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GEOTHERMAL DEVELOPMENT PROGRESS IN THE EASTERN CARIBBEAN ISLANDS

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ABSTRACT

The actual geothermal activities in the last year have dropped in comparison to the projected development plans. These 11 volcanic islands of the Eastern Caribbean lying on the inner arc have an estimated power potential of 16,310 MWe collectively, according to USDOE studies. Guadeloupe as of 2004 has an operating facility of 15.7MWe and is the only island in the region harnessing power for its geothermal resource. St. Lucia, Nevis and most recently Dominica have drilled exploratory wells to analyse the resource for commercial exploitation. The British territory of Montserrat in February 2012 has issued an invitation of interest to private companies interested in the exploration of the expected superheated geothermal resource on the north side of the island. The most significant progress seen for this period is being financed by the Government of Dominica, European Union and the French Development Agency in the drilling of 3 exploration deep vertical wells in Dominica. The first of these wells have been completed as of January 28th 2012 and the second well has started.

1. INTRODUCTION

The archipelago of islands stemming from Bahamas in the North to Trinidad and Tobago in the South is commonly referred to as the Eastern Caribbean Islands. Within this chain of islands, geothermal activities have been found on the islands that lie on the active inner arc on the Caribbean plate. The Caribbean Plate is mostly an oceanic tectonic plate covering approximately 3.2 million square kilometres in area (Olego, 2012). It borders with the North and South American Plate along with the Cocos Plate (Figure 1). The active subduction zone formed from the oceanic lithosphere of the Atlantic Ocean subducting under the thicker Caribbean Plate give rise to these discrete islands that start as far North as Saba and stretch to Grenada in the South as see in Figure 2. The eastern (outer) arc is older and has extinct volcanoes while the western (inner) arc is younger and has dormant to active volcanoes. The two arcs are joined at Martinique and trend southward into the Paria Peninsula of Venezuela (Maynard-Date and Farrell, 2011).

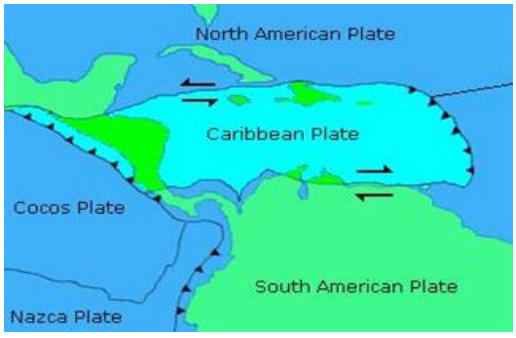

FIGURE 1: Caribbean Plate (Olelog, 2012)

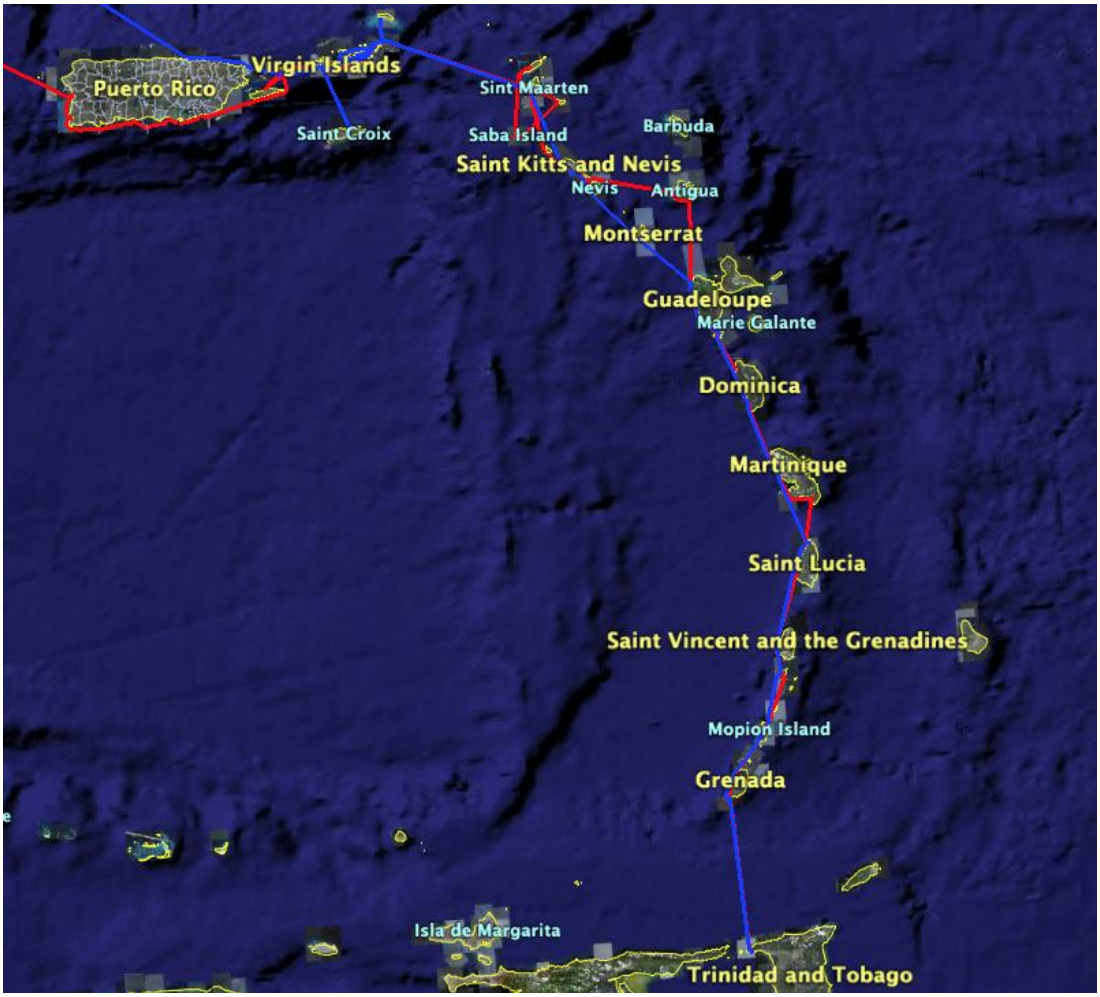

FIGURE 2: Map of the Eastern Caribbean (Svaurora, 2008)

Collectively the Eastern Caribbean islands have a total of 21 volcanoes (Table 1) with an estimated power production of approximately 16,310MWe according to the USDOE studies conducted in the region (Joseph, 2008; Huttrer, 1996; Huttrer, 1998 (a and b) and Huttrer, 2000). These islands use only a fraction of the possible power they can generate via geothermal energy thus the excess power can be exported to neighbouring islands.

2. PRE 2011 GEOTERMAL ACTIVITIES IN THE EASTERN CARIBBEAN

In 2008, the government of Saba signed an agreement with West Indies Power Holdings (WIPH) to conduct exploratory work for geothermal resources and such work started in 2009 (Maynard-Date and Farrell, 2011). However, no type of drilling has taken place on the island thus far.

In the case of Nevis, various studies have been done all strongly pointing to the existence of a possible rich commercial geothermal energy deposit on the western side of the island.

In 2007 the Nevis Island Administration (NIA) granted license to WIPH to do exploratory work in this area. As part of their work 3 slim-hole wells were successfully drilled (see Table 2). These wells were named Nevis 1-3 respectively. Nevis 1 and 3 were found to be self-flowing wells with down hole and well head pressure of 82 and 16 bars respectively, Nevis 3 being the more impressive of the two. Nevis 2 did not flow since upon reaching a depth of 732 m the drill bit got stuck and since a temperature of 260ºC was reached at this point, drilling was abandoned and operation moved to the

TABLE 1: Caribbean countries with volcanoes (Stewart, 2000)

Country	Name of Volcano
Saba	Mt. Scenery
St. Eustatius	The Quill
St. Kitts	Mt. Liamuigua
Nevis	Nevis Peak
Montserrat	Soufrière Hills
Guadeloupe	La Soufrière
Dominica	Morne Aux Diables
	Morne Diablotins
	Morne Trois Piton
	Wotten Waven/Micotrin
	Watt Mt.
	Valley of Desolation
	Morne Anglais
	Grand Soufrière Hills
	Plat Pays Volcanic Complex
Martinique	Montagne Pelée
St. Lucia	Soufrière Volcanic Centre
St. Vincent	The Soufrière
Grenada	Kick 'em Jenny
	Ronde/Caille
	Mt. St. Catherine

subsequent well now known as Nevis 3. In the three years that followed, the geothermal progress on the island slowed tremendously, largely due to financial reasons and worsened with the economic downturn internationally, the involvement of the IMF in the Federation and the political undercurrents within the island.

On the French territory of Guadeloupe, a 4.5MWe double flash geothermal plant was installed in 1984 which supplied electrical energy to the leeward coast of Basse-Terre and was later upgraded to a 15.7 MWe in 2004.

During the initial stage of this project between 1969 and 1970 three production size wells were drilled and named Bouillante 1-3 accordingly. These wells, Bouillante 1-3 reached depths and temperatures of 800m at 220ºC; less than 400m at 242 ºC and 445 m at 240ºC (Battocletti, 1999) respectively. Bouillante 3 was later deepened to 850m but with little change in the production rate. Bouillante 4 was drilled to 1200 m but was a poor producer (Maynard-Date and Farrell, 2011). With the success of the geothermal programme in Guadeloupe in 2004 - expansion of the plant, it encouraged the French authorities to extend work to Martinique. The EDF/CFG conducted geophysical studies and shallow drilling that year with the hope of harnessing power. The results were inconclusive and deep drilling was recommended to prove geothermal potential on the island.

In a joint venture between the Commonwealth of Dominica (Dominica) in 1977 and the French Bureau de Recherches Géologiques et Minières (BRGM) geothermal exploration started in Dominica and 3 areas namely, Wotten Waven, Boiling Lake and Soufrière were identified as potential geothermal sites for commercial development. In 1982 BRGM expanded its exploration program and focused on Boiling Lake and Wotten Waven. The government of the Commonwealth of Dominica continues to work jointly with BRGM to develop the Wotton Waven area. WIPH was granted license in 2008 to explore and develop the geothermal resources in the last of the three sites identified in 1977, the Soufrière area and have done some degree of surface exploratory work.

In St. Lucia, seven exploratory wells ranging in depth form 116m to 725m were drilled by Mertz and McLellan, four of which were found to be productive. Later in the 1980s, Aquater (Italy), Los Alamos National Laboratory (funded by USAID), and the UN Revolving Fund for Natural Resources Exploration (UN/RFNR) and USAID conducted prefeasibility studies which included drilling production-size exploratory wells. Two deep wells drilled (SL-1 at Belford, SL-2 at Sulphur Springs); only SL-2 (1413 m) was productive with a flowing enthalpy of 2900 kJ/kg and a flow rate of 9.3- 17.5 kg/s. Fluids from SL-2 had a high gas/steam ratio (up to about 25% in weight), high H_2/H_2S ratio, HCl in the condensed steam, and high acidity (pH of 2.8) (Maynard-Date and Farrell, 2011) This well

TABLE 2: Slim hole wells information (WIPH, 2008a and b)

Well	Year	Depth (m)	Pres. (bars)	Temp (ºC)
Nevis 1	Jun. 2008	1065	82	250
Nevis 2	Jul. 2008	732	-	260
Nevis 3	Oct. 2008	899	16	201

however suffered mechanical failure and was closed. In March 2011, Qualibou Energy Inc., reported that the due diligence between them and the government of St. Lucia had concluded (ThinkGeoEnergy, 2011a). The company is expected to develop a 120MWe plant by 2015 starting with 15MWe by 2012 in the first stage (Kaye, 2010).

Minor work had been done in St. Vincent and the Grenadines since the 1990s despite the numerous surface manifestations on the island. Between1995-1996 prefeasibility studies were conducted by USAID. In 1997 to 1998, Growth Capital Holdings (GCH) an American company, signed a MOU with the government to conduct geological studies and selected drilling target. WIPH formed a joint venture with Government to develop the geothermal resources on the island and conducted geological, geophysical and geochemical surveys in 1998 (Maynard-Date and Farrell, 2011).

2. POST 2010 GEOTERMAL ACTIVITIES IN THE EASTERN CARIBBEAN

The island of Montserrat since 1995 had experienced a series of eruptions which affected two thirds of the island and resulted in the migration of the larger portion of its population. It currently services an energy demand of approximately 2MWe and wishes to develop geothermal resources in the designated safe zone (north of the island). This development is expected to harness power in excess of the island's demand therefore consideration will be given to the sale of the excess energy to neighbouring island/s.

The government of Montserrat has issued in February 2012, an invitation for expression of interest to private companies for the confirmation and exploitation of the expected superheated geothermal resource on the north side of the island (Jamaica Observer, 2012). The interested companies are expected to show that they possess the necessary technical know-how and have a sound economical standing to finance the drilling stage of the project. The press release indicated once the developer is successful, they will be given the opportunity to install a generating plant that can meet the present and future needs of the island. As a backup plan, the government will seek public funding to drill for this resource once the expression of interest does not meet their requirement.

The Commonwealth of Dominica (Dominica) started exploratory drilling in the last quarter of 2011 with the objective of determining the energy potential of the geothermal resource in the Wotten Waven area. This project is being funded by the Government of Dominica, the European Union and the French Development Agency (ThinkGeoEnergy, 2011b).

The initial phase of the project is to drill a series of three deep exploratory wells in the Wotten Waven Geothermal Field located in the Roseau Valley (detail of sites can be seen in Figure 3). These vertical wells will be drilled to a maximum depth of 1500m and employing the wire-line coring technique. The Dominican government has secured the services of Iceland Drilling Company (IDC) as the drilling contractors; Iceland GeoSurvey (ISOR) for well testing; Geothermal Resource Group (GRG) for drilling supervision and Offshore Civil & Marine Inc. (OCM) for site preparation. The scope of work is expected to be achieved under the USD 6.29 million signed contract (ThinkGeoEnergy, 2011a).

On December 16th 2011, the first well started at Trafalgar (WW-1) (Figure 4). It reached a depth of 1,469m; 185^{0}C and was completed within 65 days of start date on the 28th of January 2012. During the 65 days, 41 of those days were spent drilling. The completed well had the following features: 18-5/8" conductor casting; 13-3/8" casting to 24.5m; 9-5/8" casting to 79.5m; 7" production casting to 427.5m and 4-1/2" perforated liner to 1337m.

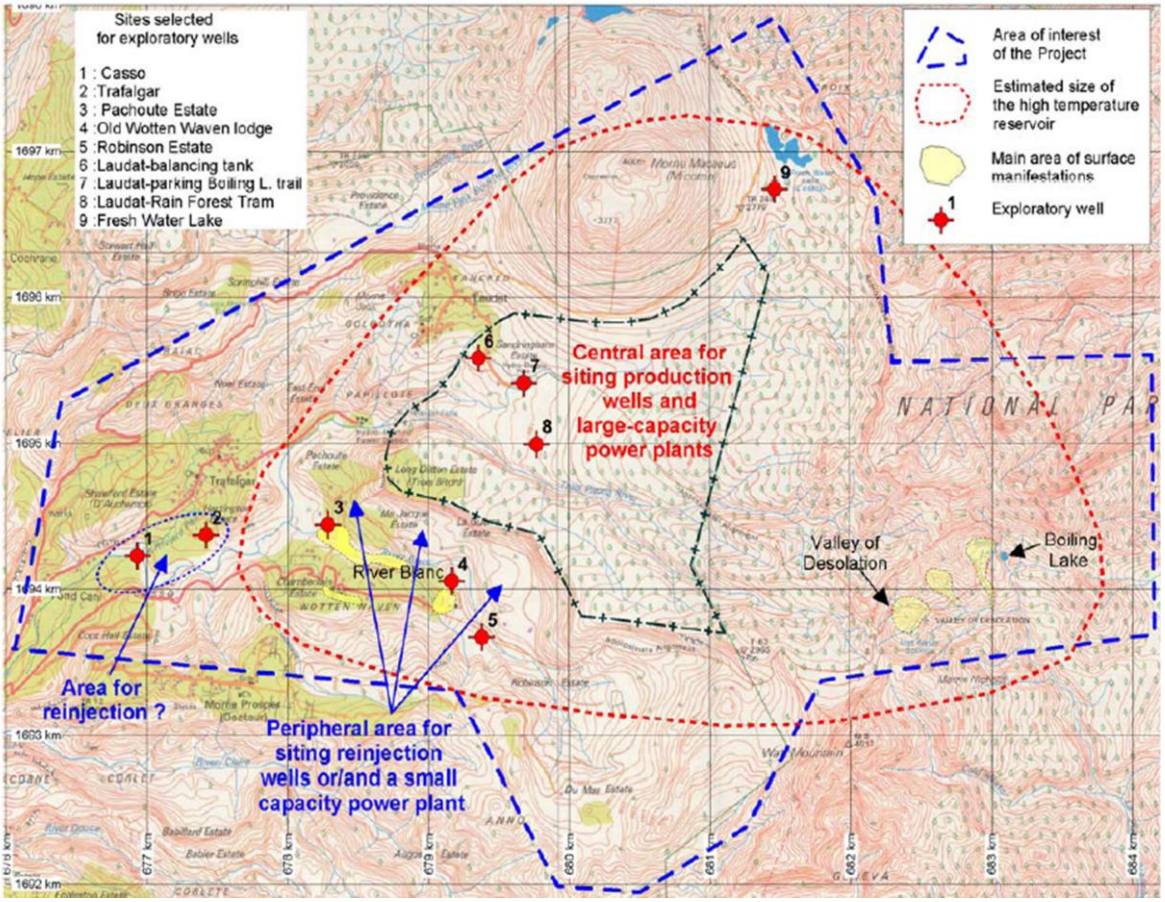

FIGURE 3: Dominica's drilling plan

There were some challenges faced in the drilling of the first well at Trafalgar. These include:

1. Access route to drill pad due to winding roads.
2. Loss of circulation of drilling fluid at shallow depths cause for use of more cement so that the area can be plugged.
3. Drillers encountered a zone of soft rock between 430-570m and the presence of gas caused an increase in well head pressures and resulted in the collapsing of the well.
4. Blockage along depth of the well created difficulties in the placement of the 4 ½ "slotted liner.
5. All of the above problems resulted in the increase in drilling time and an increase in the cost of the well.

Work has started at the second designated site at Rain Forest Aerial Tram – Laudat (WW-2) and upon completion of this well it is expected that work will proceed to the third and final well at DOMLEC's Balancing Tank – Laudat (WW-3).

This exploratory stage of the geothermal development in Dominica is setting the stage for the construction of a 5-10MWe geothermal plant. This plant is expected to be expanded to a 120MWe to supply the neighbouring French territories of Guadeloupe and Martinique with electrical power.
The Commonwealth of Dominica is by far the country in the Eastern Caribbean that experiences the most significant geothermal development in recent times and if its rate of development continues in this manner it is likely to be the second country in the Eastern Caribbean to have an operation commercial geothermal facility.

3. DISCUSSION AND CONCLUSION

FIGURE 4: Trafalgar (WW-1) drill site

The geothermal activity in terms of prefeasibility studies in the Eastern Caribbean dated as far back as the 1950s. Nonetheless, only one operating geothermal facility has been built in the region thus far. A few of the islands have drilled exploratory wells but confirmation on the size of the reservoirs have not been ascertained as yet on any of the other islands. The development of geothermal facilities in the Eastern Caribbean islands takes on the same profile since the project size is usually limited by the power demand. This realization provokes its own set of problems since it will not attract many drilling companies thus reducing the bargaining power of the country. Often times the lack of experience in geothermal development in the Eastern Caribbean leave decision makers guessing as to the right approach to adopt to develop the natural resource.

The fundamental problem faced in the regions is the 'economies of scale' in that geothermal development is a capital intensive venture while power demands on the islands are relatively low, hence the rate of return on investment will usually be slow. Therefore to make projects of this nature more appealing to the investors, the possibility to export power will have to be explored.

Additionally, since financial institutions regard the initial exploration and drilling stage to be risky, the decision makers may find it fruitful if they themselves secure funding through grants for this stage. Once this approach is successful then the project becomes more viable and consequently the bargaining power increases for the country.

Part of the solution to the problem faced in the Caribbean regarding geothermal development is human resource capacity building. It becomes vital that each Head of State in the Caribbean understands firstly, that geothermal possibilities do exist in the Eastern Caribbean and the science to explore, harness and transport electrical energy throughout the region is not new. What may be new to the Caribbean are the various disciplines that are needed by the people to develop its own natural resource. With the explosion of geothermal activities within the region, greater attention must be placed on capacity building. This will serve to reduce the labour cost of the project and empower the people in developing and protecting its inheritance.

In all this it is understood that development of this resource has numerous benefits to the socio-economic growth of the Caribbean. The region is also cognizant of the fact that the development of this resource must be done in a sustainable manner to ensure that the profit can be exploited for generations to come. With no foreseeable relief in the oil prices, the price of electricity might only be reduced with the use of geothermal energy. The people of the region will also see an increase in jobs; the reduction in harmful emissions; benefits of secondary utilization of the excess heat and growth in the economy.

In conclusion, geothermal activities and development in the Eastern Caribbean is occurring too slowly. The growth is primarily being affected by 'economies of scale'. Some recommendations that can be employed to enhance the development are:

1. Human Resource capacity building.
2. Securing funding/grants to complete the exploratory and drilling stage of the project in-house.

3. Explore the possibility to build a submarine interconnection electrical grid within the region so that the power demand can be increased relative to the host country.

With these simple improvements in the approach within the region the resource can be developed in a sustainable and controlled manner.

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