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The Role of Donor Funds in Reducing Risks and Attracting Foreign Investments for Africa's Geothermal Resource Development

Ralph K. B. Nyakabwa-Atwoki

Sustenersol Uganda Limited, P. O. Box 71572 Kampala, UGANDA

E-mail: bcwakira@gmail.com

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ABSTRACT

Paleo-Indians settlers living around hot springs were the first to explore and utilize geothermal resources in North America over 10,000 years ago. European settlers moving westward probably encountered hot springs in Yellowstone area and recorded large scale hot springs energy used in La Grande, Oregon in 1862.

With steady geothermal development in the US, the need for strategic geothermal energy policy, institutional, and regulatory framework became apparent. Overtime, Geothermal Resource Acts, Loan Guaranty and Financial Assistance were enacted. These Acts were instrumental in acquisition of public and federal lands for sustainable geothermal exploration, investment in and environmental development of its geothermal resources.

Explorer Stanley reported the geothermal manifestations in Africa in Burundi in 1878 and for the first-time, geothermal based electric power generation was invented in Italy in 1904 and entered Africa in 1911 by Bas-Katanga Engineers and the first geothermal Power Plant producing 550.000-kWh of electricity per year, constructed in 1952 at Manono Province in the Democratic Republic of Congo (DRC).

Subsequent geothermal exploration has been carried out in the continent's Geothermal Resource Countries (GRC) from 1952 to early 2005 largely supported by funds from their country governments, regional programs and international agencies among others as enumerated in Section 1.

GRC's resources remain undeveloped because of the high financial resource development and financial risks in addition to lack of strategic geothermal energy specific policy, institutional, and regulatory barriers.

Kenya's acceleration to the 9th rank among geothermal top ten countries in the World and Djibouti's current geothermal development status is attributed to the creation of geothermal specific corporate body the Geothermal Development Company Ltd (GDC) and Djibouti Office for Geothermal Energy Development (ODDEG), respectively.

The Current progress especially in surface survey and drilling of test wells phases is owed to the de-risking of the geothermal resource development using regional, bi and multi-lateral agencies' (including some of those above) funding programs that has witnessed increased regional, continental and foreign capital flows of both public and private investors. It is incumbent upon governments and policymakers of GRCs create or enhance their policy framework to ensure the continent's rapid geothermal energy development.

1. INTRODUCTION

The North America's geothermal resource developers took cognizance of the need for strategic geothermal energy policy, institutional, and regulatory framework one hundred and sixty (160) years ago (Web (2020). This led to enactment of Geothermal Resource Acts for example, Loan Guaranty and Financial Assistance that were instrumental in acquisition of public and federal lands for sustainable geothermal exploration, investment in and environmental development of its geothermal resources.

Just as Paleo-Indians settlers alluded to in the abstract, explored and utilized their hot springs over 10,000 years ago, Africans used their hot springs as exemplified by the King of Toro and his chiefs spending days lying and riding themselves of wastes in warm waters of Rwagimba sulphur hot springs of River Rwimi, (Web ibid) Explorer Stanley reported the geothermal manifestations in Africa in Burundi in 1878 and unlike the settlers of North America, neither the development and wide use of the resource nor enactment of policy framework took place hence limiting and retarding the development of the continent's geothermal Bizana, (2014)

Geothermal based electric power generation was, for the first-time, invented in Italy in 1904 and brought to Africa in 1911 by Bas-Katanga Engineers and the first geothermal Power Plant producing 550.000-kWh of electricity per year, constructed in 1952 at Manono Province in the Democratic Republic of Congo (DRC), Makuku, (2019). No further significant geothermal resource exploration or development was recorded until 1952 to early2005, when, exploration was carried out in GRC using Donor Funds implemented by agencies like the United Nations Development Program (UNDP), IIDA/INEA, the United Nations University-Geothermal Training Programme (UNU-GTP), Kenya Electricity Generating Company Limited (KenGen), Geothermal Development Company (GDC) Kenya, ICS-UNIDO, United States Agency for International Development (USAID), Icelandic International Development Agency

(ICEIDA), the African Union Commission (AUC) and the Deutsche Gesellschaft für Internationale Zusammenarbeit/German geological institute/ Entwicklungsbank (GIZ/(BGR)/(KfW) among others, (Bizana, (2014)

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The Current progress especially in surface surveys and drilling of test wells phases is owed to the de-risking of the geothermal resource development using regional, bi and multi-lateral agencies' (including some of those above) funding programs that has witnessed increased regional, continental and foreign capital flows of both public and private investors, *source (year*)*.

The way forward is for policy makers to take advantage of the progress initiated by donor funded exploration by harnessing policy interventions that address and mitigate the barriers to and incentivize development of geothermal power. The de-risking instruments considered to ease the burden on investors, Oliver and Statesman, (2015) as will be articulated in Section 4 of this paper.

2. AFRICA: THE CONTINENT

2.1 Africa the dark continent

One of the very many explanations of why Africa is called the dark continent is from a London conference on "Electric Africa." The delegates were shown a satellite image depicting the power distribution across the globe and the African continent, with the exception of few bright spots in the north and south extremities, was the only one all dark (ICA,2016).

The information available indicates that the 16 percent of the world's population has no access to electricity. Africa's share is said to be 600 million people without electricity (WB, 2010). Even those privileged to have it; continental Africa's power generated and consumed remains the lowest amongst all continents. as depicted in Figure 1.

Figure 1 illustrates a few bright spots showing South Africa and Algeria lit at night and being the only African continent's countries ranked 19Th and 48th among the first 50 with Morocco and Ghana in 61st and 98th of 100 positions, as depicted in Table 1. The full list of all African countries indicating their positions appears in Appendix 1 at the end of this paper.

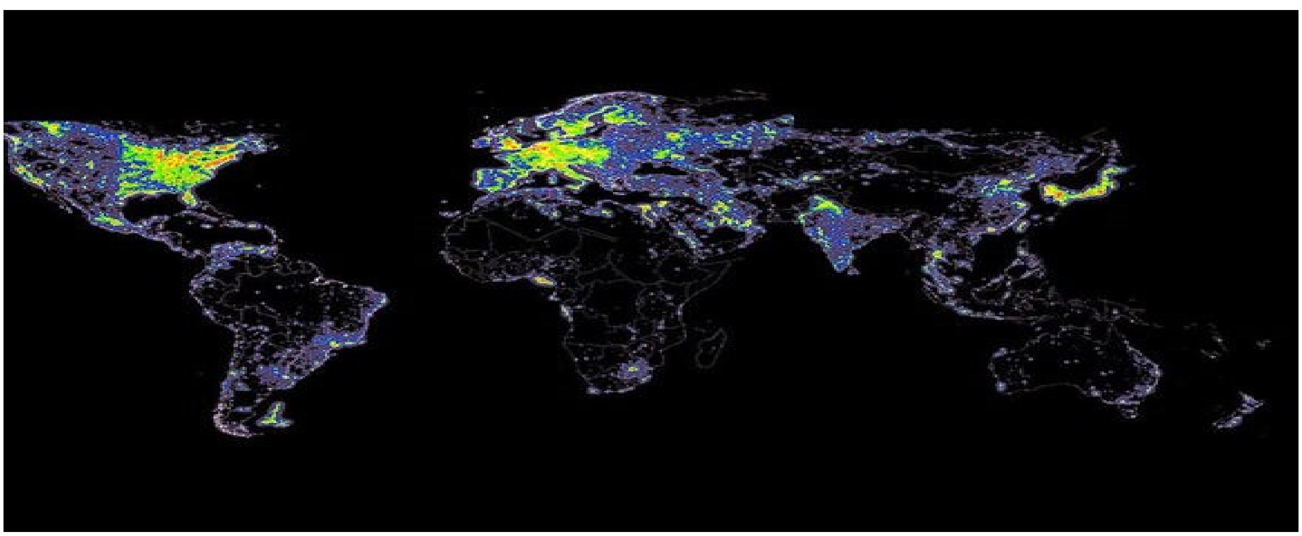


Figure 1: Satellite picture of Africa by night power.

Africa's bleak energy consumption should be treated as a security matter because there is no adversary with such lethal fangs as poverty and should be fought like a conventional military war but with peaceful economic renewable resources such as the 'heavy weapon' endowment of geothermal resource (Simiyu, 2012. The answer to these challenges is not beyond our reach, the solution, in fact, lays in our hands and with it our ability to change the future (Zervos et al, 2010).

2.2 Africa economic and energy sector indicators

2.1.1 Economic indicators

At a glance Africa's population is estimated to be 2.051 billion, in 2019, GDP $2.19 billion (nominal 2017, GDP growth 3.7, GDP per capita $1.720, unemployment 15% with over 600 million of its population without electricity and most of its countries grouped in the Low Human Development Index as per Africa Human Development Report. (AfHDR, 2016).

Another criterion used is the ease of doing business (World Bank, 2019). Africa's ranking on the ease of doing business has, using country rank groupings, 2 member counties in the first 50, 8 in 50 to 100, 14 in 101 to 150 and 24 in the last group of 151 to 200 (WB, 2019) as depicted in Table 1 overleaf.

TABLE 1 Africa's ease of doing business ranking

Rank Group	Country Rank Grouping	Country or Region
1st to 50th	20,29	Mauritius, Rwanda
51st to 100th	60, 61, 80, 82, 86, 87, 96, 99	Morocco, Kenya, South Africa, Botswana, Zambia, Seychelles, Djibouti
101st to 150th	106, 107, 111, 114, 120, 122, 127, 141, 143, 144,145, 146, 148, 149	Lesotho, Namibia, Malawi, Ghana, Egypt, Cote d'Ivoire, Uganda, Senegal, Niger, Tanzania, Mali, Nigeria, Mauritania, The Gambia.
151st to 200th	151, 152,153,155,159,162,163, 164, 166,168, 169, 171, 173,174, 175, 180, 181, 183, 184, 185,186, 189, 190	Burkina Faso, Guinea, Benin, Zimbabwe, Algeria, Ethiopia, Sudan, Sierra Leone, Comoro, Cameroon, Burundi, Gabon, Iraq, Angola. Liberia, Guinea-Bissau, Congo Republic, Chad, Democratic Republic of Congo, South Sudan, Libya, Eritrea, Somalia

2.1.2 Energy sector indicators

The Africa's power consumption remains very low just as is the ease of doing business. Africa's power generated in selected African countries has, using country rank groupings, 3 member counties in the first 50, 2 in 51 to 100, 2 in 101 to 150 and 2 in the last group of 151 to 200 (WB, 2019) as depicted in Table 2. Therefore, investment in renewables, especially geothermal, should be given priority (Simiyu, ibid).

Table2: Power generated in selected African countries compared to the World and China

Partial Country Rank & Grouping		Country/ Region	Electricity consumption (kWh/year)	Population	Average energy per capita	Average power per capita
The World and China		World	21,776,088,770,300	7,322,811,468	2,674	309
	1	China	6,310,000,000,000	1,403,500,365	4,475	510
1st to 50th	19	South Africa	212,000,000,000	54,300,704	3,904	445
	48	Algeria	49,000,000,000	40,263,711	1,216	138
51st to100th	61	Morocco	29,000,000,000	33,655,786	861	98
	98	Ghana	9,200,000,000	26,908,262	341	39
	102	Angola	8,100,000,000	20,172,332	401	45
101st to 150th	148	Mali	1,400,000,000	17,467,108	80	9
	151	Burkina Faso	1,200,000,000	19,512,533	61	7
151st to 200	200	Samoa	100,000,000	198,926	502	57
	201	Equatorial Guinea	91,140,000	759,451	120	13

3. THE NATURE OF GEOTHERMAL RESOURCES

Geothermal energy is the heat energy of the Earth's crust, which originates from the original formation of the planet and from radioactive decay of materials (Government of Burundi). This heat in a fluid called lava found in the outer core is at very high temperatures as shown in Figure 2-a and flows to the surface of the earth through a complex system formed by seismological and earthquake activities in mainly two states namely volcanic and hot springs/ steam as depicted in Figures 2-b Matek, (2016) and 2-c Johnson, (2018).

(a) (b) (c)

Figure 2: (a) Fluid outer core, (b) Nyiragongo lava Lake and (c) Buranga hot spring.

This lava is a high temperature energy dependent on its chemical composition and ranges in temperature from 700 -1259^{o}C and with the centre of the earth composed of magma estimated at between 5000^{o}C and 7000^{o}C Francis, (1933) as shown in Table 3.

Table: 3. List of temperatures for the common types of lava:

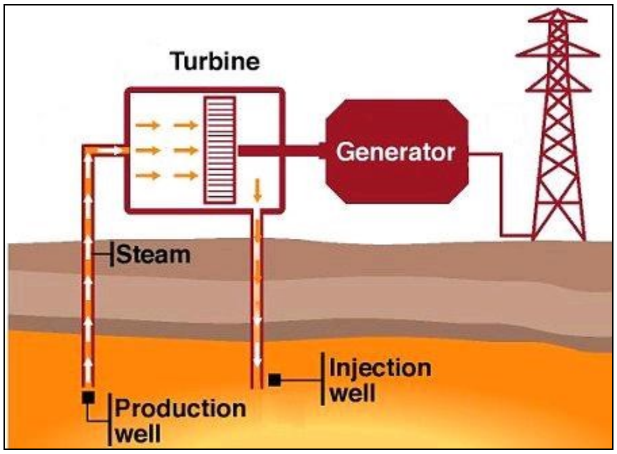
Rock type	Temperature (c^{o})	Temperature (f)
Rhyolite	700-900	1292-1652
Dacite	800-1100	1472-2012
Andesite	950-1200	1742 2192
Basalt	1000-1250	1832-2282

Source Francis, P.: 1933, Volcanoes, a planetary perspective:

One of the unique aspects of geothermal heat is that it is found everywhere throughout the world. Call it a “democratic” energy source that anyone can take advantage of, regardless of the conditions at the Earth’s surface, such as the weather (UNDP, 2016).

The geothermal energy however, undergoes a complicated, financially and technically demanding project cycle carried by specialist specialized human resource, before it can be converted into useful electric power, heating and other applications in agriculture, produce and other production processes.

The exploration cycle is composed of surface survey, trial drilling, qualitative and quantitative laboratory analyses to ensure sufficient quantity and quality and environmentally safe steam to mitigate against financial risks and encourage investors to develop the resource. Once all the above requisite parameters are proven then the geothermal resource is drilled and harnessed by the owner country to generate power and converted to other applications as demanded or necessary. Geothermal energy driven electricity generation is shown as a simplified typical model consisting of steam production, injection wells, turbine, generator and the power evacuation transmission system in **Figure** 2a and a geothermal wellhead 2.52 Megawatt electric plant installed at Eburru in Kenya in **Figure** 2b.



Figures 3-a: Generation of geothermal power and 3-b Eburru wellhead power plant

4. GEOTHERMAL RESOURCE DEVELOPMENT

4.1 Global geothermal resource development

The geothermal energy resources are disproportionally spread all over the world and exploited in the same way. According to Geothermal Energy Association (GEA) data collection, there is over 200 GWe of conventional hydrothermal potential globally available based on current knowledge and technology.

Therefore, communities and governments around the world have only tapped 6-7% of the total global potential for geothermal power based on current geologic knowledge, technology and operating capacity by country, Bizimana, (2014). The United States of America is leading in geothermal energy production with the Philippines coming second and Indonesia the third, respectively and the rest of the countries spread in the Americas, Asia, China, Continental Europe, New Zealand, Japan with Africa represented by Kenya and Ethiopia and ranked at 9th and 21st. respectively, Mbogo, (2018)

4.2 Geothermal resource development in African countries

Hydropower to Africa via South Africa's, gold mines at Pilgrim's Rest powered by two 6-kW hydro turbines in 1892 and one 45-kW turbine in 1894 to power an electrical railway Bhagwan, Loots *et al*, (2014). On the other hand, geothermal power manifestations in Africa in Burundi Stanley in 1878 ??? and entered Africa in 1911 brought by Bas-Katanga Engineers and the first geothermal Power Plant producing 550.000-kWh of electricity per year, constructed in 1952 at Manono Province in the Democratic Republic of Congo (DRC), Makuku, (2019).

While hydropower took root and continued to develop into major electric power source and a network of high voltage systems crisscrossing neighbouring counties, no further significant geothermal resource exploration or utilization took place. Even the 1952 Manono first geothermal Power mentioned above, disappeared altogether.

Why then, the geothermal electric power generation, invented in Italy in 1904 (Sarmiento and Steingrimsson, 2007), took Uganda and Kenya over forty years to attempt geothermal exploration? Uganda drilled for geothermal power at Buranga in Tooro with no geothermal power developed to date (Brown, 1954) and Kenya drilling two wells at Olkaria that never discharged and were abandoned (Mwangi, 2007). Kenya created a geothermal specific corporate body the Geothermal Development Company Ltd (GDC) in 2008 with the mandate of developing the geothermal resource, policy and strategy and as of now accelerated the country to the 9th rank among the top ten geothermal countries in the World (Musembi, 2014) (Mbogo, 2018**)**.

Africa's geothermal renewable energy source potential which, using present-day technology is more than 20,000MW_e Demissie, (2013) and remain largely undeveloped and like the e Africa's lack of strategic geothermal energy specific policy, institutional and regulatory barriers have so far contributed to the hampering of the systematic development and utilization of this large indigenous and renewable energy resource. In addition, the high risks associated with resource exploration, development and financial risks of investing in geothermal resource development are also major barriers.

Most of the continent's countries especially in the East African Rift System (EARS) have this resource in twenty-one (21) countries namely Algeria, Burundi, Comoros, Djibouti, Egypt, Eritrea, Ethiopia, Kenya, Madagascar, Malawi, Morocco Mozambique Nigeria, Rwanda South Africa Sudan Tanzania, Tunisia, Uganda and Zambia, Omenda, (2018), as depicted in **Figure 4** and located n the great East African Rift System (EARS) which is one of the major tectonic structures of the earth that stretches for about 6,500 kM from the Middle East to Madagascar This system consists of three main arms. The Red Sea Rift; the Gulf of Aden rift; and the EARS which develop through Eritrea, Ethiopia, Kenya, Tanzania, Zambia, Malawi and northern Mozambique floored by a thinned continental crust. The EARS is composed of two rift trends; the eastern and western branches. The western branch develops from Uganda throughout Lake Tanganyika, where it joins the eastern branch, following the border between Rwanda and DRC. Wood and Guth, (2019) as depicted in and **Figure** 5.

Figure 4. African Countries with Geothermal Resources, (Omenda, 2018)

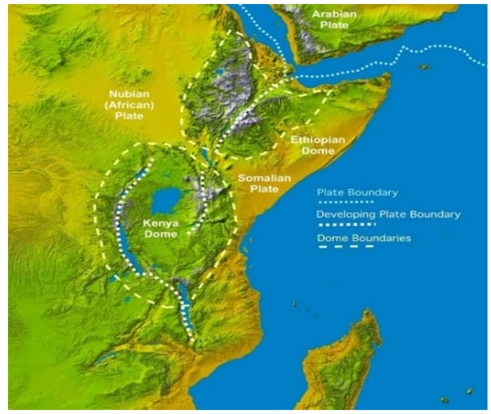


Figure 5. Eastern and West Branches of DRC EARS (Wood & Guth).

The western branch of the EARS is, however, much less active in terms of volcanism although both branches are seismically and tectonically active today. The estimated geothermal energy resource potential of the EARS is more than 20,000 MWe. Despite the high geothermal potential of the EARS, only Kenya and Ethiopia have installed a capacity of about 675 MWe in total. Other countries are still at different surface exploration or drilling stages and yet to locate their geothermal reservoirs (Wabunoha, ibid).

4.3 Geothermal resource development in selected African countries

Burundi, Union of Comoro and Djibouti were selected to illustrate; a) long-term involvement with geothermal exploration without further development or power generation, b) short-term exploration to drilling cycle, c) the role played by Regional, Bilateral and Multilateral agencies and d) need and role of national **geothermal development specific policy** in the developing geothermal resources in these countries.

The above state of affairs may be attributed to lack of justifiable economic activities to warrant high investments in energy resource development as small loads could be supplied by diesel or petrol driven electric generators, political will of colonial masters of the day, availability of kerosene and gas for high end and biomass (firewood) for the majority of citizens. Many Post Independence African countries experienced political upheavals and others without highly qualified and experienced national technical human resources, financial support, material and equipment to carryout meaningful energy mix projects. These countries and the rest of the continent, none ranks in Very High, only 2 rank in High, 10 in the Medium and 29 in Low Human Development Index (Chaheire and Chamassi, 2015) and committed themselves to ambitious promises to meet Sustainable Energy for All (SE4ALL) in 2030.

4.3.1 Burundi

The first research in the geothermal manifestations in Burundi was given by Stanley in 1878 and since then, a series of others carried out in1966, 1969, 1972, 1981, 1982 by the Government under auspices of several agencies (Sinzinkayo et al, 2015). and more recently, geothermal reconnaissance in September 2012 on behalf of Icelandic International Development Agency (ICEIDA shown in Burundian Geothermal sites and Principal geological structures of central Africa. depicted in Figure 6 and Figure 7, respectively.

Work done so far indicate that the Burundian geothermal resources appear to be too low for conventional geothermal power production, calling for further investigations to find high temperature geothermal areas for energy production using binary technology.

Surface, geochemical and geophysical explorations will be carried out before the drilling the thermal gradient wells. Where the resulting steam is promising, deep wells will be drilled and if unsuitable steam temperature is obtained then will be will be used for other activities such as drying of agricultural products (Beegle, *et all*, 2016). Other applications aiming to alleviating Burundi's energy sector deficit in producing enough power for its population (Rubomboras, 2016) would be i) the using the heat pump systems instead for heating tap water and cooling rooms in some hotels in Bujumbura or other cities to save electric power costs; ii) the use of enhanced geothermal methods (ICA 2016).

4.3.2 Union of Comoros

Union of Comoro conducted Magnetotelluric (MT) surveys in five regions with among them. The interpretation shows that there is evidence of a geothermal reservoir at depth of 1000- 1700m and a heat source for the geothermal system at a depth of more than 5000m.\

This prospect is being drilled and will be the first island based geothermal facility in the region. The geothermal energy could provide cost effective, secure baseload source of electricity and significant social and economic benefits and reduction of diesel dependency.

4.3.3 Djibouti

The Republic of Djibouti in bid to harnessing its geothermal energy, potential in estimated to be around 1000 MW; has carried out phased geothermal preliminary field and geophysical studies, first drillings in 1970-1975 in Assal Rift geothermal area and Nord-Goubhet Geothermal field.

This was followed drillings at Hanlé, new drillings and geophysics, scaling and corrosion study of Assal rift deep reservoir and Nord-Goubhet studies in 1981-1990; and from 2000 to date, is continuing with new exploration project of the Assal rift REI, capacity building of the National Centre of Research of Djibouti (CERD) and completing the prefeasibility studies of Nord-Goubhet, lake Abhé and Obock FIALE deep drilling projects. This resource will be the key to the country's economic development and attainment of the MDG goal and access to electricity and energy for all (WB, 2010).

The creation the Djibouti Office for Geothermal Energy Development (ODDEG) is a good example of putting in place the requisite institutional framework for geothermal development is cardinal in achieving favorable environment for investments, holistic and applicable to the whole sector from the entry point of research, prospecting, exploration and drilling to energy production. The North - Ghoubhet Geothermal field and the location of Assal-Fiale Caldera Drilling Target Geothermal Sectors are depicted on the Geological map of Assal Exploratory Wells in Figure10 and Figure 11 Abdillahi, *et all*, (2016).

ODDEG acquisition of the geothermal drilling rig machine and the support of an international banking consortium led by the World Bank have demonstrated the government involvement to speed up the development of geothermal energy in order to enable the green energy development strategy of the country Moussa, Suleiman, (2015)

5. CHALLENGES TO INVESTMENT IN AFRICAN GEOTHERMAL RESOURCE

5.1 Exploration and development risks

In many countries, early stage exploration and development risks are the main barriers preventing geothermal energy from making a bigger contribution to meeting energy demand. Oliver and Statesman (2015). These include inadequate policy or absent law instruments to cover public de-risking, Financial risk, mitigation guarantees, political risk insurance. partial risk guarantee, mitigation of currency risk and currency hedging, among others, Banda, S. O,(201.9

5.2 Political Consensus and Sovereignty

Developing appropriate regional infrastructure is only one aspect of regional integration. Compared with economic or political integration, infrastructure integration has more clearly defined benefits and requires countries to cede less sovereignty (Eberhard, Rosnes, O. et al, (2011). Regional infrastructure cooperation is therefore a good first step toward broader integration.

Unfortunately, almost all such opportunities in Africa involve crossing frontiers between sovereign states. In all of this, governments are understandably concerned with preserving national sovereignty. While appropriate in some cases, this focus can encourage zero-sum thinking. A better strategy would be "responsible sovereignty". The concept of national sovereignty tools for economic development, the improvement of human, physical and social well-being, and for the protection of national sovereignty, NPCA, 2014). Some countries have more to gain from regional integration than others In particular, regional power trade benefits small countries with high power costs.

Any regional initiative requires national and international political consensus. Methods for building consensus vary, but broad principles apply. Some major challenges can be addressed constructively at the regional or bilateral level, including regional trade and security issues using the requisite and essential effective information exchange (World Bank, 2013).

5.3 Internal Regional Challenges

Some of the major constraints are the planned processes of member states which do not take into cognizance of the need to have a regional component in the planning process and matter of interests of individual member states. Consensus becomes difficult because junior or middle level officers come with fixed briefs from their countries and they stick to them with no room for flexibility, the whole aspect of the national ownership of the programmes, as opposed to what are regional interests. How for example, can a regional organization transposition or show the usefulness of our regional programmes when they are juxtaposed with the national programmes? Member states do not want to pay their dues, pay on time without any follow-up in addition to weakness in the rate at which member states meet their commitments (Maalim, 2013). Un even human resource and technical competencies in geosciences and technologies. Fear to combat corruption because of risk to commit political suicide (Kiltgaard, 1998).

5.4 External Regional Challenges

Some of the key challenges facing the regional geothermal industry are the reluctance of many investors to finance exploration endeavors, weak ability to attract sufficient and competitive foreign direct investment as well as risks that directly affect production, power markets, venture liquidity and profitability that are external in character. These risks are the same as those that face the investors in other large projects elsewhere in the world but more pronounced in geothermal exploration, especially before the advent of the successful showcase Kenyan geothermal power projects.

Nyakabwa-Atwoki.

5.5 Investor bias

A given potion of investors takes international agencies community based and non-government organisations take regional or individual country reports especially those on governance, corruption and politics on surface value and at times without accurate or deep analysis. Yet, some sections of the same or sister reports hip praise on the very country or agencies they have criticized. Some corporate culture or behavior, fall short of recognizing opportunities in Africa. One global firm is reported to have spent more time each year on selecting the company's holiday card than debating its vital Africa, strategy, Mankins, (2004).

6. AFRICA'S GEOTHERMAL DEVELOPMENT STRATEGIES

International and Bilateral Programmes should be credited support geothermal development. These include Africa Rift Geothermal Development Facility (ARGEO) Mitigation Funds, EAC's membership of Multilateral Investment Guarantee Agency (MIGA) of The World Bank, KfW/European Union Risk Mitigation Facilities, US East Africa Geothermal Partnership between USAID and Geothermal Energy Association in addition to those mentioned in Section 1 of this document.

There are numerous Regional and Continental Africa Private Sector Researchers engaged in The Power Sector to Compliment Public Sector Players. For example, all East African Country Energy Regulators are members of the Energy Regulators Association of East Africa (EREA) and are represented at the Power Working Group of the East African Community and partner with Eastern African Power Pool (EAPP) to Implement Regional Power Master Plan (Wako, 2014). These researchers need Establishment of training centres to train new entrants into the geothermal fraternity and organize refresher courses for people already in geothermal business and development. Such training centres would also sensitize political leadership to embrace renewable energies and geothermal in particular to protect the environment and promote environmental sustainability.

Support to advance their research initiates with the aim of promoting innovation in the renewable industry and geothermal energy in particular. Harmonization of national geothermal policies and laws into regional policies and legislation. Promotion of technical cooperation at regional by pooling resources, manpower and equipment for geothermal resources exploration and development.

6.1 Highly trained geothermal human resource

Africa has developed a highly qualified and experienced human resource in all discipline related to geothermal resource i.e. geochemistry, geophysics, and geology and attendant interrelated engineering e.g. reservoir engineering, drilling and others.

From the start in 1979, the annual 6-month training in Iceland has been at the core of UNUGTP's operations. Of 694 UNU Fellows, completing the 6-month training from 1979 to 2018, 270 or 39% have come from 17 African countries. In addition, 37 of 62 UNU-GTP MSc graduates to date (late 2018) are from 8 African countries, and the 2 PhD graduates to date have both come from Kenya, with 3 more Africans now enrolled for PhD studies in Iceland on UNU-GTP Fellowships. Most of the UNU Fellowships for training or studies in Iceland have been financed by the Icelandic Government, while some have been sponsored through international support, or by local institutions or companies, Georgsson, Haraldsson and Ómarsdóttir (2018),

6.2 The need of a financial model

One of much needed tools for geothermal exploration is instituting a good and all-encompassing financial model as suggested by Randle, (2005), below

Project models, incorporating financial and/or economic data, are required for a number of reasons, including:

- Economic analysis of project viability – often from a national economic perspective
- Evaluation of technical alternatives
- Tender evaluation
- Business planning
- Project financing for both equity and debt participants

Engineers and geoscientists are very familiar with creating

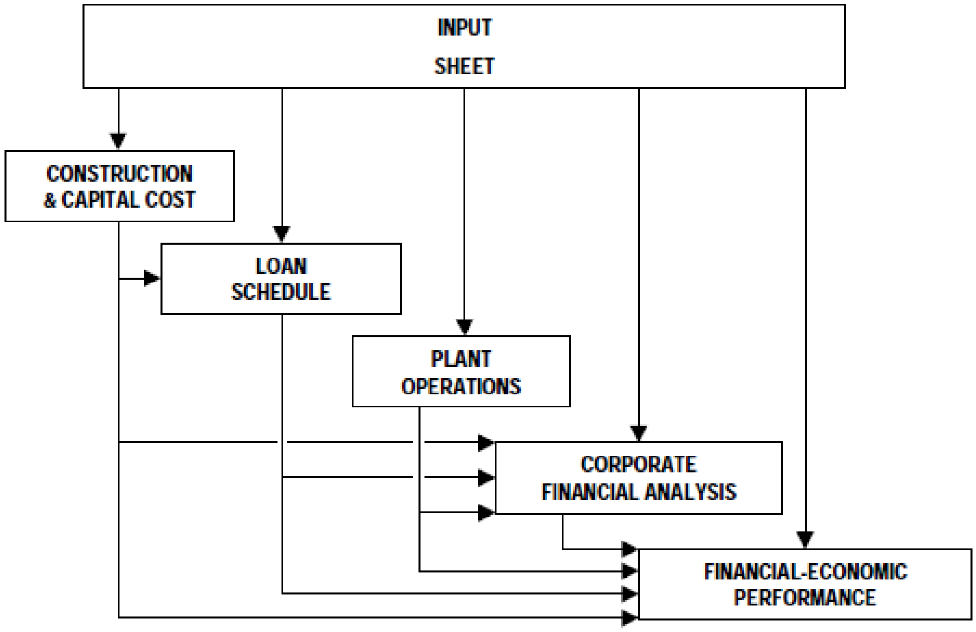
some of these, but not with all, especially the last two.

Similarly, financiers and economists are familiar with

many, but again not all, Randle, (2005), below

The Pro-Forma Geothermal Project Financial Model provides a useful starting point for someone experienced in using Excel spreadsheets to develop a project specific financial model, with confidence that the major technical and financial elements of the model are correctly represented and integrated.

Once the basic model is erected, the extraction of various indicators is relatively simple as the users are presented with financial information in a conventional form of projected financial statements. The projected financial statements will also be of benefit to the project company in planning its future operations.



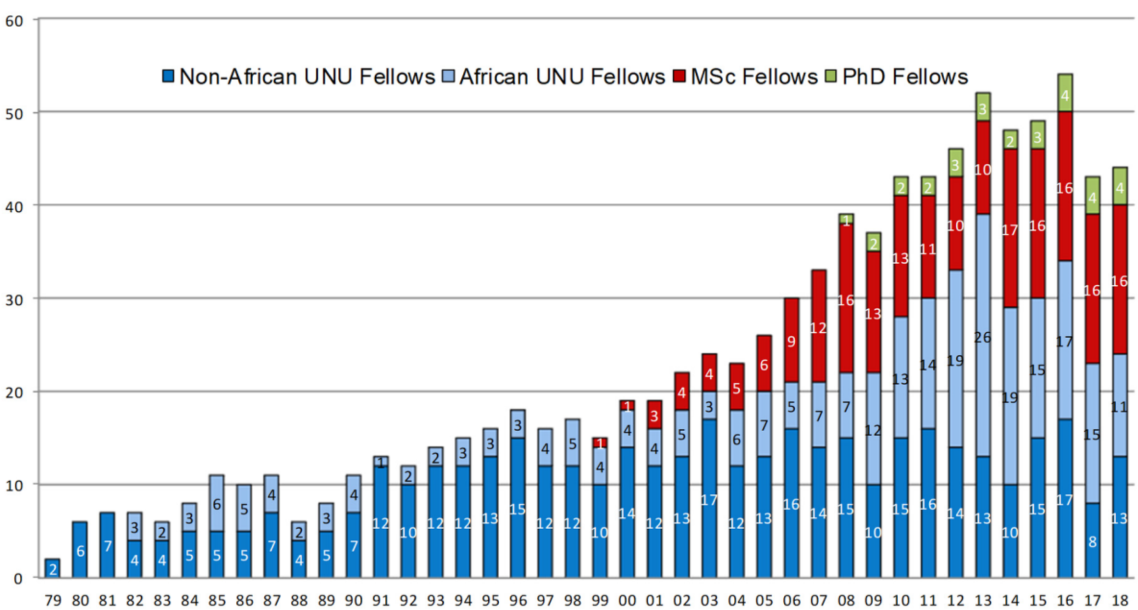


Figure 1: UNU Fellows completing the 6-month training and studying for MSc and PhD in Iceland in 1979-2018.

7. CONCLUSION

Integrated geothermal development would address energy resource development imbalance across the region, overcome national financial and associated risks, investors' reluctance to invest in the capital intensive exploration, optimizing regional and international facilities in addition to triggering private investments and their protection. A more promising alternative would be to base political union not on trade but on economic policy-making and infrastructure where the scope for mutual gains is likely to be much greater.

Nyakabwa-Atwoki.

Great challenges are facing African countries with regard to environmental destruction, protection and response to the impact of climate changes on their economies and attendant climate risk management and adaptation. This further demonstrates the need for the integration of and developing and strengthening climate change capacity for African countries and, climate risk management and adaptation strategy into geothermal energy development.

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