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Geothermal Energy Development in Uganda: A Country Update 2012

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ABSTRACT

Exploration for geothermal energy in Uganda has been in progress since 1993. The studies have focused on three major geothermal areas namely Katwe, Buranga and Kibiro. The three areas are in advanced stages of surface exploration and will soon be subjected to exploratory drilling that will pave the way for a feasibility study. The overall objective of the study is to develop the country's geothermal energy resource in order to complement hydro and other sources of power to meet the energy demand especially in the rural areas. Recent works carried out included geological, geochemical, hydrological and geophysical surveys in order to elucidate subsurface temperatures and the spatial extent of the geothermal resource. The results indicate that the geothermal activity in the three areas is related to the volcanic and tectonic activities of the Rift Valley, which has a higher thermal gradient than the surrounding Precambrian crust. Subsurface temperatures of approximately 140-200˚C for Katwe, 120-150˚C for Buranga, and 200-220˚C for Kibiro have been estimated from geothermometry and mixing models. Anomalous areas have been delineated in Katwe and Kibiro prospects using geophysical methods. Drilling of shallow boreholes to a depth of 200-300m for temperature gradient measurement was carried out. The temperatures measured (30-36˚C/km) were slightly above the global average of 30˚C/km, which suggests that either reservoirs in Katwe and Kibiro are deeper or geothermal reservoirs were offset from the drilled areas. Additional geophysical surveys to locate the deep reservoirs and drill sites in the two areas are recommended. The results will then be used to update the geothermal models that will be a basis of siting and drilling of deep geothermal wells in the two areas. The Buranga area still needs detailed geophysical surveys to delineate anomalous areas that could be targets for drilling. The fourth area, Panyimur in Nebbi district, West Nile region, has indications of a geothermal resource following the results of the petroleum drilling programme that encountered high temperature gradient (maximum 80˚C/km) in the vicinity of the thermal area. Preliminary investigations to promote the area for further studies are under way. Three areas Katwe, Buranga and Panyimur have been licensed to the private sector for exploration and development. Preliminary geothermal investigations on other geothermal areas of Uganda have been done. The results indicate subsurface temperatures in the range of 100-160ºC which is suitable for electricity generation and direct uses. Further geothermal investigations are recommended for these areas.

1.0 INTRODUCTION

1.1 The Geothermal Resources

Geothermal resources were estimated at about 450 MW in the Ugandan Rift System (McNitt, 1982). Most of the geothermal areas of Uganda are all located in the Western Rift Valley that runs along the border of Uganda with the Democratic Republic of Congo, and is part of the western branch of the East African Rift System (Figure 1).

The main geothermal areas are Katwe-Kikorongo (Katwe), Buranga, Kibiro and Panyimur located in Kasese, Bundibugyo, Hoima and Nebbi Districts respectively. Other geothermal areas are located in the South-west, North and North-east Uganda.

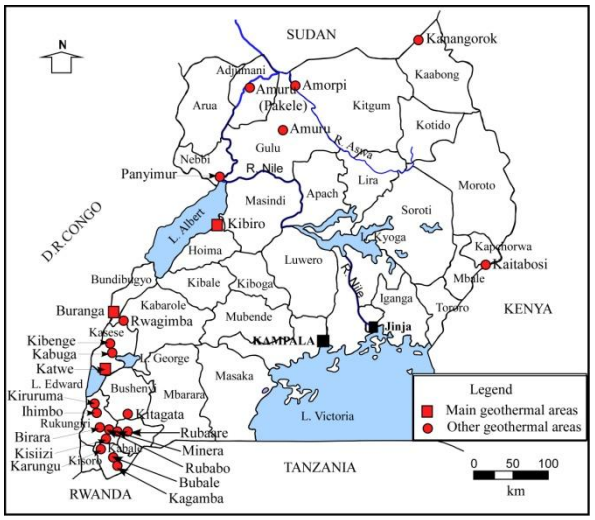

Figure 1: The geothermal areas of Uganda

Geothermal resource exploration in Uganda is still at the pre-feasibility phase with three most promising prospects Katwe, Buranga and Kibiro in advanced stages of surface exploration and will soon be subjected to the drilling of the first deep exploration wells and feasibility studies. Subsurface temperatures of approximately 140-200˚C for Katwe, 120-150˚C for Buranga, and 200-220˚C for Kibiro have been estimated from geothermometry and mixing models. The temperatures are suitable for electricity production and for use in industry and agricultural sectors. Recent geological, geochemical and geophysical surveys have identified geothermal anomalous areas for further investigations and location of drill sites. The temperature gradient results (30-36ºC/km) from shallow boreholes of 200-300m in Katwe and Kibiro prospects, suggest that the source of heat is either deep seated or is offset from the drilled areas. There is therefore a need for additional geophysical surveys using methods which probe deeper into

the subsurface to locate the heat source and its extent, in order to complete surface exploration in the three areas.
The fourth area, Panyimur in Nebbi District, West Nile region, has indications of a geothermal prospect following the results of the petroleum drilling programme that has encountered high temperature gradients (maximum 80˚C/km) in the vicinity of the surface manifestations (hot springs). Detailed surface studies by the Government of Uganda have already started with the aim of locating geothermal reservoirs.

Preliminary geothermal investigations on other geothermal areas of Uganda have been done. The results indicate subsurface temperatures in the range of 100-160ºC, which suitable for electricity production and direct uses.

1.2 The Energy Sector

The country is endowed with considerable hydropower resources with the potential estimated to be in excess of 2,500 MW. Other alternatives being investigated are mainly renewable sources that include geothermal, biomass, wind, peat, mini and small hydros, and solar energy. The discovery of oil in the Western Rift Valley will also contribute to electricity generation.

The country's per capita energy consumption of 30.116 Kwh is among the lowest in the world (Energy statistics, 2006). The grid electricity access rate is very low: 12% for the whole country and about 6% for the rural areas. Electricity production is approximately 2,280 GWh per year with a demand for power growing by 10% per anuum.

1.3 Legal and Institutional Framework

The Ministry of Energy and Mineral Development (MEMD) implements the national energy policy with two departments i.e. Energy Resources (ERD) and Geological Survey and Mines (DGSM) involved in geothermal exploration and development. The DGSM is responsible for exploration and development of the geothermal resources while the ERD is responsible for the formulation and implementation of energy policies and administration of energy laws. The Ministry is undergoing restructuring following new developments like the discovery of oil and the growth of the mineral and energy sectors. The Geothermal Department is proposed to focus on geothermal development in the country.

The Uganda Energy Policy was enacted in 2002 and is operationalized by the Uganda Electricity Act, 1999. This Act provides for an independent Electricity Regulatory Authority (ERA), private sector participation in power generation and distribution with transmission remaining a government parastatal in the medium-term. The major goal of the Energy Policy 2002 is to meet the energy needs of Uganda's population for social and economic development in an environmentally sustainable manner. To achieve the above goal, there is need to tap all possible sources of energy in the country, including the new and renewable sources, to which geothermal belongs. Accordingly, one of the Energy Policy, 2002 objectives is to establish the availability, potential and demand of the various energy sources.

To further focus on the above objective, a New and Renewable Energy Policy, 2007 was enacted. The Policy aims at providing a framework to increase in significant proportions, the contribution of renewable energy in the energy mix. The policy has:

a. Introduced the feed in tariffs;
b. Standardized Power Purchase Agreements;
c. Obligated fossils fuel companies to mix products with biofuels up to 20%; and
d. Introduced tax incentives on renewable energy technologies.

Licensing of geothermal resources is currently done under the Mining Act 2003, which defines geothermal as a mineral. The above legal and institutional framework is not focused on geothermal and therefore a need for an adequate policy and legal framework. A review of the current legal and institutional framework carried out in 2011 with support from the KfW and USAID recommended the establishment of an Institutional Model and a Geothermal Act to accelerate geothermal development in Uganda. The Government has drafted Terms of Reference for the development of a Geothermal Policy and Act, to be funded by the Government of Uganda with support from the KfW and USAID.

This paper presents the current status of the geothermal exploration project, planned exploration and development activities on the geothermal systems of Uganda.

2.0 STATUS OF ELECTRICITY PRODUCTION

2.1 Current Installed and Effective Capacity

Uganda presently has a total installed capacity of electricity power production of 778.5 MW of which 682.5 MW is hydropower, 70 MW is generated from thermal power plants and 26 MW from cogeneration in sugar industries. The operating (effective) capacity depends on hydrological conditions in the catchment areas for hydropower sources. The effective capacity therefore is estimated to be in excess of 500 MW. The details are presented in Appendix 1.

The demand for electricity is estimated at 540 MW. To offset the demand, the government in the short-term is to construct two hydropower dams at Karuma (600 MW) and Isimba (140 MW) along the River Nile by 2015. The feasibility studies are complete and construction is expected to start this year (2012). In addition, other small hydros in the western part of the country are under construction or feasibility studies. In the medium-term, government will develop Ayago (600 MW) also located along the River Nile.
In the long-term, government will study the possibility of developing three more dams namely; Kalagala (450 MW), Murchison Falls (600 MW) and Oriang (400 MW). The three hydropower sites on the River Nile have raised socio-economic and environmental issues and therefore there is a

need to diversify the energy sources. The complementary energy sources under study for electricity production are: peat, solar, biomass and geothermal. The potential for Geothermal Energy Resources is estimated at 450 MW (Mc'Nitt, 1982) and no new figures have been put forward since then.

3.0 STATUS OF GEOTHERMAL DEVELOPMENT IN THE COUNTRY

The main geothermal areas in the County are Katwe, Buranga, Kibiro and Panyimur (Figure 1). The four areas were identified for further studies because of their volcanic and tectonic features that are suitable for development of a geothermal system.

Other areas are located within or on the outskirts of the Rift Valley in south-west, west, north and in isolated places in north-east Uganda (Figure 1).

3.1 Katwe Geothermal Prospect

3.1.1 Geology

The results of geological surveys in the Katwe geothermal prospect indicate that explosion craters, ejected pyroclastics, tuffs with abundant granite and gneissic rocks from the basement dominate the area (Figure 2). The volcanic rocks, mainly composed of pyroclastics and ultramafic xenoliths, are deposited on the extensive Pleistocene lacustrine and fluvial Kaiso beds and in some places directly on Precambrian rocks. Minor occurrences of lava are found in the Lake Kitagata and Kyemengo craters. The age of the volcanic activity has been estimated as Pleistocene to Holocene (Musisi, 1991). The deposit is greyish, generally coarse to fine-grained, calcareous and mixed with sand and silt of Pleistocene sediments. Travertine deposits have been found in Lake Katwe, Lake Nyamunuka, Lake Kasenyi, and Lake Kikorongo (Groves, 1930) and in the vicinity of Lake Kikorongo at Kikorongo junction (Kato, 2003). The lava flows, craters and extinct hydrothermal deposits give an indication of a heat source for the geothermal activity. The prospect stretches from Lake Katwe to Lake Kikorongo and occupies an area of approximately 150km^2. Outside the crater area, the geology is characterized by surficial deposits to the east and the west, and to the north lie the Ruwenzori Mountains whose geology is dominated by gneisses, granites, granulites, amphibolites, schists and in some places quartzites.

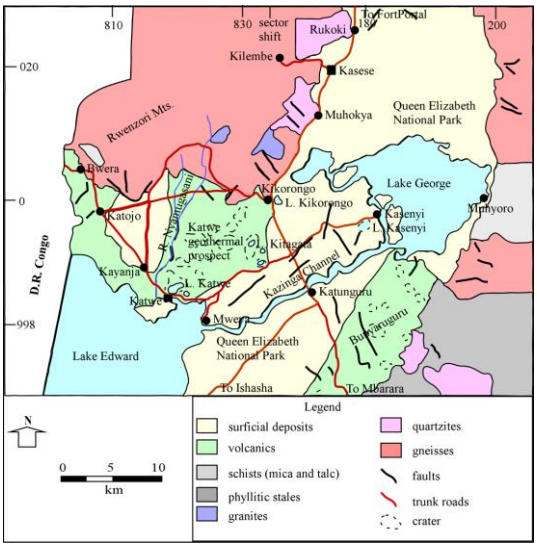

Figure 2: Geology of Katwe volcanic field and surroundings

3.1.2 Geothermal Manifestations

The geothermal surface manifestations in the Katwe prospect are hot springs located in the Lake Kitagata crater, and warm springs and travertine deposits that have built up tufas in the Lake Katwe crater, which is located 12km south-west of Lake Kitagata (Figure 2). The maximum surface temperature in the hot springs in Lake Kitagata crater is 70°C, while in Lake Katwe Crater it is 32ºC.

3.1 3 Geochemistry

The geothermal fluids are characterized by high carbonate and sulphate, and salinity of 19,000-28,000 mg/kg total dissolved solids. High carbonate and sulphate in the geothermal water tend to invalidate solute geothermometer results in Katwe. Subsurface temperatures are estimated at 140-200ºC using plausible solute geothermometers (Armannsson, 1994). The thermal fluids from Lake Kitagata and Lake Katwe craters are characterized by the presence of high levels of hydrogen sulphide of about 30-40 ppm which suggests that the source of the geothermal water is volcanic and hydrothermal (Bahati, 2003).

3.1.4 Isotope Hydrology

A number of water samples from hot springs, cold springs, rivers and lakes as well as rock samples were collected and analyzed for isotopic compositions. The objective was to provide hydrological information essential to the exploration of geothermal resources using isotopes. Isotopes analyzed for included those of hydrogen (δ^2H_{H2O}, $^3H_{H2O}$), oxygen ($\delta^{18}O_{H2O}$, $^{18}O_{SO4}$), sulphur ($\delta^{34}S_{SO4}$), and strontium ($^{87/86}Sr_{H2O}$, $^{87/86}Sr_{Rock}$).

The results indicate that the Katwe geothermal system is most likely recharged from high ground in the Ruwenzori Mountains. The tritium concentration in the thermal waters from the Katwe area is minimal suggesting that the hot spring water is not mixed with cold groundwater. The isotopic composition of sulphur ($\delta^{34}S$), and oxygen ($\delta^{18}O$) in sulphate suggests a magmatic and hydrothermal source of

the geothermal water. Strontium isotopes in water and rock ($^{87/86}Sr_{H2O}$, $^{87/86}Sr_{Rock}$) indicate an interaction between the rocks sampled and the geothermal fluids. The rocks interacting with the fluids, i.e the reservoir rock types, in Katwe are basalt. The major source of salinity is rock dissolution, but some magmatic input is suggested (Bahati, et. al., 2005).

A temperature of 140-150°C was obtained for the sulphate-water ($S^{18}O_4$-$H_2{}^{18}O$) isotope geothermometer (Bahati, et. al., 2005) which compares reasonably well with that from solute geothermometers.

3.1.5 Geophysics

Geophysical surveys which included Transient Electromagnetic (TEM) and Gravity were conducted in the Katwe geothermal prospect (Gislason, et. al., 2005). The results indicate the existence of two low resistivity anomalous areas (Figure 3).

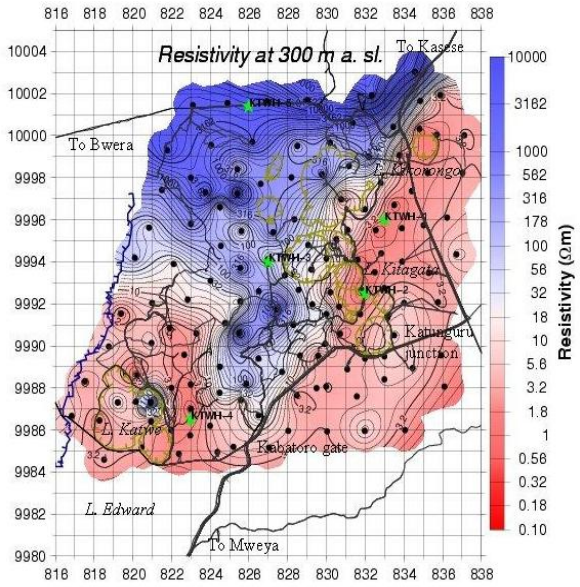

Figure 3: Katwe - resisitivity at 300 masl, (Source: Gislason et. al., 2005)

The first one is located around Lake Katwe and the second stretches from Lake Kitagata to Lake Kikorongo. The gravity data agrees with the TEM resistivity data and indicates that the two low resistivity anomalous areas are controlled by a N-S fault east of Lake Katwe and a NNE-SSW fault in the Lake Kitagata-Lake Kikorongo area (Figure 3).

3.1.6 Temperature Gradient Drilling

The drilling of six thermal gradient wells up to a maximum of 300m depth in the volcanics did not show any indication of Olivine-Biotite-Pyroxene (OBP) series. This confirms that the depth to the intrusive source of heat is greater than 300m to which the wells were drilled (Gislason et.al., 2008).

The results from the temperature gradient measurements give almost linear profiles indicating conductive heat transfer (Gislason et.al., 2008). However, the values between 30 and 36˚C/km are slightly above the global average of 30˚C/km suggesting that the geothermal reservoir is either deep-seated or offset from the drilled sites.

3.2 Kibiro Geothermal Prospect

3.2.1 Geology

The Kibiro geothermal prospect is divided into two entirely different geological environments by the escarpment, which cuts through the field from SW to NE (Figure 4). To the east of the escarpment, the geology is dominated by Precambrian crystalline basement, characterized by granites and granitic gneisses that are mylonitic in the fault controlled valleys. To the west lies an accumulation of thick sequences of Rift Valley arenaceous Kaiso and argillaceous Kisegi sediments of at least 5.5km thickness, but without any volcanic rocks on the surface. The faults of the escarpment that strike N50ºE constitute the main structures in the tectonic environment. The forces causing the rifting of the Archaean plate have put stress on the granitic rocks resulting in block faults with two main directions, N20ºE and N90ºE.

Crosscutting joints striking mainly E-W and N20^{0}E with vertical dips are found in all the rock types. A less common joint set of N130^{0}E also occurs (Gislason et.al., 2004) (Figure 4).

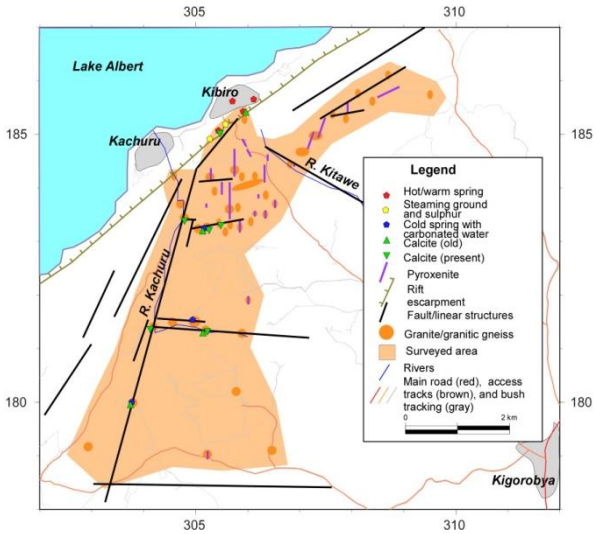

Figure 4: Kibiro - geology and geothermal surface manifestations (Source: Gislason, et. al., 2004)

Some joints are open while others are filled with secondary minerals commonly quartz or siliceous material and rarely by calcite. The faulting and jointing in the crystalline basement constitute high yielding aquifers as evidenced by the shallow thermal gradient wells drilled in the area.

Recent geological and geophysical studies show anomalous areas that can be traced along faults in the block faulted granites to the east and away from the Rift escarpment (Gislason, et. al., 2004).

3.2.2 Geothermal Manifestations

The geothermal surface manifestations in the Kibiro geothermal prospect are mainly concentrated at Kibiro, west of the escarpment, on the shores of Lake Albert. They comprise hot and warm springs (Figure 4). There is fresh and continuous deposition of sulphur in the Kachuru area and along the escarpment for approximately 1.5km from the Kibiro hot springs towards the Kachuru fault. The deposits are cold and preliminary interpretation indicates that they could be related to petroleum or geothermal. Calcite deposits are observed in cracks and fissures in many locations along the escarpment, Kachuru fault, Kitawe fault and in the crystalline rocks located south-southeast of Kibiro, indicating extinct thermal fluid discharges (Figure 4).

The hot springs at Kibiro are located along the Kitawe fault that strikes NW-SE and east of the main fault, the Tooro-Bunyoro fault (Getahun et. al., 2011). Gislason et. al., 1994 observed that the hot springs are controlled by the intersection of a secondary oblique fault and the Tooro-Bonyoro fault. The total flow measured from the hot springs is approximately 7 l/s and the maximum surface temperature is 86.4ºC (Gislason et. al., 1994).

3.2.3 Geochemistry

The fluids are characterized by a neutral pH, and salinity of 4,000-5,000 mg/kg total dissolved solids. A subsurface temperature of 200-220°C is inferred by geothermometry and mixing models (Armannsson, 1994).

3.2.4 Isotope Hydrology

Stable isotope results show that two groups of waters located east and south of Kibiro represent the groundwater that could be the source of recharge for the Kibiro hot springs (Figure 5). A massive flow of groundwater from a higher elevation than all the cold-water sampling points is also suggested. This high ground is represented by the Mukhihani-Waisembe Ridge in Kitoba sub-county, located 20km southeast of Kibiro.

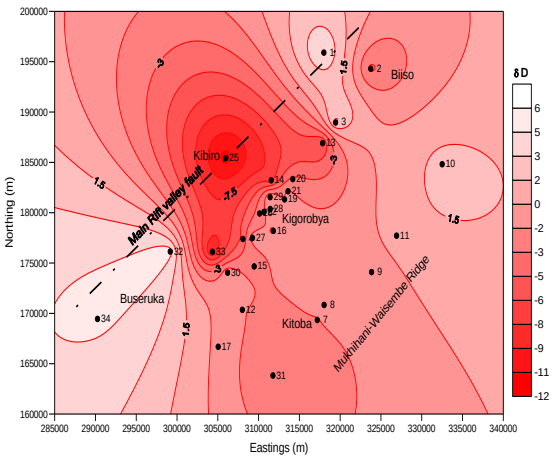

Figure 5: Kibiro - deuterium variation in surface and ground waters, dots represent sampling points

The tritium concentration of the Kibiro hot spring water is 1.25 TU similar to that of the groundwater (0-3.5 TU), and indicates that the hot spring water has cold groundwater contribution as suggested by geochemical modelling and is therefore a mixture of a hot water component and cooler water (Ármannsson, 1994). However, it should be noted that the tritium background in precipitation for the area is rather low, up to a few tritium units only, and indications of mixing may not always be clear.

The isotope composition of sulphur and oxygen in sulphates expressed in $\delta^{34}S$ (SO_4) and $\delta^{18}O$ (SO_4) suggest a magmatic contribution. Strontium isotopes in water and rock ($^{87/86}Sr_{H2O}$, $^{87/86}Sr_{Rock}$) indicate an interaction between the granitic gneisses and the geothermal fluids. The reservoir rock types in Kibiro are, therefore, granitic gneisses (Bahati, et. al., 2005).

3.2.5 Geophysics

The results of the geophysical surveys indicate the existence of anomalous areas in the Kibiro prospect (Gislason et. al., 2004). A low resistivity anomaly trench was traced into the crystalline basement, following the fault lines of the block-faulted granites, first to the SSW away from Kibiro and then following W-E fault lines toward Kigorobya Town (Figure 6).

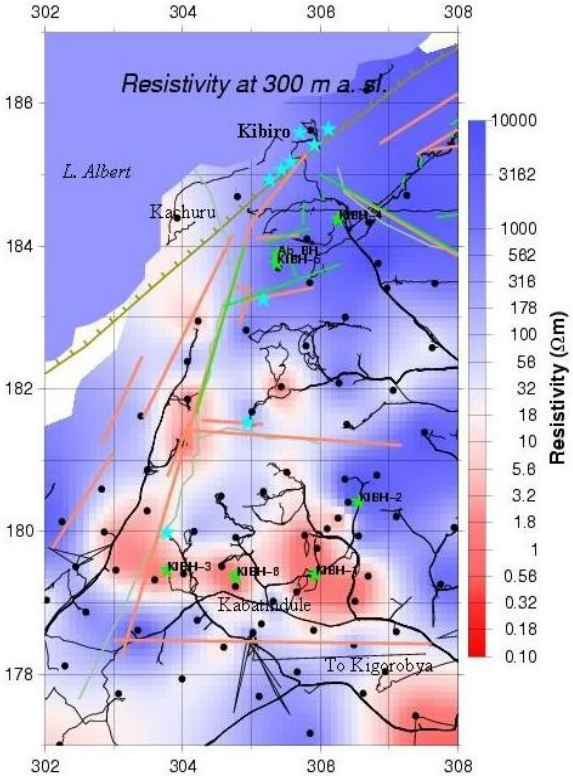

Figure 6: Kibiro - resistivity at 300 masl faults and fractures, geothermal surface manifestations (stars) (Source: Gislason et. al., 2005)

The gravity data does not show any distinct density variations, except for the large density contrast between the sediments in the Rift Valley and the granites east of the

escarpment. There is, however, an indication of a higher gravity field in an area roughly coinciding with the W-E low-resistivity anomalous area (Figure 6). This might indicate a deep higher density intrusive acting as a heat source for the geothermal activity producing the low-resistivity anomaly.

The cause of these low-resistivity anomalies can, at the moment, not be stated with certainty, but the most likely explanation is conductive alteration minerals in fractures in the otherwise resistive base-rock. Saline water in fractures could also be a possible candidate, but the relatively low salinity of the water discharges from hot springs at Kibiro and other cold springs in the area makes this rather unlikely.

3.2.6 Temperature Gradient Drilling

Six thermal gradient wells were drilled up to 300m in the geophysical anomalous areas in the crystalline basement. The lithological analysis and the temperature gradient results indicate absence of a geothermal gradient east of the escarpment (16˚C/km) but slightly elevated towards the escarpment (31˚C/km). The results indicate that the anomalous area in the crystalline basement east of the escarpment is not caused by a geothermal activity or represents an old geothermal system that has cooled down. The elevated temperature gradient towards the escarpment is either influenced by the hot springs at Kibiro and/or their suggested source of heat along the Kitawe fault.

3.3 Buranga Geothermal Prospect

3.3.1 Geology

Buranga is located at the foot of the Rwenzori massif near the base of Bwamba escarpment and localized by the major Rift Valley faults (Figure 7). Buranga has no evidence of volcanism but is highly tectonically active.

The hot springs emerge through sediments of Kaiso beds and peneplain gravels. The Kaiso beds and peneplain gravels consists of variable sands and gravels with irregularly distributed boulders containing sub-angular fragments.

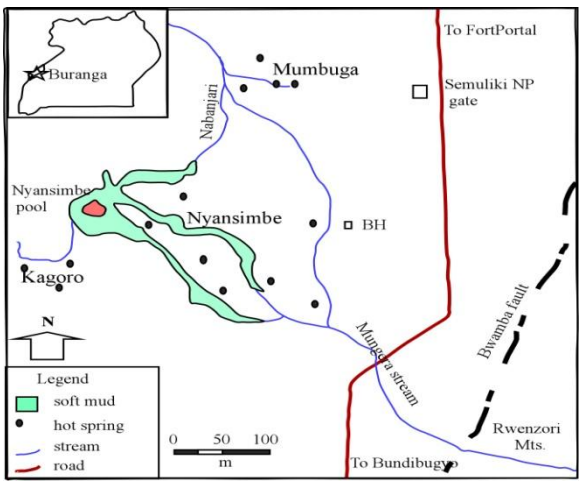

Figure 7: Buranga geothermal area

The Kaiso sediments are underlain by fine to medium-grained, poorly consolidated sands and clays; some coated with calcareous material. Precambrian rocks of the main rift fault, which strikes N45ºE and dips N60-65ºE, underlie the sediments. The rocks form the northern half of Rwenzori massif and consist mainly of migmitites, gneisses and amphibolites. They strike N10-30ºE and have complex joint systems. The hot springs seem to lie on a fracture/fault line striking N40ºE parallel to main rift fault.

3.3.2 Geothermal Manifestations

Buranga has the most impressive surface geothermal manifestations with a wide areal coverage in the whole of the western branch of the East African Rift System. They include hot springs that are close to boiling and calcareous tufa. The surface temperature is close to 98ºC and the flow is approximately 10-15 l/s, an indication of high permeability.

3.3.3 Geochemistry

The fluids are neutral with a pH of 7-8 and salinity of 14,000-17,000 mg/kg total dissolved solids. In the earlier study by Ármannsson (1994) a good agreement was obtained for all plausible solute geothermometers tested for several hot springs and pools in Buranga and it was concluded that the subsurface temperature was 120-150°C. This temperature is in agreement with the results of gas analysis which show absence of hydrogen, suggesting that the subsurface temperature is less than 200°C.

3.3.4 Isotope Hydrology

The results from stable isotopes suggest that the geothermal water is from high ground in the Ruwenzori Mountains like in Katwe (Figure 8). There is no tritium in the thermal water from Buranga which implies that it is not mixed with cold groundwater. The strontium ratios in rocks indicate that the geothermal water, most likely, interacts with granitic gneisses. The source of sulphate is minerals or rock (terrestrial evaporates) with a possible magmatic contribution (Bahati et. al., 2005). Studies by the Federal Institute for Geosciences and Natural Resources (BGR) of Germany and the Government of Uganda using helium isotopic ratio ($^3He/^4He$) in gaseous discharges from hot springs also suggest a magmatic source of solutes for Buranga (BGR-MEMD, 2007).

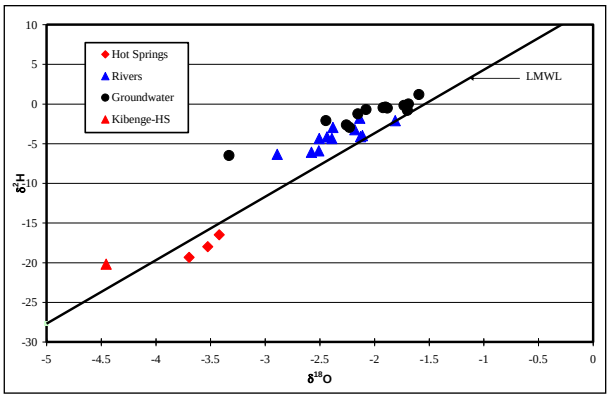

Figure 8: Buranga - stable isotopic composition of hot and cold water samples.

3.4 Panyimur Geothermal Prospect

3.4.1 Geology

Panyimur hot springs are located on escarpment front just near the shores of Lake Albert, in Panyimur sub-county, Nebbi District shown in Figure 1 above. The area is characterized by fractured crystalline basement rocks such as coarse hornblende gneisses, coarse hornblende garnet rocks, talcose rocks and pegmatitic veins in a gorge that dips into the escarpment from the hot springs. A foliation/basement schistose trends NNE-SSW. Others schistose trend almost NE, parallel to the local major faults.
Rocks in the area include crystalline basement rocks (coarse jointed granitic-gneiss outcrops to the west) and Pleistocene sediments to the east of the Rift fault boundary.

3.4.2 Surface Manifestations

The thermal area can be divided into three groups of hot springs namely; Amoropii, Okumu and Avuka, all along the faults that mark the western escarpment of the Rift Valley. The hot springs are aligned in a north-east direction and possibly controlled by the intersection of the traverse faults and the main rift fault. The hot springs stretch for a length of approximately 1.5km along the main rift fault with Amoropii further north-east and Avuka further south-west. Other surface manifestations reported include deposits of travertine, sulphurous algae and the smell of hydrogen sulphide characteristic of a high temperature area. The surface temperature ranges from 35-60°C. The maximum surface temperatures at Avuka is 55°C, at Okumu is 47°C and 60°C at Amoropii.
The Okumu hot spring is tapped through a protected spring which is surrounded by inactive travertine mounds (old spring deposits). All the discharges are characterized by gas bubbling.

3.4.3 Geochemistry

The fluids are slightly above neutral with a pH of 7-9 and low salinity of 300-900 mg/kg total dissolved solids (Armannsson et. al., 2007). The presence of hydrogen sulphide in Avuka (6.1 ppm), Okumu (10.7 ppm) and Amoropii (12.0 ppm) hot spring waters indicates that the source of heat could be magmatic and, therefore, the possibility of a high subsurface temperature in the area. But the Quartz and NaK predicted geothermometer temperatures of 100-115°C and 100-140°C respectively for Panyimur are low suggesting that the sampled waters may not be at equilibrium and are most likely contaminated with surface cold waters. A repeat of the sampling is needed to get more representative samples which could assist in delineating the subsurface temperature of the area.

3.4.4 Geophysics

Figure 9 shows a high gravity anomalous area north of the hot springs which coincides with a low magnetic anomaly in Figure 10. The two figures also show the positions of the surface manifestation (hot springs) with Amoropii further north-east, Okumu in the middle and avuka to the south-west of Okumu. This suggests the existence of a geothermal anomaly. More data needs to be collected to delineate the two results.

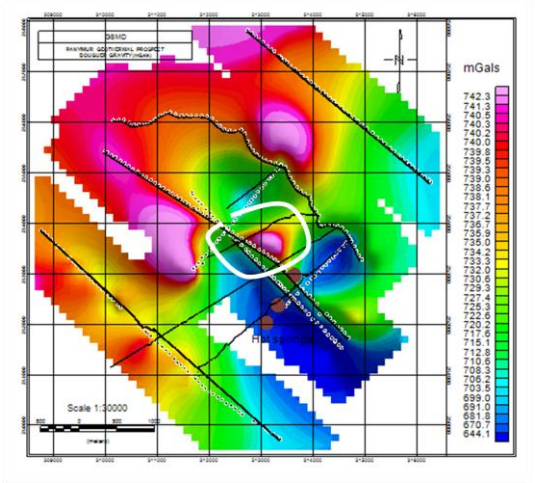

Figure 9: Panyimur - high gravity anomaly inside the white circle and three brown spots south of the anomalous area are surface manifestations (hot springs)

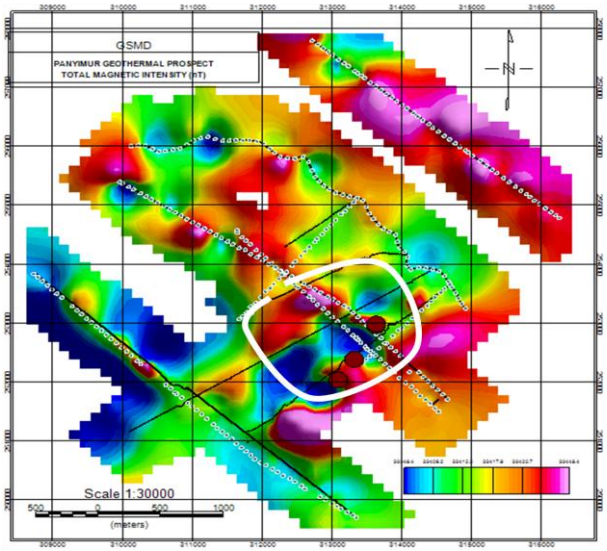

Figure 10: Panyimur - low magnetic anomaly inside the white circle. Also enclosed are surface manifestations (hot springs).

3.5 Other Geothermal Areas

The rest of the geothermal areas of Uganda are at a preliminary level of investigation. The current results predict subsurface temperatures of 100-160˚C, which are suitable for electricity generation and direct uses. Four areas have been selected for detailed surface exploration and they include Rubaare in Ntungamo District, Kitagata in Bushenyi District, Ihimbo in Rukungiri District, and Kanangorok in Kabong District.

4.0 PRIVATE SECTOR PARTICIPATION

The government has licensed four companies to carryout geothermal exploration and development in three geothermal prospects as follows: (i) Cozumel Energy Ltd and (ii) Katwe Geothermal Power Project Limited were licensed in 2010 and 2012 respectively to explore and develop the Katwe geothermal prospect; (iii) GIDS Consult Ltd was licensed in 2011 to explore and develop the Buranga prospect; and (iv) Pawacom (U) Ltd was licensed in 2012 to explore and develop the Panyimur prospect.

4.1 Cozumel Energy Ltd

Cozumel Energy Ltd has formed a consortium with a number of European companies and Universities and has also signed a Memorandum of Understanding with PT Pertamina Geothermal Energy (PGE) of Indonesia. Cozumel Energy Ltd is currently reviewing previous results from the studies carried out by ISOR and the Government of Uganda. They are also reinterpreting previous passive seismic results of the study carried out by Frankfurt University between the years 2006 and 2012. The above study did not target geothermal at that time but the data collected is being analyzed to provide additional and more specific information for geothermal prospecting. Petrological and hydrological studies using results of previous studies are also on-going.

Following the current review of the previous studies, Cozumel Energy Ltd will target the Katwe geothermal prospect with new methods namely: passive seismic, remote sensing and Libar. They will also extend the survey to areas beyond the current Katwe concession to locate the source of heat and up flow zones and possible geothermal reservoirs.
Depending on the outcome of the above study scheduled to end by December 2012, Cozumel Energy Ltd will consider using TEM and MT surveys.

4.2 Katwe Geothermal Power Project Limited

The management of Katwe Geothermal Power Project Limited (KGPPL) has completed the project's Pre-investment Study and is currently soliciting permits and other requisite documents for use by Project Promoters from National Statutory and Regulatory Agencies before commencing activities in the concession area.
KGPPL is also negotiating the Expression of Interest (EOI) with Kenya's Geothermal Development Company Limited (GDC) to carry out geophysical surveys in the area. The surface surveys will consist of Magnetotellurics (MT) and Transient Electromagnetic (TEM) Soundings. The surveys are expected to commence in last quarter of 2012.

4.3 GIDS Consult Ltd

The GIDS Consult Ltd is reviewing the previous data and findings at Buranga and integrating information/data with other studies in the Rift Valley. The results will lead to additional geological, geochemical and detailed geophysical surveys focused on location of drill sites. Geophysical methods proposed to be used are Transient Electromagnetics (TEM), Magneto-tellurics (MT) and Gravity.

4.4 Pawacom (U) Ltd

Licensed in 2012 to explore and develop the Panyigoro area that is adjacent to Panyimur which is currently being investigated by the government of Uganda. The company is reviewing previous results in the Panyimur area and negotiating access with the DGSM with the aim of merging the two areas.

5. INVESTMENT OPPORTUNITIES

5.1 Opportunities for Geothermal Energy

Uganda has a number of geothermal areas most of which are located in or close to the Western Rift Valley along the border of Uganda with the Democratic Republic of Congo (Figure 1). Three prospect areas namely Katwe, Buranga and Panyimur have been licensed to the private sector. The rest are still in hands of the Government which is carrying out surface exploration to prepare them for private investment. The potential investors can therefore take on new areas or form partnerships with the companies already holding the licenses.

5.2 Incentives Offered to Developers

The incentives offered by the government to developers of renewable energy including geothermal are laid down in the Renewable Energy Policy 2007. The policy provides for the establishment of an appropriate financing and fiscal policy framework for investments in renewable energy technologies. The key strategies for fostering this initiative include:

i) Implementing, through public private partnerships (PPP), innovative financing mechanisms, including targeted subsidies to stimulate the market penetration of renewable energy technologies;
ii) The introduction of specific regimes that favor renewable energy, including preferential tax treatment, tax exemption and accelerated depreciation; and
iii) Implementation of innovative risk mitigation mechanisms and credit enhancement instruments, to provide comfort to project lenders.

6.0 CONCLUSIONS

- Subsurface temperatures of 140-200°C, 120-150°C and 200-220°C are inferred from geothermometry for Katwe, Buranga and Kibiro respectively.
- These temperatures, if confirmed, are good for electricity production and for direct use in industry and agriculture.
- Anomalous areas have been partially mapped by geological and geophysical studies in Katwe and Kibiro prospects.
- Temperature gradient measurements (30-36°C/km) suggest geothermal reservoirs in Katwe and Kibiro are either deep seated or offset from current drilled positions.
- Isotope hydrology results indicate that the source of the geothermal fluids is from high ground in the Ruwenzori Mountains for Katwe and Buranga, and from the Mikihani-Waisembe ridge for Kibiro.
- Reservoir rock types are most likely basalt in Katwe, and granitic gneisses in Buranga and Kibiro.
- Panyimur, has indications of a geothermal system.

- Presence of H_2S in the thermal waters of Panyimur is an indication of a volcanic source of heat and a high temperature area but predicted subsurface temperatures are as low as 100-140ºC.
- Other prospects in the country suggest geothermal potentials with subsurface temperatures of 100-160ºC which is good for electricity production and direct heat for industry and agriculture.
- The entry of the private sector in Uganda's geothermal development programme gives hopes for geothermal and therefore a need for government support.

7.0 THE WAY FORWARD/RECOMMENDATIONS

7.1 Katwe and Buranga

Before the feasibility study is undertaken, the following need to be done:

a) Additional geophysical surveys using the MT and TEM methods to delineate the boundaries of the low resistivity anomalous areas, probe in the deeper layers of the crust and delineate the heat source;
b) Structural geological and hydrological mapping focused on locating drill sites; and
c) Updating of the geothermal models and location of drill sites.

7.2 Kibiro

Before the feasibility study, the following need to be done:

a) A package of geoscientific studies aimed at delineating the area and target features for geophysical exploration; and at estimating underground conditions as accurately as possible; and
b) Geophysical surveys to identify subsurface features of possible geothermal association, i.e., reservoir type features and deep fault planes; and to propose alternative exploration drilling sites.

7.3 Panyimur

This area is still at the reconnaissance stage of investigation. The following activities need to be done before the area is recommended for the feasibility study:

a) Detailed geological, geochemical and geophysical (MT, TEM and Gravity) surveys to delineate geothermal anomalous areas, identify the source of heat and targets for deep drilling;
b) Hydrological and hydrogeological surveys to study in detail the structures that control the fluid flow mechanisms; and
c) Updating of the geothermal model and location of drill sites.

7.4 Feasibility Study

Drilling of 2-3 wells to discover a reservoir in the most promising prospect(s); Katwe, Buranga, Kibiro and Panyimur are recommended.

The objective of the feasibility study is to drill at selected sites; prepare technical and financial/investment plans for the installation of an appropriately sized power plant and feasibility of direct use in industry and agriculture.

7.5 Other Areas

The rest of the geothermal areas should be investigated in detail using all geoscientific methods to identify the resource for the possibility of producing electricity and direct heat for industry and agriculture.

8.0 GEOTHERMAL ENERGY STRATEGY

- The current institutional model for geothermal activities is inadequate since the activities are divided between two departments making the execution of geothermal projects difficult.
- There is therefore a need for a single independent institution that should take the resposibility for geothermal exploration and development and a geothermal department is proposed.
- The above legal and institutional framework is not focused on geothermal and therefore a need for a geothermal strategy.
- The strategy should put in place an adequate Policy, Institutional and Regulatory frameworks for geothermal energy development.
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APPENDIX 1: STATUS OF ELECTRICITY PRODUCTION IN UGANDA

PLANT NAME	TYPE	INSTALLED CAPACITY	OPERATING CAPACITY
Kiira	Large Hydro	200 MW	150-200 due to hydrology
Nalubaale	Large Hydro	180 MW	
Bujagali	Large Hydro	250 MW	250 MW
Kilembe Mines	Mini Hydro	5 MW	Depends on hydrology
Bugoye	Mini Hydro	13 MW	Depends on hydrology
Kasese Cobalt Company	Mini Hydro	10 MW	Depends on hydrology
Ishasha	Mini Hydro	6.5 MW	Depends on hydrology
Mpanga	Mini Hydro	18 MW	Depends on hydrology
Jacobsen-Namanve	HFO Thermal Generator	50 MW	50 MW
Electro-Maxx- Tororo	HFO Thermal Generator	20 MW	20 MW
Kakira Sugar Works	Baggase	19 MW	12 MW to the grid
Kinyara Sugar Ltd	Baggase	7 MW	5 MW to the grid
Total		778.5 MW	Approx. 500 MW