La Vuelta and La Herradura" will contribute to the Sustainable Development of Colombia?
6. Any additional comments you would like to make.

The surveys addressees were:

1. **Dr. Adiela Reyes Collazos**. Head of Planning at Frontino Municipality and Member of the Supervising Committee for the Hiring of the Project Staff.
2. **Dr. Diana Jannet Zapata**. Frontino Municipality Representative and Member of the Supervising Committee for the Hiring of the Project Staff.
3. **Tech. Elkin Jaramillo Vergara**. Director of the Farming and Environment Technical Assistance Unit of Frontino Municipality.
4. **Eng. John Fredy Cardona**. Manager of the Far East Public Administration Company – Empucol Ltd. (a company belonging to the municipalities of the region).
5. **Dr. Rubén Rojo Moreno**. Mayor of Abriaquí Municipality.
6. **Soc. Doris Eugenia Montoya Álvarez**. Community Development of the Abriaquí Municipality.
7. **Eng. Jairo de Jesús Ortiz Rojas**. Head of Planning of Cañasgordas Municipality and Member of the Supervising Committee for the Hiring of the Project Staff.
8. **Tech. Humberto Quintero Manco**. Head of Public Works at Cañasgordas Municipality and Member of the Supervising Committee for the Hiring of the Project Staff.
9. **Ms. Elvia Rosa Ramos Henao**. Corregidor at Abriaquí Municipality and Member of the Supervising Committee for the Hiring of the Project Staff.
10. **Mr. Luis Fernando Zapata**. Mayor of Cañasgordas Municipality.
11. **Eng. Edison Isaza Ceballos**. Manager of Corpourabá at Urabá region.

E.2. Summary of comments received

>> A synthesis of the comments received is summarized in Table 10. The most important point highlighted by local stakeholders is added to the answers.

Table 10: Stakeholder comments.

Persons / Questions	Manager Empucol Ltd.	Head of Planning Frontino	Representative Frontino	Director of Farming and Environment	Manager Corpourabá
Do you believe that the socio-economic situation of the region will improve due to the implementation of “La Vuelta” and “La Herradura” hydro projects?	yes, employment generation and improvement of regional economics	yes, social and economics improvements	yes, under correct funds destination	yes, employment generation	yes, employment generation
Is the implementation of projects able to improve the environmental situation in the region?	indifferent	yes, reforestation	yes	yes	yes, under right use of electric sector transferences
How does the development of projects affect you (positively or negatively) or on your environment?	positively	positively		positively, under correct use of royalties	positively, strengthening of the region
Would you recommend private companies or	yes	Yes	yes, improvement	yes	yes, contribution to

authorities to develop projects of this nature?			of life quality		the electricity system
Do you think “La Vuelta” and “La Herradura” will contribute to the Sustainable Development of Colombia?	yes	yes	yes	yes	yes, depending on political decisions
Any additional comments you would like to make	needs for more investments	high employment rate		helping regional development	

E.3. Report on consideration of comments received

>> The comments received by local stakeholders were highly positive. They were in line with a previous survey performed for identifying the main social and environmental concerns of local community, as a part of the environmental impact study and following tasks. The main issues and needs for corrective actions were already taken into consideration by EE.PP.M in order to comply with the Environmental Management Plan Following recommendations.

SECTION F. Approval and authorization

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Appendix 1: Contact information of project participants

Organization name	EMPRESAS PÚBLICAS DE MEDELLÍN E.S.P.
Street/P.O. Box	Carrera 58 N° 42-125 / P.O. Box: 940
Building	
City	Medellín
State/Region	Antioquia
Postcode	Does not exist in Colombia
Country	Colombia
Telephone	011-57-54-3808080
Fax	
E-mail	
Website	
Contact person	
Title	Ingeniero
Salutation	
Last name	Rubiano
Middle name	Carlos
First name	Luis
Department	Subgerencia Planeación Generación Energía
Mobile	
Direct fax	011-57-54-3806795
Direct tel.	011-57-54-3804230
Personal e-mail	lrubiano@eeppm.com

Organization name	MGM Carbon Portfolio S.a.r.l
Street/P.O. Box	67 rue Ermesinde,
Building	
City	
State/Region	
Postcode	L-1469
Country	Luxembourg
Telephone	+1.786.425.9251
Fax	
E-mail	mgmcp@mgminter.com
Website	
Contact person	
Title	
Salutation	Mr
Last name	Fernandez de Mello e Souza
Middle name	
First name	Pablo
Department	
Mobile	
Direct fax	
Direct tel.	
Personal e-mail	

Organization name	Electric Power Development Co., Ltd.
Street/P.O. Box	15-1, Ginza 6-Chome
Building	
City	Tokyo
State/Region	Asia
Postcode	104-8165
Country	Japan
Telephone	(81.3) 3546-2211
Fax	
E-mail	webmaster@jpower.co.jp
Website	www.jpower.co.jp/english/
Contact person	
Title	Director, Climate Change
Salutation	
Last name	Nonaka
Middle name	
First name	Yuzuru
Department	Corporate Planning and Administration Dept.
Mobile	
Direct fax	(81.3) 3546-9531
Direct tel.	(81.3) 3546-9375
Personal e-mail	yuzuru_nonaka@jpower.co.jp

Appendix 2: Affirmation regarding public funding

No funds from public national or international sources are involved in any aspect of the proposed project.

Appendix 3: Applicability of selected methodology

All information on the validity of the selected methodology is provided in Section B.2.

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

The key data used to determine the baseline scenario, that is considered fixed along the crediting period, is given in the following tables.

1. Coal

Table 11: Coal data

	Item	Value	Units	Data sources
OXIDcoal	**Oxidation factor**	**0.98**		Ref.1, Table 1-6 page 1.29 Coal - Fraction of carbon oxidized.

EFCO2coal	CO2 emissions factor	**94.6**	**ton CO2/TJ**	Ref. 1, Table 1-1 page 1.13. Other Bit. Coal: 25,8 t C/TJ lower heating value basis. x 44/12 = 94,6 ton CO_2/TJ.

Table 12: Natural gas data

	Item	Value	Units	Data sources
OXIDNG	**Oxidation factor**	**0.995**		Ref.1, Table 1-6 page 1.29 Gas - Fraction of carbon oxidized.
EFCO2NG	CO2 emissions factor	**56.1**	**kg/GJ**	Ref. 1, Table 1-1 page 1.13. Natural gas (dry): 15.3 t C/TJ lower heating value basis. x 44/12 = 56.1 t CO2/TJ.

Reference 1: IPCC Guidelines for National Greenhouse Gas Inventories: Reference Manual Volume 3 (1996).

The fuel emission factors have been taken from IPCC values since country specific emission factors have not standard values because they depend on the fields where the fuels are taken, e.g. there is not a unique emission factor for natural gas since thermal plants are receiving this gas from different distribution companies that use a combination of sources (different gas wells with very different gas properties – specific gravity, heating value, molecular weight, composition) not allowing to have a fixed national or regional value. Thus it is considered that the most conservative approach is to use IPCC values.

Additionally, the CO2 emission factors of thermal power plants in the Colombian interconnected system are shown in the table below.

Table 13: CO2 emission factors of thermal power plants

Name	**Fuel**	**Capacity (MW)**	**Heat rate (GJ/MWh)**	**Emission Factor (t CO2/MWh)**
BARRANCA 1	nat gas	12	12.913	0.7208
BARRANCA 2	nat gas	12	12.871	0.7185
BARRANCA 3	nat gas	63	13.166	0.7349
BARRANCA 4	nat gas	30	12.238	0.6831
BARRANCA 5	nat gas	20	13.799	0.7703
BARRANQUILLA 3	nat gas	64	10.229	0.5710
BARRANQUILLA 4	nat gas	65	11.636	0.6496
CANDELARIA 1	nat gas	150	10.073	0.5623
CANDELARIA 2	nat gas	150	10.213	0.5701
CARTAGENA 1	nat gas	60	10.724	0.5986
CARTAGENA 2	nat gas	50	11.830	0.6603
CARTAGENA 3	nat gas	67	10.481	0.5851
EMCALI 1	nat gas	233	7.163	0.3993
FLORES 1	nat gas	150	7.621	0.4254
FLORES 2	nat gas	99	10.802	0.6030
FLORES 3	nat gas	550	10.110	0.5648
GUAJIRA 1	nat gas	151	10.343	0.5773
GUAJIRA 2	nat gas	151	10.238	0.5716
MERILECTRICA 1	nat gas	154	10.166	0.5676
PAIPA 1	coal	28	16.195	1.5010
PAIPA 2	coal	68	13.965	1.2950
PAIPA 3	coal	68	14.176	1.3140
PAIPA 4	coal	150	11.005	1.0200
PALENQUE 3	nat gas	14	16.096	0.8426
ROELECTRICA 1	nat gas	45	8.618	0.4810

PROELECTRICA 2	nat gas	45	8.618	0.4810
TASAJERO 1	coal	155	9.214	0.8540
TEBSAB	nat gas	750	7.739	0.4320
TERMOCENTRO 1	nat gas	285	7.410	0.4136
TERMODORADA 1	nat gas	51	9.619	0.5369
TERMOPIEDRAS	nat gas	3	9.885	0.5518
TERMOSIERRA	nat gas	470	6.683	0.3731
TERMOVALLE 1	nat gas	210	7.136	0.3983
TERMOYOPAL 2	nat gas	50	13.404	0.7482
ZIPAEMG 2	coal	35	11.377	1.0550
ZIPAEMG 3	coal	62	10.401	0.9640
ZIPAEMG 4	coal	62	11.032	1.0230
ZIPAEMG 5	coal	63	9.602	0.8900

Appendix 5: Further background information on monitoring plan

The monitoring plan allows the determination of anthropogenic GHG emission reductions generated by the project activity, in a straightforward manner.

The Monitoring Plan is based on recording mainly electricity generation of the proposed power plant and the electricity generation of all power plants serving the interconnected national system. Data should be collected on an hourly basis during the project lifetime and the crediting period. Since most generation projects last longer than the maximum crediting period permitted under CDM, the later value of 21 years will also determine the monitoring period.

GHG emissions following project implementation are determined from the above data. The baseline emissions basically comprise CO2 emissions from natural gas and coal combustion in the thermal plants.

This type of project will require only straightforward collection of data, as described below.

Considering the project boundary, the following data need to be monitored in order to estimate baseline emissions and emission reductions are:

GHG related data:

- Hourly electricity generation of the hydroelectric plants of the project. EE.PP.M is likely to be taking measurements every hour.
- Hourly electricity generation of all power plants serving the interconnected national system.
- Plant dispatch order of the grid.
- Changes of power plant specific consumptions (e.g. due to efficiency improvements, retrofits, inclusion of new plants, plant shutdown, fuel substitution, power capacity redefinitions, etc.) for each fuel and its corresponding lower heating value.

Non-GHG related data:

- EE.PP.M should execute an Environmental Management Plan in order to deal with environmental, social, and economic aspects of the region and their inhabitants.

In order to register monitoring data a spreadsheet model is proposed. This spreadsheet takes monitored data as input, and automatically calculates baseline emissions, for each year following project implementation, in a dynamic manner.

The spreadsheet proposed model is an electronic GHG monitoring and calculation workbook for electricity generation projects to be connected to the national interconnected grid. The electronic workbook serves as the data management and analysis system for the project managers and operators, and can be used throughout the lifetime of the project.

EE.PP.M. management will use data collected as inputs to fill out the spreadsheet. The data monitored in an hourly basis will be processed in the workbook. Once established the 10% marginal plants, the spreadsheet will calculate the associated emissions and the corresponding emission factor. Finally, considering the yearly emission factor and the CDM project generation, the spreadsheet will calculate the emission reductions in a yearly basis. The calculations will be done with the equations provided in section D of this PDD.

The staff of EE.PP.M responsible for Project monitoring should complete the electronic worksheets on anmhourly basis. The spreadsheet will automatically provide annual totals in terms of GHG reductions achieved through the implementation of the project.

Appendix 6: Summary of post registration changes

1. Changes to the project design of a registered project activity

Project capacity

Explanation and justification of the difference of the capacities included in the PDD registered for the first crediting period (Version 6 – 06 September 2006) and this revised version:

The registered PDD of the first crediting period (Version 6 – 06 September 2006) includes three different capacities for each of the two power plants – i.e., La Vuelta and La Herradura – included in the CDM project:

1) **Installed capacity** (effective net output capacity): This is the "net effective output capacity" of each power plant at the interconnection point with the electricity grid, i.e. it represents the capacity of the power plant to deliver and sell electricity to the grid. This capacity depends on the characteristics and configuration of the total plant as a system. Basically, the turbine capacity is limited by the generator, which acts as a bottleneck. The equipment and transformer, as well as the transmission line to the substation, also have power losses that affect the net effective output of the plant. Moreover, the plant has an auxiliary consumption, which also needs to be subtracted, resulting in the effective net output capacity.

   This effective output capacity is the official capacity used by the CREG (*Regulatory Commission* for *Gas* and *Energy)* as per the definition in the Annex 4 of Resolution No. 059 of November 6th, 1999[12]. Most importantly, this capacity defines and limits the power delivered to the grid (maximum capacity) as per the Colombian regulation and therefore is the key parameter for the electricity that can be delivered to the grid and corresponding income (independent from specific

[12] **Definition**: The Net Effective Capacity is the maximum capacity (expressed in MW) that can be delivered by a plant and/or generation unit in normal operational conditions, measured at the interconnection point (note: this point is called "commercial front" in Colombia).

turbine and generator capacities).

2) **Turbine capacity** (nominal power output): This is the nominal capacity of the turbine(s), determined by the equipment provider at laboratory conditions, and as such included in the first PDD (version 06).

3) **Generator capacity** (nominal power output): This is the nominal capacity of the generator(s), determined by the equipment provider at laboratory conditions, and as such included in the first PDD (version 06).

The following table summarizes the values for the different capacities included **in the original PDD**:

Parameter	La Vuelta Sub-Project	La Herradura Sub-Project
Effective net output capacity (MW). This is used as the "**installed capacity" in the original PDD.**	11.7 MW	19.8 MW
Turbine capacity (MW)	12.25 MW	20.8 MW (2 x 10.4 MW)
Generator capacity (MW)	14.0 MVA; or 11.9 MW [(1)]	24.0 MVA (2 x 12.0 MVA); or 20.4 MW (2 x 10.2 MW) [(1)]

(1) Power output in MVA multiplied with the power factor (cosine φ) = 0.85

Since the "effective net output capacity" determines the capacity of energy generation at the interconnection point with the grid, the corresponding value of 31.5 MW[13] (11.7 MW La Vuelta and 19.8 MW La Herradura), was included in the PDD registered for the first crediting period (version 6) as the "installed capacity".

For the renewal of the crediting period, the validating DOE has requested to include the nameplate capacities of the turbines and generators observed onsite. These capacities may differ from the original PDD, since previously the capacities under laboratory conditions were included, as explained above. Moreover - as also explained above - the turbine capacities are not equal to the "effective net output capacity" as defined by the CREG due to the definitions and technical reasons.

The onsite nameplate capacities of the turbine capacities and the generator as included **in this new PDD** are given in the following table (also including the effective output capacity of the plant for comparison):

Parameter	La Vuelta Sub-Project	La Herradura Sub-Project
Effective net output capacity (MW)	11.7 MW	19.8 MW
Turbine capacity (MW) This is used as the "**installed capacity" in the new PDD**.	12.4 MW	21.08 MW (2 x 10.54 MW)
Generator capacity (MW)	14.0 MVA; or 11.9 MW [(1)]	24.0 MVA (2 x 12.0 MVA); or 20.4 MW (2 x 10.2 MW) [(1)]

(1) Power Output in MVA multiplied with the power factor (cosine φ) = 0.85

[13] see published official data of the bidding process provided in "Diario Oficial 05-06-2002 (see page 7).pdf"

It can be observed that the **generator capacities are identical** to those in the first PDD and only the turbine capacities differ slightly, due to the differences that occur between laboratory and onsite conditions. **Since the generators act as a bottleneck in the power plant by limiting the power generation from the turbines, any increase in the turbine capacity would not affect the real power output capacity. This is also confirmed through the information available from the regulatory entity CREG, where it can be observed that the effective net output capacity is still the same (i.e. 11.7 MW + 19.8 MW = 31.5 MW total); thus no additional energy and income are generated!**

Besides, the changes of the turbine capacities observed are actually of formal nature, i.e. they result from comparing different references for the **same** equipment (onsite vs. laboratory).

Based on the above analysis, in the following section each point of CDM Project Standard (version 05.0) paragraph 225 is briefly described and it is explained why none of them is affected by this **formal change of the reference data of the capacity**.

(a) The applicability and application of the applied methodology under which the project activity has been registered;

Please refer to section B.2., where it is demonstrated the applicability and application of methodology ACM0002 is fulfilled. The applicability is not affected since the power plant design remains the same and the applicability of large scale methodologies does not depend on the capacity installed.

(b) Compliance of the monitoring plan with the applied methodology;

No change that would affect the monitoring plan of the power plant has occurred. All procedures regarding energy generation measurement and reporting to the grid operator (XM), as well as QA/QC and calibration procedures are not affected in any way. For details, please refer to the monitoring section of this PDD.

(c) The level of accuracy and completeness in the monitoring of the project activity;

As in (b), the monitoring is not affected, i.e. the level of accuracy and completeness in the monitoring of the project activity are also guaranteed. For details, please also refer to the monitoring section of this PDD.

(d) The additionality of the project activity;

The additionality is not affected, mainly because the power plant still uses the same equipment and no real increase in power generation capacity has occurred as explained above. The output capacities of the plants that determine project generation (and therefore revenues) are still 11.7 MW (La Vuelta) and 19.8 MW (La Herradura), with a total capacity of 31.5 MW for the project.

The change of the turbine capacities in the PDD does not result in any higher potential generation or income, since it is limited by the generator capacities that act as a bottleneck and that have not been change; and the effective net output capacity remains the same as confirmed by the CREG's (regulatory entity) public information. Besides, the change is of formal nature, but does not consist in a real change that would increase power generation or affect any other relevant variable for additionality. Since the generators capacities (bottleneck) and the effective net output capacities are identical, the generation and income are the same and the expected cash flows presented in the financial analysis of the registered

PDD are not altered. Thus, no changes in the financial spreadsheet have to be done and the NPV remains the same, as well as the conclusion that the project is additional.

Even if we assumed that the difference between the turbine capacities in original PDD (laboratory conditions) and the new PDD (real conditions) would result in a proportional increase of generation and income, it is very clear that the alteration of the NPV is minimal and does not affect additionality (see modified financial analysis "NPV-LV&LH (10Mar14)":

- Turbine capacity in original PDD (laboratory conditions): 31.5MW
- Turbine capacity in new PDD (conditions onsite): 33.48 MW
- "Turbine capacity increase" 5.91%

For a simplified analysis, it is assumed that the final cash flow would increase proportionally to the generation which on the other side would increase proportionally to the turbine capacity. The NPV in the original PDD was -9.084 million USD. An increase of 5.91% of final cash flow would lead to an NVP of -7,342.39 million USD. **In order to reach the breakeven for the NPV, the cash flows and (as a simplification) the generation would have to increase by about 30.82%!** Thus it is very clear that this is very unlikely and additionality is not affected under any circumstances.

Please also take into account that the additionality analysis in the first PDD also includes four barriers that were accepted and approved (for details see additionality section):

- Barrier due to prevailing practice
- Sectoral barrier
- Social and institutional barrier
- Political and investment barrier

Since those are still valid and additionality in any case is guaranteed (independent from the financial analysis).

(e) The scale of the project activity.

The project activity has applied a large-scale methodology (ACM0002 Version 6) since its registration for the first crediting period. For the renewal of the crediting period, the project applies the most recent version of the same methodology (ACM0002 Version 13.0.0) and fully complies as shown in section B.2. Therefore the scale is not affected by the capacity issue.

2. Corrections

MGM Carbon Portfolio was included as project participant in section A4 since this project participant was approved after project registration.

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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.
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