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Geothermal Resources Development in Rwanda: A Country Update

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ABSTRACT

The Government of Rwanda is looking at future strategies for solving the country's needs for electricity by developing over 500 MWe in the next 4 years through diversified least cost and cost reflective sources of electricity. Rwanda has no indigenous fossil fuels and the small hydro resources are almost fully developed. The other potential sources are from peat, shared hydro sites and methane gas from Lake Kivu.

When looking at available options for energy, the concept of geothermal appears one option, given that the resource is proven and the development cost is acceptable. To determine the viability of the geothermal resources, exploration wells are currently being drilled on the southern slopes of Karisimbi volcano which is one of the four identified geothermal prospects in the country.

This paper presents the current status of geothermal exploration, issues affecting geothermal and the programmatic approach of geothermal resources development in Rwanda.

1. INTRODUCTION

The Republic of Rwanda is a small landlocked country in east central Africa along the western branch of the Great Rift Valley. The country is bordered by Tanzania (east), Uganda (north), Burundi (south) and the Democratic Republic of Congo (west) (Figure 1). The total area of the country is 26,338 km^2 with a population of 11 million inhabitants.

Figure 1: Geographical setting of Rwanda in the regional context (Photo RNW)

Rwanda is currently confronted with an energy supply problem due to the rapid growth of the population and limited energy resources. Most of the population uses wood as their basic energy need leading to an increasingly scares of fuel wood and thus creating deforestation. Biomass dominates as the principal source of primary energy for 85% of the population followed by imported petroleum fuels for 11% dominating the local industries energy supply. In the third level is electricity which account for 4% and is currently used by 16% of the population. The electrical energy in Rwanda is currently predominantly on diesel generation followed by hydropower, which is limited due to low rainfall and an increasing demand for electricity. The high prices of oil are putting a strain on the national budget and constitute presently a serious hurdle to the economic growth for a landlocked developing country such as Rwanda.

Overall, the country's vision is to ensure universal access to electricity from both grid and off-grid solutions. Detailed plans have been developed to spread the electricity network across the country. In tandem with the relocation driven by urbanisation and resettlement policy, this should bring the grid within reach of around 48-50% of the population (Ministry of Infrastructure, 2013).

The present total generation capacity available in Rwanda is about 110 MWe, with hydro-generation accounting for 54% and 46% from fuel fired plants. The cost of electricity is still high with an average end-user cost at US$ 23 cents/kWh for domestic consumers despite heavy government subsidies. For industrial consumers, the tariff is US$ 29 cents/kWh during peak hours and US$ 16 cents/kWh for off-peak hours under a time-of-use tariff regime. This situation cannot allow a financially sustainable off-

taker and discourages investments into the sector. Therefore, to minimize the dependency on energy imports, save foreign currency and create conditions for the provision of safe, reliable, efficient, cost-effective and environmentally appropriate source of energy, geothermal development seems to be the long term solution that could end the current energy crisis.

The development of geothermal energy resources in Rwanda is at early stages compared to some East African countries such as Kenya and Ethiopia. The exploration of this resource really boomed in 2006 with a view of diversifying energy sources in the generation of electricity and meeting the electricity demand in the country. The volcano areas, the geological context and the hydrothermal manifestations of Rwanda are an indication of the possible existence of potential geothermal systems. Early geothermal investigations (Egbert et al., 2009; Mariita et al., 2010) pointed out the north-west area as a potential for large, high temperature geothermal systems, while the rift in the south-west part of the country along Lake Kivu is believed to present an environment for low to moderate temperature resources (Demange et al., 1983 and Newell et al., 2006) but these predictions are being reviewed in consideration with the recent exploration drilling results in the northern part of the country.

The strategy of the Government of Rwanda (GoR) is to know how much geothermal potential is available for the country to meet its energy demand. This step will be implemented by drilling exploration wells in potential geothermal areas to prove the existence of the resource.

2. BACKGROUND ON GEOTHERMAL EXPLORATION

Geothermal investigations in Rwanda started in the 1980's but the existence of geothermal resources in identified geothermal prospect areas still needs to be confirmed through drilling. Several reports exist, indicating two areas as prospective zones for geothermal energy; the first zone (Gisenyi, Karisimbi, and Kinigi) in the north-western region, which is associated with volcanoes and the second zone (Bugarama) in the southern region associated with faults in the East African Rift (Figure 2). Among the four prospects, the development activities for Karisimbi are the most advanced followed by Kinigi and Gisenyi. Bugarama on the other side is still at a reconnaissance stage to be followed by geo-scientific survey to estimate the potential of this area

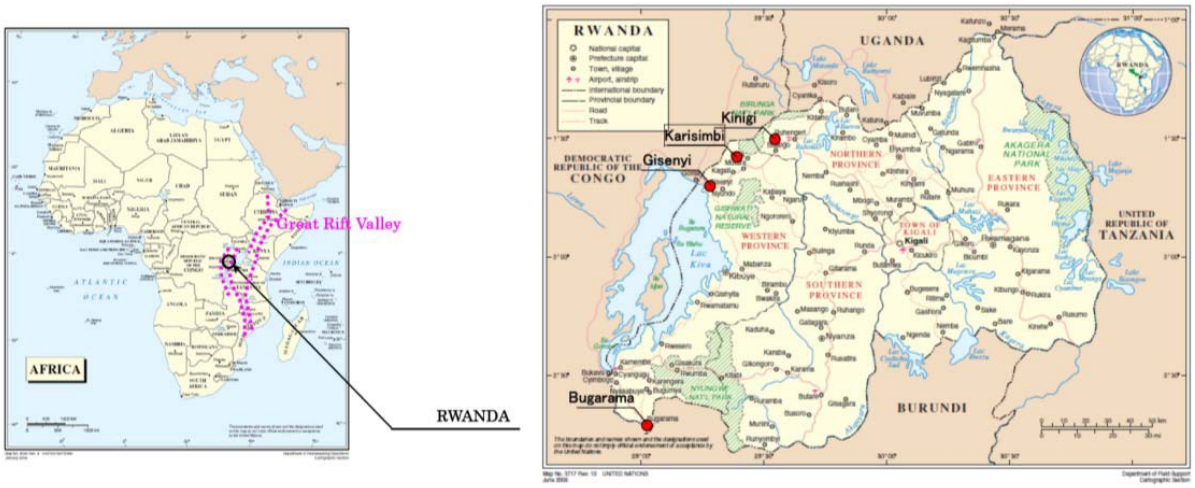

Figure 2: Geothermal potential prospect areas in Rwanda (West JEC et al., 2013)

Serious investigations on Rwanda geothermal resources started in 2006 with a view of diversifying energy sources for electricity generation and meet the electricity demand in the country. Surface exploration studies to prove the resource have been carried out in several phases:

In 1983, the French Bureau of Geology and Mines (BRGM) identified Gisenyi and Bugarama as potential sites for geothermal energy with estimated reservoir temperatures of over 100°C (Demange et al., 1983).

In 2006, Chevron carried out geochemistry studies in the Bugarama and Gisenyi geothermal prospects and estimated the geothermal reservoir temperatures to be more than 150°C (Newell et al., 2006).

In 2008, the Germany Institute for Geosciences and Natural Resources (BGR), in collaboration with the Kenya Electricity Generating Company (KenGen), the Icelandic Geo Survey (ISOR) and the Spanish Institute for Technology and Renewable Energies (ITER) carried out surface studies in the Gisenyi, Karisimbi and Kinigi areas. The results from this study concluded that a high temperature geothermal system (>200°C) may exist on the southern slopes of Karisimbi volcano and that a medium temperature geothermal system may exist around Lake Karago (150-200°C) (Egbert et al., 2009).

In 2009, KenGen acquired additional surface studies (geochemistry and geophysics) and carried out a baseline environmental impact assessment (EIA) on the southern slopes of the Karisimbi Volcano. Findings recommended drilling three exploration wells in the Karisimbi prospects (Mariita et al., 2010).

In 2011, an additional geothermal survey was done by the Institute of Earth Science and Engineering (IESE) through Auckland UniServices, New Zealand aiming at developing a conceptual model for the entire western region and locating a site for exploration drilling in the three prospects, Karisimbi, Kinigi and Gisenyi (Shalev et al., 2012).

Workshops were organised in 2012 and 2013 with panel of experts aiming at merging all findings, to come up with one unified model for the Karisimbi area allowing for the definition of the location of sites for exploration drilling in Karisimbi (EWSA, 2012 and EWSA, 2013).

Presently, the four geothermal prospects can be ranked as shown in Table 1.

Table 1: Exploration status for Rwanda geothermal prospects

Geothermal prospects	Reconnaissance study	Detailed survey	Wells sited	Wells drilled
Karisimbi	yes	yes	yes	yes
Kinigi	yes	yes	yes (1)	no
Gisenyi	yes	yes	yes (1)	no
Bugarama	on-going	no	no	no

3. CURRENT GEOTHERMAL EXPLORATION

3.1 Karisimbi prospect

The Karisimbi area is located near the Karisimbi volcano within the National Volcano Park and Virunga volcanic chain complex. Detailed surface geo-scientific studies and Environmental and Social Impact Assessment (ESIA) have been completed. Drilling of three deep exploratory wells (Figure 3) was planned and currently drilling of two wells (KW01 and KW03 in the figure) is completed by Great Wall Drilling Company (GWDC). Drilling materials were supplied by the China Petroleum Development and Technology Corporation (CPTDC) The rehabilitation of the road to the drilling site was carried out by a local company ERGECO and the water supply system to the site and civil works was awarded to a Kenyan Company, YASHINOYA limited.

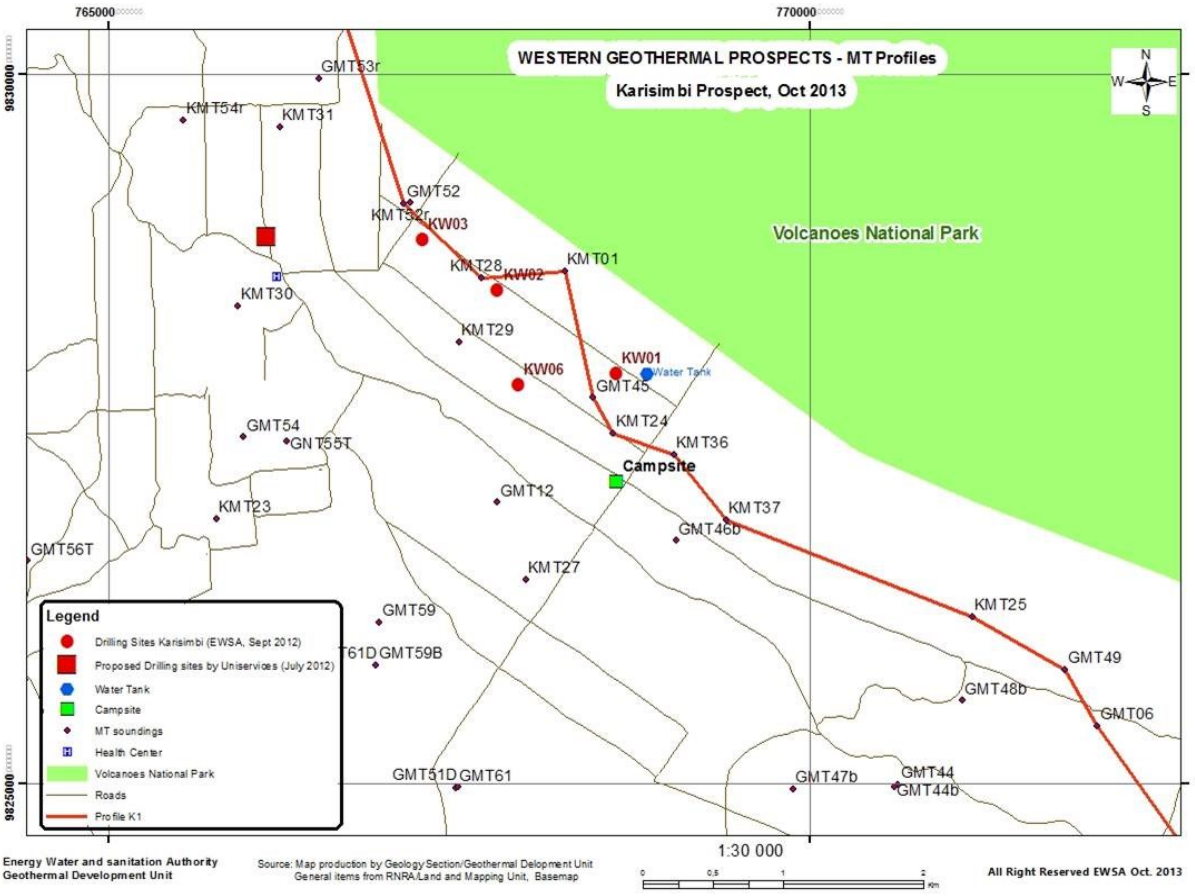

Figure 3: Location of wells in Karisimbi prospect (GDU, 2013)

Well testing services was provided by the Geothermal Development Company (GDC) from Kenya. Technical assistance prior to drilling was provided to the Geothermal Development Unit by the Japanese International Cooperation Agency (JICA). On the job

training during drilling was provided by the Icelandic Geological Survey (ISOR) through funding from the Icelandic International Development Agency (ICEIDA). The drilling supervision for the first well was carried out by Reykjavik Geothermal Company (RG) and funded by the Nordic Fund through the Nordic Environment Finance Corporation (NEFCO) and the drilling supervision of the second well was provided by Geothermal Resources Group (GRG) experts in collaboration with GDC.

Exploration drilling began with the Karisimbi prospect area in July 2013 with two wells (KW01 and KW02) at 3,003 m and 1,367 m, respectively; however it was observed from the two wells that there was no evidence of the existence of a geothermal system in the area. This led to the decision of halting the drilling activities on March 22nd, 2014.

The way forward is to review all the studies available for the geothermal sector in Rwanda to identify possible gaps in data collection or in on-going work and provide an action plan and a budget for future activities.

3.2. Kinigi prospect

The Kinigi geothermal area is located to the east of Karisimbi (Figure 2). Detailed surface studies as well as an Environmental and Social Impact Assessment (ESIA) have been completed. Additional studies for updating the conceptual model of Kinigi geothermal prospect was proposed and submitted to the United Nations Environmental Programme (UNEP) for support. The terms of reference are currently being reviewed by UNEP. The Government of Belgium through Belgium Technical Corporation (BTC) is committed to support exploration drilling in this area. This contribution should cover the infrastructure works and the drilling of three exploration wells. In addition to these initiatives, the Government of Rwanda has submitted an Expression of Interest to the Geothermal Risk Mitigation Facility (GRMF) for support in infrastructure and exploration drilling

3.3. Gisenyi Prospect

The Gisenyi geothermal prospect is located south of Karisimbi (Figure 2) and is defined by a NW trending resistivity anomaly aligned with Nyiragongo and Nyamuragira active volcanoes in the Democratic Republic of Congo (DRC) and hot springs at the shore of Lake Kivu. Surface studies have been completed. Additional studies to complement existing geophysical, geological and structural data in the Gisenyi area and to quantify geothermal potential and locate sites for drilling 3 exploration wells have been proposed and submitted to the European Union (EU) for funding.

3.4 Bugarama

The Bugarama geothermal prospect is located in the southern part of Rwanda (Figure 2). The geothermal manifestations in this area are hot and warm springs and travertine deposits, which is being mined as feedstock for a nearby cement factory. This prospect probably extends into Burundi and the Democratic Republic of Congo. No detailed geo-scientific work has been carried out in this area.

A regional geothermal exploration study funded by the EU was started in November 2013 for the three countries, Democratic Republic of Congo, Burundi and Rwanda. The exploration study will conclude with location of targets for 1 deep exploratory well drilling. The project is financed by EU and the consultancy firm hired for this project is RG. Great Lakes Energy Agency (EGL) is mandated for the coordination of this regional project.

4. OTHER INITIATIVES

A detailed Geothermal Strategy and Geothermal Act have been developed which will both be formally approved. The short term strategy is to take geothermal exploration to a next level by drilling multiple exploration wells to map the geothermal resources in different prospects in the country. In the mid-term, proving the presence and feasibility of geothermal resources is a necessary step in attracting private investors who could scale up the geothermal energy production. In the long term, the plan is to develop over 300 MWe of least cost, base load and environmentally friendly geothermal energy through public and private sector partnerships. This geothermal strategy is being reviewed through the EU Energy Initiative Partnership Dialogue Facility (EUEI PDF) by the consulting firm Fichtner. This study will considered the current information from geothermal exploration in the country and will result in developing a new strategy for geothermal exploration and the definition of the approach to private sector involvement in geothermal development of the country. The geothermal policy and law draft was reviewed by UNEP and submitted to the government for approval.

JICA is supporting the development of a master plan for the geothermal energy development in the country. The study is expected to be finalized in February 2015 and is executed by West Japan Engineering Consultants (West JEC). The master plan will provide a clear plan of priorities for the exploration of potential geothermal sites in the country.

Technical assistance and capacity building are provided and financed by several institutions; JICA, ICEIDA, the United Nations University Geothermal Training Programme (UNU-GTP), the African Rift Geothermal Development Facility (ARGeo), EUEI and others.

A new institutional framework for the Geothermal Development Unit (GDU) in the Energy, Water and Sanitation Authority (EWSA) is being discussed with development partners involved in the geothermal sector in Rwanda to fast track the geothermal programme in the country.

5. ISSUES AFFECTING THE DEVELOPMENT OF GEOTHERMAL ENERGY IN RWANDA

Theoretically, the estimates of geothermal energy potential can supply all the national power needs for Rwanda for the next 10 years. However, the pace and level of development of geothermal resources has not been effective. This is mainly due to lack of funds and the perceived risk in developing geothermal resources. Financing from multilateral institutions or international lenders is difficult without adequate data. The GRMF is one of the alternatives to be utilized. Based on the request from the African Union Commission (AUC) to submit expression of interest for GRMF, Rwanda has submitted Kinigi prospect for exploration drilling.

Geothermal energy development generally has very high project development costs. Unlike diesel plants, where you can purchase the fuel when required, in geothermal you have to prove the availability of the fuel (steam) in advance before power construction.

Other issues affecting the development of geothermal energy are marketing, institutional, and policy impediments. The role of geothermal development in the energy mix needs to be clearly defined with set and funded targets to prove the viability of a geothermal resource. There is need to share and disseminate information among all stakeholders and potential investors. The fear of developing geothermal energy has to be overcome among policy makers and opinion leaders. There is a need to build adequate human resource capacity while at the same time encouraging local education institutions to provide training relevant to geothermal development. Clear guidelines on the level of participation of local communities and other stake holders in geothermal development and utilization are required.

6. CONCLUSIONS

Rwanda has very positive indicators of geothermal prospects, which can be exploited commercially for electricity generation and industrial uses. Four potential geothermal areas, Karisimbi, Gisenyi, Kinigi and Bugarama have been identified and two exploration wells have been drilled in the Karisimbi area. There is however a need to carry out a thorough assessment of the data to minimise the risks of sinking unproductive wells. A criterion for sitting wells needs to be established. A cautious approach will be utilised in the exploration program to increase the success rates. The establishment of a legal and regulatory framework and agreed geothermal exploration strategy are urgently required. Furthermore, to implement effectively the geothermal development plan of the country, additional staff should be hired and trained, and institutional provisions must be developed for GDU.

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