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Development of Low Enthalpy in El Salvador

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ABSTRACT

Geothermal development in El Salvador has been progressing over time, and El Salvador is currently a benchmark in Latin America for best practices in Geothermal. In El Salvador, the experience in High Enthalpy dates back to the 60s of last century, and translates into a participation of 24% in the energy matrix. LAGEO with a research vision, has also been working on low enthalpy projects, but since 2014 has innovated in mechanisms and ways of working with direct use projects of Geothermal Energy; projects that will allow a social development of the areas surrounding the geothermal power plants, projects that will boost the economies in the geothermal fields' environments, projects that allow students to implement their knowledge, skills and enthusiasm in research, this paper will share the experiences of how LAGEO, a company dedicated to the generation of electrical power, looked for ways to investigate and develop pilot projects in low enthalpy with the aim of improving the conditions of the inhabitants surrounding the two geothermal power plants in El Salvador.

INTRODUCTION

The development of the geothermal zones in El Salvador has been mainly for the generation of electricity; El Salvador in the geothermal issue has studies dating back to the 60s´.

LAGEO has installed two geothermal plants in El Salvador, the first in 1975 which has three condensing units with an installed capacity of 95MW and the second in 1992 which it has three condensing units and one binary cycle for a total of 109 MW of installed capacity. With the two geothermal plants in production, LAGEO contributes an average of 1,430 Gwh to the Salvadoran Electric System with 94% availability, which represents a 24% share in the national electricity market. Escobar, R. (2018)

Currently LAGEO, through its subsidiary San Vicente 7 Inc, is developing two new geothermal fields: San Vicente with a potential of 30MW and Chinameca with a potential of 50MW. The San Vicente Geothermal Field has a concession area of 100 km2. A resource of 12 MW is already available, with 8 wells drilled. The Chinameca Geothermal Field has a concession area of 99 km2 and a resource of 22 MW is available with the drilling of 10 wells. In El Salvador there are 12 zones identified with underground temperatures that are estimated between 90 to 150 ° C and we can consider them as low enthalpy and for direct uses. Figure 1 and Table 1. Campos, T. (1988)

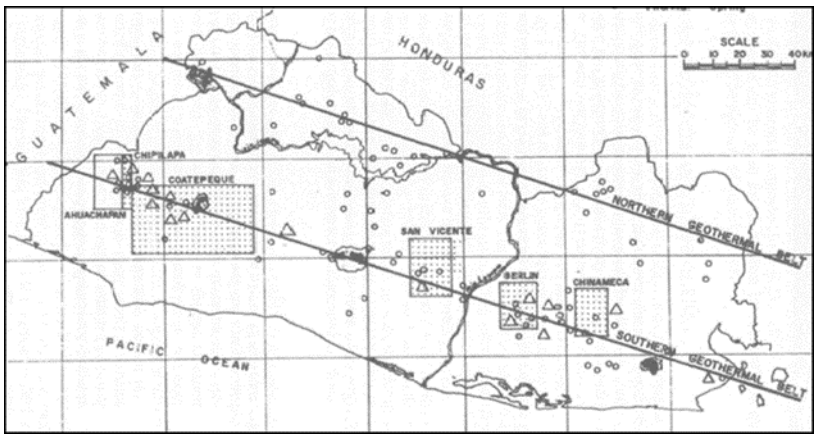

Figure 1: 12 zones identified with underground temperatures in El Salvador

Table 1: 12 zones identified with underground temperatures in El Salvador, localization and temperature

No.	Area	Localizacion	Temperatura promedio del reservorio C°
1	Toles	Ahuachapan	126±6
2	Guija	Santa Ana	129±9
3	Los Apoyos	Santa Ana	133±7
4	Agua Caliente	Chalatenango	133±7
5	El Paraiso	Chalatenango	133±7
6	Nombre de Jesus	Chalatenango	151±8
7	Tihuapa	La Libertad	128±11
8	El Salitral	La Paz	123±10
9	Obrajuelo	San Vicente	133±14
10	Carolina	San Miguel	141±11
11	Santa Rosa	La Union	126±12
12	El Sauce	La Union	118±12

However, specific projects have not yet been generated for the use of these zones, because the focus has been mainly on the generation of electricity, as there are still populations in the country that do not have access to electricity. However LAGEO, whose main activity is the generation of electric power, has searched for ways to investigate projects that use the heat of the earth in low enthalpy, and that is when LAGEO, since 2015 a project was designed to achieve three objectives: 1) the investigation of the direct use of Geothermal Energy, 2) support for the best senior students of university and 3) development of the communities surrounding the geothermal power plants.

2. GENERA PROJECT

The GENERA project started in 2015 with the signing of a cooperation agreement between LAGEO and the National University of El Salvador and the main objective is to promote scientific and technological research that promotes efficiency, productivity and rational use of resources, especially those of renewable type with potential for the generation of energy and direct uses.

In LAGEO, Engineering Management, is in charge of developing the research and it is through the coordination of renewable energies that it has been possible to investigate projects with the use of low enthalpy geothermal energy, this has been developed under the modality of works of Graduation, internships and social hours with students from different universities with which agreements have been signed throughout these 5 years.

LAGEO prepares a list of topics of interest and in the universities the students together with the teachers decide according to the specialty they are studying which projects they will investigate. Students are assigned an advisor within LAGEO, accident insurance is covered, LAGEO accompanies the student on field visits, supports them with bibliography, interviews, and everything necessary to complete the project satisfactorily. Students dream, innovate and build a prototype. This is how to date 27 graduation projects have been developed and 207 students from different universities have benefited. Figure 2

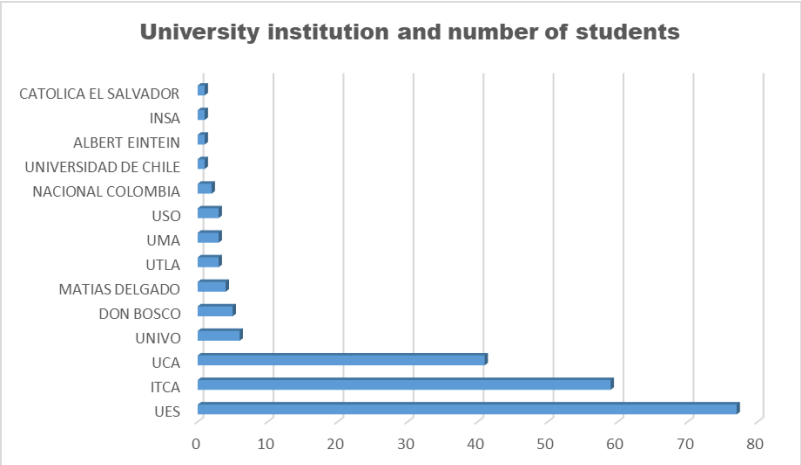

Figure 2: University institution and number of students

Specifically, 27 graduation works, 50 interships and 11 students for social hours have been carried out. Table 2

Table 2: Projects per year

Projects	2015	2016	2017	2018	total
graduation works	8	6	9	4	27
social hours	1	1	5	4	11
internships	6	11	25	8	50

2.1 Internships and Social Hours

Within these two modalities of the Genera Project, LAGEO together with the students have achieved different investigations in electrical, mechanical, fluid sampling, fumarole monitoring, industrial safety, Instrumentation, risk mapping, wildlife management, among others; the most important from the analysis of direct uses were: the existing potential in the geothermal fields of production Ahuachapán and Berlin, which quantified the amount of energy in low enthalpy that was available in the fields and that could be used for projects of direct uses within each geothermal plant. Market studies were also obtained for the sale of coffee, cocoa and cereals in the Berlin area and a market study for dairy products.

2.2 Graduation Jobs

Within this modality, graduation projects were accomplished on chemical analysis, feasibility of a school of geology, control of fluid losses, designs of camps for employees in the geothermal fields, simulations of efforts of derricks, studies on corrosion of fluids, area of protection of animals in danger of extinction, geophysical data base, drilling muds, failure analysis in binary cycles, among others.

The graduation projects related to low enthalpy were: Design of a system for heat supply in textile maquila, Marketing of dehydrated fruit with geothermal heat, Coffee Dryer, Milk Pasteurizer, Candle making, Photovoltaic system at central offices of LAGEO.

3. CONSTRUCTED PROTOTYPE

3.1 Coffee Dryer

3.1.1 Designe:

Using a fan, air is injected into a heat exchanger (consisting of two concentric tubes). The inner tube is the one that conducts the geothermal fluid and the second is made to conduct the air in such a way that it heats up as it advances on the surface of the inner tube. The air is forced out under a table where the coffee beans are placed. The temperature at which the air exits is 50 ° C, and in this way it transfers the heat to the coffee beans, reducing the humidity of the same from 50% to 11%. The estimated cost of the design with a drying area of 3 square meters and using a reinjection pipe of 28.80 meters is $ 55,000.00

3.1.2 Objective:

The main objective is to reduce the humidity of coffee beans, which usually have between 45% to 55% humidity (in the process of treatment within the Benefits). But, it is necessary to reduce the humidity up to 11% so as not to affect the quality of the flavor. The traditional drying in patio, allows to reduce the humead of the coffee but for it, it is required to wait up to 15 days. On the other hand, the dryer with low enthalpy allows to dry the coffee beans in 2 days.

3.1.3. Construction and Operation of the prototype:

The project was carried out in conjunction with 3 students from the mechanical engineering career of the University of El Salvador, the construction of the prototype lasted approximately 3 months and was carried out with recycled materials from the Berlin geothermal plant, with the support of the personnel and equipment of the central. The total cost of the prototype was approximately $ 600.00

The tests were performed on the TR4 platform of the Berlin Geothermal Field and a reinjection pipe was used, the temperature of the geothermal fluid inside the pipe is about 180 degrees Celsius, it was observed that the temperature decrease due to the heat transfer It was 1 degree Celsius.

The drying time varies according to the quality of the grain, however it was found that the duration of the tests was on average 2 days. The flavor of the coffee was verified and it was acceptable and pleasant in the test group.

There have been more tests with different types of grain, the students graduated with excellent qualification, and one of them was hired by LAGEO to follow the low enthalpy projects.

Figure 3: Coffee dryer in TR4 platform, Berlin Geothermal Field

Figure 4: Coffee dryer in AH8, Ahuachapan Geothermal Field

3.2 Milk Pasteurizer

The pasteurization of milk is a thermal treatment by which its temperature rises to approximately 65°C, achieving with it to eliminate bacteria that should not be consumed by humans.

3.2.1 Design:

The system operates with two heat exchangers, one is a coil mounted on a reinjection haul pipe, the other is a concentric pipe. A pump sends water at room temperature to the coil of the haulage pipe. The coil is made of copper and inside it is the water, which as it advances begins to heat up, since geothermal water is conducted in the opposite direction in the pipeline.

The pumped water leaves the coil at 80ºC and is conducted to the annular space of the concentric tube. The inner tube (concentric tube) contains milk. Which starts to heat up to about 65 ° C. Pasteurization is achieved when the milk is kept 30 minutes at 63°C.

Pasteurized milk can follow the process of becoming cheeses or creams as the milk producer requires.

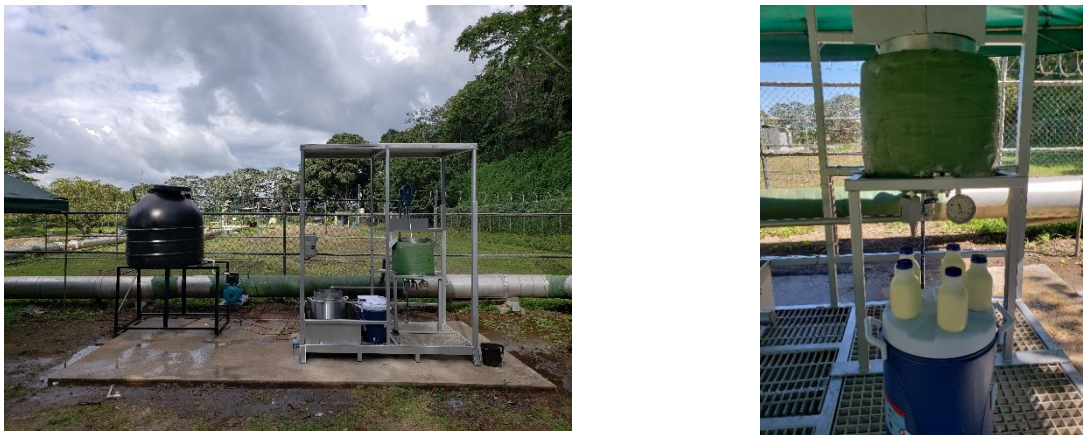

Figure 5: Milk Pasteurizer in Berlin Geothermal Field

3.3 Machines for making candles

The manufacture of candles consists of raising the temperature of the raw material that is the paraffin, to melt it and to make the candles according to the sizes, colors and tastes.

3.3.1 Design:

The design consists of placing a concentric tube in an isolated well. This well casts steam at 140°C, in the inner tube (concentric tube), the paraffin and other ingredients with which the candles are made are placed. The paraffin melts at 65°C and one of its components at 90°C. The geothermal steam from the insulated well reaches 100°C to the external tube (from the concentric tube) and transmits heat to the inner tube. After about 15 minutes the paraffin and its ingredients have melted and in its liquid state pour into different molds with a candle shape. The candles are expected to solidify for two hours.

Figure 6: Machines for making candles in the Ahuachapan Geothermal Field

4. ADVANCES IN DIRECT USES

4.1. Course on Direct Uses of Geothermal Energy

In October of 2018, a letter of understanding was signed by LAGEO and GIZ (in its Geothermal Development, German Cooperation program) with the objective of "Cooperating in areas of common interest related to the field of geothermal energy for the development of projects for use direct in El Salvador ", where the exchange of knowledge through training and development of projects in the field of geothermal mainly direct uses."

One of the main commitments was to design a training module for the use of heat in direct uses, to date the progress in this activity is significant, the design of the course was prepared by a consultant of GIZ Dr. Rolf Bracke (Center Geothermal International in Bochum Germany) together with specialists from LaGEO, at the beginning of April 2019, the first course was given to professionals from different geothermal companies in Central America, the course was taught in LaGEO and 40 participants graduated. The second edition of the course it developed in the first week of July 2019, graduating 42 participants from Central America and Colombia.

Objectives of the Course: that the participants acquire specific technical and scientific knowledge of the direct uses of geothermal energy associated with the development of projects for the use of this heat.

Agenda: Geothermal potential, Characterization of the resource, Technical systems, drilling and technology, pumping and sustainable operation, Project development, Risks and financing options.

At the end of the course given in July 2019, Dr. Rolf Bracke, as director of the International Geothermal Center Bochum and LaGEO, signed a Letter of Intent for Dr. Bracke to acquire 200 candles made in the prototype of Usos Direct installed in Well AH8 of the Central Geothermal of Ahuachapán, with the intention of demonstrating an excellent example of how low enthalpy can be used in our countries and its desire is to communicate to the geothermal world about our progress. LaGEO, meanwhile, will manufacture the candles with local labor, specifically women from the neighboring communities of the Ahuachapán geothermal plant.

Figure 7: First edition of course of direct uses of geotermal

5. CONCLUSIONS

Speaking of direct uses of geothermal energy is talking about the future, all international agendas focus on issues such as access to energy, reduction of hunger, gender equity, among other objectives.

Geothermal energy is a renewable, constant and that does not depend on the climate, geothermal energy is our treasure with which we can deal with the problems raised in these global agendas and contribute to several of the objectives for the good of humanity.

Currently the applications are so diverse and represent for many countries economic, environmental and social benefits that even possess them as the most sustainable countries on the planet, as an example the case of iceland, who have developed technologies for warming spaces, greenhouses for vegetable crops, vegetables and fruits , warming of agricultural soils, melting of snow for access roads, fish and algae nurseries, dehydration of agricultural products, industrial uses such as wood drying, among others.

LAGEO facing these challenges has set the path, has dabbled in the investigation of projects related to the direct uses of geothermal energy, to date we can say that with the geothermal resource the drying of food such as coffee and seeds is possible, significantly reducing process times, that milk can be pasteurized in a few hours and that we can make the most beautiful candles with the heat of the earth.

It is important to transmit this experience and acquired knowledge, as well as to continue investigating other uses of geothermal heat,

The panorama is broad and the different uses that can be given to geothermal energy go beyond the generation of electricity, we can make a cascade use with the residual energy of the electric generation process and in this way contribute to combat the change climate. With the Direct Uses we can: energize the economies of the populations close to the geothermal power plants, contribute with food security, benefit rural women with direct employment activities, and achieve a better acceptance of the geothermal development in neighboring populations, among others.

LAGEO has the experience and experts, who are the teachers of this course, has the experience of graduates and short geothermal courses, has a trained technical staff, with which LAGEO is positioned as a Geothermal reference in the region.

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