Colombian Geothermal Energy Development: Technical and Economic Factors Favoring Foreign Investment

Jonathan A. Hernandez, Juan F. Cardona, and Elsa Juliana Vega S.

Dewhurst Group, L.L.C.

Keywords

Colombia, geothermal investment, risk mitigation, finance, business development, market analysis, country update

ABSTRACT

Colombia has emerged as a site of untapped geothermal potential in the last five years, while its economy has shown a favorable environment for the influx of foreign investment. This paper is designed to show how technical and economic factors are shaping both policy and private enterprise in Colombia for geothermal energy development. Colombia has an economy that is willing, and perhaps needing, to diversify its national energy portfolio. This paper will detail the favorability of the Colombian economy for geothermal development, along with other favorable factors for development such as: willing domestic stakeholders, government incentives for developers, well-researched areas of potential, relatively accessible sites, currency advantages, and strong trade relations with geothermally developed countries. Furthermore, foreign investment has already taken place in the Colombian geothermal sector. The aim of this paper is to provide further geoscientific and economic analyses so that investment may continue.

Introduction

Located in the northernmost tip of South America with a population of nearly fifty million, Colombia has studied the development of geothermal energy for nearly half a century. Some potential geothermal sites that have been studied are near large metropolitan areas. Due to its near-equatorial position, Colombia experiences very little seasonal change, with local climates that are usually elevation dependent. In areas of high altitude *and* high geothermal potential, hydrology is often very favorable for geothermal production, as abundant working fluids have served the country's hydroelectrical production for decades.

Colombia is uniquely positioned geologically, amidst the tectonic kinematic collisions of the Pacific, Nazca, and Caribbean plates. Located in the Northern Volcanic Zone (Almaguer Rodríguez, 2013), the country's volcanism occurs throughout different parts of three main mountain ridges (western, central, and eastern) (Jiménez Chisica & Montes Quintero, 2015). Geological and geothermal studies in Colombia go back decades—in 1968, for instance, the first geothermal investigations of the Nevado del Ruiz volcanic zone (Figure 1) were conducted. By the Instituto Colombiano de Energía Eléctrica (ICEL).

Colombian Geothermal Studies

ICEL's studies were conducted through an affiliated consortium between the Italian firm ENEL and the local state hydroelectric developer Central Hidroeléctrica de Caldas (CHEC). These studies included topography, geology, gravimetry, geoelectric, and geochemical studies. In 1983, CHEC also performed a prefeasibility study determining areas of geothermal potential, and subsequently in 1984, GeoEnergía Andina S.A. (GESA) completed investigations and selected well

sites for exploration drilling. In 1993, the first MT (magnetotelluric) studies were conducted, and four years later GESA drilled well N-1. Unfortunately, there were problems with drilling operations, deadlines, budgets, tools, and subsurface conditions. The well eventually ended up as a deviated, over-budget dry hole.

Thirteen years after the N-1 project, ISAGEN—one of the largest energy providers in Colombia—carried out their own studies of Nevado del Ruiz sponsored by the Unites States Trade Development Agency (USTDA). In 2013, CHEC joined with parent company Empresas Públicas de Medellín (EPM) to investigate the area's geothermal potential on their own. In 2016, CHEC and EPM completed another USTDA-financed project, resulting in a Feasibility Study Report for Nevado del Ruiz. The development of the Nevado del Ruiz region is currently undergoing licensing adaptations regarding permitting of concessions, due to a complicated system that delegates these concessions on both a federal and state level. (The production capacity of a geothermal power plant in the Nevado del Ruiz region is estimated to be less than 100 MWe, which makes it thereby subject to state-level agencies—in this case, Corporación Autonóma Regional de Caldas, or CORPOCALDAS.

The United Nations, via the Economic Commission for Latin America and the Caribbean (CEPAL, 2000), published a report in 2000 citing the early studies done in the southernmost volcanic zone of Colombia. Sharing a border with Ecuador, this volcanic zone, known as Tufiño-Chile-Cerro Negro (TCCN) **(**Figure 1**)**, has been geothermally investigated since 1978, when INECEL did reconnaissance studies for high-temperature thermal sources in the region. In 1979, the Organization for Latin American Energy (OLADE), along with Italian entity Aquater and the French Geological Survey (BRGM), completed a reconnaissance study for Ecuador, arriving at a favorable conclusion on the geothermal potential of TCCN. In 1981, The Instituto Ecuatoriano de Electrificación (INECEL), OLADE, and Aquater developed Phase 1 for a prefeasibility study of the area; six years later, in 1987, tit was completed.

Another area where geothermal potential has been studied in Colombia is around the Azufral Volcano **(**Figure 1**)**. In fact, the Inter-American Development Bank (BID) approved financing for Colombia via Project TC-97-06344-CO (Gutierrez and Orjuela, 2009); the objective was to complete the first phase of geothermal feasibility studies in Azufral, which consisted of geoscientific and environmental studies.

Approximately 180 km NE of Colombia's capital, Bogota, studies are currently being conducted on the geothermal possibilities for a small resort town in the state of Boyaca. There, the Paipa geothermal system was studied in 2004–05 by INGEOMINAS (now Servicio Geológico Colombiano, or SGC). These preliminary studies were surface explorations that looked for surface features, thermal manifestations, and gas emissions, (Gutierrez R. & Orjuela C., 2009). After these studies were reviewed, a prefeasibility report highlighted two sites in the region: Paipa and Iza, with Paipa indicated as more attractive. There is evidence to suggest that high-temperature thermal manifestations are perhaps related to the presence of an intrusive magmatic body of acidic nature at approximately 5 km depth (Gutierrez R. & Orjuela C., 2009). Further studies have been proposed by SGC, and preliminary models are currently being refined in order to mitigate risk prior to the next phase of investigation.

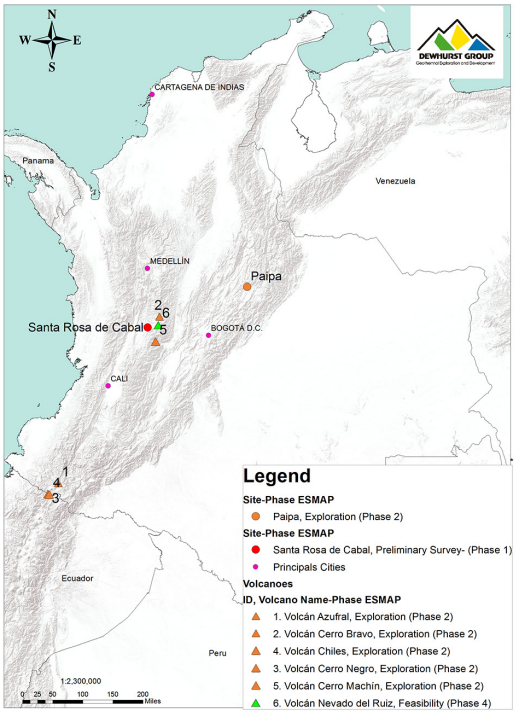


Figure 1. Location map and summary according to ESMAP.

Colombian Geothermal Development

According to ESMAP, the different stages of a geothermaldevelopment include information relevant to each stage. Phase 1, preliminary inspection, includes the reconnaissance of the geothermal area, based on regional studies and literature review of preliminary studies of the site. Presently, it is important to determine the justification and the necessity of the project. In Colombia, only the project of Santa Rosa de Cabal (Table 1) is at this stage, because researchers there have not yet conducted contemporary studies but have only evaluated earlier ones.

Phase 2, exploratory studies, includes geological, geochemical, geophysical, and other geostudies. In order to move to Phase 2, Phase 1 should reach a feasible determination. Most projects in Colombia are at this stage, drawing upon various geostudies conducted at different times. In the particular case of Paipa (Table 1 and Figure 2), Phase 2 studies have been completed so that the Colombian Geological Service (QMS) now has a conceptual model based on the work of Alfaro Valero et al.

Phase 4, feasibility studies (Table 1 and Figure 2), encompass subsurface and surface exploration. In the area of Nevado del Ruiz, several developers currently have concessions in the area, which overlap in certain regions. As mentioned before, CORPOCALDAS will be designated as the authorizing agency for pertinent permitting further development. The Nevado del Ruiz zone stands alone as the most investigated, and apparently attractive potential geothermal resource in the country to date. Aside from production potential, this area's location near one of the most important agricultural regions of the country—Colombia's coffee-growing axis—makes it even more important to industries outside of the energy sector. Due to confidentiality agreements, specifics regarding any confirmation or exploratory drilling (ESMAP-Phase 3) is not publicly available.

Table 1. Current status of projects in the region according to ESMAP.

Site Name	Departament	Phase ESMAP	Color
Santa Rosa de Cabal	Risaralda	Preliminary Survey (Phase 1)	
Paipa	Boyaca	Exploration (Phase 2)	
Volcan Azufral	Nariño	Exploration (Phase 2)	
Volcan Cerro Bravo	Tolima	Exploration (Phase 2)	
Volcan Chiles	Nariño	Exploration (Phase 2)	
Volcan Cerro Negro	Nariño	Exploration (Phase 2)	
Volcan Cerro Machin	Tolima	Exploration (Phase 2)	
Volcan Nevado del Ruiz	Caldas-Tolima	Feasibility (Phase 4)	

Current Countrywide Energy Situation

Since October 2015, the "El Niño" phenomenon has forced the Colombian government's hand to take measures to counteract a drought-related energy crisis. Due to increased energy costs, especially at the end of 2015 during the Christmas holiday season, the presidency initiated a national energy-saving program at the beginning of 2016. The crisis was twofold, with an unavailability of natural gas from Venezuela coupled with the drought's effects on decreased hydroelectric production. Colombia's largest method of electricity generation is hydroelectric—which accounts for nearly 70% of its energy sector, according to national magazine *Semana* (Figure 3). The drought caused a significant drop in reservoir capacity, to approximately 63% (Semana, 2015). As recently as March 2016, the government has launched the "Apagar, paga" campaign whose goal is to reduce national energy consumption in homes and small businesses, with an established daily goal for every type of consumer. This entire program is outlined in Colombian Resolution 029 of 2016, and was reported in the national newspaper *El Tiempo* on March 9, 2016. This situation further adds to the need for Colombia to develop renewable-baseload power sources such as geothermal energy in their energy portfolio. The development of geothermal power production as an energy source will benefit the country by bringing increased energy independence that is far more "drought-proof" and reliable.

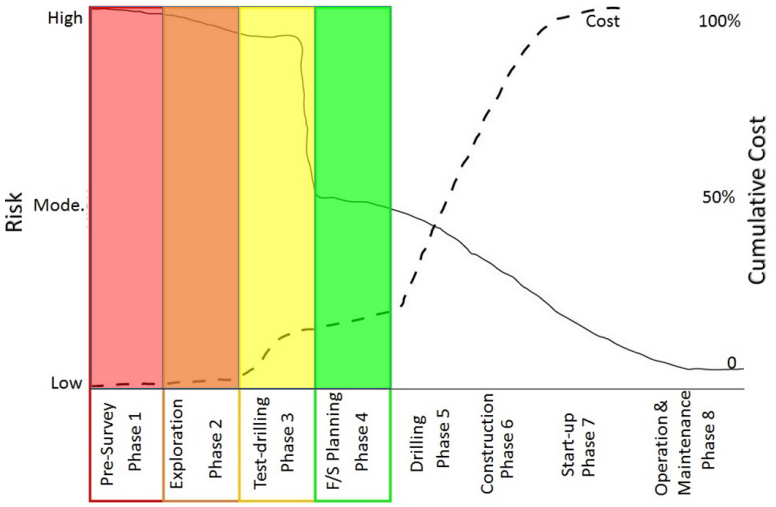


Figure 2. Diagram of phases according to ESMAP 2012, Modified from ESMAP 2012.

The average KWh in Colombia for the 2015 fiscal year, as calculated by Bogota's largest electricity provider (CODENSA, 2015), is about 347.08 COP$/KWh, which at the current exchange rate as of the writing of this paper would equal about 0.12 USD$/KWH According to ESMAP (World Bank, 2012), Mexico's average energy cost is 0.08 USD$/KWh. Mexico's national economy is comparable to Colombia's; however, comparing kwh costs, Colombia spends about 4 cents more per kwh than Mexico, or a premium of about 45%. Other factors to consider in the context of geothermal are the environmental benefits of clean and renewable energy, such as lower emissions, as well as the national-security benefits that come from developing a domestic power source that is not subject to international tariffs or market forces.

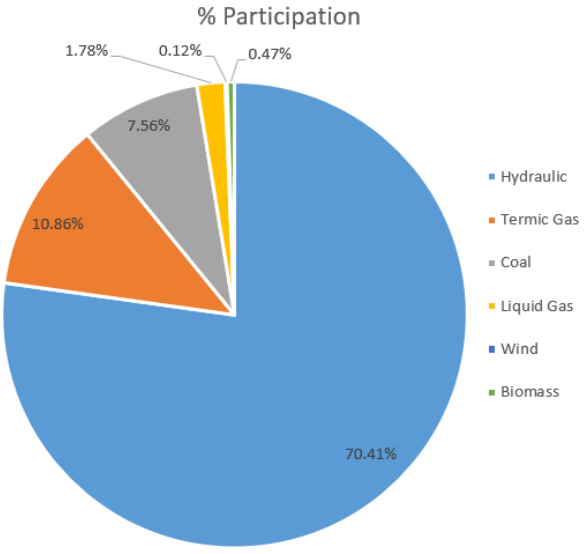


Figure 3. Colombian Energy Portfolio by Source (UPME, 2015).

Colombian Economy

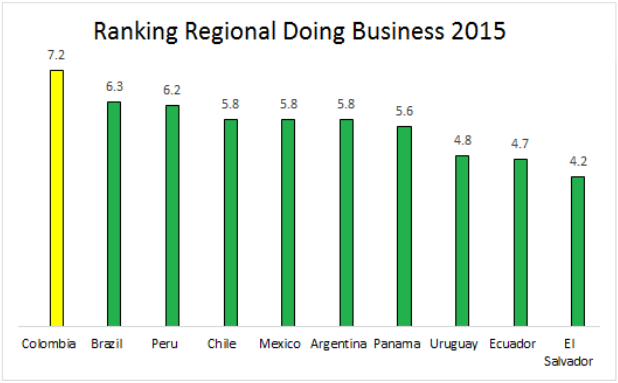
Colombia currently boasts one of the most stable economies in Latin America. Over the last five years, the Colombian economy has had an average growth of 4.8%. During 2014, Colombia's GDP grew at a rate higher than the Latin American average: while the region's average was 1.3%, Colombia experienced a 4.6% growth.

A country with a pro-investment grade from internationally respected institutes such as Standard and Poor's (S&P) and Moody's and Fitch (Figure 4), Colombia has recently shown signs of being an investment-friendly climate. In 2014, Moody's increased the country's rating from Baa3 to Baa2. This upgrading was primarily due to Colombia's good growth dynamics and implementation of a fourth-generation infrastructure overhaul, and expected prudent fiscal management of future projects.

Risk Rating Company	Term	Rating	Perspective
Estandar&Poor's	Long term-Foreign Money	BBB	Stable
FithRatings	Long term-Foreign Money	BBB	Stable
Moody's	Long term-Foreign Money	Baa2	Positive

Figure 4. Ratings by rating agency. Modified of ProColombia (2015).

Colombia maintains its position as a trend-setter in Latin America when it comes to investment reforms implemented recently: since 2005, the country has implemented twenty-nine new reforms. Government obligations are the major theme, as Colombia now offers a new plethora of incentives to further stabilize foreign investments and put investors at ease. According to the World Bank's "Doing Business" rankings for 2015 (Figure 5), Colombia ranks tenth in the world, and first in Latin America, in terms of protecting investors' interests (Figure 6). This study identified Colombia as a flagship Latin American economy for foreign investment.



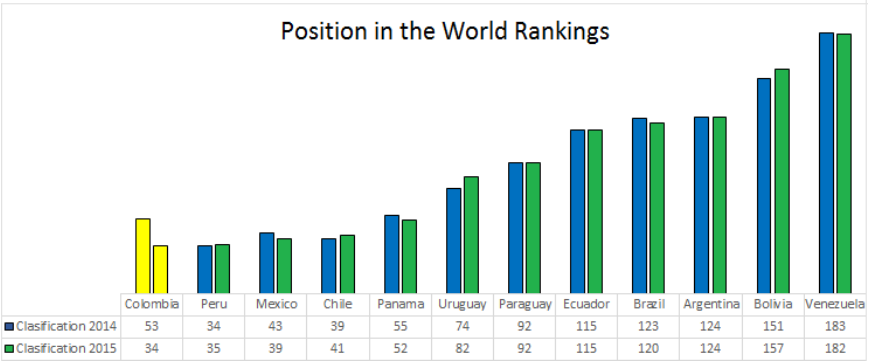


Figure 5. Ranking Regional Doing Business 2015, Modified of Diario Financiero.

With Colombia emerging in the global market as a wise destination for foreign investment, the country is also beginning to capitalize on trade agreements throughout the world, which open up extensive opportunities for national and foreign stakeholders to participate in exportation operations. These opportunities are supported by easy access to markets, minimum tariffs, and fair conditions for competition, all within clear legal outlines.

Investor protection Index-Doing Business 2015

Workd Ranking	Country
10	Colombia
35	Brazil
40	Peru
56	Chile
62	Mexico
62	Argentina
76	Panama
110	Uruguay
117	Ecuador
152	El Salvador

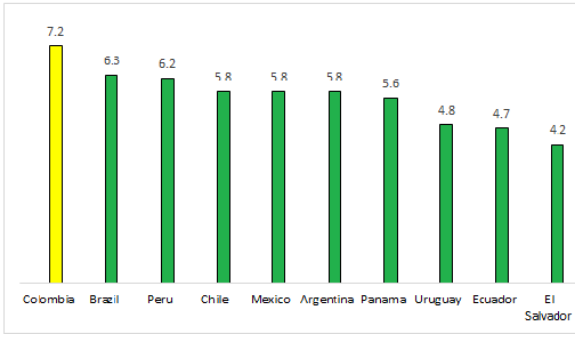


Figure 6. Investor protection index. Modified of ProColombia (2015).

Currently, Colombia has thirteen commercial agreements and eight under negotiation, which will allow preferential access to more than 1.5 billion consumers worldwide. The network of agreements for Colombia include twenty-five International Investment Agreements (IIA) that are either finalized or in negotiations, as well as sixteen accords to prevent double-taxation that are either finalized or in negotiations (Colombian Ministry of Commerce, Industry and Tourism, 2015 cited ProColombia (s.f.)).

Government Support for Investment in Renewable Energy

With the law 1715 of 2014 (UPME 2014) a new scenario for the electricity sector has been established, which promotes the efficient use of energy resources and the diversification of traditional sources of electricity. Unconventional Renewable Energy Sources are defined (FNCER acronym in Spanish) as: "those renewable energy resources available worldwide that are environmentally sustainable, but in the country are not used or are used marginally and not widely commercialized. Are considered as FNCER (Unconventional Renewable Energy Sources): biomass, small hydroelectric plants, aeolic, geothermal, solar and ocean. Other sources of this type can be considered as such by UPME."

Incentives for Unconventional Renewable Energy Sources (Translated)

Article 11

"Incentives for the generation of nonconventional energies. With the purpose of stimulating research, development and investment in the production and use of energy generated from Fuentes No Convencionales de Energía (FNCE) which in English translates to Sources of Non-Conventional Energies. These incentives also include efficient energy management, and those obliged to file income tax returns who have invested in this type of project will be entitled to reduce annually from their asset values, during the five years following through to the fiscal year in which the investment was made, fifty percent (50%) of the value of their investment.

The deductible amount for this concept in no case should exceed 50% of the contributor´s net income, determined before subtracting the value of the investment.

To be eligible, the investment should receive the environmental benefit certificate, issued and properly certified by the Ministry of Environment and Sustainable Development, according to the article 158-2 of the Tax Statute."

Article 12

"Instruments for the promotion of the FNCE. Value Added Tax incentive (IVA, for its acronym in Spanish). To foster the use of energy generated from FNCE, the equipment, elements, machinery and national and imported services destined for pre-investment and investment, for the production and use of energy from non-conventional sources, as well as for measuring and evaluating potential resources, will be exempt from IVA.

To this effect, the Ministry of Environment and Sustainable Development will certify the equipment and services excluded from this tax, based on a list issued by UPME."

Article 13

"Instruments for the promotion of renewable energies. Tariff incentive. Natural or legal persons that upon entry into force of this Law hold new investments in new FNCE projects, will be exempt from paying import tariffs for machinery, equipment, materials and inputs exclusively destined for pre-investment and investment projects with said resources. This tariff incentive will be applicable only to machinery, equipment, materials and inputs not produced by national industry and whose only means of acquisition is subject to their importation.

The exemption of import tariffs mentioned in the previous paragraph will be applied to FNCE projects and must be requested to the National Taxes and Customs Direction (DIAN, for its acronym in Spanish) at least 15 workdays before the import of the machinery, equipment, materials and inputs required and exclusively destined to develop renewable energy projects, according to the documentation of the project endorsed in the certificate issued by the Ministry of Mines and Energy or the entity entitled by it to this purpose."

Article 14

"Instruments for the promotion of FNCE. Accounting incentive for the accelerated depreciation of assets. The activity of energy generation from FNCE will enjoy the benefits of the accelerated depreciation of assets regime.

Accelerated depreciation of assets will be applicable to machinery, equipment and civil works required for pre-investment, investment and operation of energy generation from FNCE, which are acquired and/or built exclusively to this end, upon entry into force of this law. To this purpose, the annual depreciation rate will not exceed twenty per cent (20%) of the global annual rate. The rate may be varied annually by the project owner, prior notifying DIAN, as long as the adjustment does not exceed the limit mentioned in this article."

Relationship Between the Colombian Peso and US Dollar

During the year 2015 the dollar has increased in value. At the beginning of 2014, the value of a dollar in Colombian pesos was about 2000 pesos (Figure 7), but in December 2015 it reached a maximum exchange value of 3356

pesos, according to Web Dollar (s.f). Although the exchange rate of dollar has decreased in March–April 2016, it has not declined to the values of 2014.

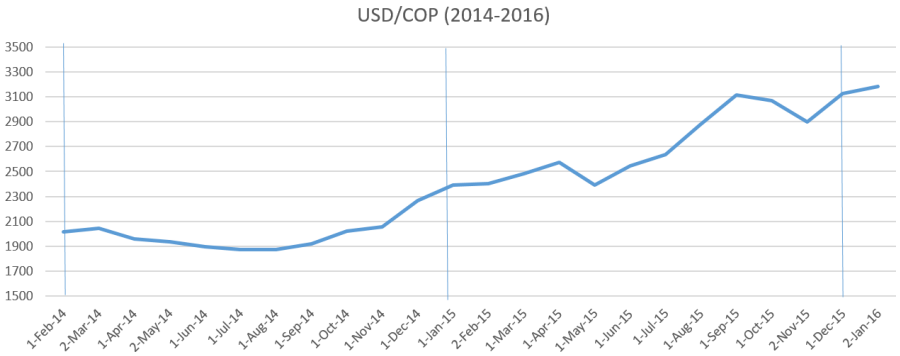


Figure 7. Variation of the dollar against the Colombian pesos for the period 2014-2016.

Conclusion

Colombia is currently growing as a Latin American flagship economy, while the South American continent remains the earth's last undeveloped frontier for geothermal energy. When combining the established resource potential in Colombia, with the national necessity to diversify its energy portfolio with clean, reliable, and renewable baseload electricity, it becomes apparent that geothermal is a viable option in Colombia. While risk mitigation is proportional to investment, the country has begun to independently identify potential sites, that if successfully exploited could provide major metropolitan areas with local renewable energy. Now that need and supply have been roughly identified, development remains to be done. With various government incentives for investment and a favorable exchange rate, the "cost of doing business" is now increasingly advantageous for foreign investors.

The purpose of this paper was to provide a clear, updated view of the current climate for foreign investment in Colombian geothermal energy. We feel that the technical aspects of potential resources and existing exploratory efforts, combined with current government support and incentives, point to a window of opportunity that has been developing during the last few years.

References

Alfaro Valero C. (2010), Available at: http://redcolombianafa.org/apc-aa-files/1611c317ca4b218ac03d71b8efb638cd/4.%20Exploracion%20geotermica%20Colombia%20-%20CLAUDIA%20ALFARO%20VALERO.pdf.

Almaguer Rodríguez, J.L. (2013). "Estudio magneto-telúrico con fines de interés geotérmico en el sector norte del Volcán Nevado del Ruiz, Colombia." Tesis (Maestro en Ciencias de la Tierra). Juraquilla (Querétaro, México): Universidad Autónoma de México, 133 p.

CEPAL. (2000). "Estudio para la evolución del entorno del proyecto geotérmico binacional "Tufiño-Chiles-Cerro Negro."" 76 p. Available at: http://www.cepal.org/publicaciones/xml/6/5696/lcr1995-e.pdf.

CODENSA, (2015), Available at: https://www.codensa.com.co/document/Tarifario_enero_2015.pdf.

Diario Financiero (s.f.), "Socios de la alianza del Pacífico desplazan a Chile en el ranking Doing Bussiness 2015," Available at: https://www.df.cl/noticias/internacional/actualidad-internacional/socios-de-la-alianza-del-pacifico-desplazan-a-chile-en-el-ranking-doing-business-2015/2014-10-28/231317.html.

Dólar Web, valor histórico del dólar. Available in: http://dolar.wilkinsonpc.com.co/dolar-historico/dolar-historico-2015.html.

Gutierrez R. D. F. y Orjuela C. J. F., 2009. "Análisis tecnológico para la explotación de energía geotérmica en zonas de alto potencial en Colombia". Tesis (Ingeniero Electricista). Bogotá: Universidad de la Salle, Facultad de Ingeniería. Programa de Ingeniería Eléctrica. 128 p. Available at: http://repository.lasalle.edu.co/bitstream/handle/10185/16982/T42.09%20G985a.pdf?sequence=2&isAllowed=y.

Jiménez Chisica, R.D, & Montes Quintero, Ó.H. (2015). "Implementación de un sistema de información geográfica para el almacenamiento, despliegue y análisis de información sismológica en el Observatorio Vulcanológico y Sismológico de Manizales". Trabajo de grado (Especialista en SIG). Manizales (Colombia): Universidad de Manizales, Facultad de Ciencias e Ingeniería. 52 p.

ProColombia (s.f.), "Crecimiento, confianza y oportunidades para invertir". Available at: http://www.inviertaencolombia.com.co/Adjuntos/Presentacion_Colombia_2015-mayo.pdf.

ProColombia (s.f) "Crecimiento, confianza y oportunidades para invertir". Available at: http://www.inviertaencolombia.com.co/images/Adjuntos/Brochure_inversion_en_Colombia.pdf.

Revista Semana (2015), Available at: http://www.semana.com/nacion/articulo/fenomeno-del-nino-apagon-para-colombia/448929-3.

UPME (2014), "Ley 1715 por medio de la cual se regula la integración de las energías renovables no convencionales al sistema energético nacional". Available at: www.upme.gov.co/Normatividad/Nacional/2014/LEY_1715_2014.pdf.

UPME (2015), "Informe Mensual De Variables De Generación Y Del Mercado Eléctrico Colombiano – diciembre de 2015 Subdirección De Energía Eléctrica – Grupo De Generación".17 p. Available at: http://www.siel.gov.co/portals/0/generacion/2015/Seguimiento_Variables_Diciembre_2015.pdf.

WORLD BANK (2012), ESMAP Geothermal Handbook: Planning and Financing Power Generation. 150p.