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Africa: The New Frontier for Geothermal Investment and Development

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ABSTRACT

The geothermal electric power generation was invented in Italy in 1904. In Africa, Uganda and Kenya among others, undertook geothermal exploration in 1954 and 1956, 40 and 42 years ago respectively. Then why have these countries no geothermal power developed to date while Kenya is generating 667 MW of geothermal power and 188 MW under construction? The answer lies in Kenya's overcoming the lack of policy, institutional and regulatory framework including geothermal specific corporate bodies that are barriers to the geothermal development. The country created the Geothermal Development Company Ltd (GDC) with a clear mandate of developing the geothermal resource, policy and strategy which in turn attracted partnership of several reputable national, regional, bilateral and multinational financial houses to raise millions of fund inflows for a spectrum of activities ranging from consultancies, feasibility studies, drilling rigs, financial management and technical assistance and a host of others to enable Kenya to rank the ninth out of the World's top 10 geothermal countries to date. The African geothermal resource estimated at 20,000-MWe, using present-day technology is distributed in 21 Geothermal Resource Countries (**GRC**) namely Algeria, Burundi, Comoros, Djibouti, Egypt, Eritrea, Ethiopia, Kenya, Madagascar Malawi, Morocco Mozambique Nigeria, Rwanda, South Africa, Sudan, Tanzania, Tunisia, Uganda and Zambia. Once these countries create holistic policy framework and corporate bodies and those currently implementing surface surveys and test well drilling projects using Risk Mitigation Fund (GRMF) funds are completed, Africa will not only become the new frontier for billions of dollars in geothermal energy investment and development but also pave the way to eliminating its image as the 'Dark Continent' and relieving the majority of 600 million people without electricity. The diversity of the continent's energy systems requires that a concurrent Africa energy policy of common energy market be developed to build on and expand the ongoing backbone power infrastructure of the five Regional Power Pools (**RPP**) towards the creation of Africa's Continental Power Grid. This will guarantee power wheeling of reliable and affordable power to meeting constituent countries' goals of reducing greenhouse gases and sustainable electricity for all (SE4ALL) by 2030.

INTRODUCTION

The paradox; energy poverty in the middle of plenty is best illustrated by considering Africa's geothermal renewable energy source potential which; using present-day technology is more than 20,000MW$_e$ (Demissie, 2013) that remain largely undeveloped. Africa's lack of strategic geothermal energy specific policy, and 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 also been lacking the appropriate investment and institutional settings to fast track geothermal development (Wabunoha, 2014).

This explains why 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. With Uganda drilling 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).

Djibouti, like Kenya, attributes its current geothermal development status to the creation the Djibouti Office for Geothermal Energy Development (ODDEG) that put in place the requisite institutional framework for geothermal development (Abdillahi et all, 2016) and highlights how such policies address barriers, incentivize developers whether public or independent power producers and mobilise financial resources for successful geothermal development. One important outcome is the Donor involvement that has reduced development risk by mitigating high risk exploration drilling and confirmation of geothermal resources that are high investment with no direct control over outcome together with power plant design and construction that are equally high investment but with direct control over outcome (Guelleh, 2013).

The specific geothermal policy model has been cardinal in achieving reduction of exploration risks and creation of favourable environment for investments that has attracted partnership of several reputable national, regional, bilateral and multinational financial houses with fund inflows amounting to billions of dollars (Musembi, *ibid*) (Mbogo, 2018) for a spectrum of activities ranging from consultancies, feasibility studies, drilling rigs, financial management, technical assistance and other infrastructure for example RPP interconnectivity power wheeling (Power Africa, 2017) as enumerated in Subsection 8.1 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.

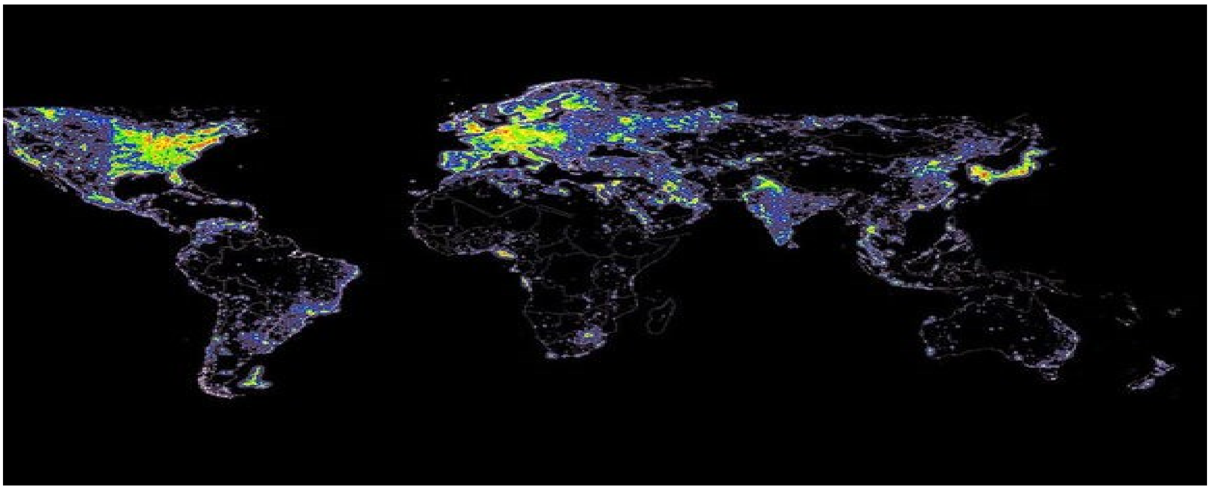


Figure 1: Satellite picture of Africa by night power.

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, 2010).

2.2 Africa economic and energy sector indicators

2.2.1 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 tits countries grouped in roe Low Human Development Index as per Africa Human Development Report of 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, 20189) as depicted in Table 1.

2.2.2 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).

Table 1: Africa's ease of doing business ranking

Rank Group	Country Rank Grouping	Country/ Region
1st to 50th	20, 29	Mauritius, Rwanda
51st to 100th	60, 61, 80, 82, 86, 87, 96, 99,	Morocco, Kenya, Tunisia , 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 200	151,152,153,155,157,159,162, 163, 164, 166,168, 169, 171, 173, 174, 175,180, 181, 183, 184. 185,I86,189, 190	Burkina Faso, Guinea Benin, Zimbabwe, Algeria, Ethiopia, Sudan, Sierra Leone, Comoro, Cameroon, Burundi, Gabon, Iraq, Angola, Liberia, Guinea-Bissau, Congo Republic, Congo republic, Chad, Central African Republic, Congo Dem Republic, South Sudan, Libya, Eritrea, Somalia

Table 2 : 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
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
	61	Morocco	29,000,000,000	33,655,786	861	98
51st to 100th	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 [14] 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 (Nyakabwa-Atwoki, 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°C and with the centre of the earth composed of magma estimated at between 5000°C and 7000°C (Matek, *ibid*) as shown in Table 3.

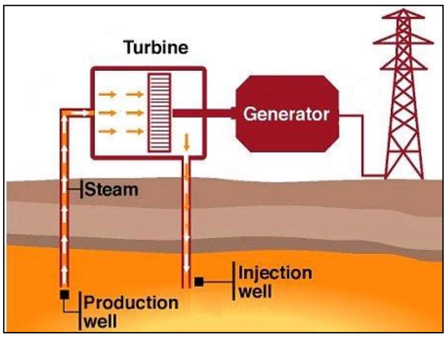
Table 3: List of temperatures for the common types of lava:

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

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, specialized human resource, financially and technically demanding project cycle 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 is 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

3. WORLD'S GEOTHERMAL RESOURCES

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).

Worldwide, the United States of America is leading in geothermal energy production with the Philippines coming second and Indonesia the third, and the rest of the countries spread in the Americas, Asia, China, Continental Europe, New Zealand and Japan. Africa is represented by Kenya ranking 9th and Ethiopia at 21st as depicted in Figure 4.

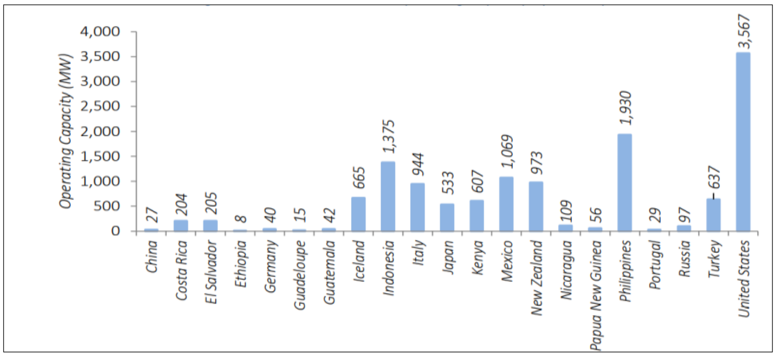


Figure 4: Global geothermal operating capacity by country

4. AFRICA'S GEOTHERMAL RESOURCE

Africa's geothermal energy resources, like the rest of the world, are equally disproportionally spread over the continent and developed in the same way.

This resource is in 21 countries namely Algeria, Burundi, Comoros, Djibouti, Egypt, Eritrea, Ethiopia, Kenya, Madagascar Malawi, Morocco Mozambique Nigeria, Rwanda South Africa Sudan Tanzania, Tunisia, Uganda, Zambia [20] as depicted in **Figure 5(a)** and located as follows: Algeria, Egypt, Nigeria, and Tunisia are in North and West Africa with rest in the great East African Rift System (EARS) that is one of the major tectonic structures of the earth that stretches for about 6,500 km from the Middle East (Dead Sea-Jordan Valley) in the North to Mozambique - Madagascar in the South. It passes through Eritrea, Djibouti, Ethiopia, Kenya, Tanzania, Uganda, Rwanda, Democratic Republic of Congo (DRC), Zambia, Malawi, Mozambique and 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 as depicted in and **Figure** 5(b).

Figure 5 (a): African Countries with Geothermal Resources, (Omenda, 2018)

Figure 5(b): Eastern and West Branches of DRC EARS (Wood & Guth, 2016).

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, 2014

4.1 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) the need and role of national geothermal development specific policy in the developing geothermal resources in these countries.

This 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 carry out meaningful energy mix projects. In 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.

4.1.1 Burundi

The first research in the geothermal manifestations in Burundi was given by Stanley in 1878 (CERD, 2010) and since then, a series of others were carried out in 1966, 1969, 1972, 1981, 1982 by the Government under the auspices of agencies such as UNDP, IIDA/INEA (Khaireh and Aye, (2012), and more recently, a geothermal reconnaissance in September 2012 on behalf of Icelandic International Development Agency (ICEIDA) (Harper Collins publishers 2005) showed Burundian geothermal sites and principal geological structures of Central Africa depicted in Figure 6 and Figure 7, respectively.

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

Figure 6: Map of Geothermal sites in Burundi

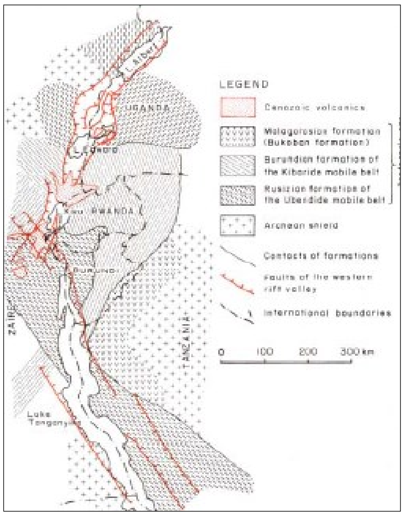


Figure 7: Principal geological structures of central Africa

Surface, geochemical and geophysical explorations will be carried out before the drilling of thermal gradient wells. Where the resulting steam is promising, deep wells will be drilled and if unsuitable steam temperature is obtained then will be used for other activities such as drying of agricultural products (Beegle, *et all*, 2016). Other applications aiming at alleviating Burundi's energy sector deficit in producing enough power for its population (Rubomboras, 2016) would be: i) 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).

4.1.2 Union of Comoros

The Union of Comoro conducted Magnetotelluric (MT) surveys in five regions with Karthala geothermal prospect 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 as shown in **Figures** 8 and 9.

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.

Figure 8: Five regions where the Magnetotelluric (MT) were conducted.

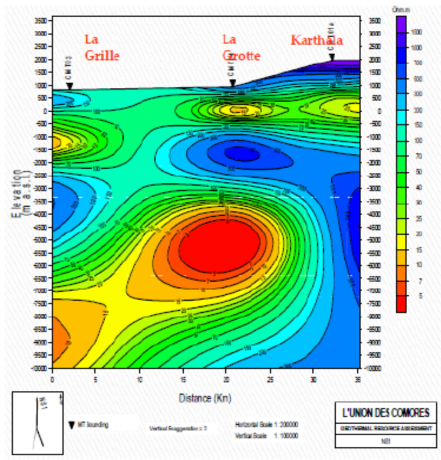


Figure 9: Exploration, analysis and interpretation results of the surface geophysical studies.

To solve these problems, the Ministry of Energy is evaluating solutions, among them the development of geothermal energy as suitable, clean, and less expensive. The Government through the Geological Bureau of Comoros and the partnership with the African Union, the Government of New Zealand and UNDP, conducted surface studies which were used to define the first stage of the project. In November 2014, geochemical studies were conducted and supplemented by 80 Magnetotelluric and 208 gravity measurements in July-August 2015. The results obtained together with analysis and interpretation of geochemical and geophysical data, a geothermal potential extending over an area of 4.1-km^2 in the Northeast of the caldera and estimated at more than 40-MW was found (Chaheire and Chamassi, 2015).

4.1.3 Djibouti

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

This was followed by 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 favourable 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).

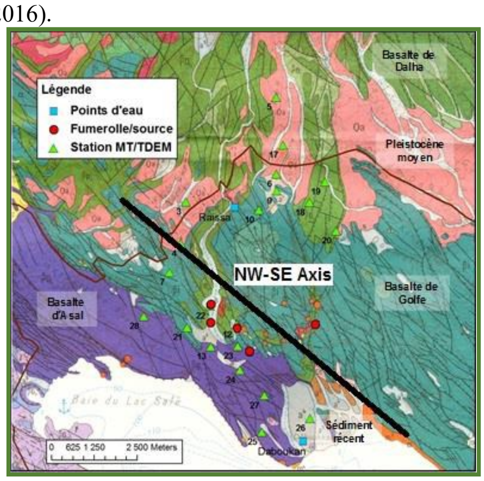


Figure10: Geological map of Ghoubhet Geothermal Field Geothermal Sectors

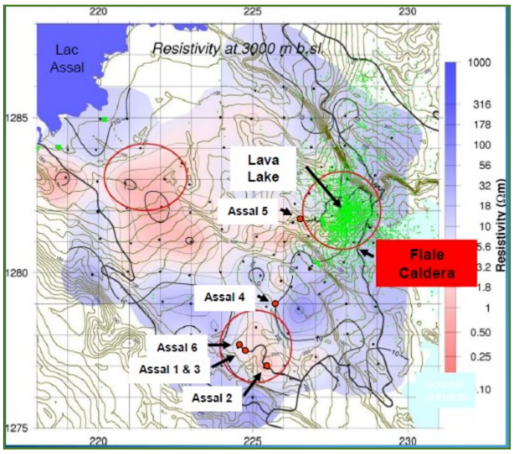


Figure 11: Assal-Fiale Caldera Drilling Target North- and Location of Assal Exploratory Wells

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. DEVELOPMENT OF AFRICA'S GEOTHERMAL ENERGY POLICIES

The agreed consensus defines policy as a plan, rules and regulations or set of actions adopted or pursued by an individual, government, party, or business for use for economic, social, planning and environmental aspects to meet their internal and external goals (Harper Collins Publishers 2005).

Africa needs a geothermal policy that will develop this energy resource whose long term reliable and sustainable availability will address four key areas: First, holistic conducive harvesting, second) chronic poverty, third) environment and the fourth) the 'magic year 2040's thousand-megawatts of electricity for all, set by Africa regions in general and the continent's countries in particular. One of the major barriers to investment is lack of quality and dependable statistics. An important, often underappreciated reason for low investment in statistics in Africa is that frequent and high-quality statistics do not enjoy strong support from politicians and policy makers. Once produced, its use does not preclude another person's use of it. As such they can be used by independent researchers, advocacy groups, and rival politicians to illuminate progress but also to audit performance of incumbents. Because of these problems, the foundation on which to make policy and demand accountability for results is weak (Beegle, *et all*, 2016).

5.1 Developing national holistic conducive geothermal harvesting policy

The national policy makers should aim at developing geothermal policies that should address the country's impediments and challenges to their countries' geothermal energy resources development total value chain from resource identification, surface exploration, test drilling, evaluation and final geothermal power plant design, acquisition construction, testing, commissioning and operation and maintenance on long term availability and sustainability. These policies should equally guarantee harmony between other national interrelated and none mainstream policies that otherwise create sources of conflict among stakeholders from both public and private sectors with embedded regional outlook and without challenges that would spill over encumber regional cooperation or constituting cross border power trader barriers.

5.2 Developing regional geothermal policy

The African continent has constituted organisations or bodies charged with overseeing and operationalising regional programmes, especially removal of tariffs and barriers to trade i.e. East African Community (EAC), Economic Community of West African States (ECOWAS) Central African Economic and Monetary Community (CEMAC), Southern African Development Community (SADC); and Southern African Customs Union (SACU) plus an embracing one the Common Market for Eastern and Southern Africa (COMESA) [35].

Based on policies and operating frameworks, regional policy and energy experts should be mandated to work together to harmonize and integrate the member countries' geothermal policies into forming of regional geothermal policies that address the continental uneven geothermal development in above organisations to lay the foundation for the formation of African geothermal policy for ratification by African Heads of State and placement within Infrastructure and Energy Commission of the Africa Union. The main outcome of these policies should be that of' integration of related infrastructure connected with regional electric power transmission interconnections being implemented by regional power pools (ICA, 2016

6. DEVELOPMENT OF AFRICA'S POWER POOLS

In bid to harness available and reliable electrical power across regions of Africa and in line with the organisations alluded to in Section 5.2, African regional power pools were formed and charged with developing and overseeing and operationalising regional power transmission infrastructure programmes across the continent. [36].

African Power Pools, namely the East African Power Pool (EAPP), West African Power Pool (WAPP), Comité Maghrébin De L'electricité (COMELEC), Southern Africa power pool (SAPP) were created and aligned to EAC, ECOWAS, CEMAC and SADC), respectively. The current status of each power pool based on Infrastructure Consortium for Africa (ICA) November 2016 updated data is outlined below:

6.1 EAPP: with a membership of 11 countries, has attained a growth in the installed capacity from 38,513 MW and the corresponding consumption of 162,322 GWh in and 2008 to 54,311 MW and 232,505 GWh in 2013 respectively. Based on the proposed roadmap, the attainment of a centralised trading regime may occur between 2020 and 2025.

6.2 WAPP: with a membership of 14 countries, WAPP has attained a growth in the installed capacity from 14,669 MW in 2008 to 19,648 MW in 2015. The corresponding consumption increased from 46,936 GWh in 2008 to 50,634 GWh in 2015 respectively. Based on the proposed roadmap, the attainment of a centralised trading regime may occur by 2019 subject to the completion of the regional interconnection projects.

6.3 SAPP: with a membership of 11 countries, has attained a growth in the installed capacity from 55,948 MW and the corresponding consumption of 260,081 GWh in and 2008 to 61,859 MW and 269,375 GWh in 2015 respectively. The Southern African Power Pool (SAPP) was created in 1995 and is now the most advanced power pool on the continent; given the developments taking place in the region, it is expected that more countries will be operational members by the end of 2018, and there will also be an interconnection between EAPP and SAPP.

6.4 CAPP: with a membership of 10 countries, has attained a growth in the installed capacity from 5,345 MW and the corresponding consumption of 15,238 GWh in 2008 to 6,299 MW and 24,744 GWh in 2013 respectively. Given the developments in the region, it is probable that by the end of 2020, CAPP may start functioning as a Power Pool for the interconnected countries.

6.5 COMELEC: with a membership of 5 countries, has attained a growth in the installed capacity from 24,027 MW and the corresponding consumption of 160,322 GWh in 2009 to 36,367 MW and 120,200 GWh in 2013 respectively. Given the enhanced support to regional power development, COMELEC could start its operations as a Power Pool as early as late 2018; but this depends more on political rather than technical considerations [36].

7. DEPLOYMENT OF THE POLICY FRAMEWORK TO DELIVER AFRICA'S POWER GRID

The earlier electric power trade in East Africa known to this author was between Kenya and Uganda powered by electricity generated by the then Owen Falls (renamed Nalubale) hydroelectric power station that began in mid-1950s to date and transmitted by steel towers at 132 – kilovolts. The power station was hailed as the best thing done for Uganda by Uganda Protectorate colonial administration Kaberuka, 1990).

These two and neighbouring countries have made tremendous economic progress and undergone high population growth that require matching electricity generation, transmission and distribution networks to avail reliable and sustainable electricity to their citizens. However, this is not possible for economic, physical political and other related matters match electric demand and supply such that 600 million people un-electrified in Africa, to date. By enacting national, regional, continental and participating and embracing bilateral, multilateral programmes, partnerships with development partners and foreign governments; Africa's ubiquitous 'dark continent' is headed for oblivion by 2030-2040.

7.1 Current state of regional electric power transmission grids

One of the leading agencies in the development of regional electric power transmission grids is the Nile Equatorial Lakes Subsidiary Programme (NELSAP) (Rubomboras, 2016) through its Department of Power and Development and Trade. NELSAP facilitates support and strengthens the identification, preparation and implementation of the regional's power projection for the benefit of all riparian countries namely Burundi, Democratic Republic of Congo (DRC), Egypt, Ethiopia, Kenya, Rwanda, Sudan, South Sudan and Uganda. The interconnection of electric grids of Nile Equatorial Lakes Countries covering Burundi, Democratic Republic of Congo, Kenya, Rwanda, Sudan, and Uganda aims at cross border energy exchange worth US$ 460 million, other projects at various project development stages include Rusumo hydropower project to supply Burundi, Rwanda and Tanzania worth US$ 468 million, Tanzania – Zambia interconnection that will connect EAPP and SAPP at US$ 74 million, Uganda - (DRC) interconnection at US$ 165 million and Uganda –South Sudan interconnection estimated at US$ 3 million.

7.2 The position of transmission grids

African regional power pools are developing and constructing inside member countries' new backbone 220-kV and /or upgrading their traditional 132-kV transmission grids to 220-kV in preparation for regional inter power pool grid interconnections, as exemplified by bullet 3 -Tanzania – Zambia interconnection that will connect EAPP and SAPP, above. Kenya is completing the 400-kV AC line to Lake Turkana making interconnection to South Sudan and eventually Sudan a viable option, and has almost completed its Kenya-Uganda-Rwanda interconnector, as well as completing its 612- km long section of the 500-kV DC Ethiopia-Kenya system (Kiilu, 2016, Kaberuka, 1990).

The completion of these power transmission infrastructure programmes and those across the continent, will lay a strong foundation for the power pools to justify the formulation of and overseeing and operationalising African power grid policy framework. At this stage, the challenges to establishing the continental grid are more on political rather than technical considerations.

8. AVAILABLE GEOTHERMAL AND POWER EVACUATION DEVELOPMENT FACILITIES

8.1 International and bilateral programmes

Geothermal energy exploration carried out in the continent so far is owed in part to international, bilateral and multilateral programmes. Those continuing to finance geothermal projects include: Multilateral Investment Guarantee Agency (MIGA) of The World Bank, the German Development Bank KfW/European, US East Africa Geothermal Partnership between USAID and Geothermal Energy Association among others.

8.2 Regional and continental programmes

The Africa Rift Geothermal Development Facility (ARGEO), Africa Union Risk Mitigation Fund (GRMF), the beneficiaries of the rounds of GRMF are presented in Tables 2. The AfDB announced the 'New Deal on Energy for Africa' to unlock Africa's energy potential and eventually move to lower carbon energy which runs from 2016 to 2025 and is impartial to the source of energy or technology. The plan will let countries develop their resource strengths in renewable and non-renewable resources. The bank will invest $12 billion in the next five years and US$50 billion will be sought from the public and private finance.

Table 4: Depicting recipients of GRMF for geothermal development.

No	Name of Bidder	Country of Bidder	Project Name	Activity
1	Cluff Geothermal Ltd	Ethiopia	Fantale	Drilling Programme
2	L'Office Djiboutien de development de l'Energie Geothermique (ODDEG)	Djibouti	Arta	Surface Study
3	Geothermal Development Company Ltd	Kenya	Paka	Drilling Programme
4	Geothermal Development Company Ltd	Kenya	Korosi	Drilling Programme
5	Cluff Geothermal Ltd	Ethiopia	Butajira	Surface Study
6	Bureau Geologique des Comores,	The Comoro	Karthala	Drilling Programme
7	Energy Development Corporation	Rwanda	Kinigi	Drilling Programme

9. CONCLUSION

Africa's large geothermal renewable energy source potential which largely remain undeveloped. The lack of strategic geothermal energy specific policy, institutional, and regulatory barriers in the have so far contributed to the hampering of the systematic development and utilization of renewable energy resource. Kenya and Djibouti' creation of geothermal specific policy requisite institutional framework for geothermal development accelerated the country to be ranked the 9th among geothermal top ten countries in the world and Djibouti attributes its current geothermal development status to the same development. The continent should now couple geothermal development with the development of an Africa's power grid if it is to achieve its objective of electrifying its 600 million people with se4all by 2030 and leapfrog to high economic development.

10. RECOMMENDATIONS

The major recommendation is directed towards African countries developing the continent's renewable energy policies that are devoid of challenges that would hamper cross border energy trade especially inhibiting integration and harmonisation of power pool operation.

This could be achieved by setting up: a) expert technical committees to polish national policy frameworks with a view of setting up robust regional power pools, then b) in turn, the regional power pools be enabled to work on modalities for heads of states to ratify, lending the necessary political will and other related technical, human and financial resources to establish power grid to wheel the continental generated power.

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