

# **MONITORING REPORT**

September, 2008

***Empresas Públicas de Medellín E.S.P***

**La Vuelta and La Herradura Hydroelectric Project**

(UNFCCC #0735)

Project Participants (host)

***Empresas Públicas de Medellín E.S.P.***

Carrera 58 N° 42-125, Medellín, Antioquia, Colombia

[www.eppm.com](http://www.eppm.com)

Prepared by

***MGM International***

Junín 1655 1°B

C1113AAQ, Buenos Aires

Argentina

[www.mgminter.com](http://www.mgminter.com)

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### 1. INTRODUCTION

The purpose of the present monitoring report is to show the calculation of the emission reductions achieved by the implementation of the project activity since January 1<sup>st</sup> 2005 until 31<sup>st</sup> December 2007.

The report also shows the Monitoring and Verification Plan for data collection and auditing followed by *Empresas Públicas de Medellín E.S.P.* in order to determine real and credible emission reductions.

The project activity development applies the approved CDM methodology *ACM0002 (version 6): "Consolidated baseline methodology for grid-connected electricity generation from renewable sources"*.

The project has been successfully registered by the CDM Executive Board on January 15<sup>th</sup>, 2007. It can be found in <http://cdm.unfccc.int/Projects/DB/DNV-CUK1161865279.03/view.html>

### 2. DESCRIPTION OF THE PROJECT ACTIVITY

The purpose of the project activity is to build a hydroelectric power plant with a total installed capacity of 31.5 MW, in order to take advantage of the capacity of La Herradura River, by means of installing two hydroelectric plants in a chain: *La Vuelta Hydro plant* and *La Herradura Hydro plant*.

The project would displace other generation sources connected to the local grid that use fossil fuels to produce energy. The project provides clean energy and reduces CO<sub>2</sub> emissions in Colombia.

The following table shows a description of the technology applied in the project:

Table 1: La Vuelta and La Herradura Hydroelectric Project

Hydro Plant Characteristic	La Vuelta	La Herradura
Installed Capacity	11.7 MW	19.8 MW
Mean flow	12.3 m <sup>3</sup> /s	14.0 m <sup>3</sup> /s
Fall	112 m	220 m
Hydraulic turbine	Francis, horizontal axis	Francis, horizontal axis
	One unit	Two units

### 3. PROJECT LOCATION

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

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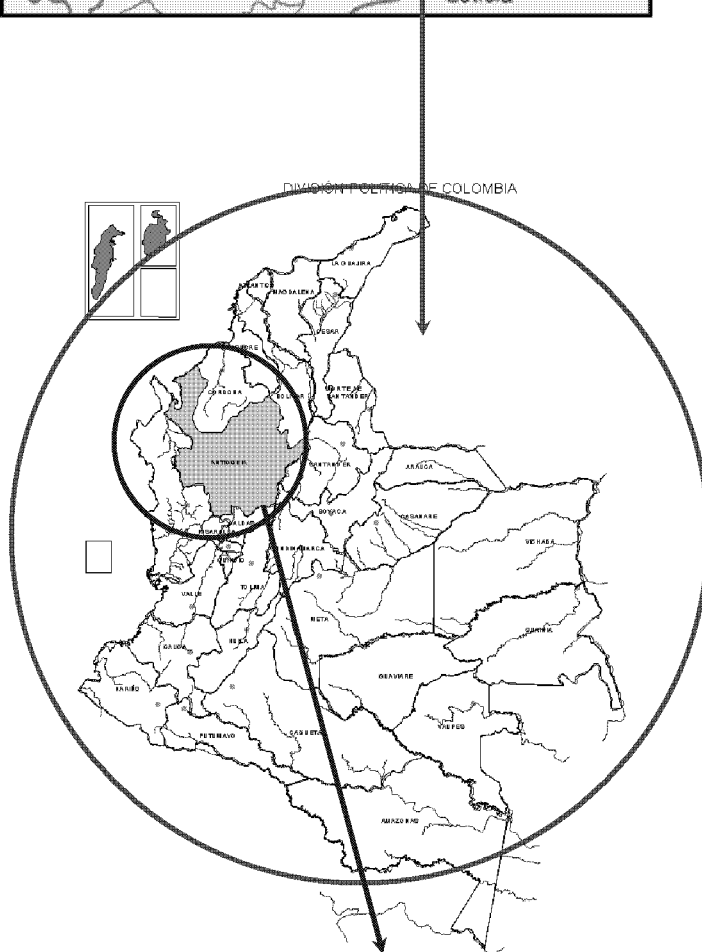
### **La Vuelta and La Herradura Hydroelectric Project**

located (See Figure 1).

La Herradura plant is located on La Herradura River, starting from an existing topographic fall between that river and the Cañasgordas River. Both rivers later join to form the Sucio River basin, a tributary to the Atrato River. The hydrographic basin area of La Herradura River is 320 km<sup>2</sup>, which contributes to a mean flow of 14 m<sup>3</sup>/s at catchment point. The construction is located in Frontino and Cañasgordas jurisdictions.

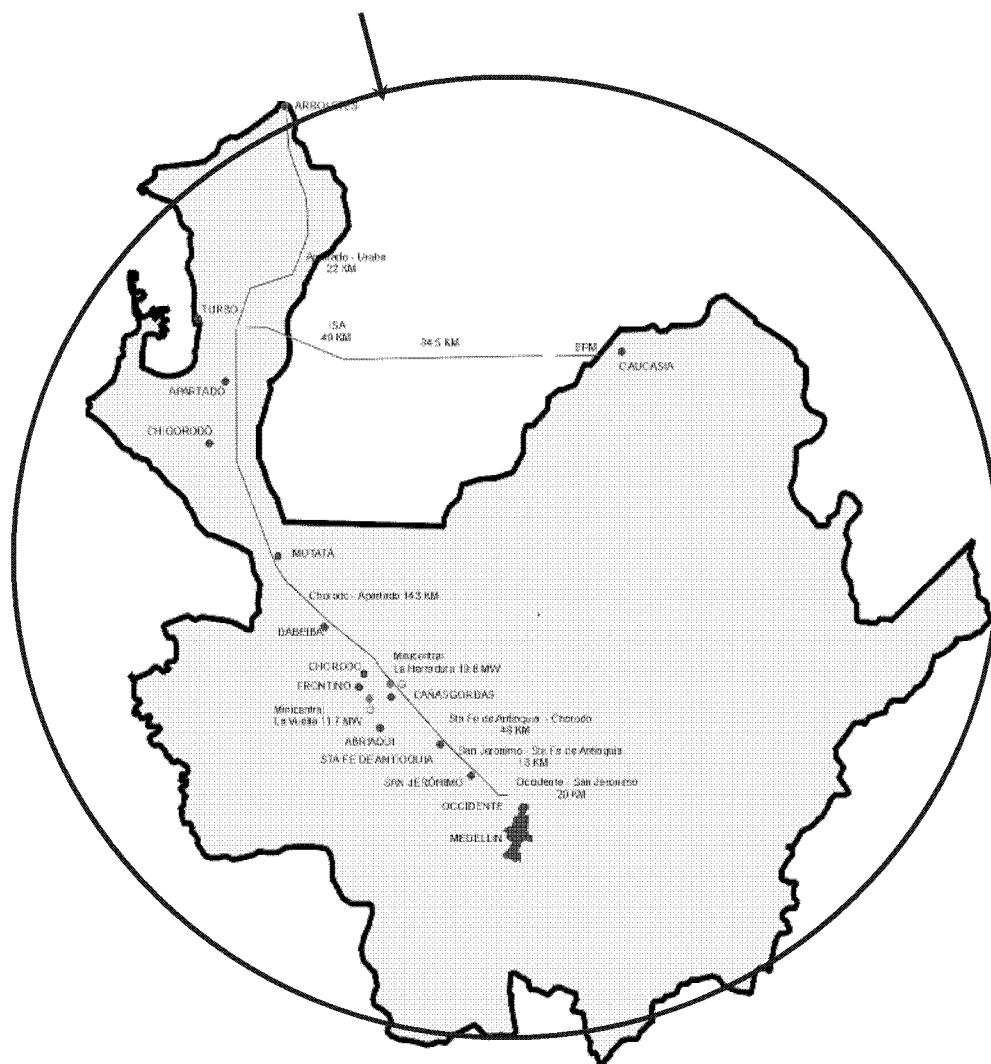
La Vuelta plant is located in the upper and middle basin of La Herradura River, up to the fork at the Nancuí gulch, at 1,595 m elevation, covering all Abriaquí municipality and the limits coincide with the dividing basin and to a lesser extent with Frontino municipality. The hydrographic basin area of La Herradura River contributes to a mean flow of 12.3 m<sup>3</sup>/s at catchment point.

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**Figure 1: Colombia (above) and Antioquia Department (below)**  
 Geographic coordinates: Approx. 6°N, 76°W  
 Source: <http://www.eia.gov/cia/publications/factbook/geos/co.html>  
 Green dots represent La Vuelta and La Herradura power plants location

### 4. APPLIED METHODOLOGY

The methodology applied to the registered CDM project activity is ACM0002 Version 6: *"Consolidated methodology for grid-connected electricity generation from renewable sources"*. Also the methodology refers to the *"Tool for demonstration and assessment of additionality"*.

According to information about the electricity grid mix of Colombia, it is dominated by hydro plants (65.6%) and to a lesser extent by thermal plants (34.4%). Power plants are dispatched according to their generation costs, the least-cost plants enter first, while the plant dispatched later to cover the demand sets the marginal price of electricity.

In the context of the renewable project activity only baseline emissions are considered to calculate emission reductions. Leakage emissions are not to be included under this methodology

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and as power density of the project is greater than 10 W/m<sup>2</sup> (for La Vuelta is 1,893 W/m<sup>2</sup> and for La Herradura is 6,199 W/m<sup>2</sup>) then methane emissions are to be disregarded.

Baseline emissions are calculated applying the combined margin emission factor (CM), calculated as the combination of the operating margin (OM) and the build margin (BM). The chosen method to calculate the OM is **option c) Dispatch Data Analysis (DDA)** of ACM0002 Version 6 that provides a more accurate calculation. Moreover, **Option 2** of the methodology is selected to calculate the BM.

The weights applied to the OM and the BM in order to calculate the CM are 0.5 and 0.5 respectively.

### 5. MONITORING PLAN IMPLEMENTATION

The monitoring plan was delineated in accordance with the requirements of ACM0002 Version 6. According to it, the variables to be monitored during the crediting period are:

- Electricity generation from the proposed project activity.
- Data needed to recalculate the OM, if needed, based on the choice of the method to determine the OM, consistent with the consolidated baseline methodology.
- Data needed to recalculate the BM, if needed, consistent with the consolidated baseline methodology.
- For new hydroelectric projects, the surface area of reservoir at the full reservoir level.

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

The following two sub-sections of this report show variables monitored and also not monitored parameters used to calculate the emission reductions from the CDM project.

#### 5.1 - Variables under monitoring

For the calculation of the combined margin emission factor historical data on the most relevant variables are obtained through an online service based on databases of the wholesaler energy market. The ASIC (*Administrador del Sistema de Intercambios Comerciales* – Administrator of the Commercial Transactions System) provides information to the generators supported on the largest Data Warehouse of the energetic sector of Colombia. As a result, the search for information is done online in a more consistent and faster way.

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The following table shows those variables that were monitored during the crediting period, how they were monitored and the quality assurance procedures applied during their monitoring.

**Table 2: Data for Baseline Emissions calculation**

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Data variable	<i>Electricity Generation (EG)</i>
Data unit	MWh
Source	EE.PP.M
Measurement and recording frequency	Hourly measured. Monthly recorded. See table 4 in section 8.1 where the monitored values are.
Measurement procedures And Comments about QA/QC	<p><b>Measurement of Electricity Generation:</b></p> <p>Electricity generation is measured by <i>electronic electricity meters</i>. The obtained values are cross-checked with the generation measured in terminals and vs. SCADA system (“Supervisory Control And Data Acquisition”).</p> <p>This information is backed up by the IT Department of EE.PP.M through the software for <i>GCE-Grandes Clientes de Energía</i> (“Large Energy Consumers”). Daily information is remotely taken by applying <i>MV-90xi</i> software.</p> <p><b>Quality Control and Quality Assurance:</b></p> <p><u>Calibration of meters:</u></p> <p>Electricity meters were calibrated at EE.PP.M laboratory before being installed in the plant (year 2004) and again in August 2008. The zip-file “<i>Calibration protocols</i>” show the calibration protocols used to calibrate the meters. Calibration tasks follow national standards and are in accordance with the calibration instructive specified in Colombian standard NTC 4,856 for electricity metering devices. The calibration frequency is approximately every 4 years.</p> <p>EE.PP.M has adopted its own procedure based on the Colombian technical norm NTC-ISO-IEC 17,025 and NTC 4,856, under the so-called “Instructive to perform on-site electricity meter proofs with a pattern metering device” (DIS-EM-LE-IN-009-01).</p> <p>The patterns used to calibrate the electricity meters <i>in-situ</i> could be any of the following:</p> <ul style="list-style-type: none"> <li>• Portable Standard MTE N° 16, 17, 18 (accuracy 0.05)</li> <li>• Calibration Bench LANDIS TALOGYR 6061</li> <li>• Calibration Bench ZERA ED 6816</li> </ul> <p><u>Maintenance of meters:</u></p> <p>Maintenance activities consist of verifying that the meters are in compliance with the standard NTC 4,856 and within the expected accuracy for that device. The meters are also checked for alarms.</p>



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<b>Data variable</b>	<i>Colombian grid emission factor (EF): Combined Margin emission factor (CM)</i>
<b>Data unit</b>	tCO <sub>2</sub> /MWh
<b>Source</b>	EE.PP.M.
<b>Measurement and recording frequency</b>	This variable is calculated as the weighted sum of OM and BM emission factors. Annually updated and recorded. See spreadsheet " <i>LVLH Monitoring_ER_12AUG08.xls</i> " where combined margin is calculated.
<b>Measurement procedures</b> <b>And</b> <b>Comments about QA/QC procedures</b>	This variable is calculated for what it does not need specific quality control procedures.

3

<b>Data variable</b>	<i>Build Margin emission factor (BM)</i>
<b>Data unit</b>	tCO <sub>2</sub> /MWh
<b>Source</b>	EE.PP.M.
<b>Measurement and recording frequency</b>	<p>This variable is calculated as:</p> $\frac{\sum_i F_{i,y} \times COEF_i}{\sum_m GEN_{m,y}}$ <p>Annually updated and recorded as per Option 2 of ACM0002 Version 6.</p> <p>See Spreadsheets  <i>"MargenConstruccion_2005.xls"</i>  <i>"MargenConstruccion V y H_2006.xls"</i>  <i>"MargenConstruccion V y H_2007.xls"</i></p> <p>Where data used and method of calculation is developed.</p>
<b>Measurement procedures</b> <b>And</b> <b>Comments about QA/QC procedures</b>	This variable is calculated for what it does not need specific quality control procedures.

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<b>Data variable</b>	<i>Operating Margin emission factor (OM)</i>
<b>Data unit</b>	tCO <sub>2</sub> /MWh
<b>Source</b>	EE.PP.M
<b>Measurement and recording frequency</b>	<p>This variable is calculated according to <b>option c) DDA</b> of methodology ACM0002 Version 6. Annually updated and recorded.</p> <p>See spreadsheets  <i>"Margen operacion LVLH 2005.xls"</i>  <i>"Margen de operación 2006 2.xls"</i>  <i>"Margen de operación 2007.xls"</i></p> <p>Where data used and method of calculation is developed.</p>
<b>Measurement procedures And Comments about QA/QC procedures</b>	<p>This variable is calculated for what it does not need specific quality control procedures.</p>

### 5.2 - Not monitored data

According to Annex 3 Baseline Data of the Registered PDD, the following data is considered fixed along the first crediting period and, therefore, is not monitored:

**Table 3: Not monitored data**

Item	Description	Value/Unit	Source
$OXID_{coal}$	Coal oxidation factor	0.98	IPCC Guidelines for National Greenhouse Gas Inventories: Reference Manual Volume 3 (1996)
$EF_{CO2coal}$	CO <sub>2</sub> emission factor for coal	94.6 ton CO <sub>2</sub> /TJ	IPCC Guidelines for National Greenhouse Gas Inventories: Reference Manual Volume 3 (1996)
$OXID_{NG}$	Natural gas oxidation factor	0.995	IPCC Guidelines for National Greenhouse Gas Inventories: Reference Manual Volume 3 (1996)
$EF_{CO2NG}$	CO <sub>2</sub> emission factor for natural gas	56.1 ton CO <sub>2</sub> /TJ	IPCC Guidelines for National Greenhouse Gas Inventories: Reference Manual Volume 3 (1996)

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### 6. ENVIRONMENTAL MANAGEMENT PLAN

*Firstly, it is important to note that this environmental management plan was not included as part of the monitoring plan in the PDD. This is an independent initiative taken by EE.PP.M that contributes to sustainable development of the region that worth mentioning.*

La Vuelta and La Herradura hydroelectric plants apply an environmental management plan that includes actions towards mitigating the negative impacts on environment during construction and operation of the plants. In addition, EE.PP.M develops a discretionary environmental management plan that involves physical-biotic and social aspects to protect natural resources and to promote a sustainable development of the hydroelectric complex. The plan consists of:

#### Management of Environmental Impacts:

- The Environmental Licenses consider concessions and permits of spills and river banks occupation and adaptation of the internal ways of the hydroelectric plants. To achieve this, the information requirements of the *Corporación Autónoma Regional Corpourabá* (Autonomous Regional Corporation of Corpourabá) need to be met regarding environmental monitoring programs.
- Report on turbinated flows once every three months to the *Corporación Autónoma Regional Corpourabá* (Autonomous Regional Corporation of Corpourabá).
- Monitoring and control of the flow designated for energy generation and for water consumption.
- Inspection and maintenance of domestic wastewater treatment systems belonging to the hydroelectric system facilities.
- Monitoring of domestic wastewater treatment systems in order to verify the efficiency and the compliance with the estimated removal percentages in accordance with the environmental law.
- Implementation of a solid wastes management system including different containers corresponding to different type of solid wastes. Moreover, towels and sheets soaked with oils are delivered to a third party for treatment and final disposal in accordance with the applicable law.
- Visits from officials of the *Corporación Autónoma Regional Corpourabá* (Autonomous Regional Corporation of Corpourabá) to do the follow up of the application of the plan and to identify opportunities of improvement.

#### Additional discretionary programs of environmental management

##### *Process of Environmental Impacts Management:*

- Hydrologic monitoring: rainfall, runoff, transport of sediments and water quality of the main source.
- Water quality monitoring of the sources that supply drinking water to the facilities of the hydroelectric complex.

##### *Process of Conserving Natural Resources*

- Geomorphologic study of La Herradura River and its river dynamics in order to implement measures to control the critical factors that generate the torrential conditions and the high production of sediments in the basin.

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- In 2007 it was initiated the recovery of several points of erosion of the La Herradura River basin. 22,500 m<sup>2</sup> of affected areas due to erosion were identified. It is necessary to implement activities tending to protect the surface, control of runoff and stabilization of the areas in order to control the supply of sediments that affect the machines that generate energy.

### *Process of Voluntary Social Management:*

- As part of the support given to the local communities of Abriaquí, programs for solid wastes management and nutritious safety were developed. Along with the municipality of Cañasgordas there is an agreement to improve the Imántago-Morotó road and also for the establishment of agro-forestall parcels that benefit the communities. Another agreement with Frontino municipality regarding nutritious safety and environmental protection was signed too.
- EE.PP.M is working with people involved in nutritious safety, environmental protection and infrastructure improvement in order to strengthen the community organizations that are under the influence of the hydroelectric plants.
- EE.PP.M participates of the “día clásico” (classic day) and the “día del campesino” (rural people day) in the municipalities of Frontino, Cañasgordas and Abriaquí.
- EE.PP.M delivered scholar packages to the children that attend the rural schools near the hydroelectric plants of La Vuelta and La Herradura.

The total investment incurred by EE.PP.M to develop the Environmental Management Plan and the additional discretionary plans associated to the hydroelectric project during its operation phase adds up to 46 million Colombian pesos for 2004, 178 million Colombian pesos for 2005, 203 million Colombian pesos for 2006 and 311 million Colombian pesos for 2007.

## 7. FORMULAS USED FOR CALCULATION OF EMISSION REDUCTIONS

The following table provides the formulas used for calculation of emission reductions:

<i>Project emissions</i>	
Variable	Formulas
Estimated CO <sub>2</sub> emissions, <i>PE</i>	No project emissions are considered in the present project.
<i>Baseline emissions</i>	
Variable	Formulas
Estimated CO <sub>2</sub> emissions in the baseline, <i>BE</i>	<p>They are calculated applying the combined margin emission factor calculation and the energy generated by the plants:</p> $BE_y(tonCO_2 / yr) = EF_y(tonCO_2 / MWh) \cdot EG_y(MWh / yr)$ <p>Where <math>EG_y</math> is the project generation (comprising “La Vuelta” and “La Herradura” plants) and <math>EF_y</math> is the grid emission factor calculated as the weighted average of the Operating Margin emission factor (<math>EF_{OMy}</math>) and the Build Margin emission factor (<math>EF_{BMy}</math>).</p>

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<i>Leakage</i>	
Variable	Formulas
Estimated CO <sub>2</sub> emissions, <i>LE</i>	No leakage is considered in the present project.
<i>Emission Reductions</i>	
Variable	Formulas
CO <sub>2</sub> emission reductions, <i>ER</i>	<p>Considering that there are neither project emissions nor leakage for the proposed project activity, the annual emission reductions are equal to:</p> $ER_y(tonCO_2 / yr) = BE_y(tonCO_2 / yr)$

### 8. EMISSION REDUCTIONS CALCULATION

The emission reductions are calculated as per the formulae shown above. The following tables show information related to the calculation of emission reductions:

#### 8.1 - Power generation by La Vuelta and La Herradura hydroelectric plants:

Table 4: Generation of the plants for years 2005, 2006 and 2007

Year	Month	Net Generation of the plants (MWh)		
		La Vuelta	La Herradura	Total
2005	January	3,736.524	6,390.428	10,126.952
	February	4.774	5,392.112	5,396.886
	March	121.968	5,153.654	5,275.622
	April	6,213.548	11,231.726	17,445.274
	May	7,819.614	12,774.564	20,594.178
	June	7,161.199	12,379.488	19,540.687
	July	6,200.562	12,217.414	18,417.976
	August	4,763.066	5,633.782	10,396.848
	September	4,240.584	7,874.268	12,114.852
	October	7,874.100	12,286.550	20,160.650
	November	6,375.500	10,492.000	16,867.500
	December	2,738.760	12,877.190	15,615.950
Total		57,250.199	114,703.176	171,953.375
2006	January	5,283.300	10,752.006	16,035.306
	February	4,536.114	5,206.252	9,742.366
	March	3,863.882	10,188.508	14,052.390
	April	2,985.746	8,563.236	11,548.982
	May	-	7,548.458	7,548.458
	June	-	10,206.768	10,206.768
	July	4,736.094	10,830.909	15,567.003
	August	3,044.866	6,172.518	9,217.384

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	September	4,145.570	6,933.367	<b>11,078.937</b>
	October	4,077.084	11,609.357	<b>15,686.441</b>
	November	5,540.151	12,722.425	<b>18,262.576</b>
	December	4,636.435	12,454.201	<b>17,090.636</b>
<b>Total</b>		<b>42,849.232</b>	<b>113,188.002</b>	<b>156,037.234</b>
<b>2007</b>	January	5,227.993	11,325.359	<b>16,553.352</b>
	February	2,823.392	6,325.903	<b>9,149.295</b>
	March	4,536.269	7,123.777	<b>11,660.046</b>
	April	5,113.109	12,234.135	<b>17,347.244</b>
	May	3,796.519	9,363.904	<b>13,160.423</b>
	June	4,817.362	9,009.661	<b>13,827.023</b>
	July	4,818.065	13,272.711	<b>18,090.776</b>
	August	1,315.352	12,824.374	<b>14,139.726</b>
	September	6,008.707	10,251.439	<b>16,260.146</b>
	October	1,967.636	8,881.541	<b>10,849.177</b>
	November	5,326.619	11,209.353	<b>16,535.972</b>
	December	4,746.523	12,244.190	<b>16,990.712</b>
<b>Total</b>		<b>50,497.538</b>	<b>124,066.335</b>	<b>174,563.873</b>

#### *8.2 - Combined margin emission factors calculation*

##### **Build Margin Calculation**

Option 2 of ACM0002 version 6 is selected for BM calculation. This factor is updated annually *ex-post* so it was calculated for the three years 2005, 2006 and 2007. Refer to the corresponding files<sup>1</sup> to check the calculation of the build margin for each year.

The results are:

Year 2005 BM: **0.3169 tCO<sub>2</sub>/MWh**

Year 2006 BM: **0.2996 tCO<sub>2</sub>/MWh**

Year 2007 BM: **0.2923 tCO<sub>2</sub>/MWh**

##### **Operating Margin Calculation**

As explained previously, it was calculated applying the Dispatch Data Analysis (option C of ACM0002 Version 6). The results for each year are:

Year 2005 OM: **0.3665 tCO<sub>2</sub>/MWh**

Year 2006 OM: **0.3225 tCO<sub>2</sub>/MWh**

Year 2007 OM: **0.2455 tCO<sub>2</sub>/MWh**

<sup>1</sup> "LVLH\_Monitoring\_ER\_12AUG08.xls"

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### Combined Margin Calculation

Applying a 0.5 weight for both the operating margin and the build margin, the combined margin emission factors for the Colombian grid are:

Year 2005 CM: **0.3417** tCO<sub>2</sub>/MWh

Year 2006 CM: **0.3111** tCO<sub>2</sub>/MWh

Year 2007 CM: **0.2689** tCO<sub>2</sub>/MWh

The utilized weights will remain fixed throughout the first crediting period, according to the methodology.

### *8.3 - Obtained emissions reductions*

#### Baseline Emissions:

	2005	2006	2007	Total
<b>BASELINE EMISSIONS</b> (tCO <sub>2</sub> e)	58,756	48,535	46,940	<b>154,232</b>

#### Emission Reductions:

	2005	2006	2007	Total
<b>EMISSION REDUCTIONS</b> (tCO <sub>2</sub> e)	58,756	48,535	46,940	<b>154,232</b>