

**PAOLO BONA  
GEOTHERMAL CONSULTANT**

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**CTF-IDB Geothermal Development Program**

**CHILE**

**Geothermal Risk Mitigation Program (MiRiG)**

**IDB Private Sector CTF Proposal  
for Submission to the CTF Trust-Fund Committee**

**INDEPENDENT TECHNICAL REVIEW**

Report prepared for  
Inter-American Development Bank  
Climate Change and Sustainability Division  
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## ABBREVIATIONS

CAF	<i>Banco de Desarrollo de América Latina</i>
CO <sub>2</sub>	Carbon Dioxide
CTF	Clean Technology Fund
DFI	Development Finance Institution
DPSP	Dedicated Private Sector Programs
GDP	Gross Domestic Product
GEA	Geothermal Energy Association
GHG	Greenhouse Gas
GoC	Government of Chile
GW	Gigawatt
GRC	Geothermal Resources Council
IDB	Inter-American Development Bank
IGA	International Geothermal Association
IP	Investment Plan
LCOE	Levelized Cost of Energy
M	Millions
MiRiG	Geothermal Risk Mitigation Program
MtCO <sub>2</sub> e / tCO <sub>2</sub> e / tCO <sub>2</sub> e	Metric Megaton / ton, of Carbon Dioxide Equivalent
MW / kW	Megawatt kilowatt
NCRE	Non-conventional Renewable Energy
SIC	<i>Sistema Interconectado Central</i>
SING	<i>Sistema Interconectado del Norte Grande</i>
Tcal	Tera-calories
TFC	Trust Fund Committee
USD	United States of America Dollars

## 1. INTRODUCTION

Since the 2004 natural gas crisis, the Government of Chile (GoC) has been actively promoting the diversification of energy sources. The GoC recently confirmed its compromise with diversified and sustainable energy generation approving a new legislation to increase the percentage of non-conventional renewable energy (NCRE) to 20% of all new contracts by 2025<sup>1</sup>. Chile also encourages clean energy development through total/partial exemption of transmission taxes to small capacity renewable projects (< 20MW).

In Latin America, Chile is the country with the highest estimated potential for geothermal energy development. A specific legislation, issued in early 2000<sup>2</sup>, allows private investment in the geothermal sector and private developers have been increasingly arriving to Chile; however, after 13 years from the issuance of the geothermal law, the resource is still untapped. High risks and elevated costs are challenging private developers, that face barriers to raise risk capital and effectively advance exploration and project development .

The Revised Investment Plan (IP) for Chile of the Clean Technology Fund (CTF)<sup>3</sup> endorsed by the CTF Trust-Fund Committee (TFC) on 9 October 2013, includes a Geothermal Risk Mitigation Program (MiRiG). Furthermore, on 29 October 2013 the CTF TFC endorsed the creation of the Dedicated Private Sector Programs (DPSP), a new window within the CTF, independent of the national IPs, which includes a program specifically focused on the mitigation of geothermal drilling risks, available to countries that already have a CTF IP, including Chile.

Given the availability of these CTF facilities, the IDB, in collaboration with the GoC, has been working on a proposal for a Geothermal Risk Mitigation Program aimed at triggering geothermal development in the country. This proposal combines resources from the CTF IP and DPSP to support private geothermal developers that have already completed some exploratory drilling, but require concessional risk mitigation to advance with additional drilling and plant construction, and before they can access commercial debt financing.

Within this framework, the IDB - Climate Change and Sustainability Division asked the Consultant to perform an independent evaluation regarding CTF Investment Criteria and the robustness of the IDB's MiRiG proposal for Chile to the CTF. In particular, the Consultant is asked to review the CTF-Geothermal Risk Mitigation Program based on compliance with the CTF Investment Criteria for private operations.

The Consultant is an independent geologist, with 28 years of experience in geothermal energy, including technical and financial evaluations in exploration and development projects in several Latin-American countries, including Chile.

## 2. CHILE'S ENERGY SECTOR AND GEOTHERMAL PERSPECTIVES

Chile is one of the leading countries in Latin America in terms of economic development. The Chilean economy is expected to continue expanding in the next years with forecasts of GDP

<sup>1</sup> Ley No. 20.198, del 14 de octubre 2013. Propicia la ampliación de la matriz energética mediante fuentes renovables no convencionales.

<sup>2</sup> Ley No. 19.657, del 7 de enero del 2000. Ley sobre concesiones de energía geotérmica.

<sup>3</sup> [https://www.climateinvestmentfunds.org/cif/sites/climateinvestmentfunds.org/files/CTF\\_IP\\_Revision\\_Chile\\_Sept2013.pdf](https://www.climateinvestmentfunds.org/cif/sites/climateinvestmentfunds.org/files/CTF_IP_Revision_Chile_Sept2013.pdf)

growth rate of 4.7 -5% annually<sup>4</sup>. The mining and energy sectors are expected to expand; the agricultural sector will also continue to grow, supported by its large network of free trade agreements; and the construction sector will consequently expand, dragged by investment in commercial and retail projects.

This situation has been associated with a significant increase in energy demand. During the last decade, the Chilean energy consumption increased by 90% from 257,841 Tcal in 2002 to 488,944 Tcal in 2012<sup>5</sup>. Oil and electricity were the main energy sources. The transportation sector had the highest share in oil consumption, and the industry and mining sector had the highest share in electricity consumption. Chile has 17.6 GW of installed power generation capacity, and electricity consumption is projected to grow at an annual rate of 5.5%-6.5% until 2020<sup>6</sup>, which implies an additional 7-8 GW of installed capacity by then.

Today, Chile remains heavily reliant on foreign sources of energy. After the natural gas crisis, Chile replaced Argentine natural gas with other imports, largely oil and coal. While Chile has few indigenous sources of fossil fuels, it does have significant renewable energy resources. Large-scale hydropower, concentrated in the central and southern regions, makes up 35% of the country's electricity generation. The potential for NCRE is great, and the government has been promoting the development of these sources, which are currently contributing 8% of the country's electricity generation (small hydro, biomass, wind and solar)<sup>7</sup>.

Hydropower expansion could meet an important percentage of the expected demand, but one key project (HydroAysén) has faced strong social opposition and it has been suspended because of environmental concerns. Additionally, Chile's hydropower supply showed to be vulnerable to droughts that have periodically curtailed hydropower production, causing supply shortfalls and blackouts. Development of coal-based generation has also been facing opposition when plants are located near population centers.

With resource estimates of up to 16 GW<sup>8</sup>, geothermal energy represents an important option for Chile, with significant perspective to contribute domestic base-load generation. Geothermal development is also well-fitting with GoC policies that promote development of NCRE.

A specific legislation, which is in place since early 2000<sup>9</sup>, allows private investment in the geothermal sector. The GoC has also recently improved the regulation for geothermal concessions to reduce legal and market risks and expedite the regulatory processes, in order to encourage the development of this renewable energy technology<sup>10</sup>.

Despite an apparently favorable context, Chilean geothermal resources remains untapped. Private developers have been increasingly arriving to Chile since 2005<sup>11</sup>. 79 exploration

<sup>4</sup> Economist Intelligence Unit, Country Report, October 2013

<sup>5</sup> National Energy Balance, 2012. <http://bit.ly/BalanceEnergia>,

<sup>6</sup> <http://bit.ly/PAEE20>, p.9, 2013

<sup>7</sup> Toward Energy Security in Chile. A Working Paper of the Americas Society/Council of the Americas Energy Action Group. February, 2012

<sup>8</sup> Focus on Chile. Geothermal Resources Council. Bulletin Vol. 42, No. 1. Jan-Feb, 2013.

[http://www.geothermal.org/PDFs/Focus\\_on\\_Chile.pdf](http://www.geothermal.org/PDFs/Focus_on_Chile.pdf)

<sup>9</sup> Ley No. 19.657, del 7 de enero del 2000. Ley sobre concesiones de energía geotérmica.

<sup>10</sup> Decree No. 114-2012. Aprueba nuevo Reglamento para la aplicación de la ley No. 19.657, sobre Concesiones de Energía Geotérmica y deroga Decreto N° 32, de 2004, del Ministerio de Minería. <http://bit.ly/Geothermal-Regulation>

<sup>11</sup> The Italian energy company Enel Green Power (EGP) has been the first important player that entered the Chilean geothermal sector. EGP in 2005, in association with the Chilean hydrocarbon utility ENAP, created Empresa Nacional de Geotermia

concessions and 7 exploitation concessions are currently active in the county, and at least 6-7 important fields have been discovered so far, but none of them have installed generation capacity yet. The few more advanced projects are at an early exploration drilling stage.

High risks (resource, market/price, among others) and elevated cost of developing geothermal projects in Chile, still represent a concern for private investment in the sector, and creates financial barriers to raise risk capital for advanced exploration programs and project development. Specific actions with convincing transformation and demonstration effects, are therefore needed to trigger geothermal development in the country.

### 3. PROJECT DOCUMENTS AND CONTACTS

For the purposes of this evaluation the IDB - Climate Change and Sustainability Division established the following key contacts:

- Mr. Claudio Alatorre - Senior Specialist of the Climate Change and Sustainability Division (INE/CCS), responsible for the supervision of the Consultant;
- Ms. Gisela Campillo - Climate Change Consultant (INE/CCS), supervision assistant;
- Mr. Alfredo Idiarte - Private Sector Climate Finance Consultant (VPP/VPP);

and provided the following project documents to the Consultant:

- Chile Geothermal Risk Mitigation Program (MiRiG) - IDB Private Sector CTF Proposal for Submission to the CTF Trust-Fund Committee  
File: Chile Geothermal Proposal - MiRiG - final draft . clean
- Cover Page for CTF Project/Program Approval Request  
File: CTF Cover page MIRIG Chile

Information and documentation about CTF investment criteria and the CTF Investment Plan for Chile were also provided by the IDB, and additionally searched by the Consultant in the CTF website (<https://www.climateinvestmentfunds.org>). Data on the energy sector and status of the geothermal industry in Chile were independently verified by the Consultant based on personal knowledge, and through investigations in websites of the GoC and international institutions and organisms (GRC, GEA, IGA, among others).

### 4. PROJECT SUMMARY<sup>12</sup>

The analysis reported in Chapter 2 identifies specific risk-costs-financing elements that create a shortage of funding, or inadequate funding conditions, and are substantially keeping the development of geothermal power in Chile on hold. Further details and discussion about cost and risk barriers that are specifically affecting the Chilean geothermal sector (besides the well-known risk/reward imbalance and barriers normally posed by geothermal during the exploratory stages) is given in the IDB MiRiG program proposal, and are considered well founded and consistent with the real situation by the Reviewer.

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(ENG) and resumed geothermal exploration in different prospects throughout the country. Previous geothermal exploration in Chile was conducted during the 70ies by the Chilean government through CORFO, and by ENAP in the early 2000s.

<sup>12</sup> The information reported in this chapter is summarized from documents provided by IDB - Climate Change and Sustainability Division, which integrate the proposal for submission to the CTF Trust-Fund Committee of the Chile Geothermal Risk Mitigation Program (MiRiG) (see references in Chapter 3).

The proposed MiRiG program seeks to address these constraints combining resources from the CTF IP and DPSP to support few initial private projects that have already completed some exploratory drilling, but require concessional risk mitigation facilities to advance with additional drilling and plant construction, before they can access commercial debt financing. CTF concessional finance effectively has the potential to tackle some of the cost and risk barriers, fostering geothermal development and providing a strong demonstration effect and track-record of the viability of this industry in Chile. Additional effects are expected through a transformational role in the Chilean geothermal industry by catalyzing and enabling early successes of private sector projects that will in turn contribute to further market uptake

The general objective of the MiRiG program, as specifically defined in the IDB proposal document, is envisaged to *support up to three geothermal projects in Chile that have the potential to become the first in the country (and at this point in South America), demonstrating the viability of this technology in Chile and leveraging DFI and commercial financing. The program expects to directly enable a minimum of 100-150MW of installed capacity.* A preliminary analysis of the Chilean geothermal sector provide reasonable evidence that there are effectively at least 3-4 project at a stage and in conditions to fulfill the scope of the program.

CTF resources will be used in structuring financial solutions that will mitigate the effects of resource and other project development and operation risks, and incentivize project developers to make the significant additional investments still necessary to allow production drilling campaigns and plant construction to go forward. The proposed structuring solutions may include senior and subordinated long-term project loans, short-term bridge loans, and guarantees.

Resources are being requested from both CTF IP for Chile (USD 30M) and the DPSP (USD 20M) to create a combined envelope of USD 50M, which is considered a suitable condition to enhance chances of program achieving intended demonstration and transformation effects, contributing at the same time flexibility in terms of risk and cost barriers that need to be addressed.

The combined request for IP and DPSP CTF resources is supported by the following considerations:

- Given the high costs and risks associated to geothermal development in Chile, the USD 30M available through the IP represent a very limited amount to confidently expect sufficient demonstration, implying a risk that the whole program would not achieve its objective. A larger envelope, that can support at least two projects, would allow greater risk diversification and significantly enhance chances of having at least one successful case providing the intended demonstration effect.
- The geothermal DPSP program approved by the CTF TFC was defined to exclusively support resource risk mitigation, while in Chile also other risk and cost barriers are hindering geothermal development, and its mitigation is likely as crucial as resource risk mitigation. The IP resources, which are not restricted in their use to resource risk mitigation, complementary allow flexibility to customize CTF support to the individual risks and needs of each project.

Assistance from world-class independent geothermal and technical advisors will be contracted by IDB to provide expertise and advice during the execution of the program, providing additional mitigation of the risk to the CTF. The technical advisors will assist during

validation of eligibility of projects, in project evaluation, analysis of drilling plans, and determination of success and failure criteria, among other functions, to ensure a sound implementation of the program. This component is considered by the Reviewer a key element for the effective implementation and success of the program.

## 5. COMPLIANCE WITH CTF OBJECTIVES AND CRITERIA

The CTF is conceived to support high GHG abatement opportunities and to promote low carbon technologies, including power sector projects that result in substantial reduction of CO<sub>2</sub> emissions and increase the share of renewable energy in the total electricity supply. The CTF investment plans shall fit and integrate in national development plans or programs that include low carbon objectives.

The proposed Geothermal Risk Mitigation Program for Chile provides a potentially great contribution to abatement of CO<sub>2</sub> emissions, through triggering the development of a very efficient clean energy source, which generate base-load capacity, and is widely untapped in the country. The project is thus well consistent with the overall objectives of the CTF. The scope of the program is also consistent with Chile's development strategy for the energy sector, particularly its goal to increase the percentage of NCRE to 20% of all new contracts by 2025.

The CTF investment criteria and procedures for private sector operation<sup>13</sup> aims at maximizing the impact of CTF resources, and provide the following investment criteria to assess the proposed programs and projects: Potential GHG Emissions Savings, Cost-effectiveness, Demonstration Potential at Scale, Development Impact, Implementation Potential, Additional Costs and Risk Premium, Financial Sustainability, Effective Utilization of Concessional Finance, Mitigation of Market Distortions, and Risks. The compliance of the proposed program with these criteria is carefully analyzed and discussed in the IDB proposal document<sup>14</sup>, and the Reviewer agrees on all considerations reported therein. A summary of consistency with CTF investment criteria is reported hereafter.

### Potential GHG Emissions Savings

The proposed program promotes the development of geothermal power plants, which provide low carbon capacity using a clean and renewable energy source. Geothermal generation also has high load factors and contribute base-load capacity, with potential for substitution of fossil-fuels based generation.

The Program expects to trigger development of some 100-150 MW of installed geothermal capacity. The emission savings corresponding to the USD 50M of CTF resources invested in the Program are preliminarily, estimated in the project document assuming 100 MW of capacity with a plant operational life (and minimum expected resource availability) of 30 years. This results in GHG emissions savings of between 8.7 and 18.0 MtCO<sub>2</sub>e. The wide range is due to the difference in the emission factors of the two main grids (with SIC at 0.391 MtCO<sub>2</sub>e/MWh and SING at 0.806 MtCO<sub>2</sub>e/MWh) and to the uncertainty at this point of which

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<sup>13</sup> CTF Private Sector Operations Guidelines (Revised October 24, 2012); CTF Financing Products, Terms and Review Procedures for Private Sector Operations (Revised October 24, 2012);

<sup>14</sup> Chile Geothermal Risk Mitigation Program (MiRiG) IDB Private Sector CTF Proposal for Submission to the CTF Trust-Fund Committee (paragraphs 41-62)

projects will be finally supported by the program, since present opportunities are located in both grids.

Conclusion - The program will significantly contribute to reduction of CO<sub>2</sub> emissions. The CO<sub>2</sub> abatement estimates are significant and quite conservative (See Chapter 6).

### **Cost-effectiveness**

The program proposal complies with the CTF requirement of providing a calculation of the CTF investment per ton of CO<sub>2</sub>-equivalent reduced. Given the direct GHG mitigation potential mentioned above, the cost effectiveness of CTF investments would range between 0.18 and 0.38 tCO<sub>2</sub>e/USD (for projects in the SIC and SING, respectively). This corresponds to abatement costs of 5.5 and 2.6 USD/tCO<sub>2</sub>e of CTF resources. Assuming an estimated 1:10 financial leverage of CTF resources (ie. CTF providing ~9% of the total investment resources needed), total abatement cost (considering total project costs) would range between 29 and 60 UDS/tCO<sub>2</sub>e.

Considering the demonstrational purpose of CTF investments, cost effectiveness could be considered higher if indirect mitigation potential resulting from successful demonstration is taken into account. Assuming only 5% of the estimated 16 GW geothermal potential (i.e. 800 MW) is eventually developed over the next couple of decades, successful demonstration of this program would contribute to pave the way for GHG savings of 70 to 145 MtCO<sub>2</sub>e, with cost effectiveness of CTF investment further enhanced to 0.3-0.7 USD/tCO<sub>2</sub>e.

Geothermal project development costs in Chile are expected to reduce over the years as the first projects provide demonstration and activate a national market of geothermal services (particularly drilling services) contributing to future reduction of overall cost of geothermal developments. However, the expected cost reductions cannot be quantified with the information available.

Conclusion - While this review has not verified all data, details and sources of information of the preliminary economic analysis, the main technical parameters and estimates appear to be reasonable and often conservative (see Chapter 6), therefore it is opinion of the reviewer that the overall analysis indicates that the project is cost-effective.

### **Demonstration Potential at Scale**

The CTF investment criteria provides two main criteria to assess the compliance and eligibility of programs under the goal of supporting transformational investments at scale:

Scope for avoided annual GHG emissions . Chile's geothermal potential is estimated up to 16 GW. The program is designed to support directly at least 100 MW of geothermal power generation capacity, whose demonstration effect is expected to help catalyze further geothermal investment and development. After a successful demonstration effect of the project, a reasonable scenario with development of a 5% fraction of the total estimated potential (about 800 MW) in the next decades, can be reasonably assumed making reference to experience in leading geothermal countries. However, timing for this achievement would be uncertain, as well as specific conditions such as marginal emissions factors that would allow for adequate estimation of GHG savings potential. Assuming emission factors in the next few years remains in the same range as the current ones, an additional 800 MW of geothermal power capacity would result in 70 to 145 MtCO<sub>2</sub>e abatement.

Transformation potential - The program is designed to trigger investment in geothermal energy in Chile, providing multiple financial instruments and options, to tackle existing risk and cost barriers. This shall help project developers overcome financial barriers, create security for investors and generate knowledge for financial institutions. A track record for private geothermal development will be eventually established with a significant contribution to unlock the Chile's great geothermal potential. If successful, the program will definitely have a transformation effect in the Chilean energy sector, increasing the participation of geothermal base-load capacity in the energy matrix. Additionally, it will provide a learning process and a model for additional projects in the Latin America and in other parts of the world.

The program also has a multiplier effect, as it is designed to optimize the use of available funding in terms of leverage and sustainability. The programmed CTF investment of USD 50M is expected to leverage USD 280-445M from third parties sources, and up to a total financing of USD 550-825M (including capital resources), which is the currently estimated cost for development of 100-150 MW of geothermal generation in Chile. These efforts should eventually demonstrate the viability and benefits of investing in geothermal, allowing for the development of a sustainable framework in the long term.

Conclusion - The proposed program demonstrates significant potential for scaling up, with transformation and multiplier effects on the geothermal industry in Chile. The program will also generate a learning process, as well as technical and economic information that could contribute to development of solutions for geothermal energy projects in the long term, both in Chile and Latin America, or other parts of the world.

### **Development Impact**

Geothermal energy offers one of the most effective renewable, autochthonous, and low carbon alternatives for power generation. Additionally, it generally result in significant economic and social benefits, such as creation of high quality employment, demand of goods from the industry, and (in the specific case of Chile) potential to reduce the need to import fossil fuels, and therefore improve trade balance. The environmental impact of geothermal installations is easily manageable through common, technologically mature, and generally simple, mitigation and recovery measures.

This program has a significant number of potential development co-benefits. Some of them (e.g. energy security, improvement of trade balance, employment) are certain, but will become significant as the demonstration effect of the program impacts in a scale larger than that of the directly supported investments. Other potential co-benefits (e.g. access to modern energy services though rural electrification, reduced air pollution) are uncertain at this stage, as they depend on the specific location of the plants, but their existence would be assessed as specific investments are defined and confirmed.

Conclusions - The program will likely result in significant developmental impacts, consistent with CTF eligibility criteria; therefore, from an energy and environmental perspective, the promotion of geothermal generation in Chile is widely justified.

### **Implementation Potential**

The objective and structure of the program are fully consistent with Chilean energy policies and institutions, which are strongly committed with deployment of low carbon technologies and renewable energy sources. The CTF investment criteria provides the following elements

to assess the compliance and eligibility of programs under the implementation potential point of view: Country and Sector Strategies; Institutional and Implementation Arrangements; Sustainability; and Mobilization of Resources.

Country and sector strategies - Chile set a goal to increase the percentage of non-conventional renewable energy (NCRE) to 20% of all new contracts by 2025. The GoC also encourages clean energy development through total/partial exemption of transmission taxes to small capacity renewable projects (< 20 MW). A geothermal concessionary regime is in place in the country since 2000, and the geothermal regulation has been recently improved to reduce legal and market risks and expedite the regulatory processes, in order to encourage geothermal investment and development.

Institutional and implementation arrangements - Sustainability - Geothermal is strongly supported by the Ministry of Energy, which has taken development of this resource as a priority, as shown by the great number of geothermal concessions granted, and direct involvement in improvements of the geothermal regulation to expedite the administrative processes and address legal and market risks.

In addition, Chile has a very friendly regulatory environment for private sector investment, across the economy in general, but also in the power sector in particular, as it was the first country in the world to move to a private, unbundled power sector model. The GoC has strongly supported the development of the private sector since the eighties, when a series of economic reforms were made to open the Chilean economy to the world. As a result, Chile consistently ranks at the top among Latin American countries in investment climate rankings.

These positive conditions for private business in the power sector, along with high power prices and high renewable resource potential (solar, wind, geothermal), have attracted to Chile some of the top international utilities and renewable energy developers, including geothermal developers like Enel Green Power, Mighty River Power, Alterra Power Corporation, Energy Development Corporation and Origin Energy, who brought key expertise and investment resources necessary for the development of the sector. These companies have been responsible for a significant amount of exploratory drilling and significant geothermal discoveries, although still insufficient to access commercial project financing.

Mobilization of resources - The economic structure of the program is composed of funds from the CTF (USD 50M), the IDB (up to USD 140-205M), other financing DFIs, commercial banks (USD 140-240M) and sponsor equities (USD 220-330M). The Program is then expected to leverage USD 500-775M from third parties sources including private financing plus capital resources.

Conclusions - Based on the supportive energy policy and the favorable regulatory and business environment established in Chile, the project meets the CTF eligibility criteria for its implementation potential. The financial structure of the program also meet the CTF objective of mobilizing resources at scale for the deployment, diffusion and transfer of low carbon technologies.

### **Additional Costs and Risk Premium**

The program is aimed at triggering few initial and significant geothermal development projects in Chile, providing financial solutions to mitigate the barriers encountered by private developers to access to financing sources.

Geothermal resource and other geothermal development risks are perceived as significant by lenders during the exploratory and production drilling stages, significantly limiting debt financing to: corporate lending backed by a strong balance sheet; or concessional financing by public sector development banks or bi/multilateral donors. When project debt financing is not available, and sponsors need to finance this stage with equity, the cost of capital is often prohibitive, especially in a market like Chile, where no PPAs may be available to ensure an adequate return commensurate with LCOE..

CTF resources used as in the proposed program, would provide the missing project debt financing (or in cases maybe even concessional corporate debt) or project guarantees to support further drilling. These financing solutions are not available from other lenders, and are critically needed to allow sponsors achieve a certain measure of risk-sharing, and reduce the amount of additional capital at risk required before commercial debt is available. Additionally, they allow leveraging of sponsors equity and enhance the economics of projects, in order to achieve a competitive LCOE. Depending on each specific project and the relevant financing structure, CTF would provide price and/or risk concessionality (subordination, security, tenor) to achieve this objective.

Conclusions . These scopes and project structure are consistent with CTF requirements for financing.

### **Financial Sustainability**

The Project is designed to support the take-off of the Chilean geothermal sector through demonstration of some first developments. Then, the demonstration and transformation effects generated by the Project, are expected to favor market conditions for future cost reductions, replicability and sustainability of geothermal power development, without a continuous flow of CTF resources. The following key factors are expected to contribute to financial sustainability:

- Reduced project development cost when technical and financial expertise, supply of equipment and drilling/construction services will be further developed and established in the country, incentivized by the evidence of a growing sector.
- Increased likelihood of securing PPAs as technology, timing, reliability and development costs are demonstrated. This could contribute to more secure and improved returns, and a reduction of risk perception for project sponsors and financiers.
- Demonstration and clear definition of successful and viable financing schemes, reducing financing risk perception and costs.
- Success of projects will further gain government and public support, to encourage further improvement of enabling environment and public support through incentives.
- Recently increased renewable energy targets expected to progressively increase the premium compensation for renewable energy projects.
- Reduced perception of multiple project development and operation risks (resource, technology, financing, environmental and social, among other) should increase access to debt financing reducing project development cost and LCOE.

Conclusions . The project scopes and structure are consistent with CTF requirements for financial sustainability.

## Effective Utilization of Concessional Finance

Given the situation of the Chilean geothermal sector, summarized in Chapter 2 and widely discussed throughout this document, concessional finance is required to help overcome the increased cost and risks faced by private developers. Despite the GoC has developed incentives for renewables, and has improved regulation to further promote geothermal development, this support is insufficient as there is no direct financial offer available to mitigate geothermal development cost or share its risk. Chile's unbundled and privatized power market, on the other hand, limits the government's ability to directly intervene in support of geothermal development.

Conclusions . The project scopes and structure are consistent with CTF requirements for effective utilization of concessional finance.

## Mitigation of Market Distortions

The program is designed to use CTF resources in structuring financial solutions for few initial significant projects that will mitigate the effects of resource and other development and operation risks. No alternative offer of project debt financing during the drilling stages of geothermal projects is currently available in Chile, therefore the market will not be distorted.

Conclusions . The project scopes and structure complies with CTF requirements to avoid market distortions.

## Risks

The IDB proposal identifies few main risks for the program and define mitigation measures a follows:

Lack of demonstration given drilling failure. The risky nature of geothermal development (and the use of CTF resources to mitigate some of the entailed risks) could led to failure of individual projects, in which case the intended demonstration effect may not be achieved.

This risk is mitigated by:

- Selection of projects where significant sponsor equity has already been invested in exploration drilling and pre-feasibility studies provide a certain level of confidence on the viability of the development, making sponsors willing to continue to invest their own equity. The technical evaluations and eligibility of projects will be conducted by the IDB with support from a world-class geothermal advisor.
- The Program is structured to support more than one project, diversifying the risk to increase the likelihood that at least one case will successfully provide the intended demonstration of the viability of geothermal power development.

Financing risk. Sponsor equity and CTF support could not be sufficient to fully finance prospect projects. Additional debt financing could be needed to support field development, and plant and other infrastructure construction. Besides residual resource risk, other risks such as the difficulty obtaining a PPAs and the volatility of spot price may pose a challenge securing commercial financing even when production drilling is advanced/completed and resource risk reduced.

To mitigate this risk CTF will provide risk and price concessionality, to help reduce LCOE and increase DSCR for senior lenders, thus reducing perceived project risk and crowding such lenders in to secure needed financing.

Public support given environmental/social potential impacts. The Chilean civil society has demonstrated over the years its ability to effectively oppose developments with perceived undesired environmental or social impacts. Some large hydro and coal plants developments have been discontinued or delayed on that basis, and also the geothermal project at El Tatio, located in a sensitive and high value touristic area, was eventually suspended in 2009 due to social opposition. However, given the normally smaller footprint of geothermal projects, as well as their positive GHG externalities, similar opposition is in principle not expected to be encountered in most of geothermal development projects, as long as environmental and social regulations are abided by, and lessons from previous experiences (El Tatio) are capitalized in further developments. This said, the little experience so far developing these projects in Chile (with no project having yet completed the full project cycle to effectively deliver power) presents certain level of risk that unexpected social or environmental concerns may arise.

To mitigate this risk, qualified technical support on environmental, social and operational management of the project is planned as part of the IDB/WB CTF geothermal program in Chile.

Conclusions . The program document satisfactorily addresses CTF requirements for risk identification and mitigation.

## **6. OTHER OBSERVATIONS AND COMMENTS**

The IDB proposal for the Chile\$ Geothermal Risk Mitigation Program program is composed of a main document and a summary cover page for CTF Project/Program Approval Request, which together represent a thorough analysis of the problem and clear argumentation for the proposed solutions. The Consultant reviewed the whole set of documents and found them well structured and comprehensive of all the information required for the definition of the program in all of its aspects (background, problem and justification, intervention proposed, financing structure, risks and strategies).

The program effectively focus on a key element that is preventing geothermal development - lack of financing - and looks clearly and efficiently designed to trigger the development of geothermal energy in Mexico, providing multiple financial instruments and options for private developers. The analysis reported in the previous chapter shows that the proposal is well consistent with the overall objectives and investment criteria of the CTF, and of Chile\$ development strategy for the energy sector.

One important aspect worth to be stressed is that, besides a preliminary approach at this stage of the proposal, calculations of project economics and potentials for CO<sub>2</sub> abatement are mostly based on well-founded, but somewhat conservative assumptions, and nevertheless they deliver positive and promising results.

## 7. CONCLUSIONS AND RECOMMENDATIONS

The IDB proposal for the Chilean Geothermal Risk Mitigation Program was reviewed by the Consultant, and found satisfactorily addressed and documented at the preliminary level intended for the document. The overall content of the program looks well-structured and consistent with the objective of seeking a demonstration and transformational intervention by triggering few initial and significant geothermal development projects in Chile. CTF resources are used to provide financial solutions to afford the risks that private companies and commercial lenders are not able to bear.

The program meets the overall eligibility criteria for CTF financing of private operations, therefore, its co-financing with CTF resources is justified.