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Geothermal Energy Development in East Africa: Barriers and Strategies

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Authors' contributions

This work was carried out in collaboration between both authors. Author EYK designed the study and wrote the first draft of the manuscript. Author JM managed the analyses of the study. Both authors read and approved the final manuscript.

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ABSTRACT

The East African Rift is among the most crucial regions of the world endowed with a remarkable geothermal potential. Using current technologies, East African countries have a geothermal power potential of more than 15,000 MWe. Nevertheless, the zone is still at an early stage of geothermal development with few plants producing a few hundred MWe. Among East African countries that have carried out research on geothermal resources, Kenya is leading in utilising geothermal energy resources for electricity generation. Eritrea, Uganda, Tanzania and Djibouti are at exploration stage while Malawi and Rwanda have so far not gone past geothermal resource potential record work. This study sought to address the challenges and barriers to the adoption of geothermal energy as well as the strategies to implement geothermal energy plans in East Africa.

Keywords: Challenges; strategies; East Africa; geothermal energy plan.

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ABBREVIATIONS

AEPRN : African Energy Policy Research Network
UNU : United Nation University
IEA : International Energy Agency
KPLC : Kenya Power and Lighting Company

1. INTRODUCTION

Most of the East African countries depend on the diminishing fossil fuels as a primary source of energy. The major energy crisis surrounding this energy sources is hastily becoming the biggest challenge facing our generation. With diminishing supplies of fossil fuels as well as increase in pollution [1-2], East African governments are committed to explore and develop alternative sustainable energy sources [3]. The commitment arises due to the following factors [4]:

1. The continued intensification of global energy demand
2. The decline in fossil fuel supply
3. Recent effects of drought

Traditional biomass fuels consumption in East Africa represent 70 to 90% of total energy production [5]. However, its high consumption leads to deforestation which further contributes to environmental degradation.

Renewable energy sources such as solar, hydro, geothermal etc. represent the smallest fraction of the total energy generation, averaging to 2% for solar, geothermal and hydropower generation as illustrated in Table 1.

Currently, hydro is the predominant source of electrical energy production averaging 70%, [6]. However, the recent droughts leave many to query how reliable this source is. Therefore, to reduce the overreliance on fossil fuel, there is a need to explore geothermal energy generation which is an environmentally sensible alternative to fossil fuels [7-9].

In this paper, the endeavour has been made to assess the geothermal energy resource utilisation and potential in East Africa as well as the barriers to its adoption and the strategies to overcome them.

2. GEOTHERMAL ENERGY POTENTIAL IN EAST AFRICA

The Great East African Rift illustrated in Fig. 1 is among the most crucial regions of the world endowed with a remarkable geothermal potential [10]. Using current technologies, East African countries have geothermal power potential of more than 15,000 MWe [5]. Regardless of this potential, only Kenya has an active geothermal project as part of her infrastructure for electricity generation [11].

The world produces about 8,900 MWe of geothermal power with Philippines producing over 1,900 MWe and Indonesia producing approximately 589 MWe. Kenya and Ethiopia have an installed geothermal energy capacity of 137 MWe. Since the early 1980's, the total geothermal power generation of Kenya has been rising from 15 MWe to 130 MWe at Olkaria [12].

Varying level of geothermal research and exploration have been carried out in Uganda, Eritrea, Zambia, Tanzania, Djibouti and Malawi. It was established from the research and exploration that Djibouti, Kenya, Uganda, Ethiopia and Tanzania have the greatest geothermal energy potential for electricity generation [12].

Table 1. Total electricity production in the East Africa in MWe [6]

Country	Thermal	Hydro	Geothermal	Wind	Total
Djibouti	85	-	-	-	85
Eritrea	130	-	-	-	130
Ethiopia	113.1	669.9	7	-	783
Kenya	346	584	130	1	1052
Tanzania	202	561	-	-	763
Uganda	-	300	-	-	300
Total	**875**	**2116**	**137**	**1**	**3127**

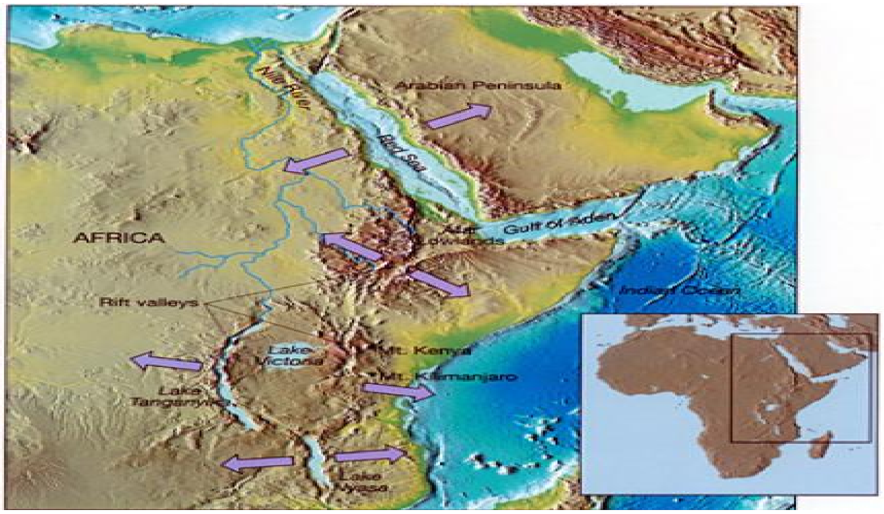

Fig. 1. The Great East African Rift System [13]

3. GEOTHERMAL ENERGY OPPORTUNITIES IN EAST AFRICA

Recently there has been increasing geothermal energy utilisation in East African with Kenya leading in its development. Currently Rwanda, Ethiopia, Djibouti, and Tanzania are taking steps in harvesting the underdeveloped energy resource [13].

East Africa has a huge geothermal power potential of capacity more than 15,000 MWe which is more than double the existing installed geothermal power capacity across the East Africa [14]. However, high upfront capital cost, resource exploration risk, and lack of technical expertise makes it less attractive for public investment.

On May 2015, the East Africa Geothermal Energy Facility (EAGEF) funded by the UK Department for International Development (DFID) was established to enhance public and private stakeholder's participation in geothermal energy development for electricity generation in Kenya, Ethiopia, Rwanda, Uganda and Tanzania [14]. EAGEF provides advice to help put in place transparent regulatory framework, legal conditions, and the right policy in order to attract private investors who are interested in financing geothermal projects in East Africa [12].

4. BARRIERS AND CHALLENGES TO THE ADOPTION OF GEOTHERMAL ENERGY IN EAST AFRICA

Developing geothermal energy takes years for initial survey, resource exploration, drilling and testing, field development, constructing power plant, and operation and maintenance. The major barriers to the adoption of geothermal energy in East Africa can be categorised into: financial barrier; institutional barrier; social and environmental barrier; and technological barrier [15-17].

4.1 Financial Barriers

Economic feasibility is a crucial factor in geothermal energy development. Large upfront cost, difficulties in resource discovery, and long payback period are the major obstacle to the implementation of geothermal energy projects [18-19]. The slow pace of geothermal energy development in East Africa is due to the high initial capital of drilling wells which costs over US$5 million to drill one test well [11]. Investing in geothermal energy requires one to drill a number of wells in order to assess its potential for a particular prospect [16].

High initial costs and the associated risks of geothermal energy exploration is highly attributed to lack of co-operation between the various stakeholders within the East African governments and the private sector [16]. Majority of the Africa countries with national poverty level of 50-70% [20] cannot afford developing geothermal projects. Furthermore, the stringent requirements for bank loan applications exclude them from qualifying [21].

4.2 Institutional Barriers

The successful introduction of geothermal energy largely depends on the existing government policy. Government policies are crucial factors with the ability to create an enabling environment for the successful dissemination of geothermal energy resources in developing countries [15]. Furthermore, they encourage the investment of private sector in development of geothermal energy.

Most East African governments have no clear-cut policy on renewable energy development and promotion. This leads geothermal projects developments to follow a path with no clear link to national power master plans which are unavailable [22]. Very low budgetary allocations to renewable energy technologies in most East African countries demonstrate limited policy support for the development of renewable energy. They place more emphasis on diminishing fossil fuel for energy generation than on renewables energy [23] making geothermal energy projects development difficult.

4.3 Technical Barriers

Geothermal resources development relies on a range of professionals with differing technical backgrounds and experience [16]. Since 1970s geothermal energy training has been done through financial sponsorship in the Geothermal Institute of Auckland in New Zealand, Pisa University in Italy, United Nations University in Iceland, Kyushu University in Japan, and the University of Iceland [24]. Unfortunately, there are fewer opportunities, around the world, for geothermal training than there were in the 1980's and 1990's. With only the United Nations University in collaboration with the University of Iceland being the current international graduate school offering training in geothermal science and engineering [25-27].

A visual inspection of East African geothermal plant revealed a great number of foreign technicians, with the help of a few local consultants. This shows that the East African governments have not yet developed an adequate technology capacity to meet the demands of this sector and therefore depend on foreign technologists. This explain the low uptake geothermal energy projects in East Africa.

4.4 Social and Environmental Barriers

Geothermal is an environmentally benign source of energy. However, construction of geothermal plants has an impact on nature which includes: noise, visual impact, surface disturbance, displacement of families, and production of highly corrosive brine [28]. Therefore, social acceptance and proper environmental regulations are crucial factors for sustainable geothermal energy development. Their lack seriously hinders geothermal development.

5. STRATEGIES TO OVERCOME BARRIERS FOR GEOTHERMAL ENERGY DEVELOPMENT

5.1 Financial

East Africa governments should give priority to the establishment of innovative and sustainable financing mechanisms to promote the exploration and utilisation of geothermal resources [12]. This may range from:

1. Loans and grants from International Organisations to finance geothermal exploration and development e.g. Word Bank, Clean Development Mechanism grant by Global Environment Facility and African development bank [29-30] etc.
2. The participation of private investors in geothermal energy development
3. Established Risk Guarantee fund by development agencies for exploratory and appraisal drilling of projects
4. Tax incentives to encourage developers to undertake their own geothermal resource assessment [30]
5. Enhanced coordination among countries and local institutions [17].
6. Reduced energy investment risks through feed-in tariffs, Public-private partnerships etc [31]. This attracts private investors to finance geothermal energy.

5.2 Institutional

In order to boost geothermal energy growth in East Africa, each East African country should:

1. Establish favourable policies and incentives to attract private investors [2,12].
2. Establish clear policy to enhance geothermal energy development and promotion [18].

5.3 Technical

In order to enhance geothermal energy development in East Africa, each East African country should [12]:

1. Establish geothermal energy training institutions designed to train manpower with the appropriate technology to enhance easy exploration of geothermal resources.
2. Set up some Regional Geothermal agency networks to certify the promotion and utilisation of geothermal knowledge in East Africa.

5.4 Environmental

Developers must meet local environmental requirements by:

1. Establishing special treatment for the highly corrosive brine which is produced from geothermal schemes.
2. Conducting regular environmental audits
3. Creating a budget to support clean environment project activities in order for the communities around the project area to feel part of it [28].
4. Involving the local in decision making for activities which have great impact on them [28].

6. CONCLUSIONS

In this study, the East Africa energy situation has been outlined and her energy mix presented. It is shown that East Africa largely depends on traditional biomass, however, its high consumption leads to deforestation which further contributes to environmental degradation. From the renewable energy data presented, East Africa is endowed with a remarkable geothermal potential which can contribute to its energy supply. Despite the fact that East Africa is endowed with vast geothermal energy potential, it experiences a slow growth rate of geothermal energy. The barriers to the adoption of geothermal energy in East Africa are: unreliable financing mechanisms, unclear policies and regulation framework to enhance geothermal energy development and promotion, lack of coordination among countries and local institutions, shortage of trained manpower and lack of involvement of local people in decision making for activities which have great impact on them. The analysis suggests strategies to enhance the growth of geothermal energy East Africa.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Institute of Mechanical Engineers. Types of Fossil Energy; 2015.
(Accessed on 12 June 2018)
Available:http://www.imeche.org/knowledge/themes/energy/energy-supply/fossil-energy/types-of-fossil-energy
2. Erdogdu E. A snapshot of geothermal energy potential and utilization in Turkey. Renewable and Sustainable Energy Reviews. 2009;13:2535–43.
3. Georgsson LS, Fridleifsson IB. Geothermal Energy in the World from Energy Perspective [Presentation]. Short course IV on Exploration for Geothermal Resources. Lake Naivasha, Kenya; 1st to 22nd November 2009.
4. Coyle DE, Simmons AR. Understanding the Global Energy Crisis 2nd Ed. West Lafayette: Purdue University Press; 2014.
5. Omenda P, Teklemariam M. Overview of geothermal resource utilization in the East African Rift System [Presentation]. Short course V on Exploration for Geothermal Resources. Lake Bogoria, Kenya; 29th October to 19th November 2010.
6. IEA. Key world energy statistics. Paris, France: Chirat; 2007.
7. Macharia MW, Gachari MK, Kuria DN, Mariita NO. Low cost geothermal energy indicators and exploration methods in Kenya. Journal of Geography and Regional Planning. 2017;10(9):254-65.
8. Chandrasekharam D, Lashin A, Arifi NA. The potential contribution of geothermal energy to electricity supply in Saudi Arabia. International Journal of Sustainable Energy. 2014: 1-10.
9. Rosso-Cero´n AM, Kafarov V. Barriers to social acceptance of renewable energy systems in Colombia. Current Opinion in Chemical Engineering. 2015;10:103 –10.
10. Younger PL. Missing a trick in geothermal exploration. Nature Geoscience. 2014;7(7): 479-80.
11. KPLC. Annual Financial Report 2008/2009. Nairobi: Governent of Kenya Printer; 2008.
12. Karekezi S. Renewable Energy in Africa: Prospects and Limits. In: United Nation. Workshop for African Eneergy Expert on Operationalizing the NEPAD Energy Initiative. Novetel, Dakar, Senegal; 2003.
13. Teklemariam M. Overview of geothermal resource utilization and potential in East African Rift System [Presentation]. Short course II on Exploration for Geothermal

Resources. Lake Naivasha, Kenya; 2nd to 17th November 2007.

14. BMI Research. Geothermal power opportunities in the rift valley; 2018. (Accessed on 20 August 2018) Available:https://www.bmiresearch.com/blog/geothermal-power-opportunities-in-the-rift-valley
15. Adam Smith International. Enabling investment in geothermal power in East Africa; 2018. (Accessed on 23 August 2018) Available:https://www.adamsmithinternational.com/explore-our-work/east-africa/kenya/enabling-the-development-of-geothermal-energy-in-east-africa
16. Pan SY, Gao M, Shah KJ, Zheng J, Pei SL, Chiang PC. Establishment of enhanced geothermal energy utilization plans: Barriers and strategies. Renewable Energy; 2018. (In press)
17. Zalengera C, Blanchard RE, Eames PC, Juma AM, Chitawo ML, Gondwe KT. Overview of the Malawi energy situation and A PESTLE analysis for sustainable development of renewable energy. Renewable and Sustainable Energy Reviews. 2014;38:335–47.
18. Wilkins G. Technology transfer for renewable energy: Overcoming barriers in developing countries. United KIngdom: The Royal Institute of International Affairs; 2001.
19. Nguyen NT, Ha-Duong M, Tran TC, Shresth RM, Nadaud F. Barriers to the adoption of renewable and energy-efficient technologies in the Vietnamese power sector. GMSARN International Journal. 2010;4(2):89-104.
20. Mbuthi PN, Andambi HK. Feasibility and Enhanced Role of Geothermal In Kenya's Energy Supply; 2004. (Accessed on 26 June 2018) Available:http://www.afrepren.org/draftrpts/hbf/geo_ke.pdf
21. World Bank. Attacking poverty. New York: Oxford University Press; 2001.
22. Mapako M, Mbewe A. Renewables and energy for Rural Development in Sub-Saharan Africa. Malta: Gutenberg Ltd; 2004.
23. Mwakubo S, Ikiara M, Aligula E. Strategies for securing energy supply in Kenya. Nairobi: Kenya Institute for Public Policy Research and Analysis. 2007;74.
24. Mariita NO. Status and challenges in training on geothermal energy in Africa. In: Geothermal Development Company. World Geothermal Congress 2015. Melbourne, Australia; 2015.
25. Fridleifsson IB. Twenty five years of geothermal training in Iceland. In: University of Auckland. World Geothermal Congress 2005. Antalya, Turkey; 2005.
26. Hochstein MP. 25-year Geothermal Institute. In: University of Auckland. World Geothermal Congress 2005. Antalya, Turkey; 2005.
27. Mwangi MN. Contribution of UNU-GTP training to geothermal development in Africa. In: United Nation University. International Geothermal Conference IGC-2003 on Multiple Integrated Uses of Geothermal Resources. Reykjavik, Iceland; 2003.
28. Mariita NO. The impact of large-scale renewable energy development on the poor: Environmental and socio-economic impact of a geothermal power plant on a poor rural community in Kenya. Energy Policy. 2003;30:1119 –28.
29. Schwerhoff G, Sy M. Financing renewable energy in Africa – Key challenge of the sustainable development goals. Renewable and Sustainable Energy Reviews. 2017;75:393–401.
30. Agoye HK. Challenges in the development of Geothermal Power to meet Industrialisation needs of Kenya. 174-78.
31. Schmidt TS. Low-carbon investment risks and de-risking. Nature Climate Change 2014;4(4):237–9.

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