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UNIVERSITY

GEOTHERMAL TRAINING PROGRAMME



LaGeo S.A. de C.V.

A CARIBBEAN GEOTHERMAL SUCCESS STORY

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ABSTRACT

The archipelago of islands that are washed on the East by the Atlantic Ocean and the West by the Caribbean Sea are commonly known as the Caribbean and are closely knit, economically, politically, socially, culturally, spiritually and geographically. Some of these islands show great potential for geothermal development and have been utilising low temperature geothermal applications such as bathing since the early 1600s. According to a series of studies done in the Caribbean Region (Huttrer, 1996; 1998a; 1998b; 2000), collectively these islands have the potential to produce geothermal energy in excess of 16 GWe. Additionally, according to the peak demand forecast from Nexant (2010) these islands would only be using approximately half of this value by 2028.

The recent success story of the Commonwealth of Dominica in its geothermal development has positioned this country to be the next country in 30 years to build a commercial geothermal plant in the Region. Based on the overall objective of this project, the Commonwealth of Dominica would also by 2020 start a Regional Electrical Power Interconnection Grid by supplying the French territories of Guadeloupe and Martinique with 100 MWe via submarine cables.

Following the path laid out by the Commonwealth of Dominica, countries in the Region with similar resources can seek to develop and sell power to the neighbouring countries, hence creating a Caribbean Regional Power Grid. This direction set out by the Commonwealth of Dominica would drastically aid in the economic and social development of the Caribbean Region and contribute positively to Climate Change.

1. BACKGROUND

The Commonwealth of Dominica is a small island nation in the Lesser Antilles Region of the Caribbean. It has a population of 71,293 (2011 Census) and measures 290 square miles. Its economy is primarily based on Agriculture and Tourism. Having no petroleum resources, the energy and transport sectors are susceptible to the fluctuating cost of oil on the international market. However,

with the potential that exists in terms of clean renewable energy production with the natural resources available, Dominica can seek to address those problems and to maintain or improve its status as the Nature Isle of the Caribbean and improve the quality of life of its people.

In 2005, great strides were made with the initiation of an exploration survey which was carried out in the Wotten Waven area in Dominica, in the frame of the Eastern Caribbean Geothermal Development Programme “Geo-Caraïbes” funded by the Organization of American States (OAS). Subsequent to the OAS programme another programme called “Geothermal Energy in Caribbean Islands” or “Géothermie Caraïbes” was initiated by the European Union (E.U), the Commonwealth of Dominica and France under the European INTERREG IIIB Programme “Espaces Caraïbes”. The partners include the Government of the Commonwealth of Dominica (GoCD), the Regional Councils of Guadeloupe and Martinique, Agence de l’Environnement et de la Maitrise de l’Energie (ADEME) and the Bureau de Recherches Géologiques et Minières (BRGM) and CFG Services.

The programme was focused on the Roseau Valley Geothermal Field located about 8km ENE of the Capital of Roseau, which exhibits many surface manifestations including hot springs, fumaroles, phreatic craters etc. The geo-scientific surveys that were conducted by the BRGM group in 2008, identified a potential geothermal reservoir to be investigated and tested by deep exploratory wells.

2. PROJECT DEVELOPMENT

Being guided by the previous studies, the exploratory phase of the project which involved the drilling of three exploratory geothermal wells in the Roseau Valley Geothermal field commenced. The wells were drilled utilizing the ‘Wire-line Coring’ mining technique. A level area of approximately 3000m² was prepared for the drilling rig and related equipment to carry out the drilling and testing activities. The three drilling sites are located in the communities of Wotten Waven (Well site WW-1) and Laudat (Well sites WW-2 and WW-3) respectively (Figure 1).

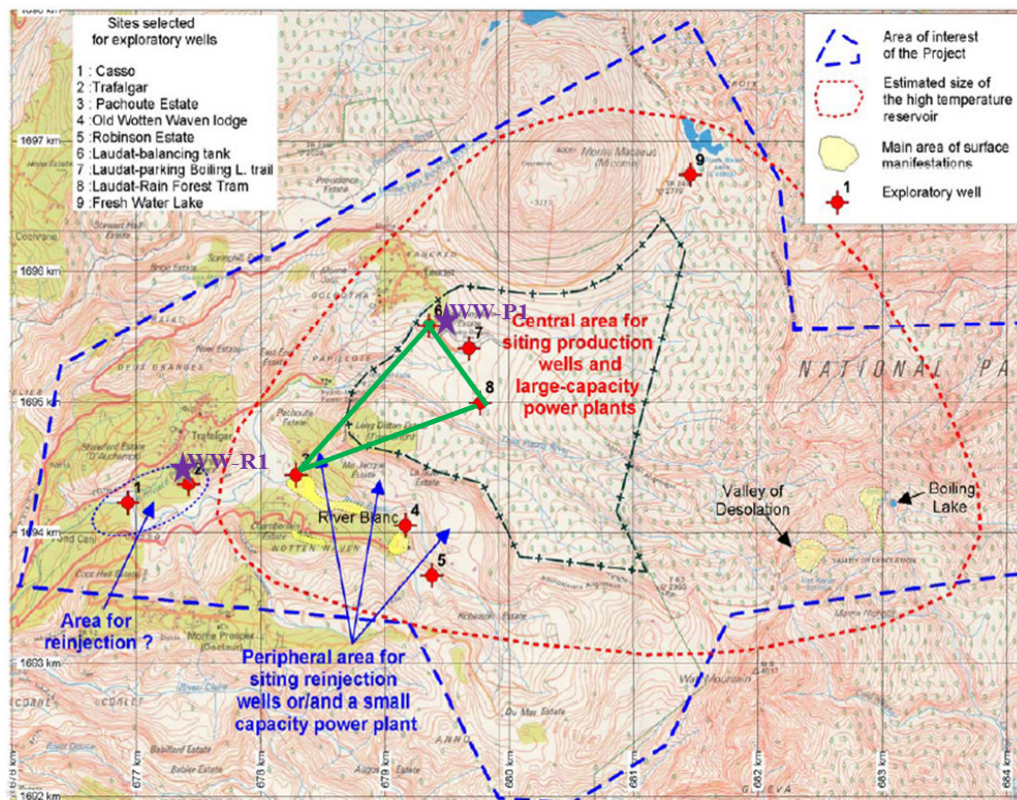


FIGURE 1: Drilling sites

The objective of the exploratory works was to determine the quantity and quality of the geothermal resource in the Roseau Valley, how this resource reacts to economic and technical exploitation and the level of electricity which could be generated to provide a cheaper source of energy for Dominica. Once successful, the overall long term objective would be the construction of a geothermal power plant to meet local demand and to sell surplus electricity to the neighbouring islands of Guadeloupe and Martinique via submarine cable.

Preliminary assessments carried out using the available data from the exploration wells drilled and the pre-feasibility studies, confirm that there was in fact sufficient geothermal resources to develop the proposed Small Geothermal Power Plant (SGPP) of up to 15 MW for the local market. The completed flow tests and collected data (Tables 1 and 2) confirm a geothermal resource base of 65 MW at a 90 percent (P90) probability of confidence which is considered to be a usual threshold for commercial developers and financiers (Figure 2) to determine the bankability of an investment.

TABLE 1: Summary of drilling operations for exploratory wells

Activity	WW-2	WW-3	WW-1
Commencement date	16-Dec-2011	15-Feb-2012	28-Mar-2012
Completion date	28-Jan-2012	14-Mar. 2012	27-Apr-2012
Final depth	1469 m	1613 m	1200 m
Depth of 4 ½" slotted liner	1337 m	1605 m	1200 m
Number of days drilling	41	29	31
Total number of work days	65	40	42

TABLE 2: Flow test results of exploratory wells

	WW-2	WW-3	WW-1
Date of flow test	Mar. 9-10 2012	17-Apr-2012	27-Jun-2012
Highest temperature logged	241°C	245°C	238°C
Highest pressure logged	82 bars	98 bars	100 bars
Enthalpy	940 kJ/kg	980 kJ/kg	1028 kJ/kg
Potential generation rate	0.5 MW	2.9 MW	3.9 MW

Having successfully completed the phase of drilling and testing of three exploratory wells and proven the existence of a viable geothermal resource, GoCD has progressed to the next stage of seeking to develop a 10 – 15 MWe Small Geothermal Power Plant (SGPP) within the Roseau Valley Geothermal field. The GoCD has received funding from the AFD by way of a €6.5M concessionary loan agreement for the implementation of the drilling and testing program that basically consists in the drilling and testing of 2 full size wells (a production well [WW-P1] and an injection well [WW-R1]). The sites for drilling are

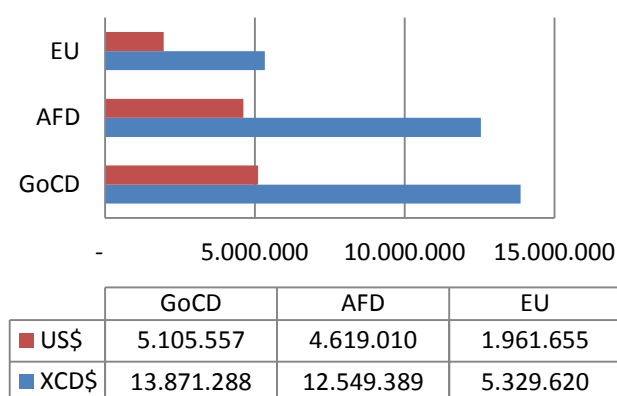


FIGURE 2: Overall cost of exploratory drilling

located in Laudat (Well Pad WW-3) and Trafalgar, approximately six (6) and four (4) miles respectively, from the capital Roseau (Figure 1).

The drilling of the reinjection well WW-R1 started on November 6, 2013 and was completed by December 20, 2013. This well achieved a depth of 1915m and its completion saw the commencement of the directional production well WW-P1 in January 14, 2014 and was completed on March 1, 2014 with a depth of 1505m. The flow test of the production well WW-P1 is planned for the end of May 2014. Preliminary injection tests indicate that the well is highly permeable with temperatures above 230 degrees Celsius, with an expected generation capacity of 5-7 MW.

Being the Nature Isle of the Caribbean, the GoCD seeks to consider all the relevant impact such a project will have on key aspects of the country such as the Environment. Therefore, the Environmental Impact Assessment (EIA) for the drilling of two production wells commenced at the end of August 2013 prior to the disturbance of any flora or fauna in the desired area. The EIA was funded by the Regional Council of Guadeloupe and was carried out by a number of consulting firms to include:

- Caraïbes Environnement is a consulting firm based in Guadeloupe with 18 years of experience in conducting EIA's.
- ASCONIT Consultants is a private consulting firm specialized in Water Resource Monitoring and Management and is based mainly in Guadeloupe and Martinique since 2005.
- TERANOV is a consulting firm with expertise in Geothermal Energy.
- Eclipse Inc. is a local Management Consulting Firm which specializes in Natural Resource Management, Environmental Impact Analysis, and Ecological Analysis among others. Their main focus for this EIA study will be as Experts in Flora and Fauna.

3. FUTURE PROSPECTIVE

The future advancement of the geothermal success story for the Commonwealth of Dominica lies in the effort of the GoCD in seeking to develop a 10 – 15 megawatt Geothermal Power Plant within the Roseau Valley Geothermal field in keeping with the initial objective laid out in this project. It is envisaged however, that this development will occur in incremental phases, which will be determined in the production planning stage, and based to a large extent on the productive capacity of the wells, the scale at which a base-load geothermal power plant can be absorbed on the local grid and to the dictates of local demand.

The development of the Small Geothermal Power Plant (SGPP) is intended to reduce the cost of electricity to consumers, and will also serve as a pilot and demonstration plant which would allow for further assessment of the resource and to observe the reaction of the reservoir to commercial exploitation, thereby guiding the planning and management of the further exploitation and development of the resource to provide electricity for Martinique and Guadeloupe by way of a 100 – 120 MW Large Geothermal Power Plant (LGPP).

Technical Assistance Team ELC is carrying out this feasibility study with assistance from the World Bank and other international experts. Similarly the GoCD is working closely with the Dominica Electricity Services Limited (DOMLEC) and the Independent Regulatory Commission (IRC) in terms of integrating geothermal energy into the current energy mix and to assess whether any regulatory changes to the existing concession agreement would be deemed necessary. The first phase of the SGPP is slated to be commissioned by the end of 2015 or first quarter of 2016.

The development strategy as put forward in the 2008 study under the INTERREG III B programme proposed 10-20 MW for the Dominican Market and 50 MW each for Martinique and Guadeloupe.

The proposed configuration would include 4 x 30 MW units situated in the community of Laudat (Figure 3).

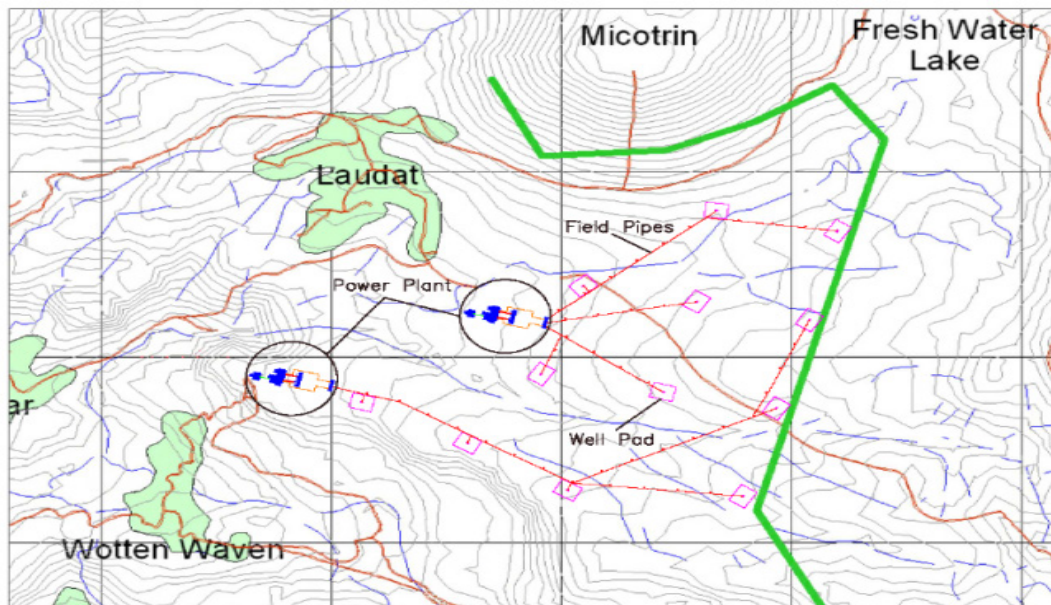


FIGURE 3: Proposed locations for drilling pads and power plant Facilities

A tentative time schedule for the large scale development of the geothermal project (portion to be exported) are:

- 60 MW, Units 1 and 2 on line – 4th Quarter of 2018; and
- 60 MW, Units 3 and 4 on line – 4th Quarter 2020

The total estimated cost to develop the large scale geothermal project for the export of electricity to Guadeloupe and Martinique including the interconnection between the three islands is US \$450 M – \$500 M.

4. IMPLICATION FOR THE OTHER EASTERN CARIBBEAN COUNTRIES

The bold steps taken by this small island state has open the eyes of the neighbouring islands in that the creation of a Caribbean interconnection grid can be a real and practical solution to the staggering increase in fuel prices on the international arena (Nexant, 2010). After 30 years from the installation of a 4.5 MWe double flash geothermal plant in Bouillante in Guadeloupe (Maynard-Date and Farrell, 2011), the Caribbean Region is now seeing its second commercially viable geothermal plant to be installed in short order in the Commonwealth of Dominica.

According to a series of studies done in the Caribbean Region (Huttrer, 1996; 1998a; 1998b; 2000) collectively, these islands have the potential to produce geothermal energy in excess of 16 GWe. And based on work done by Nexant (2010), the peak demand forecasted for the region including countries from the Republic of Dominica in the North to Grenada in the South is only half this amount (8.1GWe) at peak by 2028.

The distances between the islands in the Caribbean are relatively short and the countries are already deeply entwined sharing common climatic challenges; economic hurdles etc; and organisations such as CARICOM are becoming acutely aware that energy independence can help to eradicate some of the

Region's problems and strategically position the Region for economic and social growth. This can be easily done with the development of geothermal energy on the islands that has the potential (those islands found on the inner arc) and then creating an interconnection with submarine cables. The longest distance from island to island will remain shorter than the longest submarine cable found in the world.

Work envisioned in the Commonwealth of Dominica with the addition of the French territories of Guadeloupe and Martinique to their electrical grid is expected to start the process of this Regional interconnection grid. With future geothermal development in islands such as Nevis (Maynard-Date and George, 2013), Montserrat (Jamaica Observer, 2012), St. Lucia (Kaye, 2010), St. Vincent and Grenada (Battocletti, L., 1999) the Region is place to reduce its dependency on fossil fuel and contribute significantly to the reduction of green house effect not to mention improve on the economic standing of the Region.

5. CONCLUSION

In the case of the Commonwealth of Dominica, the island is poised to develop its first commercial geothermal power plant and only the second geothermal plant of that type in 30 years within the Caribbean Region. The results from the exploratory phase have confirmed the existence of a commercially viable geothermal resource which can address the high energy costs that currently exists not only for this country but for neighbouring territories. Attaining the objectives listed in the development of its geothermal resource would also start the Region's Electrical Power Interconnection Grid with the addition of French territories by 2020.

This success story for the Commonwealth of Dominica can be motivational to other countries in the Region that share similar resources and through the development of these resources, the Caribbean can see a significant reduction for some and total for others as it related to fossil fuel dependency for energy generation.

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