



GEOHERMAL EXPLORATION IN RWANDA: STATUS REPORT

Uwera Rutagarama
Energy Development Corporation Limited
Rwanda Energy Group
Kigali
RWANDA
urutagarama@edcl.reg.rw

ABSTRACT

Rwanda is looking at future strategy for solving the country's needs for electricity by developing over 500 MWe in the next 3 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. To resolve the increasing demand of electricity and diversify its energy resources, Rwanda has put its focus in developing the existing potential energy sources from peat, shared hydro sites and methane gas from Lake Kivu. When looking at other available options for energy, the concept of geothermal appears one option, given that the resource is proven and the development cost is acceptable. This paper outlines the background and current status of geothermal exploration including the initiatives for future exploration and development of geothermal resources in Rwanda.

1. INTRODUCTION

Rwanda is currently confronted with energy supply problem due to rapid growth of population and limited energy resources. Most of the population use 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 used by 24% of the population.

Overall, the country vision is to ensure universal access to electricity from both grid and off-grid solutions, over the EDPRS II period (Economic Development and Poverty Reduction Strategy). 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. [Energy Sector Strategic Plan (ESSP) 2013-2018 (ESSP), 2013]

The Strategic Plan (2013-2018) projects electricity demand of 563 MW to be generated from a sustainable generation mix of hydro, methane, peat to power and solar to gradually phase out thermal power within two years. The Government of Rwanda plans to achieve additional 400 MW compared to current installed capacity. The current total installed generation capacity available in Rwanda is 160 MWe from hydro, thermal, Solar and Methane gas. The cost of electricity is still high with an average end-user cost at US\$ 24 cents/kWh for domestic consumers despite heavy government subsidies. For industrial consumers, the tariff is US\$ 16 cents/kWh. This situation cannot allow a financially sustainable off-taker and discourages investments into the sector. Therefore, to minimize the dependency on energy imports 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 solutions 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 for electricity generation and meets the electricity demand in the country. The volcanoes area, 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 the 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 of the Northern part of the country.

The current 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 analysing in detail the previous exploration work, identifying the gaps, carrying out detailed surface exploration in all potential prospects in order to rank them and finally exploration drilling to prove the existence of the resource.

2. BACKGROUND ON GEOTHERMAL EXPLORATION

Rwanda is located along the Western branch of the Great Rift Valley. The geothermal potential was estimated at 170-340 MW by the Geothermal Energy Association in 1999 (GEA, 1999). Geothermal investigations in Rwanda started in the 1980's but the existence of geothermal resources in the identified geothermal prospects is still to be confirmed. Several reports exist, indicating two areas as prospective zones for geothermal energy; the first zone (Gisenyi, Karisimbi, and Kinigi) in the north-western region associated with volcanoes and the second zone (Bugarama) in the southern region associated with faults in the East African Rift (Figure 1).

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 baseline environmental impact assessment (EIA) on the southern slopes of the Karisimbi Volcano. Findings recommended drilling three exploration wells in the Karisimbi prospect. (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 sites for exploration drilling in the three prospects, Karisimbi, Kinigi and Gisenyi. (Shalev et al., 2012).

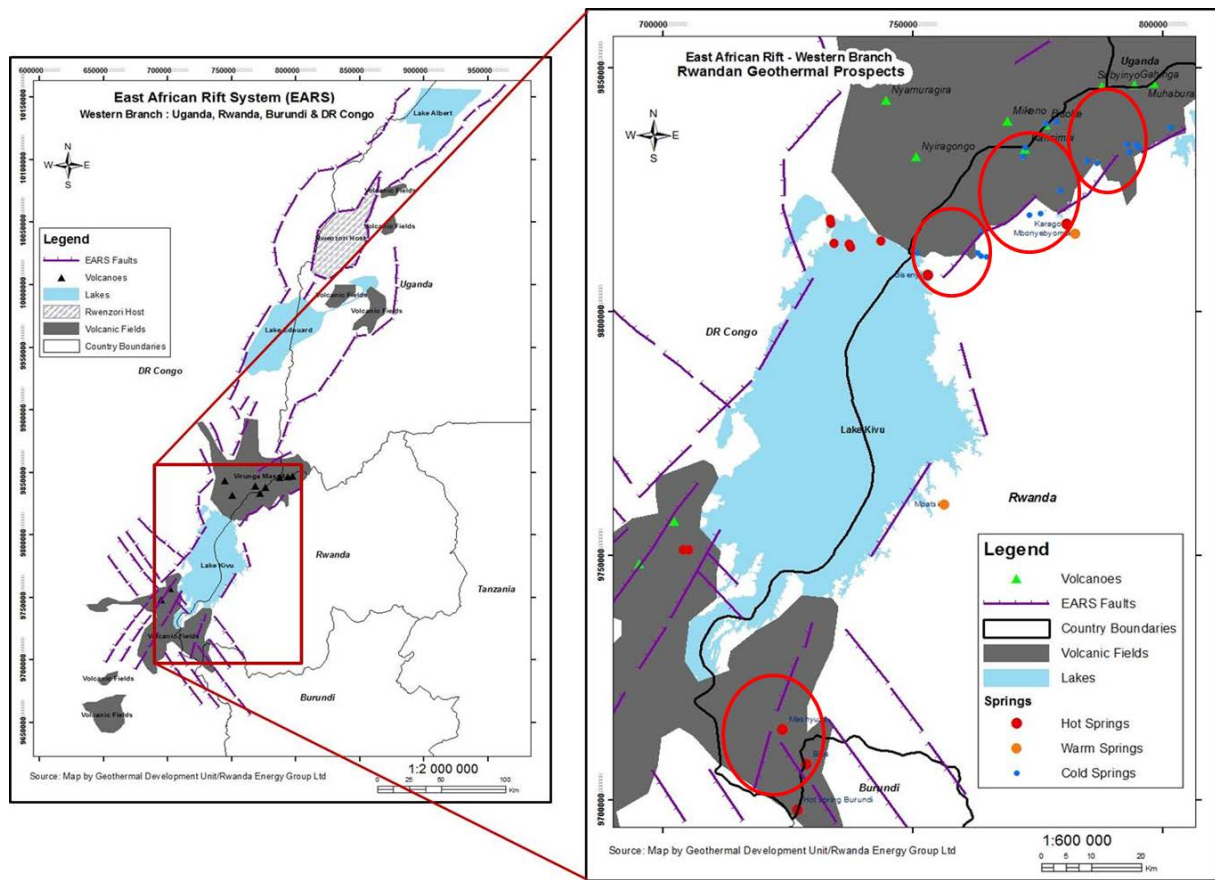


FIGURE 1: Location of Rwanda geothermal prospects (GDU, 2014)

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)

In 2013-2014, two exploration wells were drilled in the southern slopes of the Karisimbi volcano to 3,015 and 1,367 m depth, respectively. Alteration mineralogy and measured temperatures are consistent with normal continental geothermal gradient (i.e. ~30°C/km) conclusively demonstrating that there is not a geothermal reservoir under the southern slopes of Karisimbi.

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

TABLE 1: Exploration status for Rwanda prospect (Rutagarama, 2015)

| Geothermal prospects | Reconnaissance study | Detailed survey | Gradient wells | Wells sited | Wells drilled |
|----------------------|----------------------|-----------------|----------------|-------------|---------------|
| Karisimbi | yes | yes | no | yes | yes |
| Kinigi | yes | yes | no | yes (1)* | no |
| Gisenyi | yes | yes | no | yes (1)* | no |
| Bugarama | yes | yes | planned | no | no |

*: From Shalev et al., 2012

3. CURRENT DEVELOPMENT

3.1 Karisimbi geothermal prospect

The Karisimbi area is located near the Karisimbi volcano within the National Volcano Park and Virunga volcanic chain complex. No geothermal manifestations such as fumaroles or alteration have been reported in the Rwandan part in this area. Couple of hot springs are located south and out of the volcanic field with the highest temperature of 64°C at Karago (Figure 2). Detailed surface geo-scientific studies have been completed and two exploration wells drilled.



FIGURE 2: Location of Karisimbi geothermal prospect (ISOR, 2014)

Drilling of three deep exploratory wells was planned and funded by GoR but only two wells (KW01 and KW03 in Figure 3) were drilled. The drilling contractor was 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 contract for water supply system to the site and civil works was awarded to a Kenyan Company, YASHINOYA limited.

Well testing services were provided by the Geothermal Development Company (GDC) from Kenya. Technical assistance prior to drilling was provided to the Geothermal Development Unit by the Japan International Corporation Agency (JICA). On job training 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) while the drilling management and geology supervision of the second well was provided by Geothermal Resources Group (GRG) in collaboration with GDC as drilling supervisor.

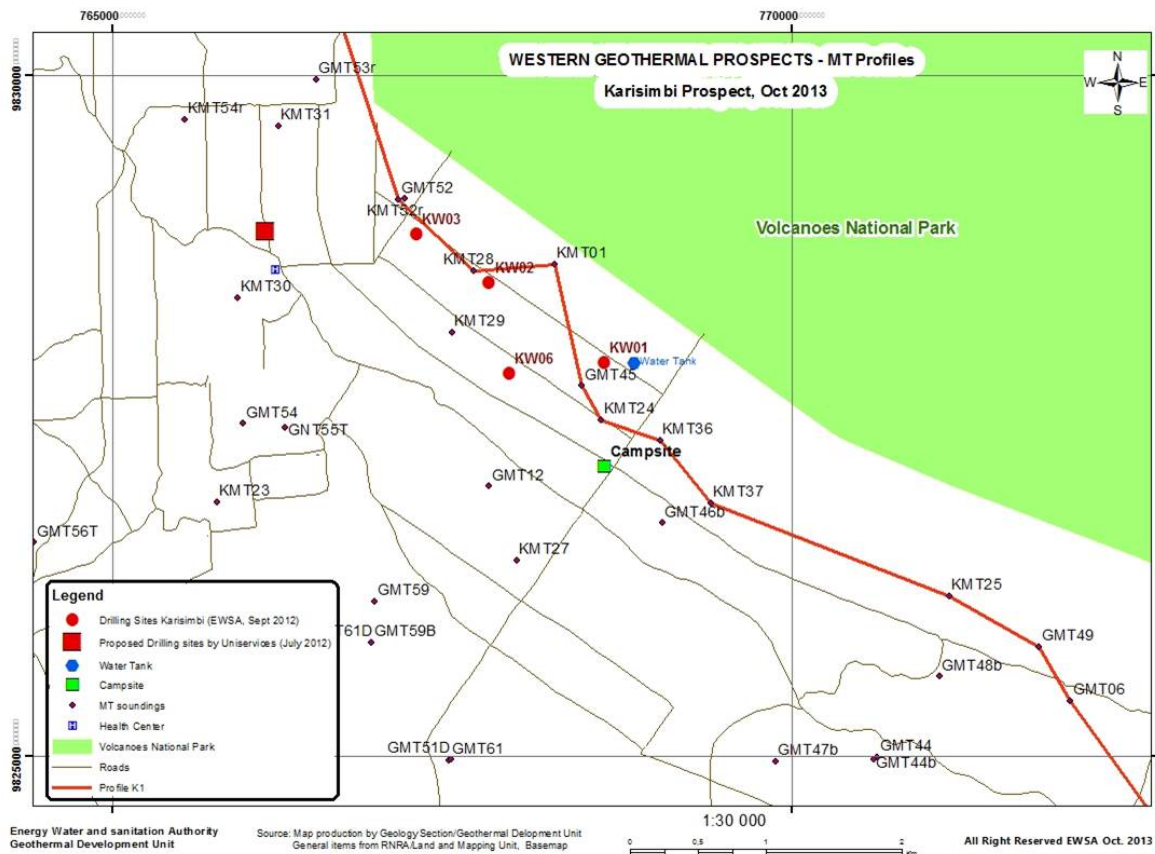


FIGURE 3: Location of drilled wells in Karisimbi prospect (GDU, 2013)

Exploration drilling began with the Karisimbi prospect area in July 2013 with the first well KW01 to a depth of 3,015 m followed by the second well KW02 on December 2013 to a depth of 1,367 m. From these two wells, there was no evidence of the existence of a geothermal system in the area and this led to the decision of halting the drilling activities on March 22nd, 2014.

The existing geo-scientific data and drilling data were reviewed by ISOR and JICA and the results of the analysis was the basis for the elaboration of a new strategy for Rwanda geothermal exploration and development

3.2 Kinigi geothermal prospect

The Kinigi geothermal area is located to the east of Karisimbi (Figure 1). Detailed surface studies as well as Environmental and Social Impact Assessment (ESIA) have been completed. Additional studies are required to decide on the way forward for the exploration of this prospect.

Therefore, additional geoscientific surveys in Kinigi carried out by the West Japan Engineering Consultants (WestJec) and funded by JICA started in June 2015. Geological and gravity surveys have been completed. The final report is expected to be submitted by March 2016. The objective of this study is to update the conceptual model of the Kinigi prospect.

In addition to the above initiative, the Government of Rwanda has submitted an Expression of Interest to the Geothermal Risk Mitigation Facility (GRMF) for support in infrastructure and exploration drilling of slim holes in Kinigi.

3.3 Gisenyi geothermal prospect

The Gisenyi geothermal prospect is located south-west of Karisimbi (Figure 1). Hot springs of about 75°C are located in the prospect at the shores of Lake Kivu. Geoscientific investigations have been carried out in the area. A contract of 6 months for additional studies is being signed with the consortium of GDC and SARL Geo2D. The field work is planned to start end of November 2015. The study will be funded by the European Union Commission (EU).

3.4 Bugarama geothermal prospect

The Bugarama geothermal prospect is located in the southern province of Rwanda (Figure 1). 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. The highest temperature for the springs is about 55°C. This prospect probably extends into Burundi and the Democratic Republic of Congo.

A regional geothermal exploration study funded by EU has started in November 2013 for the three countries, Democratic Republic of Congo, Burundi and Rwanda. The consultancy firm hired for this project is Reykjavik Geothermal (RG). Great Lakes Energy Agency (EGL) is mandated for the implementation of this regional project. Detailed geo-scientific surveys for the three countries are completed. Drilling of thermal gradient wells in the Rwandan part is planned to start by end November 2015.

4. OTHER INITIATIVES

A detailed Geothermal Strategy and Geothermal Act have been developed but are yet to be formally approved. The existing geothermal strategy has been reviewed through the support of EU Energy Initiative Partnership Dialogue Facility (EUEI-PDF) but the final report is yet to be submitted. This study has considered the existing geothermal data and has developed a new strategy for geothermal exploration that will define the approach to private sector involvement in geothermal exploration and development of the country.

Furthermore, JICA supported the preparation of electricity development plan for sustainable geothermal energy development and its integration into the Electricity Master Plan. This master plan gives estimates of the identified potential geothermal prospects based mainly on existing data with an action plan for exploration and development of each prospect. Conclusions indicate a maximum estimation of 90 MWe geothermal resources potential for the country

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

5. ISSUES AFFECTING THE DEVELOPMENT OF GEOTHERMAL ENERGY IN RWANDA

Theoretically, the estimates of geothermal energy potential can highly contribute to the supply of the national power needs for Rwanda. 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.

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 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 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 community and other stakeholders in geothermal development and utilization are required.

6. CONCLUSIONS AND RECOMMENDATIONS

Rwanda has positive indicators of geothermal potential but the resource still need to be confirmed. Four potential geothermal prospects, Karisimbi, Gisenyi, Kinigi and Bugarama, have been identified and two exploration wells were drilled in one prospect, Karisimbi. There is however need in the future to carry out a thorough assessment of the data to minimise the risks of sinking unproductive wells. A criterion for sitting wells therefore needs to be established.

Existing data need to be reviewed and additional data collected in order to define a clear way forward and strategy for geothermal development in Rwanda. A careful approach is to be utilised in the exploration program to increase the success rates in future.

The western branch of the Rift needs to be deeply investigated to understand the geothermal system of this part of the rift. This will help in designing an appropriate strategy for geothermal exploration of countries lying along the western rift including Rwanda.

Considering the high risk for exploration drilling, the GoR should involve development partners and potential investors to assist for the exploration and development of Rwanda geothermal resources. Capacity building is required from the first stage of reconnaissance to the implementation of the project. There is a lack of appropriately trained local graduates from Rwandan Universities in some fields related to earth sciences (geology mainly). On job training is needed for young graduate scientists and engineers to understand the steps for geothermal exploration and development.

REFERENCES

Chevron, 2006: *Preliminary assessment of Rwanda's Geothermal Energy Development Potential*; report for Government of Rwanda.

Demange, J., Fabriol, R., Rançon, J.Ph. and Verzier, P., 1983: *Reconnaissance Géothermique de la République du Rwanda: Rapport de synthèse*. Bureau de Recherches Géologiques et Minières, Orléans, France, 36 pp.

Egbert J., Gloaguen R., Wameyo P., Armannsson H., and Perez P .A. H, 2009. *Geothermal Potential Assessment in the Virunga Prospect, Northern Rwanda*. Report – GEOTHERM 1 for the Rwandese Ministry of Infrastructure by Federal Institute of Geosciences and Natural Resources of Germany

Energy Sector Strategic Plan (ESSP) 2013-2018 (ESSP), 2013.

EWSA, 2012: Proceedings Validation and Peer Review Geothermal Workshop, Kigali, Rwanda 2nd – 4th April, 2012, 54 pp.

EWSA, 2013: Data and Final Report Validation Workshop. Golden Hills Hotel, Kigali Rwanda, 9th – 10th January 2013, 19 pp.

GDU: Map of locations of wells, Karisimbi prospects. Map by Geothermal Development Unit, EWSA. (2013).

GDU: Location of Rwanda geothermal prospects. Map by Geothermal Development Unit, Energy Development Corporation Limited (2014).

Geothermal Energy Association, 1999: *Preliminary report: Geothermal Energy, The potential from clean power to Earth*, Washington DC, USA, 15 pp.

ISOR, 2014: *Geothermal Resources of Rwanda: Assessment of Geoscientific Data and Conceptual Models*; Report prepared for Government of Rwanda.

KenGen, 2009: *MT survey of Virunga geothermal prospect, Rwanda*. The Kenya Electricity Generating Company (KenGen), report prepared for the Federal Institute for Geosciences and Natural Resources (BGR), 48 pp.

KenGen, 2010: *Geothermal potential of the Karisimbi Prospect, Rwanda*.

Mariita, N.O., Wanjohi, A., Opondo, K., Kemboi, E. and Gachau, E., 2010: *Geothermal Potential Appraisal of Karisimbi Prospect, Rwanda (Combined Report)*, 178 p. incl. appendices.

Ministry of Infrastructure, 2013: Energy Sector Strategic Plan (ESSP) 2013-2018.

Newell, D., Rohrs, D. and Lifa, J., 2006: *Preliminary Assessment of Rwanda's Geothermal Energy Development Potential*. Chevron, 27 pp.

Rançon, J., and Demange J., 1983. *Reconnaissance geothermique de la Republique du Rwanda, Rapport geovolcanologique*, BRGM, Paris.

Rutagarama, U., 2015. *Geothermal Resources Development in Rwanda: A Country Update*, Proceedings World Geothermal Congress 2015. Melbourne, Australia, 19-25 April 2015

Shalev, E., Browne, P., Wameyo, P., Hochstein, M., Palmer, J., and Fenton R., 2012 : *Geoscientific Surveys of the Rwandan Kalisimbi, Gisenyi and Kinigi Geothermal Prospects. Final Report*. Institute of Earth Science and Engineering. University of Auckland.

West Japan Engineering Consultants, Inc., Kyushu Electric Power Co., Inc. and Mitsubishi Material Techno Corporation, 2015: *Electricity development plan for sustainable geothermal energy development in Rwanda; Final report*. JICA, Rwanda.