Review of Geothermal Development in the Western Branch of the East African Rift System

Reuben Gad Mugagga¹, Hope Baxter Nqcube Chamdimba², Dorothy Mwanzia Kanini³

¹,²School of Engineering, Energy Technology Department, Kenyatta University, Kenya. ³Jomo Kenyatta University of Agriculture and Technology, Kenya.

Email: gadrobben@gmail.com

Keywords: Geothermal energy, Geothermal development, Renewable energy, Western rift.

ABSTRACT

The Eastern branch has for long gained attention due to the concerted efforts that have aided it gain ground in generating over 864.4 MWe and thereby being among the leading producers of geothermal energy in Africa. Though the East African Rift System (EARS) is endowed with an estimated potential of over 20,000 MW due to the characteristic volcanism in the region, considerable developments shall be pivotal to fully exploit much of the untapped resource. Correspondingly, the Western rift has not gained adequate momentum irrespective of the endeavors devoted due to several challenges rendering it less operational. This paper, aims to highlight the geothermal resource developments structured into the country policy and regulatory situation and the geothermal development status of the countries through which the western rift traverses i.e. Uganda, Rwanda, Burundi, United Republic of Tanzania and Malawi. Also covered are the challenges, discussion as well as the recommendations that could emanate from compounded strategies for which the Eastern rift could be an essential benchmark for potential developments.

1. Introduction

Shaped in narrow elongated escarpments with reducing lithospheres due to moderate earthquakes and ancient tectonic patterns, the EARS is among the earths’ largest volcanic regions. The EARS (fig. 1) is recognized as the most preserved continental rift on Earth that stretches to over 6500 Km (Scoon 2018). It comprises of three distinct branches namely; the Western, Eastern and the Ethiopian rift. The western branch stretches over 2100 Km through several countries inclusive of Uganda, Democratic Republic of Congo (DRC), Rwanda, Burundi, United Republic of Tanzania and Malawi and Mozambique (Chorowicz 2005). Also termed as the Albertine rift, this branch has seen relatively limited developments over the years as opposed to the other aforementioned rift branches hence having juvenile geothermal production capacity.

The rationale behind the less activity could in part be explained by geomorphology associated to the tectonic and rift geometries as the Albertine rift is characterized as being less viscous and amagmatic hence leading to a rather more thicker, stronger and stable lithosphere as opposed to the more magmatic central Kenyan (Gregory) Rift (Ring 2014; Varet 2018). The low temperatures of the Western rift are thus evident of deeper magmatic sources. The
preceding plume activity of the Eastern and Ethiopian rifts are categorically more pronounced (Scoon 2018) due to increased volcanicity and crustal seismicity which provides the basis for more geothermal viability due to the presence of shallow depths within the reach of hot magma (Varet 2018). This renders them more mature as opposed to the Albertine rift due to the increased occurrences of crustal thinning leading to high heat flow.

The geothermal energy resource is one of the renewable energies existent today widely known for its capacity to provide base load energy while considerably reducing the greenhouse gas (GHG) emissions in power generation. By 2019, the EARS generated 670MW of electricity from geothermal power. This capacity was representative of 5% of the global geothermal installed capacity (IRENA 2019). However, the success of the EARS is attributed mainly to Kenya and Ethiopia that are currently spearheading these endeavors which are geographically located in the Eastern branch. This therefore, motivated the undertaking of this review in order to ascertain the prevalent geothermal development situation along the western branch.

Figure 1: The East African Rift System. Source: (Chorowicz 2005)

This paper reviews the geothermal resource developments in the Western branch on a country basis inclusive of Uganda, Rwanda, Burundi, United Republic of Tanzania and finally Malawi. The country discussion is structured into two main sections i.e. the country policy and regulatory situation and the geothermal resource potential (tab. I) and development status.

2. The Country Geothermal Situation

2.1 Uganda

2.1.1 Policy and Regulatory Situation

With the current installed generation capacity of 1252.4 MW by the end of 2019, geothermal power is still deemed a prospect in furthering power generation in the country. The significance of geothermal energy to the country was stipulated in the 2002 energy policy and subsequently, the Renewable Energy (RE) policy of 2007. The later helped initiate the incentives for renewable energies Feed in Tariffs (REFiT) meant to last for two years then. But due to limited uptake by private developers, amendments where done birthing the second phase. The stipulated REFiT under the second phase for geothermal technology was of US cents 7.7. After 2016, the REFiT for geothermal was scrapped in the revised phases 3 and 4.
with the latter being in place up to 2021 (ERA 2019). The Least Cost Generation Plan (LCGP) (2016-2025) too does not highlight any envisaged geothermal power generation at least up to 2025 due to the high drilling risks and costs involved as well as the long lead times (ERA 2016). This preference by Electricity Regulatory Authority (ERA) in part explains the omission of the REFiT for geothermal.

Conversely, with the support from the Climate Technology Centre and Network (CTCN) and key stakeholders, the country in 2016 promulgated a new geothermal policy, legal and regulatory framework in order to regulate the exploration, development and production of geothermal energy (Baguma et al. 2016).

2.1.2 Geothermal Resource Potential and Development

Geothermal reconnaissance studies on potential sites with surface manifestations depicted in form of fumaroles, hot springs and mud pools were first reported as early as 1935. Consequently, several geochemical, geophysical and geological studies have been carried out at Katwe, Kibiro, and Buranga by the collaboration of the Government of Uganda (GoU) and other external partners since 1993. More recently, Panyimur and Ihimbo were also enlisted (fig. 2) specifically due to their depiction of high heat manifestations and permeability (Lugaizi et al. 2018; Kato and Babirye 2018). In addition, other potential sites with the likes of Kiruma, Rubaare, Kanungu, Kitagata, Rubabo and Minera have gained interest due to their predicted subsurface temperatures of 100-140°C as discussed by (Armannsson, Bahati, and Kato 1994). However, these could actually be hotter than what the preliminary studies suggest.

Based on the first Department of Geological Survey and Mines (DGSM), geochemical exploration studies performed together with the utilization of mixing models on the hot springs of Katwe, Buranga, and Kibiro with flow of over 0.5L/s in the early 90’s, revealed that these geothermal fields consisted of subsurface temperatures of 140-160°C, 120-150°C and, 200-220°C respectively (Bahati and Natukunda 2018). Remarkably, the failure to identify the geothermal reservoir at Katwe following the drilling of Temperature Gradient Holes (TGH) in 2007 was not evident enough to halt further re-examination together with the other potential sites during the East African Geothermal Energy Facility (EAGER) and Ugandan Geothermal Resource Department (GRD) project. As such, a detailed structural mapping was conducted with conclusions that this prospect is likely to be a deep circulation system located at Lake Kitagata (Heath et al. 2018) though no conceptual model has been developed to date (Bahati and Natukunda 2018).

Figure 2: Location of the main geothermal sites in Uganda
Based on the second DGSM project, a lower temperature of 140°C was obtained from the isotope thermometers for the Kibiro prospect. This exploration further revealed low temperature gradients indicating lack of permeability. As was with the Katwe prospect, this geothermal field also seems to host a deep seated geothermal reservoir. In 2018, a more detailed geology and structural mapping was undertaken by the EAGER and GRD which proved that the hottest spring clusters where between 77-87°C which led to the development of a conceptual model for the field (Hinz, Cumming, and Sussman 2018; Heath et al. 2018). This formed the basis for recommendation for shallow TGH drilling which would further be informative of deeper well drilling (Bahati and Natukunda 2018).

The more recently explored Panyimur located North West of Lake Albert has been subjected to geologic, gravity studies, geologic mapping and geophysical surveys i.e. Magnetotellurics and Transient Electromagnetic Method (MT and TEM respectively) which led to the development of revised conceptual models to facilitate advancements for TGH drilling (Heath et al. 2018). This is because the geo-thermometry studies also delineated the possible occurrence of a shallow aquifer with temperatures of 100-120°C (Hinz, Cumming, and Sussman 2018). An updated review of the existing data with effort to develop more robust conceptual models so as to concretize the information pertaining to future TGH drilling was performed through additional geological studies. These, further revealed that geothermal resource temperatures where in the range of 110-150°C (Lugaizi et al. 2018).

According to (Bahati and Natukunda 2018), Buranga happens to have the most impressive geothermal manifestations with a shallow aquifer outflow of 98.7°C. It has undergone several geothermal explorations which have led to the development of a conceptual model for this field due for TGH test drilling which shall more certainly be constrained by its inaccessibility. The Ihimbo geothermal prospect is akin to Buranga due to its distinct manifestations in form of hot and warm springs with temperatures of up to 70°C. Following recent geological, geochemical and geophysical surveys i.e. MT, the prospect is assumed to have an underlying geothermal reservoir whose conceptual model is yet to be developed subject to a detailed structural mapping (Kato and Babirye 2018). Late in 2019, the exploration program plan funded in collaboration by the GoU and the Geothermal Risk Mitigation Facility (GRMF) set out with a target of drilling 16 TGH at Kibiro and Panyimur which started in early 2020 but works where halted due to an oil sip in the Albertine graben (Muhwezi 2020).

### 2.2 Rwanda

#### 2.2.1 Policy and Regulatory Situation

With the country electricity generation capacity being 218 MW, geothermal is envisaged as one of the key resources for energy generation to boost the diversification of energy. This is well stipulated in both the current Energy Sector Strategic Plan (ESSP) (2018/19-2023/24) (MININFRA 2018) and 2015 Energy policy. Towards its commitment to the green and low carbon trajectory in the electricity sector, the Rwanda Utilities Regulatory Agency (RURA) opened its power generation market to the public and private investors through adoption of a feed-in tariff policy. However, this was only set for small hydropower (50kW – 10MW) (RURA 2012). Absence of the geothermal FiT gives no guarantee for the attracting investment but, being an emerging sector in the country, more competitive tendering is still a prospect.

Nonetheless, the country has an existing geothermal policy and has devoted to these envisaged developments by continually facilitating investments, setting up the institutional
framework that is inclusive of the geothermal regulations and act, geothermal resource exploration and development strategy 2011-2017. However, irrespective of the expression of interest in the GRMF and continuous donor assistance, the likelihood of geothermal generation in near term scenario is minimal and was omitted in the recent Least Cost Power Development Plan (LCPDP) (REG 2019). Nonetheless, this is no limitation towards the government commitment and other financial institutions in funding upstream risks for green field projects as a motivation towards increasing their power capacity substantially.

2.2.2 Geothermal Resource Potential and Development

The country has four prospective sites (fig. 3) for geothermal exploration which are situated in two major geothermal regions. Kinigi, Karisimbi, and Gisenyi are located in the North Western part while Buragama is in the south western part of the country (MININFRA, 2018). Geothermal investigations in the country date back to the 1980’s and have included; the assessment of the generating capacity of geothermal prospects through the examination of green field data, geoscientific exploration studies at Bugarama and Gisenyi, as well as surface surveys at Karisimbi geothermal fields (JICA, 2013). Consequently, this led to the development of the conceptual models for both the Bugarama and Kinigi geothermal fields, structural geology identification of the Gisenyi geothermal field, sinking of exploration wells at the Karisimbi volcano from which deductions of the absence of geothermal reservoirs from this field were drawn (Rutagarama 2018). This helped unearth the postulations from previous studies undertaken by KenGen for the Karisimbi geothermal field which drew conclusions of estimated subsurface temperatures of 100-120°C and generation of 300 MWe.

The authors (Uwiduhaye, Mizunaga, and Saibi 2018) also carried out geophysical investigation using gravity information and their results affirm to the existence of a geological structure and futuristic geothermal prospects for the Kinigi geothermal field through the NW-SE orientations.

However, more detailed studies still need to be done to ascertain the commercial resource viability at this site (MININFRA 2018). This is mainly backed by the existing several geothermal manifestations that take the form of hot springs the hottest being north of Lake Kivu at Gisenyi with a temperature of 73.6°C which could

Fig. 3: Geothermal Sites in Rwanda. Source: (JICA 2013)

feature subsurface temperatures of 250°C at a depth of 2Km (JICA 2013). Furthermore, the appearance and disappearance of the Gisunyu river is testament to the prevalence of tectonic movements and alterations in the Gisenyi geothermal prospect (Ngaruye and Haganje 2018). In light of these manifestations, preliminary studies have been conducted relating to four marked geothermal fields of interest i.e. Kilwa, Gisenyi, Muti and Kanzanza. So far,
following the geoscientific reconnaissance studies carried out, these target fields call for more in-depth surface explorations to enlighten future expeditions.

A geoscientific data review by (Varet 2018) also hints on the fact that there is a promising underlying untapped geothermal resource along the Rwanda – DRC border due to hydrothermal manifestations alongside Lake Kivu with three existent thermal springs namely Kihira, Tingi and Sake. He further underscores that limited knowledge of geothermal resources in this area have been limited to the reconnaissance and surface surveys carried out by both countries. However, a coalition by both governments shall be pivotal in understanding the hydrothermal outlay of the Kivu rift through the establishment of bilateral research. These studies are therefore a call for more interventions in regard to further geological, geoscientific studies and measurements in the highly prospected fields to provide ground for further explorations.

2.3 Burundi

2.3.1 Policy and Regulatory Situation

Burundi relentlessly grapples with the challenge of energy access as 89% of the population was un-electrified by 2018 due to chronic electricity deficits, yet it has several opportunities for the development of RE resources (Sinzinkayo, Sliwa, and Wakana 2015). This is because the country continues to rely mostly on hydropower for energy generation prone hydrological vulnerabilities with the remaining energy balance being met by thermal energy generation. With an installed capacity of 51.7 MW (Sinzinkayo, Sliwa, and Wakana 2015), the country is still faced with the looming conundrums of energy insecurity, energy inefficiency and slowed economic development thereby increasing its reliance on regional interconnections. Accelerated energy development in view of the Country’s 2025 vision, only envisages RE promotion through solar, wind, biogas and ethanol but not geothermal (MoPCD UNDP 2011). Hitherto, geothermal does not even feature in the Integrated Power Master Plan developed for the period 2018-2040 and the country has no existing geothermal framework, policy and FiT.
2.3.2 Geothermal Resource Potential and Development.

The earliest reported geothermal investigations date way back to 1969. Over time, several geological studies have been carried out on the distributed geothermal sites (fig.4) mainly characterized as water pools. The most promising sites are located in the Rusizi valley whose temperature lies in the range of $100 - 160^\circ C$. In 2010, a hot spring prospection survey was carried out at the sites of Kamunyange, Ruhagarika, Mugara, and Ruhwa which among others revealed that no vapor or steam was present at all the sites though the site temperatures from the geo-thermometry were $39 - 40^\circ C$, $48^\circ C$, $48^\circ C$, and $68^\circ C$ respectively (Nizeye 2012).

The evidence put forward from the studies on the 15 hot springs and 14 geothermal locations available depicts that most of the potential geothermal fields are mainly suitable for direct heat utilization considering that the highest recorded temperature is about $70^\circ C$. It was against this backdrop that the potential use of direct heat through borehole heat exchangers for heating and cooling was acknowledged through mathematical analysis for typical hotels of Bujumbura (Sinzinkayo, Sliwa, and Wakana 2015). However, not much geothermal development progress has been realized in the country and this leaves a deficit of knowledge yet to be obtained.

2.4 Tanzania

2.4.1 Policy and Regulatory Situation.

In bid to increase energy security, reliability and supply with reduced power costs geothermal power generation holds as a sustainable solution in diversifying this sector with installed capacity of 1565.72 MW as of 2019. This shall be significant in meeting the growing energy demand as portrayed in the current Power System Master Plan stipulating 100MW of geothermal power generation by 2035 (MEM 2013). At the backbone of this developments is a robust Ministry of Energy and Mineral Resources (MEMR) which plays a central role in the promotion and development of the geothermal resource through improving the technical capacity, reducing exploration related risks, ensuring the development and adoption of a sound regulatory framework as well as providing a level playing field for private sector involvement. In existence, are the FiTs for other renewables but that of geothermal was overlooked (EWURA 2019). Also, the country has no existing geothermal energy policy and geothermal energy act reported so far, these efforts are only enshrined under the 2015 revised National Energy Policy pursuant to diversification of the energy mix. Nevertheless, the
government is finalizing with the drafting of the geothermal law which in essence shall aid in the development of geothermal energy in the country (Takouleu 2019).

Transformative measures to expedite the set geothermal power generation goal led the government through the MEMR to institute a separate entity in 2013, the Tanzanian Geothermal Developmental Company (TGDC), and has since sought to among others carry out a nation-wide geothermal resource survey, establish the regulatory framework and create a favorable investment climate to mobilize finances for resource development (Mnjokava, Kabaka, and Mayalla 2015).

2.4.2 Geothermal Resource Potential and Development.

The country lies in both arms of the EARS which strategically positions the most promising sites appropriately in four distinctive regions i.e. the Northern, South Western, Coastal basin and in the intra cratonic volcanic provinces with the most precise potential sites being situated at Songwe, Luhoi, Ngozi and Kienjo Mbaka all at the surface exploration stages (Kajugus et al., 2018). The Western rift in the country comprises of both the Tanganyika and Rukwa rifts. The former spans from the South Western Burundi border through Lake Tanganyika and fairly meets up the later leading up to the triple junction. This junction happens to be the intersection between the Nyasa (Karonga), Rukwa and Usangu rifts. The complexity of triple junction outlays a distinct form of tectonism and volcanicity which provides the basis for the existence of geothermal fields like the Songwe, Kienjo-Mbaka, Ngozi, Kasimulu, Mampulo, Kilambo.

Geothermal site surveys have been conducted in the country since 1950’s which included the analyses of the water and gas flows in hot springs as well as attaining the surface temperatures. The Ngozi prospect, located in the Rungwe volcanic province, turns out to be the most researched geothermal field in the country and has thus undergone more surface exploration studies. With an estimated reservoir temperature of 232°C, this site is one of the few sites in the Western rift (fig.5) that are magmatically heated (Hinz, Cumming, and Sussman 2018).

To this end, a detailed conceptual model has been developed and the authors (Kajugus, Kabaka, and Mnjokava 2018) reported that shallow well drilling at Songwe and slim drilling at Ngozi were to be commenced in the 2018/19 financial year since the environmental drilling permit for the Ngozi geothermal field had been secured. As such, the government secured funding worth US$21.7 million from the Climate Investment Funds (CIF) for the Ngozi geothermal power plant and the construction is slated for start in 2021. With the drilling of three pilot geothermal wells, this ought to be the inception of the phased 600 MW project into Tanzanian power grid (Takouleu 2019).
Studies conducted at the Songwe geothermal field revealed that it was a medium temperature geothermal system and was a suitable for direct use applications. Following the recommendations from the EAGER study completed in 2018, were the first structural map and comprehensive geology where performed, temperature gradient holes were to be drilled to ascertain the availability of the resource for direct utilization in areas with active surface manifestations (Hinz, Cumming, and Sussman 2018; Heath et al. 2018).

Additionally, the geothermal fields of Kienjo-Mbaka and Luhoi are also in the pipeline for test drilling as they form the focus in the view of 200MW geothermal power generation by 2025. This is further backed by the 2D and 3D geophysical modeling of the Kienjo-Mbaka field by (Rizzello et al. 2018) which characterizes this field as a low temperature geothermal alteration with surface geothermal manifestations as hot springs as well as conductive regions to the order of 1-10 ohm m. Similarly, the Luhoi geothermal field hosts a low temperature resource though it’s out of context of this review being located along the coastal region of the country.

Figure 5. Location of the selected geothermal sites in the United Republic of Tanzania

2.5 Malawi

2.5.1 Policy and Regulatory Situation.

Malawi has for long been reliant on hydroelectricity mainly generated on Shire River which is disposed to the growing impacts of climate change. With view of unlocking the country’s energy potential (with installed capacity of 445MW (MoFEPD 2019)) and to revolutionize initiatives of development, Malawi revised the former energy policies to the now 2018 Energy Policy in which among others seeks to promote the diversification of the sources of energy through the adoption of RE technologies such as geothermal energy. This recent policy emphasizes about the conducting of feasibility studies, expedite assessment and consequently development of prospective sites so as to realize at least one geothermal power plant of 0.85MW by 2023 (MoNREM 2018). The above mentioned policy was an addition to FiT policy structured by the Malawi Energy Regulatory Authority (MERA) in 2012 for renewables inclusive of geothermal. In this policy, a tariff of less than USc 10.5 per kWh shall be applicable for 20 years after commission of the first geothermal plant but only limited to the first 200 MW of installed geothermal capacity (MERA 2012). In the long term, the country power investment aspires to attain at least 50 MW of geothermal generated power by 2050 (MERA 2012).
2.5.2 Geothermal Resource Potential and Development.

The Malawian rift happens to be the extension of the Western rift extending from the triple junction forming the confluence with the Rukwa and Usangu rifts. This half graben rift is in its early development stages and is comprised of Lake Malawi (Nyasa) spanning through the Shire River to Mozambique. The country has over 25 geothermal manifestations inclusive of hot springs and warm grounds that have eventually led to surface anomalies. The areas of Chitipa-Karonga have been reported to have about 21 hot springs with the highest recorded temperature of 79.3°C. Through the engagement of the ELC Electroconsult Company, reconnaissance studies, geological and geophysical surveys were carried out on all geothermal resources (fig.6) in the country.

Figure 6. Location of the selected geothermal sites in Malawi.

Six prospects where identified through a multi-criteria technical ranking which were inclusive of Chiweta in Rumphi, Kasitu in Nkhotakota, Kasanama, Mawira, Kanunkha and Chupudzi geothermal prospects from which the aforementioned two fields i.e. Chiweta and Kasitu emerged as more probable prospects after subjection to detailed geo-mapping and geochemical surveys (Eliyasi 2018). Following his (Tsokonombwe 2017) exploration survey on the Chiweta geothermal system where hydro-geochemistry techniques involving; geological and geothermal mapping, water chemistry together with hydrological studies were utilized, a conceptual model for the system was developed. He further suggests the suitability for well drilling following the chemical geo-thermometry study that revealed a subsurface temperature range of 132-157°C. To date, pre-feasibility studies have been conducted at the Chiweta and Kasitu geothermal fields revealing resource potentials of 13.5 and 5.6 MW respectively (MoFEPD 2019).

3. Challenges to geothermal development in the region.

The upfront costs remain high partly due to the high costs of drilling equipment. This is compounded by the risk of uncertainty related to the likelihood of sinking test wells in alien regions where no geothermal resource exists. Understanding that developers’ decisions on geothermal investments are mostly driven by the availability of data from prior preliminary studies taking the forms of geological, geochemical and geophysical surveys. These surveys are essential in order to ascertain the resource availability, location, chemical and physical resource properties, resource depth, and the required drilling technology all of which necessitate sound technical personnel who are currently limited in the region.
The lack of clear policy and regulatory frameworks is considered as one of the major hindrances in the development of the geothermal energy sector because of failure to clearly spell out how to go about pertinent technicalities. These could include though not limited to attracting financial support, outlining project development, energy incentives and tariffs, permitting, granting of concessions, licensing and timelines to mention.

With vast pressures disposed onto the energy sector in the region, geothermal energy is still largely influenced by the lack of institutional capacity through the inadequacy of facilities, equipment, trained technical expertise, and institutional process limitations that are characterized with lengthy bureaucratic processes. This eventually leads to longer gestation periods.

4. Discussions and recommendations.

Through the establishment of Public Private Partnerships and concessions, the governments shall have the capability to expedite financing mechanisms at various stages of exploration so as to further exploration and power production. This could be actualized by incorporating the Multilateral lending institutions to cushion investors of the exploration risks which in effect shall attract investors. Additionally, through the commitment of the GRMF to provide grants for both surface explorations as well as the drilling and testing of reservoir wells shall continue being a catalyst for geothermal development for the countries discussed in this review save for Malawi.

Through separate entities like the TGDC, feeding into the energy ministry, they should be tasked with the coordinating of exploration and investment activities while also playing the advisory and implementation role of driving the impetus for change throughout the sector.

For the development of inherent policy, legal and regulatory framework, the approach considered in the Ugandan context towards forging partnerships with already established organizations i.e. the CTCN helped expedite this reformation. As is the case of Malawi, strong monitoring and evaluation frameworks are also influential in maintaining the trajectory of the prospects. Support raised from the EAGER advisory facility has portrayed a new approach towards the Western Rift since its inception in 2015 leading to a new structural analysis and promise for more detailed analysis through the development and revision of existing conceptual models as was the case for Katwe and Songwe geothermal fields.

5. Conclusion

As per this review, it is noteworthy that for the institutionalizing of the sector through promulgation of supporting frameworks in terms of the geothermal policy, legal and regulatory framework shall help streamline the development of geothermal energy. Though no pragmatic results have been attained to date concerning power generation, significant strides have remained at heart most especially in Uganda and in the United Republic of Tanzania reaching the stage of exploration drilling. From an optimistic view, the vibrancy of this Western rift is nearing as some sites are approaching the pre-feasibility stages. These have and shall pave way for pilot slim/full sized well drilling and ultimately power generation though this branch shall continue to trail against its counterparts.
REFERENCES


Mugagga et al.


