INVESTMENT POSSIBILITIES IN GEOTHERMAL ENERGY IN CHILE

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Key words: geathennal potential, government, investments, Chile

ABSTRACT

Chile has an important geothermal potencial especially in the north of the country. There are estimated features of high medium temperature, of at least 200 distributed throughout the country. The North of Chile is an important mining zone due to the existence of many and large copper deposits. There are many mines in operation today and many more projects in different stages. For this reason the electrical consumption is rapidly growing it is estimated that the installed rapacity will triple by 2000.

Rest of the studies to date have been made in El Tatio, a geothermal field located in the Region II and its electrical potential is estimated to be about 100 MW. This plant could be made part of interconnected electrical system already existing.

The Chilean Government is very interested in diversifying the energetic supply and considers the geothermal energy to be a good alternative, mainly in the northern area ofthe country. It was for this reason, that the government sent a law project to the Congress in 1991. Its objective is to assure the necessary future investments to be made by the private investors in order to take advantage of these resourses. This project sees geothermal energy as a bodyless property, unappropiable hut useable and enjoyable in the way assigned by authority. The franclisee is obliged to make the invesments that were agreed to a contract with the Government in order to develop the geothermal field.

1. INTRODUCTION

Chile, as a cnuntry associated with the Pacific Fire Belt, has, over its length (4000 kms), geothermal features of high and medium temperature. Investigations. made by government departments have shown the existence of at least 200 geothermal features scattered throughout the country.

Geothermal resources have, in Chile, twa important potential exploitation areas.The first one, located in the Northern part of the country, is associaled both with electric power production for towns nearby and mainly with heat uses including the supply of energy for important mining projects, both uses are being evaluated at the present time. The second area includes the Central and Southern zones of the country, where geothermal use is being aimed at the supply of energy to remote locations in the high mountains important touristic possibilities hut which are isolated from urban centers.

The huge potential of the geothermal resources of Chile has not been studied as a likely power source, except at Tatia Geysers. Only a few chemical analyses of some thermal springs and a preliminary register of them have been made. This lack of knowledge about geothermal resources is due to the existence of other energy resources with a long history of use and with development (such as hydroelectricity). Its use has so far eliminated the viability of economic exploitation of geothermal resources in Chile.

The increasing industrial progress of this country, its larger population, and the environmental impact associated with the traditional energy projects have virtually exhausted the use of the simpler, well known and low rust resources, except hydroelectricity. Therefore, the Chilean Government has made clear its interest in promoting the use of non conventional energy resources, Geothermal being one of them. The association of an abundant resource on one hand and the government's plan to develop it on the other hand, makes Chile a suitable country in which to invest in the development of gcothermal resources.

2 GEOTHERMAL RESOURCES DESCRIPTION

All along Chile, and particularly in the first or northern regions, there are a great many thermal fields. Some of them may have geothermal resources that could generate electricity.

Since 1917, in Nnrthern Chile, geothermal exploration has taken place, done by government agencies as well as private companies.

In 1964, the Chilean Goverment requested from UNDP support for geothermal studies. The agreement between the Chilean Goverment and UNDP to investigate the geothermal fields of Northern Chile was signed only in 1967. CORFO, the Corporation for the Promotion of Development was appointed as the Government representative agency. Thus, with this specific aim, CORFO created the "Committee for the Advancement of Geothermal Energy" (Geothermal Committee) that began to operate in 1967.

By 1967 several areas of interest had already heen identified such as Puchuldiza. Suriri,Lirima, El Tatio, etc. El Tatio was the best known field and the most interesting too. United Nations experts recommended that the first priority be to develop El Tatio, and CORFO, wilh a group of private persons who had mining claims in the genthermal field, set up the "El Tatio Geothermal Society S.A."

It wasn't until 1967 that more systematic geothermal research was started. Such investigations were concentrated basically in two geothermal fields : El Tatio in Region II and Puchuldiza in Reginn I. As for the rest of the thermal areas, little more has been done than to acknowledge their existence'.

In 1993, a detailed reconnaissance of the geothermal resources of Central Chile was made'. This preliminary study confirmed the huge possibilities for geothermal development in that area.

Low enthalpy geothermal resources (less than 100 °C) are abundant and occur along the eastern boundary of the Central Valley. The auspicious association in this area of a

large population and an important economic activity, allow consideration of the development of this resource in accordance with the requirements of the different zones.

Medium and high enthalpy geothermal resources (higher than 100 °C) are located all along the volcanic mountain chain of Los Andes Cordillera, often in isolated places difficult to reach. Therefore, except for Some rare cases such as the Chillán Hot Springs (Termas de Chillan), mining centers that could use high enthalpy geothermal resources for generating electricity, or other people that want require high temperalure fluid, the explaitation of this resource seems quite unlikely at present.

Among the dozen places visited, three were selected for a pre-feasibility study:

- Panimavida Hot Springs
- Catillo Hot Springs
- Chillan Hot Springs

The results show that at the first two sites (Panimávida and Catillo) Cascadeed exploitation of the resource would allow an investment return-time satisfactory enough (4.3 to 8.5 years). In the Chillan Hot Springs case, genthermometers show underground temperatures over 200 °C that would allow installation of a small Rankine cycle plant, generating 2 MW. The cost of the K W produced would cnmpete with the average cost of K W generated by traditional methods in Chile.

3. EL TATIO GEOTHERMAL FIELD

Because El Tatio Geothermal Field has been the most studied in Chile, we will give a more detailed description of it.

El Tatio Geothermal field is located in the Andes Mountains Range, 100 km East of the town of Calama and the Chuquicamata copper mine. Its altitude is about 4300 mts[3].

In the past, geological times there was strong volcanism with two main episodes:

a) Pre-Pliocene or Miocene volcanism, represented by Several units of ryolitic ignimbrites and andesitic stratn-volcanoes.

b) Plio-Quaternary volcanism that includes, besides several ignimbrite layers, andesitic strato-volcanoes and ryolitic domes located at Ihe highest parts of the Andes Mountains.

Large scale exploration of the El Tatio Geothermal field started in 1968 when the Chilean Government subscribed to an agreement with the PNUD in order to study the country's geothermal resources, CORFO being given the role of Gowrnment representative agency.

As a result of this agreement, geological and structural studies were carried on. They showed El Tatio Geothermal field to be underlain by in volcanic rocks belonging to the volcanic episodes described before and that these racks lie over a basement of an older (Cretaceous) continental sedimentary sequence. These rocks are filling a "graben" (downward block) of N-S orientation, 20 km long, limited to the West by the "horst" (upward block) of Serrania de Tucle (Tucle Hills Range) and its northern extension, the Loma Lucero (Lucero Heights). Its Eastern extensinn is unknown, though the boundary could be represented by the volcanoes of the El Tatio Volcanic Group.

The Tucle Hills Range and the Lucero Heights comprise a structure whose shales (impervious rocks) belong to the Quehrada Justo Formation and which are located beside the Plio-Quaternary permeable volcanic rocks that are spread over the upper part of the El Tatio "grabenis". In that way a natural barrier occurs all along the faults of the "graben" western edge that precludes westward movements of hydrothermal fluids.

Over the El Tatio "graben" surface there are thermal features like geysers, hot and boiling water pnuls. mud volcanoes, "siffioni", evaporating grounds, etc. The highest concentration of thermal features are found around the Río Salado riverhead, where the temperature of hot waters reach 86 °C, the boiling point at this altitude.

The electricat resistivity surveys carried out by the UNDP-CORFO experts showed a low resistivity anomally over a 30 km^2 area, confirming the great size of this thermal field.

Between 1969 and 1971 six exploration wells with an average depth of 600 m were drilled within the resistivity anomally. They verified the existence of permeable zones (reservoirs) located in the arid ignimbrites and having a temperature range between 180 °C and 253 "C.

Between 1973 and 1974, seven production wells were drilled, allowing the discovery of thrcc permeable layers. The upper one was located in the Tucle Dacites (150 to 250 m deep) with temperatures of around 160 °C; the middle one was located in the Puripicar Ignimbrite (450 to 600 m deep) with temperatures hetween 225 °C and 230 °C and the lowest one was located at the bottom of the Rio Salado Volcanic Group (700 to 1600 m deep) reaching temperatures between 200 °C and 260 °C.

At present, only three production wells of the seven drilled, are able to discharge fluids. Two wells were blocked due to the lack of adequate casing and two other holes had small discharges because of permeability problems. The blocked wells could he redrilled and have their production zones properly cased.

The geothermal fluid produced by the wells is a mixture of salt) water, steam and a small gas fraction. It has an average enthalpy of 1130 KJ/Kg.

'The three producing wells have an average discharge of 14.7 Kg/s with a pressure of X27 Pa (about 6 MW per well). The power potential of the two blocked wells was estimated to he of 5 MW each.

In spite nf all that has been investigated, the total energy potential of El Tatio Geothermal Field is still unknown. However, comparing the average heat loss in this thermal field (around 146.4 to 167.4 MJ/s) compared to some existing ones in other, better known geothermal areas of the world, some researchers have estimated its potential to he close to 100 MW.

Besides, almost everything leads to the belief that this thermal field extends to the East and to the Southeast from the area defined by the drillings. The surface Ihermal features and the geological data known so far point in that direction. However, a more accurate assessment of the extent of the El Tatio geothermal reservoir will he accomplished only through the drilling of new wells.

4. OTHER GEOTHERMAL FIELDS STUDIED[4].

Studies of Pampa de Lirima, in which Quiguata is located, started in 1969. A U.N. geophysicist using a low depth electrical resistivity method found a 10 ohmlm anomally. Also the geothermometers of SiO_2 and Na/K, applied to the chemical analysis of its waters indicated underground2 temperatures between 169 °C (SiO_2) and 211 °C (Na/K). 2This area was temporarily abandoned but in 1980 it was included in a group of promising areas where further studies should he undertaken.

Suriri is a Salt lake, with the Polloquere geothermal area located in its Southeastern part. It was preliminarly studied in 1972. Further geological and geochemical studies were undertaken in 1979. During 1980, plans were made for more in-depth studies but they had to be abandoned due to the lack of financing. There is superheated steam at the Polloquere fumaroles with a surface temperature of 110 °C. It is still considered to he a promising area.

The Jurase area, close to the town of Putre, was also identified as a promising area. Due to the fact that its waters belong lo the acid-sulphate type, the most widely used geothermometers were not suitable. It would be convenient to study and sample this area with adequate methods.

At the end of 1911, the Geothermal Committee decided to undertake a Geothermal Resources Register program, that at present is called Inventory. During 1978 there were written four reports that were Register-related. First there was a preliminary report on the Chanchoco-Copahue area, located in the High Mountains of the Southern part of the VIII Region (Bio-Bio Region). The report concluded that this was a vapour dominated field and that adequate sampling methods should he used in further studies of this remote area. It should he noted that on the other side of the Chile-Argentina boundary, in Neuquen Province exists the Copahue Thermal field that is a water dominated system where a 30 MW plant has already been built.

Later on in 1978, there was a report about the X Region regarding Petrohué Hot Springs, located close to Reloncavi Bay. This is a low temprature thermal area.

In October 1980 the "Tarapaca (Region I) thermal areas Register" report was finished and in December 1980 the "Antofagasta (Region II) thermal areas Register" was completed. In Region I, the outstanding thermal areas are Puchuldiza and its associated areas Tuja, Quitariri and Chipamire, Suriri and Pampa de Lirima. Jurase would need adequate studies to he properly assessed.

In Region II, excepting El Tatio, Alitar stands out as a new promising area. Moreover some Salt lakes (Salares) like Aguas Calientes Sur and Laguna Tujacto are interesting thermal areas due to their water chemistry and the closeness to the Iran mine of El Laco. Another outstanding area is the Aguas Calientes Salar close to the Lastarria volcano.

Finally, in 1993 the Hot Springs of Panimavida, Catillo and Chillan were identified as areas of interest following pre-feasibility studies.

5. LEGISLATION

Because of the lack of general legislation designed to prolect the important investments required for the exploration and exploitation of Geothermal energy, the Goverment sent to the National Congress a law project regarding taking adventaje of geothermal energy. This project is at present undergoing legislative proceedings.

In its more important considerations this project sees geothermal energy as a bodyless property, unappropiable in ownership, hut useable and enjoyable in the way assigned by authority. It is defined that a franchise implies property rights and that it can he established over other franchises or rights. It is granted through a Supreme Resolution of the Mining Ministery; with a previous application or public hid and a report by NCE (National Commission for Energy)'.

The franchise conditions included the use of a legal contract. The franchisee is obliged to make Ihe investments that were agreed to in the contract, including those regarding the exploration period and the ones concerning the installation project for the geothermal area exploitation. The payment of an annuity (yearly fee) is established after the exploitation project is finished. An exploration period with a maximun of five years (that may be extended two years more) is established. Three months before its end, plans for an installation project must he presented and they must include a working schedule and minimum annual investments.

The Mining Ministery will he able to cancela franchise if the investment plan is complied with. Moreover the interference from other franchises and rights, like mining, water and other rights like the existence of other matters likely to he franchised or substances whose extraction cannot he separated from the Geothermal exploitation.

Chilean Geothermal Laws, now in their final legislative steps , consider the granting of Geothermal energy franchises that will he associated to investment commitments for profitable development of this resource.

6. CONCLUSIONS

Chile has great potential for utilization of Geothermal Energy due to its volcanic environment.

Even though the Geothermal potential has been little studied, it is known that there exist big areas El Tatio whose energy resources have been investigated in detail. At present, the electric generation in this zone, the *so* called Great North, is of thermoelectric origin, using Diesel oil and coal. It is expected natural gas will be available from Bolivia from 1997 on, so that the future thermoelectric developments will he able to use it as fuel.

Thus under the energy policy being set up by the Chilean Goverment, Geothermal energy must compete on equal basis against the traditional electricily generating sources.

There are interesting possibilities for explotation of the low enthalpy Geothermal resources in Central Chile. The existence of a large population and important industrial and tourislic developments could created interesting investment possibilities in this area.

Finally, the Chilean Legislation is considering the granting of franchises on Geothermal Energy and the passage of such laws through Parliament is near,

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