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Opportunities And Challenges Of Developing Geothermal In Developing Countries: A Case Of Malawi

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ABSTRACT

It has been reported that the East African Rift System (EARS) promises a lot of energy potential to feed its respective countries. However not much has been done to realize the promise. Malawi, which is within the EARS, has its energy needs predominantly met by biomass, hydroelectricity and fossil fuels. The electricity connectivity of Malawi is at about 8% of national population despite having the promise underneath.

Geothermal energy provides an opportunity for electricity generation. With the prospected subsurface temperatures, Malawi can likely develop geothermal electricity using binary power plants as well as low pressure single flash plants. Located within the tropics, Malawi enjoys abundance of sunshine and uses the heat from sunshine for various drying purposes coupled with biomass, coal and fossil fuel for the same use and others. However, the sun drying techniques provide little control on the drying processes leading to poor and low standard products. The use of biomass and fossil fuels is not environmentally friendly leading to environmental degradation and increase of carbon emission into the atmosphere. The use of geothermal in this aspect would therefore help in various drying processes like fish and crop drying to meet specific standards while conserving the environment.

As a developing nation Malawi faces some challenges in its quest to develop the geothermal resource. The abundant presence of sunshine that has been used for various drying processes for ages, has kept people not to think of any other means of process drying. The highest office has no political will on geothermal development. The country does not have a policy to guide the development process. The initial high costs of development and lack of funding opportunities coupled with the absence of policy also obstructs the development. Challenge in technical competence among professionals to develop geothermal as well as inadequate studies that ascertain the extent of the resource that Malawi has.

There is need to come up with a national geothermal development steering committee that can assist in lobbying for the recognition of geothermal potential in offices of decision making and help in coming up with a roadmap for geothermal development. Commitment to coming up with a geothermal policy that would guide geothermal development, continue with the capacity building through the various available geothermal training programmes. Various concerned departments to streamline geothermal studies within their departmental budgets.

1. INTRODUCTION

Malawi is a country in south-eastern Africa bordering Tanzania in the north and northeast; Mozambique in the east, south and south west; and Zambia in the west and northwest. It covers a total area of 118,484 sq.km with a population of about 13 million people (NSO report 2010). The Country is within the Great Rift Valley which extends from Djibouti to Mozambique and lies at the southern end of the western branch of the East African rift system. The country is divided into three administrative regions which are Northern region, Central region and Southern region. The regions are further divided into a total of 29 districts. Malawi's economy is generally agro-based with tobacco, sugar and cotton as the major cash crops and there are also some fishing activities along Lake Malawi. Most of agricultural activities practiced in Malawi are based on peasant basis with maize being a major food crop.

Malawi has the presence of porous sedimentary horizons at depth and young Neogene rift floor deposits, which holds water and may act as good aquifer (Gondwe et al., 2012). Studies for Malawi geothermal conducted by Malawi's geological surveys department have been going on for some time but are not very detailed. From the studies done, unpublished reports stipulate that Malawi geothermal manifests in hot springs that are located mostly along or near intersections of major faults. There are over 60 hot springs that have been identified and documented and some of them have their water studied for geochemistry to understand the nature of reservoir, their temperature and the origin of the water in the system. Surface temperatures of these hot springs have been between 28° and 79°C. Further geochemistry studies suggest that most of the water, with some isolated exceptions, are immature which have not attained equilibrium thereby presenting some degree of uncertainty in geothermometry. This might be either as a result of thermal water mixing with ground fresh water or that the system is permeable and fast recharging. However subsurface temperature studies done to some level of confidence, have deduced geothermometry temperature range of 169° - 249°C with a more promising field in Chiweta. With the availability of geothermal, Malawi can develop the resource for various utilization processes. The process of geothermal development is long and requires synergy various disciplines and professions to bring geothermal concept into reality. This paper therefore discusses the various opportunities and challenges that Malawi face for Malawi to develop geothermal.

2. MALAWI'S ENERGY MIX PROFILE AND GEOTHERMAL

According to the department of energy affairs, Malawi energy mix is currently predominantly dependent on biomass in the form of firewood and charcoal (Table 1).

Table 1: Energy Mix projections for Malawi 2000 – 2050 ***Source: National energy policy for Malawi January (2003)***

	2000	2010	2020	2050
Biomass	93%	75%	50%	30%
Liquid Fuels	3.50%	5.50%	7%	10%
Electricity	2.30%	10%	30%	40%
Coal	1%	4%	6%	6%
Renewables	0.20%	5.50%	7%	10%
Nuclear	0%	0%	0%	4%
TOTAL	**100%**	**100%**	**100%**	**100%**

The energy mix has biomass and liquid fuels as lead sources of energy in the country. The majority of rural people and a significant number of urban population use firewood and charcoal to satisfy their energy needs. Liquid fuels are used much in motor vehicles and lanterns but much more also in standby generators which are used as electricity generation supplements whenever there is power blackout. The fuel wood is easily accessed from trees while liquid fuel is imported. Malawi adopted an automatic fuel pricing regime where various economic factors determine the final fuel pump price. As such, the price of fuel has been increasing due to unfavourable economic conditions that have been prevailing in the country for some time.

The current energy mix profile puts to a disadvantage the natural vegetation of Malawi as trees are wantonly cut for energy source. The Malawi government came up with the National energy policy (2003) which among others focuses on improving efficiency and effectiveness in energy supply industries and improving security and reliability of energy supply systems as well as mitigating environmental impacts of energy production and utilization. The spirit behind the policy is to reduce dependency of the population on biomass vis-à-vis firewood, by providing environmentally friendly alternatives so that the energy needs of the population are met in a sustainable manner.

2.1 Electricity generation in Malawi

Malawi generates its electricity predominantly from hydro which accounts for 95% of the total electricity generation which is 351MW. All the major power stations are located in the southern part of Malawi along a single river, Shire that runs out of Lake Malawi. One small hydro station, Wovwe power station with capacity of 4.5MW, is located in the north part of the country. Because of the geographical location of the stations, Malawi's electricity system suffers instability that comes with transmission distances and insufficient generation capacity.

As earlier mentioned, the national population of Malawi is estimated at 13 million people. Of this population, it is estimated that about 7.6% of the population have access to the national grid electricity (MCA – Malawi, 2010) which should now be approaching 8% due to various developments from 2010 to date. With such enormous numbers of populace not accessing grid electricity, the majority of the population depends on other alternative sources of energy for their daily needs.

Malawi's electricity sector is currently dominated by a state owned and vertically integrated electricity company called Electricity Supply Corporation of Malawi (ESCOM) limited. ESCOM is involved in generation, transmission and distribution of electricity country wide.

For some time now, floating aquatic weeds/plants and debris that get transported in the Shire river mostly during rainy season, have caused severe operational problems and damage to the hydro stations' intake structures. Siltation at the power plants reservoirs has also contributed immensely to the operational problems thereby significantly reducing the availability of the power plants. This leads to load shedding of power to most of the customers.

Faced with the hydro station problems as well as growing demand for electricity and high cost of fuel, Malawi seeks to explore various means of supplying its populace with electricity to complement the current hydro. With geothermal being one of the resources that the country has with the potential of generating power, Malawi needs to scale up its studies in order to develop the resource and meet the growing energy demand the country currently has.

2.2 Geothermal development in Malawi

Malawi is located within the East African Rift System (EARS) as shown in figure 1 which runs from Djibouti to Mozambique.

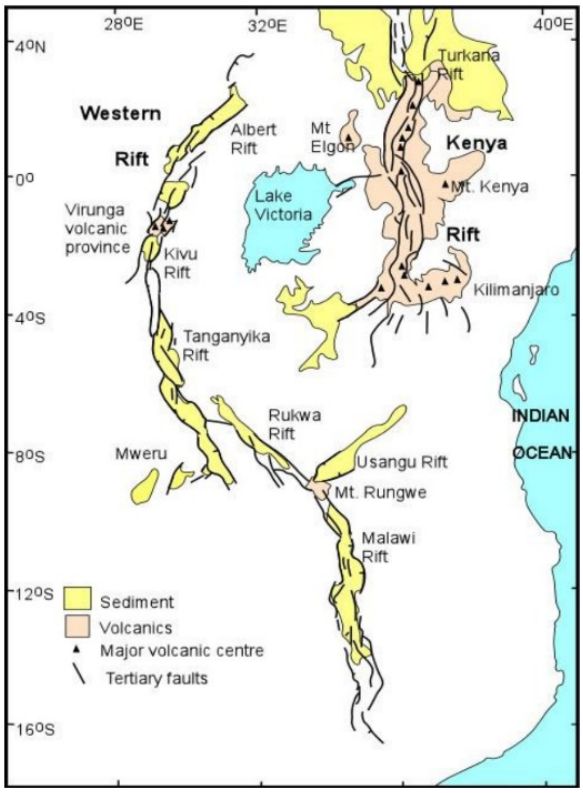

Figure 1: The East Africa Rift System. Source: Omenda (2005)

The EARS is one of the hottest geothermal zones in the world, and is endowed with significant potential geothermal energy resources. Despite its favourable location, Malawi has been slow in harnessing its potentially significant geothermal resources. Geological investigations of the Malawi sector of the EARS indicates that the Malawi rift is controlled by N-S rift parallel normal faults, that also control upwards migration of the geothermal waters feeding hot springs, which occur along the length of the rift.

There are over 60 hot springs that have so far been identified and documented by the department of geological survey, and some of them have their water studied for geochemistry to understand the nature of reservoir, their temperature and the origin of the water in the system. Surface temperatures of these hot springs have been between 28° and 79°C. Further geochemistry studies suggest that most of the water, with some isolated exceptions, are immature which have not attained equilibrium thereby presenting some degree of uncertainty in geothermometry. This might be either as a result of thermal water mixing with ground fresh water or that the system is permeable and fast recharging. However subsurface temperature studies done to some level of confidence, have deduced geothermometry temperature range of 169° - 249°C. The hot springs with most potential for electricity generation occur mainly in the northern half of the country and are thought to be sourced from porous sedimentary reservoirs at depth, either deeply buried young Neogene rift floor deposits or older Karoo sandstones, occurring in fault-bound basins within the Precambrian framework of the country (Gondwe et al. 2012). Studies reveal Chiweta as the area which provides the hottest surface temperature of 79°C and the highest geothermometry temperature of 249°C. Electricity generation in geothermal resource is commonly applied to fluid temperatures around 150°C where generation is commercially viable. However with advancement in technology, considerably lower temperatures are also being used with the application of binary fluids and binary power plants are the hope of accelerating the development of geothermal world-wide (Bertani, 2010). With this back ground, Malawi is earmarked to have an explorable geothermal resource especially when focusing on Chiweta. This gives confidence for further detailed surface exploration, to assist in exploration drilling. However there is need to conduct further detailed studies to ascertain the resource size and its characteristics.

In order to maximize the economies of scale from a given geothermal resource, integration of geothermal power generation projects with agricultural production, farm processing, distillation or dehydration facilities are rapidly growing in popularity. The trend is as a result of advancements in the generation of electricity from moderate temperature geothermal resources with temperature ranges of 100°-150°C. There is an economic advantage in full utilization of the resource in such a way. Worldwide, geothermal developers are evaluating to build projects for optimal resource utilization and reduce on waste heat rejection. This considers the various economic activities happening around the prospective geothermal resource. As such, Malawi ought to consider other economic activities, such as crop and fish drying, which are happening around geothermal resource that can benefit from the development of the resource. These activities would assist in maximum utilization of a resource.

Some of Malawi's development partners such are Icelandic International Development Agency (ICEIDA) and World Bank are keen to assist Malawi with developing proper legal frameworks and terms of reference for prefeasibility studies in geothermal development.

3. OPPORTUNITIES AND CHALLENGES OF DEVELOPING GEOTHERMAL

The journey to geothermal development from a green field is long and faces both opportunities and challenges. This is also true for Malawi as the presence of geothermal has both opportunities and challenges that the country will face for it to fully develop and utilize the resource. This paper discusses some of the opportunities and challenges for Malawi to develop its geothermal potential.

3.1 Opportunities

Geothermal potential: The basic studies that have been conducted so far have indicated that the country has potential of geothermal resource. The resource manifests itself in the form of hot springs. Basic studies and tests that have been carried out from the geothermal manifestation by the department of geology indicate that Malawi can have a resource with subsurface temperature of up to 249°C. With advancement in geothermal utilization technologies, today's utilization of geothermal resource is done at various ranges of temperature as proposed by the Lindal diagram (Figure 2). According to Lindal's diagram (Ragnasson 2006), the anticipated subsurface temperatures for Malawi suggest that Malawi has the potential to develop the resource for various uses such as power generation and various industrial uses.

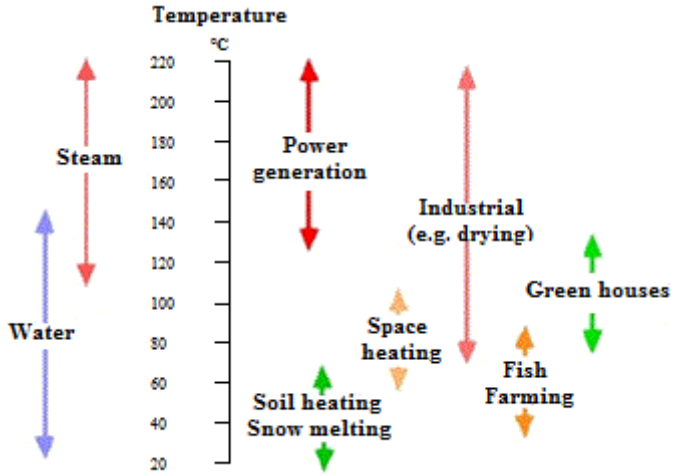

FIGURE 2: Lindal's geothermal utilization diagram. *Source: modified from Ragnarsson, (2006)*

In broader terms, geothermal utilization is divided into two categories, direct utilization and indirect utilization. The current common trend in geothermal development is utilizing a geothermal resource through cascading of the power plant with other direct applications that may be possible. Generally, geothermal power plants are based on flash technology and the flashing is appropriate where resource temperatures are above 150°C. However some developments emanating through studies seem to indicate that flashing technology can be employed at temperatures as low as 120°C or less and at a cost significantly lower than that of a similarly sized binary plant (Pritchett, 1996). Malawi can therefore utilize its resource through electricity generation couples with other functions such as fish drying, crop drying and other related industrial uses. This means that Malawi may develop either binary power plants or hybrid plants which are a combination of binary and flash plant. The economy of some of the areas with geothermal manifestation, are surrounding on fishing, maize and coffee growing. Processing of the fish and coffee is done by sunshine and firewood at temperatures that are mostly not controlled. The end result is normally products that are not that much of quality. Geothermal would provide such areas with needed energy for fish processing and crop drying that meet desirable standards while conserving the environment.

However, Malawi needs to conduct detailed studies for the resource to have meaningful data that leads to development of the resource. Since geothermal development is multi disciplinary, there is need for further studies to be carried out using MT and TEM soundings to know the geophysical properties of Malawi resource. Exploratory wells can then be drilled to confirm the obtained data from the geochemistry and geophysical explorations.

High dependence of hydro with low availability: The availability of a power plant consists of the amount of time that the power plant is able to produce electricity over a given period. The availability of a power plant differs depending on the type of energy source, the design of the plant and the plant operation. As it is normally observed, hydro electricity generation generally has a low availability rate (75%). The low availability factor comes with various factors. Some of these factors include: siltation at the pond, invasion of floating weeds into the turbines mostly during rainy season, seasonal changes of water levels due to rainfall patterns, e.t.c. The lower availability rate of hydro also affects the reliability of the system. This is true with Malawi's hydro system. Apart from the factors that contribute to availability, almost all of Malawi's hydro generation is sourced from a single river and hence Malawi needs to substantially diversify its generation. This gives geothermal development an opportunity in such a way that it is sourced from underground and that its generation availability is mostly beyond 95% and adds reliability to the power system. Because of its high availability and reliability, is good for base-load such that it can operates 24 hours a day, 7 days a week regardless of changing weather or effects of environment, providing a uniquely reliable and continuous source of clean energy. Studies have also revealed that among the leading renewable energy technologies i.e. wind, solar and biomass, geothermal energy has a higher capacity factor of the range 89 – 97% (Kagel et al. 2007). This therefore indicates that by adding geothermal electricity to Malawi's national grid, it will assist with the overall system availability as well as its capacity factor.

High rate of un-electrified of population: Malawi has a very high rate of un-electrified population. As reported in the MCA – Malawi 2010 report, only around 7.6% of the population is connected to the national grid and hence more than 90% of the

population is not connected to electricity. The energy demand as projected in the national energy policy stipulates that there is a 6% growth rate in the electricity towards 2050. Evident by the back log of new connection applications which date even as far as 3 years at ESCOM customer centers, is a clear indication that there is a high demand for electricity in Malawi. Any additional electricity that would be injected into the grid will have a ready off-taker. This gives a chance to geothermal energy that once it is developed, there is a ready market to consume it.

Geo-political stability: During the colonial era, Malawi was colonized by Britain but got its independence in the year 1964. The country was under a single party rule for almost 30 years until the dawn of multi-party system of government in the year 1994. After the first democratic elections in 1994 to present, Malawi has conducted four elections where national leaders were elected. In all the elections conducted, they have been peaceful, free and fair. Leadership change after all the elections has been perfect without quarrels. In the year 2012, Malawi lost its democratically elected sitting president through an unexpected death. Unlike in other countries where such a sudden loss of leadership would be a recipe for civil strife, Malawi experienced a smooth leadership transition during this difficult time. All in all, since it gained independence, Malawi has never gone to war with itself or its neighbours. Because of the peace that it enjoys, Malawi has offered refuge for unstable countries such Mozambique, Somalia, Democratic Republic of Congo, Rwanda and Burundi. This shows that geo-politically, Malawi is stable and peaceful and therefore gives confidence to potential geothermal developers for a peaceful environment of investment.

Available legislations and enabling environment: Malawi does not have legislation that directly address geothermal, but various pieces of legislations do have a bearing on geothermal. Herewith are some of the legislations that touch on geothermal and would aid its development.

The National Energy Policy: To enable developments in the electricity sector, Malawi developed the power sector reform strategy of 2003 and the National Energy Policy of 2003. The two documents were informed by the Malawi Vision 2020 (MV20), a government blue print document that was meant to provide framework for short to medium term plans that would guide Malawi in its development part towards the year 2020. However, to the MV20 has been relaxed due to changes of governments overtime as every government pursued their own policies.

Malawi further developed a set of energy laws that were released in the year 2004 and 2012 which were informed by the energy policy. In 2004, the Energy Regulation Act and the Electricity Act were enacted and published.

The Energy Regulation Act: The Energy Regulation Act No.20 of 2004 brought into existence a national energy regulator called the Malawi Energy Regulatory Authority (MERA). Among others, MERA is mandated by the Act to perform such functions as: licensing all energy undertakings, and approve tariffs and prices of energy sales and services, monitor and enforce compliance by licensees to their license conditions (Energy regulation Act, 2004). Under the same Act, the regulator is mandated to facilitate increasing access to energy supplies and promote the exploitation of renewable energy resource. With such functions of a regulator as guided by the Act, development of renewable energy such as geothermal are supposed to be covered by the regulator. MERA regulates the electricity supply industry using the Electricity Act no. 22 of 2004.

The Energy Regulation Act says that no person may establish, operate, carry on or be involved in any manner in an energy undertaking in Malawi, without a license issued by the regulator. This means that any energy undertaking, including geothermal energy, is subjected to this Act and persons intending to carry out such undertakings are supposed to apply to the Authority for a license which comes with appropriate conditions depending on the type of undertaking being pursued. It is an obligation for energy undertakings to apply for a license otherwise any person that contravenes this law shall be guilty of an offense.

The Electricity Act: Another law for electricity sector is the Electricity Act no. 22 of 2004. This Act expands from the Energy Regulation Act and prescribes the obligations of the energy licensees and the duties of the regulator. The Act makes provisions for the regulation of generation, transmission, distribution, sale, importation, exportation and safety of electricity in Malawi. As part of licensing process, the Authority considers all matters or activities which may adversely affect or result in damage to the environment. In this regard, the department of environmental affairs is requested to certify the licensee's environmental impact assessment for the mutual benefit of the licensee and the environment. The Act also mandates the Authority to regulate electricity tariffs of the industry. The reasoning behind this regulation is to make sure that the production of electricity is done in a manner that promotes both sustainability and further investment while making the electricity affordable to the general public. Thus far, the composition of tariff modelling considers exchange rate movement, consumer price index increases and other unavoidable cost increases and expected efficiency gains in the sector. With the introduction of automatic pricing mechanism, the prevailing economic factors are continuously monitored and price adjustments are made and effected accordingly so that the industry has a positive going concern.

The Malawi Feed-In-Tariff policy: As part of promoting renewable technologies, MERA introduced a Feed-In-Tariff policy. From the National Energy Policy of 2003, Malawi Government commits itself to promoting electricity generation from Renewable Energy and is encourages potential Independent Power Producers (IPPs) to carry out studies on renewable energy generation on the basis of which power purchase agreements can be negotiated. As such, MERA developed a guiding frame work on feed in tariffs for electricity generated from various renewable energy sources including geothermal resource partly to safeguard the investments made by the respective developers and generally boost the development of renewable energy sources. The policy has been designed in a way that it shortens lead times, reduce bureaucratic overheads thereby minimizing project costs. It also allows power producers to sell generated electricity to a distributor at a pre-determined fixed tariff for a given period of time as guaranteed by the third party access to the grid (Transmission and Distribution) provisions of the Electricity Act of 2004.

Some of the objectives of the Feed in tariff policy are: to try to provide investment security and market stability for investors in the renewable electricity generation, to encourage private investors to operate their power plants prudently and efficiently so as to maximize returns. However, the policy has been designed not only to benefit the developer at the expense of the end user, but that the end user should also be protected from high electricity charges.

The policy recognizes that Malawi has the potential of developing geothermal and further stipulates the recognition of Government of Malawi in accelerating development of geothermal resources which require joint effort from both public and private sectors. The policy focuses on geothermal development for electricity of at least 50MW by year 2050. As such, to attract private sector capital in geothermal energy resource electricity generation, the policy fixed a tariff of not exceeding US Cents 10.5 per Kilowatt-hour of electrical energy supplied in bulk to the grid operator at the interconnection point. The tariff applies for 20 years from the date of the first commissioning of the geothermal power plant.

The National Environmental Policy (2004): The Government of Malawi adopted the first National Environmental Policy in 1996 to provide guidance and set standards for development of sector policies in environment and natural resources. The policy provided a framework from which relevant sectoral environmental policies are informed to ensure that there is consistence with the principles of sustainable development. Among others, the National Environmental Policy seeks to promote the efficient utilization and management of Malawi's natural resources and promote cooperation between Government and various stakeholders in the management and sustainable utilization of the natural resources and the environment. The policy was revised in 2004 following the development of new national economic instruments and strategies which had significant impacts on environment and natural resources management. The policy revision was aiming at keeping current with economic trends while responding to new challenges and incorporates lessons learnt as time was going by. The policy objective regarding energy is to meet national energy needs with increased efficiency in an environmentally sustainable manner. The policy seeks to minimize dependence on petroleum products as a source of energy while promoting energy saving mechanisms, renewable energy technologies and environmentally friendly energy technologies in reducing greenhouse gas (GHG) emissions from the energy sources. It is generally agreed that geothermal energy emits very low levels of greenhouse gases as compared to other energy sources such as coal and fossil fuels. Geothermal power plants do not involve combustion as is the case with fossil fuels and coal plants, thus emitting low levels of greenhouse gases. This is in agreement with this policy objective and that the policy would appropriately assist in developing the geothermal resource. Further to GHG emissions, geothermal energy is considered to have a very small land-use per kilowatt among the smallest different power generation technologies which including coal, nuclear and wind. As such, geothermal development complies with the policy in efficient utilization and management of land resource.

The Mines and Minerals Policy (2013): The nature of geothermal resource tapping (exploration and production) is by means of drilling. In some countries, exploration and production of geothermal resource falls under the provisions in the mining laws because the exploration strategy for geothermal are similar to those used in mineral exploration. This brings about the mining policy into geothermal development in Malawi. The goal of Malawi's Mines and Minerals Policy is to enhance the contribution of mineral resources to the economy of the country so as to move from being agro-based to mineral based economy. The policy acknowledges that the full mineral potential of the country is not yet sufficiently known just as the extent of the geothermal resource is unknown. Therefore the policy incorporates basic geological work to be conducted, this includes mineral exploration to determine and confirm the extent of the potential. Through the policy, government commits to provide sufficient financial resources to generate, collect and disseminate basic geological information which could speed exploration. The exploration exercise benefits geothermal development in a way that the geological mapping will also assist in ascertaining the extent of geothermal resource that Malawi has.

3.2 Challenges in Malawi geothermal development

Even though there are opportunities of developing geothermal in Malawi, there are some impeding factors that face the development. Some of the challenges for developing geothermal in Malawi are as outlined below.

Outdated and inadequate legal provisions: From the foregoing, it is observed that for Malawi to develop its geothermal resource, it will have to depend on bits and pieces of various policies. Despite some of these provisions addressing issues relating to geothermal development, they do not directly address salient geothermal development areas. It is observed that only acts and policies that are currently being formulated or revised do give geothermal provisions. An example is the feed-in-tariff policy which provides for geothermal electricity. Otherwise many policies are inferred or borrowed.

It is noted that most of the inferred legal provisions for geothermal development are outdated. The national energy policy was developed in the year 2003, the energy laws and the environmental policy in 2004, a time when geothermal was not recognized in the country and is as now almost 10 years old. The objectives in policies address issues faced at a particular time. These issues and their relative importance do change with the passage of time. Malawi policies provide a time frame for the policy to undergo a review and updating every five years. All these provisions are therefore outdated and due for review and updating process. There is need to incorporate geothermal development in Malawi energy laws as the provisions undergo reviewing.

In order to accelerate development of geothermal in Malawi, Malawi needs to develop its own geothermal policy. The policy would act as a road map for geothermal development and attract developers. The policy would help to institutionalize geothermal development by establishing a national geothermal development unit and would also assist in coming up with a geothermal resource act where things of geothermal exploration, resource development, production and end use would be clearly defined. The policy would also consolidate various protocols that Malawi is a signatory to and have a direct bearing on developing geothermal. One of such protocols is the United Nations Framework Convention on Climate Change (UNFCCC) whose objective is to stabilize the emissions of greenhouse gases (GHG) to levels that would preserve the global climate.

Low prevailing tariff regime: Tariffs are the avenue of a utility company to collect revenue for sustenance of the utility. The tariff assists the utility in financing its undertakings as well as planning for expansion projects. For a long time, government of Malawi had been subsidizing electricity tariffs and as such cost of production was higher than what the customer paid. However around the year 2010, the electricity utility company was allowed to operate as a business entity meaning that it had to make profits. The utility company was allowed by the regulator to adjust upwards its tariffs in steps towards cost of production. The electricity tariff regime for Malawi segregates customers depending on the type of use as implemented by the country's sole electricity service provider ESCOM. Among others the segregation considers whether the customer is connected at either single-phase for domestic

use, or connected at three-phase for domestic and industrial uses. The current tariff of electricity in Malawi with respect to the customer type is in the range of US$0.06 – US$0.12 per kWh (ESCOM website). Even though adjustments have been effected, the tariff has not yet reached the cost reflection and requires further adjustments.

Lack of technical competence: Geothermal development requires a multi-disciplined approach if serious development is to be achieved. The major technical competences or disciplines that are required for geothermal development include geology, geochemistry, geophysics, reservoir engineering environmental science and geothermal engineering. Malawi through the United Nations University - Geothermal Training Program (UNU-GTP) and Kenya's geothermal fraternity has managed to train some scientists and engineers. By October 2013, Malawi has managed to send about 11 engineers and scientist to Kenya for training in geothermal surface exploration and from the 11, 2 have gone further with the 6 months specialized training in geothermal utilization and geology at UNU-GTP in Iceland. This is also manifested in the number of published works relating to Malawi geothermal and reveals an information gap which is not good to the would-be developers. The little number of qualified geothermal trained personnel is a challenge for Malawi to ably develop geothermal. Malawi needs to develop its technical capacity through specialized geothermal training programmes.

Lack of political will: With a good number of perennial rivers that have potential for hydro power generation, government's much focus on additional electricity generation is on hydro. Lack of government leadership in spearheading the assessment of the geothermal resource in Malawi is keeping the progress of geothermal development to remain low. There is need for lobbying the higher authorities for geothermal awareness so that geothermal development receives the attention that it deserves.

Need for institutionalization of geothermal: Malawi does not have a proper set up for geothermal development. The current set up has given provision for a convenient desk officer in the energy department, responsible for coordinating development of geothermal. However, with the focus on hydro development that the country has, geothermal development is not given enough attention in this aspect. It would be ideal if a fully fledged geothermal unit is established within the structures of the Ministry of Energy. This would assist in integrating geothermal development with the various energy developments done at the ministry

Lack of Financial capacity: Geothermal development has got a high upfront cost during exploration stages such as conducting surface studies, exploration drilling, appraisal drilling and feasibility studies. This is in contrast with some of the technologies like coal fired electricity generating plant that would yield results in no time. In Malawi's case, there is no direct public financial support mechanism for geothermal development and this creates a funding gap for the early stages which also have high risks at high cost. There is need to mobilize funding for geothermal development. There is therefore geothermal development in its initial stages requires government commitment if there is will to realize the yields.

Low scale agricultural activities to support geothermal: Malawi lies within the tropics and hence enjoys abundance of sunshine for a bigger part of the year. Due to lack of modern technologies applied in the sector, the majority of agricultural produce are not commercially viable. As such, for a long time Malawians do process their fish and agricultural produce through sun drying. Unless modern technologies are applied and groups of farmers form cooperatives, introduction of geothermal to be incorporated in the agricultural processing would not be economically viable. Farmers would continue to rely on firewood and the abundant sunshine to process their produce.

4. CONCLUSION

The journey towards geothermal development is long but exciting and achievable. With Malawi located within the east Africa rift system, it holds a promise of geothermal potential. With various applications that can be applied on geothermal in Malawi, development of the resource would add much value to the economy of the country. It is to the benefit of geothermal that some legal and regulatory provisions are available to necessitate the development kick start. However, the provisions need to undergo review and updates in order to incorporate geothermal development in the provisions. Further studies need to be done to really ascertain the extent of the resource's existence. This includes coming up with geophysical data, geochemical analysis and mapping various fields to come up with conceptual models. In this regard, various stakeholders and government departments such as the geological surveys, department of energy affairs and the department of environmental affairs, need to streamline geothermal development within their budget lines. The capacity building strides that have been followed so far, needs to be continued in order to have more competent human capital that would be capable of developing geothermal. With appropriate lobbying to elicit political will, there is need to demonstrate commitment to develop geothermal and international support is welcome.

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