

Unlocking the East African Rift System's Geothermal Power Potential as Means of Guaranteeing Reliable Electric Power

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ABSTRACT

Research surveys carried out between 2011 and 2013 indicate that many Africans believe their governments are failing to provide enough power, as shown by only South Africa being ranked the 16th while the rest of the East African region are occupying between 104th and 163rd in the world. Sub-Saharan Africa generated power is estimated at 68-Gigawatts no more than that of Spain, with South Africa alone accounting for 40-GW. The East African Rift System (EARS) 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 in the South. The EARS passes through Eritrea, Djibouti, Ethiopia, Kenya, Tanzania, Uganda, Rwanda, Democratic Republic of Congo (DRC), Zambia, Malawi, Mozambique and Madagascar. Its estimated geothermal energy resource potential is more than 15,000 MWe. Despite the high geothermal potential of the EARS, only Kenya and Ethiopia have installed a capacity of about 217 MWe. Other countries are still at the surface exploration stage and yet to locate their geothermal reservoirs. Geothermal energy presents a clean and more environmentally friendly alternative to traditional fuels and has the potential to provide long-term, secure base-load energy and greenhouse gas (GHG) emissions reductions. However this potential can only be realized if the geothermal exploration and exploitation planning processes and strategies currently taking place at member state level are geared towards regional cooperation endeavours. The concerted regional development of geothermal resources will consolidate financial, technical and human resources and eliminate or mitigate risks associated with resource exploration and development; lack of funding; and lack or inadequate geothermal policy, legal and institutional frameworks in most countries of the EARS. The regional geothermal development strategies will enhance absorption of upfront and political risks, consolidate private, bilateral capital and other foreign direct investments in addition to guaranteeing conducive investment environment as well as being vital to overcoming many investors reluctance and triggering the region's growing energy demands.

1. INTRODUCTION

1.1 The Lion and Gazelle Strategy

The need for a concerted and dynamic strategy to overcome Africa's bleak energy consumption is best illustrated by lion and gazelle survival strategy. Each morning in Africa, lions and gazelles wake up with the same thought: "What a beautiful day! All I have to do is to run faster than the slowest gazelle around". Yet the lion knows that every day he has to be a little bit faster, because today's slowest gazelle runs faster than yesterday's slowest gazelle. And at the same time, the gazelle is aware that it must continuously improve its own speed, or one day it will inevitably be the slowest (Richner, 2012).

The harsh reality shown above is akin to Africa's power generation, challenges of overcoming the dire energy needs in rural and urban environments across the continent in general and the East African region in particular, response to the impact of climate changes on their economies and the need to re-design and integrate national into regional energy development especially renewable energy and in our particular interest; geothermal energy. Energy should be treated as a security matter because there is no adversary with such lethal fangs as poverty (Simiyu, 2012). The answer to these challenges is not beyond our reach, the solution, in fact, lies in our hands and with our ability to change the future (Zervos, 2010).

1.2 The Regional Geothermal Resource

The great East African Rift System (EARS) is one of the major tectonic structures of the earth that extends for about 6500 km from the Middle East (Dead Sea-Jordan Valley) in the north to Mozambique and Madagascar in the south. This system consists of three main arms: the Red Sea Rift; the Gulf of Aden rift; and the East African Rift, which develops through Eritrea, Ethiopia, Kenya, Tanzania, Zambia, Malawi and northern Mozambique floored by a thinned continental crust (Figure 1).

The EARS is composed of two rift trends; the eastern and western branches. The western branch starts from Uganda and follows the border between Uganda, Rwanda Burundi on the eastern side and the Democratic Republic of Congo (DRC) on the western side and then throughout Lake Tanganyika, where it joins the eastern branch. The western branch is, however, much less active in terms of volcanism although both branches are seismically and tectonically active today.

The East African Rift is one of the most important zones of the world where the heat energy of the interior of the earth escapes to the surface in the form of volcanic eruptions, earthquakes and the upward transport of heat by hot springs and natural vapor emanations (fumaroles). The eastern branch, that forms the Ethiopian and Kenyan rifts, possesses, by far, the most extensive geothermal resource base in Africa and one of the most extensive in the world. The rest of the countries in the EARS have lesser but still important geothermal resource bases. Using today's technologies, EAC has the potential to generate more than 15,000 MW of energy from geothermal power. However, only 298MW is currently generated in Kenya (293MW) (Omenda, 2014) and Ethiopia (5MW) (Omenda and Teklemariam, 2010).

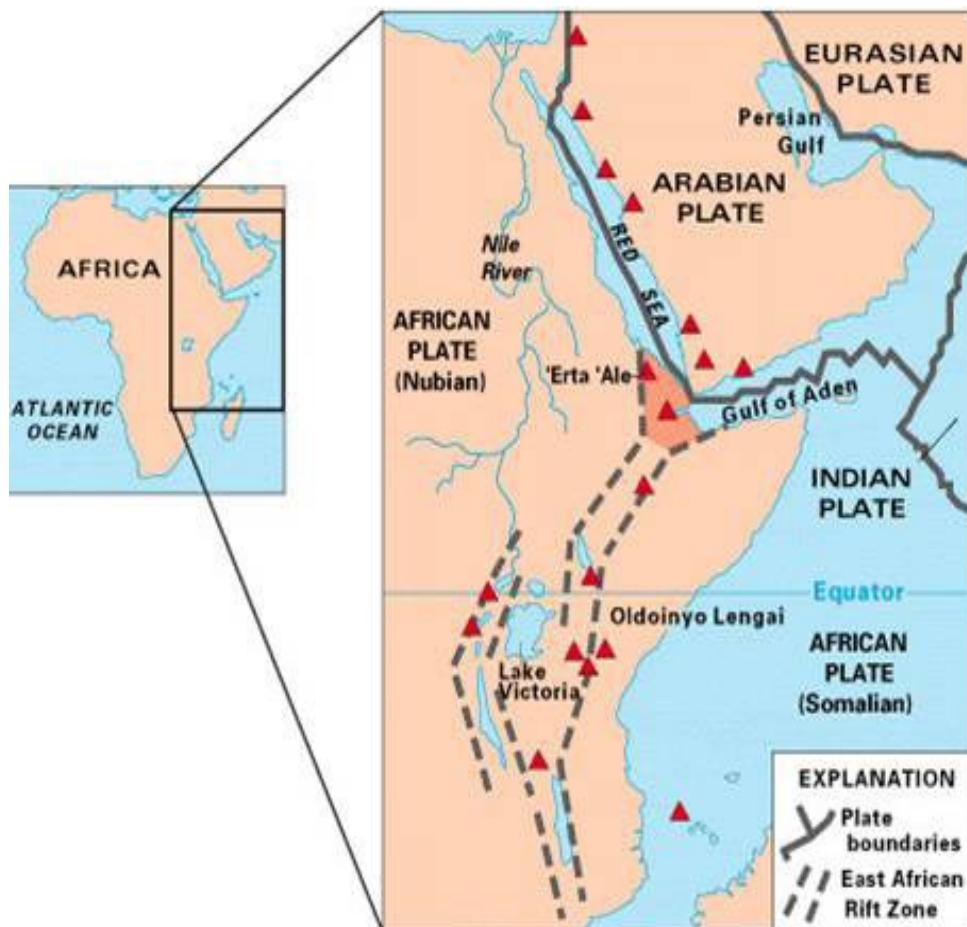


Figure 1: The East African Rift System

2. THE EAST AFRICAN COMMUNITY

The original East African Community (EAC), which was formed in 1963 and collapsed in 1977, composed of Kenya, Tanzania and Uganda. It was one of the most enviable regional communities replete with a single currency, comprehensive services composed of a railway, airline, ports and harbors, custom union, post and telecommunication system and their requisite infrastructures among others. This EAC broke down because of political differences brought about by the then president of Uganda, H.E. Amin Dada (RIP), and the leaders of Kenya and Tanzania who were fighting for superiority. The community was revived in 2000 after ratification of the EAC treaty signed earlier in 1999 by member states of Kenya, Uganda and Tanzania. Rwanda and Burundi joined the Union in 2007. As by the treaty, the objectives of the EAC are to develop policies and programs aimed at widening and deepening co-operation among the partner states in economic, social, cultural and political fields for their mutual benefit. Within this framework partner countries also resolved to establish amongst themselves a customs union, a common market, subsequently a monetary union and ultimately a political federation to strengthen, regulate, and enhance an accelerated harmonious, equitable and sustained economic development (EAC, 2007). This collaboration of efforts has so far yielded a customs union launched in 2005 and the common market established in 2010 (Kutesa, 2012).

2.1 Regional Economic and Energy Sector Indicators

2.1.1 Economic indicators

At a glance the EAC common market covers a geographical area of 1.82 million square kilometers and a growing population of 133.1 million people. The economic community displays some improvements in economic growth despite country level differences in economic performance.

This region borders with South Sudan and Ethiopia in the north, Democratic Republic of Congo (DRC) and Zambia in the west, Somalia and Indian Ocean in the east and Mozambique in the south. Its Countries are among the 46 Sub-Saharan Africa (SSA) countries with Kenya and Tanzania shown as Coastal while Burundi, Rwanda and Uganda are Landlocked by the Collier Classification (Collier and Venables, 2008) as shown in Table 1.

Table 1: African first nature geography

Country	Collier Classification	Year
South Africa	Coastal	2005
Kenya	Coastal	2004
Tanzania	Coastal	2005
Uganda	Landlocked	2005
Burundi	Landlocked	2005
Rwanda	Landlocked	2005

Selected East African Community Member countries from Table 1, page 6,
 Source: Collier, P. and Venables, T' see References section of this document.

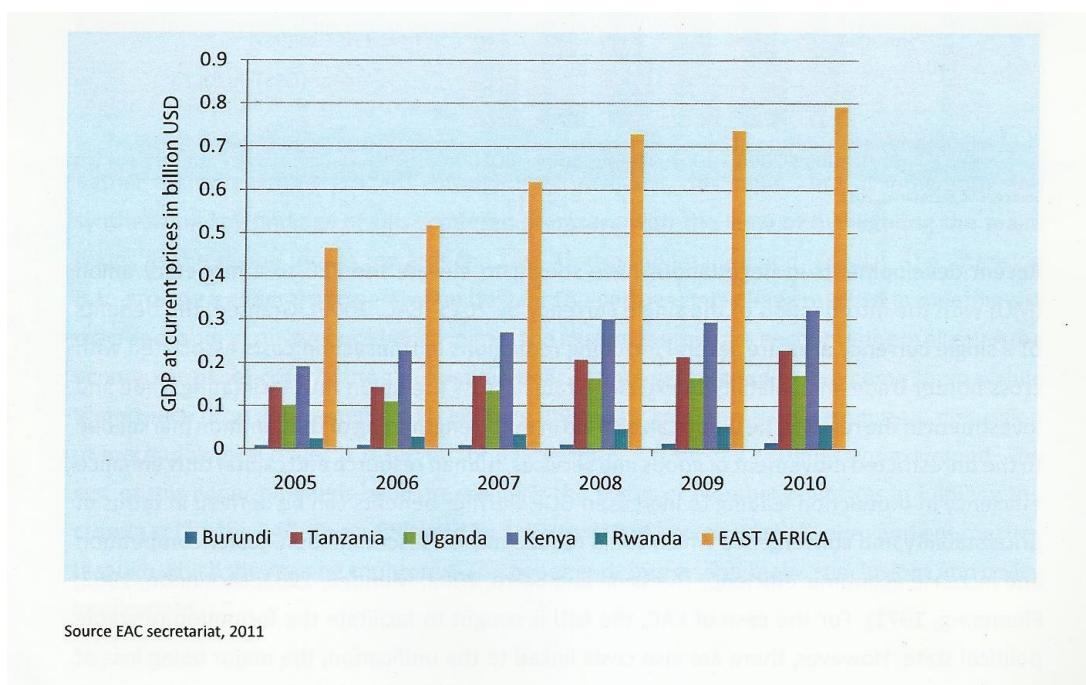
The entire region is ranked under Low Human Development on the Human Development Index of the United Nations Development Programme compared to Norway and Botswana that are in the very high and medium human development categories, respectively (HDR, 2013). Currently, Kenya is ranked highest at 145, Tanzania 152, Uganda 161, Rwanda 167, and Burundi the least at 179 with average annual growth between 1980 and 2012 (Table 2). Market price gap which stood at USD74.5 billion accordingly in 2005 registered USD79.2 billion in 2010 (Figure 2) (Kutesa, 2012).

Table 2: Human Development Index (HDI) Trends 1980 – 2013

HDI Rank /Country	Rank	HDI Rank Change		Average Annual HDI Growth %				
		2013	2007-2012	2011-2012	1980-1990	1990-2010	2000-2010	2000-2012
Very High Human Development								
Norway*	1	0	0	0.59	0.79	0.32	0.29	
Medium Human Development								
Botswana**	119	-1	-1	2.71	0.00	0.77	0.66	
Low Human Development								
Kenya	145	1	0	0.89	-0.33	1.34	1.24	
Tanzania	152	15	1	-	0.43	2.36	2.15	
Uganda	161	0	0	-	2.06	1.84	1.65	
Rwanda	167	2	0	-1.74	3.05	3.07	2.73	
Burundi	179	2	-1	2.26	-0.07	2.59	2.31	

Norway leads the 47 very high human development countries group in the world and Botswana leads Sub-Saharan Africa (SAA) countries.

Source: (UNDP Human Development Report 2013). A positive value indicates improvements in Product (GDP)

**Figure 2: Regional Trends in GDP at Current Prices**

Regional Trade Balance for the 2004 to 2009 period shows only Kenya posted positive trend, Tanzania's was negative for the first three and positive for the rest of period while Burundi, Rwanda and Uganda were negative all through (Table 3) (Shinyekwa and Mawejje, 2013)

Table 3: Intra-trade flows in the EAC Regional (Exports and Imports 2004–2009 in US\$ Millions)

Year	Trade Flow	Uganda	Tanzania	Kenya	Rwanda	Burundi	Total
2004	Export	132.0	124.0	810.0	25.0	5.3	1096.0
	Import	416.0	138.0	38.4	69.1	54.1	716.0
	Trade Balance	-284.0	-14.1	772.0	-44.2	-49.0	380.0
2005	Export	144.7	128.9	974.1	34.9	4.0	1287.0
	Import	551.5	160.6	61.5	99.1	59.1	9312.0
	Trade Balance	-406.9	-31.7	9126.6	-64.2	-55.1	355.0
2006	Export	152.9	157.8	736.0	33.1	5.5	1085.0
	Import	430.4	175.5	84.3	143.3	60.8	894.0
	Trade Balance	-277.5	-17.7	651.7	-110.2	-55.1	191.0
2007	Export	274.8	205.9	952.2	40.1	5.5	1479.0
	Import	530.9	110.0	191.6	209.1	79.6	1121.0
	Trade Balance	-256.1	95.8	760.6	-169.0	-74.1	357.0
2008	Export	377.4	259.9	1213.0	46.2	6.6	1903.0
	Import	570.6	205.0	182.0	394.2	84.7	1437.0
	Trade Balance	-193.0	54.9	1013.0	-348.0	-78.1	467.0
2009	Export	398.8	323.5	1167.0	47.3	6.0	1943
	Import	547.0	316.9	162.2	449.7	129.0	1605
	Trade Balance	-148.2	6.5	1005.0	-402.3	-123.0	338

Source: East African Community Facts and Figures – 2009 and 2010

Another criterion used is the ease of doing business (World Bank, 2013). Despite the reform efforts of all 5 members, the EAC's average ranking on the ease of doing business has remained static over the past 4 years, at around 117. This is a clear indication that critical obstacles to entrepreneurial activity remain and that economies in other regions have picked up the pace in improving business regulation. But good regulatory practices do exist in the EAC. Indeed, if a hypothetical EAC economies were to adopt the best practices among partner states as measured by ease of *doing business* indicators, its ranking would stand at 117 (average for all the five EAC countries) in the global ranking (Table 4).

Table 4: East African Member Country Doing Business Ranking

Rank	Economy	DB2013 Reforms
1	Singapore*	0
52	Rwanda	2
120	Uganda	1
121	Kenya	1
134	Tanzania	1
159	Burundi	4

Note: The rankings for all economies are benchmarked to June 2012. This year's rankings on the ease of doing business are the average of the economy's percentile rankings on the 10 topics included in this year's aggregate ranking. The number of reforms excludes those making it more difficult to do business.

Source: Doing Business database.

2.1.2 Energy sector indicators

The biggest project undertaken under the 1946 plan in Uganda was the building of a hydroelectric station at the Owen Falls Jinja (Kaberuka, 1990). The station remained the sole major supplier of electricity to Uganda and supplemented the power generated in Kenya and Tanzania. This scenario persisted until late 1990s when another hydropower extension was added. The regional power sector like Uganda was state owned monopolies and like other state enterprises of public like the rest of the developing world, had to undertake electricity sector reforms directed towards services (Bhagavan, -1990) and (the WB-IFC, 1988). It was thus inevitable that member states, improving the rises, characterized by inefficiency, waste, and corruption in the quality of service, connectivity and other pertinent areas to achieve overall efficiency and attraction of private capital investment to the sector (Mawejje et al, 2012). The regional power is grouped in East Africa Power Pool (EAPP) a nine member countries composed of Burundi, Djibouti,

Egypt, Ethiopia, Kenya, Rwanda, Sudan, Tanzania; Central Africa Power Pool (CAPP); Southern Africa Power Pool (SAPP); and Western Africa (WAPP). The consumption in EAPP remains very low with the population growth and GDP growth and the resulting projections for electricity demand growth under both Base and Low growth scenarios for 2006 -2015 period (Orvika Rosnes et al, 2009), are shown in as shown in Table 5 and Table 6, respectively.

Table 5: Power consumed in selected sub-Saharan African countries compared to the World and China

Rank	Country	Electricity consumption (MWh/yr)	Year Of data	Population	As of	Average power Per capita in (watts/person)
—	World	18,471,105,332	2002-10	6,882,980,472	2005-12	306
1	China	4,603,700,000	2011	1,347,350,000	2011	389
16	S. Africa	212,200,000	2008	50,586,757	2011	478
104	Dr Congo	6,036,000	2008	71,712,867	2011	10
107	Kenya	5,738,000	2008	41,070,934	2011	16
117	Sudan	3,787,000	2008	30,894,000	2008	14
120	Tanzania	3,431,000	2008	43,188,000	2010	9
133	Uganda	1,958,000	2008	32,369,558	2009	7
159	Burundi	273,400	2008	10,216,190	2011	3
163	Rwanda	236,800	2008	11,370,425	2011	2

Source: CIA “The World Fact Book (2013-14 Edition)” ISSN 1553-8133, 2013

Table 6: Increase in population, income, and market demand for electricity in study countries, 2006–15 (%)

Country	Annual population growth	Base growth scenario Total (annual)		Low growth scenario Total (annual)	
		GDP/capita	Electricity demand	GDP/capita	Electricity demand
Burundi	3.2	14 (1.3)	45 (4.2)	7 (0.7)	35 (3.4)
Djibouti	1.9	15 (1.4)	29 (2.9)	8 (0.7)	19 (2.0)
Egypt	1.8	26 (2.3)	41 (3.9)	13 (1.2)	24 (2.5)
Ethiopia	2.3	29 (2.6)	52 (4.8)	14 (1.4)	33 (3.2)
Kenya	2.6	16 (1.5)	39 (3.7)	8 (0.8)	28 (2.8)
Rwanda	2.2	31 (2.7)	54 (4.9)	6 (0.6)	22 (2.2)
Sudan	2.0	32 (2.8)	53 (4.8)	16 (1.5)	31 (3.1)
Tanzania	1.8	26 (2.3)	41 (3.9)	13 (1.2)	24 (2.4)
Uganda	3.8	13 (1.2)	51 (4.7)	7 (0.6)	43 (4.0)

Note: Only the Nile Basin–East Africa Power Pool countries are selected from Table 2.3 depicting all the six (6) power pool of the Sub-Saharan Africa on pages 6 and 7.

Source: Orvika Rosnes et al, see References section of this document.

3. CHALLENGES TO EAST AFRICAN REGIONAL INTEGRATION

3.1 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, A., 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).

3.2 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). In order to meet market demand for power in 2015 while eliminating power shortages and achieving national policy targets for access to electricity, substantial investments in the power sector will be required in addition to refurbishing Africa's old, capacity operational since 2005 before 2015 (Orvika Rosnes et al, ibid), Table 7. Investment in renewables, especially geothermal, should be given priority (Simiyu, ibid).

Table 7 Estimated annualized cost of meeting power needs of Sub-Saharan Africa under two trade scenarios (national targets for electricity access)

US\$ billions and % of GDP	Southern Africa Power Pool	Eastern Africa Power Pool	Western Africa Power Pool	Central Africa Power Pool	Island States	Total Sub-Saharan Africa
<i>Trade expansion</i>						
<i>Total estimated cost</i>	18.4 3.7%	15 5.7%	12.3 4.2%	1.4 2.0%	0.6 3.1%	47.6 4.2%
<i>of which total</i>						
<i>Capital costs</i>	10.0 2.0%	8.2 3.1%	8.2 2.8%	1.2 1.8%	0.2 1.4%	27.9 2.4%
<i>Operating Costs</i>	8.4 1.7%	6.8 2.6%	4.0 1.4%	0.2 0.2%	0.3 1.7%	19.7 1.7%
<i>of which total</i>						
<i>Generation</i>	11.1 2.2%	10.5 4.0%	6.5 2.2%	1.0 1.4%	0.4 2.0%	29.5 2.6%
<i>Transmission & distribution</i>	7.3 1.5%	4.5 1.7%	5.8 2.0%	0.4 0.6%	0.2 1.1%	18.1 1.6%
<i>Trade-stagnation</i>						
<i>Total estimated cost</i>	19.5 3.9%	16 6.0%	12.7 4.4%	1.5 2.2%	0.6 3.1%	50.3 4.4%
<i>of which total</i>						
<i>Capital costs</i>	10.0 2.0%	6.3 2.4%	8.0 2.7%	1.1 1.6%	0.2 1.4%	25.6 2.2%
<i>Operating Costs</i>	9.4 1.9%	9.7 3.7%	4.8 1.6%	0.4 0.6%	0.3 1.7%	24.7 2.2%
<i>of which total</i>						
<i>Generation</i>	12.6 2.5%	11.6 4.4%	7.1 2.4%	.2 1.7%	0.4 2.0%	32.8 2.9%
<i>Transmission & distribution</i>	6.9 1.4%	4.4 1.7%	5.7 1.9%	0.3 0.5%	0.2 1.1%	17.5 1.5%
<i>Trade-stagnation</i>						
<i>Total estimated cost</i>	19.5 3.9%	16 6.0%	12.7 4.4%	1.5 2.2%	0.6 3.1%	50.3 4.4%
<i>of which total</i>						
<i>Capital costs</i>	10.0 2.0%	6.3 2.4%	8.0 2.7%	1.1 1.6%	0.2 1.4%	25.6 2.2%
<i>Operating Costs</i>	9.4 1.9%	9.7 3.7%	4.8 1.6%	0.4 0.6%	0.3 1.7%	24.7 2.2%
<i>of which total</i>						
<i>Generation</i>	12.6 2.5%	11.6 4.4%	7.1 2.4%	.2 1.7%	0.4 2.0%	32.8 2.9%
<i>Transmission & distribution</i>	6.9 1.4%	4.4 1.7%	5.7 1.9%	0.3 0.5%	0.2 1.1%	17.5 1.5%

Note: Subtotals may not add up to the totals because of rounding

Source: Orvika Rosnes et al, see References section of this document.

3.3 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.

4. GEOTHERMAL DEVELOPMENT STRATEGIES

International and Bilateral Programmes should be requested to support regional geothermal development. These include Africa Rift Geothermal Development Facility (ARGE) 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 among others.

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 in addition to supporting advancement of their research initiatives in promoting innovation in the renewable industry and geothermal energy in particular.

Member countries' should reaffirm their commitment towards Harmonization of their national geothermal policies and laws into regional policies and legislation and foster the Promotion of technical cooperation regional level by pooling resources, manpower and equipment for geothermal resources exploration and development.

5. 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.

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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