

Geothermal Development in Bolivia - A Country Update

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ABSTRACT

The geothermal development in Bolivia started in the 1970s with surface explorations along the Andean Cordillera, and, demonstrating a prospective geothermal potential in some areas, such as Sajama, Empexa and Laguna Colorada (Sol de Mañana). Six geothermal wells were drilled between 1988 and 1992 in the geothermal field Sol de Mañana, as part of the geothermal project Laguna Colorada. In 1996, the CFE certified the Laguna's Colorada geothermal potential (240 MW). Between 2012 and 2013, with the financial support of JICA and the technical supervision of West JEC, the well testing of the existing wells was done and it was concluded that at least 100 MW can be exploited. By the end of 2018 and with the aim to provide energy to the future plant construction works, an ORC pilot power plant (5 MW) construction contract was signed and its operation is expected by the end of 2020. Likewise, the tender documents for the drilling of 25 new wells would be issued in the second semester of 2019 and the field operations would start in 2020. The first 50 MW unit is expected to be constructed in 2024 and the second 50 MW unit by 2025. On the other hand, the government is seeking funding for the development of Sajama and Empexa. The geothermal development in Bolivia started in the 1970s with surface explorations along the Andean Cordillera, and, demonstrating a prospective geothermal potential in some areas, such as Sajama, Empexa and Laguna Colorada (Sol de Mañana). Six geothermal wells were drilled between 1988 and 1992 in the geothermal field Sol de Mañana, as part of the geothermal project Laguna Colorada. In 1996, the CFE certified the Laguna's Colorada geothermal potential (240 MW). Between 2012 and 2013, with the financial support of JICA and the technical supervision of West JEC, the well testing of the existing wells was done and it was concluded that at least 100 MW can be exploited. By the end of 2018 and with the aim to provide energy to the future plant construction works, an ORC pilot power plant (5 MW) construction contract was signed and its operation is expected by the end of 2020. Likewise, the tender documents for the drilling of 25 new wells would be issued in the second semester of 2019 and the field operations would start in 2020. The first 50 MW unit is expected to be constructed in 2024 and the second 50 MW unit by 2025. On the other hand, the government is seeking funding for the development of Sajama and Empexa.

1. INTRODUCTION

Bolivia is located in the centre of South America with an estimated population of 11,63 million by 2020 (INE, 2019). Its economy is based on manufacturing, hydrocarbons and minerals among others. By the end of 2019, the total energy install capacity reached 2,236.86 MW (Table 1).

One of the most important policies about energy was made in 2015, when the National Electric Plan Bolivia 2025 "Plan Eléctrico del Estado Plurinacional de Bolivia 2025" was approved. The plan aimed to increase the energy install capacity to, at least, 4,354 MW. According to this plan, the renewables energies such as hydro, wind, solar and geothermal should play an important role in the next years.

The first geothermal studies in Bolivia were carried out in the 1970's when surface explorations were done along the Andean Cordillera. As a result of these studies, forty-two (42) major geothermal manifestations as hot springs, fumaroles and mud pots were identified in different areas (GEOBOL, 1978). Complementary studies demonstrate that the most prospective areas in the country were: Sajama, Empexa and Laguna Colorada. Due to its great potential, Laguna Colorada was chosen as the best option for first development in the country (Villarroel, 2014)

Therefore, six geothermal wells were drilled in the 1980's in the Sol de Mañana (Laguna Colorada) geothermal field. In 1996, the CFE (Comisión Federal de Electricidad de México) certified that at least 240 MWe of electricity can be generated for at least 25 years with the drilling of 33 production wells and 10 reinjection wells (CFE, 1997).

In 2010, the government of Bolivia, ENDE (Empresa Nacional de Electricidad) and JICA (Japan International Cooperation Agency) started discussions for the finance of the construction of a 50-100 MWe geothermal power plant in Sol de Mañana. Between 2012 and 2013 with the technical supervision of West JEC, ENDE conducted the well testing of wells SM-01, SM-02, SM-03 and SM-04 (Villarroel, 2014) the data obtained was important to update the conceptual model and also to provide key information for the future works.

Table 1 Present and planned production of electricity of Bolivia (CNDC, 2018)

	Geothermal		Fossil Fuels		Hydro		Solar		Wind		Biomass		Total	
	Capacity MWe	Gross Prod. GWh/yr.	Capacity MWe	Gross Prod. GWh/yr.	Capacity MWe	Gross Prod. GWh/yr.	Capacity MWe	Gross Prod. GWh/yr.	Capacity MWe	Gross Prod. GWh/yr.	Capacity MWe	Gross Prod. GWh/yr.	Capacity MWe	Gross Prod. GWh/yr.
In operation in December 2018	-	-	1 444.35	6 368.62	664.91	2 605.79	65.06	122.06	27.00	58.84	35.57	74.89	2 236.89	9 230.20
Under construction in July 2019	5.00	39.27	100.00	53.70	69.00	66.80	-	-	-	-	-	-	174.00	159.77
Funds committed, but not yet under construction in December 2019	100.00	785.43	-	-	493.20	-	50.00	-	93.00	-	-	-	736.20	785.43
Estimated total projected use by 2020	5.00	39.27	1 544.35	6 422.32	733.91	2 876.21	115.06	215.86	120.00	261.51	35.57	74.89	2 553.89	9 890.06

In 2018, ENDE signed a contract with the joint-venture Sacyr-Ormat for the construction of a Pilot Power Plant 5 MWe, the aim of this plant is to provide energy for the future works and also to provide energy to the small indigenous communities located close to the area. Likewise, ENDE is planning to issue the tender documents for the drilling of 25 new wells in the area, according to the last numerical simulation of the reservoir, 21 wells are required for a 100 MWe generation.

2. GEOLOGICAL SETTINGS

The geothermal area of the geothermal field Laguna Colorada is comprised of Miocene-Pleistocene rock of the Andes volcanic arc extending in N-S, and overlies marine and terrestrial sediments of Cenozoic-Paleogene age (Ramos, 2015). The regional structure has two directions: N-S and NW-SW.

The area is mainly covered by an extensive ignimbrite unit and overlies an andesitic-dacitic lava sequence and possibly ignimbrites from the Neogene. This system is related to seismic events whose effects are still appreciable in the zone (Ramos, 2015). Figure 1 shows the stratigraphy and structural geology of the Laguna Colorada (Sol de Mañana) area.

At least one huge magmatic chamber is located below and in the west part of the most important manifestations areas, according to geovolcanological studies carried out in 1986 (ENDE, 1986).

Geothermal vapour fluids thorough the faults and fractures caused by a secondary deep fracturing and creating hydrothermal alterations zones when reaches surface springs (CFE, 1997).

3. GEOTHERMAL RESOURCES, POTENTIAL AND INVESTMENT

Since only three geothermal areas have been studied (Sajama, Empexa and Laguna Colorada,) it is not possible to confirm a geothermal potential of the country to date. However, considering these three areas, the production of electricity could reach at least 510 MWe (Gawell et al, 1999). Due to these areas are not closely located to populated areas, low-enthalpy geothermal projects (utilization) have not been considered yet.

Table 2 presents the total investment carried out for the research and explorations for these areas and the field development investment done in Laguna Colorada mainly.

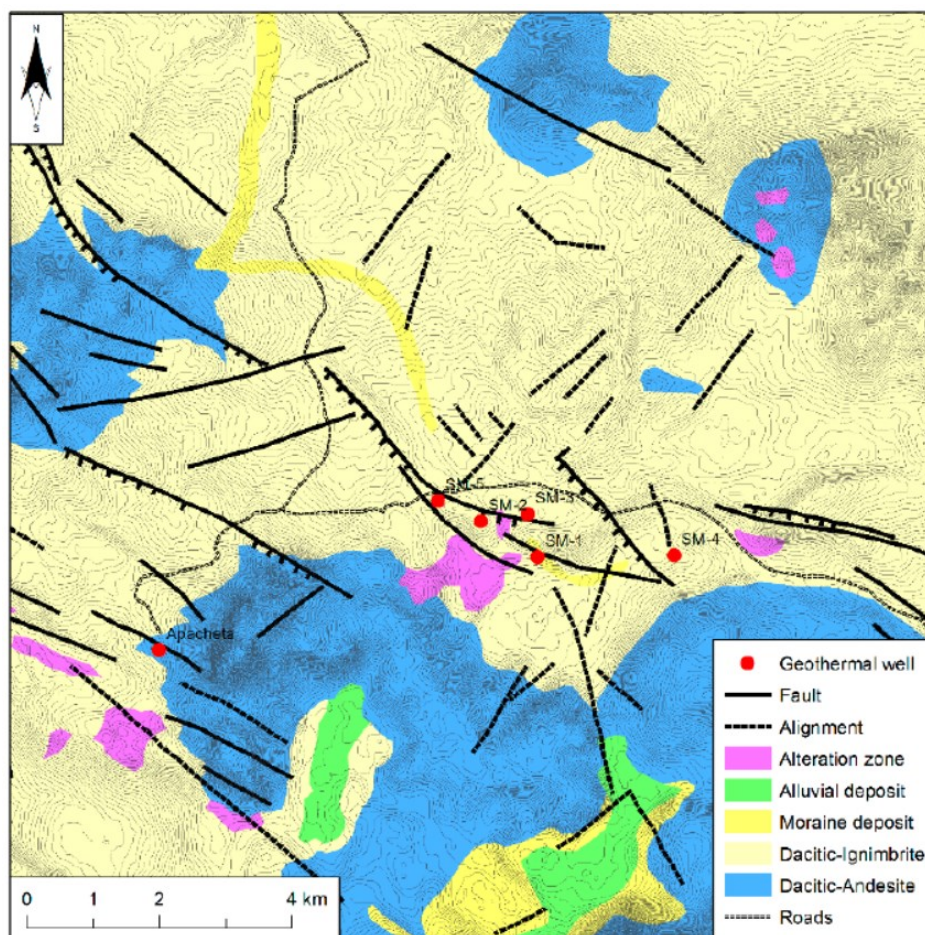


Figure 1: Stratigraphy and structural geology map, geothermal area Laguna Colorada (Ramos, 2015)

Table 2: Total investments in geothermal in Bolivia

Period	Research & Development Incl. Surface Explor. & Exploration Drilling	Field Development Including Production Drilling & Surface Equipment	Utilization		Funding Type	
			Direct	Electrical	Private	Public
	Million US\$	Million US\$	Million US\$	Million US\$	%	%
1995-1999	-	-	-	-	-	-
2000-2004	-	-	-	-	-	-
2005-2009	-	-	-	-	-	-
2010-2014	2.90	-	-	-	-	100
2015-2019	0.86	28.06	-	-	-	100

4. CURRENT AND FUTURE DEVELOPMENT

Being the first geothermal power plant in Bolivia, a 5 MWe ORC power plant is expected to be concluded in Laguna Colorada (Sol de Mañana field) by the end of 2020 or early 2021. In addition, the drilling works (25 wells in total are expected) should start in 2020 and the first 50 MW unit would be in operation in 2024 and the second 50 MW unit in 2025.

With the support of the Geothermal Development Facility for Latin America (GDF), ENDE would conduct geoscientific explorations in Empexa in 2020; the first feasibility study of the area is expected to be by 2021. Complementary studies for the Sajama geothermal area are also going to be conducted with the support of the GDF.

5. SUMMARY

As a result of new policies among others, the importance for the development of geothermal has increased in the last years in Bolivia. The first production of electricity (5MW) is expected by 2020 in Laguna Colorada and a 100 MW power plant would be commissioned in 2025; at the same time, surface explorations are going to be done in Empexa and Sajama.

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