DOCUMENT OF THE INTER-AMERICAN DEVELOPMENT BANK

COLOMBIA

INVESTMENT GRANT FOR THE FINANCING AND RISK TRANSFER PROGRAM FOR GEOTHERMAL POWER

(CO-G1007)

PROPOSAL FOR OPERATION DEVELOPMENT

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ABBREVIATIONS	
Bancóldex	*Banco de Comercio Exterior de Colombia S.A.*
CRG	Contingent Recovery Grant
CO_2	Carbon Dioxide
COP	Colombian Pesos
CPI	Climate Policy Initiative
CTF	Clean Technology Fund
DPSP	Dedicated Private Sector Program
EIA	Environmental Impact Assessment
ESMAP	Energy Sector Management Assistance Program
ESMS	Environmental and Social Management System
FI	Financial Intermediaries
GDP	Gross Domestic Product
GEA	Geothermal Energy Association
GGDP	Global Geothermal Development Plan
GHG	Greenhouse Gas
IDB	Inter-American Development Bank
IEA	International Energy Agency
IFC	International Finance Corporation
IGA	International Geothermal Association
kWh/MWh/GWh	Kilowatt-hour/Megawatt-hour/Gigawatt-hour
MDB	Multilateral Development Bank
MT	Mega ton (millions of tons)
$MTCO_2e$	Mega ton of Carbon Dioxide Equivalent
MW/GW	Megawatt/Gigawatt
MWe/GWe	Megawatt equivalent/Gigawatt equivalent
NAFIN	*Nacional Financiera*
NCRE	Non-conventional Renewable Energy
NDP	National Development Plan
NPV	Net Present Value
OR	Operating Regulations
POD	Proposal for Operational Development
PPP	Public-Private Partnership
RE	Renewable Energy
tCO_2e	Ton of Carbon Dioxide Equivalent
UNEP	United Nations Environment Programme
UPME	*Unidad de Planeación Minero Energética*

PROJECT SUMMARY

COLOMBIA

INVESTMENT GRANT FOR THE FINANCING AND RISK TRANSFER PROGRAM FOR GEOTHERMAL POWER (CO-G1007)

<table>
<tr><th colspan="5">Financial Terms and Conditions</th></tr>
<tr><td colspan="3">Beneficiary and Executing Agency: Banco de Comercio Exterior de Colombia S.A. (Bancóldex).</td><td colspan="2">CTF
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The objective of the program is to scale up investment in geothermal power generation projects by making available a financial mechanism tailored to meet the specific needs of a project's earliest development stages, specifically at the exploration phase. To this end, the program intends to trigger power production from geothermal sources, thus contributing to the reduction of Global Greenhouse Gas emissions and the diversification of Colombia's energy matrix.</td></tr>
<tr><td colspan="5">Special contractual conditions prior to the first disbursement:

It is a special contractual condition that prior to the first disbursement of the grant resources Bancóldex should provide evidence, to the Bank's satisfaction that: (i) the program coordinator has been hired in accordance with the terms of references previously agreed upon with the Bank; and (ii) the program's Operating Regulations (OR) has been approved and entered into effect, in accordance with the terms and conditions previously agreed upon with the Bank (¶3.5).</td></tr>
<tr><td colspan="5">Exceptions to Bank policies:

None.</td></tr>
<tr><td colspan="5">The project qualifies for[(a)]: SV ☐ PE ☐ CC ☑ CI ☐</td></tr>
</table>

(a) These resources will be provided by the Clean Technology Fund (CTF) through its Contingent Grant Recovery (CGR) Fund and their availability would be subject to the approval of the resources by the Trust Fund Committee (TFC) of the CTF. CTF will recover any funds that, at the end of the execution period, have not been utilized. The term contingent recovery grant obeys to the fact that the CTF will recover the funds of the CGR Fund if the drilling activities are successful and therefore funds remain at the end of the program's executing period (estimated in ten years). The possibility of grant financing is contemplated under CTF products, terms and procedures for public sector operations, when projects involve significant risks and use innovative financing instruments. This program is under the agreement between the Bank and the CTF, "Proposal for the establishment of the Clean Technology Fund (CTF) in the Inter- American Development Bank.

(b) SV (Small and Vulnerable Countries), PE (Poverty Reduction and Equity Enhancement), CC (Climate Change, Renewable Energy and Environmental Sustainability), CI (Regional Cooperation and Integration).

I. DESCRIPTION AND RESULTS MONITORING

A. Background, Problem Addressed and Justification

1.1 Emerging economies all over the globe are facing the challenge of trying to meet increasing demands for energy in a sustainable and cost-efficient manner. International practice increasingly calls for policies and mechanisms that help energy systems around the world transition into low-carbon ones. International funding is readily available to support this process in less-developed economies, in which investments in power generation from clean sources play a large role. One of the least explored sources of Renewable Energies (RE) in the world is the geothermal energy that comes from reservoirs of steam and hot water beneath the earth's surface. Many developing countries are endowed with substantial geothermal resources that could be more actively put to use. Making use of this technology will help the transition process to cleaner energy systems.

1.2 In regions where the existence of geothermal resource is apparent, geothermal energy[1] is particularly relevant because of its ability to provide power in a reliable and flexible manner to meet both base load energy demand and respond to fluctuating supply from other technologies. Geothermal power production increases the reliability of the power system, by providing a continuous source of clean energy, which can substitute fossil fuels (coal and gas) as a baseload power source. Moreover, due to its high capacity factor,[2] geothermal facilities can provide more flexibility and balance to the energy system as they offer back-up capacity that can consistently respond to the electricity demand, covering the balancing cost (often overlooked) of other inherently intermittent RE such as wind and solar.

1.3 Geothermal energy indeed offers one of the most effective renewable and low carbon alternatives for power generation. It is a mature technology with competitive production costs and economic lifetime of plants typically around 20 to 30 years minimum,[3] which has proved to be viable in a number of places without the support of subsidies.[4] The aforementioned high capacity factor and the absence of fuel and other variable costs over the long life of geothermal projects give geothermal power one of the lowest levelized costs[5] among RE.[6]

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1 Energy stored in rock and in trapped vapors or liquids, such as water or brines (available as heat contained in or discharged from the earth's crust). International Energy Agency (IEA).

2 The United States Energy Information Administration lists geothermal power as having a capacity factor of 92%, higher than coal (85%), natural gas (87%), and biomass (83%), and significantly higher than other RE such as wind or solar, which range below 50%. There is a cost associated to intermittency, as the sun does not shine nor the wind blows 24 hours a day all year long. The capacity factor is the ratio of the actual output over a period of time to its potential output (if it were possible to operate at full capacity continuously over the same period of time).

3 Sustainably managed reservoirs can maintain energy production for decades, even over 50 years.

4 However, government support has been key in the initial stages of geothermal power development due to the risks discussed below.

5 The levelized cost of energy represents the per-kilowatt hour cost (in real dollars) of building and operating a power plant over an assumed financial life and duty cycle. For medium sized plants (around 50 MW), levelized costs of generation are typically between US$0.04 and US$0.10 per kWh (Energy Sector Management Assistance Program (ESMAP), 2013). Operation and management costs are a small

Furthermore, its development entails significant economic and social benefits, such as high quality employment creation and the potential to reduce the need to import gas. Studies comparing jobs created in energy sectors state that geothermal energy supports and generates a significant number of jobs when compared to other energy technologies.[7] From an energy and environmental perspective, the expansion of geothermal energy in countries with the potential of having the necessary resource is fully justified, since CO_2 emissions from geothermal power generation, while not exactly zero, are far lower than those produced by power generation based on burning fossil fuels.[8]

1.4 In Colombia, currently 67% of electricity production is based on hydroelectric power, 27% comes from natural gas and coal, and less than 1% from other renewable sources. The national electric system as a whole has not shown any significant growth since 2010. Even when the current contribution of Colombia to global Greenhouse Gas (GHG) emissions may not appear significant (0.4% of total global emissions), the energy system dependence on water resources may pose a significant vulnerability, particularly under changing weather conditions, due to uncertainties in the costs associated to managing backup supplies of energy. The system is especially vulnerable to extreme hydrologic conditions (such as the ones occurred in 1991-1992 and 1997-1998) and particularly to El Niño, which might be affected by climate change.[9] At the same time, growth of the hydroelectric generation is limited due to high environmental and social risks. If hydroelectric contributions to the system continue to have a declining trend, the use of fossil fuels to cover for these deficits will continue to increase, impacting the level of GHG emissions in the long term. Thus, due to the mentioned limitations to increase hydroelectric power generation in Colombia, geothermal energy appears a technology that provides the advantage of: (i) being cleaner than the thermal generation alternatives; (ii) having a competitive levelized cost, especially in comparison with the other non-conventional sources of energy; and (iii) providing base load power to the energy system since the geothermal resource is not subject to the interruptions inherent to other RE.

1.5 After the energy crisis of 1992, the country implemented institutional and regulatory changes that have rendered a more efficient, robust and diversified energy system able to cope with extreme weather conditions. However, the National Development Plan (NDP) 2014-2018 acknowledges that the increase in

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percentage of total costs because geothermal requires no fuel, which significantly increases economic viability.

6 In comparison with other energy sources, levelized costs of geothermal energy in Colombian Pesos (COP) are 30 COP/KWh, lower than wind (50 COP/KWh), higher than big hydro (19 COP/KWh), but smaller than small hydro (38 COP/KWh). Levelized costs of geothermal are also higher than other conventional alternatives such as coal and gas thermal energy (around 20 COP/KWh and 22 COP/KWh respectively), but present important environmental benefits. See *Análisis Coste Beneficio de energías renovables no convencionales en Colombia.* Fedesarrollo, 2013.

7 Promoting Geothermal Energy: Air Emissions Comparison and Externality Analysis (Geothermal Energy Association (GEA), 2013); Green Jobs through Geothermal Energy (GEA, 2010); A Handbook on the Externalities, Employment, and Economics of Geothermal Energy (GEA 2006).

8 Geothermal emissions are around 91 grams of CO_2 per Kilowatt-hour, far lower than for natural gas (599), oil (893) or coal (955). See Energy Sector Management Assistance Program. Geothermal Handbook. 2014.

9 The Bank is currently preparing a Technical Cooperation on Climate Change Vulnerability and Adaptation Measures for Hydroelectric Systems in Andean Countries, including Colombia (RG-T2673).

residential and industrial energy demand produces a deficit in the balance between demand and supply in adverse hydrologic conditions, which requires high levels of thermoelectric generation. At the same time, the NDP 2014-2018 also recognizes the need to introduce new generation plants with lower operating costs and less intensive use of liquid fuels, in order to reduce prices in the spot and forward markets.[10] For this reason, the National Government of the Republic of Colombia is interested in maximizing the use of its natural resources (both renewable and not renewable), while complying with the highest environmental and social standards, in order to prevent an ever increasing need for thermal energy generation, especially in adverse weather conditions.[11] The NDP 2014-2018 prioritizes the creation of incentives and use of the existing opportunities to leverage international funding in order to promote investment in non-conventional energy sources

1.6 The Republic of Colombia is located in one of the regions with the highest geothermal energy source potential in the world.[12] Part of its territory is situated within the so-called Ring of Fire, in the basin of the Pacific Ocean, where subsurface temperatures are abnormally high and important volcanic activity occurs. There is evidence of geothermal energy resources with potential for electricity production in various areas near volcanoes within the region.[13] The intrinsic characteristics of the resources make such region very attractive in order to achieve the above-mentioned energy objectives stated in the NDP 2014-2018. However, despite several efforts, Colombia has yet to attain an effective way to tackle the potential offered by geothermal resources as an efficient, sustainable and clean technology.

1. Barriers to geothermal industry development in Colombia[14]

1.7 Geothermal power production is well below its estimated potential worldwide, and its development in regions with highest potential has been rather slow, almost negligible in comparison with other renewables. Latin America is home to four of the world's 15 biggest geothermal producers, and practically every country in the Pacific basin is suitable for high-efficiency geothermal projects. However, the Andean Region is lagging behind, with no geothermal production so far despite its great potential. In countries such as Mexico, El Salvador and Costa Rica,[15] the

[10] A simulation performed by the *Unidad de Planeación Minero Energética* (UPME) shows that the introduction of 2,000 MW of non-conventional energy sources in Colombia's energy matrix could have a significant impact in the long run marginal cost of the system, estimated in some US$9 per MW/h. (2015). Generation and Transmission Expansion Plan 2014-2018.

[11] Electricity demand is estimated to increase 1.8% annually over the next ten years (Dewhurst Group, 2014). As of December 2014, installed capacity was 13,886 MW and projections for 2020 are to increase capacity to 14,971 MW (UPME). In the case of Geothermal energy, an in-depth analysis of the technical and economic benefit of geothermal energy production in Colombia is provided in the program's Economic Analysis (Annex IV).

[12] Total potential is estimated to be in the range of 1,340 to 2,210 MW (Bank's Energy Division (ENE), 2014).

[13] Sector Nevado del Ruiz (Nevado del Ruiz, Cerro Bravo, Santa Rosa de Cabal), Sector Nariño (Tufiño Chiles-Cerro Negro, Cumbal, Azufral, Galeras), Sector Paipa Iza, and Sector Nevado del Tolima (Dewhurst Group, 2014).

[14] RE Essentials: Geothermal, IEA; ESMAP, 2013; GEA; Latin American Geothermal, Electric Power Intelligence Series, BNamericas, 2012.

[15] Geothermal energy installed capacity in México is 958 MW (2.7% of total energy production), 204MW in El Salvador (25.5%), and 166MW in Costa Rica (11.9%).

industry has been traditionally led by public sector companies. However, the private sector is majorly leading prospects for development in areas that have emerged as “geothermal hotspots”, including Chile, Peru, Argentina, Nicaragua and Guatemala (Kurmanaev; Electric Power Intelligence Series, BNamericas, 2012). A considerable pipeline of projects is already in some stage of development in the region. Chile is expected to become South America’s first geothermal producer. However, not a single commercial plant is under operation so far.

1.8 With currently no geothermal capacity installed, there is still very limited experience in Colombia, and the volcanic regions where the resource is located usually lack infrastructure for accessing them, making it more difficult for developers to structure the projects. In addition, due to the incipient nature of the industry, local norms and regulation related to the use of the resource have yet to evolve, so as to facilitate the development of this technology. Even when technical engineering capacity in most developing countries can be outsourced fairly easily, geothermal energy development can provide many jobs in different important areas (such as in network connection, roads, and facilities construction, procurement of goods and services). Besides, there are important learning externalities from outsourced technology development that can improve local human capital. In the particular case of Colombia, certain similarities between the capacities and the equipment needed for oil and geothermal exploration, introduce important complementarities that may facilitate the adjustment costs of developing a new technology.

1.9 **Geothermal-specific regulation.** The current energy regulatory framework in Colombia lacks a specific regulation for the exploitation of geothermal resources. This increases the perception of risk by investors and imposes an additional barrier to investment. The Government of Colombia is making progress in the establishment of clearer and specific standard rules for the evaluation of geothermal projects for licensing (including environmental and social aspects), which addresses some other risks that are considered important inputs for investment decision making. Also, Colombia has begun to promote the use of non-conventional energy sources in general. In May 2014, Colombia passed the Law 1715, which fosters the development and use of non-conventional energy sources in the national energy system, by integrating them to the electricity market through investment incentives (tax and value-added tax exclusions, income and accelerated amortization profile). However, specific regulation such as defined concession areas for geothermal –which would avert the risk of free riders exploiting the same area– do not exist, and proper policy and institutional changes still need to be made in order to attract international and local investors at a larger scale and achieve full potential for geothermal in Colombia.[16] Despite its incipient stage, relevant local players in the energy sector have demonstrated their willingness to invest in this technology, therefore contributing to the development of a competitive geothermal market in Colombia and benefiting from the gains of becoming first comers in this emerging and profitable business.

[16] Although not absolutely necessary, offering geothermal concessions for private development can reduce regulatory risk significantly, provided that government institutions in charge of granting them are capable and credible. Countries in the region that have established these concessional regimes include Chile, Peru and, most recently, Mexico.

1.10 **Financing geothermal investments.** From a financial perspective, a successfully deployed geothermal power plant can have significant long-term benefits. However, for an investor or developer –public or private–, geothermal power generation is a high risk-high return venture, of a much more complex financial nature than the one associated to other RE. These projects entail substantial risk related to finding and developing the geothermal resource, mainly at the initial stages of a project, implying extremely high value at risk. Any greenfield geothermal power project requires:

a. **Relatively long lead time to discover, confirm, and develop the resource.** Geothermal resources require exploration activities, but unlike oil and gas, once it is discovered, it cannot generate a return on investment until a suitable power plant is constructed. The duration of the entire process is approximately five to seven years before any revenue can be realized (two to five years to discover the reservoir, develop the field and carry out the drilling program and an estimated of two additional years to build the plant and begin operations).

b. **High upfront capital for the drilling and exploration phases, where most of the risk is undertaken.** Significant financial commitment needs to be made before the characteristics of the resource can be fully known. Although vast information about subsurface conditions can improve significantly the odds of success in initial exploratory wells at a relatively low cost (via a combination of geological, geochemical and geophysical surface surveys), yet approximately 35% to 40% of the total capital costs of an average geothermal power project needs to be invested in well field exploration (actual drilling) until deep wells penetrate the geothermal reservoir and resource uncertainty and risk is overcome.[17]

1.11 The risks described have an adverse impact on the willingness to finance these projects. In a great part, the financial constraint explains why this technology remains largely underdeveloped. Even when project bankability increases after resource risk is dissipated, debt financing is typically unavailable during the early stages of the project (in general, industry experts estimate that around 50% of investment has to be made prior to accessing typical debt funding), increasing the need to rely on more costly options such as equity capital (Geothermal Energy Association (GEA), 2014). Private sector developers would either self-finance or enter into a partnership to share the drilling risk among multiple parties. But even well-capitalized, geothermal-focused developers may struggle to internally justify greenfield projects, and only those capable of diversifying risk and absorbing the losses can carry out these projects from such an early stage. On the other hand, equity partnerships or joint ventures require alternative

[17] Furthermore, costs for each development vary significantly, as they depend on specific characteristics of the resource, location, drilling markets, size of the project, and type of plant (dry steam, flash, binary), imposing added uncertainty on ex ante cost estimations. A single well may cost between US$1 million and US$7 million (International Finance Corporation (IFC), 2013) depending on the geographic location and local geology. In Colombia, geophysical conditions can lead to exploration costs higher than in other parts of the world, thus increasing financial risk aversion and making the resource risk even more critical to tackle through public policy intervention.

structures if debt finance is to be used (i.e. project finance), which makes projects riskier from a financier's perspective.

1.12 Global trends in RE investment show a positive, although relatively slow, evolution of new investment in geothermal, growing 8% over the last decade (wind and solar grew 21% and 28% in that same period, respectively). Despite its growth, levels remain small and significantly below all other RE technologies, except for marine RE. There are virtually no financing vehicles available for funding geothermal. Solar energy still dominates project bond issuance worldwide, and institutional investors face barriers in –or simply lack appetite for– the RE market as a whole, due mainly to policy context, financial regulation and limited knowledge of the clean energy sector (United Nations Environment Programme (UNEP), 2014).

2. Problem addressed and intervention proposed

1.13 The diagnosis described above identifies the broad aspects affecting the pace of development of geothermal power production in Colombia (see ¶1.7-1.12). The lack of regulation and relatively low technical capacity at a local level pose important issues and uncertainties that slow down geothermal progress. The consolidation of local expertise will only be attained in the long term, once there is reasonable scale in the market so that it makes sense to invest in proper domestic training and research centers. In the meantime, outsourcing this expertise remains a much more viable and efficient alternative, as has been the case in other countries developing this technology with relative success. In terms of regulation, substantial efforts are still needed to improve general issues and enforce the development of rules particular to this technology. The Bank has already been providing support to Colombia in this sector. Resources have been provided for institutional strengthening and development of technical capacity at the local level.[18] However, even if these ongoing efforts were to overcome every technical and legal issue, the absence of financial mechanisms for geothermal projects will continue to deter investment. With this in mind, the proposed program will focus on overcoming the financial problems that affect the development of these projects.

1.14 The characteristics described in ¶1.10 result in the inexistence of financing options for developers, especially in the early stages. Moreover, lack of knowledge and the absence of a performance record negatively affect investors and financiers in more subtle and permanent ways. Financing is of course dependent on a "bankable" geothermal reservoir, but financial institutions lack the expertise and knowledge to understand the financial economics of geothermal technologies. This affects negatively the banking system capacity to evaluate the feasibility of geothermal projects. Taking into consideration also the lack of available technical capacity to explore and assess geothermal resources, risk is often perceived as unbearable even after discovery of resource. Hence, financing is unavailable and developments rely exclusively on scarce and expensive capital resources, slowing down or precluding investment in the sector

[18] This includes equipment for exploration, communication and dissemination activities, trainings, workshops, participation in seminars and international conferences, etc. See *Emprendimiento de la energía geotérmica en Colombia, Marzolf, Natacha C.,* Inter-American Development Bank (IDB). See also ¶1.27.

until the construction and operation phase is imminent. Logically, all these effects are stronger in countries, such as Colombia, with potential but without any geothermal field developed.

1.15 These are the reasons why geothermal power has been developed worldwide with public sector backing of one type or another.[19] The Geothermal Exploration Best Practices (International Geothermal Association (IGA), 2013) report presents a number of alternatives for its development. The option of a public sector company is among the most popular (Indonesia, Philippines, among the largest producers) and was extremely successful in the past in countries such as Mexico. However, due mainly to fiscal restrictions, it is likely that governments with the capacity to develop this technology end up underinvesting in geothermal, vis-a-vis fossil fuel plants with shorter lead times and higher returns, leaving its potential widely untapped.

1.16 There is consensus on the need for financial support to develop geothermal power generation. The International Energy Agency (IEA) suggests the development of financial instruments to promote geothermal exploration (by governments, development banks and commercial banks) among their recommendations for market facilitation and transformation of the sector (Technology Roadmap for Geothermal Heat and Power, 2011). The lack of risk mitigation and financing mechanisms is often credited for holding back projects in emerging economies (Global Geothermal Development Plan (GGDP) Roundtable 2013, Climate Policy Initiative (CPI) Geothermal Dialogue 2014 and 2015). Development banks have increasingly become an important source of clean energy investments over the last decade (Frankfurt School - UNEP, 2014), and virtually all geothermal projects recently developed or underway in developing countries have benefitted from the involvement of development banks. Private finance for both debt and equity, if available, is particularly prevalent only in developed markets such as the United States of America and New Zealand (CPI, 2014).

1.17 If properly devised, a risk mitigation instrument with clear and specific rules that govern its functionality should encourage investment flows into the Colombian market, contributing to an increase in the quality and supply of clean energy and to improve operating efficiency of the national electric system.

1.18 **Proposed intervention.** The risk levels inherent to each phase of a geothermal development decrease over time as the project advances. Consistently, risks at the early resource identification and exploratory drilling phases are seen as the biggest barriers to obtaining financing. But much of the current public support remains confined to either the pre-development phase (i.e. preliminary surveys and surface exploration) or the operational phase of the project (CPI, 2014), leaving an important gap in the riskier portion of project development.

[19] According to CPI, 76% to 90% of geothermal project investments utilize some public debt or equity support. See also *Experiencia internacional en la mitigación del riesgo y desarrollo de la energía geotérmica*. GeothermEx for the World Bank, June 2010.

1.19 Under the scheme proposed, the program will provide a risk sharing instrument that will support the financing of early drilling stages of geothermal projects,[20] in order to increase debt and equity financing for geothermal developers. As part of a set of proposed activities, the program will also aim to provide technical assistance in order to improve project execution enhancing the technical capacities of the executing agency and accompany government actions to promote the acceleration of regulatory reforms that will enable a more attractive environment for these investments (e.g. the provision of inputs for the preparation of draft rules and procedures associated to overcoming some of the development risks).

B. Objectives, Components and Cost

1.20 The objective of the program is to scale up investment in geothermal power generation projects by making available a financial mechanism tailored to meet the specific needs of a project's earliest development stages, specifically at the exploration phase. To this end, the program intends to trigger power production from geothermal sources, thus contributing to the reduction of GHG emissions and the diversification of Colombia's energy matrix.

1.21 The program will channel resources through the *Banco de Comercio Exterior de Colombia S.A.* (Bancóldex). Bancóldex will act as the fiduciary manager of a Guarantee Fund created to insure geothermal developers against resource risk. The program will be implemented through two components:

1.22 **Component I - Risk mitigation grant facility (US$9.33 million).** Under this component the program's resources will be used to support the establishment and funding of a credit guarantee scheme to be managed by Bancóldex to guarantee the amount of individual loans taken by eligible beneficiaries of the project to mitigate the risks associated with the initial stages (i.e. drilling) of exploitation of geothermal energy projects[21] (subprojects) being financed by either the private developer itself or by a credit provided by eligible financial intermediary institutions (including Bancóldex). The guarantee will be provided exclusively for the resource risk prevailing in the early stages of the subprojects, where the aforementioned risks are higher and inhibit financing and investment. Support for initial surface exploration phases (geothermal resource studies, field

[20] The Geothermal Handbook (ESMAP, 2013) provides a good recount on evidence of exemplary models of support for geothermal development. In Iceland, a government funded insurance scheme for geothermal drilling proved to be critical to the development of geothermal in the country (currently representing 25% of its total electricity production). France and Germany have also established risk insurance funds (providing one-off guarantees or combining them with project financing via credit); despite their lack of resources, they are currently the countries with the 5th and 6th largest geothermal capacity in Europe (GEOELEC, 2013). In the 80s, the US Federal Government agreed to guarantee the value of loans taken by private geothermal companies (up to 80%) for well/field development and plant construction, effectively increasing their ability to raise money via credit at lower costs. The government also promoted an insurance scheme, which did not take off commercially, presumably due to high cost of premiums (GeothermEx, 2010). This proposal takes on all these experiences in the design and operation of geothermal funds in Europe and the U.S., as well as some recently implemented programs in Central Asia and Africa, and uses their valuable lessons to better structure the financial mechanisms proposed.

[21] Early stage refers to first exploration wells drilled, after significant knowledge of the geothermal resource has been attained through geological surveys. Developer must present due diligence of surface studies and have them certified by an independent consultant in order to be eligible.

surveys and detailed geothermal exploration surveys) is not included in this component, as these can generally be financed by the eligible beneficiaries (i.e developers). The operating mechanism of the guarantee shall be as follows: (i) in case of unsuccessful drilling at the initial stage (i.e. existence of geothermal resource is not confirmed in pre-defined levels of quality and quantity), program's resources will be used to reimburse the amount of the credit component of the funding incurred by the developer for drilling; and (ii) in case of successful drilling, the committed resources will be released so that they can be used to cover/guarantee new exploration subprojects. By providing resource risk coverage to funding raised for early drilling stages, this component aims to contribute to overcoming initial geothermal reservoir risks and enabling subprojects to advance towards subsequent phases of development.[22] If successful, it is expected that private developers will continue to invest in the geothermal energy facility construction and set up phases in order to fully exploit the resource. At this stage the project is more bankable and financial intermediaries will be more prone to provide the financing required for this investment since the major risk (resource risk) is out of the table, the project is well advanced (around 30% of total investment is already undertaken), and tangible revenues are expected in two or three years. It is in this sense that the project, setting up an instrument to manage the resource risk, seeks to mobilize the resources needed to finance at least one geothermal plan of 50 MW with an estimated cost of US$200 million. If needed, grants may be used to partially cover insurance and insured loans premiums and rates.[23] The specific procedures, conditions and requirements for the operations (including technical, regulatory and financial criteria for accessing the guarantees), the eligibility criteria for the participating Financial Intermediaries (FI), and criteria for eligible subprojects are described in the Operating Regulations (OR). These criteria will establish the legal, financial, environmental and technical requisites of each individual subproject. Such criteria and conditions will be consistent with Bank policies and procedures, (including environmental and social standards) (see ¶1.24 and ¶ 3.3).

1.23 **Component II. Implementation and technical assistance activities. (US$0.2 million).** Project execution will benefit from the technical assistance directed to key activities of the project**.** This component will be funded with US$200,000 and will provide technical support to manage the major project risks further described in ¶2.3 and ¶2.5. Thad Component entails two Subcomponents. In the first place, Subcomponent II.1 will focus in improving subproject evaluation and surveillance. The activities under this subcomponent will provide a credible mechanism for proper technical implementation. In this regard, resources will be used to: (i) finance an independent third party to provide expert advice to Bancóldex in order to evaluate the technical requirements of each subproject, as well as to provide independent verification services of the success and failure on

[22] Even when a first well is not successful, the information gathered from this process provides a basis for understanding the reason for failure, thus improving the probability of success on subsequent wells.

[23] Since there is little information available for actuarial calculations at the initial exploration drilling stage, recently developed risk insurance schemes for geothermal wells are being implemented only for later drilling stages, after the resource has been discovered and confirmed. In order to bring the insurance market to earlier stages of geothermal exploration, the program will study the possibility to cover part of the insurance premium.

the drillings and arbitrage services if needed; and (ii) analyze the environmental and social impact of the subprojects in order to attend potential gaps between the projects assessment and required international standards. Secondly, Subcomponent II.2 will provide the national authorities with technical support to update the required regulation, including legal comparative studies, drafting regulatory proposals, and training agencies personnel on geothermal project evaluation. These resources will help guarantee a sound and efficient program, while also ensuring local capacity building regarding geothermal power projects financial assessment (see ¶1.24 and ¶3.3).

1.24 **Beneficiaries.** The intended beneficiaries of the program will be developers of geothermal projects. Public or private firms, as well as Public-Private Partnerships (PPP) will be eligible as beneficiaries. The program will seek to build a model that assures competitive practices and maximizes return on the public sector accumulated assets (i.e. know how, studies, land permits). Due to the high technical requirements of geothermal generation and the lack of previous experience in Colombia, it is expected that the initial beneficiaries and developers of geothermal energy in the country will be big private or public firms. Based on the amount of resources available, a very limited number of subprojects may benefit from the program, though its design will seek to maximize its impact in terms of number of ventures.[24] Subprojects eligibility will be determined by Bancóldex and the Bank, based on technical reports, according to a pre-established set of criteria and conditions to be specified in the program's OR (see ¶3.3). In addition, Colombian population will indirectly benefit from positive externalities associated with the environmental and economic impacts of the program.

1.25 **Magnitude of resources needed.** Worldwide, geothermal investment costs are in the range of US$2 million and US$4 million per MW for a condensing flash plant and US$2.4 million and US$5.9 million per MW for a binary plant (IEA).[25] Smaller plants can be more costly because of the lack of economies of scale in drilling. A long term analysis carried out by the *Unidad de Planeación Minero Energética* (UPME) includes projections of different scenarios for expansion of Colombia's energy system. Taking into consideration the recently approved law for incentives to non-conventional RE (see ¶1.9), scenarios of expansion, considering all Non-Conventional Renewable Energy (NCRE), include between 275MW and 375MW of new geothermal capacity added to the system by 2030. Based on these projections, the total investment in geothermal needed for this expansion would reach up to US$1,500 million over the medium to long term[26]. Program resources will be used to maximize leverage of additional private and

[24] The actual beneficiaries of grant resources shall not be pre-defined. Given its magnitude, it is expected that program resources would be sufficient to support at least two geothermal exploration projects, with the successful development of at least one geothermal plant in the country (based on the assumption of a conservative probability of resource success of 50% and the identified potential demand), as well as to develop the financial and technical capabilities to further encourage geothermal exploration and development in the country.

[25] Total costs per MW include: Preliminary surveys and exploration (2.5% of total costs); test drillings and feasibility studies (12.5%); drillings (35.5%); plant construction (38.5%); steam gathering system and substation (8.5%); start up and commissioning (2.5%). Source: ESMAP, 2014.

[26] Assuming a debt-to-equity ratio (total debt / total equity) of 2.5, the required debt financing would be approximately US$1,070 million.

public funds. Expected investments to be mobilized by the program are around US$200 million, which would represent a contribution of some 13% to total country geothermal investment needs by 2030.

1.26 **Strategic alignment.** The program will contribute to the lending priorities of the Ninth General Increase in the Resources of the Inter-American Development Bank (GCI-9) in lending to support climate change initiatives, RE and environmental sustainability. It will also contribute to the regional development goals of protecting the environment, responding to climate change and promoting RE by reducing CO_2 emissions per US$1 Gross Domestic Product (GDP). The program is also consistent with the IDB Country Strategy with Colombia 2012-2014 on its priority sector of access to financial services, specifically with its objective of increasing the availability and variety of financial instruments and services. The program is also aligned with the IDB strategic priorities stated in the IDB Infrastructure Strategy and the Support to SMEs and Financial Access / Supervision Sector Framework Document.

1.27 **Lessons learned.** Bank's previous experience in the development of financing solutions for clean energy projects via public development banks has proven viable and effective with a number of operations, not only in Colombia but also in Mexico and Uruguay.[27] All of these had objectives related to the support of private sector investment in clean power generation and energy efficiency, with strong focus on maximizing the leverage of public and donor resources used. Lessons learned from these operations applied in this program are: (i) the importance of providing technical support to the executing agency for improving subproject evaluation; and (ii) the allocation of funds and efforts to guarantee subprojects compliance with environmental and social international standards. In the geothermal area, the program capitalizes on IDB's particular experience in Mexico (see ME-L1148: Geothermal Financing and Risk Transfer Program, and ME-G1005: Investment Grant for the Geothermal Financing and Risk Transfer Program), as well as on the work initiated in 2011 in Colombia in terms of RE regulation, geothermal resource identification and exploration and development strategies (CO-X1009: Catalytic Investments for Geothermal Power). The latter work contributed significantly to building capacity in important geothermal developers in the country. Important lessons derived from all these projects are applied in the operating rules of the program, regarding the technical, financial and legal requirement of the projects.

C. Key Results Indicators

1.28 At the output level, the indicators that will be measured are: (i) number of geothermal power subprojects guaranteed by the program; and (ii) number of studies carried out by independent consultants. The outcome indicators of the subprojects are: (i) geothermal power generation by subprojects guaranteed by the program; (ii) quantity of GHG emissions avoided through the use of geothermal energy of subprojects guaranteed by the program; and (iii) level of

[27] In Mexico, see ME-X1023: CCLIP flexible financing for the promotion of productive infrastructure, in preparation with Banobras, as well as several operations completed and in execution with *Nacional Financiera*. In Uruguay see operation UR-L1099: Financial Program for Productive Development.

additional financing raised by the subprojects guaranteed by the program.[28] At the impact level, indicators are: (i) GHG emissions in Colombia's energy sector; and (ii) contribution of geothermal power to non-conventional energy sources. These indicators include CTF core indicators regarding GHC emissions avoidance and additional financing (see more details in Annex II).

1.29 The proposed program seeks a transformational intervention by building a track record of geothermal projects and providing the possibility to replicate successful outcomes in other countries in the region and the world. The program also has a multiplier effect, as it is designed to optimize the use of funding available in terms of leverage and sustainability. Continuing these efforts should allow for the development of a permanent support framework in the long term, after demonstration of the benefits of investing in geothermal has permeated the economy. Moreover, in the scenario where the insurance industry would evolve into building risk management instruments that make sense for geothermal technologies, the proposed program could contribute to improve data on historical loss patterns and technical information that could help facilitate the development of solutions for geothermal energy projects in the long term.

1.30 **Economic evaluation.** The proposed program is expected to finance some 50MW of new geothermal capacity in the long term, which could lead to emissions savings of around 77,394 tCO_2 per year. Based on estimated reductions of CO_2 emissions over the course of a 30 year lifetime of projects financed, the cost of abatement is estimated at: (i) US$4.31 per tCO_2e considering CTF financing; and (ii) US$86.14 when all project investment costs (including all public and private funds leveraged) are considered[29] (see Annex IV). The cost benefit analysis of the program compares the net benefits of the geothermal project and compares it to the net benefits of a counterfactual scenario without project. The value of averted CO_2 emissions by the geothermal plant is contemplated as a benefit in the analysis. The Net Present Value (NPV) of the program is US$45.54 and is calculated using a 12% discount rate. A sensitivity analysis is further performed by stressing some important variables such as load factors, investment costs, construction times and price of electricity.

II. FINANCING STRUCTURE AND MAIN RISKS

A. Financing Instruments

2.1 The CTF provides scaled-up financing for public and private sector projects that contribute to the demonstration, deployment, and transfer of low-carbon technologies with significant potential for GHG emissions reduction. Investments for the promotion of RE, sustainable transport and energy efficiency are eligible under the CTF. In addition, CTF resources may be used for the financing of

[28] In addition, the project will have the following milestone: Installed capacity of geothermal power of projects guaranteed by the program.

[29] These abatement costs are well within the range of the CTF (US$200 per tCO_2e) and to that extent, are proof of the cost effectiveness of the program. The threshold of cost-effectiveness was established for projects/programs in the CTF investment criteria with a view to maximizing the impact of the limited resources.

projects with very high additional costs or with significant risks. Resources from the CTF are transferred to the Bank, acting as implementing agency, under a Financial Procedures Agreement and are administered by the Bank in a trust fund created within its organizational structure (IDB-CTF Trust Fund). In October 2013, the Trust Fund Committee approved funding to be deployed for Dedicated Private Sector Programs (DPSP). Under the DPSP, a utility-scale RE program proposes to focus initially on geothermal energy and more specifically on addressing the geothermal resource risk through well drillings. Consistent with CTF practice, DPSP is intended to make use of a range of financing instruments taking risks that commercial lenders are not able to bear. An initial US$115 million were assigned to existing CTF countries, namely Chile, Colombia, Turkey, and Mexico.

2.2 The program will be financed with resources from the CTF on a nonreimbursable basis. Resources will finance Components I and II (see ¶1.22-¶1.23) for a total amount of US$9.53 million. Bancóldex will use this funding to guarantee the initial stages of geothermal projects under conditions and criteria established in the program's OR. In addition**,** the Multilateral Development Bank (MDB) fees on the CTF grant resources (administrated by the Bank) could be used to finance additional technical evaluation of projects as needed. MDB fees will be up to US$470,000.

B. Environmental and Social Safeguard Risks

2.3 **Environmental and social risks.** According to Directive B.13 of IDB's Environment and Safeguards Compliance Policy, this program does not require classification. However, some geothermal projects (including initial drilling) are considered high-risk and can have adverse environmental or social impacts that can be significant, and which need to be assessed and managed on a project by project basis. The Environmental and Social Management System (ESMS)[30] will enable the identification of potential impacts and risks and ensure that the beneficiaries of the program will implement environmental and social assessment, prevention, mitigation and management measures consistent with Bank safeguard policies. Component II of this program also includes technical assistance to deal with potential gaps between the environmental and social impact studies of the projects and international best practices. Bancóldex shows a strong institutional capacity in the management of environmental and social risks, with a full-fledged environmental and social management system designed and implemented with the technical assistance of the Bank. Bancóldex is among the most advanced financial institutions in the region in the management of environmental and social risks for second-tier banking activities.

C. Fiduciary Risk

2.4 Bancóldex has experience in the implementation of programs with resources financed by the Bank and has shown since 2008 capacity as Executing Agency through several programs –loan CO-L1078: First Program: Investment Projects,

[30] Following examples of previous experiences of similar projects - specifically, loan ME-L1148: Geothermal Financing and Risk Transfer Program currently in execution in Mexico by *Nacional Financiera* (NAFIN), a Mexican development bank.

Productive Restructuring, Export Development for US$100 million and loan CO-L1082: II Loan for Investment Financing, Restructuring, Business Development for US$200 million– funded under a Conditional Credit Line for Investment Projects (CCLIP) approved in 2008 for US$650 million. Bancóldex is currently executing loan CO-L1132: III Loan for Investment Financing, Restructuring, Exporting Development for US$200 million, loan CO-L1124: CTF Energy Efficiency Financing Program for the Services Sector for US$10 million and loan CO-L1096: Bogota's Integrated Public Transit System Transformation Program for US$40 million; and has sufficient capacity to perform activities of financial management and administration of the resources of this operation. The fiduciary risk is low. In order to strengthen the capacity of Bancóldex to manage geothermal projects, an independent expert will be hired to assist Bancóldex in the task of evaluating geothermal projects and structuring the agreements between the guarantee fund and the developers (see Component II of the program in ¶1.23).

D. Other Key Issues and Risks

2.5 **Development risks.** The program identifies a high risk in the lack of clear and specific regulatory framework for geothermal energy exploration licensing procedure. The lack of specific geothermal regulation and of licensing experience by the national authorities makes the concession of exploration and exploitation permits more time intensive and uncertain. This may result in important delays and, thus, will not be eligible for the guarantee granted by the Contingent Recovery Grant (CRG) fund. In order to mitigate this risk, the Bank's project team will ensure a strong policy dialogue with relevant authorities in order to detect any technical or regulatory bottlenecks as early as possible. At the same time, specific technical cooperation funds are comprehended in this proposal that will be used to assist authorities in building the technical capacity or the specific regulations needed to evaluate geothermal energy development proposals. There is also a high development risk of having limited or insufficient human capacity (specific geothermal technical expertise) to accompany the development of subprojects supported. Several aspects are considered for mitigating this risk, including overseeing with Bancóldex the proper implementation of quality standards by providing technical advisors to assist in each participating subproject, engaging the Bank's own Center for Geothermal Training in El Salvador, and using existing certified international knowledge and ensuring transfer from third party technical expertise to develop local competencies.

2.6 The capabilities developed by Bancóldex, as well as in other financial intermediaries involved in financing geothermal energy, will constitute an asset for future potential geothermal developments in Colombia. Bancóldex will develop: (i) technical capabilities related to geothermal project management and risk evaluation, mitigation and supervision; and (ii) managerial capabilities to coordinate the multiple actors involved in geothermal power generation (developers, financial institutions, regulators and technical advisors). These capabilities will constitute a solid basis that national authorities and international organizations could use in order to undertake new programs to develop non-conventional sources of energy in Colombia.

III. IMPLEMENTATION AND MANAGEMENT PLAN

A. Summary of Implementation Arrangements

3.1 The Beneficiary of the investment grant and the Executing Agency (EA) of the program will be Bancóldex, a well reputed national credit institution with ample experience in finance structuring and fiduciary management. The EA has available the necessary administrative, fiduciary and control mechanisms to provide and to maintain a transparent and effective administration of the program, including the financing of the guarantees. Bancóldex as an EA will allow: (i) enhancement of management and operational synergies between the guarantee and the credit provided either by Bancóldex or the eligible financial intermediaries; (ii) use of financial techniques in structuring the pricing of the guarantee, as well as the insurance instrument, if applicable; and (iii) improvement of financial risk analysis of geothermal subprojects in Bancóldex and the eligible FI involved. Previous works with Bancóldex, along with technical assistance from the Bank to strengthen their institutional and financial capacity, makes them a suitable partner with strong will to continue working and evolving in the sector of clean energy. The program also builds upon a strong coordination with the energy authorities, especially the UPME and the Ministry of Energy.

3.2 Bancóldex will implement the program under its current organizational structure. The provisions governing program execution, FIs' participation, and eligibility of each subproject to be granted access to the use of funds from the program, will be established in the OR agreed between the Bank and Bancóldex, in accordance with their standards and policies, local laws, and Colombia's financial industry practice. Bancóldex will be responsible of supervising the adequate use of program financial resources and of the timely provision of human and technical resources necessary to implement the program. The program will apply the standard procedures established by the Bank for monitoring and evaluation of investment operations, but will also be consistent with reporting obligations to the CTF.

3.3 The OR of the program will define the specific process, timing and requirements for the exploration projects to access the contingent recovery grant resources. To be eligible, projects shall comply with: (i) regulatory requirements, particularly exploration permits assigned by the responsible authority under the national applicable law for the use of the geothermal resource –in the case of Colombia, regulatory requirements include a complete Environmental Impact Assessment (EIA);[31] (ii) economic requirements, economic sustainability plan of the project, including estimated financing sources and costs; (iii) the environmental and safeguard requirement of the IDB; and (iv) technical requirements established by the CTF. This means to comply with all the technical pre-feasibility and feasibility studies on which the assumed exploitable potential of the reservoir is funded. The studies will include economic potential, infrastructure availability and geophysical, geochemical and geological studies.

[31] The Bank's Environmental Safeguards Unit will validate that the corresponding EIA meets IFC international standards.

The aim of the technical requirements is to guarantee that there is real economic potential for a given project, as well as to reduce the risk of allocating funds to less viable projects, in order to maximize the use of the guarantee fund. Financial requirements will be used as an element of competition and prioritization among different potential interested parties in the use of the guarantee fund, as well as an upside benefit for the CTF fund. These rules will not alter the optimal financial decision from the project developer standpoint and their main purpose is to maximize the financial potential of the guarantee fund. The financial elements may be centered in the asking price and/or the degree of equity and debt financing leveraged by the use of the guarantee fund. The price for the use of the guarantee fund will be related to project risk. This is a clear potential upside for the CTF resources, maximizing their potential use for future geothermal projects, and aligning incentives between developers and the guarantee fund. At the same time, eligibility will be limited to projects that provide technical information supporting that resource drilling risk is below 50%.

3.4 An agreement between Bancóldex (acting as fiduciary of the guarantee fund) and each eligible subproject will provide the precise terms and conditions of the coverage in terms of geological parameters (temperature, flow rate, fluid chemistry and others), upon which the success or failure of the drilling activities are to be measured in a quantifiable manner, and upon which the amount of the compensation will be determined. The agreement will operate as an insurance and will only cover resource risk (not drilling, construction or other risks).[32] Bancóldex and the Bank will call for expressions of interest and select a portfolio of eligible subprojects. There will be no targets for the proportion of resources that has to be disbursed under a specific financing alternative, which allows both Bancóldex and developers to opt for the alternative best suited to their financing needs. The deployment of this scheme is intended to distribute the risk associated to the use of resources between developers, donors, the government and the private sector (financiers, insurance companies, etc.) and across as much investments as possible, so as to maximize the impact of the use of concessional resources.

3.5 **Disbursements, execution and administration framework.** The execution period and the disbursement period will be ten years. This execution period will permit two important objectives: (i) monitor and evaluate the expected results and impacts of the project that, because of the inherent characteristics of geothermal exploration, require a long-term evaluation framework (see ¶1.28); and (ii) allow for the development of several projects in case the first guaranteed drillings have been successful. Bancóldex will receive the resources in a special bank account (designated account) in US$ dollars. The Bank will disburse program resources in the form of advances of funds to the designated account, based on the liquidity needed by Bancóldex for program implementation. At the end of the disbursement period, any unused resources will be returned to the CTF. Given the nature and characteristics of the program, disbursements will be

[32] The guarantee may be applied to a single well exploration or an agreed number of first exploration wells drilled by the private or public developer. In the latter case, the criterion for triggering the coverage would be the performance of the whole portfolio against a benchmark. This approach has the advantage that the guarantee does not need to be called upon if dry wells are compensated for by highly productive wells and that the coverage cost per project is lower.

made subject to the signature of the corresponding guarantee agreement to be entered into Bancóldex and each of the corresponding beneficiaries of the program. Bancóldex may justify the payment to the IDB at the time the payment/reimbursement to the beneficiary under the guarantee agreement is made. **It is a special contractual condition that prior to the first disbursement of the grant resources Bancóldex should provide evidence, to the Bank's satisfaction that: (i) the program coordinator has been hired in accordance with the terms of references previously agreed upon with the Bank; and (ii) the program's OR has been approved and entered into effect, in accordance with the terms and conditions previously agreed upon with the Bank.**

3.6 **Financial statements.** The execution of resources and the eligibility of program expenditures will be audited annually by an independent auditing firm acceptable to the Bank, which will be contracted by Bancóldex. The auditing firm may be the same firm to audit the financial statements of Bancóldex.

3.7 **Procurement of goods and services.** Procurement actions will follow current Bank policies. Since Component I of the program is mainly a financial intermediation activity, the program's Procurement Plan will only incorporate activities under Component II.

B. Summary of Arrangements for Monitoring Results

3.8 The program will apply the standard procedures established by the Bank for monitoring and evaluation of investment operations, but will also be consistent with reporting obligations to the CTF. The evolution of indicators should be periodically reported by Bancóldex to the Bank during program execution. Upon completion of the program, Bancóldex will prepare a final evaluation report.

3.9 **Monitoring and reporting.** In accordance with legal obligations of record keeping, Bancóldex will compile, produce and maintain all information, indicators and parameters, including annual plans, midterm review and final evaluation, necessary for the preparation of the Project Completion Report and any ex post assessment the Bank or the CTF may wish to conduct.

3.10 **Evaluation.** The evaluation plan considers a cost-benefit ex post methodology. Due to the scale and scope of the intervention, considered as one of many elements that will contribute to the long-term development of the geothermal sector in Colombia, the proposal is not able to present a thorough evaluation on the specific impact of the risk mitigation instrument proposed by the program on the structural indicators of the sector. This would require much more information which is not accessible –or non-existent–, as well as controlling for a series of variables that are out of the scope of the program (see Annex III).

COLOMBIA
FINANCING AND RISK TRANSFER PROGRAM FOR GEOTHERMAL POWER

CO-G1007

FIT WITH CTF INVESTMENT CRITERIA

FIT WITH COLOMBIA'S INVESTMENT PLAN

A Clean Technology Fund (CTF) Investment Plan (IP) for Colombia was endorsed by the Trust Fund Committee (TFC) of the CTF in March 2010, with an envelope of up to USD 150 million in CTF funding. This IP was proposed as a two-phase process. The first phase addressed the implementation of abatement measures in two key sectors included in the IP, urban transport and energy efficiency. As the Government took further steps toward creating an enabling environment for non-conventional renewable energy (NCRE), this sector was presented in the original CTF IP as a priority sector for a possible second phase of the IP, which could include as well further programs on energy efficiency and transport.

In 2013, the original plan was revised. The overall rationale for CTF intervention remained unchanged, but the revisions to the IP reflected adjustments, circumstances and the evolution of relevant national policies and priorities, especially through the National Development Plan (PND) 2010 – 2014, adopted by law 1450 of 2011. Among these circumstances, a new environment for investments in generation capacity through NCRE, including incentives and the promotion of alternative energy sources as a source for the national interconnected system (SIN) was identified as a strong window of opportunity for the development of this sector. As a result, the government proposed to bring in the NCRE Program as a third priority sector of the IP, which originally proposed this sector as a possible Phase II priority. From the USD 150 million, USD 11 million originally allocated to energy efficiency were reallocated to the other two priorities: USD 1 million to urban transport and USD 10 million to NCRE.

The impact of the revised programs on CTF objectives is comparable to the one envisioned in the original CTF Plan, but the revised version added specific NCRE indicators, including additional potential GHGs reduction by substituting coal thermal capacity with wind or geothermal power plants.

In October 2013, the TFC approved funding to be deployed for Dedicated Private Sector Programs (DPSP). Under the DPSP, a utility-scale RE program proposes to focus initially on geothermal energy and more specifically on addressing the geothermal resource risk through well drillings. An initial amount of USD 115 million was allocated to existing CTF countries, namely Chile, Colombia, Turkey, and Mexico. Consistent with the priorities established by the revised IP, this program proposes the use USD 10 million resources from the DPSP, for the development of financial instruments to promote geothermal development in Colombia.

POTENTIAL FOR GHG EMISSIONS SAVINGS

The Results Matrix of the program outlines the indicators and the means to verify the accomplishment of the program's targets. Given its magnitude, it is expected that program resources would be sufficient to support at least two geothermal exploration projects, leading to the successful development of at least one geothermal plant in the country – based on the assumption of a conservative probability of exploration success of 50% and the identified potential demand. This in turn is expected to represent the deployment of new geothermal capacity in Colombia of 50 MW, producing electricity by 2026 and leading to emissions savings of around 77,000 tCO_2 per year.

COST-EFFECTIVENESS

The proposed program is expected to finance some 50MW of new geothermal capacity in the long term, which, once fully operative will deliver an annual average production of 416,100 MWh and 2.31 M tons of CO_2 emissions reductions over the 30 years of life of the plants financed[1]. Based on these estimations, the investment per ton is projected at: (i) USD 4.3 per tCO_2e, when considering CTF financing only; and (ii) USD 87 per tCO_2e, when total project investment costs (including all public and private funds leveraged) are considered. The proposal includes a cost benefit analysis of the program, which applies a methodology that compares the net benefits of the new geothermal capacity installed as a result of the program to the net benefits of a counterfactual scenario without program. The value of the averted CO_2 emissions by the operating geothermal plants is contemplated as a benefit in the analysis. The NPV of the program is USD 45.54 million and is calculated using a 12% discount rate, as per IDB standards. A sensitivity analysis is performed by stressing some critical variables such as load factors, investment costs, construction times and prices of electricity[2].

DEMONSTRATION POTENTIAL AT SCALE

The increase in residential and industrial energy demand in Colombia imposes the need to introduce new generation plants with lower operating costs and less intensive use of fossil fuels. As of December 2014, installed capacity in Colombia was 13,886 MW and projections for 2020 are to increase capacity to 14,971 MW (*Unidad de Planeación Minero Energética*, UPME). As Colombia is located in one of the regions with the highest geothermal energy source potential in the world, estimated to be within the range of 1,340 to 2,210 MW (IDB, 2014), geothermal offers one of the most effective renewable and low carbon alternatives for power generation, and therefore an attractive alternative in order to achieve the energy objectives stated in the National Development Plan (PND) 2014-2018.

Worldwide, geothermal investment costs are in the range of USD 2 million to USD 4 million per MW for a condensing flash plant and USD 2.4 million to USD 5.9 million per MW for a binary plant (IEA). Smaller plants can be more costly because of the lack of economies of scale in drilling. A long term analysis carried out by UPME includes projections of different scenarios for expansion of Colombia's energy system. Taking into consideration the recently approved Law 1715 that offers incentives to NCRE, scenarios of expansion considering all NCRE include between 275MW and 375MW of new geothermal capacity added to the system by 2030. Based on these projections, the total investment in geothermal needed for this expansion would reach up to USD 1,500 million over the medium to long term.

The proposed program intends to use CTF grant and contingent grant resources (a total of USD 10 million) to mobilize funds from third party sources up to a total of USD 190 million, for a total investment of USD 200 million altogether. This would represent a contribution of some 13% to total country geothermal investment needs by 2030. The goal of the program is to trigger investment in geothermal energy by using a scheme where the developer is able to share the risk during initial exploration, thus helping unlock the development of the first geothermal power plant in the country. The successful deployment of one exemplary project will help demonstrate the technology's viability and indirectly contribute to the improvement of the country's financial and technical capabilities to further encourage geothermal exploration and development.

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1 Power generation is calculated applying the assumed load capacity for geothermal plants in Colombia. Avoided emissions are calculated using an emission factor of 0.186 tCO_2e/MWh.

2 For further detail on how these values are obtained, please refer to the Economic Analysis (Annex IV).

The program includes a technical cooperation component that will ensure thorough supervision of its execution, specifically related to risk analysis, and to the technical and environmental due diligence of projects. It is expected that the program will also contribute to the building of local capacity, provide impulse to the revision of standards and regulations that will create a better environment for investing in geothermal, and foster synergies with other related initiatives, such as the Geothermal Training Center in El Salvador and the recently launched Geothermal Development Facility led by the German Development Bank (KfW). Synergies with other IDB programs related to the financing of geothermal (Mexico and Chile already in execution, and Eastern Caribbean recently approved) will be sought and knowledge transfer will be guaranteed.

DEVELOPMENT IMPACT

Besides the relevance of its potential impact in terms of the environment, geothermal is a power source that entails other significant economic and social benefits for Colombia, such as high quality employment creation and the potential to reduce the need to import gas.

Studies comparing jobs created in energy sectors state that geothermal energy supports and generates a significant number of jobs when compared to other energy technologies. The construction of the plants is more labor intensive than comparable energy sources, resulting in benefits for the local population[3].

The introduction of geothermal to the mix of technologies that constitute the country's energy matrix can also lead to considerable reductions in the price to final consumers. As a reference for the case of Colombia, a simulation performed in 2015 by the UPME shows that the introduction of 2,000 MW of non-conventional energy sources (including geothermal, from which its inherent characteristics make it more economically attractive than other renewables) in Colombia's energy matrix could have a significant impact in the long run marginal cost of the system, estimated in a reduction of approximately USD 9 per MWh.

IMPLEMENTATION POTENTIAL

The Government of Colombia is making progress in the establishment of more clear and specific standard rules for the evaluation of geothermal projects for licensing (including environmental and social aspects), which address some other risks that are considered important inputs for investment decision making. Although specific regulation such as defined concession areas for geothermal does not exist, Colombia has begun to promote the use of non-conventional energy sources in general. In May 2014, Colombia passed the Law 1715, which promotes the development and use of nonconventional energy sources in the national energy system, by integrating them to the electricity market through investment incentives (tax and value-added tax exclusions, income and accelerated amortization profile). While proper policy and institutional changes still need to be made in order to attract investors at a larger scale, relevant local players in the energy sector have demonstrated their willingness to invest in this technology (having already invested resources in exploratory studies), therefore contributing to the development of a competitive geothermal market in Colombia and benefiting from the gains of becoming first comers in this emerging and profitable business.

The executing agency for the program, *Banco de Comercio Exterior de Colombia S.A.* (Bancóldex), is a national credit institution established to promote investment and financial

[3] See Green Jobs through Geothermal Energy (GEA, 2010); A Handbook on the Externalities, Employment, and Economics of Geothermal Energy (GEA 2006); Promoting Geothermal Energy: Air Emissions Comparison and Externality Analysis (GEA, 2013).

support for Colombia's industrial and economic development. Bancóldex will act as the fiduciary manager of the CTF funds, implementing the program under its current organizational structure. The provisions governing program execution, financial intermediaries' participation, and eligibility of each subproject to be granted access to the use of funds from the program will be established in agreement between the IDB and Bancóldex, in accordance with the institutions' policies, local laws, and Colombia's financial industry practice.

Based on its experience in the implementation of programs with resources financed by the IDB (since 2008 it has demonstrated its capacity as Executing Agency through several programs adding up to USD 300 million in financing), Bancóldex has been determined capable of responsibly supervising the adequate use of the program's financial resources and of the timely provision of the human and technical resources necessary for its implementation. The program will apply the standard procedures established by the IDB for monitoring and evaluation of investment operations, but will also be consistent with reporting obligations to the CTF. However, in order to strengthen the capacity of Bancóldex in managing the specifics of geothermal, an independent expert will be hired to assist Bancóldex in evaluating geothermal projects technically and financially, as well as to properly structure the financial agreements for each project.

ADDITIONAL COSTS AND RISK PREMIUM

For an investor or developer, public or private, geothermal power generation is a high risk-high return venture, of a much more complex financial nature than the one associated to other renewables. These projects entail substantial risk related to finding and developing the geothermal resource, mainly at the initial stages of a project, implying extremely high value at risk. Any greenfield geothermal power project requires significant financial commitment (in average, 35% to 40% of the total capital costs) to be made before the characteristics of the resource can be fully known. And even when the resource has been discovered, it cannot generate a return on investment until a suitable power plant is constructed (which altogether can take up to five to seven years). In Colombia, geophysical conditions can lead to exploration costs higher than in other parts of the world, thus increasing financial risk aversion and making the resource risk even more critical to tackle through public policy intervention.

There is consensus on the need for financial support to develop geothermal power generation. The IEA includes the development of financial instruments to promote geothermal exploration (by governments, development banks and commercial banks) among its recommendations for market facilitation and sector transformation (Technology Roadmap for Geothermal Heat and Power, 2011). The lack of risk mitigation and financing mechanisms is often credited for holding back projects in emerging economies (Global Geothermal Development Plan (GGDP) Roundtable 2013, Climate Policy Initiative (CPI) Geothermal Dialogue 2014 and 2015). Development banks have increasingly become an important source of clean energy investments over the last decade (Frankfurt School - UNEP, 2014), and virtually all geothermal projects recently developed or underway in developing countries have benefitted from their involvement. Private finance for both debt and equity, if available, is particularly prevalent only in developed markets such as the United States of America and New Zealand (CPI, 2014).

In Colombia, there are currently no financial mechanisms that encourage developers to invest in a high risk venture such as geothermal, despite the significant long-term benefits that it entails for the country's economy.

FINANCIAL SUSTAINABILITY

CTF resources are expected to enable financing for the initial exploration of two projects, with a successful development of at least one geothermal project in Colombia. Lack of knowledge and absence of a performance record in a country with no existing geothermal capacity negatively affects investors and financiers. As long as the viability of these projects is not demonstrated in the country, risk will remain unknown, financing will be unavailable, and developments will have to rely exclusively on scarce and expensive equity resources, slowing down or precluding investment in the sector. The demonstrative effect of one power plant operating in the country – and the region – will help reduce the risk perceptions of private investors and commercial banks.

Through the generation of a track record and knowledge for investors, financial institutions, insurers and developers, it is expected that the perceived risks will be lower and additional finance will be available to further develop the sector in Colombia. However, given the challenging context of geothermal development worldwide, particularly in developing countries and regions, is should be expected that some public support will continue to be needed in the short and medium term for this industry to evolve in a way that is self-sustainable for either private or public stakeholders.

Moreover, the capabilities developed in Bancóldex, as well as in other financial intermediaries involved in financing geothermal energy, will constitute an asset for future potential geothermal developments in Colombia. It is expected that Bancóldex will develop (i) technical capabilities related to geothermal project management and risk evaluation and supervision; and (ii) managerial capabilities to coordinate the multiple actors involved in geothermal power generation (developers, drillers and other service providers, financial institutions, insurers, regulators, and technical advisors, among others). These capabilities will constitute a solid basis that national authorities and international organizations could use in order to undertake new programs to develop nonconventional sources of energy in Colombia and the region.

EFFECTIVE UTILIZATION OF CONCESSIONAL FINANCE

Whether projects are being financed via equity or lending, these need to be combined with risk sharing instruments. Consistent with its principles and objectives, CTF funding will take risks that commercial lenders or investors are not able to bear, crowding in the private sector by catalyzing investment that would not have happened otherwise. Resources will be concentrated on riskier phases of exploration, following the DPSP's objective of prioritizing available concessional funds towards exploratory drilling and geothermal resource validation.

CTF contingent recovery grant resources will support the deployment of a risk mitigation instrument designed to maximize leverage of CTF resources and to back the financing of the projects. CTF funding will cover resource risks by operating as a guarantee, fully or partially guaranteeing loans or equity. The sponsor/lender would have recourse to an agreement with the grant fund (managed by Bancóldex) and present a request for it to fully or partially cover these expenses in the event that technical triggers for failure are determined. Because the costs for a project to assume the associated fees are fairly high, a subsidy may be needed to make this instrument financially viable for the projects. CTF grant funding will help offsetting these upfront costs.

CTF contingent recovery grant resources to support projects shall be administered through a special account. This account will receive any income from the investment of its funds as well as the fees charged for their use. Funds will be available to support as many projects as are technically and financially viable over the execution period. The revolving nature will however be

limited by the success/failure rate of projects. During the execution period all funds shall be used in support of geothermal projects consistent with the objectives of the program until resources are fully utilized, under the supervision of Bancóldex and the IDB. Any remaining grant funds after the execution period shall be returned by Bancóldex to the CTF. In all cases, a thorough due-diligence of projects by an independent expert/ insurance company is expected to reduce the risk of moral hazard.

MITIGATION OF MARKET DISTORTIONS

There is currently no geothermal market in Colombia, so no potential distortions are foreseen. The program is expected to crowd in private investment, as well as to develop the necessary incentives for a competent and competitive institutional framework for geothermal to be strengthened. Also, there are no subsidies expected in the tariff structure for this technology, specifically.

RISKS

The program identifies a high risk in the lack of clear and specific local regulatory framework for the procedure of geothermal energy exploration licensing. This may result in important delays in the implementation of potential beneficiary projects. In order to mitigate this risk, the IDB's project team will make efforts to maintain a robust dialogue with relevant authorities, in order to detect any technical or regulatory bottlenecks as early as possible. Funds are being budgeted as part of the technical cooperation package for the purpose of assisting authorities in improving their regulatory framework as needed.

Another development risk has been found on the limited or insufficient local human capacity (specific geothermal technical expertise) to accompany the development of subprojects supported. Several aspects are considered for mitigating this risk, including overseeing with Bancóldex the proper implementation of quality standards in the ex-ante evaluation of subprojects using existing certified international knowledge, as well as engaging the IDB's own Geothermal Training Center in El Salvador with developers that are participating in the program.

Some geothermal projects (including initial drilling) are considered high-risk and can have adverse environmental or social impacts that can be significant, and which need to be assessed and managed on a project by project basis. As per IDB requirements, the Environmental and Social Management System (ESMS) will allow for the identification of potential impacts and risks and ensure that the final beneficiaries of the program will implement environmental and social management practices consistent with IDB's safeguard policies. The technical assistance package also includes support for the analysis of potential gaps between the local environmental and social criteria and international best practices. Bancóldex shows a strong institutional capacity in the management of environmental and social risks, with a full-fledged environmental and social management system designed and implemented with the technical assistance of the IDB.

STAKEHOLDER ENGAGEMENT

The multidisciplinary nature of this industry will require that the country develops multi sector approach and engagement plans and consultations. The promotion of geothermal requires the involvement and support of several public actors, including authorities from sectors such as Energy and Mines, Environment, Finance and Planning (DNP), as well as regulators in the electricity market. From a private perspective, and due to the reduced number of potential beneficiaries in the market, a high level of engagement is expected from developers since the beginning of the implementation. Their interest and contributions to the program have been

crucial in the design and preparation activities of the proposal. Other stakeholders, such as partner organizations working in geothermal (like KfW) or private insurers, will also be considered during program implementation.

GENDER ISSUES

As standard practice enforced by the IDB, the executor (Bancóldex) will develop a Social and Environmental Management System (SGAS) which shall comply with the requirements for consultation and compensation, and will actively promote the inclusion of women in the workplace. However, due to the nature of the program and the characteristics of the sector[4], the inclusion of specific indicators directly related to this is not contemplated, as it may reduce the flexibility and sufficiency of contracting processes.

[4] For example, the limited supply of very specific expertise and high quality services involved in the value chain.

RESULTS MATRIX

Project Objective:	The objective of the program is to scale up investment in geothermal power generation projects by making available a financial mechanism tailored to meet the specific needs of a project's earliest development stages. To this end, the program intends to trigger power production from geothermal sources, thus contributing to the reduction of Global Greenhouse Gas (GHG) emissions and the diversification of the Colombia's energy matrix.

EXPECTED IMPACTS

Indicators	Unit	Baseline		Goals		Means of verification	Observations
		Value	Year	Value	Year		
EXPECTED IMPACT							
Greenhouse gases emissions in Colombia's electricity sector.	$MtCO_2$	11.57	2016	**8.4**	2026	Source: IDB/ Bancóldex with information coming from World Bank's development.	It is expected that the program will contribute to this development indicator by helping reduce the CO_2 emissions that are produced by electricity generation.
CO_2 emissions per dollar of GDP.	CO_2 emissions per dollar of GDP	0.13	2016	**0.11**	2026	Source: IDB/ Bancóldex with information coming from World Bank's development.	It is expected that the program will contribute to this development indicator by helping reduce the CO_2 emissions that are produced by electricity generation.

EXPECTED RESULTS

Expected Results	Unit	Baseline		Intermediate		Goals		Means of verification	Observations
		Value	Year	Value	Year	Value	Year		
EXPECTED RESULT									
Geothermal power generation by projects guaranteed by the program.	GW/hr	0	2016			525.6	2026	Source: UPME.	This measures the annual generation of electricity by the expected 50 MW installed capacity. The calculation is based on a 95% capacity factor. **Milestone**. Additionally, the project will have the following milestone: *Installed capacity of geothermal power of projects guaranteed by the program.* This will have a baseline value of 0 MW and a target value of 50 MW for 2026. UPME will provide data for monitoring.
Greenhouse gases emissions avoided through the use of geothermal energy of projects guaranteed by the program.	Tons of CO_2 ($tCO_{2)}$	0	2016			232,183	2026	Source: UPME.	This indicator measures the cumulative tons of CO_2 avoided (the incremental value as compared to a business as usual scenario) through the use of geothermal energy. It is calculated by multiplying the emissions factor for

Expected Results	Unit	Baseline		Intermediate		Goals		Means of verification	Observations
		Value	Year	Value	Year	Value	Year		
									the electricity sector in Colombia by the actual power generation of the plant, adjusting for load capacity factor.
Additional financing raised by the projects guaranteed by the program compared to non-beneficiaries projects.	US$ Million	0	2016			190	2026	Source: Bancóldex.	This indicator measures the difference between the additional funds raised by guaranteed projects and the funds raised by non-guaranteed projects.

PRODUCTS

Products	Estimated Cost (US$)	Unit	Baseline	Year 1	Year 2	Year 10	Final Goal	Means of verification
Component I: Risk mitigation grant facility								
Number of geothermal power projects guaranteed by the program.	9.33 million	Number	0	1	1	0	2	The project will provide guarantees for the development of two geothermal projects. Source: UPME.
Component II: Implementation and technical assistance activities								
Number of studies carried out by independent consultants (Subcomponent I).	0.15 million	Number	0	2	1	0	3	These studies will provide third party expertise for the technical validation of eligibility of projects, as well as verifying success and failures on drillings. Source: Bancóldex.
Number of studies carried out by independent consultants (Subcomponent II).	0.05 million	Number	0	1	0	0	1	These studies will provide third party expertise for the support to the development/reform of norms and regulation that will contribute to making the geothermal sector attractive for investment. Source: Bancóldex.

DOCUMENT OF THE INTER-AMERICAN DEVELOPMENT BANK

COLOMBIA

INVESTMENT GRANT FOR THE FINANCING AND RISK TRANSFER PROGRAM FOR GEOTHERMAL POWER

(CO-G1007)

MONITORING AND EVALUATION ARRANGEMENTS

I. Introduction

A. General Framework

1.1 The main purpose of this document is to present the monitoring and evaluation plan of the CTF Grant for the Financing and Risk Transfer Program for Geothermal Power.

1.2 The proposed program will focus on overcoming the financial problems that affect the development of geothermal projects. It shall provide a risk sharing instrument that will support the financing of early drilling stages of geothermal projects in order to increase debt and equity financing for geothermal developers. As part of a set of proposed activities, it will also aim to support government actions to promote the acceleration of regulatory reforms that will enable a more attractive environment for these investments (e.g. the provision of inputs for the preparation of draft rules and procedures associated to overcoming some of the development risks).

1.3 This intervention is expected to trigger power production from geothermal sources, thus contributing to the reduction of global GHG emissions and the diversification of Colombia's energy matrix.

1.4 In Colombia, currently 70% of its electricity installed capacity is based on hydroelectric power, 29% comes from natural gas and coal and less than 1% from renewable sources. The country's energy system has been experiencing reductions in hydroelectric generation since 2011, associated with declining contributions of this source (leading to higher contributions from gas and coal, to compensate for these deficits) and uncertainty about the occurrence of El Niño and the need to manage water resource with caution. Thus, even when the current contribution of Colombia to the Global greenhouse Gas (GHG) emissions may not appear significant (0,4% of total global emissions), its energy system's high dependency in the hydroelectric generation makes it especially vulnerable to extreme hydrologic conditions (such as the ones occurred in 1991-1992 and 1997-1998) and, in particular, to the El Niño. Moreover, if hydroelectric contributions to the system continue to be below average, the use of fossil fuels to cover for these deficits will continue to increase, impacting the level of emissions in the long term.

1.5 Geothermal energy offers one of the most effective renewable and low carbon alternatives for electricity generation, opening up the possibility of increasing the share of clean sources in Colombia's energy matrix. Furthermore, the role of geothermal power goes beyond its environmental contribution because it can produce significant economic and social benefits

B. Scheme for Implementation and Monitoring

1.6 The executing agency for the program will be Banco de Comercio Exterior de Colombia S.A. (Bancóldex). Bancóldex is a well reputed national credit institution

with ample experience in finance structuring and fiduciary management. This will allow: (i) to enhance management and operational synergies between the lending guarantee facility and the credit provided either by Bancóldex or the financial intermediaries; (ii) the use of financial techniques in structuring the pricing of the lending facility, as well as the insurance instrument; and (iii) to improve financial risk analysis of geothermal projects in Bancóldex and the financial intermediaries involved. The project also builds upon a strong coordination with the energy authorities, especially the Unidad de Planeación Minero Energética (UPME) and the Ministry of Energy.

1.7 Bancóldex will execute the program under its current organizational structure. The provisions governing program execution, financial intermediaries' participation, and eligibility of each project to be granted access to the use of funds from the program, will be established in the OR agreed by the IDB and Bancóldex, in accordance with Bancóldex and IDB standards and policies, local laws, and Colombia's financial industry practice. Bancóldex will be responsible of supervising the adequate use of program financial resources and of the timely provision of human and technical resources necessary to implement the program. The program will apply the standard procedures established by the IDB for monitoring and evaluation of investment operations, but will also be consistent with reporting obligations to the CTF.

1.8 Eligibility will be determined by Bancóldex and the IDB, based on technical reports, according to a pre-established set of conditions to be specified in the program's OR. Resources are to be fully committed and disbursed within 6 years from the effective date of the CRG fund agreement. CTF contingent recovery grant resources to support projects (Component I) shall be transferred to in one disbursement and managed by Bancóldex exclusively for the execution of the program and administered through a special account. This account will receive any income from the investment of its funds as well as the reimbursements from sub projects and the fees charged for their use. Any remaining grant funds after 10 years shall be returned by Bancóldex to the CTF. In addition to the conditions prescribed in General Norm Article 4.01, it is a special contractual condition prior to the first disbursement of the program that the executing agency Bancóldex will provide evidence, to the Bank's satisfaction, of: (i) the formal designation of a program coordinator; and (ii) the entry into effect of the program's Operating Regulations (OR) agreed with the IDB.

During the disbursement period, Bancóldex is required to submit audited financial statements of the program within 180 days after the closing of each fiscal year, duly audited by an independent firm acceptable to the IDB and contracted by the executing agency.

Table 1.1 Costs of the Program by Expected Output (USD million)

Cost component	Y1	Y2	Y3	Y4	…	Y20	Total
Outputs Component I.							
Number of geothermal power projects guaranteed by the program.	4.66	4.67	0	0	…	0	9.33
Output Component II.							
Subcomponent I.Number of studies carried out by independent consultants.	0.075	0.075	0	0	…	0	0.15
Subcomponent II.Number of studies carried out by independent consultants.	0.05	0	0	0	0	0	0.05
Total program financing	**4.785**	**4.745**	**0**	**0**	**…**	**0**	**9.53**

II. Monitoring

A. Indicators

2.1 The monitoring intends to follow up the execution of the program in order to identify the intermediate milestones achieved in each phase, identify corrective actions if necessary and evaluate its outcomes and fulfillment of proposed targets. The indicators to be monitored will be those included in the Results Matrix and in the Progress Monitoring Report (PMR). Table 2.1 summarizes them and includes information on the source and frequency of collection and reporting process.

Table 2.1 Indicators

Indicators	Unit	Frequency of measurement	Description / Source of verification
OUTPUTS COMPONENT I: RISK MITIGATION GRANT FACILITY			
Number of geothermal power projects guaranteed by the program.	Number	Annual	Values based on guarantee agreements. Target is inclusive of all projects supported, both successful and failed. Source: Program report from Bancóldex.
OUTPUTS COMPONENT II: IMPLEMENTATION AND TECHNICAL ASSISTANCE ACTIVITIES			
Subcomponent I. Number of studies carried out by independent consultants.	USD million	Annual	These studies will provide third party expertise for the technical validation of eligibility of projects, as well as verifying success and failures on drillings. Source: Program report from Bancóldex.

Subcomponent II. Number of studies carried out by independent consultants.	USD million	Annual	These studies will provide third party expertise for the support to the development/reform of norms and regulation that will contribute to making the geothermal sector attractive for investment. Source: Bancóldex
RESULTS			
Installed capacity of geothermal power of projects guaranteed by the program.	MW	Twice, baseline and end of execution period	The funds are expected to back the installment of 50 Megawatts of power based of the expected geothermal resources in the region. Source: Program report from Bancóldex with information provided by UPME.
Geothermal power generation by projects guaranteed by the program.	GW/hr	Twice, baseline and end of execution period	This measures the annual generation of electricity by the expected 50 MW installed capacity. The calculation is based on a 95% capacity factor. Source: Program report from Bancóldex with information provided by UPME.
Greenhouse gases emissions avoided through the use of geothermal energy of projects guaranteed by the program.	tCO_{2e}	Twice, baseline and end of execution period	Tons of GHG emissions that will be avoided once the plants guaranteed by the program begging operating. Source: IDB estimations made using UPME methodology, based on installed capacity (see indicator above), load factor, production, and the conversion factor for electricity generation in Colombia measured at the moment by UPME. tCO_{2e} = Tons of CO_2 equivalent
Additional financing from third parties mobilized to complete geothermal projects financed at some stage by the program compared to financing raised by non-beneficiaries	Millions of USD	Twice, baseline and end of execution period	Additional third-party direct finance leveraged by the program beneficiaries compared program non-beneficiaries. Includes all financing from sources other than the CTF funding (government, Bancóldex and other financial institutions). The comparison group will be constituted by the projects that applied but were not approved for the guarantees. Interviews will be conducted in order to monitor this indicator on the comparison group. Source: Program report from Bancóldex.

2.2 It should be noted that projects funded by the program may have environmental and social impacts that require an effective evaluation system for proper mitigation and management. To mitigate these risks, the IDB will define an Environmental and Social Management System (ESMS), which will enable the identification of potential impacts and risks and ensure that the beneficiaries of the financing will implement environmental and social assessment, prevention, mitigation and management measures consistent with IDB safeguard policies. Bancóldex shows a strong institutional capacity in the management of environmental and social risks, with a full-fledged Environmental and Social

Management System designed and implemented with the technical assistance of the IDB. Bancóldex is among the most advanced financial institutions in the Region in the management of Environmental and Social (E&S) risks for Tier 2 banking activities.

B. Data Collection and Instruments

2.3 Bancóldex will collect the necessary data for monitoring and present annual reports to the IDB. In some cases, the IDB will make calculations required for some indicators, based on the information provided by Bancóldex in the annual reports. The IDB must report annually to the Clean Technology Fund Trust Fund Committee (CTF TFC) on results or estimations/projections of results (in case of plants in state of construction and non-operational as of reporting date). Table 2.1 presents the main indicators to be monitored during the execution period of the operation, the methodology to be used, source of information, and responsible of data gathering.

2.4 From the Bank's side, the project team composed by specialists from IFD/CMF, INE/CCS and INE/ENE, with support from the country office in Colombia, will be in charge of following up the execution, monitoring and evaluation of the program. The executing agency and the Bank have committed to carry out monitoring meetings according to a regular schedule to be agreed upon between the two parts (see Table 2.2 Monitoring Work Plan for an indicative schedule).

C. Reporting Monitoring Results

2.5 Bancóldex will report to IDB through annual reports including the defined indicators and any other relevant information on the performance of the program. Based on the information provided by these reports, the executing agency and the IDB could introduce adjustments to the program. Bancóldex will deliver the reports within 60 calendar days after the end of each year of the program's implementation. The reports will include information regarding the evolution of the indicators, as well as financial information regarding the use of the resources and the state of the program's account. The Bank will be entitled to request additional information, if necessary.

D. Monitoring Coordination, Work Plan and Budget

2.6 Bancóldex will be responsible for the supervision, technical and administrative coordination of the program. It will also be responsible for the execution of the activities envisioned under the program, and performing the necessary reporting duties to the Bank.

2.7 CTF resources are to be fully committed and disbursed within ten years from the effective date of the loan agreement.

2.8 The cost and planned schedules for the activities are shown in Table 2.2. Resources to cover these costs will come from the supervision budget included in the CTF funding plus any standard administrative costs associated to IDB and Bancóldex staff involved in the project. Third-party resources may be required as part of the supervision activities financed by the CTF resources or, if applicable, to the IDB operational budget.

2.9 The program considers an allocation of US$0.2 million (Component II) for implementation and technical assistance activities, which will finance the contracting of expert services that will provide technical soundness to the program and help build capacity in the financial sector and local authorities for the continued support of the industry.

Table 2.2 Monitoring Working Plan

Activities	Year 1		Year 2		Year 3		…		Year 9		Year 10		Responsible	Budget (USD)
	I	II	I	II	I	II	I	II	I	II	I	II		
Coordination meetings and supervision visits		X		X		X		X		X		X	Bancóldex /IDB	**24,000**
Collection of data for output indicators														**20,000**
• **Component I**		X		X		X		X		X		X	Bancóldex /IDB	10,000
• **Component II**		X		X		X		X		X		X	Bancóldex /IDB	10,000
Collection of data for outcome indicators														**25,000**
• **Installed capacity of geothermal power of projects guaranteed by the program.**												X	Bancóldex	5,000
• **Geothermal power generation by projects guaranteed by the program.**												X	Bancóldex	5,000
• **Greenhouse gases emissions avoided through the use of geothermal energy of projects guaranteed by the program.**												X	IDB	5,000
• **Additional financing raised by the projects guaranteed by the program.**		X		X		X		X		X		X	Bancóldex	10,000
Final report (input for PCR)												X	Bancóldex /IDB	**35,000**
													Total	**104,000**

III. Evaluation

A. Main Evaluation Questions

3.1 This section aims at proposing a plan to carry out an evaluation of the impact of the program. The main evaluation questions are:

a. What is the installed capacity of geothermal power projects guaranteed by the program?

b. What is the geothermal power generation by projects guaranteed by the program?

c. What is the amount of greenhouse gases emissions avoided through the use of geothermal energy of projects guaranteed by the program?

d. What is the amount of additional financing raised by projects guaranteed by the program?

3.2 The evaluation will use an ex-post economic analysis. The analysis will use in situ measurements in an annual basis (when applicable) during the ten years of the execution period. After this, projections on the expected results will be made based on the collected data (More details on section D below).

B. Existing Knowledge

3.3 Important studies have been undertaken in recent years focused on the development of non-conventional renewable energy in Colombia. Among these, *"Integración de las Energías Renovables no Convencionales en Colombia"* (UPME 2015) makes an exhaustive analysis of the benefits, costs, a regulation aspects of integrating non-conventional renewable energy, geothermal among them, in Colombia. Also, *"Analisis Costo-Beneficio de Energías Renovables no Convencionales en Colombia"* (Fedesarrollo 2013) performs a prospective evaluation of renewable energy compared to fuel-based ones. Furthermore, UPME reference plan of generation expansion for 2028[1] analyses the impact of introducing geothermal and other renewable sources on emissions reductions, price of electricity and system stability for Colombia. Additionally, relevant information required to evaluate the benefits in terms of costs of these projects can be found in the document *"Costos Indicativos de Generación Eléctrica en Colombia" (UPME, 2005).*

3.4 The ex-ante cost-benefit analysis[2] found that the net cash flows discounted at a rate of 12% produce a net present value (NPV) for the program of US$45.54 million. Besides, the cost-efficiency analysis gave a very positive output of the program in terms of mitigation costs of renewable energy technologies. Based on estimated reductions of CO2 emissions over the course of a 30 year lifetime of projects financed, and using indicative total resources of US$10 million from the CTF, the cost of abatement is estimated at some: (i) US$4.31 per tCO2e considering CTF financing and (ii) US$86.14 when considering total program financing.

[1] UPME (2015). *Plan de Expansión de Referencia Generación – Transmisión 2014-2028*
[2] See the Economic Analysis Annex

C. Key Outcome Indicators

3.5 The proposed indicators and their corresponding description, frequency of measurement and means of verification are listed in Table 3.1:

Table 3.1: Indicators

Indicators	Unit	Frequency of measurement	Description / Source of verification
RESULTS			
Installed capacity of geothermal power of projects guaranteed by the program.	MW	Twice, baseline and end of execution period	The funds are expected to back the installment of 50 Megawatts of power based of the expected geothermal resources in the region. Source: Program report from Bancóldex with information provided by UPME.
Geothermal power generation by projects guaranteed by the program.	GW/hr	Twice, baseline and end of execution period	This measures the annual generation of electricity by the expected 50 MW installed capacity. The calculation is based on a 95% capacity factor. Source: Program report from Bancóldex with information provided by UPME.
Greenhouse gases emissions avoided through the use of geothermal energy of projects guaranteed by the program.	tCO_{2e}	Twice, baseline and end of execution period	Tons of GHG emissions that will be avoided once the plants guaranteed by the program begging operating. Source: IDB estimations made using UPME methodology, based on installed capacity (see indicator above), load factor, production, and the conversion factor for electricity generation in Colombia measured at the moment by UPME. tCO_{2e} = Tons of CO_2 equivalent
Additional financing from third parties mobilized to complete geothermal projects financed at some stage by the program compared to financing raised by non-beneficiaries	Millions of USD	Twice, baseline and end of execution period	Additional third-party direct finance leveraged by the program beneficiaries compared program non-beneficiaries. Includes all financing from sources other than the CTF funding (government, Bancóldex and other financial institutions). The comparison group will be identified from the projects that applied but were not approved for the guarantees. Interviews will be conducted in order to monitor this indicator on the comparison group. Source: Program report from Bancóldex.
IMPACTS			

Greenhouse gases emissions in Colombia's electricity sector.	$MtCO_{2e}$	Twice, baseline and end of execution period	UPME projects that greenhouse gases emissions will decrease as more investment is made in clean energy in order to replace highly contaminant technologies. Source: UPME $MtCO_{2e}$ = Millions of tons of CO_2 equivalent
CO2 emissions per on dollar of GDP	Kg CO_2 per 2005 PPP $ of GDP	Twice, baseline and end of execution period	It is expected that the program will contribute to this development indicator by helping reduce the CO2 emissions that are produced by electricity generation. Source: IDB/Bancoldex with information coming from World Bank's development indicators and national accounts.
Contribution of geothermal power to non-conventional energy sources.	%	Twice, baseline and end of execution period	The UPME projects that there will be an installed capacity of 100 MW of geothermal power by 2020, of a total of 977.6 MW of installed capacity of non-conventional power sources Source: UPME
Price of electricity	US$/MWhr	Twice, baseline and end of execution period	It is expected that the price of electricity will decrease as more power is generated from more stable and renewable sources. Source: UPME

D. Evaluation Methodology

3.6 The evaluation will follow an ex-post cost-benefit analysis based on the ex-ante model, but replacing estimates and projections with measured data and measured structural parameters when information availability allows it. It will also rely on additional data gathering activities that will help construct a counterfactual that reflects to the best possible extent the scenario had the project was not developed.

3.7 For the economic analysis, the Net Present Value (NPV) and the Internal Rate of Return (IRR) are calculated for the lifespan of the program (30 years) at a rate of 12%. This requires establishing the costs and benefit flows for the geothermal project and for the counterfactual.

3.8 **Counterfactual.** The counterfactual will be defined as a representative plant with weighted average revenue and costs from the most representative generating technologies in Colombia. The weights will be equal to the share of participation of each predominant technology (hydroelectric, thermoelectric-gas and thermoelectric-coal) in Colombia's energy matrix. The weights, as well as sales and costs data used for the analysis should be updated yearly in order to account for the evolution of the counterfactual during the ten years of execution. From year ten onwards, projected values for the main variables will be used.

3.9 The measured values of the counterfactual will be contrasted with information that will be gathered from interviews with energy authorities from MME and UPME as well as from field experts, private investors and intermediary financial institutions. This additional data gathering effort will have the objective of accounting for possible differences between the measured data and their possible values had the geothermal project was not developed. Information on Colombia's energy matrix, energy investment costs and times, O&M costs and electricity prices will be contrasted.

3.10 Hence, the analysis will be based on the following calculations:

a. Technology Parameters

i. Geothermal capacity

The actual geothermal installed capacity of the plant shall be used for the analysis. If the plant is not operating by the end of the monitoring timeframe, the most up-to-date estimation of its capacity should be used. The installed capacity of the counterfactual plant shall mirror the capacity of the geothermal plant. This should be validated with information coming from interviews regarding a possible value had the project was not implemented.

ii. Load capacity

The actual load capacity of the geothermal plant shall be used for the analysis. If the plant is not operating by the end of the monitoring timeframe, the most up-to-date estimation should be used. For the counterfactual, the most updated value for load capacities for Colombia should be used.

iii. Distribution of current technologies sources.

The share for hydroelectric, thermoelectric-gas, thermoelectric-coal (and other technology in case it becomes a non-negligible participant in the energy matrix) should be calculated for each year of the operation in order to use them as the weights for the construction of the counterfactual. This should be validated with information coming from interviews regarding possible values for the shares had the project was not implemented. After the tenth year, a projection of these shares shall be used.

b. Benefits

i. Sales of electricity.

For the geothermal plant, in the scenario when it begins its operation during the timeframe for monitoring, their annual electricity sales should be used for the analysis. After the tenth year, a projection should be used, taking into account the projected electricity inflation.

For the counterfactual scenario, the sales of the representative plant can be calculated using the most current data on load factors and price of electricity (see below for details about price data) for each technology for each year. This should be validated with information coming from interviews regarding a possible value had the project was not implemented. After the tenth year, a projection of these values should be used.

ii. CO_{2e} emissions avoided

To calculate the greenhouse gases emissions reduced (number of metric tons of CO_2 equivalent emissions averted) by the geothermal plant, estimations will be made using the average emissions factor for electricity in Colombia (0.186 tCO_2/MWh) and the load factor for the geothermal plant. The average emissions factor for electricity in Colombia will be validated yearly, if updated information is available.

c. Costs

i. Investment Costs.

For the geothermal project, data of the annual progress reports and any information relating to investments made during the program will be used, distinguishing between CTF and third-party financing. For the counterfactual, updated data on investment costs (USD per installed MW) for current power generation technologies in Colombia should be used, if available. This should be validated with information coming from interviews regarding possible costs had the project was not developed.

ii. O&M Costs

For the geothermal project, the O&M costs (measured in USD/MWh or USD/MW installed) should be calculated as follows: (i) If the geothermal plant starts operating before the end of the timeframe for monitoring, the O&M costs should be calculated using real operational data and then projected for the remaining of the expected life of the plant. (ii) If the plant does not start operating before the end of the timeframe for monitoring, O&M costs should be calculated as a projection based on the most recent estimates for these costs in Colombia, if available. Colombia's projected inflation rate should be taken into account for this calculation.

For the counterfactual plant, updated O&M costs data for current power generation technologies in Colombia should be used, if available. This should be validated with information coming from interviews regarding possible values of costs had the project was not implemented. After the tenth year, projected series of costs based on the data previously obtained should be used.

iii. Price of electricity

The annual average price of electricity sold by power plants[3] should be collected in order to use it for sales calculations. This should be validated with information coming from interviews regarding possible price trends had the project was not implemented. After the tenth year, a projection of its evolution should be used.

iv. Inflation rate for Colombia

After the tenth year, a projection of Colombia's inflation rate should be used to calculate projected O&M costs for the plants.

d. Net present value and economic return

The Net Present Value (NPV) of the overall program will be calculated as follows[4]: First, the NPV of the geothermal plant will be calculated by discounting the flows of net benefits. These are calculated by subtracting the recorded and projected total costs from the recorded and projected benefits (sales of electricity plus CO_2 emissions avoided).

Second, the NPV of the counterfactual plant will be calculated by discounting the flow of net benefits. These are calculated by subtracting the total costs from the energy sales, for each year recorded, plus the remaining projected values.

Finally, the programs NPV will be the difference between the NPV of the geothermal and the NPV of the counterfactual scenario. The internal rate of return (IRR) will be calculated based on the programs NPV.

3.11 This method is appropriate because: (i) there is a small population of companies/developers in the sector, and (ii) the availability of outcome indicators is very high.

3.12 It will be the responsibility of the Bank, through its Division of Capital Markets and Financial Institutions (IFD/CMF) and Climate Change and Sustainability (INE/CCS), to supervise the execution of the ex post cost-benefit analysis from the data collected in accordance with the plan proposed. It is expected that the information needed to make such an evaluation will be available from national sources as indicated in Table 3.1 and from the final report produced by Bancóldex and included in the monitoring activities.

3.13 **Treatment and control groups.** The selected methodology does not require the assignment of treatment and control groups. However a counter factual scenario is constructed to compare the outcomes of the geothermal project taking care of contrasting the measured data with information of possible values had the project was not implemented

3.14 **Data collection.** Bancóldex will collect the necessary data from the information sources as indicated in Table 3.1, and by submitting annual reports to the IDB.

[3] Translated as *precio bolsa* in Spanish.
[4] For an illustration of this procedure, see the Economic Analysis Annex.

Information systems and existing databases in Bancóldex and UPME are considered sufficient to monitor the proposed indicators.

3.15 Bancóldex makes systematic field visits to monitor the risk and monitor their financing programs. Supervision visits are also carried out by Bank's staff members, an activity that is included in this monitoring and evaluation plan.

E. Technical Aspects of Selected Methodology

3.16 The execution of an ex-post cost benefit analysis is highly dependent to the data collection of indicators set out in the monitoring work plan. For the methodology to be effective it is very important to have the information gathered for the monitoring indicators concerning the results matrix (see Table 3.1).

F. Reporting Evaluation Results

3.17 Bancóldex will report to IDB through annual reports on the defined indicators and in the detailed performance of the program. Based on the conclusions of these reports, Bancóldex and IDB could introduce adjustments to the program. The executing agency will deliver the reports within 60 calendar days after the end of each year of the program's implementation. The reports will include information regarding the evolution of the evaluation indicators as well as any other information considered relevant to the performance of the program. The Bank will be entitled to request additional information, if necessary.

G. Complementary Evaluation (Optional)

3.18 Besides the annual reports and the scheduled contacts for monitoring of the operations carried out under the program, Bancóldex and the Bank will conduct a midterm evaluation within 36 months from the date of the first disbursement of financing. The evaluation will assess progress in accomplishing program objectives and outcomes based on the Results Matrix, in order to identify any corrective action required.

3.19 An extended project monitoring report (XPMR) and a Project Completion Report (PCR) have been planned, to be carried out six months after the disbursement conditions for the last operation under the program have been met. The PCR will evaluate the fulfillment of targets and review the results of the operation. The assumptions in the Results Matrix will be taken into consideration as well as the methodology explained in this document.

H. Evaluation Coordination, Work Plan and Budget

3.20 Bancóldex will be responsible for the supervision, technical and administrative coordination of the program and perform the necessary reporting duties to the Bank.

3.21 For the implementation of this assessment, it is expected that Bancóldex will use its own staff, with the supervision of the IDB, which are considered adequate and sufficient to ensure the quality and success of the evaluation work. For activities that require additional expertise, consultancy services may be hired by Bancóldex or the IDB (see Table 3.2).

3.22 Bancóldex and the IDB will conduct a midterm evaluation within 36 months from the date of the first disbursement of financing. The evaluation will assess progress in accomplishing program objectives and outcomes based on the Results Matrix in order to identify any corrective action required. Periodical monitoring meetings are also scheduled. The executing agency will provide the information necessary for the Bank to conduct a Project Completion Report (PCR), to be carried out six months after the disbursement conditions for the last operation of the program have been met.

3.23 The Bank, through its Division of IFD/CMF and INE/CCS, with support from the Office of Strategic Planning and Development Effectiveness (SPD), will collaborate with Bancóldex in any aspects required and requested. The Bank may provide technical and financial support to carry out the activities of specialized analysis on the economic assessment.

3.24 The costs of the activities listed in this plan will be financed by the supervision budget included in the CTF funding and/or with transactional budget of the CMF division. Its completion is expected by the end of the execution period of the program (see details in Table 3.2). Bancóldex and the IDB have the structure and resources to ensure compliance with the tasks and commitments in this assessment plan. Any further evaluation with more specific purposes or seeking to determine externalities resulting from the execution of the program may be carried out if considered relevant, but will not be incorporated as part of this Monitoring and Evaluation Plan.

Table 3.2 Evaluation Working Plan

Activities	Year 1		Year 2		Year 3		…		Year 9		Year 10		Respon-sible	Budget (USD)
	I	II	I	II	I	II	I	II	I	II	I	II		
Collection of data for outcome indicators														**25,000**
• **Installed capacity of geothermal power of projects guaranteed by the program.**												X	Bancóldex	5,000
• **Geothermal power generation by projects guaranteed by the program.**												X	Bancóldex	5,000
• **Greenhouse gases emissions avoided through the use of geothermal energy of projects guaranteed by the program.**												X	IDB	5,000
• **Additional financing raised by the projects guaranteed by the program.**		X		X		X		X		X		X	Bancóldex / IDB	10,000
Data Projections and Analysis												X	Consul-tant	**15,000**
Final Evaluation: Cost-Benefit Analysis												X	(Consul-tant/Firm)	**20,000**
Distribution and discussion of the report												X	Bancóldex / IDB	**5,000**
											Total			**65,000**

DOCUMENT OF THE INTER-AMERICAN DEVELOPMENT BANK

COLOMBIA

INVESTMENT GRANT FOR THE FINANCING AND RISK TRANSFER PROGRAM FOR GEOTHERMAL POWER

(CO-G1007)

ECONOMIC ANALYSIS ANNEX

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I. INTRODUCTION

1.1 In the current context of global climate change, governments in emerging economies have to face the important challenge of responding to increasing demands for energy while maximizing their system's supply reliability, efficiency and sustainability. Investments in power generation from clean sources play a big role in this process, contributing to diversifying the countries' energy matrixes and mitigating the negative environmental impacts of conventional power technologies.

1.2 In Colombia, currently 70% of its electricity installed capacity is based on hydroelectric power, 29% comes from natural gas and coal and less than 1% from renewable sources. The country's energy system has been experiencing reductions in hydroelectric generation since 2011, associated with declining contributions of this source (leading to higher contributions from gas and coal, to compensate for these deficits) and uncertainty about the occurrence of El Niño and the need to manage water resource with caution. Thus, even when the current contribution of Colombia to the Global greenhouse Gas (GHG) emissions may not appear significant (0,4% of total global emissions), its energy system's high dependency in the hydroelectric generation makes it especially vulnerable to extreme hydrologic conditions (such as the ones occurred in 1991-1992 and 1997-1998) and, in particular, to the El Niño. Moreover, if hydroelectric contributions to the system continue to be below average, the use of fossil fuels to cover for these deficits will continue to increase, impacting the level of emissions in the long term.

1.3 According to a study carried out by UPME[1], the potential for greenhouse gases (GHG) emissions abatement through clean energy generation by 2021 is 3.17 million of tCO2e in Colombia. It also projects that by 2020 there will be 977.6 MW of installed capacity of non-conventional renewable power sources. However, despite the countries potential for the use of clean power sources, most of it still remains untapped.

1.4 The strategy of the government and the energy planning authorities is to progressively substitute thermal energy generation sources for other energy generation technologies with two main characteristics: (i) a high load factor that can function as a base load providing security to the system; (ii) clean energy production; (iii) lower levelized costs. Geothermal energy meets these three criteria.

1.5 Geothermal energy offers one of the most effective renewable and low carbon alternatives for electricity generation, opening up the possibility of increasing the share of clean sources in Colombia's energy matrix. Furthermore, the role of geothermal power goes beyond its environmental contribution because it can produce significant economic and social benefits.

[1] Unidad de Planeación Minero Energética (UPME) (2015). *Plan de Expansión de Referencia Generación – Transmisión 2014-2028*

1.6 The objective of the program is to kick start power production from geothermal sources in Colombia as well as to contribute to the diversification of the energy matrix and reduce dependency on gas and coal as backup sources of power in case of insufficient hydroelectric generation. To this end, the program intends to promote investments in geothermal power generation projects by providing guarantees that seek to reduce the risk associated with this type of investments.

II. ASSUMPTIONS AND METHODOLOGY

A. Methodology

2.1 Evidence of the economic viability of the proposed program is presented below, based on: (i) a cost-effectiveness analysis of the proposed intervention; and (ii) a cost-benefit analysis focused on the objective of the program, namely, the increase in geothermal energy production, valued by reduction in greenhouse gases emissions.

2.2 The economic analysis for the proposed intervention presents two main results:

i. A cost-effectiveness ratio, comparing the total investment of the program per CO2 unit abated to other types of electricity generation in Colombia.

ii. A value of the net benefits obtained by comparing the benefits of investing in geothermal plants against the benefits of investing in a similar capacity plant representative of the actual energy matrix in Colombia. These benefits are measured during a period of 30 years, which is the estimated lifetime of projects financed by the program) and discounted at a rate of 12%.

2.3 The basic information to estimate the costs and benefits of the program includes:

i. **Classification of benefits**. The information for calculating the benefits of the program come from the power generation capacity of the project, the projected price of electricity and the contribution of geothermal plants to the reduction of GHG emissions. The Results Matrix outlines the indicators and the means to verify their performance. Based on these targets, the benefits considered consist of[2] :

i. The sales of electricity by the geothermal plants. This is estimated using the planned installed capacity, the estimated load factor for the projects and the average projected price of electricity for the life of the plant.

ii. The value of expected GHG emissions reduced (number of metric tons of CO2 equivalent emissions averted) by the plants financed by the program. For this calculation we use information of the emissions factor for Colombia, planned electricity generation and estimated price for CO2.

[2] For more detail on the calculations see Section III: *Economic Benefits and Costs*

ii. **Classification of costs.** The basic information for estimating the costs of the program comes from the financial terms of the overall resources to be disbursed for the program, and the operation and management costs (O&M) of the project. Hence, the costs consist of :

i. *Investment cost***,** which consist of (i) The Clean Technology Fund (CTF) investment grant for US$10 million[3]; (ii) the expected US$190 million in financing raised by private developers in order to start operating the geothermal plant.

ii. *O&M costs.* These are the annual costs incurred by the plants for operations and management expenses. This information is obtained from estimations made by studies for Colombia energy sector.

iii. **Costs and benefits in the counterfactual**. To evaluate an alternative scenario to the project, we consider the costs and benefits of developing a similar capacity plant that is representative of the actual technologies used in Colombia's power generation. The benefits are calculated as electricity sales and the cost consists of investment costs and O&M costs.

2.4 The cash flows of annual benefits and costs, as detailed above for both the project and the counterfactual, are then discounted at a rate of 12% (standard for IDB programs) in order to obtain their Net Present Value (NPV). The difference between both NPVs will be the program's NPV.

2.5 Finally, this document includes a sensitivity analysis. This analysis is performed considering independent variations in three criteria: (i) load capacity factor[4] of geothermal plants, (ii) load capacity factor of counterfactual technologies, (iii) investment costs for geothermal plants, (iv) development time of geothermal plants, and (v) electricity price. Furthermore, simultaneous variations of some characteristics are evaluated.

B. Assumptions

2.6 The main assumptions for the estimation of benefits and costs of this project are:

Geothermal Energy Assumptions

i. **Geothermal potential**. Colombia is yet to have a geothermal plant installed in the country. However, the government projects that by 2025 there will be 375 MW of geothermal capacity installed in the country[5]. The program is expected to finance projects that will contribute with the first 50 MW in

[3] CTF amounts used may vary from the ones indicated in the POD, as those incorporate deductions due to MDB fees. Possible differences are considered to be marginal and irrelevant with regards to this analysis.
[4] See the definition of the concept in assumption (iv).
[5] Unidad de Planeación Minero Energética (UPME) (2015). *Plan de Expansión de Referencia Generación – Transmisión 2014-2028*

Colombia. This is in line with estimations made for the prospective geothermal plant in the country[6].

ii. **Number of geothermal projects and plants**. It is estimated that the program will provide guarantees for the earliest development stages (drilling stages) of two geothermal projects. However, given the 50% percent success rate[7] for this stage, it is expected that one project will proceed to the next stages of development while the other will not be successful in finding the geothermal resources. Hence, the expected value of plants that will be finally constructed is one. For this reason, we will conduct the analysis considering one plant of 50 MW of installed capacity as a final outcome of the program.

iii. **Stages of Development and Calendar**. The development of a geothermal power plant can be divided into four stages: Exploration, Confirmation and Drilling, and Development[8]. The construction of the plant can go from five to nine years[9]. For the purpose of this analysis, we assume that the plant will begin to operate in the seventh year of the project.

iv. **Load Capacity Factor**. The load capacity factor of a power plant is the ratio of its actual output over a period of time, to its potential output if it were possible for it to operate at full nameplate capacity indefinitely. This factor can vary depending of the design of the plant and fuel that powers it. Geothermal plants are powered by underground heat that is produced by the Earth's core. This represents a continuous and stable source of energy that allows the plant to operate around the clock for decades regardless of weather or other climatic phenomena, hence yielding a very high load capacity. We assume a 95% load capacity for a 50 MW geothermal plant following the information reported in ESMAP's Geothermal Handbook[10].

Other Energy Sources Assumptions

v. **Distribution of current energy sources.** By October 2014, the total installed capacity of the power sector in Colombia was 15,478 MW. Table 2.1 illustrates the distribution of electricity generation in Colombia based on the type of power plant.

Table 2.1 Distribution of Electricity Generation in Colombia by Type of Power Plant

	Hydroelectric	Thermoelectric-Gas	Thermoelectric-Coal	Others
MW	10,772.69	3,909.74	701.15	94.42
Percentage	69.6%	25.26%	4.53%	0.61%

Source: UPME[11]

[6] UPME (2015). *Integración de las Energías Renovables no Convencionales en Colombia.*
Fedesarrollo (2013). *Análisis Costo-Beneficio de Energías Renovables no Convencionales en Colombia.*
[7] UPME (2015). Op.cit.
[8] Ibid.
[9] ESMAP (2012). *Geothermal Handbook: Planning and Financing Power Generation.*
[10] Ibid.
[11] UPME (2015). *Plan de Expansión de Referencia Generación – Transmisión 2014-2028*

Given that the other types of power plant account for less than 1%, we will not consider them in the cost benefit analysis for the sake of simplification. Hence, we will work with the assumption that hydroelectric plants account for 70% of installed capacity, thermoelectric-gas plants account for 25% and thermoelectric-coal plants account for 5%.

vi. **Stages of Development and Calendar**. Following the estimations of Fedesarrollo[12], and considering a target capacity of 50 MW, we will assume that the estimated time of construction for hydroelectric plants is three years, for thermoelectric-gas plants one year and for thermoelectric-coal plants two years.

vii. **Load Capacity**. Following the estimations made by International Renewable Energy Agency (IRENA)[13] we assume that the load capacity for the hydroelectric plant is 50%. For the thermoelectric-gas plant we assume a factor of 40%, following the estimates for combustion turbine and combined cycle plants made by ESMAP[14]. Finally, we assume a 36% factor for coal fueled thermoelectric plants following the estimation made by UPME[15].

Table 2.2 Load Capacity Factors for Types of Power Plants

Geothermal	Hydroelectric	Thermoelectric-Gas	Thermoelectric-Coal
95%	50%	40%	36%

Source: Fedesarrollo (2013), IRENA (2015), ESMAP (2012), UPME (2005)

Cost Assumptions

viii. **Investment Costs**. For the geothermal plant, we use the estimated cost of USD 4 million per installed MW, following the calculations of the Energy Sector Management Assistant Program[16]. For the hydroelectric plant, we assume an investment cost of US$2 million per MW following the estimates of IRENA. For the thermoelectric-gas plant we assume an investment cost of US$1.05 million per MW[17] and for the thermoelectric-coal we assume US$1.46 million per MW[18].

ix. **Operation and Management Costs**. The geothermal plant in Colombia is expected to have a US$7.98/MWhr operational cost[19]. Meanwhile the yearly O&M cost for a 50 MW hydroelectric plant in Colombia is assumed to be

[12] Fedesarrollo (2013). Op. cit.
[13] IRENA (2015). *Renewable Power Generation Costs in 2014*
[14] ESMAP (2012). Op. cit.
[15] UPME (2005). *Costos Indicativos de Generación Eléctrica en Colombia*.
[16] ESMAP (2012). Op. cit.
[17] Fedesarrollo (2013). Op. cit.
[18] UPME (2005). Op. cit.
[19] Fedesarrollo (2013). Op. cit.

44,972.1 USD per MW installed based on the costs reported by UPME[20], which also calculates a yearly cost of US$380,738 per MW installed for thermoelectric-gas plants and US$6.9/MWhr plus US$88,276/MW for thermoelectric-coal plants. Table 2.3 resumes these assumptions and presents the estimates for a 50 MW plant that will be used for the cost-benefit analysis.

Table 2.3 Cost Assumptions for Power Plants

	Geothermal	Hydroelectric	Thermoelectric-Gas	Thermoelectric-Coal
Investment Cost (MUSD/MW)	4	2	1.05	1.46
Investment Cost for a 50 MW plant (USD million)	200	100	52.47	73.25
O&M Costs for a 50 MW plant (USD million)	3.32	2.47	19.04	5.5

Source: Fedesarrollo (2013), IRENA (2015), ESMAP (2012), UPME (2005)

x. **Price of electricity**. We assume a price of electricity of US$90/MWhr for the first year, and then an annual inflation rate of 1.78% for the life of the project based on the projections for this period made by UPME[21].

xi. **Inflation rate for Colombia**. Based on projections for Colombia[22], we assume an annual inflation rate of 4% for the life of the project. This inflation is applied to the O&M costs for the remaining years of the project.

Assumptions Regarding CO_2 Emissions

xii. **Emissions factor for Colombia Electricity Sector.** We follow UPME (2015) by using the estimated 0.186 tCO_{2e} per MW/hr emissions factor for Colombia. As a conservative measure, we chose this over the 0.2 tCO_{2e} per MW/hr used by Fedesarrollo (2013). It is worth noting that this emission factor is low when compared to other countries like Mexico (0.5 tCO2e/Wh). The reason for this is the high contribution of hydroelectric power in Colombia, which has a low emission factor. However, as it is mentioned in the introduction, there are important reasons for Colombia to search for alternatives to hydroelectric generation.

xiii. **Price of CO_2 Emissions.** We follow the carbon pricing used by Ministry of Mines and Energy of Colombia to calculate the value of the CO_2 emissions averted by generating electricity through a geothermal plant[23]. They follow the estimates of the UK Department of Energy and Climate Change[24] that account for the traded and non-traded value of carbon dioxide emissions in order to estimate the real cost that should be internalized in order to account

[20] UPME (2005). Op. cit. In addition, there is a variable cost equal to 0.6% of electricity sales and US$0.42/MWhr. These costs are also included in the estimation of total O&M cost for a 50 MW plant.
[21] UPME (2005). Op. cit.
[22] Trading Economics (2015). Colombian Inflation Rate Forecast
[23] UMPE (2015). Op. cit.
[24] DEEC (2014). *Valuation of energy use and greenhouse gas (GHG) emissions.*

for the externalities on climate change. Hence, the calculated economic value of the CO_2 emissions averted by geothermal plants is 19 USD/MWh (UPME (2015)), which gives a CO_2 price of US$102/t$CO_{2e}$.

Assumptions regarding the implementation of the program

xiv. **Disbursement of funds**. We assume that the disbursement of the investment will be evenly divided during the first six years of the project, until the plant begins to operate.

xv. **Life of geothermal plant**. The timespan to analyze the benefits will be 30 years, which is a conservative estimate of the life of a geothermal plant. It is worth noting that the life of the other plants is less in average than the life of a geothermal plant, but we ignore this in our analysis to make it more conservative.

xvi. **Macroeconomic Framework**. For the benefits estimated in this analysis to be accomplished, it is assumed that the economy of the country will keep a framework that ensures appropriate conditions for consumption and investment, both public and private.

Additional General Assumptions

xvii. **Additional benefits from geothermal plants.** As a conservative measure, we are not including in our analysis additional social and economic benefits of a geothermal plant calculated by UPME (2015) for Colombia. This positive externalities include employment, economic value, savings in fossil fuels, health and biodiversity impacts. These are summarized in Table 2.4:

Table 2.4 Values of Additional Positive Externalities for Geothermal Generation in Colombia

Externality	2014 USD/ MWh
Employment	0.28
Economic value	9.28
Fossil fuels savings	7.15
Health	0.83
Biodiversity	0.05
Total	**17.59**

Source: UPME (2015)

xviii. **CO_2 emissions in the counterfactual.** Since this analysis uses the social viewpoint for the consideration of benefits and cost of the program, the emissions externalities of the counterfactual should also be taken into account. Hence, for each MW/h generated by the counterfactual scenario, CO2 emissions should be calculated using the 0.186 tCO_{2e}/MWh emissions factor for Colombia and added to the counterfactual costs. However, as a conservative measure, we are not accounting for negative externalities in the counterfactual.

III. RESULTS OF THE ANALYSIS

A. Cost-Effectiveness Analysis

3.1 Table 3.1 below presents the results of the cost-effectiveness analysis. It is expected that the geothermal plants financed by the program, once fully operative, will deliver an annual average production of 416,100 MWh and 2.3 MMT of CO2 emissions reductions over the 30 years of life of the project.

3.2 Power generation is calculated applying the assumed load capacity for geothermal plants in Colombia. Emissions are calculated using the assumed emissions factor of 0.186 tCO_{2e}/MWh.

3.3 Hence, the unit abatement cost is US$4.31 per tCO_2 considering total CTF investment and US$86.14 when the total project investment costs are considered.

Table 3.1 Results of Cost-Effectiveness Analysis

Electricity Generation		**Investment Costs (USD million)**	
MW installed	50	**Total Program Investment**	200
Total Investment per MW installed (MUSD)	4.0	**CTF Investment**	10
Annual Generation (MWh)	416,100	**Private Investment**	190
Annual CO_2 emissions averted (tCO_2)			**77,394.6**
Total CO_2 emissions averted 30 years (tCO_2)			**2,321,838**
CTF cost per emission averted (USD/tCO_2)			**4.31**
Total investment per emission averted (USD/tCO_2)			**86.14**

3.4 Both measures of abatement costs are below the maximum established by the CTF, which is US$200/$tCO_2$. Following these criteria, the project is efficient in terms of maximizing environmental impact in a context of limited resources.

B. Cost-Benefit Analysis

3.5 **Definition of the counterfactual.** Since one the aims of the project is to finance the development of a 50MW geothermal plant that contributes to the stability of the electric system (now affected by climate factors as El Niño), instead of recurring to current contaminant technologies, we assume a counterfactual that could represent an alternative to this investment. We define the counterfactual as

an investment project in a 50 MW plant representative of the main energy sources in Colombia (hydroelectric, gas plants, coal plants). For the construction of this representative plant, we calculate the benefits and costs for 50 MW hydroelectric, thermoelectric-gas and thermoelectric-coal plants. Then we average those benefits and costs weighting them by the participation of each technology in Colombia's power generation. (See assumption (v) for the weights). We also average the time of construction for each plant. This implies that our counterfactual project will begin operating in the third year of the project.

Economic Benefits

3.6 **Benefits for geothermal project.** For the geothermal plant we calculate the following benefits:

i. *Sales of electricity*. The sales of electricity for a given year t is calculated by multiplying the MWh generated in that year by the average price of electricity.

ii. *Value of CO2 emissions averted*. The number of tons of CO2 emissions averted by the use of geothermal power is calculated by multiplying the emissions factor for Colombia by the total MWh generated in one year and by the price of carbon emissions assumed.

The global benefits will be the sum of the benefits described above.

3.7 **Benefits for counterfactual project.** For the counterfactual project we calculate the benefits as the weighted average of annual sales of the hydroelectric, thermoelectric-gas, thermoelectric-coal plants of 50MW each. The weights for each plant are equal to the share of the correspondent technology in Colombia's national installed capacity.

Economic Costs

3.8 **Costs for the geothermal project.** For the geothermal project, we calculate the following costs:

i. *Investment Cost.* The investment cost is US$200 million, which consist of US$10 million from CTF grant and US$190 million expected to be raised from the private sector. We assume that the investment is evenly disbursed in the six years prior to the beginning of operations of the plant.

ii. *O&M Costs.* This cost is calculated by multiplying the assumed US$7.09/MWh O&M unit cost by the annual power generation.

3.9 **Costs for the counterfactual project.** For the counterfactual project we calculate the following costs:

i. *Investment Costs***.** It is calculated as the weighted average of the required investment for developing three 50 MW plants (hydroelectric, thermoelectric-gas, thermoelectric coal). Each of this investment is calculated using the investment cost assumed for each type of plant (See Table 2.3). The weights for each plant are equal to the share of the correspondent technology in Colombia's national installed capacity (assumption (v)). We assume that the investment is evenly disbursed in the two years previous to the beginning of operations of the representative plant.

ii. *O&M Costs.* This cost is calculated as the weighted average of the annual O&M Costs for three 50 MW plants (hydroelectric, thermoelectric-gas, thermoelectric coal). The individual O&M Costs for each plant are the assumed for this analysis (See table 2.3). The weights for each plant are equal to the share of the correspondent technology in Colombia's national installed capacity.

C. Economic Returns

3.10 **Net Present Value**. Based on the calculations of costs and benefits detailed above, the difference between net benefits from the geothermal project and the counterfactual, discounted at a rate of 12%, produce a net present value (NPV) for the program of US$45.54 million. A detailed chart with the calculations is annexed at the end of this document.

3.11 **Internal Rate of Return**. The project has in internal rate of return (IRR) of 17%.

Table 3.2 Summary of Benefits and Costs Analysis

NPV per concept	(MUS$)
Geothermal project	
Electricity Sales	185.61
Total CO2 reductions	31.18
Total costs	(159.16)
Geothermal NPV	**57.63**
Counterfactual Project	
Electricity Sales	149.23
Total Costs	(137.14)
Counterfactual NPV	**12.09**
Program NPV	**45.54**
Program TIR	**17%**

3.12 As it can be seen, the high load factor (95%) compared to the other technologies yields a higher NPV for electricity sales, since it can effectively generate more MWh per MW installed. On the other hand, the high investment costs for geothermal plants yields a higher NPV cost compared with the counterfactual. However, the NPV of CO2 emissions averted leads to a positive NPV for the program.

3.13 It is worth mentioning that the program's NPV is likely to be higher if we take into account the other positives externalities generated by the geothermal project reported in Table 2.4, and the negative GHG-related externalities associated with the counterfactual. We have omitted both as a conservative measure.

3.14 It is also important to mention that, in addition to the benefits considered in this analysis, the project is expected to have a substantial demonstration effect on the private sector investors and developers.

IV. SENSITIVITY ANALYSIS

4.1 Complementary to these results, a sensitivity analysis is included in this section, where variations on key parameters (load factor, as a proxy to total production/capacity installed, O&M cost of other renewable technologies, and price of electricity) are simulated to gauge their impact on the benefits. In other words, values are stressed in order to verify the tolerance of the program to variations on the conditions that may have an impact on the results established above.

4.2 The parameters that were changed for the sensitivity analysis and each of their breakeven values (minimum values for the program to remain viable, based on the analysis of the program NPV, discounting flows at a 12% rate), are shown in the table below. Hence, the program would become unviable only if the values of any of these variables, independently, were equal to or less than the figures indicated below.

Table 4.1: Summary of Sensitivity Analysis

Parameter that was changed	Value Used for Economic Returns Estimations	New Value for Sensitivity Analysis	NPV with the new value (MUSD)	Variation in parameter (%)
Load Factor for Geothermal Plants	95%	72.775%	0	**-23.4%**
Load Factor for counterfactual technologies	Hydroelectric (55%) Gas Plants (40%) Coal Plants (36%)	Hydroelectric (72%) Gas Plants (52%) Coal Plants (47%)	0	**31%**[25]
Investment Cost for Geothermal Plants	4 USDM/MW	5.329 USD/MW	0	**33.23%**
Price of Electricity (USD/MWh)	90 USD/MWh	62.057 USD/MWh	0[26]	**-31.05%**

[25] With the new simulated load factors, the energy sales and costs are weighted using the share of each technology in the energy matrix.

[26] In this case we look at the NPV of the geothermal plant only and not the NPV of the overall program, including the counterfactual. The reason for this is that a drop in the price will affect the counterfactual project in a more severe way, making the geothermal plant to be *less* worse that its alternative, thus making the overall NPV always positive, even if both individual NPVs are negative.

Beginning of operations of geothermal plant	7th year	10th year	8.37	**42%**
(i) **Load Factor for Geothermal Plants** **(ii) Investment Cost for Geothermal Plants** **(iii) Price of Electricity (USD/MWh)** **(iv) Beginning of operations of geothermal plant**	(i) 95% (ii) 4 USDM/MW (iii) 90 USD/MWh (iv) 7th year	(i) 90% (ii) 4.4 (iii) 81 USD/MWh (iv) 10th year	-8.65 10.26 (with additional positive externalities[27])	**(i) -5% points** **(ii) 10%** **(iii) -10%** **(v) 42%**

4.3 The analysis highlights the importance of three of the main characteristics of geothermal plants. On one hand, the high load factor guarantees a high efficiency in the generation of electricity, which compensates for the high investment costs at the time of calculating the net benefits. That is why a drop bigger than 23.4% would make the project unviable. On the other hand, the NPV is sensitive to increases in the investment cost of geothermal plants. We see that an increase bigger than 33.23% in the investment cost per MW installed would make the project unviable. Finally, if the development of the plant is delayed so that it begins to operate in the tenth year, the NPV of the program decreases to 8.37. This speaks to the importance of international efforts aimed to ease the investment costs barriers for early stages of development of this technology in countries like Colombia. It also highlights the importance of considering the social-environmental benefits of geothermal energy at the time of valuating this type of investment.

4.4 On the other hand, we observe that an increase in 31% on the load capacity of the counterfactual technologies gives a NPV of zero. This is because the relative low cost of hydroelectric plants, which has an important share in Colombia's energy matrix. However the analysis does not consider the production risk associated with meteorological phenomena, which is one of the reasons for looking for alternative renewable energy sources other than hydroelectric. We also see that a drop bigger that 31% of the price of electricity will render a zero-value NPV for the geothermal plant. It is important to mention that this drop would have an even bigger effect on the counterfactual scenario, given the low efficiency rates of the other technologies, thus making geothermal projects more resistant to price drops in the long run (see footnote).

4.5 Finally, a scenario with simultaneous variations is tested. We observe, that a negative NPV is obtained when we consider at the same time, a delay of three

[27] See Table 2.4

years in the beginning of operations, a 5% point decrease in geothermal load factor, a 10% decrease in the price of electricity and a 10% increase in the investment cost per MW installed. However, if we introduce in the model the additional positive externalities that were ignored in the base scenario (Table 2.4) the program still achieve a positive NPV of USD 10.26 million.

V. CONCLUSIONS

5.1 The cost benefit analysis shows how the discounted net benefits of the geothermal project are greater than the discounted net benefits of the counterfactual scenario, thus resulting in a positive Program Net Present Value (NPV).

5.2 With regards to the benefits of the geothermal plant, the NPV of CO_2 emissions averted is equal to US$31.18 million. The monetary net benefits of the geothermic plant are estimated on USD 57.63 million. Since, the NVP of the counterfactual scenario is USD 12.09 million, the overall NPV of the Program is estimated in US$45.54 million, which yields a 17% IRR. In addition, the sensitivity analysis shows the importance of the high load factor of geothermal plants and the sensitivity to the investment costs and development times. It also highlights the importance of the high load capacity of geothermal plants in making the investments on them more resistant to electricity price drops in the long run.

5.3 There are relevant factors that were not considered for calculations for this analysis, which has likely underestimated the real benefits of the program. The analysis shows that when additional positives externalities are considered, the program remains viable even when simultaneous negative shocks are considered.

5.4 In general, the project team has used plausible and contrasted assumptions, with aims of a conservative approach for the analysis. Based on this, the project team recommends the Bank to approve the financing of this program.

ANNEX 1. DETAILED ANNUAL CASH FLOWS – COST-BENEFIT ANALYSIS

Geothermal Project	Y1	Y2	Y3	Y4	Y5	Y6	Y7	Y8	Y9	Y10	Y11	Y12	Y13	…	Y26	Y27	Y28	Y29	Y30
Benefits																			
Electricity Sales	0.00	0.00	0.00	0.00	0.00	0.00	41.63	42.37	43.13	43.89	44.68	45.47	46.28	…	58.21	59.25	60.30	61.37	62.47
CO_2 emissions avoided	0.00	0.00	0.00	0.00	0.00	0.00	7.91	7.91	7.91	7.91	7.91	7.91	7.91	…	7.91	7.91	7.91	7.91	7.91
Total Benefits	0.00	0.00	0.00	0.00	0.00	0.00	49.54	50.28	51.03	51.80	52.58	53.38	54.19	…	66.12	67.15	68.21	69.28	70.37
Costs																			
Investment Costs	33.33	33.33	33.33	33.33	33.33	33.33	0.00	0.00	0.00	0.00	0.00	0.00	0.00	…	0.00	0.00	0.00	0.00	0.00
O&M Costs	0.00	0.00	0.00	0.00	0.00	0.00	4.20	4.37	4.54	4.73	4.92	5.11	5.32	…	8.85	9.21	9.57	9.96	10.36
Total Costs	33.33	33.33	33.33	33.33	33.33	33.33	4.20	4.37	4.54	4.73	4.92	5.11	5.32	…	8.85	9.21	9.57	9.96	10.36
Net Benefits	-33.33	-33.33	-33.33	-33.33	-33.33	-33.33	45.34	45.91	46.49	47.07	47.67	48.26	48.87	…	57.26	57.95	58.63	59.32	60.02
Project NPV	**$57.63**																		
Counterfactual	Y1	Y2	Y3	Y4	Y5	Y6	Y7	Y8	Y9	Y10	Y11	Y12	Y13	…	Y26	Y27	Y28	Y29	Y30
Benefits																			
Electricity Sales	0.00	0.00	20.54	20.91	21.28	21.66	22.04	22.43	22.83	23.24	23.65	24.08	24.50	…	30.82	31.37	31.93	32.50	33.07
Costs																			
Investment Costs	43.39	43.39	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	…	0.00	0.00	0.00	0.00	0.00
O&M Costs	0.00	0.00	7.32	7.62	7.92	8.24	8.57	8.91	9.27	9.64	10.02	10.42	10.84	…	18.05	18.77	19.52	20.30	21.11
Total Costs	43.39	43.39	7.32	7.62	7.92	8.24	8.57	8.91	9.27	9.64	10.02	10.42	10.84	…	18.05	18.77	19.52	20.30	21.11
Net Benefits	-43.39	-43.39	13.22	13.29	13.36	13.42	13.48	13.53	13.57	13.60	13.63	13.65	13.66	…	12.77	12.60	12.41	12.19	11.96
Counterfactual NPV	**$12.09**																		
Project - Counterfactual	Y1	Y2	Y3	Y4	Y5	Y6	Y7	Y8	Y9	Y10	Y11	Y12	Y13	…	Y26	Y27	Y28	Y29	Y30
Overall Benefits	10.06	10.06	-46.55	-46.62	-46.69	-46.75	31.86	32.38	32.92	33.47	34.03	34.61	35.20	…	44.49	45.35	46.23	47.13	48.06
Program NPV	**$45.54**																		