Research Article

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Regional Energy Integration for Sustainable Development in Eastern Africa: The Case for Geothermal Energy

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Abstract

Energy is a crucial factor in international relations and a critical input to achieve global economic growth and development. Provision of affordable, sustainable, and reliable energy is necessary and a prerequisite for any country's economic growth and prosperity. The United Nations Agenda 2030, through its Seventh Sustainable Development Goal (SGD 7) and the African Union Agenda 2063 Aspiration 1recognise the centrality of access to energy towards realising the ambitions enlisted in these documents. The asymmetric distribution of natural resources and the political, strategic, financial, and technological challenges in utilising these resources hinder countries from availing affordable, sustainable, and reliable energy by using domestic sources alone. The inability to attain energy independence makes a compelling case for nations to increasingly integrate their energy supply chains to international and regional energy markets. As a result, ensuring access to affordable energy has become a core interest of regional foreign relations. Therefore, if geopolitics permits, energy cooperation and interdependence become the ultimate and sustainable path towards energy security. Africa has tremendous potential ranging from hydrocarbons to renewable energies. Nevertheless, it has failed to provide adequate energy for its social and economic needs mainly due to poor governance and related challenges. Africa has to utilise such humongous and diversified energy resources by embracing an optimal energy mix that contributes to regional economic development and energy integration. Eastern Africa, home to various renewable energy resources, is one of the energy-poor regions in Africa. The prevailing energy system in the sub-region is hydro-based and lacks reliability. The sub-region has tremendous renewable energy resources such as wind, solar, and geothermal. Still, their utilisation is negligible due to several challenges, including governance and lack of access to finance and technology. This paper argues that an integrated and regional approach to developing the energy sector in Eastern Africa can address the energy-related challenges and contribute towards regional integration in Eastern Africa. In particular, the development of geothermal energy, within the optimal energy mix in the sub-region, for both power generation and direct use application will play a crucial role in forging energy integration in Eastern Africa. In this regard, regional institutions such as power pools and regional economic communities are indispensable.

Keywords: *energy mix, integration, geothermal, sustainable development*

1. Introduction

Energy plays a critical role in the survival of humankind. It also threatens humanity's survival due to the dangers of climate change. Energy is a vital input in human development, without which no meaningful transformation can take place. It is the lifeblood of any society and is the passport to economic transformation. The United Nations recognised the centrality of energy as an input to economic development by, among others, dedicating a specific goal, Goal 7, in its 2030 Agenda for Sustainable Development. The African Union Agenda 2063 also recognises the significance of availing affordable energy to realise the ambitions enlisted in the document.

Africa is endowed with numerous and vast energy resources stretching all over the continent ranging from brown to green forms of energy. Africa has7per cent of the world's oil resources (Bazilian et al., 2012), 13 per cent of the gas resources (UNEP, 2017), 20 per cent of the uranium resources (AFREC, 2019), 40 per cent of the manganese reserves (IEA, 2020), 660 000 Terra Watt-hour per annum of solar electricity, 35 Gigawatt of hydro (IEA, 2019), and 20,000 Mega Watt of geothermal capacity (Omenda and Teklemariam, 2011).

In Eastern Africa, geothermal energy has tremendous potential as a catalyst for development. Eastern Africa's geothermal resources are known for their high qualities and can be exploited using proven and straightforward technologies. Besides, the region can capitalise on locally available human capital, knowledge, and physical infrastructure to consider a regional approach to its development and use (Stefansson, 2005). In short, geothermal energy can become the next best primary energy source in the Eastern African energy mix following hydropower.

However, underinvestment, lack of diversification, and fragmentation slow down the energy sector; thus, energy poverty remains a serious obstacle to economic and human development in Africa. And yet, Africa's renaissance depends on its ability to embrace sustainable development approaches that bring together elements of integration, sustainability, and diversification.

This paper has five sections. After the introduction, the second section presents a theoretical discussion on how international relations theories conceptualise the pursuit of energy security. The third section underscores the centrality of energy to human development and argues that energy diversification and regional energy cooperation are plausible approaches to energy security and sustainable development in Africa. Section four has three parts: following the line of argument from the previous part on achieving optimal energy mix, its first part discusses the challenges and opportunities of geothermal energy as a significant energy source for regional energy integration and energy mix in Eastern Africa. The second part of section four discusses a regional approach to energy development and use as the most favoured approach to address the challenges of the energy sector in general and geothermal energy development and uses. The last part of the same section underscores the importance of regional institutions such as the Eastern Africa Power Pool as facilitators of energy cooperation in their respective regions. The paper then concludes that if the Eastern Africa region could overcome the daunting challenges of access to technology and finance, geothermal energy for power generation and direct use application could play a crucial role in enhancing energy security and forging regional energy integration.

2. Energy and International Relations: A Theoretical Overview

Energy security (ES) is a crucial element among the core interests advanced by states in international relations. First, access to energy influences the economy, security, and livelihood of the state and its citizenry, making energy one of the determinants and manifestation of national interest (Deese, 1979). Second, energy is such a strategic resource that disruption affects both international and domestic politics. The Oil Embargo in the 1970s disrupted global peace and security and contributed to numerous regime changes, including the deposition of the Ethiopian Emperor (Hamilton, 1985). In short, the pursuit of energy security is an integral part of states' national security, determining domestic and foreign policies. The increased acknowledgement of the importance of energy and the

inability to attain energy independence puts energy as one of the states' foreign policy objectives.

What are the relevant theories of international relations that explain the role of energy as a strategic resource in human development? This theoretical overview attempts to review some of the pertinent international relations theories concerning the energy question.

Realism, the *oldest theory* (Burchill, 2005)in international relations, anchors its analysis of international politics on *egoism*, *anarchy*, and *state* (Gilpin, 1984). Consequently, rationality and state-centrism appeared to be the core foundations of the realist theory of international relations (Molloy, 20003). States gain power for self-preservation and to increase their capabilities (Burchill, 2005). As a significant source of power and a threat to the state's survival, energy creates a security dilemma between energy producers and consumers (Monaghan, 2006) and among consumers (Skinner, 2005). The first ES dilemma is between producers, who prioritise a stable energy market at a reasonable price, and consumers who sought inexpensive and reliable energy supply. The energy relations between Russia and the European Union can be a perfect example (Aalto, 2008). As a strategic resource, ensuring reliable access to energy increases its overall capabilities and casting insecurities to its rivalries. For example, China's aggressive ES policy creates a security dilemma for other consumers, especially the US, India, and Japan. Realists further argue that energy will be one of the causes of war in the twenty-first century because it is a strategic resource, no country is energy independent (Bryce, 2008), a significant portion of the world's energy supply is in conflict-prone regions (Klare, 2008), and energy is a finite resource. Realism's discontents in explaining the energy factor in broader international relations mainly emanate from its utmost focus on only one source of energy that is oil, and its globalist predisposition which limit its explanatory power on other sources of energy, mainly renewable energy resources that are the fundamental energy sources in the twenty-first century. Also, with its fixation on anarchy, realism overlooks the emergence of regional and institutional frameworks to manage global energy relations.

Liberals, on the other hand, believe that there may be conflict but not because energy is a strategic resource whose pursuit hinges on absolute gain. Instead, it is the type of approach an actor employs in pursuing energy security that will likely cause security dilemma and conflict. Thus, the liberal theory argues that interdependence and cooperation are likely, and conflict is avoidable and futile for three reasons (Fettweis, 2008). Firstly, war is pointless to energy security because war damages energy infrastructure and supply chains, creating further energy insecurity. Second, conflict arises when actors have diverging interests, and compromise becomes off the table. However, when we look at different nations' energy interests, it is not too diverging to induce war. Also, countries are relegating war to pursue international economic interests, especially after the Cold War, and all countries, including major oil-exporting ones, are not energy independent (Verrastro & Ladislaw, 2007). Thus, energy becomes one of the crucial regional or global commodities whose transaction breeds cooperation and interdependence.

Contemporary international energy relations show that the volume of energy trade in the world is increasing. Global energy infrastructure like pipelines, tankers, ports, refineries, and regional energy institutions, regional power pools (RPP) included strengthening interdependence in the energy sector. Therefore, energy interdependence is the prevailing reality. Liberalism's ES discourse mainly focuses on the indispensability of cooperation. However, liberalism may not fully explain the evolution of regional electric pools in Africa because of its misgivings on the state's role. Like realism, liberalism focuses on traditional strategic energy sources such as natural gas and oil and limits its explanatory power on renewable resources.

Realism and liberalism, two of the most prominent international relations theories, are not handy in explaining the concepts of energy integration, sustainable development, and alternative sources of energy. The central argument of this study revolves around regional energy integration for the attainment of sustainable development and the need to embrace an optimal energy mix. It can be achieved by pursuing the least-cost approach to regional energy development and utilisation, with efficient facilitation from regional institutions. Thus, considering the variables at hand, the study selects the liberal institutionalism theory based on its significant predisposition and compatibility

with part of the primary argument of the study, as explained further below.

When it comes to energy cooperation and institutions in the context of sustainable development, the theory of liberal institutionalism, which provides a peculiar perspective on the role of institutions, as the name suggests, becomes the most important tool to decipher international energy relations. After World War II, states realised that they were increasingly incapable of addressing global challenges unilaterally, and they needed a mechanism to manage these challenges. The growing interdependence and cooperation environment gave birth to the "*trading state*" in place of an "*independent and self-sufficient state*" (Burchill, 2005). The post-war period witnessed the establishment of institutions such as the United Nations to encourage cooperation and interdependence. These institutions paved the way for developing a rule-based international system whereby actors' behaviour is managed by a set of *rules, norms,* and *regimes*. The formation of the United Nations underscored the growing confidence of states over institutions' ability to manage international relations. States also recognised that institutions are paramount in dealing with multifaceted challenges of environmental degradation (Slaughter, 2001) and energy crisis (SIPRI, 1974). Regarding transboundary issues, states realised the inadequacy of a unilateral approach to address global and national energy challenges. They opted for instituting more cooperative frameworks regionally and globally.

Numerous international institutions have emerged to manage global energy relations. International Energy Agency (IEA), the Organization of the Petroleum Exporting Countries (OPEC), International Energy Forum, International Renewable Energy Agency (IRENA), and UN-Energy are some of the institutional attempts regulating international energy relations in the world. Besides, some countries in several parts of the world have pursued regional mechanisms to address their respective ES challenges. African, Asian, and European countries established numerous regional institutions to promote energy cooperation and interdependence in their quest for ES. The regional power pool arrangements in Africa are a case in point. Thus, the liberal institutionalist theory of international relations, whose founding blocks are states, institutions, and interdependence (Johnson & Heiss, 2018), adequately explains the institutional approach states chose to address global energy challenges.

The emergence of international institutions in the management of international energy relations is the product of age-old competition between energy-producing and consuming countries. The First Oil Crisis in 1973 was a deliberate supply disruption by OPEC on western industrial nations, leading to a global energy crisis. The embargo caused economic shocks on energy importing countries and forced them to reassess their energy security situation domestically and internationally. At the national level, the oil-importing countries took numerous measures, including shifting to more energy-efficient technologies to mitigate their oil dependence on foreign sources. At the global level, oil-importing and industrialised countries established IEA, mandated to enhance its member's ES through energy cooperation. The establishment of institutions such as OPEC and IEA inculcated structure, collaboration, and interdependence in international energy relations.

Establishing these institutions is crucial for institutionalists because the world decides to tackle pressing ES issues by embracing interdependence and cooperation anchored on institutions. The institutionalists observed the state's capability to identify transboundary challenges and cooperate and solve common concern issues under an institutional umbrella regardless of its strength. Oil-importing countries made the effectiveness of future oil embargo challenging by addressing unprecedented oil shortage by agreeing to supply the deficit from the strategic reserve managed by IEA (Keohane, 1984). Since its establishment, the IEA, for example, had successfully influenced oil-producing countries' behaviour up to the Second Oil Crisis in 1979. IEA provides an excellent example in extrapolating how institutions successfully manage global energy relations.

The evolution of energy-related institutions across time shows that the nature and magnitude of challenges change. Still, states continue to believe in the institutions' ability to manage the challenges sustainably.

3. Energy Diversification for Sustainable Development

Energy is one of the major prerequisites to economic development, and lack of it is a significant hurdle to sustainable development in Africa. Increased access to reliable, clean, and affordable energy is a critical factor for achieving sustainable development. In contemporary international energy relations, states pursue cooperation and interdependence as a viable solution to address energy security challenges. However, energy cooperation is not a natural state of affairs; it has to be cultivated, and institutions play a significant facilitation role. Factors such as differences in natural resource endowment and the ability to produce energy at the least cost are mostly the pulling factors behind energy cooperation (Rosnes & Vennemo, 2009). The level and scope of energy cooperation depend on the kind of energy source involved – while a global cooperation regime governs petroleum, a regional mechanism governs electricity. The IEA, OPEC, and several regional power pools in Europe and Africa are relevant cases in point. In all forms of energy – cooperation, markets and institutions play a crucial role. However, institutions have peculiarities in dealing with a particular form of energy within a predetermined geographic scope. For instance, the IEA and OPEC are focused on oil, a global energy commodity, while regional power pools are constituted to manage electricity trade regionally.

As crucial energy cooperation is for the successful pursuit of ES, collaboration in the developing south is minimal, mainly due to weak regional institutions and fragmented regional markets. In some energy cooperation cases, the pattern is based primarily on the availability of surplus energy from a particular source. In Africa, bilateral and long-term contracts between state actors dominate regional cooperation arrangements. Also, the energy trade depends on the availability of surplus produced, usually from one source. In early post-independence Africa, hydropower dominated regional markets. The hydropower dams in Eastern and Western Africa have been the sources of regional energy trade. For example, in Eastern Africa, the Kenya –Uganda, the Ethiopia – Djibouti, the Ethiopia – Sudan, Ethiopia – Kenya, and Kenya – Tanzania interconnections rely heavily on hydroelectric dams. However, reliance on hydropower generation is vulnerable to climate change because power generation depends on the water level at the reservoir, and as a result, numerous crises have occurred. For instance, the Akosombo Hydropower Dam's power crisis in 1995 (Bekoe & Logah, 2013) and the Kenya – Uganda Power Trade Agreement review with a diminished amount show the vulnerability of hydro-dominated power markets (Medinilla et al., 2009). In addition, in Southern Africa, a similar energy crisis took place in the early 1990s. The hydro-based energy trading system involving Zambia and Zimbabwe collapsed due to the great drought between 1991 and 1992, leading to the expansion of the trade arrangement to include the Democratic Republic of Congo and South Africa to provide additional sources of electricity, hydro, and coal, respectively, to enhance the energy mix.

Further, the Southern African Power Pools, a regional institution aiming at providing a platform for energy cooperation and trade, was formed with one of its objectives being connecting the northern part of the region where hydropower is dominant with that of the southern part where thermal energy is the primary energy source. Evidently, besides the challenge of relying on unpredictable hydroelectricity, Africa lacks the much-needed optimal energy mix due to fragmented energy systems. The establishment of a regional mechanism to embrace other energy sources is the way to go. In short, hydro alone has proved to be an unreliable energy source in the African context and has needed supplementary energy sources available in the given region.

As observed, the lack of a diversified energy system is one of the most pressing energy security challenges whose solution hinges on the extent to which a state or a region embraces energy mix or diversity in energy systems. A diversified energy system incorporates and prioritises several energy resources based on the least-cost approach to mitigate the risk of potential disruption by a source using the others. Therefore, a diversified energy supply chain is indispensable in tackling reliability as an energy security challenge. Reliability emanates from mixing energy sources in producing energy or diversification. In the African energy system, supplementing the hydro-dominated power sector with

a diversified energy mix, including geothermal, wind, or solar, will likely minimise climate-related exposure and provide extra energy for export to neighbouring countries (IPCC, 2012). In this regard, the contribution of geothermal energy from the Great African Rift Valley will be paramount. The optimum energy mix of at least hydro and geothermal will likely strengthen energy security and cooperation in the region.

In general, regional approaches that enhance energy diversification and security are primary drivers of sustainable development and energy cooperation in the form of energy trade plays a central role. Ensuring energy security and driving the sustainable development agenda in Africa requires embracing regional energy diversification and installing energy trade along sub-regional lines through institutions such as regional power pools.

4. The Role of Geothermal Energy in Regional Energy Integration in Eastern Africa

Energy source diversification enhances energy security in general (Luft & Korin, 2009), and the pursuit of an optimal energy mix addresses the reliability pillar of energy security (Paravantis & Kontoulis, 2020). The previous section discussed the impact of hydro-dominated energy sector development on attaining energy security and sustainable development in Africa. It recommended an optimal regional energy mix scenario whereby several different energy sources, including geothermal energy, play a significant role. The scenario is in line with the notions of regional integration whereby participants show leadership and political will to share sovereignty and enable national economies to integrate based on comparative advantage and complementarity. For any type of interdependence or integration to flourish, including energy, political will is a requirement. However, several studies have concluded that *'narrow nationalistic concerns'* and *'zero-sum game'* characterise the challenges of regional integration in Africa in general (Elhiraika et al., 2015). Be this as it may, contemporary international energy relations demonstrate how interdependence and cooperation flourish amid political challenges mainly due to the nature of energy.

In general, the growing energy intensity, the need for energy efficiency, and soaring prices are making energy interdependence inevitable and indispensable to address the multifaceted energy security challenges. How do we capture the energy dynamics in Eastern Africa? What is the promise of geothermal energy? What are the primary challenges of the energy sector in general and geothermal in particular? What are the possible remedies to the challenges, and what is the role of institutions in addressing these challenges? The following section will attempt to address these questions.

4.1 Geothermal in the Eastern Africa Region: Opportunities and Challenges

The Eastern African countries are endowed with diverse energy resources. Electricity generation in the region is dominated by renewable energy sources, mainly hydropower, while biomass is the primary domestic fuel (P. Omenda & Teklemariam, 2011). Since the year 2010, the total installed electricity capacity has grown by about 5% annually in the region (AFREC, 2019). Despite this growth, the region's power sector suffers several challenges, including low grid coverage, high electricity tariffs, minimal cross border trade in electricity, low diversification, and low electricity access rate. The region has pursued diverse approaches, including mini and off-grid alternatives and regional cooperation initiatives such as the regional power pools to solve the rampant energy poverty. In this regard, geothermal energy will play a significant role because of its unique attributes in general and its comparative advantage in Eastern Africa.

Geothermal energy is one of the most reliable sources of energy for the following reasons. First, geothermal energy plants with a 95 per cent availability rate are the most reliable sources of baseload electric power (Omenda, n.d.). Second, geothermal energy is well-suited to support a power supply system where the primary energy is hydropower plants which typically operate at about 50 per cent load factor. Third, geothermal power generation uses established sciences and technologies to be

learned and applied successfully in the otherwise not so well-advantaged African scientific and technical environment (IRENA, 2017). Fourth, geothermal power plants are characteristically robust, and reasonable care and maintenance entail low spending (Kabeyi, 2019). Fifth, geothermal energy is a clean form of energy with little or no negative impact on the environment. Besides, its development has a minimal social impact as people tend to stay far from geothermal fields. In short, geothermal can be one of the candidates to complement the hydro-dominated energy system in Africa.

Figure 1: Geothermal Resource Potential in Eastern Africa (Davies, 2008)

Geothermal energy is East Africa's signature energy resource and likely the preferred one to supplement the hydro-based regional energy trade pattern for several reasons. First, geothermal resources are abundant up to 20000MW and are suited to electricity development and use in industry, agriculture and the health tourism/recreation industries (P. Omenda & Teklemariam, 2011). Secondly, the natural conditions of the developed geothermal fields are representative of a variety of most of the resource prospect areas such that the success achieved to date in geothermal exploration and development in Kenya is widely replicable in the region, reducing the level of resource risk and the cost of the required works. Thirdly, geothermal resources' high physical and chemical qualities are expected to prevail among the numerous known resource prospect areas, availing the opportunity for exploitation using proven and straightforward technologies. The conservative estimate of 20,000 MW potential for electricity generation relates to the resources found in the shallowest about 3 km depth of the subsurface and are suited to utilisation using currently available technologies (Zemedkun, 2011). A much more enormous potential awaits the development of emerging technologies that will apply to deep-seated and super-critical resources. Besides, the presently available human capital, knowledge, and physical infrastructure can serve as significant pillars around which capacities can be expanded for a much more expanded regional program (Stefansson, 2005). In short, geothermal energy should theoretically be the next primary energy source in the Eastern African energy mix. Despite its reliability and sustainability, geothermal energy could not be available and affordable due to several challenges associated with the value chain from exploration to installation.

Geothermal energy is one of the least developed energy sources in the world. The global potential for geothermal power production ranges between 200 GW and 240 GW(IPCC, 2019; Stefansson, 2005). Nevertheless, the global geothermal power installed capacity reached 15400MW in 2020 and is expected to reach 28,000 MW in the next two decades (IRENA, 2017). The low level of

geothermal utilisation is mainly attributed to its high up-front capital costs, associated resource risks, and lengthy operationalisation period (IRENA, n.d.). The average cost of building geothermal power projects ranges from USD 1 870/kW to USD 5 050/kW (IRENA, *2019*). The relatively high capital and technology requirement and the pre-development risk factor associated with it explain why it accounts for less than 1 per cent of electricity and 3 per cent of heat demand globally (Brommer, 2018). The geothermal potential of Eastern Africa is about 20000 MW (Klarl, 2019), but the total installed capacity stands at 867 MW (Zemedkun, 2011) because of the challenges mentioned above (Kabeyi, 2019).

Energy production is the equation of physical endowment, finance, and technology. When it comes to geothermal energy, only 10 per cent of the surface of the earth has the potential to harness it; finance is scarce because of the high level of risk associated with the exploration and development of geothermal fields, and technological advancement in the field is inaccessible and concentrated in the industrialised world. Thus, it can safely be argued that geothermal energy development and use is sustainable and reliable but not available and affordable.

The East African Rift System has a tremendous geothermal energy potential capable of significantly contributing to addressing many of the energy-related challenges, including the rampant energy poverty, in the region. As discussed above, geothermal energy development in most parts of the world is minimal because it is capital and technology-intensive, which the Eastern African region lacks. Nevertheless, embracing a regional approach, including through institutions such as the East African Power Pool, will likely play a positive role in availing geothermal energy at a reasonable price to the region. The following parts discuss these approaches.

4.2 Regional Approach to Energy Cooperation in Eastern Africa

Regional energy cooperation creates a relatively larger regional market that can attract private sector investment if the region has an enabling policy environment. The cooperation can create a vast market in Eastern Africa, which will likely unlock several untapped potentials, mainly its geothermal potential. It is partly because the economies of scale associated with the growing cooperation will encourage the private sector to invest actively attracted by a sizeable regional market (Bellanca & Wilson, 2012). As the private sector amasses technology and capital, its active participation in regional energy development will likely solve challenges associated with the same for geothermal energy development in Eastern Africa.

The substantial contribution in the private sector and regional market arrangements can easily be observed from Kenya's somewhat developed geothermal energy resource. Kenya's enabling policy environment for geothermal energy exploration made it one of the top ten geothermal energy developers globally and Africa's centre of excellence. On the other hand, Ethiopia's slow pace in liberalising the energy sector significantly precludes it from harnessing its resource due to financial and technological challenges. Thus, an energy policy that embraces and prioritises regional energy cooperation encourages the private sector and solves the significant challenges of geothermal energy development.

Regional energy cooperation also makes energy diversification possible at the regional level. Its mechanisms involve considering the different energy sources from the participating countries and prioritising them using the least cost or other relevant criteria for development. There is a high possibility that the list of priority projects would be of different sources lending diversification and reliability to the regional energy system. In Eastern Africa, the likely list of priority projects includes hydro and geothermal, abundant in Ethiopia and Kenya, two of the region's net energy exporters.

Geothermal energy will likely play a crucial role in the emerging optimal energy mix in Eastern Africa. Ethiopia's hydro will most likely be supplemented by Kenya's geothermal energy source before the full-fledged geothermal development in Djibouti, Eritrea, Ethiopia, and Tanzania, altering the national energy mix and the pattern of trade in the region. In most cases, the geothermal energy development targets national energy markets; however, if the geothermal potential is fully utilised, it

could be one energy source for regional markets in East Africa. Geothermal power generation has significantly boosted Kenya's electricity export to Tanzania and Uganda from 26.9 million kWh to 46.6 million (Richter, 2016).

In general, regional energy cooperation enhances clean and affordable energy to meet the rapidly growing demand and improve Africa's prospect for sustained growth and development. In many developing countries, factors such as relatively small market size, poor management and maintenance of existing infrastructure, inadequate and inappropriate tariffs, and low revenue collection discourage investment and contribute to the looming energy crisis (Avila et al., n.d.). In particular, geothermal energy development is technology and capital intensive, contributing to its underdevelopment in Eastern Africa. Thus, pursuing a regional approach whereby the East African Power Pool plays a crucial role in mobilising its members and partners to solve the mentioned challenges, especially following a market-based approach to its development, is highly advisable.

4.3 Eastern Africa Power Pool and Geothermal Energy in East Africa

Energy is a strategic resource – the unattainability of energy independence makes a compelling case for energy cooperation. Energy cooperation takes regional and global forms. While international markets govern oil and natural gas, regional power pool systems govern primarily renewable energy sources such as hydro and geothermal. The regional approach to energy cooperation is mostly through bilateral arrangements and power pools. The latter is an arrangement where electric outputs from different utilities in each region are linked together and dispatched according to prior agreements in a given sub-region.

In Africa, bilateral energy cooperation can be dated back to the early post-independence years. On the other hand, a regional approach to energy cooperation is a recent phenomenon. The establishment of five regional power pools in southern, eastern, western, northern, and central Africa has stimulated energy cooperation and interdependence. Regional power pools facilitate the development of the electricity market, optimise the employment of renewable energy resources, enhance access to electricity, reduce the production cost of electricity, and create a conducive environment for investment (UNECA, 2017). Thus, regional power pools play a significant role in fostering cross-border electric trade in particular and energy security by addressing several energy sector challenges (UNECA, 2011). In so doing, regional power pools could play a crucial role in harnessing energy resources for regional benefits. In Eastern Africa, the Eastern Africa Power Pool is expected to play such a role.

The Eastern Africa Power Pool (EAPP), headquartered in Addis Ababa, is a regional pool established in 2005 and comprises of members of the Intergovernmental Authority on Development (IGAD) such as Ethiopia, Djibouti, Uganda, Kenya, and Sudan; members of the East African Community such as Tanzania, Burundi, and Rwanda; and Egypt and the Democratic Republic of Congo. In EAPP, the 370 million people, with a regional average annual electricity consumption growth rate of 7.6 per cent per annum and economic growth of 5.4 per cent, have to be supplied with affordable, reliable, and sustainable energy. Such a demand calls on EAPP to facilitate an integrated and interdependent approach to energy development and use (Musau et al., 2017). The call is in line with EAPP's mandate, whose primary purpose is to improve access to electricity, foster energy cooperation, and promote regional integration in the Eastern African region (Verhaeghe & Woolfrey, 2017).

The EAPP seeks to interconnect Eastern and North-Eastern Africa countries' national electric power supply systems to create a unified power supply system. The sizeable regional electricity market aims to accommodate multiple providers and consumers of electricity and raise the reliability, volume, quality, and security of supply at a low cost. The intention is to increase electricity access by the region's population and promote its increased economic production and use. The EAPP plan envisages the powering of the regional interconnections by significant generation capacity additions using renewable energy resources, mainly hydropower, supported by wind power and geothermal

energy-based generation – displacing petroleum use.

In the East African energy system, supplementing the hydro-dominated power sector with geothermal energy, according to EAPP, will contribute towards the attainment of optimum energy mix and strengthening of the state of energy security and cooperation in the region. EAPP's master plan has given geothermal a fair projection when analysing Ethiopia and Kenya's energy outlook, two significant geothermal energy-rich countries. The Master Plan Study recommends a combination of hydro and thermal systems. In the short term, the program suggests the construction of hydropower capacity, wind, solar, and some diesel-fired capacity (the latter to be subsequently converted to gas). Still, most notably, the Master Plan recommends the development of 5000MW geothermal power before 2037 (EAPP, 2014).

5. Conclusion

For Africa to achieve its sustainable development Agenda by 2063, renewable energy's role and contribution must be recognised and embraced. Renewable energy should be given its rightful place in the planning and implementation of development programs. As Kenya's case successfully demonstrated, Eastern African countries can capitalise on the tremendous geothermal energy resource potential (in the context of Energy Mix) to ensure their energy security at a national and regional level.

There are significant infrastructural, political, investment, technological, and institutional challenges to developing the energy sector in general and the geothermal sub-sector in particular. A regional approach to energy exploration, development, and trade can address significant constraints of the industry. Financial institutions can also play a crucial role in crafting innovative solutions that encourage regional geothermal projects to address the investment and financial bottleneck. The untapped potential of geothermal in Eastern Africa can start flowing into the energy mix. In light of this, regional institutions such as the Eastern Africa Power Pool should be empowered to play a leading role in forging the much-awaited sustainable development through regional energy integration.

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