CATALYTIC INVESTMENTS FOR GEOTHERMAL ENERGY
- 2 Components -

Project GEF-IDB: CO-X1009

Final Assessment Report

Jorge Luis Rodríguez Sanabria
Consultant

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ABBREVIATIONS

ACIEM	Asociación Colombiana de Ingenieros Eléctricos y Mecánicos (Colombian Association of Electrical and Mechanical Engineers)
ANLA	Autoridad Ambiental de Licencias Ambientales (Colombian Environmental Licensing Authority)
CI	Conservation International, Colombia
CIF	Centro Internacional de Física (International Physics Center)
CNO	Consejo Nacional de Operación (National Electrical Operations Council)
COLCIENCIAS	Departamento Administrativo de Ciencia, Tecnología e Innovación (Administrative Department of Science, Technology and Innovation)
CORPOCALDAS	Corporación Autónoma Regional de Caldas (Regional Autonomous Corporation of Caldas)
CORPONARIÑO	Corporación Autónoma Regional de Nariño (Regional Autonomous Corporation of Nariño)
CREG	Comisión de Regulación de Energía y Gas (Energy and Gas Regulatory Commission)
DIAN	Dirección de Impuestos y Aduanas Nacionales de Colombia (Colombian National Taxes and Customs Direction)
DNP	National Planning Department
ENFICC	Energía Firme para el Cargo por Confiabilidad (Firm energy to be purchased at the reliability charge rate)
FNCE	Non-Conventional Sources of Energy
FNCER	Non-Conventional Sources of Renewable Energy
GEF	Global Environment Facility
GGE	Greenhouse Gas Emissions
IDB	Inter-American Development Bank
IDEAM	Instituto de Hidrología, Meteorología y Estudios Ambientales (Institute of Hydrology, Meteorology and Environmental Studies)
INGEOMINAS	Instituto Colombiano de Geología y Minería (Colombian Institute of Geology and Mining)
IPSE	Institute for the planning and implementation of energy solutions for Non-interconected areas
JCF	Japanese Trust Fund for Consultancy Services
MADR	Agriculture and Rural Development Ministry
MADS	Ministerio de Ambiente y Desarrollo Sostenible (Ministry of the Environment and Sustainable Development)
MCIT	Ministerio de Comercio, Industria y Turismo (Ministry of Commerce, Industry and Tourism)

MHCP	Ministerio de Hacienda y Crédito Público (Ministry of Finance and Public Credit)
MININTERIOR	Ministerio de Interior (Interior Ministry)
MME	Ministerio de Minas y Energía (Ministry of Mines and Energy)
MT	Magnetotelluric
MVR	Macizo Volcánico del Ruiz (Ruiz Volcanic Massif)
MW	Megawatt
PEN	Plan Energético Nacional (National Energy Plan)
RAC	Regional Autonomous Corporation
RE	Renewable Energy
SGC	Servicio Geológico Colombiano (Colombian Geological Service)
SGIC-FNCER	Information and Knowledge Management System of Non-Conventional Renewable Energy
SIN	Sistema de Interconexión Nacional (National Electric Grid, National Transmission System)
TC	Technical Cooperation
UDENAR	Universidad de Nariño
UNAL	Universidad Nacional de Colombia
UNAM	Universidad Autónoma de México
Universidad EIA	Universidad Escuela de Ingeniería de Antioquia
UPME	Unidad de Planeación Minero Energético (Mining and Energy Planning Unit)
USTDA	United States Trade and Development Agency
WEST JEC	West Japan Engineering Consultants
ZNI	Non-interconnected areas

1 Assessment Background

- Colombia is a country that enjoys a relatively rich energy mix both in terms of fossil and renewable resources but whose demand, like the rest of the world is based mainly on primary resources of fossil origin. Given the relative abundance of some RE sources such as hydro, solar, wind, biomass and geothermal energy in some regions, coupled with the relative maturity and assorted international developments in technology for harnessing energy from these sources, the development of Non-Conventional Sources of Renewable Energy (FNCER) projects represent an opportunity to diversify the national energy mix and gradually transform the energy sector towards an increasingly competitive and sustainable model.

- It primarily supplies its energy needs with hydroelectric power (67%) and thermal power (33%). However, considering the current situation related to the global environmental problem and the effects of climate change, in its policies, the Colombian Government has prioritized the promotion of efficient use of energy, the development of alternative energy sources, the mitigation of climate change, and the reduction of greenhouse gas emissions (GGE). It has done this through the Rational Use of Energy Law (Law 697 of 2001), Decree 3683 of 2003, the Specific Plan 2010-2015 to develop the Program of Rational and Efficient Use of Energy and Alternative Energy Sources, the National Energy Plan 2010-2030, the Comprehensive Energy Strategy Vision 2003-2020 Vision, Law 1450 of 2011 the National Development Plan, Article 105) and Law 1715 of 2014 (Integration of FNCER). These normative documents consider objectives including:

  - ✓ Expand and ensure a reliable energy supply of adequate quality at economical prices
  - ✓ Drive local and regional development
  - ✓ Incorporate new power generation sources and technology
  - ✓ Promote the use of alternative energy sources

  Therefore, there was a clear need to put these policies into practice through the development of alternative energy sources, taking advantage of the high potential of energy sources other than hydroelectricity available in the country to complement it.

- These objectives fit the axis of competitiveness within the strategy that the IDB formulated for Colombia (GN-2474), to support national efforts to achieve sustained growth, promote employment, reduce poverty and improve standards of life, particularly helping to promote the competitiveness of the energy sector which represents a fundamental pillar of national economic development.

- Therefore, the objective of this project was to foster the development of a favorable environment for the development and integration of FNCER in the Colombian energy matrix, including the support completion of the necessary studies for the development and execution of a demonstrative geothermal project in the Ruiz Volcanic Massif.

- In terms of the geothermal resource, Colombia has a privileged geographical position and favorable geology, given that part of its territory is in the Pacific Ring of Fire; an area where the gradient of the subsoil's natural temperature close to the surface is abnormally high, which is shown with the current volcanic activity.

- In Colombia, this geothermal potential is shown in the surrounding areas of the volcanoes: Chiles, Cerro Negro, Cumbal, Azufral, Galeras, Doña Juana, Sotará, Puracé, Nevado del Huila, Nevado del Ruiz and Nevado del Tolima. The recent history of eruptions and the presence of hot springs, fumaroles and areas with hydrothermal alterations in the surface could be a demonstration of the existence of a geothermal resource with suitable characteristics to be used for power generation.

2 Context

- In line with the Global Environmental Facility´s (GEF) strategic program to "*promote market approaches for renewable energy*" and the objective to "*provide reliable, safe and environmentally-friendly geothermal energy, and thus increase the range of potential alternative clean energy sources while diversifying the country's energy matrix*", it was important and fundamental to developed the two components of this program for fulfilling the GEF´s requirements.

- This document contains the final assessment of the Catalytic Investments for Geothermal Energy in Colombia Project pursuant to the guidelines and standards established by the GEF[1], to aims to promote accountability and transparency in the disclosure of the project's activities, synthesize the lessons learned when seeking to improve the selection, design and implementation of future activities of the GEF and contribute to the analysis of the efficiency of GEF operations in obtaining benefits for the environment and quality of monitoring and evaluation.

  The final assessment for this project, which was developed in two (2) components, was prepared based on different documents from the executive agencies, the Mining and Energy Planning Unit (UPME) and ISAGEN and complemented with interviews and meetings with personal from Ministry of Mines and Energy (MME),

[1] *GEF Guidelines for GEF Agencies in Conducting Terminal Evaluation*s. Evaluation Document 2008, No. 3. Washington D.C.

UPME, Conservation International Colombia (CI), ISAGEN, Inter-American Development Bank (IDB) and some consultants who participated in the project´s development[2].

Considering the differences between the two components' project (objectives, scope, activities and their duration, budget, consultancy expertise, etc.), this document was prepared for each topic analyzing the two components separately and ending with an observation for the project. If for any specific topic, there are important differences between the components, only the components´ analysis is presented.

3 The Project

3.1 Objective and Components

The overall objective of the project is to promote and support catalytic investments for geothermal energy in Colombia by strengthening its regulatory framework and the development and execution of a demonstrative geothermal project in the Ruiz Volcanic Massif, which will help to reduce and displace unrealized GGE.

The project was developed through a Technical Cooperation (TC), two (2) main components, with the following objectives:

- **Component I:** Strengthen the regulatory framework, promote market approaches for renewable energy and remove barriers that obstruct the development of FNCER. The executing agency is UPME and CI for financial and administrative topics.

- **Component II:** Support completion of the necessary studies for the development and execution of a demonstrative geothermal project in the Nevado del Ruiz or Ruiz Volcanic Massif. The executing agency is ISAGEN SA ESP.

3.2 Specific Objectives

- **Component I:**

  The specific objectives of this component were:

  ✓ To identify barriers for the development of FNCER in Colombia.

  ✓ To propose actions and mechanisms to remove the main barriers identified and analyzed.

[2] Annex 4.

- ✓ To incorporate the results of cost-benefit analyses in the definition of actions and mechanisms to be proposed, as part of policy guidelines for the development of technologies that make use of specific FNCER.

- ✓ To recommend policy guidelines that promote investments in RE projects under the approach of a competitive market.

- ✓ To develop a strategy for the development and use of FNCER in accordance with the policy guidelines to be recommended, establishing lines of action to be implemented to achieve specific goals in this context.

For this component, three (3) subcomponents were set from the beginning, each of them with specific identified objectives as follows:

Subcomponent I. Strengthening the knowledge and information base for FNCER in Colombia including: (i) improved understanding of FNCER, updating and integrating available information, (ii) an analysis of costs and economic benefits associated to the greater involvement of FNCER in the Colombian energy matrix and (iii) a platform for information and knowledge management.

Subcomponent II. Analyzing institutional and legal obstacles for the development of FNCER in Colombia and formulating low carbon policy guidelines to help in the structuring of an appropriate institutional and regulatory framework that promotes the use of these energy sources.

Subcomponent III. Reporting and disseminating the results of the development of this project and raising awareness regarding the existence and benefits offered by these FNCER, widely available in Colombia.

- **Component II:**

  - ✓ A model of the geothermal resource in the two selected areas and the temperature.

  - ✓ Identification of the type of geothermal resource and its potential capacity.

  - ✓ Recommendations regarding the exploration and development of geothermal resources.

  - ✓ Environmental and sociological studies in accordance with the scope of these activities.

  - ✓ Development and execution of the geothermal project.

  To achieve the project objectives of this component, for the development and execution of the activities included in Component II of the project: “Subsoil Evaluation Studies”, the following five (5) subcomponents were developed:

Subcomponent I. Technical Studies: Geological studies that include (i) detailed geology, (ii) detailed mapping of the areas and hydrothermal alterations, (iii) geochemical and geophysical studies, (iv) gravity study and (v) magnetometric and magnetotelluric studies and explorations of wells that include the drilling of not very deep holes, called thermal gradient holes. The leasing and purchase of magnetometric and magnetotelluric equipment are included in this subcomponent. The work from the technical studies was used to classify the subsoil's geothermal resource.

Subcomponent II. Review and Analysis of Technical Studies: Scientific analysis of the findings, documents, conclusions and recommendations presented by the consulting firm during the pre-feasibility and technical feasibility studies. The scientific analysis was carried out by specialists from a wide range of scientific specialties, such as exploration, development and production of geothermal projects.

Subcomponent III. Environmental and Social Studies: Identification and description of the natural resources that may be affected by the project, and collection of information about the natural resources within the project area and their state before the development of the project. The possible sociological repercussions of the project on the residents of the project area were also identified, and information and education programs were developed for the community about the effects of geothermal development. As part of this component, an environmental impact assessment (EIA), an environmental management plan, a social management plan, a health and safety plan and an emergency plan were carried out pursuant to the requirements of the Environmental Policy and Policy of Compliance with the Safeguards of the IDB (OP-703), the Operating Policy About Indigenous People (OP-765) and the Operating Policy on Involuntary Resettlement (OP-710).

Subcomponent IV. Institutional Improvement and Disclosure of Conclusions: Strengthening of the Company's institutional and technical capacity to facilitate the transfer of technology and information, as well as the exchange of experiences, improvement of knowledge. The workshop(s) was/were also financed to validate and communicate the conclusions and help ISAGEN to develop communications strategies, as well as achieving the participation of the affected communities during the development and execution of the project.

Subcomponent V. Project Action Plan and Development: Preparation of a future action plan of exploratory drilling for geothermal exploration. A key element of the plan is to reduce the area in question from approximately 200 km^2 at the start of Component II to a smaller area. Furthermore, the conceptual design for the geothermal power plant was updated with the new technical data from these tests. Likewise, the financial model was updated based on the results of the evaluation studies. The specific activities include: (i) analysis and review of the resistivity structure of the subsoil of the Botero Londoño area for exploratory drilling and (ii) development of an action plan to execute the project.

3.3 Stakeholders and Area of Intervention

- **Component I**

  This component is focused in the strengthen the regulatory framework, promote market approaches for RE and remove barriers that obstruct the development of FNCER. Therefore, it is related to the current and potential participants in the Colombian energy market, government, planning, regulatory and supervisory and control entities, companies or utilities which develop activities related with the energy business and users.

- **Component II**

  The direct areas of intervention of the Ruiz Volcanic Massif geothermal plant project are in the municipality of Villamaría in the department of Caldas, and in the municipalities of Herveo and Casabianca in the department of Tolima.

  The stakeholders identified when the project was conceived and during its execution are the universities (Universidad Nacional de Colombia and Universidad EIA), the Colombian Geological Service (SGC), the Administrative Department of Science, Technology and Innovation (COLCIENCIAS), the Colombian Environmental Licensing Authority (ANLA); regional autonomous corporations (RAC), Ministries of Mines and Energy (MME), Ministries of Environment, and Sustainable Development (MADS), regulatory bodies as UPME and the Energy and Gas Regulatory Commission (CREG), and the community in general.

3.4 Milestones in Design, Implementation and Finalization

With the aim to reduce the country's dependency on hydroelectricity and prevent energy restrictions because of the El Niño phenomenon, the Colombian Government proposed diversification of the country's energy matrix and promotion of the use of FNCER such as wind power or geothermal energy. These measures also help to reduce GGE and contribute to adaptation to climate change.

Therefore, the MME through the UPME proposed to strengthen the regulatory framework with the removal of barriers that limit the promotion and development of FNCER and ISAGEN, advanced with the implementation of the demonstrative geothermal project in the MVR.

- **Component I**

  The work plan initially covered a period of three (3) years, November 2011 to November 2014, and to satisfactorily develop the activities considered in the subcomponents and finished the studies taking about the project results chart, the component´s activities ended on March 2015.

- **Component II**

The initially work plan covered a period of three (3) years, October 2011 to October 2014 and to satisfactorily develop the activities provided in the subcomponents and thus complement the pre-feasibility studies conducted by ISAGEN in the MVR, the adjusted component´s activities ended on April 2016.

During the component's development, it was necessary to amend the previously approved acquisition plan to include additional activities to adjust to the needs, progress and new findings of the project regarding classification of the geothermal resource, compliance with the requirements for the project's environmental license, and current legislation in the country. The additional activities include: i) complementation of the environmental impact assessment, ii) hydro climatological characterization and development of a methodology to estimate the temperature series for the reliability charge (ENFICC) and iii) study of the project's connection to the National Electric Grid. These activities did not require the amendment of the financial contributions by the IDB-GEF, but the redistribution of them.

Additionally, there were delays due to technical issues during the hiring and execution of the project activities, which led to the term of the contract signed by ISAGEN-IDB-GEF being extended by one year and a half until April 2016.

3.5 Implementation Mechanisms

For the implementation of both components, UPME and ISAGEN adopted the IDB's policies for the procurement of the goods and services required for the adequate execution of the project. Therefore, it had the support of national and international consultants with ample experience in the environmental, social, technical, regulatory and/or financial sphere for the development of the different studies.

For the monitoring and evaluation of the required work, as the executing agencies of the project, for the Component I UPME was responsible for the technical supervision and CI for the administrative and financial supervision of the contracts to ensure satisfactory achievement of the component's objectives and of the technical quality of all the studies contracted through the UPME agreement for this component. For the Component II, ISAGEN was responsible for the technical and administrative supervision of the contracts to ensure satisfactory achievement of the project's objectives, and of the technical quality of all the studies contracted through the ISAGEN-IDB-GEF agreement for this component.

3.6 Financing

- **Component I**

The table in the Annex 1 of this document shows the activities developed with the budget assigned and the cost of them. The IDB funds for this component were one

million two hundred thousand U.S. dollars (USD 1´200,000) and two hundred ninety-six thousand and one hundred thirty and six U.S. dollars (USD 296,136) from UPME. From the total budget, 88% were utilized for the activities related to the subcomponents. The rest for paying activities related to the audits, the project management including the general and traveling expenses.

- **Component II**

The project was mainly funded by the GEF, administered by the IDB, which granted non-refundable financing equivalent to one million, five hundred and twenty-seven thousand U.S. dollars (USD 1,527,000), as well as the additional funds contributed by ISAGEN as an agreed local matching contribution of eight hundred and fifty thousand U.S. dollars (USD 850,000), which by the end of this operation amounted to USD 2,598,605. Additionally, in the preliminary phase, the project had the funding of studies for nine hundred thousand U.S. dollars (USD 900,000), from the operation of ATN/JC-12150-CO of the Japanese Trust Fund for Consultancy Services. These funds were directly executed by the bank, by hiring the NIPPON – KOEI GEOTHERMAL E- INTEGRAL Consortium. ISAGEN followed up and verified the execution of these studies.

The financing is listed below by subcomponent, with the entity responsible for contributing the necessary funds for its implementation:

Financing by Subcomponent – Component II

Component II	**Financing**			
	Estimated Contribution at the Start of the Agreement		**Actual Contribution at the End of the Agreement**	
	GEF	**Matching Contribution**	**GEF**	**Matching Contribution**
Component II, Subsoil Evaluation Studies	1,000,000	750,000	1,270,145	2,035,036
Financial Structuring – Construction of Geothermal Plant	427,000	-	240,000	-
Project Management, Supervision, Audits and Contingencies of Component II	100,000	100,000	16,855	563,569
TOTAL (USD)	**1,527,000**	**850,000**	**1,527,000**	**2,598,605**

3.7 Amendments to the Design Before and During the Project's Implementation

- **Component I**

It is also important to mention that in anticipation of the completion of the original execution period set for the November 30th 2014, in August UPME requested an extension of four (4) months for such execution (i.e. until the 30th March, 2015) which was conceived. This was done with the objective of allowing enough time to success carry out the activities planned under the contract with Carbon Trust, which required until February 2015 for its proper execution, same as to perform additional activities that emerged during this semester, which included hiring a tributary expert and

extending the technical consultancy to address specific subjects of relevance in the Act 1715. This extension time would also be used to integrate the material and documents that would-be part of the final project results publication.

- **Component II**

The project started its activities on October 11th of 2011, with an initial duration of three (3) years, and the date of completion was October 11th 2014. During its implementation, the component presented setbacks for reasons including: **i)** difficulties in the location and procurement of specialized firms to come to the country to provide the required services, **ii)** lack of professionals specialized in geothermal exploration in the country, **iii)** difficulties in the appropriation of the geophysical exploration technologies through magnetotellurics, which led to the creation of research projects with local universities for the acquisition of MT field data. Additionally, consultancy was contracted with LaGeo and the specialized company Geofields. Furthermore, a training course on magnetotellurics was carried out with the equipment manufacturer, Phoenix Geophysics. **iv)** Restart of a procurement process declared void, **v)** delays in the legal authorization and other authorizations for procurement by ISAGEN and the IDB. The processes of approval by the parties are subject to controls and joint authorizations that take time and delay the granting of authorization and the start of activities. **vi)** Unforeseen activities due to specific needs according to the project's progress and findings. These activities include 3D analysis, interpretation and modeling; measurement and in-plant distribution of the geothermal field and power plant; hydroclimatological classification and establishment of temperature series for the calculation of the plant's firm energy; connection study; and complementation of the EIA to include the phase of use of the resource. This led to the request to extend the term for execution of the agreement to April 11th, 2016.

During the execution of the project, two (2) adjustments to the acquisition plan were requested and approved, as described below:

Addition of activities:

- ✓ **Preparation of the Complementation of the *"Environmental Impact Assessment for the Geothermal Exploration Phase of the MVR Geothermal Plant Project"*:** The original study submitted by ISAGEN to the ANLA needed to be complemented for its review and update to include the activities corresponding to use of the resource, which include: construction and operation of a 50-MW power plant and the corresponding geothermal field; the additional infrastructure related to the project, such as flow lines; separators; and connection lines. The closure and abandonment activities were also included, which are an integral part of the environmental licensing process.
- ✓ **Universidad EIA/ISAGEN Agreement. Methodology for Calculation of the ENFICC and Hydroclimatological Classification:** During the execution of the ISAGEN/IBD/GEF Contract, CREG issued Resolution 132 of 2014, whereby the methodology was established for the calculation of firm energy to be purchased at

the ENFICC for geothermal plants. Considering this resolution, geothermal plants require temperature series for a minimum of ten (10) years on the plant site for the calculation of their ENFICC. Given that this kind of record does not exist in the area, an agreement had to be signed with the Universidad EIA to conduct a research project to carry out the hydroclimatological classification of the project area and develop a methodology to establish temperature series based on the available information to calculate the plant's ENFICC. The Universidad EIA was selected because it had been conducting climatic and hydrological studies in the area for several years. Additionally, with the funds from the ISAGEN matching contribution, a weather station was installed in the project area to obtain on-site climatological data and validate the methodology developed by the Universidad EIA.

- ✓ **Study of the 50 MW project's connection to the National Electric Grid:** To process and obtain the comprehensive environmental license for the project, a connection study of the project had to be conducted. This study aimed to identify the project's connection alternatives and make the electricity analyses to connect the project to the National Electric Grid, meeting the technical criteria of quality, reliability and stability required by the system.

Amendment to financing:

- ✓ **Amendment of Activity Budget. Magnetotelluric (MT) Survey and Data Processing:** As the procurement process of the MT study was declared void due to the unavailability of equipment and the low budget allocated to the activity, it was deemed viable and appropriate to generate technical capacity in the country and strengthen the Universidad Nacional de Colombia (UNAL) through a research project on MT for geothermal exploration. In accordance with the above and with the prior approval of the IDB, an agreement was signed with the UNAL to develop the MT studies. For the technical development of this activity, a consultancy agreement was signed with the LaGeo company from El Salvador, which has experience in studies for exploration and exploitation of geothermal resources in Central America. Additionally, there were technical problems during the acquisition of the MT samples because of the presence of high electromagnetic noise, possibly related to the volcanic activity of the Nevado del Ruiz, and electric fences and lines in the area. Therefore, an expert from Phoenix Geophysics, a manufacturer and supplier of MT equipment, needed to be hired to advise field staff on the classification of the area of greatest interest for the project.
- ✓ **Amendment of the Scope and Budget, Consultancy and Support for Procurement and Execution of Exploratory Drilling:** To obtain further information about the localization, dimensions and capacity of the reservoir for the definitive design and specifications of the exploratory drilling, 3D interpretation and analysis of the MT data in the project area were included and carried out. Similarly, considering the term of execution of the activity and the term of the IDB-GEF-ISAGEN Agreement, the contributions of the IDB were adjusted to cover the first phase of the project. The contributions required for the following phases will be assumed by ISAGEN as a matching contribution of the agreement.

- ✓ **Subsoil Evaluation Study:** The value allocated to this line item was increased by USD 227,722 to cover the additional activities of Complementation of the EIA; the hydroclimatological classification; the preparation of a methodology to calculate the ENFICC; and the connection study. The total budget for this line item was USD 1,227,722.
- ✓ **Financial Structuring of the Project:** The budget for this activity was reduced by USD 187,000 from USD 427,000 to USD 240,000 with IDB funds. The decrease in the value of the contract by USD 187,000 will be compensated by ISAGEN with matching contributions at the time the activity is executed.
- ✓ **Project Management, Supervision, Audits and Contingencies:** The budget for this activity was reduced by USD 40,722 from USD 100,000. The remaining value of USD 59,278 was distributed among the activities that required a budget increase.

4 Assessments of Project Results

The aim of this final evaluation is to report the results obtained during the project's development, satisfy the accountability requirements and promote the learning, feedback and exchange of knowledge through the results, conclusions and lessons learned between the main stakeholders and partners of the project.

It is important to notice that although some delays in some activities and taking into account the general objective of this project which is to promote and support catalytic investments for geothermal power in Colombia through the strengthening of its regulatory framework and the development and implementation of a demonstrative geothermal project in the Ruiz Volcanic Massif which will contribute to reduce and displace unrealized GGE, the specific objectives of the project obtained were: (i) a white paper policy to promote use of FNCER (such as geothermal, wind and solar/PV) and specific policy and regulatory measures recommendations and implementation, (ii) a model of the geothermal resource in a selected area and its temperature, (iii) identification of the type of geothermal resource and its potential capacity, (iv) recommendations concerning the geothermal resource exploration and development, (v) environmental and sociological studies according to the scope of these activities and (vi) development and implementation of the project, the results obtained fulfilled the RESULTS FRAMEWORK & INDICATOR MATRIX presented in the document Catalytic Investments for Geothermal Power (Co-X1009), Plan of Operations Non-Reimbursable TC financed with GEF Resources. The results for both components are shown in Annex 3.

- **Component I**

The main achievements and progress made over the forty (40) months of execution of the agreement reported under this report, are:

- ✓ The implementation of the agreement signed on November 30, 2011, began with the appointment by UPME of staff in charge of structuring the early stages of the

project, under the coordination of the person in charge of the URE and FNCE group, with the support of the Unit´s specialist on FNCE and an additional engineer hired by the unit to assist with this and other tasks (with UPME resources). During this first stage, a startup workshop was carried out, followed by the selection by the IDB of CI as the appropriate entity hired to be responsible for administrative and financial component management.

- ✓ The acquisition of three computers for project´s use was also made.

- ✓ The risk analysis conducted by the Auditor stated adequate conditions and competition on behalf of UPME to act as the executor of the project, and it also prepared a risks matrix with recommendations for mitigation, which would be used thereafter as a risk management tool project.

- ✓ The Steering Committee was held, with the participation of both the MME, and the CREG.

<u>Subcomponent I</u>

- ✓ The schedule of activities and Plan of initial acquisitions were reviewed, and therefore the first adjustments and changes were made in order to decentralize execution from a few contracts with large firms to rather address the key areas of interest (e.g. barriers, instruments, plan development, etc.) as work to be developed within the internal team with the assistance of expert individual consultants to be hired with such purpose, in addition to some few specialized firms for specifics such as cost-benefit analyses. Additionally, thanks to the adjustments made, it was possible to assign some budget for hiring a consultant to redesign and update the SGIC-FNCE into the new SGIC-FNCER.

  The SGIC-FNCER administrator worked steadily in publishing contents, and procuring web traffic using social networks, while achieving the registration of nearly 100 new users per month. Also, periodic newsletters were produced, while open forums were organized, and user comments were answered, actions all of which helped position the system.

- ✓ Literature reviews started to be performed to identify barriers and opportunities for penetration of FNCER in the national and international context, and as a significant point to be considered, the first draft of Law project 096/2012 produced by Congress first came into notice of UPME, dealing with the integration of FNCER to the national energy system.

- ✓ With the consultant´s participation, meetings were held with UPME, CREG, MME, ANLA, ISAGEN and Enel Green Power to gather information to be considered in the focus of the work conducted by the team. Such themes corresponded to the following:

- Wind power projects in high potential areas (especially La Guajira)
- Photovoltaic solar energy as a means of distributed generation
- Biomass Cogeneration, especially in industry
- Geothermal Energy in high potential areas (ISAGEN projects in progress)
- Solutions with FNCER in ZNI

Thus, the identification and prioritization of barriers that initially focused on the literature review carried out before the conformation of the consultant team, now turned into identifying those barriers particularly associated with each of the 5 areas of opportunity.

- ✓ In the field of instruments, national and international consultants began the study of instruments, starting with those contemplated by Bill 278 of 2013 which was already being discussed among the project´s internal team, UPME and the MME. These instruments included investment tax incentives in projects with FNCE, bidirectional measurement schemes and differentiated tariffs for distributed generation, while also addressing particular points of interest not explicitly included within the Law, such as the aim for defining a clear environmental policy framework for geothermal projects, flexible schemes proposed for the entry of variable resources such as wind, and the relaxation of requirements to access the figure of cogeneration in industry, among others.

- ✓ A three-month course started for employees and contractors from UPME, addressing the subject of regulation of the electricity and gas sectors in Colombia. Additionally, a publication was obtained because of this course to be preserved by UPME for future reference.

- ✓ A course on project economic and financial evaluation "Training on financial, economic and social project evaluation, with emphasis in cost-benefit analyses".

- ✓ A training was conducted for the use of HOMER as a tool for economic and technical analysis of hybrid energy solutions for isolated systems, such as is the case of the ZNI. Such training was addressed to officials and contractors from UPME, IPSE, CREG, this project and the Colombian Clean Energy Program (CCEP).

- ✓ Participation in a mission for RE technology transfer in Germany, which included visits to commercial PV projects and biogas plants, same as meetings with several companies in the cities of Munich, Berlin and its surrounding areas.

- ✓ A training was given in the topic of operation of the wholesale energy market for UPME employees and contractors, addressing generation, transmission and electricity demand.

<u>Subcomponent II</u>

- ✓ Preliminary assessments of incentive proposals set in the Senate´s bill 278 of 2013 (same project as 096 of Chamber in 2012) were initiated for the specific case of investments in wind power projects. Similarly, analysis for distributed generation projects began to be carried for solar PV systems under different possible remuneration schemes, also making preliminary estimates of levelized energy costs for different FNCER in Colombia.

- ✓ The team worked directly in the review of the bill 096-2012 (278 2013 Senate) and proposed a set of adjustments and agreed modifications in conjunction with the MME, which were submitted to final reconciliation with members of Congress who conceived the bill.

- ✓ The revision of the instruments contained in Bill 278 of 2013 continued, which on May 13, 2014 became the Law 1715. Once the Law was issued, UPME assumed leadership in the process of ruling of the new Law, working with the MME in the definition of seven key issues which were:

    - Demand response
    - Excess electricity injections to the grid, from self-generation and cogeneration
    - Non-interconnected areas (ZNI) and their use of FNCER
    - Tax incentives
    - Distributed generation
    - Energy efficiency
    - FENOGE (fund created to finance RE and efficient energy management projects)

- ✓ The development of the strategy by national and international consultants, also based mainly on the framework established by Act 1715 and focused in the formulation of different sub-strategies applying specifically to each of the five addressed areas of opportunity.

- ✓ The cost benefit analyses of proposed instruments were developed. A tool in Excel, with different modules under which projects using wind, solar PV, biomass and geothermal sources and technologies could be evaluated including all costs, benefits, positive and negative externalities, and further assess these for the development of projected capacities.

- ✓ Analyzes for the island of San Andres were also developed, evaluating different alternatives for electricity generation incorporating the use of natural gas, LPG and FNCER, assessed using the HOMER tool.

- ✓ A study for evaluating proper and efficient alternatives (including the possibility of FNCER use) for street lighting in the municipality of Galapa, Atlántico, as a pilot project.

- ✓ To conduct fieldwork characterization and laboratory tests of various to make a redesign proposal for the street lighting system of the Galapa municipality, incorporating within the assessment the possibility of using FNCER to provide this service. Analyses for the use of solar PV and wind power systems, obtaining thus indications of high costs compared to those of using the energy from the network. Following this, it was proposed to consider their possible use only as pilot projects, especially in the case that the regulation of Law 1715 shall allow a favorable credit scheme which recognizes surplus electricity injected to the grid at the same rate as that paid by consumers for grid electricity. The results of this work which culminated in the first quarter of 2015 would serve Findeter to continue the work that this organization and the national government are performing in the field of sustainable development by promoting solutions such as public lighting in combination with energy efficiency projects and FNCE.

- ✓ Also projections for the penetration of solar PV in the residential, industrial, commercial and public sectors were complemented, as well as previous economic analysis that had been performed for this type of systems and large-scale wind projects.

- ✓ The analysis of instrument and strategy formulation also concluded, presented an overview of the types of both instruments used internationally and those adopted by Act 1715, differentiating as well particular aspects for the case of ZNI. On the other hand, the final recommendations regarding instruments, highlighting the possibility of using incentives above market price for renewables, contracts for differences or even carbon taxes in the case of the non-electric sector. The importance and convenience of adopting standards, certification mechanisms and/or labeling to promote a proper development of a PV market, especially in the case of small to medium scale systems.

- ✓ A proposal of a strategy to promote the development of FNCER in the context of both the SIN and ZNI, especially addressing guidelines for the delivery of surplus electricity, distributed generation, the development of specific plans for the use of wind energy in the Guajira and structured energy solutions in ZNI, among other recommendations.

- ✓ Recommendations on strategy, mainly addressing the importance of proper design of bidirectional measurement schemes, pointing at features that should be implemented in Colombia to encourage the development of small projects with FNCER and posing strategy options for developing the concept of prosumers. Also illustrated the potential effects of tax incentives provided by Act 1715, especially in the case of large companies that could benefit from these, and presented specific recommendations for the future development of solar thermal systems for water heating (as an important opportunity for the use of FNCER with non-electric purposes).

- ✓ The analysis for integrating energy coming from variable sources into the wholesale energy market, with special emphasis on wind energy. This proposal considered possible effects of such integration, combined with technical requirements, same as the valuation of benefits in terms of reliability and possible ENFICC.

- ✓ An analysis of the ruling process related to the tax incentives established by Law 1715. Because of this work, a decree was drafted for consideration of the various ministries involved with this specific topic, while all considerations considered for such draft where also documented on another report. Based on comments and meetings held with reviewing entities, a final document was put together by UPME and once approved it was made public by the MME for comments.

- ✓ Analyses were carried for defining the limit of small-scale self-generation and those differences that should simplify connection procedures for small scale projects. These were conducted in accordance with the criteria set out in Act 1715 and in accordance with the precedents set by previous electricity and other utility bills. Similarly, within these additional analyzes a concept on property management of renewable resources, obtaining recommendations of what the Colombian Law should addressed hereafter in this sense.

Subcomponent III

- ✓ Regional workshops were held in the cities of Bucaramanga and Riohacha, events in which the objectives and expected outputs from the project were socialized with the public and comments were received both regarding the existing SGIC-FNCE and in line with expected outcomes.

- ✓ Meetings were held with stakeholders in the energy sector, such as EPM, ISAGEN, EMGESA, Enel Green Power, Codensa, EPSA, Schneider Electric, same as some distributors and developers of solar PV technology and projects, and with agents from the agro industry with experience or interest in the energy sector (case of Asocaña, Incauca and Providencia, Fedepalma, Cenipalma and Fedebiocombustibles).

- ✓ Regional events were completed in this period with workshops in the cities of Cali and Bogota.

- ✓ A member of the team took part in the regional forum on geothermal energy developed in the month of November in Lima, Peru, same as in the annual forum on renewable energy held in the city of Riohacha.

- ✓ On the other side, a team member also accompanied some of the technical visits performed by consulting groups CorpoEma and Incombustion (contractors for UPME) in the cities of Medellín, Bogotá and surrounding areas, to identify opportunities for renewable energy use in the industry.

- ✓ Participation of the project within the Fourth International Environmental Fair, FIMA, in Corferias Bogotá.

- ✓ An event, being attended by over 200 people, related to the state of the art policies and global trends in RE and FNCER, and other specifics were presented, with the participation of representative from all governmental and private relevant institutions in the energy sector. Preliminary results of the work carried by the firm COWI on possible effects of wind energy integration over the Colombian energy grid were also presented by COWI representatives via teleconference.

- ✓ A workshop addressed mainly to ANLA representatives was organized, focusing in the development of geothermal projects to understand possible environmental effects or risks associated with each one of the stages involved in the development of this type of projects.

- ✓ Participation in the "Workshop: Economic Evaluation and its Application in Environmental Damage" which was held in the city of Pereira.

- ✓ UPME and the team project participated in the Fourth International Environmental Fair FIMA in Bogotá, with an institutional stand and a conference presentation of the law 1715 of 2014.

- ✓ The first business conference on projects with FNCER was held, being attended by over 60 participating companies, supplying and demanding products, services and financing related to FNCER small scale projects in Colombia.

- ✓ Participation in the Andesco´s 16th National and International Congress for Public Services, with an institutional stand which was accompanied by a space for socialization of the SGIC-FNCER and provided to facilitate meetings between companies interested in the subject.

- ✓ A survey was carried among a representative sample of the energy and industrial sector, to find on the expectations of this agents for the development of projects with FNCER during the period 2015-2030. Such survey considered scenarios with and without the existence of the conditions set by Bill 278 of 2013 (before it became law). The results of this survey would be used for the preparation of FNCER penetration prospects.

- ✓ Workshops were performed to discuss the two first of the specific topics set for its ruling process. Both events had the participation of an average 100 people each.

- ✓ Workshops for discussion and socialization of the ruling process for Act 1715 continued through 5 new events, having the attendance of about 500 people in response to the advertisements made through the SGIC-FNCER.

- ✓ An event to launch the 1715 Act with the presence of high representatives from the national government and other personalities such as the Minister of Mines and Energy Mr. Amylkar Acosta, Congress President Mr. José David Name and former President of Costa Rica Jose Maria Figueres, now president of the Carbon War Room.

- ✓ Wide dissemination of the work done within the project, by UPME and by the MME regarding Act 1715, was achieved through presentations at various events that took place in the cities of Bogotá, Cartagena, Neiva, Riohacha, Medellin and Aracataca.

- ✓ An event for sharing final project results was performed, in which interventions and presentations where performed by the leading consultants in the areas of barriers, instruments, strategy, cost-benefit, market integration and the SGIC-FNCER, complemented by presentations addressing the analysis of alternatives for generation in San Andrés, specific economic analysis for wind and solar PV technologies, and FNCER penetration projections up to 2030. The event was attended by over 120 people, some of which actively participated with comments that were useful in the preparation of results publication. Ending with this event, the number of diffusion activities organized under the project was higher than the 10 events that were originally planned to reach 16 events, excluding those not organized by the project itself, but in which the team also participated creating opportunities for presenting the work that was developed, mostly embedded in the context of Act 1715 of 2014.

- ✓ Making use of the end products received from the consultants and firms involved in the project, these were integrated, organized and consolidated to produce together with material corresponding to internal analyzes, the final project results publication, which was completed in March, consisting of almost 400 pages.

- **Component II**

To achieve the objectives, execution of the activities, and outcomes, national and international consultants, as well as academic staff (university professors, and PhD, master's degree and undergraduate students) participated in this component. They made it possible to satisfactorily achieve the component's objectives. The rating of the activities developed related to this component are shown in Annex 2.

<u>Subcomponent I. Technical Studies:</u>

- ✓ Purchase of two (2) pieces of Phoenix V8 magnetotelluric (MT) equipment, and leasing of additional equipment for the acquisition of new MT surveys in a smaller area of the project (local scale), and their subsequent one and two-dimensional (1D and 2D) processing.

- ✓ Analysis, review and integration of studies of detailed geology; hydrothermal alterations; geochemical classification of sources of hot springs and cold springs; and geophysics (gravimetry, magnetometry and magnetotellurics).

- ✓ Design and execution of a detailed magnetotelluric study in the area with greatest potential to develop the power plant (Botero – Londoño); resistivity structure of the subsoil; interpretation of results; and 1D and 2D modeling.

- ✓ Marking of the sealing layer, measurement of the reservoir, and estimation of the geothermal potential for the definition of the definitive design and technical specifications of the drilling, through the 3D modeling and analysis of the MT data obtained in the Botero - Londoño area.

- ✓ Terms of reference and minimum specifications for the procurement of exploratory drilling for the Ruiz Volcanic Massif Project. These include technical specifications, recommendations and common practices in the geothermal industry around the world.

- ✓ Hydroclimatic study of the project area and preparation of a methodology to reconstruct the synthetic temperature series on the site of a geothermal plant according to the requirements to calculate geothermal plants' firm energy to be purchased at the ENFICC according to CREG Resolution 132 of 2014.

- ✓ Identification of three (3) alternatives for the integration of the geothermal plant into the National Transmission System (SIN) and definition of the connection line.

- ✓ A favorable opinion for the connection of a 50-MW geothermal plant to the SIN was obtained from the entity responsible.

Subcomponent II. Review and Analysis of Technical Studies:

- ✓ Review and analysis of the technical studies, results, conclusions and recommendations of the project's pre-feasibility studies.

- ✓ Complementation of the conceptual geothermal model of the Botero - Londoño area from the acquisition of additional MT surveys, three-dimensional (3D) inversion and processing of the data, and preparation of the resistivity model in 2D. and 3D.

Subcomponent III. Environmental and Social Studies:

- ✓ Complementation of the EIA for exploration with the aim to include construction of a 50 MW power plant, the connection line to the SIN, the operation and maintenance of the plant and geothermal field (use of the resource) and the disassembly and abandonment of the project area. This complementation includes taking geotechnical samples for the improvement and construction of roads, drilling

platforms and the power plant; outline of alternative connection lines and complementation of the social and environmental information.

- ✓ Processing of the environmental license. The complementation of the environmental impact assessment was submitted to the competent environmental authorities (ANLA and CORPOCALDAS) for their evaluation and for the awarding of the environmental license for exploration and use of the resource.

Subcomponent IV. Institutional Improvement and Disclosure of Conclusions:

- ✓ Improvement of the technical and institutional capacity of ISAGEN through the assistance and consultancy of international experts in geothermal projects around the world, including Boston Pacific, Nippon Koei, West JEC and LaGeo. Additionally, the participation of the professionals of the ISAGEN Research and Development Team in specialized geothermal energy courses in El Salvador, Japan, Iceland and the USA was encouraged.

- ✓ Coordination, execution and participation of the theory/practice course on the use of the geophysical, magnetotelluric technique for its application in geothermal exploration, equipment management and data processing. The workshops were designed for undergraduate and postgraduate students, and professors of the Universidad Nacional de Colombia and professionals from the Colombian Geological Service and ISAGEN, and they were developed by experts from Phoenix and LaGeo.

- ✓ Training of undergraduate and master's students on the use of the MT technique for the exploration of geothermal resources through participation in the work to acquire MT data in the field; training by international experts; and support and assistance during the processing, analysis and interpretation of MT data, and preparation of dissertations.

- ✓ Communication of the results of the demonstrative project of the Ruiz Volcanic Massif through three (3) training workshops in the cities of Pasto, Bogotá and Manizales on the characteristics and potentials of geothermal energy. The workshops were designed for government, regulatory, environmental and academic entities, and the community in the project's area of influence. More than 150 people from the different invited entities attended.

- ✓ Preparation, edition and publication of the technical document “Geothermal Energy Enterprise in Colombia”. Available on the website of the IDB and ISAGEN.

Subcomponent V. Project Action Plan and Development:

- ✓ Based on the results obtained by the project, non-refundable technical cooperation from the Japan Bank for International Cooperation (JBIC) was obtained to help complement the pre-feasibility studies conducted with the support of the IDB and

GEF on aspects related to measurement, in-plant distribution of the power plant, major and auxiliary equipment, separators, and flow lines, among others.

- ✓ A memorandum of understanding (MOU) was established with the companies Toshiba, Schlumberger, West JEC and the Japan Bank for International Cooperation (JBIC) to study the potential formation of a partnership for the development of the project in its exploratory drilling and geothermal plant construction phases.

- ✓ Progress was made in the preparation of the project's financial model, the identification of funding sources, and financing systems available in the world to fund renewable energy projects. A plan was made for the financial structuring of this kind of project.

- ✓ Companies, organizations and financial entities that could financially support the project's development have been identified and contacted.

4.1 Relevance

- **Component I**

According to the component's objective, to strengthen the regulatory framework, promote market approaches for RE and remove barriers that obstruct the development of FNCER, different studies were developed to:

- ✓ Identify barriers for the development of FNCER in Colombia and propose actions and mechanisms to remove the main barriers, considering cost-benefit analyses in their definition of actions and mechanisms to be proposed as part of policy guidelines for the development of technologies that make use of specific FNCER.
- ✓ Also, includes recommendations and policy guidelines that promote investments in renewable energy projects under the approach of a competitive market.
- ✓ The development of a strategy for the development and use of FNCER in accordance with the policy guidelines to be recommended, establishing lines of action to be implemented to achieve specific goals in this context.
- ✓ The above topics were considered in the preparation of the Law 1715 of 2014. Once the Law was issued, UPME continue with the leadership in the process of Ruling of the new law, working with the MME in the definition of seven key issues which were:
    - Demand response
    - Excess electricity injections to the grid, from self-generation and cogeneration
    - Non-interconnected areas and their use of FNCER
    - Tax incentives

- Distributed generation
- Energy efficiency
- FENOGE (fund created to finance renewable energy and efficient energy management projects)

Considering the above results, mainly the Law 1715 issued, it is considered that the Component Relevance is Highly Satisfactory (HS) and the results obtained provide an important regulatory framework for promoting market approaches for RE and the development of FNCER in Colombia.

- **Component II**

The development of this component has contributed to the encouragement and promotion of geothermal energy in Colombia, a resource that is not currently exploited in the country despite having great potential for use in the generation of electricity, as well as direct uses (including tourism, aquaculture and agriculture).

As part of the project's environmental management plan, strategies for environmental conservation in its area of influence, the reduction and displacement of GGE, the mitigation of climate change and improvement of the community's wellbeing in the project area have been identified and proposed.

It is of note that this project has been the vehicle that has allowed ISAGEN and the country to progress in the acquisition and incorporation of geothermal energy into the energy matrix. Among other benefits, this will help diversify the country's energy portfolio and reduce current GGE from power generation with fossil fuels (gas and coal).

Through the subsoil evaluation studies, the uncertainties regarding geothermal exploration have been reduced, by better marking of the areas with greater geothermal potential, identifying the characteristics of the resources, complementing the conceptual geothermal model, and selecting the objectives for exploratory drilling. Considering the above, the conditions and technical knowledge are available to advance in the exploratory drilling stage and to confirm the existence of the resource at depth, meaning that the construction of the first geothermal power plant in the country is viable.

Additionally, with the progress in technical, environmental and social studies developed as part of this project, the characteristics of geothermal energy, and its impacts, related risks and potentials have been communicated to the government, regulatory and academic entities, and to the community in general.

The project's development has promoted the generation of new regulations for the commercial integration of this technology into the electricity market.

By the above, it is considered that the project's relevance is High Satisfactory (HS) and the results obtained provide important information to advance in line with the country's energy and environmental strategies, policies and commitments.

Considering the analysis done to both components and the results obtained, the project´s Relevance is High Satisfactory (HS).

4.2 Effectiveness

- **Component I**

Considering the objective to strengthen the regulatory framework, promote market approaches for RE and remove barriers that obstruct the development of FNCER, to foster the development of a favorable environment for the development and integration of FNCER in the Colombian energy matrix, which are based on the identification of institutional, regulatory and general barriers that have prevented the participation of these sources in the Colombian energy market, and the proposal and promotion of instruments and actions that could serve in removing such barriers after due analysis and prioritization, the component´s Effectiveness is Highly Satisfactory (HS).

- **Component II**

Considering that the main objective is to develop and implement a demonstrative geothermal project in the Ruiz Volcanic Massif that helps to reduce and displace GGE, the component's Effectiveness is deemed Highly Satisfactory (HS). Not only did it comply with the execution of the proposed activities, but it also increased the scope of the project to include not only the exploratory drilling, but also the use of the geothermal resource. Therefore, additional activities to those originally planned were carried out, which included the measurement of the geothermal field; the basic design of the field and power plant; the complementation of the EIA for the exploration and use of the resource; the study of connection to the SIN; hydroclimatological classification; and temperature series to determine the firm energy that the geothermal plant may deliver once it is built.

It is particularly important to consider that although the initial terms established for the development of this component were not met due to multiple technical and administrative issues, the delays are justified by the need to fully achieve the agreement's objectives, technological appropriation, and capacity generation in the country.

By the above, a synthesis is made of the achievement of the component's specific objectives:

- ✓ **3D modeling of the geothermal and resistivity model:** From the review, analysis and integration of the geological, geochemical and geophysical information acquired during the project, the magnetotelluric study was defined and

complemented, the 1D, 2D and 3D resistivity model was obtained, and the conceptual geothermal model was proposed.

- ✓ **Identification of the type of geothermal resource and its potential capacity:** With the results of the conceptual geothermal model, the type of resource present, expected temperature, measurement and depth were estimated. Additionally, a statistical calculation was made with the information obtained to determine its most likely potential.
- ✓ **Recommendations regarding the exploration and exploitation of the geothermal resource:** With the support of international experts in exploration and exploitation of geothermal fields, the locations of the sites for deep exploratory drilling were specified, which will permit confirmation of the existence of the resource at depth.
- ✓ **Environmental and social studies according to the scope of these activities:** The environmental impact assessment was prepared, complemented and submitted to the corresponding environmental authority for its evaluation and the awarding of the environmental license for exploration and use of the resource. Additionally, awareness was raised of the project and the community was supported according to the progress of the activities. The climatological classification was carried out and a methodology was established to calculate the temperature series to establish the project's ENFICC.
- ✓ **Development and implementation of the geothermal project:** The sites were defined to implement a 50 MW geothermal plant in the Ruiz Volcanic Massif, as well as the areas required for their location.
- ✓ **Financial Structuring:** Progress was made in the activities required for the prospecting of the resource for the development of the project and its financial structuring.

Considering the analysis done to both components and the results obtained, the project´s Effectiveness is High Satisfactory (HS).

4.3 Efficiency

- **Component I**

  According with initial budget and the activities and the studies to be developed, and considering that additional studies were done without modifications of the initial budget, it is considered that the Efficiency of this component is Highly Satisfactory (HS).

  In the case of the execution time of the activities, the Efficiency was Satisfactory (S), because there was an important delay in the start-up of this component that it was recovered and a requested an extension of four (4) months for ending on March 2015. It is important to notice the commitment and effort were done by UPME, CI, IDB and the team component to recovered the delay maintaining the studies quality to fulfill the objectives of it.

- **Component II**

From an economic perspective, Agreement ATN-FM-12805 had Highly Satisfactory (HS) Efficiency, given that the results proposed at the start of the agreement were achieved at a lower cost. Furthermore, additional activities were included with prior approval of the IDB, which helped to have better knowledge of the resource, measure the geothermal field, define the exploratory drilling targets, advance in the basic design of the plant, and improve the appropriation of the technology by the company and the country.

The following table presents the distribution of costs and activities budgeted at the start of the project and the actual cost of them, which were executed with IDB/GEF funds.

Budget Execution IDB/GEF Funds

Category Name	Original Budget (USD)	Executed Budget (USD)
Subsoil Evaluation Studies	1,000,000	1,270,145
Purchase of two pieces of magnetotelluric equipment	462,550	355,548
Consultancy, review of the geological and geophysical model, action plan, and leasing of equipment	170,451	332,110
Consultancy, monitoring and supervision	366,999	146,974
Complementation of the EIA for construction, plant operation and geothermal field	Additional activity	303,698.79
Escuela de Ingeniería de Antioquia - ISAGEN Agreement, Methodology for the Calculation of the ENFICC (CREG Resolution 132 / 2014), and hydroclimatological classification	Additional activity	78,310.60
Connection study	Additional activity	15,688.95
Results disclosure workshop	Additional activity	37,813.57
Financial Structuring – Construction of Geothermal Plant	427,000	240,000
Financial structuring	427,000	240,000
Project Management, Supervision, Audits and Contingencies	100,000	16,855
Supervision and follow-up	100,000	16,856
Total	1,527,000	1,527,000

With respect to the time required for the execution of the activities, the efficiency was Moderately Satisfactory (MS), because there were some delays in obtaining the results. The above is due to the fact that: i) the work required for the good development of the project is specialized and requires expert professionals and consultants in geothermal energy who are not located in the country, ii) the procurement process of the magnetotelluric studies was declared void and therefore,

the process had to be restarted to structure a research project with the Universidad Nacional de Colombia, LaGeo and other external advisors, iii) the magnetotelluric studies took longer than initially planned due to problems of cultural noise (electromagnetic noise) because of volcanic activity, iv) additional activities to those initially planned were carried out in order to locate and measure the reservoir, and propose the development of the field with the definition of the sites and dimensions of the power plant, and production and reinjection wells, v) the environmental impact assessment was complemented to comply with the requirements requested by the environmental authority during the development of the project; and vi) the procurement of "consultancy for financial structuring" was carried out in the last semester of the term of the IDB/GEF – ISAGEN Agreement with an implementation duration of 12 months, so it could not be completed within the initial term of the agreement.

Because of the above, the project was extended two (2) times, firstly for one (1) year and later for six (6) additional months, equivalent to a total duration of four years and six months (4.5 years).

The scheduled times and actual times of execution of the activities (additional activities are included) and the justification for the delays are presented below:

Schedule Implementation ISAGEN - IDB/GEF Agreement

Category Name	Scheduled Time	Actual Time	Justification
Subsoil Evaluation Studies			
Purchase of Two Pieces of Magnetotelluric Equipment	5 months (May 2012 - October 2012)	7 months (August 2012 - March 2013)	The actual procurement and bid preparation times exceeded the estimated times The process of importing and nationalizing equipment took more time than planned
Magnetotelluric Consultancy and Leasing of Equipment	8 months (July 2012 – March 2012)	30 months (June 2013 – December 2015)	Initial procurement process declared void Restart of procurement process Technical problems in the acquisition of the MT surveys due to the geological characteristics of the area and increase in the volcanic activity of the Nevado del Ruiz Extension of one year to complete the academic products (dissertations and related scientific articles)
Consultancy, Monitoring and Supervision*	24 months (July 2012 – July 2014)	June 2013 – Ongoing	The implementation of the activities was subject to the progress of the MT studies The project's environmental license must be obtained to continue with the procurement of exploratory drilling; execution of the exploratory drilling; evaluation of the reservoir; development of the field; and design of the power plant, which are part of the contract's scope New activities were included as part of the contract with West JEC, which include the 3D modeling and analysis of the reservoir and the workshops to communicate the project's results
Complementation of the EIA for Construction, Plant Operation and Geothermal Field	5 months (February 2015 - July 2015)	9 months (February 2015 - November 2015)	Rescheduling of the contract's activities because of the implementation of specialized air quality studies Delays in the awarding of permits by the environmental authority for the collection of species and additional requirements to the archaeological prospecting requested by the ICANH

Category Name	Scheduled Time	Actual Time	Justification
Escuela de Ingeniería de Antioquia - ISAGEN Agreement, Methodology for the Calculation of the ENFICC (CREG Resolution 132 / 2014), and Hydroclimatological Classification	12 months (April 2015 - April 2016)	12 months (April 2015 - April 2016)	In accordance with CREG Resolution 132 / 2014, hydroclimatological classification needed to be carried out in the area, as well as the construction of a methodology to establish long-term temperature series in the area and calculate the firm energy (ENFICC) that the project could generate An agreement was prepared and signed with the Universidad Escuela de Ingeniería de Antioquia to carry out these analyses
Connection Study	5 weeks (April 2015 - May 2015)	5 weeks (April 2015 - May 2015)	It was necessary to carry out this additional activity to define the project's connection point to the National Transmission System and the corridor of the transmission line The results of this study were incorporated into the environmental impact assessment to comprehensively process the project's environmental license, including the transmission line
Results Disclosure Workshop	One month (April 2016)	One month (April 2016)	It was agreed with the officer responsible for the project in the IDB to carry out a workshop to disclose the project's results to the community in general and nationally promote the technology
Financial Structuring – Construction of Geothermal Plant			
Financial Structuring	12 months (August 2014 - August 2015)	December 2014 – Ongoing	Delays in the preparation of the proposals by the bidders and due to the approval times in the procurement process of ISAGEN and the IDB Changes in regulations that affect the financing of renewable energy projects in Colombia and that did not permit the completion of the contract's activities

Considering to the analysis done to both components and the results obtained, the project´s budget Efficiency is High Satisfactory (HS), but the execution time of the activities' Efficiency was Moderately Satisfactory (MS).

4.4 Sustainability Risk Assessment of the Project Results

- **Component I**

  Although the objectives and the results for this component were obtained according the initial conditions, it should be recognized that given the fact that work for the promotion of FNCER should not end with the completion of this component, and should neither be stopped with the completion of the ruling procedure of Law 1715, it is essential that the current and future Ministry of Mines and Energy continues giving importance to this task, based on the relevance that the subject has received from this Act by the Congress, and that continued activities are performed following the proposed strategy and recommendations derived from this component, for the successful integration of these sources to the national energy system.

  It is important to notice the importance of the activity of monitoring the market in a permanent way, to introduce if it is required changes or modifications in the rules. Also, there are some activities related to the Law which are in developed.

Moreover, for example there is a risk that the activity of the SGIC-FNCER decreases now that there will not be a person full time in charge of procuring contents and generating users' involvement, upon receipt of the system. Also, it is expected that those people who have somehow participated of this initiative will continue to make their contributions to the system on a voluntarily basis as independent users.

It is considered that this component is Moderately likely (ML) which means that there is moderate risk that affect this dimension of sustainability.

- **Component II**

Taking into account the objectives of this component related to the development and implementation of the geothermal project in which the sites and their location were defined to implement a 50-MW geothermal plant in the area of the Ruiz Volcanic Massif and the in the activities required for the prospecting of the resource for the development of the project and its financial structuring, it means that at the ending of the above activities, the project will be ready to continue with the activities related to the power plant construction, therefore an important amount of resources is required for the exploration drilling process, which is a high risk investment activity to be developed for the project owners.

The above investment decision will be supported in the financial structuring analysis. Also it is important to notice that Colombian Government participation in ISAGEN was sold to a Canadian private investment fund, so this company is a private enterprise without public participation. Therefore, the future of this project is considerate Moderately Unlikely (MU), which means that there is a significant risk that affect this dimension of sustainability.

In the case of the Sustainability Risk Assessment of the project results, there are important differences between the components, therefore Component I is Moderately Likely (ML) which means that there is moderate risk that affect this dimension of sustainability and Component II is Moderately Unlikely (MU), there is a significant risk that affect this dimension of sustainability.

4.4.1 Sustainability

Social and Political Sustainability

- **Component I**

Considering the objectives of this component and the results obtained, which are in the Law 1715 2014, some of the benefits obtained are:

- ✓ A regulatory framework to remove barriers and promote investments in renewable energy projects under the approach of a competitive market.

- ✓ To develop a strategy for the development and use of FNCER in accordance with the policy guidelines to be recommended, establishing lines of action to be implemented to achieve specific goals in this context.

- ✓ To foster the development of a favorable environment for the development and integration of FNCER in the Colombian energy matrix, reducing GGE and support the implementation of programs that contribute to the mitigation of climate change (commitment acquired in COP21).

- ✓ Strengthening of the technical and scientific capacity of students, professionals and the community in general regarding the characteristics, impacts, uses and importance of the FNCER.

- ✓ Expression of interest by some power generation companies in developing FNCER projects.

The risk of affecting the component's social and political sustainability is deemed low, Moderately Likely (ML).

- **Component II**

From the social and political perspective, the benefits after the GEF's support has finished are:

- ✓ Strengthening of the technical and scientific capacity of students, professionals and the community in general regarding the characteristics, impacts, uses and importance of geothermal energy.

- ✓ Generation of technical capacity and availability of equipment to implement exploratory studies on the surface (including magnetotellurics) in other areas with geothermal potential.

- ✓ Operation of the hydroclimatological station and hourly measurement of the ambient temperature in the project area. This provides the information required for the definition of the power plant's firm energy, once there is confirmation of the resource at depth.

- ✓ Expression of interest by some power generation companies in developing geothermal projects, and driving and promoting the implementation of laws and/or resolutions that promote research, exploitation of this resource, and the definition of the reliability charge of this kind of energy within the National Transmission System.

- ✓ Openness of the community in the project's area of influence and regional stakeholders to the development of the Ruiz Volcanic Massif Geothermal Plant Project.

- ✓ The expression of interest by the Colombian Government in advancing with the promotion and exploitation of FNCER such as geothermal energy to diversify the country's energy matrix and support the implementation of programs that contribute to the mitigation of climate change (commitment acquired in COP21).

- ✓ Encouragement of academic projects on this kind of energy and the openness expressed by the community of the area of direct influence and regional stakeholders to the development of the project in their region.

Because of the above and the advances in the definition of the area of development, localization, measurement of the reservoir, in-plant distribution of the main works, equipment and systems, connection infrastructure, civil works, and processing of the environmental license for the exploration phase and use of the resource, which were not defined at the start of the project, the risk of affecting the project's social and political sustainability is deemed low, Moderately Likely (ML).

Considering the analysis done to both components and the results obtained, the risk of affecting the component's social and political sustainability´s project is deemed low, Moderately Likely (ML).

4.4.2 Funds

- **Component I**

After the Law 1715, the most important activities are related to the implementation of it which means that it fosters the development of a favorable environment for the development and integration of FNCER in the Colombian energy matrix. This, based on the identification of institutional, regulatory and general to promote the participation of these sources in the Colombian energy market, and the proposal and promotion of instruments and actions that help to this objective.

The market monitoring will be a fundamental tool to identify the results of this Law and for the changes or modifications which can be done in the future. This activity is currently developed for the regulation, supervision and control entities, so the risk is considered Likely (L), negligible risks that affect this dimension of sustainability.

- **Component II**

The assistance received from the IDB-GEF has enabled progress in the classification and estimation of the existing geothermal potential at surface level in the MVR. This is a very important step for the country, as well as ISAGEN as a company of the electricity sector, toward making power generation projects with this kind of resource viable. However, considering the high risk associated with geothermal generation,

which requires numerous high-risk investments for exploration, external support is still needed to give continuity to this kind of project and mitigate the related risk.

Additionally, as Colombia has hydroelectric and fossil fuel resources for electricity generation at relatively low prices compared to the costs of geothermal energy generation, the support of mitigation funds needs to be continued to try to reduce the costs and risks to make the technology competitive on the Colombian market. It is considered that now, there is high financial risk in progressing with the feasibility stage and development of a geothermal field, and its rating is Moderately Unlikely (MU).

In the case of the Fund´s project results, there are important differences between the components, therefore the risk for the Component I is Likely (L), negligible risks that affect this dimension of sustainability, but Component II is rating as Moderately Unlikely (MU).

4.4.3 Institutional Framework

- **Component I**

  The Law 1715 as a regulatory framework to promote investments in FNCER projects under the approach of a competitive market, considers the activities that should be developed for the different participants in the market, so the risk is considered as Moderately Likely (ML).

- **Component II**

  From an institutional perspective, the component has permitted the creation and consolidation of a work team with technical capacity for the development of geothermal energy generation projects, which will continue the management, planning and development of this kind of project once the GEF's support has ended.

  Taking under the follow-up of the environmental regulation and financial support that make the development of geothermal projects in the country viable, the sustainability of the institutional framework is deemed Moderately Likely (ML).

Considering the analysis done to both components and the results obtained, The Institutional Framework´s project, the risk is Moderately Likely (ML).

4.4.4 Environmental Sustainability

- **Component I**

  One of the objectives of this component is the diversification of the country's energy matrix and promotion of the use of FNCER, reducing GGE and contributing to the reduction impact to climate change, therefore most of the actions considered are in this direction, environmental sustainability, so the risk is considered Moderately Likely (ML).

- **Component II**

Geothermal energy as a renewable, clean and environmentally-friendly source of energy has likely (L) environmental sustainability once there is a power plant in operation with this energy source, which produces low greenhouse gas emissions and helps to mitigate climate change.

Therefore, the studies conducted as part of this component have permitted the estimation of the reservoir's potential, and therefore, they have made the development of the feasibility phase viable, which will confirm existence of the resource at depth.

Regarding environmental licensing, the continuation of the project in the short term and the environmental sustainability of the exploitation of geothermal energy are considered Moderately Likely (ML).

Taking under the analysis done to both components and the results obtained, The Institutional Framework´s project, the risk is considered as Moderately Likely (ML).

4.4.5 Catalyzing Role and Replication

- **Component I**

  To have a regulatory framework which promotes de FNCER in Colombia, will contribute to the diversification of the country's energy matrix, so increasing the FNCER´s participation based in different renewal energy sources.

  It is considered that the way of this component was developed, it will have a catalyzing role and replication for another economic sectors or countries.

- **Component II**

  The replication of this kind of project is vitally important to the country in the sense that it would permit mitigation of the risk associated with geothermal exploration and would facilitate the quick exploitation of this kind of energy in Colombia. This would not only contribute to the diversification of the country's energy matrix, but also drive the use of clean and environmentally-friendly energy by considerably reducing GGE resulting from the generation of energy with fossil fuels, and would help to comply with the level of emissions committed by the country in the 2015 Convention on Climate Change – COP 21.

  To date, Colombia does not have geothermal energy generation. However, this could be successfully developed considering its privileged geographical position and favorable geological conditions as part of the Pacific Ring of Fire. In this area, the natural temperature gradient in the subsoil is closely related to volcanic activity, the presence of hot springs and fumaroles, and related hydrothermal surface alterations.

  In accordance with the above, studies conducted in the nineties to assess geothermal resources in Latin America and the Caribbean have identified a geothermal potential

for Colombia of 2,210 MW[3], out of which, approximately 14.4 MW[4], are exploited for direct uses such as tourism and recreation.

Therefore, taking the country's geothermal potential as a reference, the application of this kind of project facilitates progress in the acquisition of knowledge and technical capacity in this kind of technology focused on the implementation of a geothermal plant in the country. It also enables progress in the search for strategies that mitigate the risk during the stages of exploration and confirmation of the geothermal resource at depth.

It is considered that the way of this component was developed and the acquisition of knowledge and technical capacity, it will have a catalyzing role and replication for developing future geothermal projects in Colombia or another country.

Taking under the analysis done to both components and the results obtained, the Catalyzing Role and Replication´s project risk is considered Likely (L), negligible risks that affect this dimension of sustainability.

4.4.6 Assessments of the Monitoring and Evaluation Systems

Assessment of compliance with the minimum requirements for the monitoring and evaluation of the project according to GEF policies, which has the following main objectives: i) promote accountability to achieve GEF objectives through the evaluation of the results, effectiveness, processes and performance of the associates that participate in the GEF and ii) promote learning, feedback and exchange of knowledge about the results and the lessons learned between the GEF and its associations as a basis for decision-making on policies, strategies, and program and project management to improve knowledge and performance[5].

4.4.6.1 M&E Design

The monitoring and evaluation framework of the GEF lies in the preparation of regular reports to support decision-making, the development of policies and accountability. The monitoring documents for both components include:

- Acquisition planning: Before any call for pre-qualifications or proposals can be made to award a contract, as applicable, UPME and ISAGEN must submit the component's proposed acquisition plan for review and approval by the IDB, pursuant to the bank's Acquisition Policies.

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[3] *Battocletti, L. 1999. Geothermal Resources in Latin America and the Caribbean. BoB Lawrence & Associates, Inc., p. 214. Website: http://bl-a.com/ecb/PDFFiles/GeoResLAC.pdf.*

[4] *Alfaro, C., Velandia, F., and Cepeda, H., 2005. Colombian Geothermal Resources. Proceedings World Geothermal Congress, Antalya, Turkey, p. 11. Website: http://www.geothermalenergy.org/pdf/IGA standard/WGC/2005/0137.pdf.*

[5] *GEF Monitoring and Evaluation Policy* Evaluation Document 2006, No. 1. Washington D.C.

- Ex-ante review: Unless the IDB determines otherwise, the acquisition contracts of works and assets planned in the project will be reviewed by the bank ex-ante pursuant to the procedures established in the Acquisition Policies.
- Technical and basic responsibility: As executing agencies of the project, UPME and ISAGEN carried out the supervision and technical follow-up of the development and compliance of the studies and activities implemented with GEF funds, as well as the technical supervision of the terms of reference, performance of the consultancy work, and review of the technical quality of all the studies. Also, the IDB team participates in the above activities.

4.4.6.2 M&E Plan Implementation

The components' project monitoring and evaluation documents were implemented and updated during the execution of both components. Therefore, taking as a reference the requirements of the components´ project activities, the acquisition planes were updated to achieve the expected results.

Additionally, to determine whether the project was being implemented in accordance with the established objectives, UPME and ISAGEN participated in preparation of the mid-term evaluation report to the IDB, and in 2015, carried out the external audit for the periods between December 2010 and December 2014.

Furthermore, the IDB made inspection visits and held follow-up and coordination meetings to review the components´ project progress and the budget execution respectively, and to propose the necessary adjustments.

The Final Evaluation Report, subject of this document, facilitates the punctual follow-up of the project's progress by compiling information regarding the achievement indicators.

Taking as a reference the information described in this section, the global monitoring and evaluation during the project are generally considered Satisfactory (S).

4.4.6.3 Budget and Financing for Monitoring and Evaluation Activities

- **Component I**

  According with information shown in the Annex 1, for the budget a sum of USD 152,218 was invested for the component´s monitoring and evaluation. Four evaluation audits four (4) were done at the end of years 2012, 2013, 2014 and the final, at the ending of this component on October 2015.

  The final audit evaluation concludes that both UPME and CI fulfilled with the rules and procurement procedures established for this project in the contract signed between UPME and IDB-GEF, considering the operative manual which gave as result the preparation and presentation of the financial information, according to the eligibility of expenditure to be financed which were paid with the resources assigned to this component.

- **Component II**

  Since the component was signed, a budget was included for monitoring and evaluation called “Project Management, Supervision, Audits and Contingencies” with an authorized value of USD 100,000. However, given that the cost of this monitoring was less than the value budgeted and that the project required additional resources for other activities, as a pilot and innovative project, it was necessary to reconsider the acquisition plan and allocated budget to include new activities. This was also necessary to meet the requirements requested by the environmental entities during the implementation of the environmental impact assessment.

  Therefore, considering the cash flow required by the project, the acquisition plan and allocated budget for the follow-up and monitoring activities were amended from USD 100,000 to USD 16,855. By the above, the technical follow-up and the external audit for the periods between December 2010 and 2014 were assumed by ISAGEN as the project's executing agency, and included as commitments with prior authorization of the IDB.

For both components, the M&E systems were rated as High Satisfactory (HS) because there were not shortcomings. However, in the Component II, ISAGEN assumed the technical follow-up and the external audit for the periods between December 2010 and 2014.

4.5 Monitoring of Long-Term Changes

- **Component I**

  As part of this component, UPME redesign and update the system SGIC-FNCER which is an initiative that seeks to share with all those interested in RE and FNCER available information on potential projects and initiatives in this field with the aim of facilitate the exchange of knowledge, encourage cooperation and joint efforts and thus promote the successful development of new projects that make utilization of such sources.

  The operation of the above system is UPME´s responsibility, so no difficulties were expected to get the system´s objective.

  It is important to notice that this system is the way for collaboration by which it seeks to gather information for the advancement of FNCER. It has an integrated view of the community interested in this subject as they are citizens, organizations, research groups, experts, educational institutions, universities, public and private companies, government entities and the Colombian government represented by the UPME. Additionally the above information system will support the generation of public policy guidelines, regulation and cost-benefit assessment for the development of a sustainable market for FNCER.

- **Component II**

  Considering that the Ruiz Volcanic Massif geothermal plant project is innovative and groundbreaking in the country, it is important to establish long-term monitoring systems to follow up changes in the regulatory, environmental and social policies; market needs; environmental commitments; investors; and funding sources; among others, which make the implementation of this kind of project in the country viable.

  From a technical perspective, in compliance with its corporate purpose of energy generation and sales, ISAGEN is committed to the medium and short-term development of power generation projects with conventional and non-conventional renewable energy sources, and consequently, it promotes and funds research for the development of the geothermal project in the MVR. In its Institutional Development Plan, ISAGEN defined the continuity of the studies required to confirm the existence of the geothermal resource at depth, and it monitors achievement of the proposed objectives through the Balanced Scorecard (BSC).

  Additionally, and as part of the information learned from the execution of the ISAGEN –IDB-GEF Agreement, starting exploration activities in other geothermal areas of interest has been proposed inside the Company for development in the long term.

  It is of note that despite the progress made in terms of regulation and environmental regulations, the studies' continuity is subject to environmental permits, without considering the high risk of investment for the exploratory drilling phase. Therefore, it is currently seeking funding mechanisms and hedging of this risk.

4.6 Assessment Processes Affecting Attainment of Project Results

4.6.1 Preparation and Readiness

Were the project's objectives and components clear, practical and feasible in their baseline?

For the project, the definition of the component´s objectives and subcomponents was clear and feasible to develop in the initially proposed time as shown the results which were obtained. However, for Component II external factors that were not considered in the project planning, such as an increase in volcanic activity and new requirements by the environmental authority, between others, generated delays in the fieldwork and the inclusion of additional activities, which led to the extension of project duration to achieve the expected results.

- **Component I**

  As shown in the Annex 3 Results Framework & Indicator Matrix, the expected results for this component were obtained and some of them, overcomes the expected as for example the Law 1715´s approval.

- **Component II**

As shown in the Annex 3 Results Framework & Indicator Matrix, most of this component results were obtained although some delays in some activities and in one of them related to the financial structuring of the geothermal project is not finished, but it is currently being developed. Also, additional studies had to be developed, so the execution time component was increased.

Was the capacity of the executing agencies and their counterparts considered adequate when the project was designed?

- **Component I**

  In the beginning of this component, for UPME´s management difficulties as change in the administration led a delay which was recovered with the entailment of the component´s expertise group project, the update of the acquisition plan and the commitment and effort of the expertise group, consultants, the financial and administrative management of CI, UPME and IDB´s personal for developing the different activities.

- **Component II**

  The exploration and exploitation of geothermal resources require the use of specialized technologies, which are not often used in the country, as well as specific technical knowledge and expertise to manage and interpret the results obtained during the exploration studies. Therefore, for its design and execution, the project had the participation of international consultants with ample experience in the development of geothermal projects in the world, and the participation of institutional entities such as the SGC, COLCIENCIAS and UNAL. These have worked parallel to ISAGEN in the identification and classification of the geothermal resource in the MVR. Additionally, it is highlighted that knowledge has been acquired inside ISAGEN about the technology and activities for exploration, and a team of professionals specialized in geothermal energy was formed that will be at the forefront of the MVR Project and the prospecting of new areas.

  During the project's execution, professors, and master's degree and undergraduate students of the Geoscience Department of the UNAL were trained on techniques for taking magnetotelluric data in the field, as well as the analysis and interpretation of results. Additionally, the UNAL was equipped with some geological, field and laboratory equipment for geothermal exploration.

  Therefore, the capacity of the institutions and their counterparts was adequate for the design and execution of the project. However, work needs to be continued technological appropriation for future exploitation of geothermal resources in the country and the capitalization of the experience obtained during this project.

Although some difficulties for starting the project or requirements of specific technical knowledge and expertise, the capacity of the executing agencies and their counterparts

was considered adequate. Also, it is important to notice that both agencies have developed capacities for developing the FNCER to diversify the country's energy matrix and to mitigate climate change impact.

Were the lessons of other relevant projects incorporated into the project's design?

- **Component I**

  For this component, lessons and experiences related with their objectives were included mainly in the Subcomponent I. Strengthening the knowledge and information base for FNCER in Colombia including: (i) improved understanding of FNCER, updating and integrating available information, (ii) an analysis of costs and economic benefits associated to the greater involvement of FNCER in the Colombian energy matrix and (iii) a platform for information and knowledge management. Also in the topics developed for the different consultants and experts, and the analysis developed in the different events related.

- **Component II**

  Given that the technical studies required to establish the viability of a geothermal project in Colombia are specialized, it is still at the stage of technology appropriation, and it is a groundbreaking project in the country, the recommendations given by the international experts and advisors on geothermal energy projects are incorporated for the design and preparation of the project.

  By incorporating advisors from West JEC (Japan/Africa/Asia/Costa Rica), Nippon Koei/Geothermal (Japan/Asia), LaGeo (El Salvador/Nicaragua), Phoenix (Canada), and Geofields (Russia) into the project, the experience of these companies was integrated into the development of the geothermal energy project. Additionally, the technology was appropriated as all the advisors interacted with the professionals from the UNAL and ISAGEN.

  It is important to note that the results obtained during the execution of this project are the basis to progress toward the implementation of a geothermal power plant in the Ruiz Volcanic Massif, and a guide for the planning and development of future geothermal fields in the country.

To obtain the proposal objectives, the project´s lessons, experiences and expertise from research groups, companies and consultants were included.

Were the agreement's arrangements duly identified and were the roles and responsibilities negotiated before approval of the project?

- **Component I**

  For this component, the roles and responsibilities of each entity were defined and established prior to approval of the component. On behalf of the MME, UPME was the

executing technical entity and the support of the financial and administrative management was done by CI.

- **Component II**

  Considering that this component was carried out as part of the agreement signed between ISAGEN and the IDB-GEF, the roles and responsibilities of each entity were defined and established prior to approval of the component. In this process, the parties agreed that ISAGEN would execute and coordinate the project as the "Executing Agency" under the mandate to ensure that all the activities financed by the GEF were executed within the established time and resources, and the IDB would provide technical and financial support as administrator of the GEF.

Both components were ruled by the IDB policies:

- Acquisition planning: Before any call for pre-qualifications or proposals can be made to award a contract, as applicable, UPME and ISAGEN must submit the component's proposed acquisition plan for review and approval by the IDB, pursuant to the bank's Acquisition Policies.
- Ex-ante review: Unless the IDB determines otherwise, the acquisition contracts of works and assets planned in the project will be reviewed by the bank ex-ante pursuant to the procedures established in the Acquisition Policies.
- Technical and basic responsibility: As executing agencies of the project, UPME and ISAGEN carried out the supervision and technical follow-up of the development and compliance of the studies and activities implemented with GEF funds, as well as the technical supervision of the terms of reference, performance of the consultancy work, and review of the technical quality of all the studies. Also, the IDB team participates in the above activities.

Were the matching resources (financing, staff and facilities) permitted by legislation and adequate for management of the project in Colombia?

- **Component I**

  Taking under this component´s objectives, the government entities such as the MME, UPME and CREG advanced in the implementation of a legal and regulatory framework that promotes the use of FNCER.

  Therefore, through the UPME, the MME presented the Law 1715 2014, which aims to establish the legal framework and instruments for promotion of the use of FNCER. It also fosters investment, research and development of clean technology for energy production, energy efficiency and response to demand, as part of the domestic energy policy. Additionally, the CREG issued Resolution 132 2014, which defines the methodology to determine the firm energy of geothermal plants to be purchased at the ENFICC.

  Considering the Law 1715, future regulatory definitions related to the FNCER are expected.

- **Component II**

  From a regulatory perspective, the development and implementation of power generation projects using FNCER such as geothermal energy have been limited due to factors including the absence of clear laws and/or regulations on aspects related to licensing and administration of the resource; the necessary areas for exploration and exploitation; and recognition of the contribution to the system's strength through the mechanism of contributions to firm energy for this kind of resource.

  Additionally, and in response to the country's needs to progress in knowledge and classification of the geothermal resource, ISAGEN designated the local matching contribution funds required for the full and uninterrupted execution of the demonstrative MVR Geothermal Plant Project. Therefore, as the project's executing agency, ISAGEN has contributed a higher amount than agreed of USD 850,000 as a local matching contribution.

  Error! Reference source not found. The following table presents the list of activities carried out as part of the geothermal project and the contribution made to it by the parties involved in its development.

Budget Execution ISAGEN - IDB/GEF Agreement

Component	Activity	Contribution IDB/GEF (USD)	Contribution ISAGEN (USD)
Matching Contribution	Complementation of the research and modeling of the magma-hydrothermal system in areas with geothermal potential located on the northwestern side of the MVR	-	1,186,046
	Drilling of vertical thermal gradient holes with the recovery of nuclei on the northwestern side of the MVR	-	387,660
	Consultancy for the technical evaluation of the proposal of the magma-hydrothermal model and selection of sites for the project's exploratory drilling	-	59,792
Subsoil Evaluation Studies	Supply of two (2) pieces of magnetotelluric (MT) equipment and training on the use of the geothermal exploration technique in the country	355,549	-
	Consultancy, review of the geological and geophysical model, action plan and leasing of equipment	332,110	229,164
	Review of the findings, conclusions and recommendations resulting from the pre-feasibility phase; and assistance and consultancy for ISAGEN in the procurement and execution of exploratory drilling, assessment of the reservoir and the results of this phase	146,974	-
	Environmental impact assessment for exploration and use of the geothermal resource	303,699	102,401
	Hydroclimatological classification and temperature series in the project area	78,311	69,973

	Study of connection to the National Transmission System	15,689	-
	Project results communication workshop	37,813	-
Financial Structuring – Construction of Geothermal Plant	Completion of the necessary activities for financial structuring of the project in its exploratory drilling phases; assessment of the reservoir; and technical and financial feasibility analysis once confirmation of the existence of the resource is obtained	240,000	-
Project Management, Supervision, Audits and Contingencies	External audit of the agreement	7,112	18,891
	Follow-up, monitoring and supervision of project activities	9,743	544,678
TOTAL		**1,527,000**	**2,598,605**

The matching resources (financing, staff and facilities) for the project which were permitted by legislation and adequate for management of it in Colombia were organized to develop and obtain the objectives.

4.6.2 Country Ownership/Drivenness

Was this project in line with the country's priorities and development plans?

The project was proposed and developed in line with the National Development Plan and Colombian energy policies for the period from 2003 to 2020, which established: i) an increase in the use of RE to promote power generation from FNCER, ii) diversification of the Colombian energy matrix, iii) development of technologies with low CO_2 emissions through the implementation of demonstrative pilot projects, iv) rational and efficient use of energy resources, v) reliable and safe energy supply, vi) development of innovative technology, vii) energy efficiency and viii) protection of the environment.

Do the project's results contribute to the country's priorities and development plans?

- **Component I**

  This component is aligned to the priorities establishes in the National Development Plan and Colombian energy policies for the period from 2003 to 2020. With the Law 1715 is expected to foster the power generation from FNCER, so the diversification of the Colombian energy matrix.

- **Component II**

  The component's results have contributed to the promotion, classification and exploitation of clean and renewable energy generation resources; diversification of the energy matrix; development of innovative technologies with low carbon emissions for

the country; rational and efficient use of energy; and the implementation of demonstrative pilot projects.

Therefore, the Colombian and Ecuadorian Governments have deemed the implementation of the Tufiño-Chiles-Cerro Negro Binational Geothermal Power Plant Project located on the border between the two countries as strategic. In this project, as the company appointed by the government for this purpose, ISAGEN is applying the knowledge and experience acquired during the execution of the Ruiz Volcanic Massif Project.

Was the participation of the government and civil society in the development of the project relevant?

- **Component I**

  The Law 175 was approved by the Colombian Congress; therefore, it had the supported by most of the representatives there.

- **Component II**

  As geothermal energy is not generated in the country, the development of groundbreaking projects, such as the Ruiz Volcanic Massif Geothermal Plant Project, required the support and participation of environmental, regulatory and academic entities, and the community in general to make its implementation viable.

  Therefore, during the implementation of the project, the participation of universities was sought and obtained to carry out the subsoil studies required for classification of the geothermal resource, and the hydroclimatological studies for the calculation of geothermal plants' firm energy. Additionally, as part of this project, through the UPME, the MME advanced in the strengthening of the regulatory framework for non-conventional renewable energy and promoted the proximity and communication of the project to the community of the project's area of influence, as well as the regulatory and environmental entities.

  As the environmental license is required from the relevant environmental authority to advance with the stage of confirming the resource through deep exploratory drilling, relations were managed with the environmental authorities during the development of the project. Additionally, the EIA for the exploration and use of the geothermal resource in the MVR was submitted for its review and approval.

The government and the civil society participated during the preparation and implementation stages of this project.

Does the government maintain an interest in funding the project's development?

- **Component I**

Considering the Law 1715´s approval, the government is strengthening the regulatory framework for promoting market approaches for RE and fostering the development of a favorable environment for the development and integration of FNCER in the Colombian energy matrix.

FNCER generation projects are considered in different scenarios of the Expansion Reference Generation and Transmission Plan 2015-2029 and 2016-2030 prepared by UPME.

The development of specific generation projects in Colombia is an investors' decision. The government establishes the regulatory framework for developing FNCER projects.

- **Component II**

  As an energy generation, production and sales company, ISAGEN is committed to the development of generation projects that contribute to the expansion and diversification of the country's energy portfolio, and the mitigation of climate change. During the component's implementation, it was backed by several financial entities to develop all the activities planned in the project. The necessary studies were conducted to have better knowledge of the resource's characteristics and make viable the exploitation of the resource for electricity generation.

  Seeking to integrate alternative renewable energy sources, through the legal framework established by Laws 142 and 143 of1994, Law 1665 of 2013 and Law 1715 of 2014, the objectives of the Colombian Government include the regulation of the incentives provided by Law 1715 through collective work with the MME, MADS, MHCP, MCIT, UPME, ANLA and DIAN to issue simple, quick, clear and accessible procedures for small and large investors.

  Therefore, to consolidate a legal and regulatory framework that provides clarity and certainty to agents interested in using geothermal resources, the UPME has proposed the following lines of action: i) creation of an inter-institutional roundtable to prepare a duly coordinated and supported regulatory framework for geothermal energy, ii) consolidation of a specific regulatory framework, iii) reduction of regulatory risk, iv) definition of specific technical and environmental requirements and v) joint ventures to share the risk[6].

The government will maintain interest in the project's development, mainly in the regulatory framework design and definitions, but it will not participate directly in the geothermal power plant design and construction.

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[6] *UPME Integration of Non-Conventional Renewable Energy in Colombia*. Bogotá 2015.

4.6.3 Stakeholder Involvement

Did the project use the skills and experience of government organizations, non-governmental organizations, private sector entities, local government and academic entities in the design, execution and evaluation of the project?

- **Component I**

  For the development of this component, there were several meetings, documents interchange and events to get the opinions and observations of the participants in the energy market related with the results of the different activities, mainly during the execution and evaluation. It includes government entities like MME, MADS, ANLA, DNP, SSPD, UPME, CREG, and utilities, users, associations, universities, research centers, consultants, equipment suppliers, engineering firms, banks, investment funds, etc.

- **Component II**

  As previously mentioned, for the component's development, it had the skills, experience and knowledge of academic institutions, such as the UNAL, which conducted the geophysical studies (magnetotellurics) and resistivity model of the subsoil and the Universidad EIA for the hydroclimatological classification of the project area required for the calculation of geothermal plants' firm energy.

  Furthermore, considering that this project is the continuation and complementation of the recognition and pre-feasibility studies conducted by ISAGEN in the MVR, government entities such as the SGC, COLCIENCIAS and CIF also participated in the design and implementation of the project.

  For the design, implementation and evaluation of the project activities, it had the support and consultancy of consultants with a lot of experience in geothermal energy, such as Boston Pacific, Nippon Koei, LaGeo and West JEC.

For developing the project, the utilization of the skills and the experience of government organizations, non-governmental organizations, private sector entities, local government and academic entities were considered during design, execution and evaluation stages of the project**.**

Were the vulnerable groups important opponents or supporters of the project's development?

- **Component I**

  The Law 175 was approved by the Colombian Congress; therefore, it had the supported by most of the representatives there.

- **Component II**

  Through the identification of national, regional and local institutions and agents, as well as their interaction with the communities of the component's area of influence, the local population's perception of the impacts and rights progressed with the communication of the project's characteristics, benefits, impacts, management measures and actions to follow for development of the project activities.

  To carry this out the component, it held meetings for the public in the municipal centers of the project's area of influence, which were attended by officers of the municipal government, and leaders and/or representatives of the districts in the area of direct influence; private meetings with owners and residents of the buildings located in the project's area of direct influence; meetings with the relevant ministries and environmental authorities; and workshops to raise awareness and communicate the results.

  The concerns tend to be related to generation of employment, marking out the area of influence, the benefits for the municipalities, and the project's possible pressure on natural resources.

  Generally, the evaluations reflect very good acceptance and approval by the attendees of the information and communication meetings, although they suggest improving the invitation to the communities so that more residents are informed and can participate in this kind of event. Therefore, we have had the support of the community and landowners, who have expressed their willingness to help with the completion of the activities required to establish a geothermal plant in the sector.

  Taking as a reference the results communication workshops held as part of the project, there is great openness and a high level of expectations regarding the project's development.

Overall the project was supported by the vulnerable groups, important opponents and supporters.

4.6.4 Financial Planning

Did the project have adequate financial control including reports, planning and management for making timely decisions and for an adequate flow of funds?

- **Component I**

  The activities included in this component were developed and getting the results according with the budget and the chronogram established initially.

- **Component II**

The activities included in this component were developed and getting the results according with the budget and the chronogram adjusted and approved by IDB.

For both components, as the project's executing agencies, UPME supported by CI and ISAGEN maintained an adequate and reliable financial management system, which allowed it to budget, record, account and make payments and reports in a timely manner pursuant to the acceptable provisions of the IDB. This permitted better use of resources and development of additional activities that contribute to the project's classification.

All of the changes and adjustments to the acquisition plan were submitted and approved by the IDB prior to their execution. ISAGEN prepared and submitted the requested mid-term reports, and two audits were conducted by an external entity. Regular in-person meetings with field visits were held between the ISAGEN project team and the IDB to follow up the project's progress.

Were due diligence processes or financial audits carried out, and was the co-financing executed?

- **Component I**

  Four evaluation audits four (4) were done at the end of years 2012, 2013, 2014 and the final, at the ending of this component on October 2015.

- **Component II**

  The component's main activities include project management, supervision, audits and contingencies. Therefore, two external audits were carried out during the project's implementation. The first was in 2015 for the periods from December 2010 to December 2014, and the second in July 2016 for the periods from January 2015 to April 2016.

For the project as a whole, the auditors concluded that UPME, CI and ISAGEN had complied with: i) the acquisition regulations and procedures established in the technical cooperation agreement signed with IDB-GEF, including the provisions of the operating regulations; ii) the adequate preparation and submission of the payment installment requests to the IDB-GEF; iii) the correct accumulation, valuation, accounting, validity and documenting of payment supports, which are included in this installment request; and iv) the eligibility of financing of the expenditure made; and that it has been effectively paid with the contribution of the IDB-GEF and/or local matching contribution.

4.6.5 Monitoring and Support of the GEF

Did IDB staff provide good quality support and consultancy for the project, and approve the amendments and restructuring of the project in adequate time when necessary? Did the IDB provide staff with an adequate level of skills and with continuity, and did it make field visits to the project? Did IDB staff identify problems on time and accurately estimate their seriousness?

As part of the support received from the bank's staff, as the executing agencies, UPME, CI and ISAGEN received training on the bank's policies, regulations, processes and procedures. Furthermore, the project covered aspects regarding: i) the term of execution and payment, submission of regular progress reports and their content; ii) forms and processes for the justification and request of funds; iii) acquisition plan and methods; and iv) procurement of the auditing firm and submission of audited financial statements.

Additionally, meetings were made to the UPME and ISAGEN headquarters and in the case of ISAGEN, visits to the project in the field. These meetings followed up the program's progress according to the acquisition plan and schedule of the agreement.

Also in the case of ISAGEN, the bank approved the amendments made to the acquisition plan in order to meet the project's requirements. Therefore, the bank expressed its non-objection to the redistribution of the resources to include the following activities: i) complementation of the environmental impact assessment; ii) hydroclimatological classification and temperature series for the calculation of the power plant's firm energy; iii) study of the plant's connection; and iv) results communication workshop.

In accordance with the above, the IDB-GEF supervised the components´ development and did not identify significant events that affected the reasonableness of the funds and the project's viability.

4.6.6 Delays, Results and Sustainability of the Project

- **Component I**

  An extension of four (4) months for such execution (i.e. until the 30th March, 2015) which was conceived. This was done with the objective of allowing enough time to success carry out the activities planned under the contract with Carbon Trust, which required until February 2015 for its proper execution, same as to perform additional activities that emerged during this semester, which included hiring a tributary expert and extending the technical consultancy to address specific subjects of relevance in the Act 1715. This extension time would also be used to integrate the material that would-be part of the final project results publication.

- **Component II**

  During the implementation of the project's activities, there were delays that led to the extension of the agreement by eighteen (18) months. The above is due to the fact that: i) the work required for the proper development of the project is specialized and requires expert professionals and consultants in geothermal energy who are not located in the country, ii) the procurement process of the magnetotelluric studies was declared void and therefore, the process had to be restarted with the UNAL, LaGeo and other external advisors, iii) the magnetotelluric studies took longer than initially planned due to problems of electromagnetic noise because of volcanic activity, electricity lines, and electric fences, iv) additional activities to those initially planned

were carried out in order to locate and measure the reservoir, and propose the development of the field with the definition of the sites and dimensions of the power plant, and production and reinjection wells, v) the environmental impact assessment was complemented to comply with the requirements requested by the environmental authority during the development of the project and vi) the procurement of consultancy for financial structuring was carried out in the last semester of the term of the IDB-GEF – ISAGEN Agreement with an implementation duration of 12 months, so it could not be completed within the initial term of the agreement.

5 Lessons Learned[7]

Considering the documents prepared and the analysis done, the meetings with the representatives from MME, UPME, ISAGEN, CI, IDB, etc. related to the two components' development of this project, their objectives and results, some lessons for the project are presented:

- Planning of activities, coordinated work with the bank's team, and follow-up and assistance during the implementation of the cooperation's different activities are a key factor in its success.

- The fact of having a technical staff team fully dedicated to the project, with direct day to day contact with Executing Agencies was key in developing the activities and achieving the results.

- Having a person solely in charge of administrative tasks (without simultaneous technical responsibilities) is strongly advised.

- It shall be noted that given the time that it takes to organize and coordinate events, coordinate administrative meetings, prepare minutes and other documents, certificates and other purely administrative communications, development administrative contents for periodic reports to the IDB, monitoring recruitment processes, budgeting, preparing disbursement requests and doing other related activities is representative, it would be useful to have a person mainly in charge of such responsibilities.

- Also as a lesson learnt from this project, it is considered as a good practice to hold regular team meetings, same as regular management meetings, on a weekly or monthly basis depending on the tasks and topics being addressed at each development stage of the project. Also, coordination meetings with the Bank and other entities involved in implementation, as is the case of members of the Project Steering Committee are also advised to be sustained every now and then, especially in the

[7] It is important to notice that the lessons are the "wishing list and the conditions required" which were indicated mainly by UPME and ISAGEN according with their experience during the development components' project.

early stages of development to make sure proper alignment of objectives and expectations is achieved.

- The procurement times must be considered to schedule the activities and consultancies project's development more accurately. The procurement and authorization processes could be improved by making them clearer. However, it is understandable that the mechanisms adopted ensure the processes' transparency.

- As for the preparation of the term of reference for different contracts that are part of the procurement plan, the importance of clear and concise requirements that do not lead to double interpretations or subjective interpretations by the contractor and the contractor are also noted to be of paramount importance.

- The variation in the U.S. dollar against the Colombian peso generated some cases of surplus in the estimated budget, because of the exchange rate, mainly for the activities contracted in Colombian pesos. Therefore, in the future, the possibility of including currency hedging in the budget could be assessed, so that the budget for the purchase and acquisition of local goods and services in foreign currency can be executed as planned.

- The positive experience achieved in the case of the redesign, launch and evolution of the SGIC-FNCER (Information and Knowledge Management System of Non-Conventional Renewable Energy).

- The progress of the activities required for the development of FNCER projects in the country is often dependent on the time taken by the regulatory, administrative and/or environmental authorities to respond to the procedures required for the projects' continuity. The time taken is often very long and alters the planned schedules for the implementation of project activities.

- The areas with geothermal potential in the country are in places that are difficult to access, with extreme weather conditions and with complicated topography, which on some occasions may limit the completion of field activities in the previously stipulated times.

- Training on topics related to conventional RE and FNCER sources for the professional staff of the academic and environmental institutions, regulatory institutions and government entities requires continuity to generate better technical and scientific capacity for taking decisions related to these energy topics.

- The authorities, indigenous communities and the community in general are unaware of this geothermal technology's characteristics, and there is a general fear about its relation to earthquakes and volcanic eruptions. Intense work is required on education about the characteristics of geothermal energy.

- The studies for exploration and modeling of the resource are very specialized and costly. The preliminary exploration stages involve numerous high-risk investments. Therefore, these first stages of development of greater risk could be carried out by the MME with the support of the Colombian Government, and in this case, directly by the CGS and UPME.

- Successful progress in the exploration phase requires financing mechanisms, financial support, or partial or full hedging of the exploratory drilling phase, because of the risk of this project phase.

- For this kind of FNCER and clean technology, it is important to promote the development of alternative methods of financial assessment that include unvalued externalities or related intangibles. For example, contribution to the reduction of climate change and the country's adaptation to it; diversification of the energy matrix; reduction of consumption and dependency on fossil fuels; firmer and more reliable contribution to the system; protection of areas of environmental interest; and contribution to sustainable development.

- Because of this TC, for both components, it was developed a local capacity in different specialties and levels (undergraduate students, professionals, researchers, lecturers, advisors, consultants, regulators, government staff, etc.) related to FNCER, in fields such as procurements, manage, analysis and data interpretation, field techniques, regulatory topics, studies, design topics, etc. that can support the future development of FNCER´s projects in Colombia.

  Although, it is necessary to continue with the technological appropriation for future exploitation of FNCER in the country and the capitalization of the experience obtained during this TC.

- Additionally, it is important to point out that as result of this TC, it helped to establish the regulatory framework to foster the FNCER´s development and, in this way, to promote these projects, which will make it possible to take advantage of the existing potential in Colombia and to develop the objective of this TC: *"The overall objective of the project is to promote and support catalytic investments for geothermal energy in Colombia by strengthening its regulatory framework and the development and execution of a demonstrative geothermal project in the Ruiz Volcanic Massif, which will help to reduce and displace unrealized GGE"*.

6 Conclusions and Recommendations[8]

Considering the meetings with the representatives from MME, UPME, ISAGEN, CI, IDB, etc. related to the two components' development of this project, their objectives and results, some conclusion and recommendations are presented:

- Continue strengthening technical capacity in environmental, regulatory and financial institutions, i.e. all the participants in the energy market, through the development of technical assistance and training programs on the characteristics of FNCER, related environmental impacts and mitigation plans, risk assessment, and opportunities of this kind of energy, among others.
- Promoting in a permanent way the system SGIC-FNCER.
- Continue the activities related to the Law 1715´s and the market follow to promote the adjustments and changes required to consider the FNCER´s participation in the Colombian energy matrix.
- Improve coordination between the planning and regulatory entities, such as the UPME and CREG, and government entities including the IDEAM, DIAN, ministries and CNO, with the aim to ensure the access of investors in FNCER projects to the tax, tariff and declaration benefits of firm energy.
- Greater commitment from the Colombian Government is required for the promotion of FNCER, such as geothermal energy, by defining a master plan for the development of geothermal energy in Colombia; creating a risk mitigation fund and/or subsidies for the exploration phase (studies and drilling); and defining a plan to include geothermal energy (obligations or quotas) in the country's energy portfolio.
- Drive new financing mechanisms through multilateral banking, private banking, and mitigation funds that motivate private investors to develop FNCER projects in the country.
- Develop guarantee instruments for developing FNCER projects, mainly for geothermal projects that help to reduce the return required from this kind of project.
- Strengthen harmonious work between the ANLA and RACs to improve the response times for licenses and permits to extend the examiners' specific knowledge regarding this kind of project.
- Keep promoting the design and implementation of additional policies to promote the development of FNCER from a regulatory, financial and environmental perspective.
- In the case of the geothermal projects, there is limited scientific and technical staff for the development of this technology, and uncertainty about the resource's

[8] It is important to notice that the Conclusions and Recommendations are the "wishing list and the conditions required" which were indicated mainly by UPME and ISAGEN according with their experience during the development components' project.

characteristics that increase the investment risk during the exploration stages. These aspects must be included in the planning of the financial, technical and technological resources required for the development of geothermal projects in the country.

- Given that the areas with geothermal potential in the country are mainly located in areas at high risk from volcanic activity and mudslides, the location of thermal gradient holes, exploration, production and reinjection wells, the geothermal plant, connection lines and flow lines must be carefully evaluated.
- The infrastructure for the development of geothermal fields must be built in areas where there has already been intervention, because the areas with potential are in páramo and/or forest reserve areas.
- Considering that the area required for geothermal development is small, it is recommended to allocate the free areas for the protection and recovery of the paramo, cloud forest, high Andean forest and/or related wildlife.
- Given that geothermal plants generate economic resources by legal transfer and other means, it is proposed to use these resources for purchasing land that is not in the geothermal field's area of intervention to use for conservation of the páramo.
- It is suggested to explore the potential of other uses for geothermal energy in the country in sectors including agriculture, aquaculture, heating, recreation and tourism, which could be jointly developed with power generation.
- Therefore, the resources provided by the IDB/GEF helped to drive and better classify the geothermal potential of the area of the MVR, and progress toward the establishment of energy projects that help to mitigate climate change and to diversify Colombia's energy matrix.

ANNEX 1
COMPONENT I

- **ACTIVITIES AND ASSIGNED BUDGET**

Activity	IDB (USD)	UPME (USD)
Technical Studies	**1.019.814,87**	**296.136,05**
Computer equipment acquisition	3.792,13	
Project publications	16.580,22	
Consultancy for the design and implementation of strategies for strengthening the information base and knowledge and the formation of a virtual community of FNCER to ensure their sustainability, growth, coverage and timeliness	216.742,68	
Logistics for workshops and events related to the analysis and Law 1715 2014´s launching	34.722,69	
Proposal and implementation of improvements and updates to the SGI&C in FNCER in order to have a tool for consultation and updating of information and the interaction of the virtual network of actors	57.927,57	
Consultancy for quantifying the potential impact from an economic analysis and assessment of the cost-benefit of measures and instruments for promoting FNCER in the	121.982,01	
Consultant support for project coordination, coordination of thematic and administration SGI&C in FNCER, support in the identification of legislative and regulatory barriers to FNCER and support in the development of proposals for policy and regulatory instruments and mechanisms for	75.666,51	
Technical support consultant UPME. Characterization and projection of demand scenarios for FNCER to industrial, transport and tertiary sectors with a view for formulating a national strategy for development of FNCER	84.303,58	
Consultant for conducting cost-benefit studies and economic analysis of the FNCER and coordination of specialized	51.581,33	
Consultant for conducting training on the regulatory framework for the electricity sector and Colombian gas and the state of art of this issue in the international context	9.099,95	
Business conference promotion of investment opportunities in FNCER	35.248,51	
Consultancy related to the study and proposed regulatory and policy instruments to promote the FNCER	36.443,50	
Consultancy related to the study and proposed regulatory and policy instruments to promote the penetration of FNCER in the Colombian energy sector	37.405,79	
Consultancy related to the development of a FNCER´s strategy in Colombia	38.726,02	
Consultancy for the development of a FNCER´s strategy in Colombia	39.779,00	
Consultancy on the study and analysis of regulatory and legal institutional barriers of FNCER within the Colombian energy	18.250,00	
Consultancy for strengthening the conceptual and practical knowledge in economic and financial evaluation of projects, with particular emphasis on the cost-benefit analysis, to facilitate the implementation of these tools in the development of the necessary activities to promote market-	20.856,89	
Consultant proposed integration schemes intermittent sources in the domestic electricity market	43.902,44	
Consultancy Evaluation Study and Proposed schemes for the integration of FNCER in the National Electricity Market	21.979,19	
Acquisition of HOMER software licenses and training to the component´s staff and UPME´s personal	15.800,46	
Development of a pilot project in the municipality of Galapa - Atlantico, in order to make a diagnosis of the service of public lighting and set conditions for modernization, including the assessment of technical characteristics and performance of new technologies and feasibility of using	24.390,24	
Consultancy for development a legal concept related to the incentives` regulation established by Law 1715 of 2014 and proposed legal mechanisms for their implementation	14.634,15	
UPME´s component coordination of activities and technical support	-	278.036,65
Component´s closing event (net bank yields)		16.188,65
Component´s closing event (CI contribution)		1.910,75
Management and Supervision Activities	**180.184,64**	**-**
CI´s component management	140.783,10	
External audits	12.134,83	
Travel expenses (per diem officials and airline tickets UPME´s and component personal)	20.635,81	
Operating expenses	6.630,90	
TOTAL COMPONENT I	**1.199.999,51**	**296.136,05**

ANNEX 2
COMPONENT II

- **OUTPUTS AND ACTIVITIES, RATING**

Outputs and Activities	Status (%)	Comments	Rating
SUBCOMPONENT I - TECHNICAL STUDIES			
Detailed geology	100	Gathering, analysis, review and consolidation of geology information related to types of rock, mineral composition, rock origin, structural geology such as and shape and arrangement of rock mass and rock distribution across the selected areas. The results obtained will be used to determine the type of magneto telluric studies that need to be performed.	S
	100	Final report incorporating findings of detailed geology studies.	
	100	Development and completion of the subsurface resistive structure model.	
Detailed mapping of the areas and hydrothermal alterations	100	Digital aerial photographs in scale 1:15,000.	
	100	Digital Cartography in scale 1:5,000.	
	100	Ortho photos in scale 1:5000, digital elevation model of the terrain.	
	100	Final report including physical and digital maps and models.	
	100	Completion of the subsurface resistive structure model.	
	100	Completion of magmatic hydrothermal model.	
	100	Completion of thermal gradient study for exploratory drilling.	
Geochemical and geophysical studies	100	Final report presenting main results of geochemical and geophysical studies.	
Gravimetric Surveys	100	Final report on gravimetric.	
Magneto metric and magneto telluric studies (including thermal gradient wells)	100	Execution of approximately 200 combined wide spectrum magneto telluric sounding (audio-magneto telluric – AMT- and magneto telluric soundings –MT) covering a range of depth to ensure the surface resolution required for the analysis of geological structures related with the geothermal reservoir and provide subsurface information of at least 10 kilometers' depth.	

	100	Acquisition of two magneto telluric pieces of equipment type V8-6R for finalization of the fieldwork and the subsurface resistive structure model.	
	100	Completion of the report that will present the subsurface resistivity structure model obtained.	
	100	Knowledge about the characteristics and behavior of the MVR geothermal field.	
	100	At least completion of two workshops to disseminate the findings about the magneto metric and magneto telluric studies carried out.	
	100	Scientific Review of Technical Studies.	
	100	Integrate resistive model of the subsoil based on magneto telluric soundings, the magmatic hydrothermal model and the results of the study of thermal gradient for purposes of exploratory drilling.	
	100	Validation of the subsurface resistive structure model using magneto telluric soundings.	
	100	Validation of magmatic hydrothermal model.	
	100	Validation of thermal gradient study for exploratory drilling.	
SUBCOMPONENT III - ENVIROMENTAL AND SOCIAL STUDIES			
Environmental impact assessment and social management plan	100	Final environmental impact assessment (EIA) for exploratory drilling phase.	HS
	100	Final social management plan to include, amongst others, sociological impact on inhabitants of the project area and community information and education programs regarding the implications of geothermal development.	
	100	Community outreach to inform potentially affected communities of the geothermal power plant development including EIA and social management plan results.	
SUBCOMPONENT IV - INSTITUTIONAL STRENGTHENING AND DISSEMINATION OF FINDINGS			
Workshops and knowledge enhancement	100	Participation in global geothermal expertise events.	HS
	100	Organization of at least two separate training and educational workshops.	
	100	Training of 20 professionals in magneto telluric field.	

	100	Knowledge transfer from international experts about the geothermal industry, experience in other countries and the development of geothermal energy in Colombia.	
SUBCOMPONENT V - ACTION PLAN AND DEVELOPMENT OF THE PROJECT			
Analysis and revision of subsurface resistive structure Botero Londono Area for exploration drilling	100	Integration of subsurface resistive model, magmatic hydrothermal model and thermal gradient study for purpose of exploratory drilling phase.	S
	100	Submission of the update report of the subsoil resistivity model, which contains a pseudo-three-dimensional model of the distribution of resistivity in study, and the marking of possible geothermal reservoirs	
Development of Action Plan to implement the Project	100	Review and adjustment to the action plan exploratory drilling phase.	
Geothermal off taking analysis, Transmission analysis	100	Selection of the site, type and configuration of the connection to the national interconnected system.	
	100	Elaboration the connection study, which analyzes three different alternatives from the electrical and financial studies, and studies to identify environmental and social restrictions. With this study, the way of integrating the future geothermal plant into the National Transmission System is identified and the connection line to include the project's environmental license procedure is defined.	
Financial Structuring for Plant Construction	100	Analysis the regulatory and economic environment of the ISAGEN projects to propose the points of analysis for later stages; identify potential sources of project funding; and present some preliminary financial conclusions.	
	100	Overview of the capital market to establish the exact conditions of project funding, a detailed financial model of the projects, a results report and an operating manual of the financial models	
	50	Financial structuring of the geothermal project to be contemplated on a project finance or corporate finance basis. This activity is to be carried by a first-rate investment bank. Final report shall also include financial model and economic model.	

		Delay justification: Due to the changes in regulations that affect the financing of renewable energy projects in Colombia, which have not permitted the completion of the project's activities.	
ADDITIONAL ACTIVITIES			
3D inversion of MT data and review of the conceptual geothermal model were obtained and these included: i) Outlining of the sealing layer. ii) Measurement of the geothermal reservoir iii) Information for the definitive design iv) Technical specifications of the drilling v) Definition of the power plant site and other facilities of the geothermal field vi) Estimate of the geothermal potential of the area of study.			HS
Complement of the Environmental Impact Assessment (EIA) to include the development and exploitation activities of the geothermal field, and the construction, operation and disassembly of the electric power plant that will use the geothermal resource, and the associated works.			
Hydro climatological Classification and Calculation Methodology of the Firm Energy to be Purchased at the Reliability Charge Rate (ENFICC) for the geothermal plants.			

ANNEX 3

CATALYTIC INVESTMENTS FOR GEOTHERMAL POWER
RESULTS FRAMEWORK & INDICATOR MATRIX

Component I: Promote Market Approaches for Renewable Energy (RE) by contributing to the Removal of Barriers to the Development of FNCER

Project Components	Expected Outcomes	Expected Outputs	Results
Component I Promote Market Approaches for Renewable Energy (RE) by contributing to the Removal of Barriers to the Development of FNCER	i) The country's institutional framework promotes the use of untapped RE such as geothermal and wind ii) Investors face an improved environment for geothermal and wind power iii) Innovations in geothermal and wind energy technology are being promoted for diversification of the country's power mix	A comprehensive analysis of FNCER the enhances planning authorities' knowledge regarding (i) Potential for development of RE	(i) The potential for RE use and development in the Colombian energy system was identified to lie within 5 areas of opportunity involving 4 different sources/technologies and the specific case of ZNI where RE solutions represent an economically competitive solution compared to the use of diesel for electricity generation. The 5 areas of opportunity were: 1. Large wind projects in La Guajira region (estimated potential around 18 GW) 2. Geothermal projects in areas of identified

Project Components	Expected Outcomes	Expected Outputs	Results
			potential like the Ruiz Volcanic Massif (potential is estimated in 2.0 GW when adding up high potential areas) 3. Small scale distributed solar PV generation systems (mainly roof systems). Economical potential was estimated around 1.8 GW 4. Biomass energy use for CHP purposes whenever possible, especially in the case of agroindustry. Potential based only on biomass residues is estimated in 450 PJ / year
		(ii) Cost-benefit economic analysis of increasing the participation of RE	(ii) Besides preliminary cost benefit analyses carried throughout the execution of the project, a consultant was hired to develop a tool for carrying both financial and economic analyses, especially to determine the effect of the instruments

Project Components	Expected Outcomes	Expected Outputs	Results
			introduced through Law 1715, out of which tax incentives are the most representative. The previous, focusing on projects within each of the previously identifies areas of opportunity. Besides obtained results showing overall benefits to society from implementing the instruments to promote RE, the developed tool represents a useful element to be further used by UPME and other entities for the evaluation of single projects to determine their financial viability, the effect that incentives produce over such viability and overall cost-benefit ratio based on an economic evaluation
		(iii) Improvement of the technology platform the country has to support the information and knowledge management system	(iii) After the work carried with the academic research group, the system was redesigned and rebuilt and it started operation in June 2014. During its first semester of operation it gained more than 500 registered users, besides more than 5,000 non-registered

Project Components	Expected Outcomes	Expected Outputs	Results
			users who came into contact with the platform Projects, companies, research groups and regular users have been registered in the system and numbers continue to grow. In April 2015 the system´s administration was formally delivered to UPME for its continued management and evolution
		(iv) Formulation of a national white paper on RE based on a full analysis of institutional and legal barriers	(iv) Law 1715 2014, incorporated elements that were based on identified barriers such as high investment costs, previous inability for auto-producers to inject or sell to the grid their surplus electricity, and previous lack of policy guidelines In regard to RE. The opportunity to make contributions to this Law when it was a project in Congress was a golden opportunity which facilitated the materialization of project achievements

Project Components	Expected Outcomes	Expected Outputs	Results
			into a reality that is expected to have positive effects in the promotion and deployment of RE technologies in Colombia
		(v) Formulation and implementation of least 5 (five) regulatory mechanisms to promote a low carbon policy	(v) Contributions made by the projects included the definition of criteria for the design of a proper bidirectional metering and credit remuneration scheme for valuing the surplus electricity that is to be injected into the grid by small auto-producers using FNCER, same as technical criteria for the definition of small scale auto-generation limits, and simplified connection procedures applying to these and other small electricity producers bellow 5 MW capacity. Also, guides on how tax incentives are to be granted to investors, where elaborated, same as further actions and recommendations to be followed in coming years, integrated together within an overall Strategy for the development and

Project Components	Expected Outcomes	Expected Outputs	Results
			integration of FNCER´s credit or financing schemes, distributed generation incentives on top of market price and other such as a complementary intraday market, plus recommendations on specific plans for the development of wind project development in the case of La Guajira and the use of RE in ZNI as an alternative to diesel fuel, all made part of recommendations integrated within such strategy
		(vi) One Non-Conventional Energy Development Plan	(vi) The strategy developed for the integration of FNCER, was mainly based on Law 1715 objectives, and complemented both with the instruments mentioned in the previous point, and a vision of future RE project deployment based on relevant agents´ expectations with a horizon for the next 15 years (to 2030). Also, the formulated strategy is left for planners and policymakers to review, follow-up, adjust or

Project Components	Expected Outcomes	Expected Outputs	Results
			complemented as may be found necessary every 5 years RE use and development in the transport, industry and tertiary sectors was also assessed through the review of available energy demand characterization of those sectors and the identification of energy uses where RE technologies represent opportunities to diversify the energy mix of the country on non-electrical energy uses. Such uses mainly include the use of biomass for heat purposes in industry and the use of thermo-solar technology for water heating in the residential and tertiary sector. Even though no deep elaboration was carried out regarding the transport sector, electro-mobility with some participation of biofuels are opportunities of RE penetration in such

Project Components	Expected Outcomes	Expected Outputs	Results
			energy intensive sector of the economy
		(vii) Information dissemination of findings and public awareness building to promote use of FNCER	(vii) Throughout the execution of the projects, more than 16 events and workshops, part of which covered socialization of the ruling process of Law 1715, were organized and executed. Also the first matchmaking business conferences around small scale RE projects was organized in mid 2014. Finally, training courses including cost-benefit analysis, technical-economic optimization tools, energy and gas regulation, electricity market dispatch and operation, were organized and provided to different governmental institutions and agencies such as UPME, IPSE, CREG and ANLA.
Component II: Subsurface Assessment Studies **Subcomponent II.1 - Technical**	Detailed geology	Final report incorporating findings of detailed geology studies.	Gathering, analysis, review and consolidation of geology information related to types of rock, mineral composition, rock origin, structural geology such as and shape and arrangement of rock

Project Components	Expected Outcomes	Expected Outputs	Results
Studies			mass and rock distribution across the selected areas. The results obtained will be used to determine the type of magneto telluric studies that need to be performed. Final report incorporating findings of detailed geology studies. Development and completion of the subsurface resistive structure model.
	Detailed mapping of the areas and hydrothermal alterations	Digital aerial photographs in scale 1:15,000 obtained. Digital Cartography in scale 1:5,000 obtained. Ortho photos in scale 1:5000, digital elevation model of the terrain obtained. Final report including physical and digital maps and models. Completion of the subsurface resistive structure model. Completion of magmatic hydrothermal model. Completion of thermal	Digital aerial photographs in scale 1:15,000. Digital Cartography in scale 1:5,000 Ortho photos in scale 1:5000, digital elevation model of the terrain. Final report including physical and digital maps and models. Completion of the subsurface resistive structure model. Completion of magmatic hydrothermal model. Completion of thermal

Project Components	Expected Outcomes	Expected Outputs	Results
		gradient study for exploratory drilling.	gradient study for exploratory drilling.
	Geochemical and geophysical studies	Final report presenting main results of geochemical and geophysical studies.	Final report presenting main results of geochemical and geophysical studies.
	Gravimetric Surveys	Final report on gravimetric.	Final report on gravimetric.
	Magneto metric and magneto telluric studies (including thermal gradient wells	Completion of the report that will present the subsurface resistivity structure model obtained. Knowledge about the characteristics and behavior of the	Completion of the report that will present the subsurface resistivity structure model obtained. Execution of approximately 200 combined wide spectrum magneto telluric sounding (audio-magneto telluric – AMT- and magneto telluric soundings –MT) covering a range of depth to ensure the surface resolution required for the analysis of geological structures related with the geothermal reservoir and provide subsurface information of at least 10 kilometers' depth. Acquisition of two magneto telluric pieces of equipment type V8-6R for finalization of the fieldwork and the subsurface resistive structure model. Knowledge about the characteristics and behavior of the Macizo

Project Components	Expected Outcomes	Expected Outputs	Results
		Macizo Volcanico del Ruiz geothermal field. At least completion of two workshops to disseminate the findings about the magneto metric and magneto telluric studies carried out.	Volcanico del Ruiz geothermal field. At least completion of two workshops to disseminate the findings about the magneto metric and magneto telluric studies carried out.
Subcomponent II.2 - Revision and Analysis of Technical Studies	Scientific Review of Technical Studies	Final report that will provide recommendations for the exact location of the thermal gradient wells development for the exploratory drilling phase. Validation of the subsurface resistive structure model using magneto telluric soundings. Validation of magmatic hydrothermal model. Validation of thermal gradient study for exploratory drilling.	Integrate resistive model of the subsoil based on magneto telluric soundings, the magmatic hydrothermal model and the results of the study of thermal gradient for purposes of exploratory drilling. Validation of the subsurface resistive structure model using magneto telluric soundings. Validation of magmatic hydrothermal model. Validation of thermal gradient study for exploratory drilling.
Subcomponent II.3 – Environmental and Social Studies	Environmental impact assessment and social management plan	Final environmental impact assessment (EIA) for exploratory drilling phase. Final social management plan to include, amongst others, sociological impact on inhabitants	Final environmental impact assessment (EIA) for exploratory drilling phase. Final social management plan to include, amongst others, sociological impact on inhabitants of the project area and

Project Components	Expected Outcomes	Expected Outputs	Results
		of the project area and community information and education programs regarding the implications of geothermal development. Community outreach to inform potentially affected communities of the geothermal power plant development including EIA and social management plan results.	community information and education programs regarding the implications of geothermal development. Community outreach to inform potentially affected communities of the geothermal power plant development including EIA and social management plan results.
Subcomponent II.4 – Institutional Strengthening and Dissemination of Findings	Workshops and knowledge enhancement	Organization of at least two separate training and educational workshops. Training of 20 professionals in magneto telluric field.	Participation in global geothermal expertise events. Knowledge transfer from international experts about the geothermal industry, experience in other countries and the development of geothermal energy in Colombia. Organization of at least two separate training and educational workshops. Training of 20 professionals in magneto telluric field.

Project Components	Expected Outcomes	Expected Outputs	Results
Subcomponent II.5 - Action Plan and Development of the Project	Analysis and revision of subsurface resistive structure Botero Londono Area for exploration drilling	Integration of subsurface resistive model, magmatic hydrothermal model and thermal gradient study for purpose of exploratory drilling phase.	Integration of subsurface resistive model, magmatic hydrothermal model and thermal gradient study for purpose of exploratory drilling phase. Submission of the update report of the subsoil resistivity model, which contains a pseudo-three-dimensional model of the distribution of resistivity in study, and the marking of possible geothermal reservoirs.
	No action plan for exploratory drilling.	Review and adjustment to the action plan exploratory drilling phase.	Review and adjustment to the action plan exploratory drilling phase.
	Geothermal off taking analysis, Transmission analysis	Geothermal off taking analysis, Transmission analysis	Selection of the site, type and configuration of the connection to the national interconnected system. Elaboration the connection study, which analyzes three different alternatives from the electrical and financial studies, and studies to identify environmental and social restrictions. With this study, the way of integrating the future geothermal plant into the National Transmission System is identified and the connection line to include the project's

Project Components	Expected Outcomes	Expected Outputs	Results
			environmental license procedure is defined.
Financial Structuring for Plant Construction		Obtaining the required permission from the Board of Directors of the Company to advance the project's financial structure. Obtaining the economic resources for the project implementation through available sources. Financial structuring of the geothermal project to be contemplated on a project finance or corporate finance basis. This activity is to be carried by a first-rate investment bank. Final report shall also include financial model and economic model.	Analysis the regulatory and economic environment of the ISAGEN projects to propose the points of analysis for later stages; identify potential sources of project funding; and present some preliminary financial conclusions. Overview of the capital market to establish the exact conditions of project funding, a detailed financial model of the projects, a result report and an operating manual of the financial models Financial structuring of the geothermal project to be contemplated on a project finance or corporate finance basis. This activity is to be carried by a first-rate investment bank. Final report shall also include financial model and economic model. **Delay justification**: Due to the changes in regulations that affect the financing of renewable energy projects in Colombia, which have not permitted the completion of the project's activities.

ANNEX 4

CATALYTIC INVESTMENTS FOR GEOTHERMAL POWER

FINAL ASSESSMENT REPORT INTERVIEWS

Entity	Position/Name
Ministry of Mines and Energy (MME)	Director Energía Elérctrica, Rogerio Ramirez
Mining and Energy Planning Unit (UPME)	Director General, Jorge Valencia Asesor Dirección General, Camilo Tautiva Subdirección de Demanda, Carlos García Subdirección de Energía Eléctrica, Ricardo Ramirez
Conservation International Colombia (CI)	Gerente Administrativa, Dorelly Estepa Asesor, Omar Cuervo
ISAGEN	Director Desarrollo de Proyectos, Luis Posada Profesional Desarrollo de Proyectos, Eliana Mejía Profesional Desarrollo de Proyectos, Javier Mendez
Inter-American Development Bank (IDB)	Especialista Senior Energía, José Ramón Gómez Andrea Giraldo Carlos Rojas
Consultants	Javier Rodríguez Eduardo Afanador Arcenio Torres