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THE STATUS OF GEOTHERMAL EXPLORATION AND DEVELOPMENT IN UGANDA: COUNTRY UPDATE

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ABSTRACT

Uganda is one of the countries that are traversed by the East African rift system associated with extensional tectonic event (about 30 million years ago) and is younger than Pan African event of about 650-900 Ma. This younger event (the rifting) is also associated with most of the volcanism in Uganda. The main trend is NE-SW. However, thermal springs out the rift valley are controlled by NW-SE trending Aswa shear zone. The existence of geothermal energy has been known since the times of the explorers and colonialists. Today more than 25 geothermal fields have been listed in Uganda with variable temperatures and characteristics. The theoretical potential for geothermal in Uganda has been fixed at 450 MWe, but recent findings from temperature gradient holes (TGH) have thrown some light that the potential may be greater than that value. The geothermal exploration timeline dates back to the 1950's when shallow wells were drilled in Buranga. In recent times, geothermal exploration started in 1993 and since then exploration work has been financed jointly by government of Uganda and different development partners which include UNDP, IAEA, BGR, ICEIDA, UNEP-ARGeo, EAGER, AUC-GRMF and so on. In 2019 and 2022 eight temperature gradient holes were drilled at each of the geothermal fields: Kibiro and Panyimur. Recent temperature logs show a very promising temperature gradient with two of the holes at Panyimur giving readings of over 65°C at 250 meters depth, while at Kibiro one TGH gave a temperature of over 70°C at 300 meters depth. In terms of institutional, policy and regulatory framework, geothermal in Uganda has an independent department since the year 2016. Geothermal is regulated using a hybrid model where direct utilisation and mineral extraction associated with geothermal is regulated by the mining and minerals act 2021 (Sections 105-120) and the mining and minerals regulations 2022. Any geothermal field in Uganda that is being developed for electricity production is regulated by the electricity act 2022. The geothermal resources department (GRD) intends to develop Karungu geothermal field for direct utilisation in which tea processing / drying facility will be established as well as a spa. Bidding documents have been submitted to AUC-GRMF to source financing for surface geo-scientific studies. Additional TGH drilling will be done at Panyimur as well as deep exploratory drilling through geothermal project phase 2 resulting in fixing at least one well head generator.

1. INTRODUCTION

Uganda is one of the African developing countries whose population has been growing steadily over the years. It is estimated that the population of Uganda stands at more than 49 million people (November 2023) according to the Worldometer website. This population growth is also in line with the growing energy demand. African countries, Uganda in particular, have the obligation to plan for such a huge growing energy demand. There is therefore need to have an energy mix, geothermal not being ignored because of the many advantages it has over other renewables.

1.1 Uganda energy sector overview

Uganda's energy needs have been growing over the years and the government of Uganda has tried to plan and prepare for the growing needs through an energy mix approach. The major sources of energy in Uganda include biomass, hydro, solar, and thermal. 93% of energy needs are satisfied by biomass, which is exerting pressure on environmental conservation. The rate of deforestation will worsen the climatic fluctuation which will result in reduced rain affecting hydro power generation. Decline in forest cover reported between 1990 and 2005 in Uganda is attributed to increasing demand for land for agriculture and firewood or charcoal (as a major source of energy in Uganda) to mainly support the country's growing population (NEMA, 2007; NPA, 2015).

The electricity demand follows exactly the population distribution patterns, and so does the electricity connectivity in Uganda. Access to electricity in Uganda stands at 26.1% at the national level; 57.2% in urban areas and 10% in rural areas. Therefore a big percentage of the general population relies on biomass as a major source of energy (MEMD, 2012 and 2014). Electrical energy is mainly from hydro power and has been observed to suffer from climatic fluctuation in recent years and the threat remains. Government of Uganda has taken interventions which include further diversifications by considering developing geothermal and other renewables; but also considering nuclear energy (Tumwesigye et al., 2011; NPA, 2015). Government of Uganda has therefore taken regulatory framework that will ensure increased energy production and access. The enactment of the Renewable Energy Policy of Uganda and the electricity access policy (2018-2027) will improve both production and access to electricity.

1.2 Tectonic setting

Uganda is one of the countries that are traversed by the East African rift system associated with extensional tectonic event (about 30 million years ago) and is younger than Pan African event of about 650-900 Ma. This younger event (the rifting) is also associated with most of the volcanism in Uganda. The Western arm of the East African rift covers all the western international boundary of the country almost north to south (Figure 1). This part of the rift valley

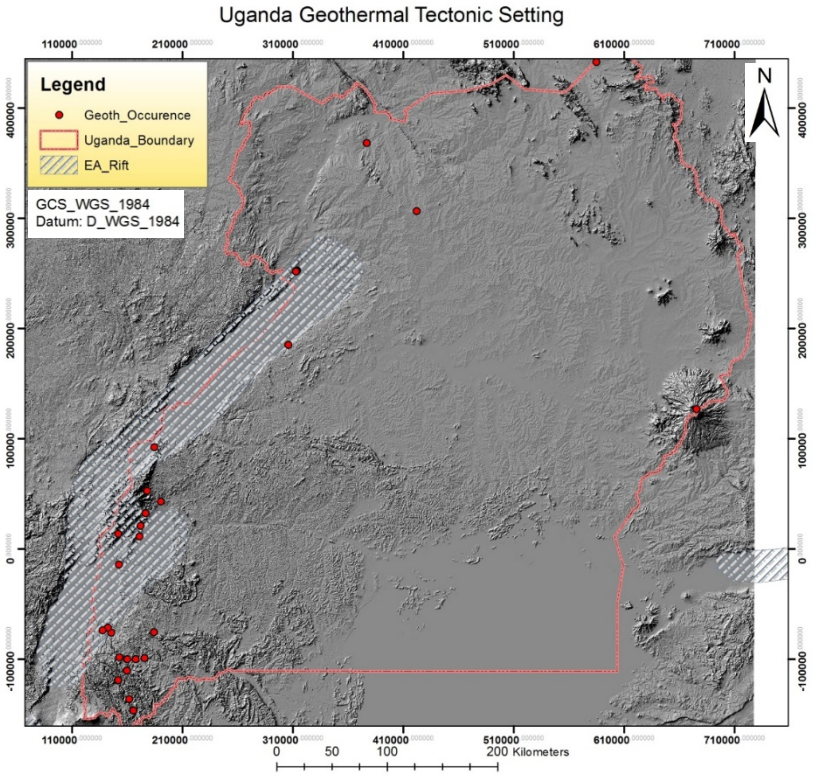


FIGURE 1: Uganda tectonic setting

is characterised by less volcanic activity than the Eastern arm, but has been observed to be seismically more active. Because this is an area which has been tectonically active in the recent geologic times (or even now), several geothermal prospects and surface manifestations occur almost the whole length of the rift within Uganda (Figures 1 and 2). The main fault system within these areas generally trend NE-SW. However, there are those geothermal areas (in Amuru District e.g. Amuru and recently located Okidi springs) associated with the Aswa shear zone (trending NW-SE). The Aswa shear zone formed as a result of transmission of extensional stress that propagated to give rise to the western branch of the East African rift valley (Figure 2). In recent times, geothermal exploration started in 1993 and since then exploration work has been financed jointly by government of Uganda and different development partners which include UNDP, IAEA, BGR, ICEIDA, UNEP-ARGeo, EAGER, GRMF-AUC and so on.

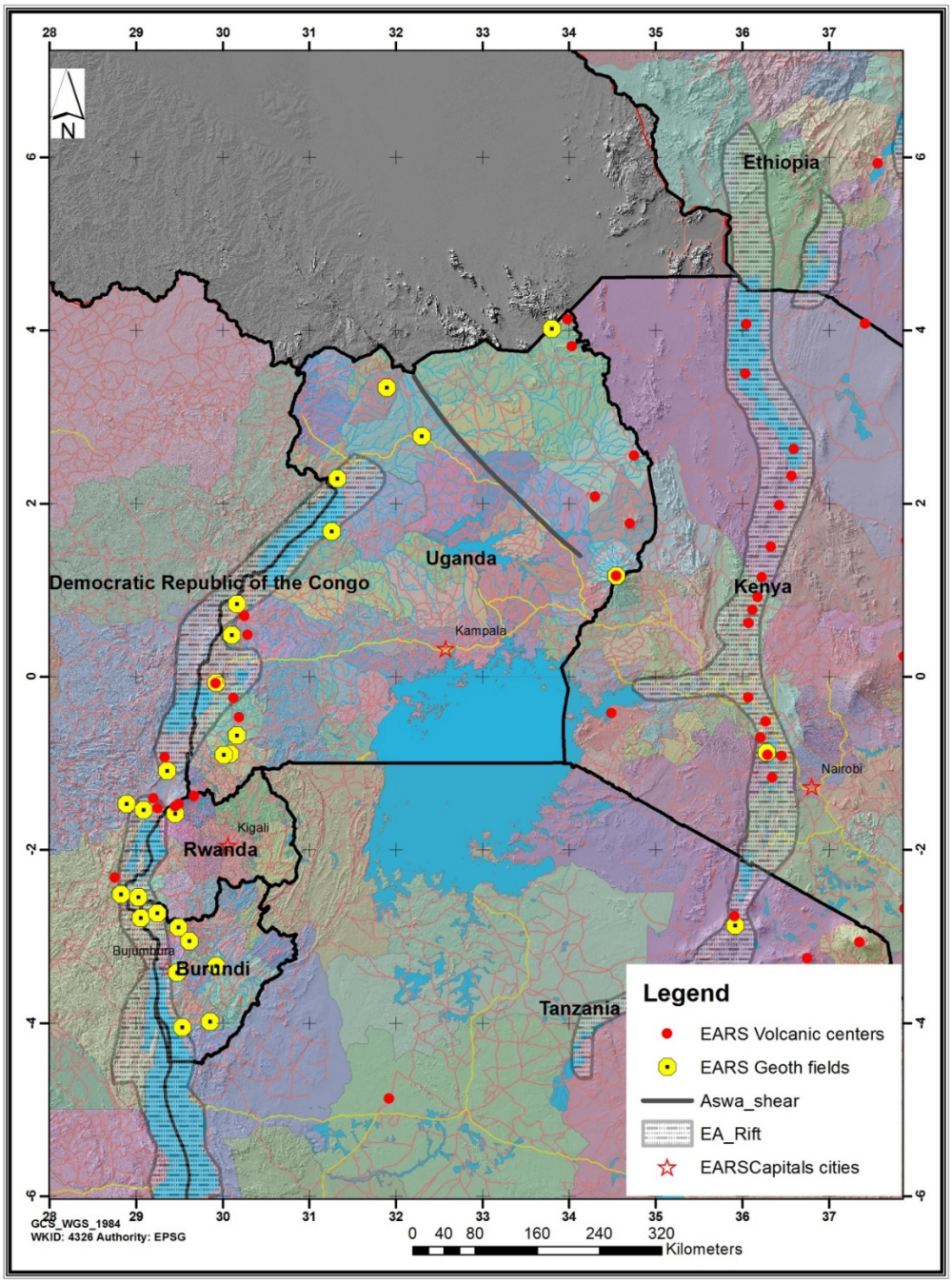


FIGURE 2: Uganda geothermal tectonic setting in the region showing distribution of geothermal areas and volcanic centres

1.3 General geology

Uganda is geologically underlain by a wide range of geology from oldest (Neoarchean) to most recent (Quaternary). Within the settings where geothermal prospects occur, still the same contrast is depicted since the geothermally active areas are within the rift areas and/or escarpment zones. Here old geological formations such as TTG gneiss (2500-2800 Ma), granites and other Proterozoic rocks (1600-2500 Ma) form the upper flanks of the rift whereas within the rift there occurs more recent rift sediments of Quaternary age. In some places volcanic rocks of Miocene to Holocene age exist, and they are associated with rifting in age (Figure 3).

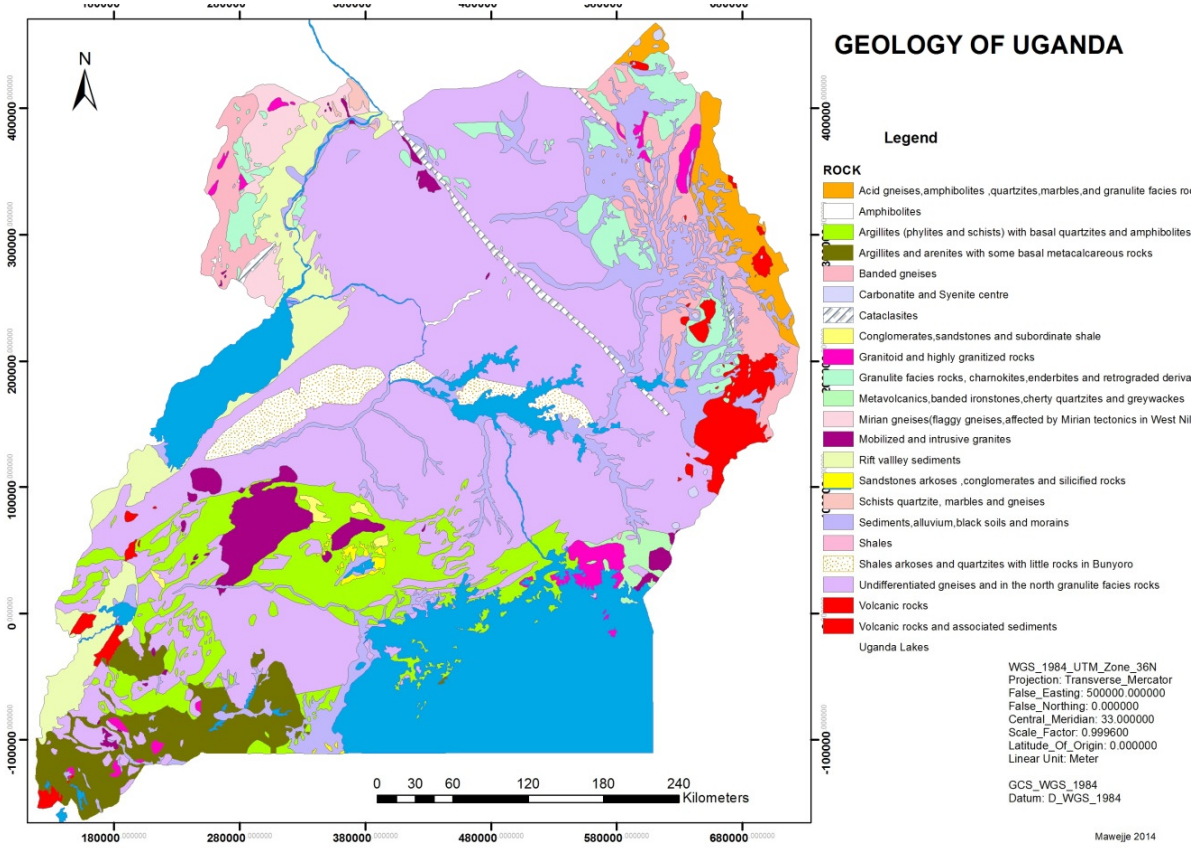


FIGURE 3: Map showing the general geology of Uganda

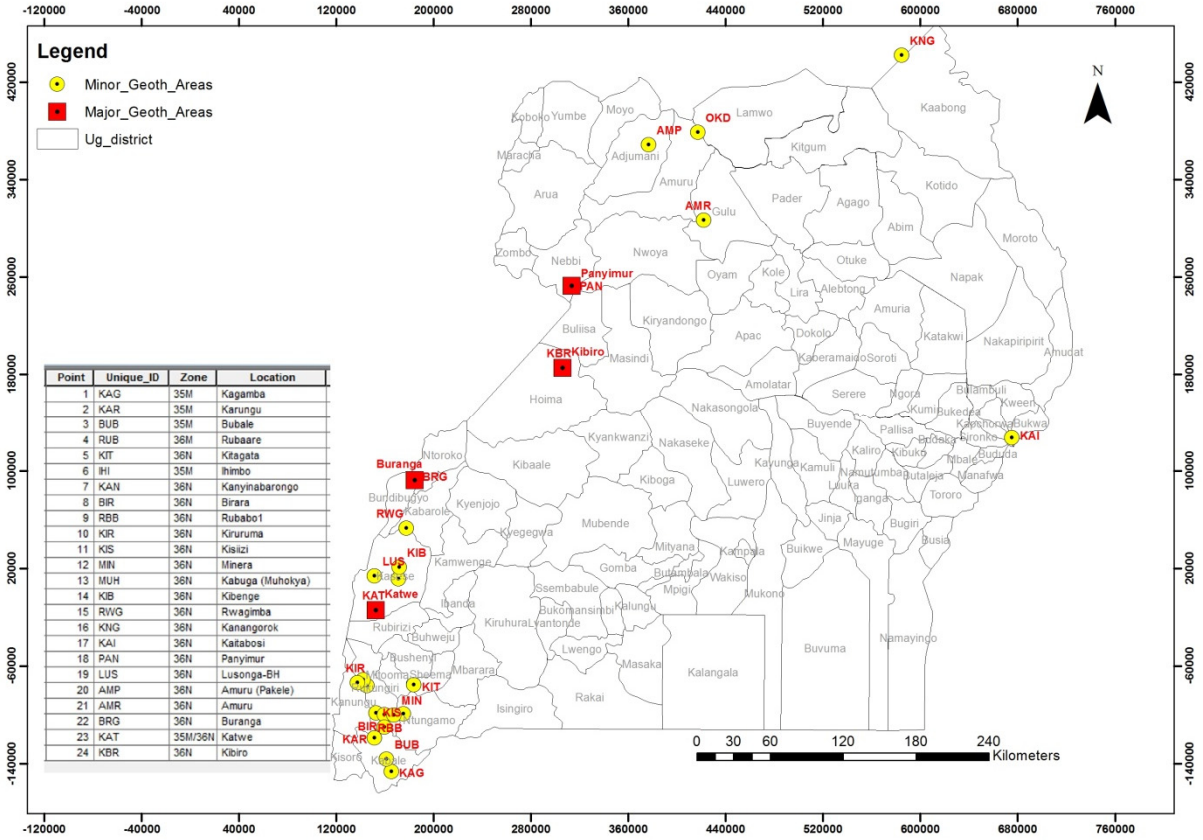
2. GEOTHERMAL IN UGANDA

The existence of geothermal energy has been known since the times of the explorers and colonialists. Today more than 25 geothermal fields have been listed in Uganda with variable temperatures and characteristics. Being a clean renewable and dependable source of energy, Uganda is starting to consider geothermal energy as one of the future sources of base load power.

2.1 Occurrence and potential

Geothermal fields in Uganda are mainly associated with the East African rifting and therefore occur close to the western branch of the East African rift system (Figure 4). Those that are found in the northern and north-eastern side of the country are associated either with the Aswa shear zone or with the Miocene volcanism of eastern and north-eastern Uganda. Over 25 geothermal areas of occurrences have been listed in different parts of the country. The numerous thermal springs distributed widely in Uganda have different surface temperatures, some of which are of the order

86°C. There is no doubt that Uganda has a potential for geothermal energy. The theoretical potential has been fixed at 450 MWe, but recent findings from temperature gradient holes have thrown some light that the potential may be greater than the 450 MWe value.



Point	Unique_ID	Zone	Location
1	KAG	35M	Kagamba
2	KAR	35M	Karungu
3	BUB	35M	Bubale
4	RUB	36M	Rubaare
5	KIT	36N	Kitagata
6	IHI	35M	Ihimbo
7	KAN	36N	Kanyinabarongo
8	BIR	36N	Birara
9	RBB	36N	Rubabo1
10	KIR	36N	Kiruruma
11	KIS	36N	Kisiizi
12	MIN	36N	Minera
13	MUH	36N	Kabuga (Muhokya)
14	KIB	36N	Kibenge
15	RWG	36N	Rwagimba
16	KNG	36N	Kanangorok
17	KAI	36N	Kaitabosi
18	PAN	36N	Panyimur
19	LUS	36N	Lusonga-BH
20	AMP	36N	Amuru (Pakele)
21	AMR	36N	Amuru
22	BRG	36N	Buranga
23	KAT	35M/36N	Katwe
24	KBR	36N	Kibiro

FIGURE 4: Map showing occurrences of geothermal fields in Uganda. Major fields means those that have been studied up to some level, while minor means green fields.

2.2 Activities undertaken

The geothermal exploration timeline dates back to the 1950's when shallow wells were drilled in Buranga. The lack of success was mainly attributed to difficultly in selecting favourable drilling sites, mainly tagged to the poor characterisation of geothermal fields.

In recent times, geothermal exploration started in 1993 and since then exploration work has been financed jointly by government of Uganda and different development partners which include UNDP, IAEA, BGR, ICEIDA, UNEP-ARGeo, EAGER, AUC-GRMF and so on. The Uganda Geothermal Resource Development Project 1199 (UGRDP), fully funded by government of Uganda started in the year 2011 and was used to fill exploration gaps in Katwe, Buranga and Kibiro and select sites for drilling and do follow up on other promising geothermal sites identified in previous projects in 2005. It was as a result of this project that Panyimur was studied further and brought up.

The funds from this project have been used to do surface studies in Katwe, Buranga, Kibiro, with geophysical studies so far limited to magnetic and gravity methods. The geophysical exploration methods were only carried out at Kibiro, Buranga and Panyimur. Geochemical methods were mainly water sampling and analysis for isotopic studies. Soil gas surveys were undertaken in Buranga and Katwe.

Inter-government approach to ensure accelerated geothermal exploration and development in the country was also considered. A memorandum of understanding (MoU) was signed between governments of Uganda, Rwanda and Kenya, in which GDC of Kenya committed to assist Uganda and Rwanda to ensure accelerated geothermal exploration, development and capacity building. This regional approach has enabled free flow of knowledge, manpower and equipment for fast geothermal development. This does not limit the three countries from sourcing services, funding or technical assistance from elsewhere.

After this MoU, the government of Uganda has been committed to look for funds and access expertise and equipment within the region to carry out exploration activities. The government also intends to improve on geothermal laboratories, improve on human capital and acquire more equipment both for field and laboratory. This will be possible to implement because of a stronger institutional framework, since a fully fledged geothermal department was operationalized.

The development partners UNEP-ARGeo and EAGER helped Uganda to do detailed geo-scientific investigations over the three geothermal areas – Kibiro, Panyimur and Katwe. UNEP-ARGeo mainly focused on Kibiro while EAGER forcused on both Kibiro and Panyimur but also did similar studies over Katwe geothermal prospect (Hinz et al., 2018). At the end of the EAGER project, sites for temperature gradient holes were sited at Kibiro and Panyimur, which were later drilled in 2019 and 2022 (Figure 5). Eight temperature gradient hole were drilled at each site.

FIGURE 5: Showing drilling activities at Panyimur

2.3 Current activities

The staff of Geothermal Resources Department continues to undertake routine exploration programs in different geo-scientific disciplines (geology, geochemistry and geophysics). Activities focus on green fields for reconnaissance surveys as well as more advanced studies such as temperature gradient hole logging. In recent reconnaissance surveys, a new geothermal area (formally Parabek and now Okidi) has been rediscovered. The springs were first reported in the 1930's, but the exact location was not known for many decades. The thermal springs have now been reached and located exactly with modern GPS coordinates. Surface temperature measured was up to 80.1°C. The thermal springs are located on the Aswa shear zone within the Achwa river bed. Recent temperature gradient logging at Panyimur and Kibiro has indicated very promising thermal gradient in which temperatures up to 65°C (Figure 6) at 250 m depth at Panyimur and over 70°C at Kibiro (300 m depth) have been encountered.

3. INSTITUTIONAL, POLICY AND REGULATORY FRAMEWORK

For many years geothermal energy exploration was being taken care of by the traditional geological survey department that is responsible for geological mapping and mineral exploration. This didn't give a chance for geothermal exploration to grow independently because the funding and all other resources were shared, hampering the growth of geothermal exploration programs. With institutional restructuring and introduction of a fully-fledged Geothermal Resources Department, there now exist

an independent budget and resources to undertake geothermal activities. This has allowed progress in the positive direction. Government is committed to financing geothermal exploration, development and utilisation in an effort to diversify energy sources.

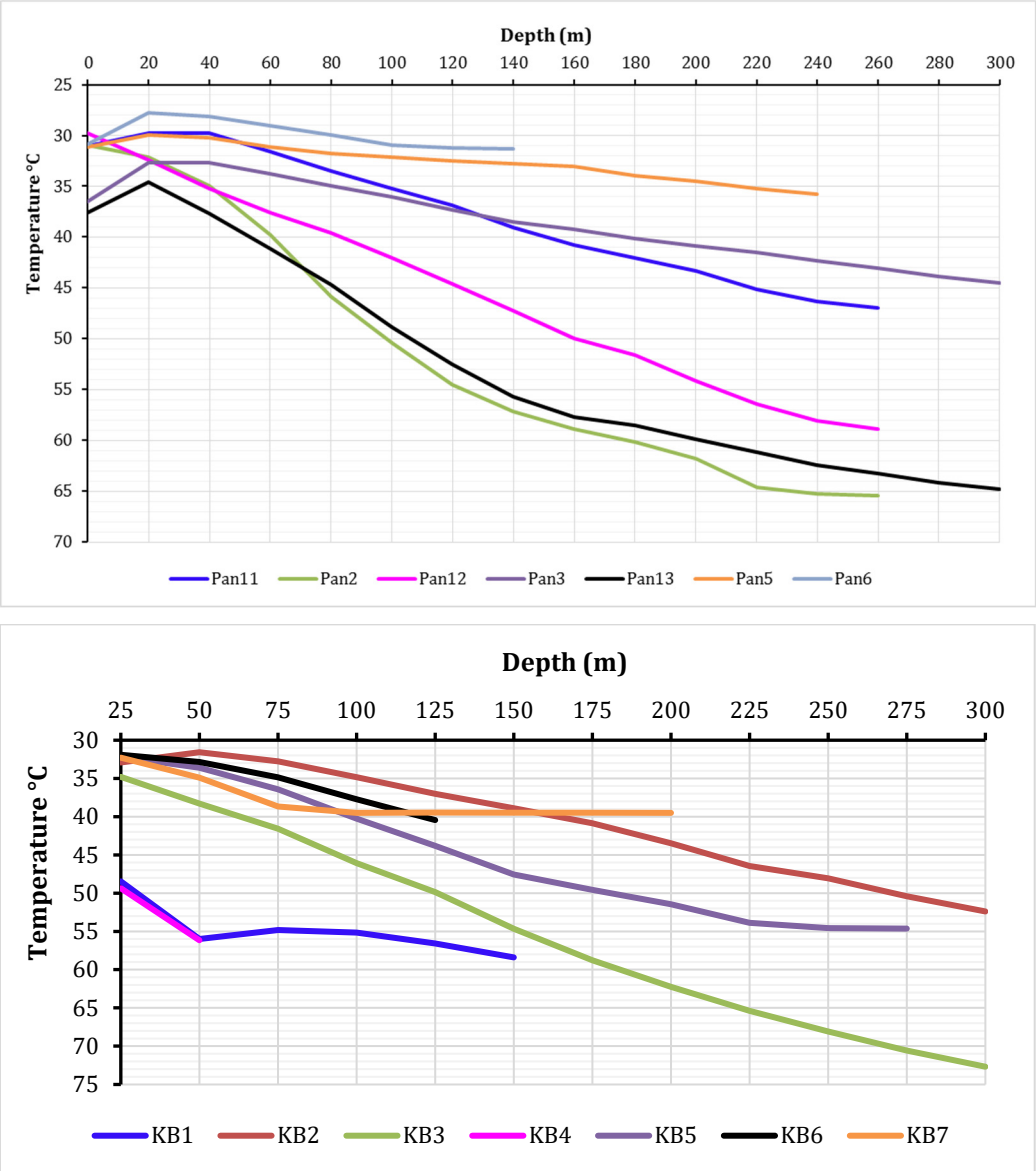


FIGURE 6: Temperature curves for Panyimur (top) and Kibiro (bottom).
The Panyimur is as at 6/11/2023.

The legal and regulatory environment is among the crucial facilitating factors for sustainable geothermal development and utilization. Geothermal bears unique characteristics which distinguish it from other renewable energy sources. These include among others, resource identification and ownership, accessibilities, investment risks as well as resource uncertainty, which require sufficiently accurate resource assessment and evaluations to reduce risks and uncertainties (Achieng, 2022).

In the area of financing, geothermal stands out for its inability to access global markets as a commodity (as e.g. oil, minerals and gases) which are liberally and transparently priced (Shakiru Idrissa Kajugus). In stark comparison, geothermal can largely be utilized and sold into energy markets with localized specific regulations and price. These unique features require creation of suitable legal and regulatory environment for sustainable development of geothermal resources within its locality of

occurrence. The government of Uganda evaluated alternative options for geothermal regulatory environment in Uganda and found that integrating geothermal with other existing laws addresses the challenges pertaining to definition of geothermal, and licensing for geothermal development and utilization. Therefore, geothermal in Uganda is currently regulated under a hybrid model.

In Uganda therefore, geothermal is not regulated under a single law, but rather several laws. The direct utilisation and mineral extraction associated with geothermal fields are now regulated within the mining and minerals Act 2021 (Sections 105-120). All concessions aiming at direct utilisation are now given and regulated like minerals concessions. But in the event there exists a mineral that is not associated with geothermal, the concession holder is not allowed to extract such a mineral and is required to declare to the minister such discoveries.

On the other hand, geothermal fields developed for electricity production are now regulated within the electricity act 2022.

4. NEW PROJECTS AND WAY FOWARD

Having undertaken several projects aiming at developing geothermal resources for Uganda and milestones reached, Uganda continues to follow up on the different activities and achievements attained over the years.

4.1 Karungu heat project

The geothermal resources department (GRD) intends to develop Karungu geothermal field for direct utilisation. In the proposed project, together with other development partners, GRD would like to develop a tea processing / drying facility around Karungu; the area being famous for tea growing. In addition to agro-processing, a spa has been suggested as another facility either as a cascade use or directly from the geothermal field. Being a green field, GRD is planning to execute a surface exploration program to assess whether the field is feasible for the intended use. Funding for exploration activities is being sought from the AUC-GRMF. Bidding documents were prepared and submitted and are being evaluated.

4.2 Additional temperature gradient hole drilling at Panyimur

Funding was secured as grant from the AUC-GRMF to drill four additional temperature gradient holes at Panyimur. The information obtained from the drilling exercise will greatly help to improve and refine the existing geothermal model. This in turn will help inform decision making when it comes to siting deep exploratory wells.

4.3 Exploratory deep drilling at Panyimur

Government of Uganda is committed to look for funds from its own treasury as well as from development partners and sponsors to undertake the activity of deep exploratory drilling at Panyimur. Bidding documents were submitted in August to AUC-GRMF and are undergoing evaluation. The next target will be Kibiro once Panyimur is done.

4.4 Government of Uganda funding and geothermal project phase two

Government has continued to support the Geothermal Resources Department for its routine exploratory, supervisory and monitoring activities. Plans are underway to approve a geothermal project phase 2 to follow up on findings and achievements of the the Uganda Geothermal Resource

Development Project 1199 (UGRDP). The objective is to carry out deep drilling and fix at least one wellhead generator.

5. CONCLUSIONS

The recent temperature gradient hole loggings at Panyimur and Kibiro, which show temperatures as high as 65°C at a depth of only 250 m, indicate anomalous thermal gradients at both Kibiro and Panyimur. Uganda has very high hopes for a geothermal reservoir that can be to utilised.

Uganda now has a standalone department, which is responsible for exploration development and utilisation of geothermal resources in the country. The department is continuously building capacity so as to be able to fulfil its mandate. The hybrid regulatory model where direct use and electricity production are regulated by different laws (the mining and minerals act 2021 together with mining and minerals regulations 2022; and the electricity act 2022) will ensure a well streamlined utilisation of geothermal resources. The institutional and regulatory framework is conducive for Uganda to harness her geothermal resources.

In recent times, Uganda has started to look at geothermal as a sleeping Giant! With this kind observation, government is more committed to financing geothermal exploration programs to reduce on risks to attract investors and partnerships.

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