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GEOTHERMAL STATUS, PROGRESS AND CHALLENGES IN THE EASTERN CARIBBEAN ISLANDS

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ABSTRACT

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 (Huttrer, 2000). Guadeloupe nonetheless still remains the only country in the region to have a geothermal plant. This 4.5MWe double flash power plant was installed in 1984 and was later upgraded to 15.7MWe in 2004. The Commonwealth of Dominica during the period of 2011 - 2012 was able to successfully complete a series of 3 exploratory wells and is slated to start the production wells with the Iceland Drilling Company in 2013. The British territory - Montserrat has also forged ahead in the development of their geothermal resource securing funding to start the drilling of 2 full size production wells on the 20th of February 2013. On the down side, works in Nevis have stopped for some time initially because of financing and most recently due to litigations between the developer WIPH and the Nevis Island Administration (NIA). The geothermal status for the region continues to evolve but at a much slower pace that previously envisioned. Its challenges such as financing and human resource building persist yet the islands are slowly finding ways to combat these issues so that more of the estimated potential of the region can be harnessed and used for the advancement of the counties.

1. INTRODUCTION

The Eastern Caribbean has been defined in terms of politics, culture, language, geographical location etc. but for the purpose of this paper, it will be considered to be largely the islands sitting on the Caribbean Plate. The Caribbean Plate is bordered by the North American Plate, Cocos Plate and the South American Plate (Figure 1). This group of islands form two archipelagos starting with Saba in the North and joining at Martinique then trending southward into the Paria Peninsula of Venezuela (Maynard-Date and Farrell, 2011) as can be seen in Figure 2. The outer of the two arcs host the older extinct volcanoes whereas those in the inner arc have numerous surface manifestations of geothermal activities. The Caribbean Plate is mostly an oceanic tectonic plate covering approximately 3.2 million square kilometres in area and is thought to

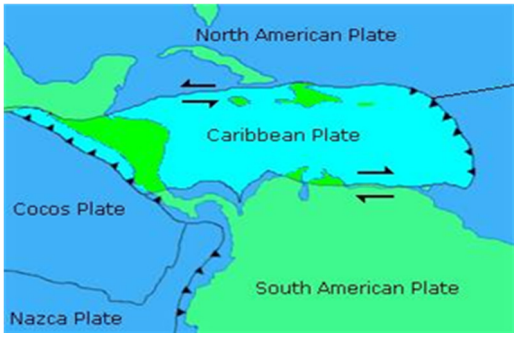

FIGURE 1: Caribbean Plate (Olelog, 2012)

be a large igneous province that formed in the Pacific Ocean tens of millions of years ago. The subduction of the western edge of the Atlantic Ocean floor under the thicker layer of the Caribbean Plate gave rise to the chain of islands in this archipelago (Olego, 2012).

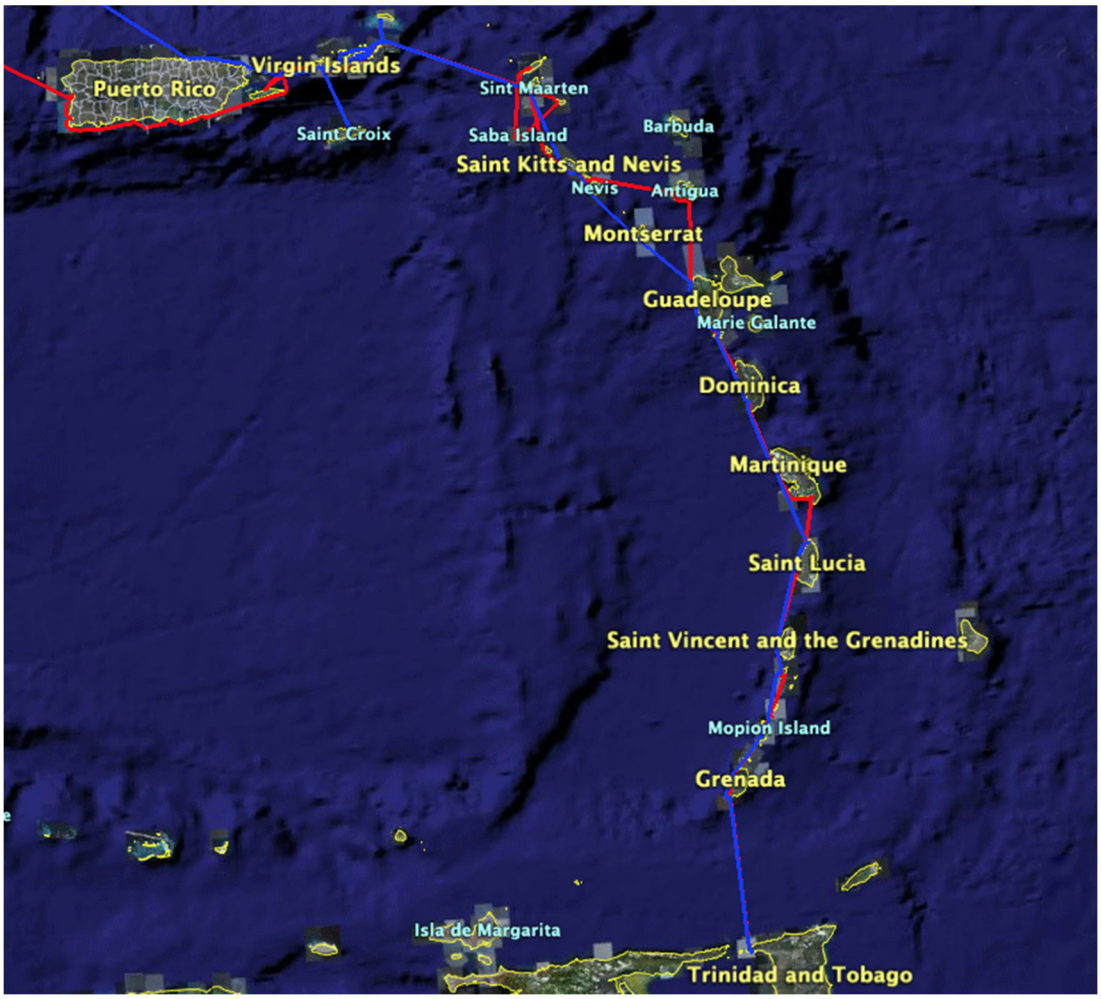

FIGURE 2: Map of the Eastern Caribbean (Svaurora, 2008)

2. HISTORY OF GEOTHERMAL ACTIVITIES IN THE EASTERN CARIBBEAN

Historically, documentation of geothermal activities has been recorded as early as the 1950's by P.H.A. Martin-Kaye in the Caribbean (Maynard-Date and Farrell, 2011). In 1969 to 1970, the French territory of Guadeloupe drilled a series of 4 wells at Bouillante reaching maximum temperature and depth of 242^{0}C and 1,200m respectively. Guadeloupe went on further in 1984 to build the first geothermal plant in the Eastern Caribbean which supplies electricity to the leeward coast of Basse-Terre. The initial plant was a 4.5 double flash plant which was later expanded in 2004 to 15.7 MWe (Maynard-Date and Farrell, 2011).

Guadeloupe is not the only island in this archipelago that saw investigative work done in terms of geothermal advancement. In 1998, prefeasibility studies were done on 11 islands on the inner arc by the United States Department of Energy (USDOE) (Huttrer, 1998a). The findings revealed an estimated 16,310MWe (Huttrer, 1998 (a&b)) of untapped geothermal energy throughout these islands collectively.

This work prompted further development for the Eastern Caribbean islands with the signing of Memorandum of Understanding (MOU) with government to do geological and related drilling works on St. Vincent with an American Company called Growth Capital Holdings (GCH). Another MOU was signed with the government of St. Lucia and UNEC Corporation of United States, a subsidiary for Qualibou Energy Inc., to build a 120MWe by 2015 (Kay 2010).

In 2007 to 2008, the government of Saba, Nevis and Dominica signed agreements with West Indies Power Holdings (WIPH) to conduct exploratory work for geothermal resources. Not much work was done in Saba or at the Soufrière site in Dominica where license was granted to WIPH.

In 2008, 3 slim-hole wells were drilled by WIPH in Nevis reaching maximum temperature and depth of 260^0C and 1,065m respectively (Table 1).

TABLE 1: Slim hole wells information (WIPH, 2008a and b)

Well	Year	Depth (m)	Pressure [Bott. hole] (bar)	Pressure [Well head] (bar)	Temp (ºC)
Nevis 1	Jun. 2008	1065	82	-	250
Nevis 2	Jul. 2008	732	-	-	260
Nevis 3	Oct. 2008	899	-	16	201

In the case of the Commonwealth of Dominica (Dominica), from a joint venture between government and the French Bureau de Recherches Géologiques et Minières (BRGM) geothermal exploration started as early as 1977 in Dominica and 3 areas namely, Wotten Waven, Boiling Lake and Soufrière were successfully identified as potential geothermal sites for commercial development (Maynard-Date and Farrell, 2011).

3. PROGRESS IN GEOTERMAL ACTIVITIES IN THE EASTERN CARIBBEAN

3.1 The Dominican story

The exploratory drilling phase of geothermal project in Dominica which is jointly funded by The European Union (EU) who contributed 1.45M Euro and the French Development Agency (AFD) 4.0M euro. This donation was used for the drilling of the exploratory well, well testing, drilling and well testing supervision and advisory and technical assistance support to the GPMU. The European Investment Bank (EIB) has pledged 1.1M Euro which will go towards the feasibility and engineering studies for a submarine electrical interconnection of Dominica with Martinique and Guadeloupe and to define the optimal power rating of the new electrical link. ADEME funded the drilling Environmental Impact Assessment (EIA). The study was undertaken by Caraïbes Environment from Guadeloupe.

TABLE 2: Slim hole wells information for Dominica

Well	Year	Depth (m)	Bottom hole pressure (bar)	Temp (ºC)
Rain Forest Aerial Tram- Laudat	Jan. 2012	1469	82	241
Domlec's Balancing Tank - Laudat	Mar. 2012	1613	98	245
Wotten Waven	Apr. 2012	1200	108	180

From prior work done on Dominica, the three drilling sites are located in Wotten Waven (Well site WW-1) and Laudat (Well sites WW-2 and WW-3) respectively (Figure 3). Work started in December 2011 and by April, all 3 exploratory wells were successfully drilled (Table 2 and 3).

Having successfully completed the drilling and testing of three exploratory wells (see test results in Table 3) and proven the existence of a viable geothermal resource, the GoCD is now seeking to develop a 10 – 15 megawatt Geothermal Power Plant within the Wotten Waven Geothermal field. 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, and to the dictates of local demand.

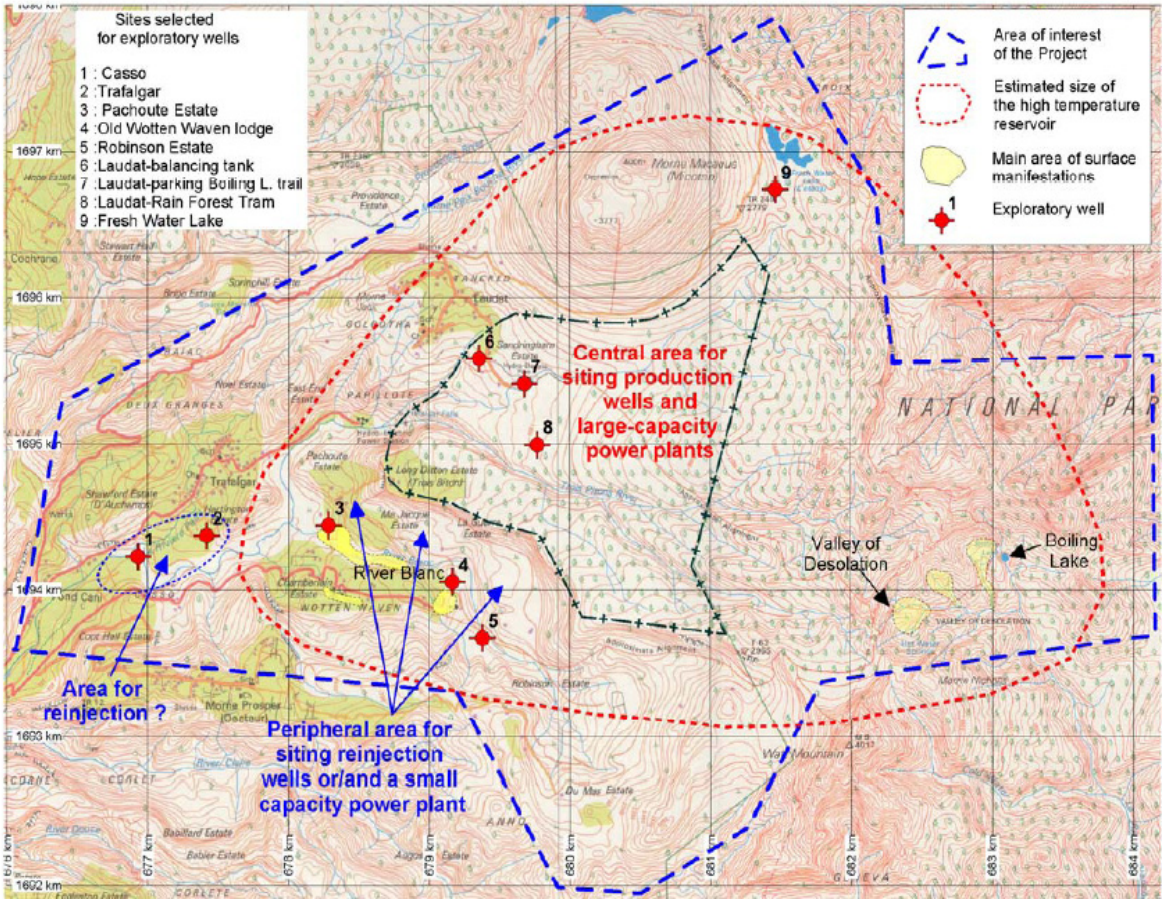

FIGURE 3: Dominica's drilling plan

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. The GoCD is currently engaged in negotiations with prospective investor Electricité de France (EDF) for the development of the small plant as well as the larger plant for export.

TABLE 3: Well summary flow results for Dominica

Well	Enthalpy (kJ/Kg)	Output (MWe)	Total estimated flow (kg/s)
Rain Forest Aerial Tram- Laudat	940-980	0.5	6.4-6.6
Domlec's Balancing Tank - Laudat	-	2.9	22
Wotten Waven	1010-1051	3.9	27.5

As a result the GoCD is also carrying out a feasibility study regarding a submarine electrical interconnection of Dominica with Martinique and Guadeloupe and to define the optimal power rating of the new electrical link, through funding from the European Investment Bank (EIB) in the sum of €500,000.00.

On Monday December 10, 2012 a drilling contract was signed between the GoCD and Iceland Drilling Company (IDC) to drill two full size wells, one production (1500-1800 m in depth) and one reinjection well (1300-1400 m in depth). Contract sum €4,735,171.00 (exclusive of VAT) Estimated commencement date – May/June 2013.

3.2 Montserrat progress in geothermal development

The government of Montserrat 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 Iceland Drilling Company won the bid to do the drilling and drilling is expected to start on February 20, 2013. This has move the geothermal development from a pre-exploration stage to an exploration phase. All works have been completed on the site for drilling to commence and well lining materials have all been delivered to site along with the drilling rig. During the exploration phase where geological, geophysical and geochemical analyses were done along with a financial risk analysis, the results yielded a focused zone of high probability between Garibaldi Hill and Weekes Village (Figure 4). Based on these findings, it was believed that there will not be much gained from drilling slim hole wells and hence, 2 production size wells are slated to be drilled between Weekes and Garibaldi Hill. The expected depth lies around 1,400-1,600m, however the rig has the capability to go up to 2,000 m. One of the wells will be used for reinjection so they will be positioned 550 m apart to prevent circulation.

FIGURE 4: Montserrat's drilling site (Google earth map)

It is the hope of the developers to meet the 2 MWe demand of the island and for such reason will be installing a 2.5MW plant upon successful completion of the wells.

4. CHALLENGES WITH GEOTHERMAL DEVELOPMENT IN THE EASTERN CARIBBEAN

In the Eastern Caribbean the fundamental problem in the development of geothermal energy is the availability of funds. The countries in the Eastern Caribbean find it quite difficult to self fund these projects. Moreover, securing financial assistance from independent companies or lending institutions

pose similar challenges since the rate of return on investment is very slow due to the small power consumption of these discrete islands. Serious consideration need to be given to the creation of a regional grid or even a 2-3 islands grid to make the project more viable to both developer and the country in question. At present, the region's lack of experience in geothermal development have left some countries with an undesirable taste to the development of geothermal energy. The region has seen developers starting projects and setting unrealistic timelines and reaping nothing at the end of it all. Also due to the lack of education on geothermal in the region, the schools are not equipping the youth with geothermal friendly subjects and as such the country has little to no technical personnel to deploy into this area. Additionally, the lack of education lends itself to secondary problems such as exploitation by developers and self servicing groups who may wish to sabotage the progress for personal gain. In the case of the development of geothermal on Nevis, the project was stopped due to litigations brought again WIPH by the Nevis Island Administration (NIA), the case was won by NIA (Da Vibes Inc., 2013) giving them the right to develop the resource themselves or invite an independent developer, however an appeal has been made to the Courts on the ruling.

The list of challenges is not exhausted by any means, nonetheless, the region continues to address them and overcome them for the betterment of the country.

5. DISCUSSION AND CONCLUSION

The Eastern Caribbean islands are beautifully placed on the Caribbean plate in an archipelago stemming from Saba in the North and extending to Grenada in the South. Of these islands, only 4 of the 11 islands that have some form of commercial source of renewable energy being supply to their grid. The countries were renewable energy exist include Dominica and St. Vincent and the Grenadines with hydro-electric plants, Guadeloupe with the only geothermal plant and Guadeloupe and Nevis with wind farms. The hydroelectric and geothermal plants are considered to be base load plants but none of the installed plants contribute 50 or above percentage to the overall power consumption. This means that a significant amount of the power generated in these discrete islands are as a result of diesel usage whose price is subjected to the international market.

To become more energy independent, there is a dire need for more base load type of energy such as geothermal. The benefits to be gained from geothermal development are far reaching and for a third world country it is extra-phenomenal. The forward movement of Dominica and Montserrat in geothermal energy advancement is encouraging and their experience is creating a plateau from which the other countries can move off in the development of their own resource. The region has great potential and must be seized in order for the area to develop. Serious consideration needs to be given to a regional grid since islands such as Antigua & Barbuda and Barbados can benefit from these resources. This too will assist in making the project more viable for the investors since collectively, economies of scale will be achieved.

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