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Annexes

SECTION A. General description of project activity

A.1. Title of the project activity:

La Vuelta and La Herradura Hidroelectric Project

Version 4 – 30 May 2005

A.2. Description of the project activity:

- **Purpose:**

The purpose of the project is to build a hydroelectric power plant 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 plants will have a total installed capacity of 31.5 MW. Moreover, this would improve electricity service in the west of Antioquia Department, contributing to regional development. Simultaneously, the project will provide clean energy and reduce CO_2 emissions.

✓ **Project Description:**
The use of La Herradura river would begin in the upper part of the basin at the La Vuelta Sub-Project. The mean flow is 12.3 m^3/s with a fall of 112 m for a potential installed capacity of 11.7 MW. La Herradura Sub-Project is located 5 km downstream (on the same river). The mean flow is 14.0 m^3/s with a fall of approximately 220 m which would permit generating about 19.8 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 mini-hydro 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 will generate 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 will be 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 could be favored with a better quality of power supply. The project would improve electricity service in the region.

Electricity service for the northwest of Antioquia Department is provided by a two-link transmission system (Fig. 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.

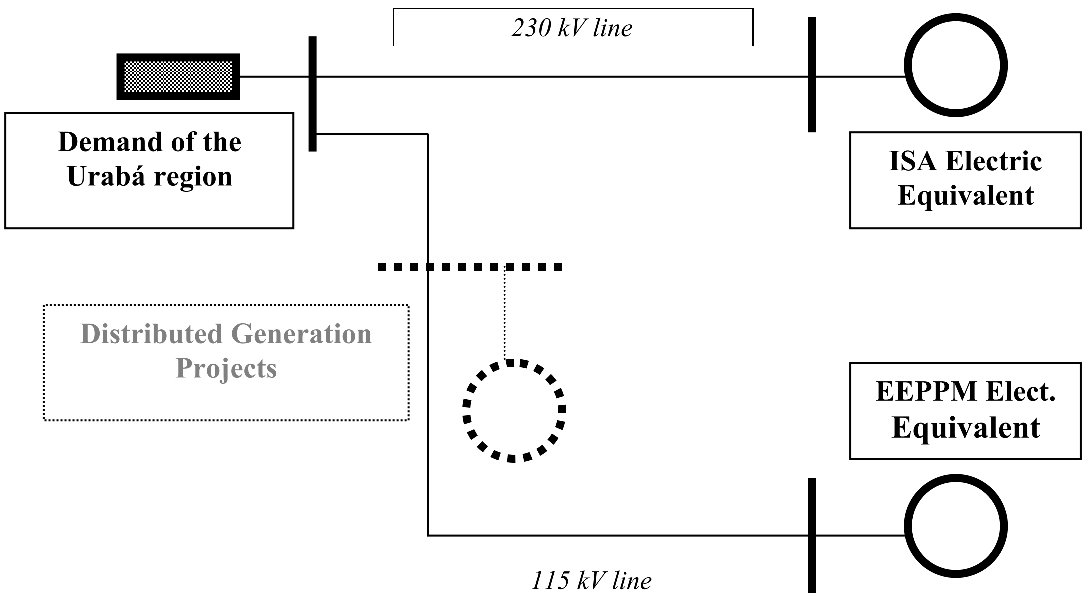


Figure 1: Electricity transmission system in the Antioquia Department

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. But if frequent guerrilla attacks in the region, which keep the 230 kV line out of order, are taken into account, the demand in the Urabá region should be limited, because through the 115 kV line it is not possible to transport 50 MW since the quality of the service cannot be secured due to the reduction in more than 10% of the nominal tension allowed in Apartadó substation. The length of the West-Apartadó line and the size of the demand covered bring about these problems of low voltage, which in spite of the installed series compensation, does not guarantee the transportation capacity required by the line in Frontino-Apartadó section.

As another additional benefit, the subprojects are bent towards distributed generation, key issue in the electric energy business all over the world, specially because they favor the development of small scale projects, near consumption centers, producing low environmental impact and minimizing the risk of technological change expected for the mid-term.

b. Environmental

The project will provide clean energy and reduce CO_2 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 will be 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, the 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 will contribute to job creation during the construction period and also during operation (about 1,000 direct and indirect employments). Also, the projects will contribute 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 regulation (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, and rights over natural resources, environmental impact studies, and documentation related to local community opinion assessment are available for validation of the project (see Annex 6). Section F also includes a summary of the main aspects and conclusions of the environmental impact studies.

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

The projects are in line with criteria for the generation capacity expansion plan of the whole national electricity system and general environmental and energy policies of the country. A summary of the related legislation is included in Annex 6.

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 to deal with local communities' needs have been considered as part of the Environmental Management Plan (see additional information in Annex 6).

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

Hydroelectricity is a clean technology which helps to avoid air pollutant emissions coming from fossil fuel-fired power plants.

A more detailed description is presented about environmental, social and economic contributions of the project in Annex 6.

A.3. Project participants:

1. Project Developer: Empresas Públicas de Medellín E.S.P. (EE.PP.M), Colombia

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

From 1955 and up to 1997, 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 y 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 the 300 MW gas-based thermal power plant La Sierra, from which a combined cycle project with additional 166 MW was later developed. This project started commercial operations on January 27, 2001. Currently, EE.PP.M is 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, taking into consideration the CDM learning-by-doing process, experience, positioning and revenues, and thus also considering the construction and operation of hydro plant Porce III (660 MW).

In terms of the company's financial status, it is estimated that by 2003 EE.PP.M investments will reach a total of 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 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 is 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 recipient of the national award "Premio Portafolio a la Empresa del Siglo XX", which is decided by a board of experts composed by academia, industrial and banking sectors of Colombia.

2. Annex I country participant:

Japan: Electric Power Development Co., Ltd.

See Contact Information in Annex 1 to this PDD.

PDD Consultant (no project participant): MGM International, SRL

Official contact: Marco Monroy
MGM International, SRL
Junín 1655 1° B - C1113AAQ Buenos Aires, Argentina
54.11.5219.1230
marcogmonroy@mgminter.com

A.4. Technical description of the project activity:

A.4.1. Location of the project activity:

A.4.1.1. Host Party(ies):

Republic of Colombia

A.4.1.2. Region/State/Province etc.:

Antioquia Department

A.4.1.3. City/Town/Community etc:

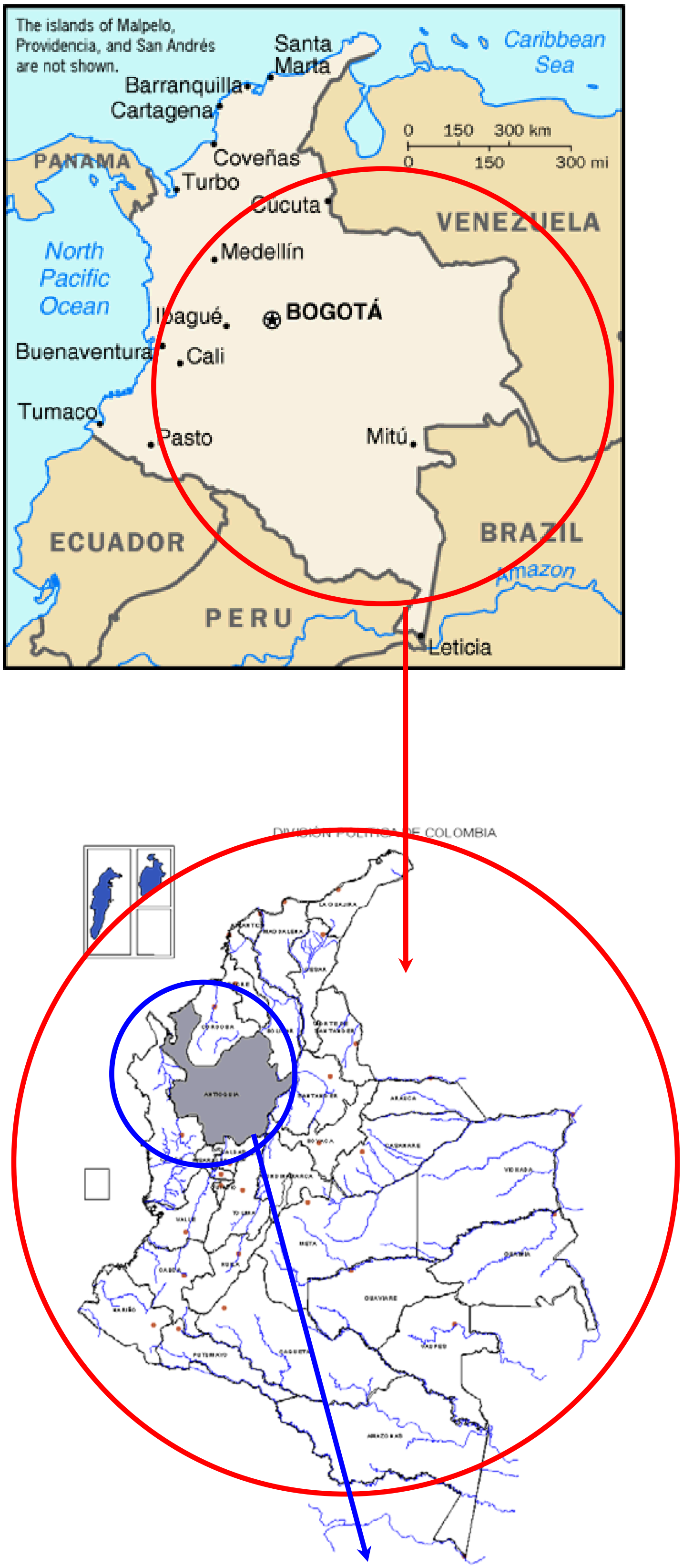
Cañasgordas, Frontino and Abriaquí Municipalities

A.4.1.4. Detail of physical location, including information allowing the unique identification of this project activity (maximum one page):

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 will be located in the northwestern part of Antioquia Department, using the water of La Herradura river, under municipalities of Cañasgordas, Frontino and Abriaquí jurisdiction, although it can be considered as regional area of influence, the whole of Urabá Antioqueño, which goes from Santa Fé de Antioquia to Arboletes. In this zone of approximately 230 km^2, important municipalities, such as Dabeiba, Mutatá, Chigorodó, Apartadó and Turbo are found. (See Fig. 2).

- ✓ **La Herradura Sub-Project**
  La Herradura subproject will take place on La Herradura river, starting from an existing topographic fall between this river and the Cañasgordas river; the two rivers later join to form the Sucio river basin, a tributary of the Atrato river. The hydrographic basin of La Herradura river used for this project covers an area of about 320 km^2, which contributes to a mean flow of 14 m^3/s at the catchment point. The construction will be located under Frontino and Cañasgordas jurisdictions.

- ✓ **La Vuelta Sub-Project**
  The subproject will take place in the upper and middle La Herradura river basin, up to the fork at the Nancuí gulch, at 1595 m elevation, covering the whole of Abriaquí municipality and the limits coincide with the dividing basin and to a lesser extent with Frontino municipality. The hydrographic basin (catchment area) of La Herradura river used by the project covers an area of about 286 km^2, which contributes to a mean flow of 12.3 m^3/s at the catchment point.


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

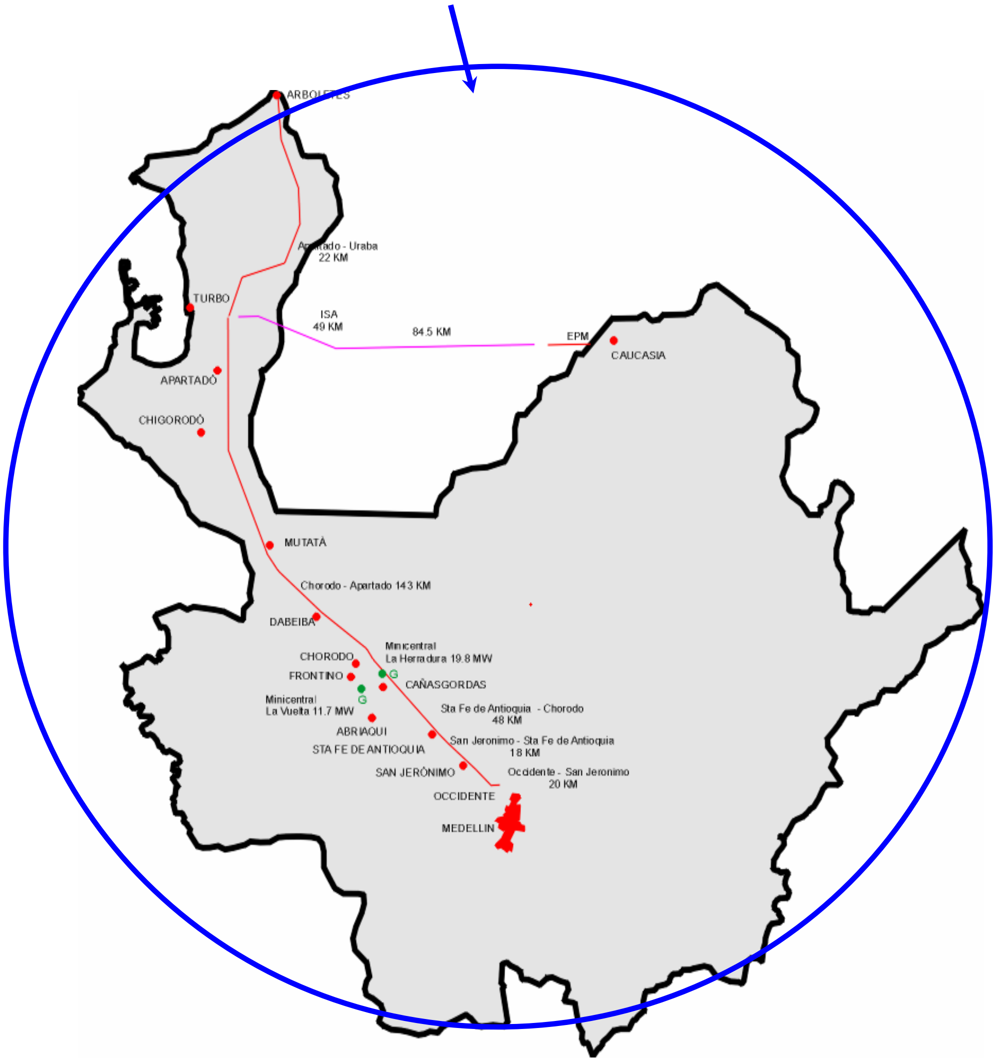


Figure 2. Colombia (above) and Antioquia Department (below)
Geographics coordinates: Aprox 6N, 76 W
Source: http://www.eia.gov/cia/publications/factbook/geos/co.html
Gren points represent La Vuelta and La Herradura power plant locations

A.4.2. Category(ies) of project activity:

There is neither a list of categories of project activities nor registered CDM project activities available yet on the UNFCCC web site to provide this information in this document. Nevertheless, in order to suggest a category for the current project activity it is decided to use the classification available for CDM small-scale project activities, according to the simplified modalities and procedures for CDM small-scale project activities.[1] Thus, the proposed "La Vuelta and La Herradura Hydroelectric" project can be categorized as a "*Renewable Energy Project with Renewable Electricity Generation for a Grid*." This

[1] Annex 6: "Indicative simplified baseline and monitoring methodologies for selected small-scale CDM project activity categories," Recommendation by the Panel on Baseline and Monitoring Methodologies (Meth Panel) adopted by the Executive Board in its seventh session (20-21 January 2003).

category comprises renewables, such as photovoltaics, hydro, tidal/wave, wind, geothermal, and biomass, that supply electricity to an electricity distribution system that is or would have been supplied by at least one fossil fuel or non-renewable biomass fired generating unit.

A.4.3. Technology to be employed by the project activity:

Technology description:

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 m^3/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	11.9 MW
Plant nominal flow	12 m^3/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
Nominal power output	12.25 MW
Rotation speed	514.28 min^{-1}
Nominal submergence (1,473.80 – 1,470.80)	3 m
Nominal flow	11.97 m^3/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}

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	
Net installed capacity	19.9 MW
Central nominal flow	10.0 m^3/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
Nominal power output	10.4 MW
Rotation speed	900 min^{-1}
Nominal submergence (940.0 – 937.5)	2.5 m
Total nominal flow (two turbines)	10.0 m^3/s (approx.)
Design net head	230.6 m
Minimum efficiency (100% opening)	92.4%
Admission valves (spherical type)	0.9 m nominal day

Taking into account the selected equipment, it was decided to assign two generating units to the power plant. Each turbine shall be 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 would have, additionally, 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. Delta connection on the low tension side and star with ground neutral on the ground netting of the central.

Mechanical auxiliary equipments: Oil in bolsters will be cooled in a dry type tower, the oil circuit will be closed and the pumps will be directly propelled by the unit axis. For the drainage of the spiral chamber, the relief valve discharge pit, the draft duct and infiltered waters 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 will be used as normal feed, fed from any of the two generators as main source. It will have a diesel electric generator of 480 V and 60 Hz emergency system.

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

Turbine specifications: The turbines will be Francis type reaction turbines with 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 in which the flow exits the turbine blades in the radial direction. Francis turbine are common in power generation and are 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 onto the blades by wicket gates. The low momentum water then exits the turbine through a draft tube.

Francis turbines can be mounted 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. They are of the inflow-impulse type on the first stage and of the outflow-axial reaction type on the second stage of their operation. That is, the blades of the first stage receive the impulse of the water entering the turbine from the outside, then the water passes down and out the bottom of the turbine and the lower section of the blades are reacted on by the water leaving the turbine.

Francis turbines are most widely used among water turbines and the development of the Francis turbines in the last decade has opened up a large range of new application possibilities for this type.

Figure 3 shows a typical configuration of a Francis turbine.

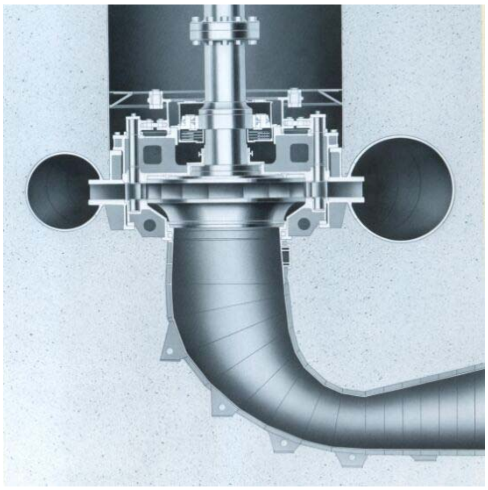


Figure 3: Francis Turbine Spiral Cased Horizontal Shaft - typical arrangement

Previous Projects in the world

The technology involved is quite standard with hundreds of similar projects all over the world. It is widely known as an environmentally sound and safe technology, since at the medium scale of the proposed run-of-river subprojects only small dams, permitting a few hours water storage, are involved.

A.4.4. Brief explanation of how the anthropogenic emissions of anthropogenic greenhouse gases (GHGs) by sources are to be reduced by the proposed CDM project activity, including why the emission reductions would not occur in the absence of the proposed project activity, taking into account national and/or sectoral policies and circumstances:

Since the power sector reform in Colombia in year 1994 (Law 142 on public services and Law 143 on electricity), capacity additions have been performed by both the public and the private sector. Table 1 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 1992 prior 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.[2])

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

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		

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

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

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

hydro. All the latter was 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 1990s.

Independent 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.

Considering Colombia's important fuel reserves and the need to guarantee electricity supply through a more balanced mix between thermal and hydroelectric generation,[3] 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.)

La Vuelta and La Herradura project was not the exception in the context of this complicated sectoral situation. The project has remained under discussion since 1965. In that year the first studies for the use of La Herradura river basin began, in order to consider the potential to develop hydroelectric power plants. Several decades have elapsed until this project can become a reality. The main reason for that was CDM (see Section B.4).

From the analysis above it is clear that the project itself was not an attractive option to be developed by EE.PP.M unless other incentives were involved. The low profitability for those subprojects, the very risky conditions for implementing electricity projects in rural areas, and many other circumstances, were important barriers to go further on these subprojects. These subprojects were 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 a project activity for registration under the CDM based on the CER revenues and the contribution to the sustainable development in Colombia.

A.4.4.1. Estimated amount of emission reductions over the chosen crediting period:

The project activity will reduce CO_2 emissions in electricity generation through the use of renewable energy sources. It is expected that the project activity will serve to displace fossil fuel-fired plants (a combination of coal and gas based power plants in the Colombian Interconnected National System) with clean energy provided by hydroelectricity. The inclusion of the project into the interconnected grid will redistribute the dispatch of all the power plants giving rise to a most efficient electricity generation of the

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

whole system. In the absence of the CDM project activity, no other project would have been implemented indeed, so that emission reductions would not occur.

From a prospective dispatch analysis (a model developed in the selected methodology) it is estimated that the project has the potential to reduce around 70,000 tonnes CO_2/year.

years	Annual estimation of emission reductions (tonnes CO_2)
2005	70,000
2006	70,000
2007	70,000
2008	70,000
2009	70,000
2010	70,000
2011	70,000
Total estimated reductions (tonnes CO_2)	490,000
Total number of years	7

A.4.5. Public funding of the 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 a baseline methodology

B.1. Title and reference of the approved baseline methodology applied to the project activity:

There is neither a reference list nor approved baseline methodologies for this project activity on the UNFCCC / CDM website. Thus, a new methodology is introduced and entitled

"*Baseline methodology for new capacity that displaces electricity generation in a centrally dispatched hydrothermal interconnected power system.*"

B.1.1. Justification of the choice of the methodology and why it is applicable to the project activity:

The proposed new methodology applies for hydroelectric power plant projects. Moreover, La Vuelta and La Herradura Hydroelectric Project belongs to the Interconnected Colombian System, which is a ***hydrothermal electricity system*** of the characteristics described in the new methodology. La Vuelta and La Herradura represent only the 0.24% of the overall system capacity.

Specifically, the baseline considers the emissions coming from dispatching power plants, with and without the proposed project activity, according to market rules (least-generation costs) established for the Colombian interconnected system and including restrictions and capacity additions. In the estimation

of baseline emissions the demand and the capacity expansion plan to satisfy such a demand is considered, as it was officially analyzed by the Ministry of Energy and Mines.[4] The reason why those emissions correspond to the baseline is justified in the fact that in the absence of the CDM registration opportunity the project would not have been chosen to be developed by the project sponsor and no other foreseeable alternative project would have been developed in place of the proposed one to be considered as the baseline, neither by the project sponsor (see Section B.4) nor other independent power producers (IPP). Therefore, the baseline considers emissions that would have occurred in the absence of the project and directly attributable to its absence, *i.e.* the part of the system emissions that will be replaced by the presence of the proposed project activity. It includes emissions of all the power plants serving the national system, in the base year (2005) as well as in the future, excluding and including La Vuelta and La Herradura into this 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).[5]

Both hydro and thermal plants have declared costs different from zero. The setting of hydro generation cost is discussed below. Power plants that are not centrally dispatched are not included either in the baseline or in the project emissions calculation, since they are not affected by and do not affect the dispatch decisions, but they are included in the simulations ("must run" power plants, which are obliged to be dispatched in the base load; they are mainly minor plants, co-generators and self-producers).

In order to estimate baseline emissions in the above mentioned electricity system, the calculation is made through a standard computational model (Stochastic Dual Dynamic Programming, SDDP[6]), which takes into account all relevant information to simulate the system dispatch according to the rules defined by the Colombian government and managed by the wholesale market manager —National Dispatch Center— (Centro Nacional de Despacho, CND). It was selected one of the most widely used models for the kind of electricity system it is going to be handled in this project.

Summarizing, the main characteristics of the proposed project activity and the selected baseline for this case are:

- Emissions to be accounted for are those generated by all thermal plants serving the national system, considering new additions —as determined in the Reference National Expansion Plan for the estimation of emissions in the absence of the project activity and as it happens in actual conditions for the calculation of emissions with the presence of the project activity—, actual electricity demand trends, historical hydrological conditions, generation costs, fuel costs, vulnerability, reliability, rationing cost, and supply parameters, etc., with and without including the proposed project into these plants (see Section B.4).
- The Colombian systems is an interconnected hydrothermal grid.

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[4] The Mining-Energy Planning Unit (UPME) of the Ministry of Energy and Mines is in charge of preparing an annual report of the foreseen and planned system capacity expansion (Reference National Expansion Plan).
[5] See Section B.4 for the discussion on additionality issues for a system dominated by hydro generation.
[6] SDDP is a model developed by PSR Inc. and can be consulted at www.psr-inc.com.br/sddp.asp. SDDP has been licensed by utilities and agencies of several countries, including Argentina, Bolivia, Brazil, Chile, Colombia (under the name MPODE, Modelo de Planeamiento Operativo Dual Estocástico), the six countries in Central America, Spain and USA. SDDP has also been selected by CIER (Regional Electrical Integration Committee) as the operational planning tool to represent all South American countries in the gas/interconnection strategic evaluation. The same kind of model is already used by the Dispatch National Center (CND) to calculate the theoretical capacity value (CRT) in order to pay the capacity able to be required, with expected demand, expansion, and system parameters provided by UPME.

- Power plants are dispatched according to their generation costs, the least-cost plants enter first, while plant dispatched later to cover the demand set 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).
- Real conditions are considered in which transmission problems along the interconnected grid are included (bottle necks, forced generation, and all kind of restrictions).

Taking these conditions into account, the best alternative is to consider a computational model able to simulate the dispatch under the constraints and characteristics of the interconnected system. Thus, a proven model was selected to estimate baseline emissions, according to its ability to deal with the features of the Colombian system, in accordance with the proposed methodology. The model is able to handle power plants centrally dispatched in hydrothermal interconnected systems with a high hydraulic component, based on least-costs of generation, with the flexibility to incorporate the set of conditions and constraints determining the actual dispatch (hydrology, electricity demand, transmission constraints, generation costs, etc.). Since the project activity belongs to a system of these characteristics, the proposed methodology allows a conventional treatment of baseline emissions, in a more precise way than considering that displaced power plants are those of lowest efficiency or taking the average of the thermal generation of the system.

B.2. Description of how the methodology is applied in the context of the project activity:

La Vuelta and La Herradura hydroelectric subprojects would displace energy produced by burning fossil fuels and substitute it with energy that would be generated from hydroelectricity. As such, the generation of the interconnected national grid as a whole would result in a production of carbon dioxide emissions lower than production that would occur if the proposed project were not implemented.

The methodology is based on a simulation of the centrally planned dispatch of all the power plants serving the interconnected national system, without and with the proposed project activity. It is applied to the current project activity in a straightforward manner, by taking into account all relevant parameters and variables determining the dispatch decisions, as they are taken by the manager of the wholesale electricity market. Annex 3 presents the overall results obtained from applying the methodology. Relevant data is obtained from UPME, CND, EE.PP.M and so on.

The main assumptions considered in running the simulation model are described below.

1. **Data base used**

The National Dispatch Center (CND) that coordinates the Wholesale Electricity Market (MEM) and operates the National Interconnected System (SIN) of Colombia, performs periodically short- and mid-term simulations of the SIN, using the Stochastic Dual Dynamic Programming (SDDP model), also called MPODE in its Spanish translation.

MEM agent stakeholders must supply data to keep the database used by CND updated, for the simulations of the SIN through the SDDP model. Likewise, CND publishes the updated database and simulations results.

For the calculation of La Vuelta and La Herradura emissions reduction, the MPODE database, supplied by CND, was used, updated until March 2003, complemented with the long-term demand, the expansion plan and other minor data (see below).

2. **Demand**

The official demand in Colombia are reported by the Energy and Mining Planning Unit (UPME), affiliated to the Ministry of Energy and Mining.

Actual demand provided by UPME at the end of every year is considered to run the model.

3. **Expansion Plan**

The official expansion plans of Colombia are performed by UPME. As from reforms introduced to the Colombian energy sector by Law 142 (public services, 1994) and Law 143 (electricity, 1994), the official expansion plans changed from compulsory to indicative plans.

The dynamics of the variables associated to electric energy generation makes necessary a continuous follow-up in order to forecast its future behavior and its impact over the system in general. Therefore, UPME must carry out a short- and long-term generation analysis. The analysis must outline future generation needs, following as criteria, expansion planning and the operation of integrated transmission and generation available resources, with the objective to minimize operation costs of the system and trying to meet energy demand according to quality, reliability and safety levels needed by users.

Alternatives (short-term) and strategies (long-term) have considered, among others, the following variables:

- ✓ Fuel costs
- ✓ Energy demand and electricity capacity
- ✓ Occurrence of El Niño type phenomenon
- ✓ Recording of generation projects
- ✓ Reliability criteria established for planning
- ✓ Transmission grid
- ✓ Unavailability of generation units and of transmission lines
- ✓ Energy reserves
- ✓ Hydro contribution

The short-term analysis was performed for the period 2002-2006. UPME considered five alternatives representing, in the best possible way, the occurrence of different outstanding events: different scenarios of electric energy demand growth, international interconnections with Ecuador and Venezuela, unavailability of the transmission system, hydrological events, etc.

CP3 was chosen from these alternatives. This alternative states that the SIN deals with the medium-demand scenario and the National Transmission System operates interconnected with Ecuador and Venezuela. The program for the recovery of the transmission network (June 2002) was considered. It comprises transmission lines recovery until December 2003. Additionally, to be able to meet demand requirements, it becomes necessary that the system includes a 150 MW combined cycle for January 2006. The plan also considers the two hydro projects, La Vuelta and La Herradura, to enter into the system.

Since 1998 UPME has performed expansion plans according to CREG Resolution 051/1998. In the revisions of the first Expansion Plan several projects were proposed. From them the Primavera-Guatiguará-Tasajero & Sabanalarga-Cartagena 230 kV line has entered into operation. At present there

are several projects under consideration for the expansion to the transmission system. The Expansion Plan of the years 2000 and 2001 are under revision, in which the execution of the 500 kV Bolivar-Copey-Ocaña-Primavera-Bacatá line, with an approximate distance of 923 km, was recommended. The new proposed expansions (220 kV Sabana-Fundación third circuit, recommended by CDN, and 220 kV Bolivar-Copey pre-energization line) and both, electricity imports and exports, are considered in the simulations for the least cost expansion plan. According to UPME, the interconnections with Ecuador and Venezuela have had so far a low impact on the Colombian electricity supply industry.

Actual expansion of the system, according to UPME data published at the end of every year, is collected to run the simulation model for the *ex post* calculation of baseline emissions.

As explained in Section B.4, EE.PP.M has already decided the construction of La Vuelta and La Herradura hydro plants, starting the civil works. UPME registered these projects a long time ago. For the new reference expansion plan there was a change of sponsors for La Vuelta and La Herradura, formerly registered by EADE and now by EE.PP.M.

The fact that these projects were *registered* did not mean that the projects were going to be executed, as already was the case until last year, since the projects were on standby for a very long time. However, the early decision taken by EE.PP.M was also submitted to UPME. Thus UPME has included La Vuelta and La Herradura as future projects to be included in scenario CP3 since early 2004.[7]

It would appear that the proposed project might be considered to be a part of the baseline, since the expansion plan already accounts for the project situation. But we assert that in order to prove additionality one must compare the situation at the time the decision was taken, that is, when EE.PP.M motivated by the CDM decided to go ahead with a pioneer sustainable project assuming risks beyond the normal CDM uncertainties.

This means that in the baseline scenario the expansion plan was considered without including La Vuelta and La Herradura subprojects, while they are included when simulating the electricity dispatch in the "with project" scenario.

Two additional comments are relevant. We have decided to use the latest expansion plan, instead of using the one developed at the time EE.PP.M decided to include the project into its future investment portfolio, in order to gain in accuracy of the whole description, since conditions actually change from one year to the next. On the other hand, we have used the same expansion plan for the baseline and for the project since it gives consistency to the analysis. The fact that in the expansion plan La Vuelta and La Herradura are included while in the baseline no, does not affect the rest of the variables determining the prospective demand scenarios, hydrology, transmission, fuel prices, energy reserves, etc.

UPME submitted five long-term strategies covering the period 2007-2011. Each one with a short-term alternative as starting point. The composition of the different long-term strategies is the result of considering among other variables: installation costs, variable and fixed costs, the medium-scenario of

[7] These projects were expected to enter into the dispatch through the national grid in June 2004. Accordingly it is reflected in the data handled in the expansion plan developed by UPME. Nevertheless, in the UPME report these projects are supposed to be ready before that time, specifically December 2003 for La Vuelta and April 2004 for La Herradura. Moreover, UPME has considered that the projects are under a technical pre-feasibility phase with the inscription of the projects under the Ministry of Environment. The projects are actually beyond this stage since some civil works have started and feasibility and environmental impact studies were also performed (compare this information with Annex D of the "Plan de Expansión de Referencia, Generación y Transmisión 2002-2011", UPME, Bogotá, October 2002) and the environmental license was conceded.

coal and natural gas prices, as well as natural gas, coal and hydro potential projects registered in the UPME future projects record.

Out of these strategies LP3 was picked up. This strategy considers in the first years CP3 alternative, it estimates a mean cost of natural gas at well-head, a free entry of natural gas, hydro and coal fired projects and a medium-scenario for demand growth. In order to meet the energy needs under these conditions, the result of the models shows that the country requires the installation of 960 MW, out of which 300 MW correspond to natural gas units and 660 MW to hydro projects.

The plants taken into account for the expansion of the generation system in the simulations for La Vuelta and La Herradura GHG emissions reduction calculation and their entry date can be seen in Table 3.

Table 3: Reference Expansion Plan

Date	Power Plant	Capacity (MW)	
		Hydro	Thermal
15/06/2004	La Vuelta	11.7	
01/09/2004	La Herradura	19.8	
2006	CC – Costa 1		150.0
2009	CC – Costa 2		300.0
2010	Hydro 1	660.0	

4. **Hydrology**

Colombian hydrology has random weather conditions mainly due to Colombia’s tropical location. This marked contingency, qualified by researchers as a chaotic type event, suggests a critical analysis of the energy projections.

Due to the own characteristics of the generation system and to the influence of decisive variables such as hydrology may have over its behavior, and specially, events such as the “El Niño” Pacific phenomenon that may affect the system from the energy point of view, hydrology must be regarded as a variable in system planning.

The Pacific phenomenon has been monitored by different international and national organizations and the variables that affect it can be identified. Although the phenomenon can be predicted, there are barriers which make it difficult to define its beginning, duration and intensity beforehand.

For the relevance of the phenomenon, it must be considered in the different generation analyses, and, through the ARP model, incorporated in the simulation model. A set of 100 flow synthetic series was generated from historical data in the different seasons. The same 100 synthetic series were used for the two scenarios, with and without La Vuelta and La Herradura project.

In actual conditions, at the end of every year, the simulation model (with and without La Vuelta and La Herradura) will be run considering a deterministic historical series for the previous year and, alternatively, including a stochastic hydrology for the next four years, in order to represent accordingly agent decisions in relation to water valorization.

5. **Ideal Dispatch and Actual Dispatch**

The “ideal” dispatch is the simulation of the electric system without considering the transmission grid. The ideal dispatch would be the one obtained by merit if there were not transmission restrictions. However the real operation (the generation) does take into consideration restrictions in transportation. By

simulating the national interconnected system and considering the national transmission grid, the approximation to the real dispatch can be obtained.

When simulations without transmission grid are considered, in theory, all the hydro energy produced by La Vuelta and La Herradura displaces thermal energy, but when simulations are carried out with the grid, energy transmission restrictions in the northern region of the country (the coast) are considered, and most of the thermal generation is concentrated there, so these thermal plants have to generate due to transmission restrictions, and La Vuelta and La Herradura hydroelectric plants, placed in the center of the country, are not able to displace all the energy that in theory (without grid) they could displace, thus increasing thermal generation and consequently emissions.

As from above, simulations obtained in SDDP are assumed, considering the transmission grid as base to calculate GHG emissions reduction produced by the generation of La Vuelta and La Herradura.

However, simulations without considering the transmission grid were also performed in order to see which would be the theoretical emissions reductions produced by La Vuelta and La Herradura, if restrictions would not exist in energy transmission in the northern region of the country or if the two hydro plants were placed in that region. In that case emission reductions are greater than in actual dispatch.

It is important to note that displaced energy due to the presence of La Vuelta and La Herradura power plants does not come from marginal plants, as they are determined in the ideal dispatch. Restrictions are very important, giving rise to the displacement of other plants not included in the ideal dispatch. The National Dispatch Center does not have a registry of power plants serving the system due to restrictions. Therefore, it results extremely difficult to include a procedure for accounting actual displaced energy within the monitoring plan. Thus, they are simulated.

6. **Emission Factors**

By knowing fuel types and considering the consumption patterns for each plant used in the SDDP simulation model, and taking fuel emission factors (on a plant-by-plant basis for natural gas and from IPCC default values[8] for coal), emission factors per GWh produced were estimated for the different plants of the system (current and future). They are listed in Table 4 (based on UPME calculation of emission factors, from heat rates provided and audited by the CND).[9]

Table 4: Plant by plant emission factors

Name	Fuel	Type	Capacity (MW)	Emissions (ton CO_2/GWh)
BARRANCA 1	Gas	Steam	12	608.08
BARRANCA 2	Gas	Steam	12	619.55
BARRANCA 3	Gas	Steam	63	690.76

[8] Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories, Greenhouse Gas Inventory Reference Manual, Volume 3 (IPCC 1996).
[9] Fuel consumption is not declared by generators (it is reserved as a part of their business strategy). Generators inform to CND, at most, specific consumptions (consumption by energy output unit; heat rate), which are used to calculate the theoretical capacity value (CRT) for the payment of the available capacity. LHV of coal plants are measured by generators to control the contractual agreements they have with fuel distributors, since these values are changing along time, depending on which kind of coal is being used (several mines supply coal to the system). Average values have been provided. Natural gas-based power plants have a similar problem since natural gas physical properties and composition depend on which oil well is producing. Thus, generators have provided average natural gas emission factors.

BARRANCA 4	Gas	Simple Cycle	30	746.62
BARRANCA 5	Gas	Steam	20	740.50
BARRANQUILL3	Gas	Steam	64	574.33
BARRANQUILL4	Gas	Steam	65	579.80
CANDELARIA1	Gas	Simple Cycle	150	556.63
CANDELARIA2	Gas	Simple Cycle	150	575.21
CARTAGENA 1	Gas	Steam	60	651.77
CARTAGENA 2	Gas	Steam	50	772.55
CARTAGENA 3	Gas	Simple Cycle	67	674.06
CC - COSTA1	Gas		150	370.63
CC - COSTA2	Gas		300	370.63
EMCALI	Gas	Combined Cycle	233	403.21
FLORES 1	Gas	Combined Cycle	150	422.20
FLORES 2	Gas	Combined Cycle	99	616.96
FLORES 3	Gas	Combined Cycle	550	370.63
GUAJIRA 1	Gas	Steam	151	572.50
GUAJIRA 2	Gas	Steam	151	564.45
MERILECTRICA	Gas	Simple Cycle	154	581.50
PAIPA 1	Coal	Steam	28	1350.27
PAIPA 2	Coal	Steam	68	1214.27
PAIPA 3	Coal	Steam	68	1221.51
PAIPA 4	Coal	Steam	150	965.73
PALENQUE 3	Gas	Steam	14	550.00
PROELECTRIC1	Gas		45	477.86
PROELECTRIC2	Gas		45	477.86
TASAJERO 1	Gas	Steam	155	585.62
TEBSAB	Gas	Combined Cycle	750	412.91
TERMOCENTRO	Gas	Combined Cycle	285	415.91
TERMODORADA1	Gas	Simple Cycle	51	559.74
TERMOSIERRA	Gas	Combined Cycle	470	370.63
TERMOVALLE 2	Gas	Combined Cycle	210	395.74
TPIEDRAS	Gas	Simple Cycle	3	575.21
YUMBO3	Coal	Steam	29	1624.65
ZIPAEMG2	Coal	Steam	35	1225.33
ZIPAEMG3	Coal	Steam	62	1150.12
ZIPAEMG4	Coal	Steam	62	1141.26
ZIPAEMG5	Coal	Steam	63	1089.79

7. **Calculation of emissions for thermal plants**

The energies generated for all the plants of the system every month were obtained from the simulations performed with the SDDP model. The energies generated by the thermal plants, not considering self-producers and co-generators, were multiplied by the emission factor of each plant and added annually to obtain the total emissions produced. This was performed for the scenario without La Vuelta and La Herradura and for the scenario in which La Vuelta and La Herradura is dispatching electricity to the national interconnected system.

From the difference of the results derived when running the simulation model for the two scenarios (with and without La Vuelta and La Herradura), GHG emission reductions when the plants La Vuelta and La

Herradura start operation were obtained. Similarly, the thermal energies displaced for those plants were obtained.

8. **General data used for SDDP Model**

The tables used for simulations of SDDP model in the present study are given below (Tables 5, 6, and 7):

Table 5 : Simulation data

Type of study	Isolated
Stage size	Months
Flows	Historical series
Maintenance program	No
Number of demand blocks	5
Number of additional years	1
Maximum number of iterations	100
Number of standard deviations	1
Discount rate	12%

Table 6 : Rationing costs

Segment (%)	Cost ($/MWh)
1.5	426.01
98.5	772.34

Table 7: Demand blocks duration

Block	Duration (%)
1	3.36
2, 3, 4, and 5	24.16

B.3. Description of how the anthropogenic emissions of GHG by sources are reduced below those that would have occurred in the absence of the registered CDM 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.[10]

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,[11] EE.PP.M has paid a great attention to the novel Clean Development Mechanism.[12] 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

[10] The only three “official” Colombian projects were developed by EE.PP.M (Jepirachi Windpower Project, Río Amoya Hydroelectric Project, and La Vuelta and La Herradura Hydroelectric Project).
[11] On that occasion EE.PP.M started working with two projects, the Jepirachi Carbon Offset Project (see the main text) and the previously low-priority —and almost already disregarded— subprojects La Vuelta and La Herradura.
[12] Take into account that by that time CER prices scenarios were highly optimistic, around US$ 20 per tonne of CO_2e.

Jepirachi Carbon Offset Project[13] (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 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.[14]

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 an interested and involved 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. In the absence of CDM registration, EE.PP.M. would have not made any other project or they would have waited and looked for another CDM project in the future.

However, not any of these projects was and remains being today a feasible project to be implemented by EE.PP.M, due to the same kind of barriers La Vuelta and La Herradura met at that time, and which were able to be overcame thanks to the CDM (a possibility that EE.PP.M has also into consideration for other almost unviable projects in the future), making possible to catch a particular project on times of awaiting for better economic and social conditions.

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 supplemented 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, etc., among other non-material aspects. Therefore, they 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 usual case in these type of projects.

As regards the baseline it must represent the situation that would occur if the project were not implemented, and this is the scenario in which the entire national system, including the expected additions in the Reference Expansion Plan, will manage to supply electricity in order to satisfy the demand (almost the part of the demand that could have been supplied by La Vuelta and La Herradura[15]), which is made through the use of less efficient power plants than those that would be dispatched if power generated by

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[13] 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.

[14] In particular, EE.PP.M has been 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 development of methodologies for the Colombian and project baseline determination. Therefore, the CDM portion of the project is highly regarded as a main part of La Vuelta and La Herradura hydroelectric project developments.

[15] La Vuelta and La Herradura do not substitute the same amount of energy as the one generated by these subprojects, since their presence reassigns the entry of all power plants into the dispatch, taking also into account the possibility of water storage by hydroelectric reservoirs and the corresponding value the water has, which not necessarily implies that all the electricity generated by La Vuelta and La Herradura would have been saved if the subprojects were not implemented.

La Vuelta and La Herradura were available in the interconnected system. The project is relatively small and in this sense it is not necessarily true that another specific project would have been developed to cover the part of the generation provided by La Vuelta and La Herradura.

The baseline chosen is conservative, since in the dispatch analysis under consideration (see Annex 3) La Vuelta and La Herradura are going to replace a combination of power plants, which also include other hydro plants and not only fossil-fuel based plants. The proposal selected here takes into account the inclusion of new plants, but only those discussed in the official Reference Expansion Plan or that actually occur, since as it was mentioned before the proposed subprojects are not strictly built to cover the expected increase in electricity demand but only they were conceived to add efficiency to the system as a whole and to contribute to the sustainable development of the Antioquia department.

The other important point is that emission reductions in this proposal are real and measurable, as it was established in article 12 of the Kyoto Protocol.

The baseline methodology proposes a two-step approach to prove additionality. The first step consists of identifying barriers that prevent project implementation. Several barriers are in place in La Vuelta and La Herradura hydroelectric project case. The proposed project formed part of the project developer's portfolio during many years without reaching consensus among directors of the developer company board to implement it. And this was due to many of the barriers commented in Section A.4.4 (Brief account of national and sectoral circumstances acting as barriers to investment in hydro projects).

Step 1: Analysis of existing barriers to the proposed project activity.

Due to prevailing practice barrier: hydro plants are not the actual and current practice in the electricity market in spite of 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 are also uncertainties on capacity charge values, circumstances related to fuel availability and prices, security of the interconnected system which cannot be based so strongly on hydroelectricity due to hydrological uncertainties (moreover now affected by the consequences of climate change).

Social and institutional barrier: Guerrilla attacks on transmission towers mainly affect hydro plants since they are located in rural areas where such attacks are more common.

Political and investment barrier: Colombia is undergoing difficult times, which makes also difficult that project developers can attract investors or get financing from banks.

Step 2: Financial analysis.

An analysis of alternative cost options in terms of investment requirements, NPV and IRR, comparing the proposed project against other potential projects by the project developer or other IPP is another way to show additionality.

To see how this kind of analysis can be performed, we present it for the options handled by EE.PP.M when 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 demonstrates that the La Vuelta and La Herrdura Hydroelectric Project was not a prioritized project of EE.PP.M, but that this project became a priority project due to anticipated CDM benefits.

The study of investment options conducted by the Planning Unit of the Energy Generation Management of EE.PP.M at the end of 1999 did not include La Vuelta and La Herradura. The resulting project portfolio and its financial analysis are shown in the tables below.

IPP Nominal 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

EE.PP.M Potential Hydroelectric Projects									
Power Plant	Technology	Capacity (MW)	Investment (US$ million, Dec. 1996)	NPV (US$ million, energy price = 33 US$/MWh)	IRR (%)	Dam Capacity (million m^3)	Flooded area (km^2)	Families to be displaced	Execution Period (years)
Riachón	Pelton	93	141	(-) 38.6	5.28	92.8	6.6	15	6
Nechí	Pelton	645	606	(-) 105.8	6.64	242	8.35	60	8
Cañaveral	Pelton	68	79	10.2	6.94	0.086	0.0003	0	run-of-river
Encimadas	Pelton	94	104	(-) 9.7	7.42	0.324	0.0004	0	run-of-river
Guaico	Pelton	139	162	(-) 11	7.87	44.5	1.91	37	8
Porce III	Francis	700	743	(-) 16	8.31	120.9	5.14	113	10

CER values were estimated at a nominal value in 2008 with a fixed increase/decrease rate along time.

It can be clearly seen that all hydroelectric options had negative net present values (NPV), with the exception of the Cañaveral hydro plant, and internal rate of return (IRR) too low as to be economically feasible. On the other hand, investment costs of the options considered were also quite high so as to inhibit going ahead with these alternatives.

EE.PP.M also entrusted the National University of Colombia to conduct a feasibility study for the 150 MW Sinifaná coal plant, which analysis was presented after completion of the hydroelectric power plant analysis. The project fell into the same disappointing financial non-viability as the hydroelectric power plants: US$ 186.6 million of investment, the NPV was negative, around US$ –84.2 million, and a negative IRR of –6.51%.

Under such a situation, by the end of 2000 another possibility came into place: two small hydro plants located in La Herradura river. La Vuelta and La Herradura power plants had better sustainable development indicators. As in the case of Sinifaná, they had important contributions to the social and economic development of the region where the power plants would be located. But contrarily to what happened with Sinifaná, La Vuelta and La Herradura were environmentally safe projects, since no emissions from coal burning were involved.

By that time CDM, with its promising environment, was emerging in the companies' business considerations. In the year 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 the least investment cost option with the best sustainable development contribution. As was explained above, the project itself was not financially viable but CDM benefits were considered as a key factor that helped support the decision-making process, leading to the formulation of the proposed project under the CDM. From the financial point of view, the project investment requirement is US$ 38.7 million. It has an

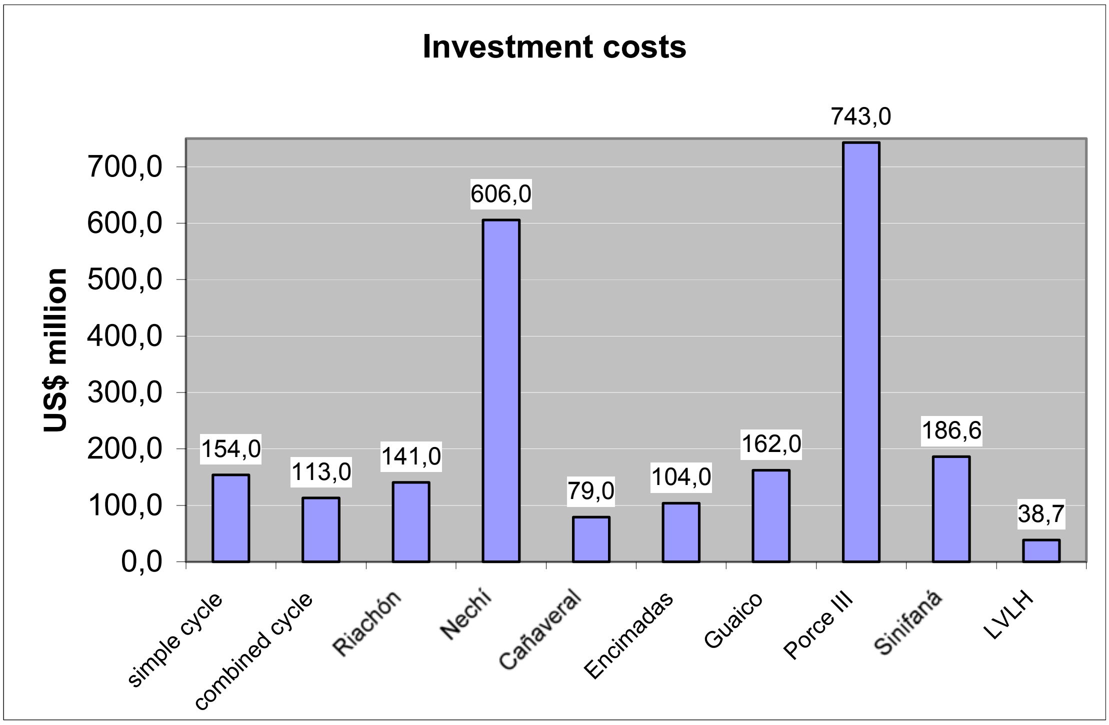
internal rate of return around 6% without carbon credits, and 6.5%, 6.8%, 7.6%, and 9.2% including them at different values per tonne of CO_2 equiv., US$ 3, 5, 10, and 20, respectively. The net present value is –9.1 million dollars without CERs and it is –6.8, –5.2, –1.3, and +6.4 million dollars with CERs valued at US$ 3, 5, 10, and 20 per tonne CO_2 equiv., respectively. ("Carbon credits" provide a total of around US$ 7 to 46.6 million in 21 years, considering US$ 3 to 20 per tonne of CO_2 equiv. and a carbon credit increase rate of 5%).[16]

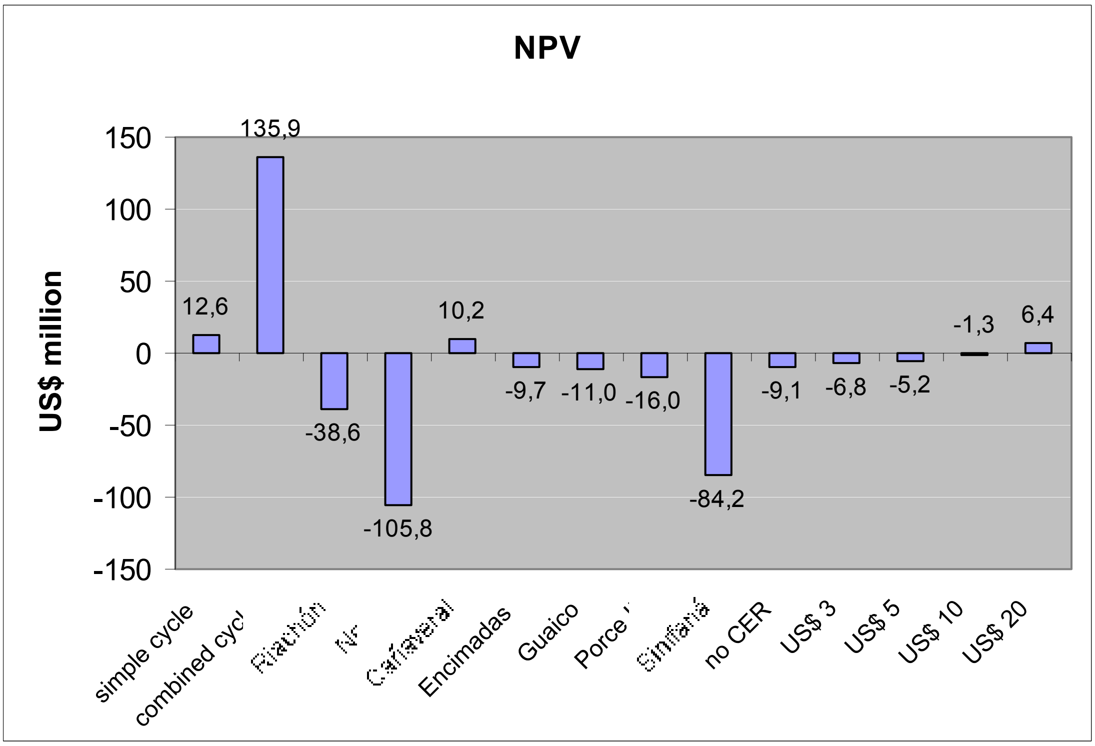
Among the other potential projects of EE.PP.M's portfolio, La Vuelta and La Herradura resulted a good candidate to simultaneously contribute to sustainable development and climate change mitigation, withstanding the low return and other risks in exchange for CDM income and environmental recognition. Neither of the project portfolio alternatives would have been developed instead of La Vuelta and La Herradura since they were quite unviable (social, political, and institutional barriers, low profitability, etc.), unless other incentives came into place. This was the case for the pioneer project La Vuelta and La Herradura. 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, as it happened with other projects considered by EE.PP.M. 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 opportunity value of CDM; this played a role speeding up the project execution decision. And what could be better than beginning with a small renewable energy project, reducing also transaction relative costs..

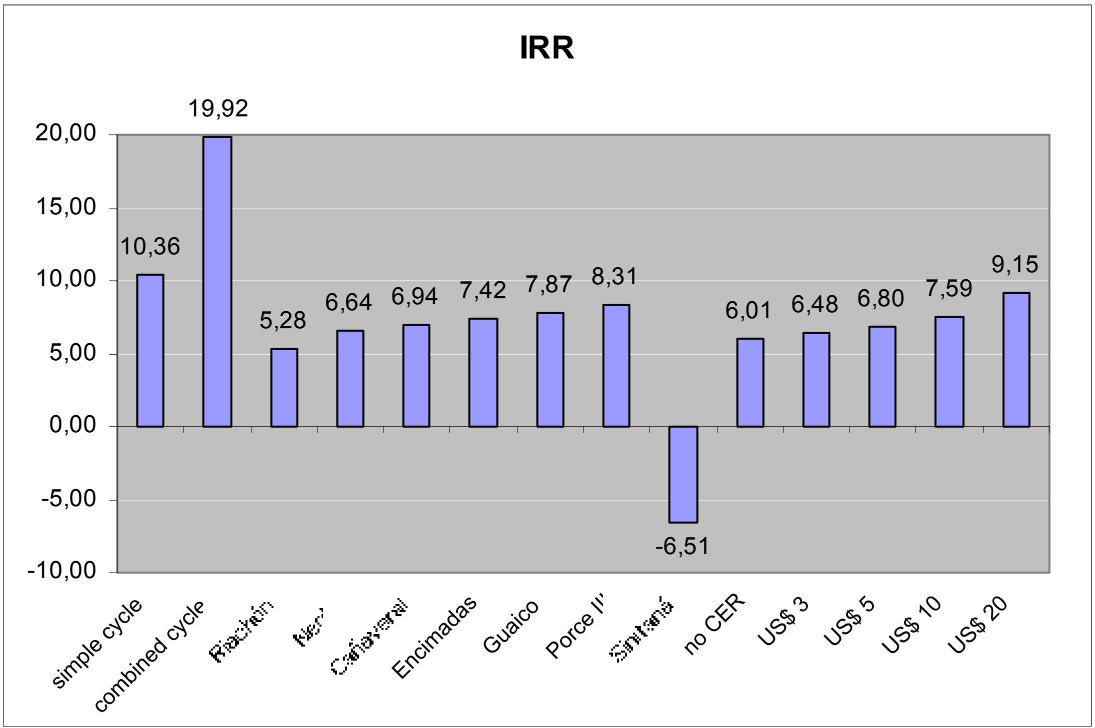
The alternative thermal plants were used for comparison and disregarded as investment options since EE.PP.M has its major background experience in hydroelectricity and due to uncertainties with future gas prices and supply.[17] Moreover, thermal alternatives were excluded due to their high investment. They correspond to larger projects so that La Vuelta and La Herradura do not delay their construction.

The whole situation, including all the projects, can be visualized in the figures below. In the second and third figures, the cases of LVLH with different values of CERs correspond to the bars at the right.

[16] Today US$ 20 per tonne of CO_2 equiv. appears too high, but it was a possible price scenario when the analysis was conducted.
[17] If the best of these options were chosen as the baseline (mainly the thermal ones), emission reductions would have resulted substantially greater than those estimated in this PDD. But we did not do so.


Investment costs
US$ million
700,0
600,0
500,0
400,0
300,0
200,0
100,0
0,0
154,0
113,0
141,0
606,0
79,0
104,0
162,0
743,0
186,6
38,7
simple cycle
combined cycle
Riachón
Nechí
Cañaveral
Encimadas
Guaico
Porce III
Sinifaná
LVLH


NPV
US$ million
150
100
50
0
-50
-100
-150
12,6
135,9
-38,6
-105,8
10,2
-9,7
-11,0
-16,0
-84,2
-9,1
-6,8
-5,2
-1,3
6,4
simple cycle
Encimadas
Guaico
no CER
US$ 3
US$ 5
US$ 10
US$ 20



Discount rate was around 8% to 10%, discouraging project development.

B.4. Description of how the definition of the project boundary related to the baseline methodology selected is applied to the project activity:

The project boundary only accounts for the physical location of La Vuelta and La Herradura power plants. In this case the baseline establishes the emissions that would have occurred without the project implementation but only associated to it, not to the entire system. Thus, if the project were not implemented what would be about to be emitted is only the proportional part to the one that would be covered by the project.

Figure 4 shows the project boundary. Boxes with CO_2 emissions represent emissions from fossil fuel burning. Strictly, there are also extremely small quantities of methane and nitrous oxide from fossil fuels burning (see Section E).

GHG emission sources of the project:

The project does not generate emissions during generation of electricity, except for a potential small amount of methane from the flooding of the near areas.

There are anthropogenic GHG emissions in the upstream lifecycle stages of the electricity generation process. The stages with the most important sources of GHG emissions are those of materials processing, component manufacture and transportation of materials and fuel burning during the use of construction machinery. Only the latter are considered.

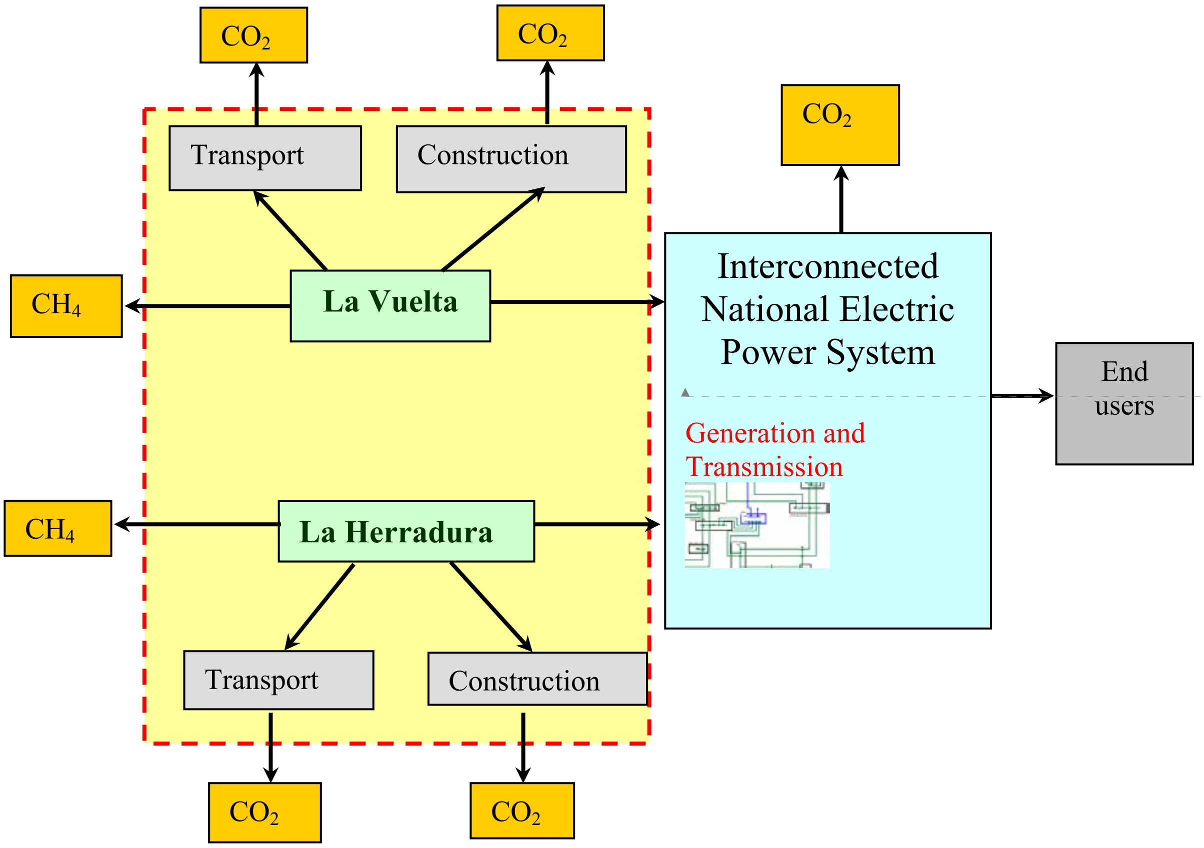


Figure 4: Project boundary (red line represents the project boundary)

In Figure 4 transport boxes stand for emissions of the transportation of materials and people by trucks and medium-size vehicles and fuel consumption of machinery used during the construction phase of the plants. Emissions are estimated from standard default values as provided by the Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories.

Direct emissions of the project are thus the almost negligible amount of methane emissions, and carbon dioxide (and in a minor extent methane and nitrous oxide) from transportation. Section E shows the explicit calculation of these two project emission contributions, which can be bounded by a maximum empirical value (see Section E.1).

Leakage:

No leakage is envisaged to be included according to the proposed methodology.

B.5. Details of baseline information, including the date of completion of the baseline study and the name of person (s)/entity (ies) determining the baseline:

Detailed baseline information is provided in Annex 3 to this PDD.

Date of completion of the baseline study: 30 May 2005

Baseline study prepared by

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F. Gaioli is not a project participant.

SECTION C. Duration of the project activity / Crediting period

C.1 Duration of the project activity:

C.1.1. Starting date of the 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 grounds and construct and improve ways 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 8 and 9 show the construction schedule for each plant.

Table 8: 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 9: 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 the project activity:

50 years

C.2 Choice of the crediting period and related information:

C.2.1. Renewable crediting period

C.2.1.1. Starting date of the first crediting period:

01/01/2005

C.2.1.2. Length of the first crediting period:

7 years

C.2.2. Fixed crediting period:

Not selected

C.2.2.1. Starting date:

C.2.2.2. Length:

SECTION D. Application of a monitoring methodology and plan

D.1. Name and reference of approved monitoring methodology applied to the project activity:

There is no methodology choice available in the UNFCCC web site. This project only requires a straightforward monitoring methodology. The proposed name for this new monitoring methodology is:

"Monitoring methodology for new capacity that displaces electricity generation in a centrally dispatched hydrothermal interconnected power system."

D.2. Justification of the choice of the methodology and why it is applicable to the project activity:

According to the baseline methodology developed for this project and taking into consideration anthropogenic GHG emissions generated by the project activity the selection of the monitoring plan is quite straightforward. Thus the monitoring methodology accounts for all data collection relevant to determine verifiable emission reductions achieved by the project. The baseline methodology clearly explains the steps followed for determining the baseline and Section E shows the steps from which emission reductions can be inferred. Therefore these steps allows one to identify key parameters, variables, and data sources that must be monitored in order to have a follow up of the registered CDM project activity. For this reason, once key issues are identified, the proposed new methodology directly applies to the present project in a consistent way.

The main data is divided into two categories, one related to specific GHG abatement matters and the other with environmental, social, and economic project performance.

GHG related data:

- Historical hydrological series and model input data (power plants configurations, transmission grid characteristics, etc.).
- Annual electricity demand, as reported by UPME.
- Power plant emission factors related data (annual fuel consumption, heat rates, lower heating values).
- Monthly electricity generation of La Vuelta and La Herradura hydroelectric plants, as routinely measured by EE.PP.M. (The EEPPM is likely to be taking measurements every hour, but we will only consider the monthly results.)
- Annual electricity generation of all thermal plants serving the interconnected national system, as provided by the National Dispatch Center (CND).
- Annual share of thermal and hydro-electricity in the grid.

Non-GHG related data:

- EE.PP.M executes an Environmental Management Plant in order to deal with environmental, social and economic aspects of the region and their inhabitants. A following of this plan is performed and reported each three months. Several programs were created under this plan (impacts management, monitoring, and contingency) reflecting EE.PP.M commitment with sustainable development and will continue during project implementation. The company will deliver the monitoring of the environmental development of the project to the same consultants that have prepared the Follow up of the Environmental Management Plan, by controlling water quality, which is the most relevant parameter to be controlled under the project activity implementation phase.

A detailed of the monitoring procedure for this project can be designed in a spreadsheet form, structurally very similar to that used in order to determine baseline emissions and estimate emission reductions. The assumptions defining emissions factors are the same in each case. Baseline emissions depend on electricity generation of the hydroelectric plants and electricity generation of all thermal plants, and are determined in a dynamic manner from data entered into the monitoring spreadsheet. The spreadsheet thus also determines emissions reductions as a result of project implementation.

EE.PP.M has many years with proven experience in the electricity market and carries out conventional procedures to give continuity to controls 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. If the validator considers that additional information is needed it will be provided under request.

D.2.1. Option 1: Monitoring of the emissions in the project scenario and the baseline scenario

D.2.1.1. Data to be collected in order to monitor emissions from the project activity, and how this data will be archived:

ID number *(Please use numbers to ease cross-referencing to D.3)*	Data variable	Source of data	Data unit	Measured (m), calculated (c) or estimated (e)	Recording frequency	Proportion of data to be monitored	How will the data be archived? (electronic/paper)	Comment

There are no project emissions that require monitoring.

D.2.1.2. Description of formulae used to estimate project emissions (for each gas, source, formulae/algorithm, emissions units of CO_2 equ.)

As it is stated in baseline methodology project emissions are: Methane emissions due to biomass decomposition in flooded areas by the project:

Since some confusion remains over this issue, mainly as a consequence of disregarding the project scale into the discussion, an extremely conservative assumption is proposed, consisting of bounding methane emissions by an upper limit extracted from literature.

For example, Hydro Québec[18] has collected information from several serious studies and provide methane emission factors for different kind of power plants in terms of electricity output, when the so-called life-cycle assessment is carried out, including emissions from fuel extraction, processing and transportation, as well as from power plant construction and electricity generation. The result obtained by applying this proposal must be compared with other already suggested approaches and with emissions one step upstream estimated independently in a more direct way.

The annual average methane emissions can be estimated by:

$$\text{Emissions (tonne } CO_2e\text{/year)} = \text{Generation (GWh/year)} \times \text{Emission factor (tonne } CO_2e\text{/GWh)} \quad \text{(D.1)}$$

[18] Greenhouse Gas Emissions from Power Generation Options, by Luc Gagnon, Hydro Québec (January 2003). http://www.hydroquebec.com/environment.

This methodology proposes to use the World Bank approach,[19] whereby methane emissions can be estimated from equation (D.7. 2), below. Hydro Québec values can be optionally considered as a cross check.

Flooding of land due to the construction of hydroelectric dams and reservoirs, construction or preservation of wetlands, or other land-use activities results in emissions of CH_4 generated by the anaerobic decomposition of (1) vegetation on the flooded land, (2) vegetation that re-grows in the water, dies, and settles to the bottom, and (3) soil carbon.

Methane emissions from the flooding of land are calculated as the product of (1) the area of land to be flooded, (2) the number of days per year that the land is flooded, and (3) an average daily CH_4 emission rate. This rate, expressed in units of mg CH_4-C/m^2-day, varies according to land type, climate, and duration of flooding.

Annual emissions of methane are calculated according to equation (D.2). As explained above, in spite of the fact that the flooded area does not give rise to organic matter decomposition, a precautionary value is even reported.

Area of Flooded Land	×	Duration of Flooding	×	Average Daily CH_4 Emission Rate	×	Conversion Factor	×	Molecular/ Atomic Weight Ratio	=	Annual CH_4 Emissions Produced
(m^2)		(days/year)		(mg CH_4-C/m^2-day)		(tonne/mg)		(tonne CH_4/ton CH_4-C)		(tonne CH_4/year)

Estimation of methane emissions from land flooding (D.2)

[19] Greenhouse Gas Assessment Handbook, A Practical Guidance Document for the Assessment of Project-level Greenhouse Gas Emissions, Paper Nº 064, Sept. 1998, The World Bank.

D.2.1.3. Relevant data necessary for determining the baseline of anthropogenic emissions by sources of GHGs within the project boundary and how such data will be collected and archived:								
ID number *(Please use numbers to ease cross-referencing to table D.3)*	Data variable	Source of data	Data unit	Measured (m), calculated (c), estimated (e),	Recording frequency	Proportion of data to be monitored	How will the data be archived? (electronic/paper)	Comment
1	Historical hydrological series	Hydro-logical stations	m^3/s	m	monthly	100%	Electronic (spreadsheet) Paper	
2	Power plant and grid configuration data (a big set of parameters)	CND	-	m	monthly	100%	Electronic (spreadsheet) Paper	
3	Annual electricity demand of the Colombian SIN (*D*)	UPME	*GWh/ year*	m	yearly	100%	Electronic (spreadsheet) Paper	Data will be monitored monthly although annual values will be used for calculation.
4	Annual electricity generated by La Vuelta and La Herradura hydro plants (g_P)	EE.PP.M	*GWh/ year*	m	hourly but registered on a monthly basis	100%	Electronic (spreadsheet) Paper	Data will be monitored monthly although annual values will be used for calculation.
5	Annual electricity generated by thermal power plant *n* of the Colombian SIN (g_n)	CND	*GWh/ year*	m	monthly	100%	Electronic (spreadsheet) Paper	Data will be monitored monthly although annual values will be used for calculation.

6	Specific consumption of thermal power plant *n* for the fuel *f* ($sc_{n,f}$)	CND	*tonne fuel/ GWh*	m	monthly	100%	Electronic (spreadsheet) Paper	
7	Lower heating value of fuel *f* (LHV_f)	UPME	*TJ/ ktonne fuel*	m	monthly	100%	Electronic (spreadsheet) Paper	
8	Share of thermal and hydro-electricity in the grid	UPME	-	m	yearly	100%	Electronic (spreadsheet) Paper	

D.2.1.4. Description of formulae used to estimate baseline emissions (for each gas, source, formulae/algorithm, emissions units of CO_2 equ.)

The baseline is supposed to be applied to electricity generation projects in centrally dispatched interconnected hydrothermal systems, under the assumption that the project displaces a portion of thermal energy that would have been delivered by other thermal plants serving the system in the absence of the proposed project activity.

The following steps identify the baseline methodology.

Step 1

Collect data needed to run the simulation dispatch model. These data are obtained from verifiable and/or official sources. National and sectoral circumstances influencing the baseline are included in this step, gathering information on characteristics of the interconnected electricity system, historical trends and activity levels, capacity expansion plans, prospective analyses on future electricity demand, fuel prices, unavailability of generation plants and transmission lines, programmed maintenance activities, energy reserves, historical hydrology, scenario analysis under political and economic trends of the sector and the country, relevant data for estimating emission factors (net calorific values, physical properties and chemical composition of fuels, specific emission factors for fuels used in the local industry, efficiencies, etc.). See Section E.2 and step 3 below.

Step 2

Estimate the power plant emission factors per unit of generated energy for the fuel *f*, based on local or national data and eventually using default values from international sources (IPCC, International Energy Agency, etc.). The already collected necessary data in step 1 is going to be used in this step. Equation (D.6.1) proposes an alternative way of estimating the emission factors, $ef_{n,f}$, corresponding to each thermal power plant centrally dispatched in the interconnected system.

$$ef_{n,f}\,(tonne\ CO_2\,/\,GWh) = sc_{n,f}\,(ktonne\ fuel\,/\,GWh) \times EF_f\,(tonne\ CO_2\,/\,TJ) \times LHV_f\,(TJ\,/\,ktonne\ fuel) \times OF_f, \quad \text{(D.6.1)}$$

where $sc_{n,f}$ is the specific consumption of the plant *n* for the fuel *f*, EF_f is the carbon dioxide emission factor of the fuel *f*, and LHV_f is the lower heating value of the fuel *f*. These factors are adjusted for incomplete combustion, OF_f, taking into account combustion efficiency default values for the different fuels burned in thermal power plants. Other alternatives can be used, depending on the initial data that can be obtained. In the absence of reliable base information, IPCC default values should be used, from the Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories.

Emission factors are going to be recalculated every time there are relevant changes in the power plants of the electricity grid (e.g. due to efficiency improvements, retrofits, inclusion of new plants, plant shutdown, fuel substitution, power capacity redefinition, etc.) and the information is available. These emission factors shall be revised every year, when the dispatch model is re-run.

Step 3

Load input data into the software platform to run the simulation model. These data include, among others (see a complete set of parameters in Section E.2 below):

a. Configuration and topology of the power plants belonging to the interconnected system and operating data. This includes technical data of the power plants and the system; identification of the centrally dispatched power plants; specific technology; nominal and net capacity; water flow, production factor and storage capacity of hydro plants; fuel efficiencies and specific consumption of thermal plants; bar and load data of the transmission lines; etc. (Section E.2 deals with these data in more detail).
b. Historical hydrology of the year for which the simulation is run.
c. Electricity demand of the year for which the simulation is run.
d. Load curve discriminated in five hourly demand blocks.
e. Annual distribution of new plants according to the Reference Expansion Plan prior to project implementation (for the simulation without the project activity, step 5 below) and actual additions to the system (for the simulation with the project activity, step 6 below).

Step 4

Build margin: In order to determine the influence of the project in investment decisions and the impact it causes delaying the construction of new power plants, the following approach applies.

Sub-step 4.1.1. Identify and list the power plants that are going to enter into operation for every year during the period covered by the expansion plan.

Sub-step 4.1.2. Set the date of entering into operation of the power plants listed in sub-step 4.1.1 (according to the dates established in the expansion plan), which will remain fixed for the entire period covered by the expansion plan. That is, every year when the dispatch model is run, the above listed set of plants will be loaded into the simulation (under the assumption that they belong to the sceanrio that would have occurred in the absence of the porject activity). Actual evolution of the system additions should reflect the delay introduced by the presence of the proposed project activity. This is a conservative assumption, because the situation that will typically happen in practice is that power plants are actually delayed more time than the one expected to occur due to build margin effects. In that case, the baseline is including more efficient power plants (under the logical assumption that the expansion plan is tending to increase efficiency of the system). Therefore, baseline emissions are lower than those that would have been ocurred, thus lowering emission reductions of the project. Otherwise, build margin effects would have been not relevant at all, but even in this case the approach is conservative.

Operating margin:

Step 5

Run the simulation model without including the project and considering the latest expansion plan published just prior[20] to project implementation. The additions considered in this expansion plan will be fixed and used for running the dispatch model every year, during the period covered by the expansion plan. After the end of this period, the simulation shall be run with the power plant system composition that have occurred every year (the same used for the simulation that includes the project).

Step 6

Run the simulation model including the project and the capacity additions that have occurred during the year that is used in the *ex post* simulation. This procedure shall be repeated every year during the crediting period.

Step 7

Gather the outputs (daily power plants generation, $\tilde{g}_{n\pm}$, where "+" stands for the simulation with the project and "–" without the project) in order to estimate relevant emissions from steps 5 and 6, formatted in MS Excel files on a monthly and yearly easily-to-handle basis. Here, "~" stands for variables estimated through the simulation model, to distinguish them from the same variables obtained in real conditions.

This step can be considered the first step of the methodology after running the simulation model (the model is an already sound computer program, and only input and output are relevant).

Step 8

Calculate annual emissions of thermal power plant *n*, $\tilde{e}_{n+}$, for the simulation performed in step 6.

$$\tilde{e}_{n+}(tonne\ CO_2\,/\,year) = \sum_f \tilde{g}_{n+,f}\,(GWh\,/\,year) \times ef_{n,f}\,(tonne\ CO_2\,/\,GWh), \qquad \text{(D.6.2)}$$

where $\tilde{g}_{n+,f}$ is the electricity generated by the thermal power plant *n* in a year, while consuming the fuel *f* (in case that more than one fuel is consumed by the power plant *n*). For the sake of simplicity, from now on it goes without saying that different fuels can be involved in $\tilde{g}_{n+}$.

Step 9

Calculate total CO_2 emissions per year, $\tilde{E}_{+}^{(th)}$, of the thermal power plants serving the system from results derived in step 8.

$$\tilde{E}_{+}^{(th)}(tonne\ CO_2\,/\,year) = \sum_{n=1(th)}^{N} \tilde{e}_{n+}\,(tonne\,CO_2\,/\,year), \qquad \text{(D.6.3)}$$

[20] This plan can be the most recent expansion plan published by an official and reliable source (e.g. a government agency), but not beyond the last two years (i.e. a project activity that starts operation in 2006 shall use the latest expansion plan, which could be the one corresponding to the years 2004, 2005, or 2006).

where N is the number of thermal plants in the system and the sum extends only over thermal (th) plants.

Step 10

Calculate the total amount of thermal electricity generated in a year, $\tilde{G}_{\pm}^{(th)}$, from results of steps 5 and 6 (with (+) and without (–) the project).

$$\tilde{G}_{\pm}^{(th)}\,(GWh/\,year) = \sum_{n=1(th)}^{N} \tilde{g}_{n\pm}\,(GWh/\,year)\,. \qquad \text{(D.6.4)}$$

Step 11

Obtain the annual average CO_2 emissions, $\langle \tilde{E} \rangle_+$, of the thermal plants serving the system, combining steps 9 and 10.

$$\langle \tilde{E} \rangle_+\,(tonne\;CO_2/\,GWh) = \tilde{E}_{+}^{(th)}\;(tonne\;CO_2/\,year)\,/\,\tilde{G}_{+}^{(th)}\;(GWh\,/\,year). \qquad \text{(D.6.5)}$$

Step 12

Calculate the thermal generation displacement factor, $\tilde{F}$, as the rate between the difference of the energies obtained in step 10 ('without the project' minus 'with the project') over the energy generated by the project itself.

$$\tilde{F} = \frac{\tilde{G}_{-}^{(th)} - \tilde{G}_{+}^{(th)}}{\tilde{g}_P}\,. \qquad \text{(D.6.6)}$$

$\tilde{F}$ is the only parameter obtained from simulation model results. It allows one to correlate emissions, when the power system includes the proposed project activity, with those that would have occurred in the absence of the proposed project activity. $\tilde{G}_{+}^{(th)}$ and $G_{+}^{(th)}$ as well as $\tilde{g}_P$ and g_P shall be compared during monitoring in order to decide whether $\tilde{F}$ remains realistic.

Step 13

Calculate baseline emissions.

Baseline emissions are defined as:

$$E_B \equiv g_P \times \left\langle \widetilde{F} \right\rangle \times \left\langle E \right\rangle_+ . \quad \text{(D.6.7)}$$

The last equation is the key equation of the proposed methodology. It reads: baseline emissions represent the amount of thermal plant emissions displaced by the project activity, where $\left\langle \widetilde{F} \right\rangle$ accounts for the fraction of this thermal energy with respect to the energy generated by the project; $\left(1-\left\langle \widetilde{F} \right\rangle\right)$ is the hydroelectric energy displaced by the project. Moreover, $\left\langle \widetilde{F} \right\rangle \times \left\langle E \right\rangle_+$ can be considered as a system emission factor, $\left\langle E \right\rangle_{sys}$, which includes part of the hydroelectric contribution. Every year a new value of $\left\langle \widetilde{F} \right\rangle$ is calculated running the simulation model again to update results with actual data. This is an important step since hydrothermal systems with reservoirs storing water for use during dry seasons alter the marginal dispatch by shifting thermal emissions and thus making unviable an estimation of emission reductions as that achieved by displacing marginal plants on a hourly or daily basis. The simulation model itself provides reliable outputs when considering the long-term behaviour of the hydrothermal system. This is one of the main characteristics of the systems to which the methodology applies.

Recall that $\left\langle \widetilde{F} \right\rangle$ is different from 1 because a part of the displaced energy generation is also hydroelectric, due to the value of water and consequent storage by hydropower generators, implying that some hydro plants are at the margin (this is one of the main characteristics of a hydrothermal interconnected system), and also because a part of thermal energy cannot be displaced due to transmission capacity limitations.

No ~ is written in $\left\langle E \right\rangle_+$ and g_P since they are calculated in actual conditions. $\left\langle \widetilde{E} \right\rangle_+$ and $\widetilde{g}_P$ are only used from the model in order to perform the first estimation of baseline emissions, but not for monitoring purposes.

The factor $\left\langle \widetilde{F} \right\rangle$ includes the information about the situation that would occur without implementing the proposed project activity. But this situation never happens in reality, then the methodology, Equation (D.6.7), provides a way to estimate avoided emissions due to the project activity, monitoring *ex post* variables and fixing a parameter. The advantage of this formulation is motivated by the fact that, under actual conditions, it is not possible to obtain power plant generation, g_{n-} (since they can only be estimated through the simulation model). The parameter fixed through the simulation has less sensitivity to variations in real conditions, since $\left\langle \widetilde{F} \right\rangle$ is based on the difference between correlated scenarios (under the same assumptions and input data).

Running the simulation model again, after actual conditions have happened every year, allows obtaining more accurate baseline emissions, but nevertheless depending on the simulation of a situation that does not happen in reality but that can be strongly correlated to actual conditions regarding hydrology, demand, and system capacity.

Output results can be obtained in a daily, monthly, or yearly basis. It is recommended to use a monthly basis –to save disk space– and thus combining these data to obtain annual values. This completes the overall description of the proposed baseline methodology steps.

To improve accuracy the simulation model shall be re-run every year based on updated data.Then, only the calculations for the first year are provided and extrapolated to the first crediting period. Actual values will be obtained through the application of the methodology as regards re-running the dispatch model at the end of every year.

D.2.2. Option 2: Direct monitoring of emission reductions from the project activity (values should be consistent with those in section E).

Not selected

D.2.2.1. Data to be collected in order to monitor emissions from the project activity, and how this data will be archived:								
ID number *(Please use numbers to ease cross-referencing to table D.3)*	Data variable	Source of data	Data unit	Measured (m), calculated (c), estimated (e),	Recording frequency	Proportion of data to be monitored	How will the data be archived? (electronic/paper)	Comment

D.2.2.2. Description of formulae used to calculate project emissions (for each gas, source, formulae/algorithm, emissions units of CO_2 equ.):

D.2.3. Treatment of leakage in the monitoring plan

D.2.3.1. If applicable, please describe the data and information that will be collected in order to monitor leakage effects of the project activity

ID number *(Please use numbers to ease cross-referencing to table D.3)*	Data variable	Source of data	Data unit	Measured (m), calculated (c) or estimated (e)	Recording frequency	Proportion of data to be monitored	How will the data be archived? (electronic/ paper)	Comment

No leakage is perceived to occur under this approach.

D.2.3.2. Description of formulae used to estimate leakage (for each gas, source, formulae/algorithm, emissions units of CO_2 equ.)

D.2.4. Description of formulae used to estimate emission reductions for the project activity (for each gas, source, formulae/algorithm, emissions units of CO_2 equ.)

D.3. Quality control (QC) and quality assurance (QA) procedures are being undertaken for data monitored

Data *(Indicate table and ID number e.g. 3.1.; 3.2.)*	Uncertainty level of data (High/Medium/Low)	Explain QA/QC procedures planned for these data, or why such procedures are not necessary.
1 Historical hydrological series	Medium	These data will be taken from hydrological stations, and those reporting to the National Dispatch Center.
2 Power plant and grid configuration data (a big set of parameters)	Medium	These data will be taken from the National Dispatch Center.

3 Annual electricity demand of the Colombian SIN (*D*)	Low	These data will be obtained from official sources.
4 Annual electricity generated by La Vuelta and La Herradura hydro plants (g_p)	Low	These data will be directly used for calculation of emissions reductions. QA/QC procedures are those requested by the electricity regulation entity.
5 Annual electricity generated by thermal power plant *n* of the Colombian SIN (g_n)	Low	These data will be used as supporting information to calculate emission reductions by project activity. QA/QC procedures are those requested by the electricity regulation entity.
6 Specific consumption of thermal power plant *n* for the fuel *f* ($sc_{n,f}$)	Medium	These data will be updated when it is necessary. Information cross-check shall be used to assure and control quality.
7 Lower heating value of fuel *f* (LHV_f)	Medium	These data will be updated when it is necessary. Information cross-check shall be used to assure and control quality.
8 Share of thermal and hydro-electricity in the grid	Low	These data serve for controlling model assumptions along time. National entities provide these data on a quite reliable basis.

D.4 Please describe 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

Calibration of energy equipments follows national standards, according to the calibration instructive specified in Colombian norm NTC 4856 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 2288, 2147, and 4052 standards, and to reactive energy meters manufactured according to NTC 2148 and 4569 standards. EE.PP.M has adopted its own procedure based on the Colombian technical norm NTC-ISO-IEC 17025 and NTC 4856, 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 allocated to 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 telemeasurement technology. The “Equipo de Medida” is in charge of measurements. This team sends the information on daily generation to the “Centro de Control Tasajera”, which receives all the information of the power plants adscribed to the Metropolitan Area. From this center the power plants dispatch is executed. It informs to the “Centro de Control Generación”, also called “Subestación Colombia”, located in Medellín. This center 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 center is connected to the "Centro de Control de Generación Nacional", which is the national center in charge of power plants operation.

D.5 Name of person/entity determining the monitoring methodology:

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F. Gaioli is not a project participant.

SECTION E. Estimation of GHG emissions by sources

E.1. Estimate of GHG emissions by sources:

a) Methane emissions due to biomass decomposition in flooded areas by the project

There is not an already universally accepted methodology for quantifying methane emissions from dams. There only exist isolated studies which have calculated methane emissions from some measurements on an modeling basis. These data is used sometimes as statistical information to provide some upper bounds for methane release. IPCC has not provided any special recommendation on this issue.

La Vuelta and La Herradura plants are placed over the high slope La Herradura river. The two run-of-river plants only need derivation structures –concrete irrigation water wheels of 7 meters high– for deviating water flows to the power-house intakes. They regulate flows on a daily basis to transfer generation from one demand block to another (base- to peak-load hours, in order to take price advantages). This kind of plants are considered as plants without dams,[21] 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 m^2 (La Vuelta) and 3,194 m^2 (La Herradura). The vegetation in these areas (backwater along the river-bed) corresponds to very small portions of grass since it was removed during the digging works. Thus no methane emissions are expected.

Several studies have shown that methane emissions are time-dependent, since they are related to organic decomposition in anaerobic conditions, which also depends on water deepness, climate conditions or region –boreal or tropical–, reservoir size, kind of vegetation, etc.).

Hydro Québec[22] has shown that methane emissions for run-of-river hydro plants with the best commercial technology (very good sites for renewables) in North America are bounded by approximately 3 tonne CO_2e/GWh, when the so-called life-cycle assessment is carried out, including emissions from fuel extraction, processing and transportation, as well as from power plant construction and electricity generation. The result obtained by applying this proposal must be compared with other already suggested approaches and with emissions one step upstream estimated independently in a more direct way. This only serves for this PDD to show the negligible order of magnitude involved in that sources of GHG emissions.

The main characteristics of the subprojects are (considering a maximal generation case) (see Table 10):

Table 10: Main characteristics of the subprojects

Hydro plant	Capacity (GW)	Utilization factor (%)
La Vuelta	0.0117	74.24
La Herradura	0.0198	89.88

Taking into consideration that

$$\text{Generation (GWh/year)} = \text{Capacity (GW)} \times \text{Utilization Factor} \times 8{,}766 \text{ hours/year} \quad (E.1)$$

electricity generation is 76.14 GWh/year (La Vuelta) and 156 GWh/year (La Herradura).

[21] Moreover, plants that can storage water for ten days are considered as plants without dams.
[22] Greenhouse Gas Emissions from Power Generation Options, by Luc Gagnon, Hydro Québec (Jaunary 2003). http://www.hydroquebec.com/environment.

To give an estimation of potential methane emissions in terms of project scale, in annual average, they are given by[23]

Emissions (t CO_2e/year) = Generation (GWh/year) × Emission factor (t CO_2e/GWh)				
La Vuelta:	228 t CO_2e/year;	La Herradura:	468 t CO_2e/year	(E.2)
Total:	**696 t CO_2e/year**			

On the other hand, following World Bank guidelines on this matter, methane emissions can be estimated from equation (E.3), below.

Flooding of land due to the construction of hydroelectric dams and reservoirs, construction or preservation of wetlands, or other land-use activities results in emissions of CH_4 generated by the anaerobic decomposition of (1) vegetation on the flooded land, (2) vegetation that regrows in the water, dies, and settles to the bottom, and (3) soil carbon. The CH_4 emissions from flooding vary according to the type and condition (i.e., biomass content) of the ecosystem that is flooded, as well as the depth and duration of flooding. Methane emissions from flooded lands are also strongly dependent on temperature, and therefore vary seasonally as well as daily. Flooding may also generate net emissions of N_2O and CO_2; however, these emissions are not accounted for at present because the flux of these gases resulting from flooding is highly uncertain.

Methane emissions from the flooding of land are calculated as the product of (1) the area of land to be flooded, (2) the number of days per year that the land is flooded, and (3) an average daily CH_4 emission rate. This rate, expressed in units of mg CH_4-C/m^2-day, varies according to land type, climate, and duration of flooding.[24]

Annual emissions of methane are calculated according to equation (E.3). As explained above, in spite of the fact that the flooded area does not give rise to organic matter decomposition, a precautionary value is even reported.

[23] Actually, the calculation of methane emissions, year by year, from the outputs of the simulation model regarding La Vuelta and La Herradura electricity generation can be performed. But the intention is only to show the order of magnitude, since emissions are explicitly calculated. The idea behind showing this alternative approach is to reduce uncertainty about these controversial emissions.

[24] Greenhouse Gas Assessment Handbook, A Practical Guidance Document for the Assessment of Project-level Greenhouse Gas Emissions, Paper Nº 064, Sept. 1998, The World Bank.

Area of Flooded Land	×	Duration of Flooding	×	Average Daily CH_4 Emission Rate	×	Conversion Factor	×	Molecular/ Atomic Weight Ratio	=	Annual CH_4 Emissions Produced
(m^2)		(days/year)		(mg CH_4-C/m^2-day)		(t/mg)		(t CH_4/ton CH_4-C)		(t CH_4/year)

Estimation of methane emissions from flooding of land (E.3)

where the Emission Rate is assumed as 75 mg CH_4-C/m^2-day (average value as proposed for floodplains in the Greenhouse Gas Assessment Handbook, A Practical Guidance Document for the Assessment of Project-level Greenhouse Gas Emissions, Paper Nº 064, Sept. 1998, The World Bank), the Area of Flooded Land is taken from existing data of the project activity (9,375 m^2), the Duration of Flooding is taken as the maximum possible value, 365.25 days, the Conversion Factor is equal to 10^{-9} t/mg, and the Molecular/Atomic Weight Ratio is 16 tonne CH_4/12 tonne CH_4-C.

Applying equation (E.3) maximum project methane emissions are obtained: **7 tonne CO_2e/year**
This value is far enough from the one obtained with equation (E.2). The difference is mainly attributed to construction and transportation CO_2 emissions (see item (b) below).

E.2. Estimated leakage:

There is not leakage in this project.

E.3. The sum of E.1 and E.2 representing the project activity emissions:

Only emissions of Section E.1 are involved. Therefore they only account for emissions of methane from the reservoir (E.3). It gives:

$$E_P\ (tonne\ CO_2e) = E_{reservoir}\ (tonne\ CO_2e), \qquad (E.4)$$

where E_P are project emissions. Applying the results obtained above, these emissions are:

E_P = **7 tonne CO_2e** for the first crediting period (2006-2011)

Total emissions per year (7 tonne CO_2e/year) are below the bound given by Hydro Québec, 696 tonne CO_2e/year [see equation (E.2)]. It can be considered as a cross-check of the results obtained under emission sources which are certainly difficult to quantify with high accuracy. These emissions will be neglected for the rest of the analysis.

E.4. Estimated anthropogenic emissions by sources of greenhouse gases of the baseline:

To estimate anthropogenic GHG emissions the steps 1 to 13 proposed in the baseline methodology and considered in Section D.2.1.4 are followed.

The values obtained from the application of equations (D.1) to (D.10) are compiled in Annex 3.

E.5. Difference between E.4 and E.3 representing the emission reductions of the project activity:

Emission reductions are obtained as the difference between equation (D.10), representing baseline emissions, and emissions of equation (E.4), representing project emissions. Equation (E.5) shows emission reductions, *ER*, of the project activity:

$$ER \text{ (tonne } CO_2e\text{/year)} = E_B \text{ (tonne } CO_2e\text{/year)} - E_P \text{ (tonne } CO_2e\text{/year)}. \quad (E.5)$$

E.6. Table providing values obtained when applying formulae above:

years	Estimation of project activity emissions E_P (tonnes CO_2)	Estimation of baseline emissions E_B (tonnes CO_2)	Estimation of leakage L (tonnes CO_2)	Estimation of emission reductions ER (tonnes CO_2e)
2005	0	70,000	0	70,000
2006	0	70,000	0	70,000
2007	0	70,000	0	70,000
2008	0	70,000	0	70,000
2009	0	70,000	0	70,000
2010	0	70,000	0	70,000
2011	0	70,000	0	70,000
Total (tonnes CO_2)	0	490,000	0	490,000

SECTION F. Environmental impacts

F.1. Documentation on the analysis of the environmental impacts, including transboundary 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.

F.2. If environmental impacts are considered significant by the project participants or the host Party, please provide conclusions and all references to support documentation of an environmental impact assessment undertaken in accordance with the procedures as required by the host Party:

Considering its historical commitment with the environment, 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[25] 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 area 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 specially due to coliforms, the macro-invertebrates in streams are clean waters indicators, with low occurrence and diversity. The area of the projects does not have wetlands ecosystems that can be affected.

The use of natural resources between local communities and projects did not 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 projects 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 removals will not take place. Only three dwellings will be removed, mainly for security reasons, since they are located on the edge of the new roads slopes. These families will be resettled within the same grounds, 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.

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 make the projects unfeasible will be generated, being the following the most relevant:

[25] 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.

- 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 projects, 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 these type of projects are, therefore, being fulfilled.

Finally, the characteristics and dimensions of the projects, together with the environmental characteristics of the region where they are 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, specially from the social point of view, emphasizing the transfers payment to the municipalities and Corpourabá, estimated at US$ 200,000/yearly during the project lifetime.

The environmental and social performance of the project is controlled under 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 measurement 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 trituration plant and concrete blending. 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 is HI-VOL, standardized by the US Environmental Protection Agency.

Into the social issues some topics are under control:

- Protection of the archeological heritage: devoted to recover pre-Hispanic cultural material which 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 active 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 periodic 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 G. Stakeholders' comments

G.1. Brief description how comments by local stakeholders have been invited and compiled:

The process followed to collect stakeholder comments was a consultation through a survey for the evaluation of the environmental performance of La Vuelta and La Herradura subprojects.

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 projects?
2. Is the implementation of projects able to improve the environmental situation in the region?
3. How does the development of projects 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.

G.2. Summary of the comments received:

A synthesis of the comments received is summarized in Table 12. The most important point highlighted by local stakeholders is added to the answers.

Table 12: 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 authorities to develop projects of this nature?	yes	Yes	yes, improvement of life quality	yes	yes, contribution to 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	

G.3. Report on how due account was taken of any 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.

Annex 1

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Annex 2

INFORMATION REGARDING PUBLIC FUNDING

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

Annex 3

BASELINE DATA

Basic data and sources

Coal

	Item	Value	Units	Data sources
OF_{coal}	Oxidation Factor	0.98		Ref.1, Table 1-6 page 1.29 Coal - Fraction of carbon oxidised
CEF_{coal}	CO_2 emissions factor	94.6	ton CO_2/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.
MEF_{coal}	CH_4 emission factor	0.7	kg CH_4/TJ	Ref. 1, Table I-15 page 1.53. Coal - Pulverised Bitominous Combustion- Dry Bottom, wall fired
$MEF_{coal\text{-}CO2equiv}$	CH_4 emission factor (in CO_2equiv)	0.0147	ton CO_2e/TJ	Calculated MEF_{coal}x $GWP(CH_4)$/1000
NEF_{coal}	N_2O emission factor	1.6	kg N_2O/TJ	Ref. 1, Table I-15 page 1.53. Coal-Pulverised Bitominous Combustion- Dry Bottom, wall fired
$NEF_{coal\text{-}CO2equiv}$	N_2O emission factor (in CO_2equiv)	0.496	ton CO_2e/TJ	Calculated NEF_{coal}x $GWP(N_2O)$/1000
$GWP\ (N_2O)$	Global Warming Potential (N_2O)	310		Ref. 2, for nitrous oxide this was 310.
$GWP\ (CH_4)$	Global Warming Potential (CH_4)	21		Ref. 2, for methane this was 21.

Natural gas

	Item	Value	Units	Data sources
OF_{NG}	Oxidation Factor	0.995		Ref.1, Table 1-6 page 1.29 Gas - Fraction of carbon oxidised
CEF_{NG}	CO_2 emissions factor (combustion)	56.1	kg/GJ	Ref. 1, Table 1-1 pag 1.13. Natural gas (dry): 15.3 t C/TJ lower heating value basis. X 44/12 = 56.1 t CO_2/TJ.
MEF_{NG}	CH_4 emission factor	6	kg CH_4/TJ	Ref. 1, Table I-15 page 1.53. Natural gas - Large gas-Fired gas turbines >3 MW
$MEF_{NG\text{-}CO2equiv}$	CH_4 emission factor (in CO_2equiv)	0.126	ton CO_2e/TJ	Calculated MEF_{NG}x $GWP(CH_4)$/1000
$GWP\ (CH_4)$	Global Warming Potential (CH_4)	21		Ref. 2, for methane this was 21.

The CO_2 emission factors of thermal power plants in the Colombian interconnected system are shown in the table below.

Name	Fuel	Type	Capacity, MW	Emission Factor (t CO_2/GWh)
BARRANCA 1	nat gas	steam	12	608.08
BARRANCA 2	nat gas	steam	12	619.55
BARRANCA 3	nat gas	steam	63	690.76
BARRANCA 4	nat gas	simple cycle	30	746.62
BARRANCA 5	nat gas	steam	20	740.5
BARRANQUILL3	nat gas	steam	64	574.33
BARRANQUILL4	nat gas	steam	65	579.8
CANDELARIA1	nat gas	simple cycle	150	556.63
CANDELARIA2	nat gas	simple cycle	150	575.21
CARTAGENA 1	nat gas	steam	60	651.77
CARTAGENA 2	nat gas	steam	50	772.55
CARTAGENA 3	nat gas	simple cycle	67	674.06
CC_COSTA1	nat gas	TBD	150	370.63
CC_COSTA2	nat gas	TBD	300	370.63
EMCALI	nat gas	comb cycle	233	403.21
FLORES 1	nat gas	comb cycle	150	422.2
FLORES 2	nat gas	comb cycle	99	616.96
FLORES 3	nat gas	comb cycle	550	370.63
GUAJIRA 1	nat gas	steam	151	572.5
GUAJIRA 2	nat gas	steam	151	564.45
MERILECTRICA	nat gas	simple cycle	154	581.5
OCOAFO	nat gas	TBD	27	474.83
PAIPA 1	coal	steam	28	1,350.27
PAIPA 2	coal	steam	68	1,214.27
PAIPA 3	coal	steam	68	1,221.51
PAIPA 4	coal	steam	150	965.73
PALENQUE 3	nat gas	steam	14	550
PROELECTRIC1	nat gas	TBD	45	477.86
PROELECTRIC2	nat gas	TBD	45	477.86
TASAJERO 1	nat gas	steam	155	585.62
TEBSAB	nat gas	simple cycle	750	412.91
TERMOCENTRO	nat gas	simple cycle	285	415.91
TERMODORADA1	nat gas	simple cycle	51	559.74
TERMOSIERRA	nat gas	comb cycle	470	370.63
TERMOVALLE 2	nat gas	steam	210	395.74
TPIEDRAS	nat gas	simple cycle	3	575.21
YUMBO3	coal	steam	29	1,624.65
ZIPAEMG2	coal	steam	35	1,225.33
ZIPAEMG3	coal	steam	62	1,150.12
ZIPAEMG4	coal	steam	62	1,141.26
ZIPAEMG5	coal	steam	63	1,089.79
BM POWER PLANT	nat gas	comb cycle	31.5	370.63

Annex 4

MONITORING PLAN

The monitoring plan permits the determination of anthropogenic GHG emissions generated by the project activity, and in the baseline, 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 thermal plants serving the interconnected national system and running the simulation model every year. Data should be collected on a monthly basis for the duration of the project lifetime and 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 CO_2 emissions from natural gas and coal combustion in the thermal plants. There are also some methane and nitrous oxide emissions from natural gas and coal combustion. Since this project involves new hydroelectric plants, project emissions are due to the construction of the power plants (which take place before power generation takes place) and methane emissions from the reservoir (which are assumed to be constant in time in this model). Thus, project GHG emissions are *entirely determined* before project implementation and remain unchanged throughout the crediting period.

However, baseline emissions are determined in a dynamic manner from monitored data, which also permit estimation of emission reductions achieved by the project activity. This type of project will require only straightforward collection of data, described below.

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

GHG related data:

- Simulation model input data.
- Monthly electricity generation of the project hydroelectric plant. EE.PP.M is likely to be taking measurements every hour, but we will only consider the monthly results.)
- Monthly electricity generation of all thermal plants serving the interconnected national system.
- The share of thermal and hydro-electricity in the grid.
- Changes of power plant emission factors (e.g. due to efficiency improvements, retrofits, inclusion of new plants, plant shutdown, fuel substitution, power capacity redefinitions, etc.), including reported annual thermal plant specific consumptions 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 model is an electronic GHG monitoring and calculation workbook for electricity generation projects to be connected to a 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.

The spreadsheet is structurally very similar to that used in order to determine baseline emissions and estimate emission reductions. Baseline emissions depend on electricity generation of the project activity and electricity generation of all thermal plants, and are determined in a dynamic manner from data entered into the spreadsheet. The spreadsheet thus also determines emissions reductions as a result of project implementation.

The staff of EE.PP.M responsible for Project monitoring should complete the electronic worksheets on a monthly basis. Given that some of these data may be collected more frequently, data need to be aggregated to allow monthly inputs into the spreadsheet. The spreadsheet automatically provides annual totals in terms of GHG reductions achieved through the implementation of the project.

The spreadsheet determines the emissions associated with project implementation. The model contains a series of worksheets with different functions:

- Data entry sheets:
    - *Historical hydrological series.*
    - *Annual electricity demand.*
    - *Power plant and grid configuration data.*
    - *Thermal power plant specific consumptions of each fuel.*
    - *Lower heating value of each fuel.*
    - *Monthly electricity generation of the project activity.*
    - *Monthly electricity generation of each thermal plant in the interconnected system.*
    - *Annual share of thermal and hydro-electricity in the grid.*
- Calculation sheets:
    - *Monthly thermal power plant emission factors.*
    - *Monthly and annual electricity generation of each thermal plant in the interconnected system, and the total.*
    - *Monthly and annual CO_2-equivalent emissions associated with each thermal plant, and the total.*
    - *Monthly difference between actual total thermal generation and that obtained from the simulation model.*
    - *Monthly difference between actual project generation and that obtained from the simulation model.*
    - *Monthly total CO_2-equivalent emissions in the baseline.*
- Result sheet:
    - *Monthly reduction of CO_2-equivalent emissions*

Annex 5

SUSTAINABLE DEVELOPMENT

Review of sustainable development criteria proposed by OCMCC

The Colombian Office for Climate Change Mitigation (Oficina Colombiana para la Mitigación del Cambio Climático, OCMCC) has prepared a draft version[26] of sustainable development criteria and indicators to be considered under the clean development mechanism of the Kyoto Protocol. The main issues under consideration by OCMCC are summarized as follows:

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

(a) *Property rights, rights over natural resources, certificates, license*s

The available documents are:

- Resolution # 194197 (October 24, 1997): original Environmental License for the construction and operation of the La Herradura Hydroelectric Power Plant, conceded to Hidroeléctrica La Herradura S.A. E.S.P. (this License includes the concession of water resources) by the Corporation for the Sustainable Development of Urabá (CORPOURABA).
- Resolution # 000702 (January 8, 2002): Cession of the already approved Environmental License from Hidroeléctrica La Herradura S.A. E.S.P. to Empresas Públicas de Medellín E.S.P., certified by the Corporation for the Sustainable Development of Urabá (CORPOURABA).
- Resolution # 159397 (August 21, 1997): original Environmental License for the construction and operation of the La Vuelta Hydroelectric Power Plant, conceded to Hidroeléctrica La Vuelta S.A. E.S.P. (this License includes the concession of water resources) by the Corporation for the Sustainable Development of Urabá (CORPOURABA).
- Resolution # 000402 (January 8, 2002): Cession of the already approved Environmental License from Hidroeléctrica La Vuelta S.A. E.S.P. to Empresas Públicas de Medellín E.S.P., certified by the Corporation for the Sustainable Development of Urabá (CORPOURABA).
- Resolution # 053702 (June 20, 2002): Modification of the Environmental License of La Herradura Hydroelectric Power Plant, as it was requested by EE.PP.M on February 21, 2002, due to variations of the original works in order to optimise the construction of the plant and reduce the environmental impacts (Ministry of Environment).

(b) *Environmental impact studie*s

The environmental impact studies available are:

- "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).

[26] "Criterios y Procedimientos para la Aprobación Nacional de Proyectos de Reducción de Emisiones de GEI Elegibles al Mecanismo de Desarrollo Limpio, Propuesta en Discusión (June 2003)", OCMCC, Bogotá D.C., Colombia. We acknowledge OCMCC for informally providing us with this draft version in order to improve our PDD preparation.

- "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).

These studies were transferred from EADE to EE.PP.M.

(c) *Compliance with local and national legislation*

There are several laws, decrees and plans to be followed and complimented in order to be authorized to implement the subprojects. These regulations were taken into account in the preparation of the environmental impact studies.

- Political Constitution of Colombia, 1991.
- Law 23, 1973 (Colombian Congress): through which extraordinary powers are granted to the President of the Republic to draw up the National Code of Natural Resources and of Protection of the Environment.
- Law 99, 1993 (Colombian Congress): through which the Environmental National System and the Ministry of the Environment are created.
- Decree 2811, 1974 (President of the Republic of Colombia): through which the National Code of Renewable Natural Resources and of Protection to the Environment is enacted.
- Decree 1753, 1994 (Ministry of the Environment): it regulates Environmental Licenses.
- Decree 1933, 1994 (Ministry of the Environment): it regulates article 45, Law 99, 1993, regarding transferences of the energy gross sales from the electric sector.
- Decree 1594, 1984 and Decree 1541, 1978 (Ministry of Health): through which the use of waters and liquid wastes are regulated.
- Decree 2104, 1983 (Ministry of Health): it regulates the solid waste disposition.
- Decree 541, 1994 (Ministry of the Environment): it regulates the management and final arrangement of materials removed.
- Resolution 2309, 1986 (Ministry of Health): it regulates the management of hazardous or special wastes.
- Decree 948, 1995 (Ministry of the Environment) and Decree 02, 1982 (Ministry of Health): they regulate atmospheric emissions.
- Decree 2206, 1983 (Ministry of Health): it substitutes Chapter XVI from Decree 02, 1982 about atmospheric emissions.
- Resolution 8321, 1983 (Ministry of Health): it regulates noise emissions.
- Decree 2811, 1974 (Ministry of Energy and Mining): it regulates the exploitation of alluvial material deposits.
- Decrees 2655, 1988 and 2642, 1989 (Ministry of Energy and Mining): they regulate the exploitation of materials from the quarry.
- Decree 2222, 1993 (Ministry of Energy and Mining): through which the sanitation and safety regulation is issued in open sky mining works.
- Resolution 655, 1996 (Ministry of the Environment): it establishes requirements and conditions for the request and obtaining of the environmental license established by article 132 of Decree-Law 2150, 1995.
- Development Plan of Frontino Municipality, elaborated in June 1995.
- Terms of Reference for the Environmental Impact Study, issued by CORPOURABÁ.

2. <u>Contribution and compatibility with government policy (local, regional, and national planning, programs and projects)</u>

Some extracts from documents with national policies and guidelines concerning the environment, related to the projects under study, are transcribed below.

1. **National Energy Plan 1997-2010**[2]

1.1. Features related to the environment in general

"Introduction

"The National Energy Plan –PEN– (1997-2010) states that in order to contribute to the Sustainable Human Development, it is fundamental the due consideration of energy-environment-economy-society interactions, as well as the establishment of environmental impacts along the energetic chain, to fix actions and corrective measures oriented to compensate unfavorable effects of energetic development and strengthen positive effects. The conservation and improvement of environmental quality, in all decision-making instances, productive processes and future investments in the sector, is one of the basic objectives of the integral strategy adopted by the country.

"The environmental management planning constitutes the principal instrument to direct the incorporation of the environmental dimension in the social and sectoral management of the energetic development in the country. Environmental management should be oriented to create accurate conditions for the development of the sector in the framework of policies and recommendations defined in the expansion plan, which addresses the consolidation of private investment participation in the development and conformation of the energy market, to meet technical, environmental and economic conditions that guarantee the proper service supply."

✓ Relation with the project:

La Vuelta and La Herradura hydroelectric projects are framed within the previous guidelines, since the environmental variable has been incorporated in all stages, together with the remaining economic and technical considerations making possible this sort of developments. Therefore, due environmental impact assessments have been forwarded and all licenses required by this sort of projects have been obtained, including the environmental license. Their costs have been incorporated within the overall costs of the project, making possible an adequate management of environmental impacts.

This working procedure of "Empresas Públicas de Medellín E.S.P." is a consequence of a historical commitment with the environment, materialized in the formulation of an entrepreneurial environmental policy that needs to incorporate the environmental variable in the development of all its projects, works and activities. This is a way to demonstrate its commitment with sectoral and national environmental policies.

1.2. Guidelines concerning environmental management and cleaner production

"9. Energetic Environmental Management

"The environmental national policy oriented to sustainable human development, tries to keep renewable resources, the redirection of its economic use and the conservation of the ethnical and cultural diversity of the nation, with the objective to promote a culture of development that takes into account social, technological and environmentally healthy consumption patterns, defining environmental improved programs such as: Protection of strategic ecosystems, better waters, seas and clean coasts, more forests, better cities, a clean production and the territorial ordering, as a fundamental instrument for the energetic and environmental planning of the country.

"The energy policy is oriented to rationalize the use of energy resources, guarantee their reliable and efficient supply, reduce costs, increase coverage, protect users and increase the contribution of exports to

[2] Republic of Colombia, Ministry of Energy and Mining, Energy and Mining Planning Unit. National Energy Plan 1997-2010.

the economy. The conservation and improvement of the environmental quality in all definite instances, productive processes and future investments of the sector is one of the basic objectives of the integral energetic strategy adopted by the country.”

“Support to cleaner production policy

“PEN recommends to develop and adopt cleaner technologies and promote the re-conversion program of the Colombian thermal park and refineries to clean technologies, according to policies and goals of pollution reduction and environmental impact. Special emphasis should be put on the energy efficiency increase of plants, and actions should be directed towards atmospheric emissions control.”

“9.4 Environmental Management Strategy

“Since the qualitative and quantitative knowledge of the current environmental impacts and the energy development potentials of the country are inadequate, as well as the actions and environmental investments required to create the conditions necessary for environmental sustainability for the country’s energy development, a strategy directed to define public and private environmental management should be defined to achieve PEN’s key objective.”

“Frame 9.1 Guidelines: Energy-Environment

- *Embedding of energy policy with environmental policy.*
- *GHG emissions estimate by means of energy sub-sectors.*
- *Implementation of instruments to incorporate a cleaner production policy in the energy sector.*
- *Strengthening of environmental management in the energy sector entities.*
- *Encouragement of the involvement of communities in the environmental management of infrastructure projects in the energy sector.*
- *Involvement of the energy sector in the environmental territorial development*
- *Participation and evaluation in the setting up of economic-environmental instruments.*
- *Implementation of a control system and follow up of environmental quality for the companies in the energy sector.*
- *Development of an energy-mining environmental information system.*
- *Monitoring of the energy sector impact on climate change, in the framework of international commitments taken by the country.”*

✓ Relation with the project:

The environmental impact evaluations forwarded for the projects and the incorporation of environmental costs in the projects´ budgets, made possible the implementation of the necessary management plans to accurately deal with environmental impacts. This not only accounts for the implementation of a favorable environmental management, to achieve a high level of performance, but also the support cleaner production policies that the Colombian State has set up for the electric sector.

Likewise, the contribution made by the different instruments that have enabled the communication and involvement of the community on matters related to their own interest, should be underlined, such as:

1.3. Guidelines related to the wide and efficient supply of energy

“7.5 Alternative energies

“Alternative energies involvement in the country’s energy supply is very low. However, the electric energy supply is very expensive, more than 70% of the country’s municipalities with less than 10,000

inhabitants, with the consequent reduced energy consumption levels, have to face very expensive costs to be supplied with electric energy.

"From the study of the alternative energy potential in Colombia, it can be concluded that there are sectors in the market for the development of the following supply sketch:

- *Within urban markets level, the heating of water with solar energy.*
- *For urban marginal market areas and/ or non- interconnected, decentralized electrification (with small hydro plants through gasification of timber, with solar and wind technology).*
- *For isolated rural and/or scantly populated communities, alternative energies may become possible options."*

✓ Relation with the project:

The projects under analysis correspond to small hydro plants located in urban marginal areas that differ from the ones traditionally used by EE.PP.M for the development of projects, located rather in the east and central regions of Antioquia Department.

In this way, the development of projects is being stimulated in a new region, near a farming region with an important agro-industrial development, specially for banana plantations (Urabá Antioqueño) requiring large quantities of electric energy. Therefore, its development is embedded into this national policy.

2. National Development Plan 2002-2006[3]

2.1. Features related to Public Services

"4. Residential public services

"Institutional schemes to make the service supply feasible, will be constituted in the non-interconnected areas by the use of renewable energy among other sources. The energetic regional integration for the natural gas and electric energy will be promoted."

✓ Relation with the project:

Through the development of these two renewable energy generation projects, the interconnection of remote regions in Antioquia Department is made possible, even when these regions are currently interconnected, due to the difficult situation the country is going through, they are permanently affected in connection with energy supply (by blowing up of towers), this can be mitigated by these projects since the system will have new connections.

2.2. Development plan features related to the environment

"8. Environmental Sustainability

The goal is to keep the natural basis as a factor for the country's development, increase production and environmentally healthy goods and services supply and national production sustainability. It is also an objective to rely on a strong environmental National System, the following programs will be immediately implemented:

"c. Income generation and "green employment"

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[3] Republic of Colombia, National Planning Department. National Development Plan 2002-2006. http://www.dnp.gov.co/.

… "In the manufacturing sector, companies devoted to solid waste recovery, clean energies and sustainable mining will be fostered.

"As regards environmental services, the development of a GHG sequestration national project, with an estimated reduction of 250 thousand tons of CO_2 equivalents." …

"d. National production environmental Sustainability

… "The country's involvement in the international carbon market will be encouraged and four energy projects (with a reduction of 1 million tons of CO_2 equivalent) will be fostered, two projects of less contaminant public transportation (with a reduction of 800,000 tons), and one methane recovery landfill project (with a reduction of 10,000 tons). Thus, the country will be able to generate about 2,000,000 CERs and incomes for about US$ 8 millions in the period of four years." …

- ✓ Relation with the project:

Companies dealing with clean energy exploitation and supporting the national project of GHG sequestration and emissions reduction will be encouraged within the previous guidelines. La Vuelta and La Herradura subprojects fit in properly with these two national policies.

3. Environmental National Policy[4]

"7. Towards a cleaner production

"The aim is to introduce environmental dimension into productive sectors and re-direct them towards the use and management of healthy environmental technologies to increase efficiency in the use of hydro and energy resources, substitute raw materials, improve processes or modify products and reduce waste production.

"The clean production policy for the energy sector will be mainly oriented to encourage the use of cleaner fuels such as gas, final energy demand management through energy efficiency, and the support to non-conventional sources, such as coal bricks and firewood from dendro-energetic forests, wind solar energy based systems provided they are environmental and economically feasible. Concerning electric energy generation, atmospheric emissions control will be a priority, as well as the management of thermal plants solid waste and reforestation of basins contributing to hydro projects."

- ✓ Relation with the project:

La Vuelta and La Herradura subprojects are duly embedded within this policy, since as it has already been mentioned, the notion and development of the environmental variable has been accurately incorporated, the use of natural resources was improved in the region through the exploitation of water and the topographic and geological shaping of the region for the development of small hydro plants suitable to these conditions.

The projects are provided with a cleaner production for the environmental management they were dealt with, as much in the social as in the physic biotic factors. Likewise, atmospheric emissions are reduced since the building of new thermal plants will be avoided.

Moreover, a reforestation program was designed to protect and recover La Herradura river basin, La Nancuí and Timotea breaks, and the Abriaquí municipal tree nursery. Additionally a revegetation program was developed to prevent slopes from blocking the access roads to the power plants.

[4] Republic of Colombia, National Planning Department. National Environmental Policy. CONPES-2750-Minambiente-DNP-UPA, Santafé de Bogotá, D.C., December 21, 1994.

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)

EE.PP.M has developed a series of capacity building activities to training employees working in La Vuelta and La Herradura plants. Four workshops were held and other two are foreseen for the rest of this year.

EE.PP.M has devoted an important percentage of the total budget for the project to environmental management. Specifically 36.18% of the initial investment is destined to La Vuelta hydroelectric plant (63.82% of the budget is used in civil works) and 17.5% of the budget is used in La Herradura hydroelectric plant (82.5% are devoted to civil works).

An important employment rate has been generated by the project implementation. From April 2002 to December 2002, 934.5 full-time positions were created for La Herradura subproject and 1,276.5 for La Vuelta subproject. The first subproject employed people from Frontino municipality (25%), Cañasgordas municipality (25%), other Antioquia municipalities (44%) and outer departments (6%). The numbers for the second subproject are: Abriaquí (24%), Frontino (27%), Cañasgordas (1%), other Antioquia municipalities (45%), outer departments (3%). A lot of goods were acquired to provide resources to workers in the project. This has created a local market which is in place successfully.[27]

From the social perspective a local radio and a local journal were created. Sanitary services, social security and social programs were also developed to cover needs.

Procedures for solid waste treatment were implemented and potable water is being produced for human consumption.

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

In this project a sound technology is used (Francis type turbines, synchronic generators, etc.). The other matters associated to cleaner production and environmental impacts are already covered in the other subsections of this review. Environmental impacts are controlled under the Environmental Management Plan Following.

As regards technology transfer, in the contractual process for the supply of electromechanical equipment (through the Public Bidding 006665, June 2002), it was clearly specified that the project sponsor (EE.PP.M) will only accept suppliers or manufacturers accrediting experience in at least two previous hydro plants using Francis type turbines with a capacity greater than 10 MW and with synchronic generators whose power were higher than 10 MVA. The suppliers must have certified their quality-providing systems with ISO 9001 quality standards. Moreover, construction and operation characteristics of the generators must satisfy the international standards of the American National Standard Institute (ANSI), International Electro-technical Commission (IEC), Institute of Electrical and Electronic Engineers, Inc. (IEEE), The National Electrical Manufacturers Association (NEMA), Verband Deutscher Elektrotechniker (VDE), and Japanese Industrial Standard (JIS).

[27] All this information is taken from the Report of the Environmental Management Plan Following (Informe Trimestral Octubre-Diciembre, Proyecto Hidroeléctrico La Herradura, EE.PP.M, Subgerencia Proyectos Generación, January 2003). The company in charge of the construction of the plants is Arquitectos e Ingenieros Asociados S.A. (A.I.A) and the company in charge of the advisory and intervention is Consorcio Integral S.A – Sedic S.A. Civil works were initiated on March 18, 2002 for La Vuelta and April 22, 2002 for La Herradura. Three quarterly reports were already presented by EE.PP.M.

Annex 6

NON-ANNEX I DNA APPROVAL LETTER

In separate files (DNA_Letter_English.pdf and DNA_Letter_Spanish.pdf) the approval letters (English and Spanish) granted by the DNA of the República de Colombia, the Ministry of Environment, Housing and Territorial Development, are attached.