GEOTHERMAL DEVELOPMENT IN TANZANIA A COUNTRY UPDATE

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ABSTRACT

Tanzania's power system has for decades relied on hydro and oil based generation mix. As a result, the power supply has been prone to variability and uncertainty due to frequent drought spells and oil price fluctuations. As a short term remedy, the government has resorted to emergency fuel oil based power plants to bridge the supply gap. This solution is not only expensive but also environmentally unfriendly. Knowing that energy is vital for economic, social, and human development, Tanzania has determined to develop a sustainable energy mix that will ensure that households, communities, businesses and industries receive supply that is adequate, available when needed, reliable, convenient, healthy and safe for supporting the county's development agenda. Geothermal being abundant and reliable source of base load supply, is one of the options for achieving sustainable energy supply portfolio. Tanzania has the geological setting that is favorable for hosting the geothermal resources. The country's theoretical potential of geothermal is estimated to exceed 5,000 MW but remains un-taped for several reasons among others being, limited awareness about the unique positive features of geothermal (renewable, clean, and base load supply), avoiding to take upfront exploration cost and risks, long lead time in comparison with hydro and gas, and lack of manpower for developing the resource. At the moment, the government is keen to develop its geothermal energy resources so as to contribute to the country's envisaged sustainable generation mix and to benefit the local communities through direct utilization of geothermal heat. With the purpose of developing the resource, the government has taken a number of steps including setting generation targets, establishment of dedicated company for geothermal development in 2013, establishment of enabling environment for attracting private sector participation, and development of human capacity for supporting the exploration, development and utilization. In parallel with that, Tanzania has developed a portfolio of prioritised geothermal sites to focus on, Ngozi and Songwe prospects being top on the priority list. Detailed surface study of Ngozi and Songwe has been concluded, recommending test drilling to confirm the resource. Preparation are in progress for making sure that test drilling takes place at Ngozi in year 2017. This country paper presents new developments in geothermal development since 2014 when the last country update was presented during ARGEO -C5 in Arusha, Tanzania.

1. INTRODUCTION

The energy sector in Tanzania is largely dominated by biomass, which account for 85 % of total primary energy consumption, 9 % is contributed by oil and gas while electricity account for 5% and renewable energies 1 % of total consumption (NEP, 2015). The energy sector is geared toward diversifying generation sources, enhancing affordability, reliability and increasing connection and access to electricity. The country's power system is mainly relaying on hydropower, gasoline and gas based generation. The total grid installed capacity is 1357.69 MW of which hydro contributes 42%, gas 45% and liquid fuel 13%. In June 2016, the total capacity was reduced by 10.4% from 1516 MW to 1357.69 MW by retiring fuel oil based emergency power plants. The annual electricity consumption per capita was 105 kWh in 2014, which is below acceptable global average per capita consumption of 500 kWh (Energy Qtly Digest, June 2016).

The National Development Vision 2025, envisages Tanzania to become a middle income country by 2025. To attain this goal, sustainable, renewable, reliable and affordable energy technologies are needed to strengthening and increase energy security and diversity. Geothermal, being renewable energy source is expected to be one of the main contributor to the country's energy mix.

Tanzania is traversed by the East African Rift system which is the main host for the geothermal resources. The country is endowed with enormous geothermal potential that has not yet been taped. Initial geothermal studies of surface manifestations across the country suggested that the potential is exceeding 5,000 MW. Unlike other countries in the region, the geological settings that host geothermal resources in Tanzania is highly variable and include young volcanic provinces in the north and south western Tanzania, the western rift arm, faulted granites in central Tanzanian craton and young coastal sedimentary formations in the east.

2. INSTITUTIONAL ARRANGEMENT, LAWS AND REGULATIONS

The main governmental players in the electricity sub- sector in the country include the Ministry of Energy and Minerals (MEM), the Tanzania Electric Supply Company Limited (TANESCO), Rural Energy Agency (REA), Energy and Water Utilities Regulatory Agency (EWURA) and Tanzania Geothermal Development Company Limited (TGDC), which is the government entity that is solely dealing with geothermal development.

The Ministry of Energy and Minerals (MEM) is responsible for provision of overall sector leadership, oversight guidance and policy directions on energy including geothermal. It is responsible for formulation and articulation of policies for creation of enabling environment for sustainable development of renewable energy, geothermal inclusive. TANESCO is the country's principal electricity generator, transmitter, and distributor and the main off-taker. TGDC is 100% owned by the government through TANESCO and is charged with the duty of spearheading development of geothermal resources in the country. The structural relationship among the institutions is as shown in Figure 1.

The first National Energy Policy (NEP) was formulated in 1992, in response to the major socio-economic reforms that took place in the 1990s. Thereafter, the National Energy Policy was re-formulated in year 2003 and 2015 with the objective of developing a vibrant energy sector that contributes significantly to economic growth and improved quality of life of Tanzanians. NEP, 2015 has been formulated, among other things to increasing access to modern energy services and increase the share of renewable energies in electricity generation mix to enhance availability, reliability and security of supply. In order to enhance utilization of renewable energy resources so as to increase its contribution in diversifying resources for electricity generation, the government intends to take two main measures: (i) establish feed-in-tariffs for renewable energy technologies and (ii) Establish frameworks for renewable energy integration into the national and isolated grids (NEP, 2015).

According to the Mining Act 2010, geothermal is categorized as a "mineral" under the general definition that a mineral means "*any substance, whether in solid, liquid or gaseous form, occurring naturally in or on the earth, or in or under the seabed formed by or subject to a geological process, but does not include petroleum or surface water*". For that reason, prospecting license for exploration of geothermal is granted under the Mining Law. Currently, the exploration, exploitation and utilization of geothermal resources are not comprehensively regulated by mining act and regulations. Knowing that geothermal is unique and is not regulated sustainably under the existing laws, the government through Scaling Up Renewable Program (SREP) is developing the geothermal strategy, legal and regulatory framework and risk grantee scheme. This demonstrates the government commitment to reduce geothermal resource uncertainty and improve structural governance and encourage private sector participation in the development of geothermal resources.

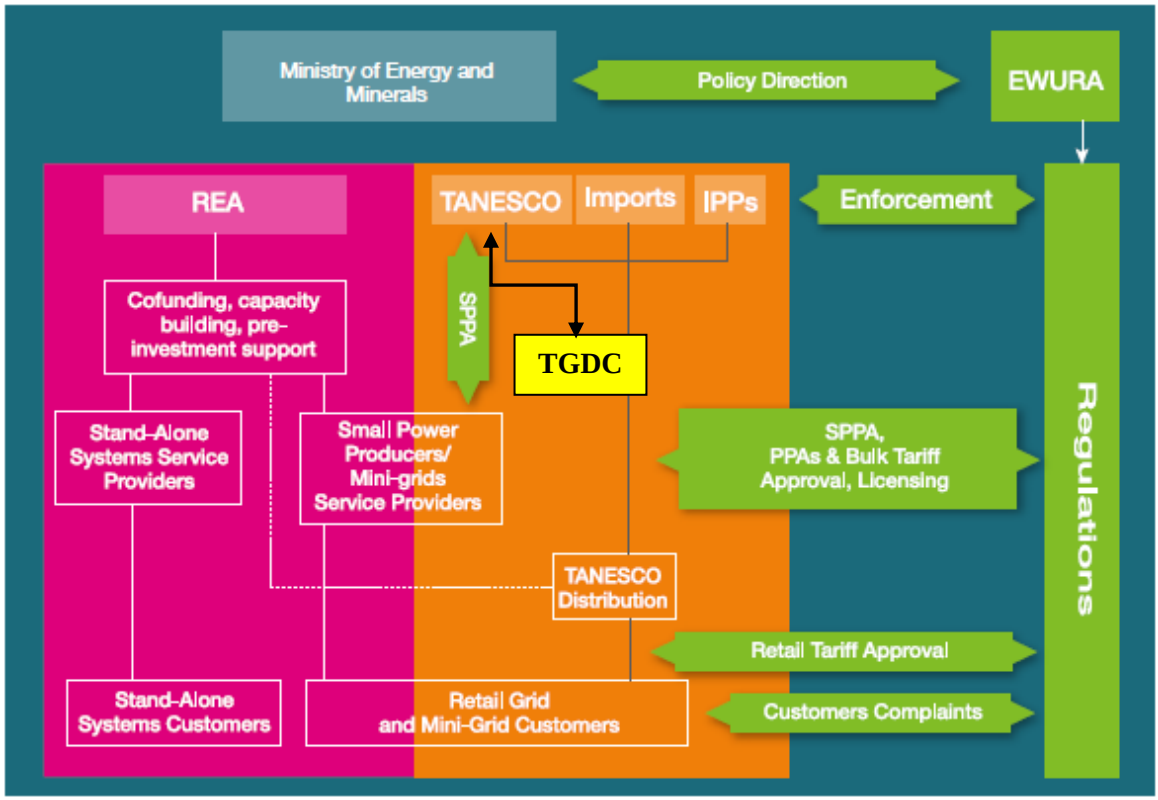

Figure 1: Institutional Framework and Market Structure (modified from: SREP, 2013).

3. NEW DEVELOPMENTS FOR EXPENDING GEOTHERMAL PROJECTS

In order to expedite the development of geothermal in the country, the government has taken certain steps, the major ones include establishment of a dedicated geothermal company, improvement of enabling environment, setting geothermal generation target for year 2025 and advancing detailed surface studies of Ngozi, Songwe, Kusaki Luhoi and Mbaka-Kiejo geothermal potential sites.

3.1. Establishment of Geothermal Company

The government established Tanzania Geothermal Development Company Limited (TGDC) in 2013 as public entity dedicated to geothermal resource exploration, development and utilization. TGDC is a subsidiary company of TANESCO; 100% owned by the Government. The company mandates include, among others geothermal exploration and drilling as a measure to de-risk the initial phase of the project development, which the cannot be done by private developers. Currently, the company is owning prospecting rights over several sites countrywide, the main one ones being Ngozi, Songwe, Natron, Kusaki, Natron, Luhoi and Mbaka-Kiejo.

3.2. Creation of enabling environment

Presently, there is no specific law governing geothermal development. However, with the intention of speeding-up geothermal power development, the government under SREP is formulating a legal and regulatory framework for geothermal. A tender has been advertised for hiring a consultant for preparation of "*geothermal strategy, legal, institutional and regulatory framework and risk mitigation and guarantee scheme*".

3.3. Setting Geothermal Generation Target

In year 2014, the government published the Electricity Supply Industry Reform Strategy and Roadmap 2014 – 2025, which sets a target of 200MW from geothermal generation by year 2025. For ensuring that this target is met, the government through TGDC has lined up Ngozi and Songwe in Mbeya, Natron (Arusha region), Kisaki and Luhoi (Coast region) as priority geothermal project for development.

4. PLANNED GEOTHERMAL PROJECTS

4.1. Geological Framework For Geothermal Resources

In Tanzania, geothermal energy resources are mostly located in the Rift Valley and the common surface manifestations are clusters of hot springs. There are more than 50 clusters of hot springs in the country occurring in different geological conditions but they are all located on the main rift valley or on major fault structures related to rift faulting (Fig. 2). Existence of thermal energy is inferred mainly from the presence of hot springs, volcanic activities and fault structures. Hochstein et al. (2000) argue that the geothermal resources of Tanzania appear to be rather small and limited in terms of existing technology. McNitt (1982-UNDP), based on analogy methods, estimated that the geothermal potential of Tanzania could be as high as 650 MW but current estimates based on surface manifestations across the country suggested that the potential exceeds 5,000 MW. This value is based on the natural heat flow discharge from hot springs. The estimates are based on integrated the geophysical, geochemical and geological techniques without test drilling.

In simple geological zoning, the geothermal potentials of Tanzania are found in four distinct geological/geographical; (i) volcanic provinces in Northern and South Western Tanzania (ii) fault based in western rift (iii) fault based in the central Tanzania and (iv) fault based potentials along the coastal belts. Very few hot spring clusters are found outside these main zones.

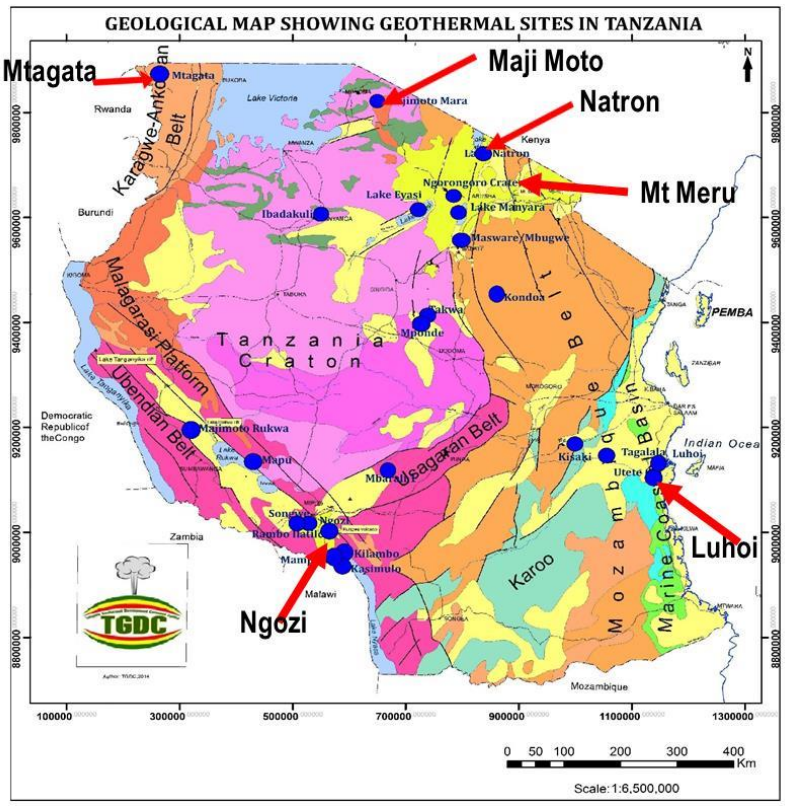

Figure 2: Location of main geothermal manifestations in Tanzania

4.2. Status of Planned Geothermal Projects

For achieving the planned target of 200MW by 2025, few strategic geothermal projects have been selected for development. The project selection was based on existing technical information, local capacity to implement the projects and projected support from development partners. Ngozi and Songwe prospects which are located in Rungwe volcanic province in South western were selected as priority projects followed by Kisaki, Natron, Luhoi and Mbaka –Kiejo. The projects are still in the

exploration phase but Ngozi and Songwe are ready for test drilling. The status levels of the projects is presented in Table 1 below;

Table 1: Status of Planned Geothermal Projects

Site	Status	Next Level of assessment	
Ngozi/ Songwe	Detailed surface study completed	Exploratory drilling (2017/18)	Funds mobilization for test drilling in progress.
Kisaki	Preliminary surface study ongoing	Detailed surface study (2017)	Packaging of GRMF Application for detailed surface exploration ongoing.
Luhoi	Preliminary surface study ongoing	Detailed surface study (2017)	In execution with Technical support from MFA (Iceland)
Mbaka-Kiejo	Preliminary surface study ongoing	Detailed surface study (2017)	In execution with Technical support from MFA (Iceland)
Mt. Meru	Preliminary surface study ongoing	Detailed surface study (2018)	In execution with Technical support from BGR (Germany)
Natron	Preliminary surface study ongoing	Detailed surface study (2019)	In house

4.3. Ngozi and Songwe Geothermal Projects

Ngozi and Songwe prospects have been investigated by many workers including Geological Survey of Tanganyika (1958) and Harkin (1960), but these studies were focusing on general geology of the area, structures and hot spring manifestations without extending the knowledge to geothermal power production and direct application. DECON (2005) carried out gravity and resistivity measurements in the area and proposed a geothermal model for Songwe prospect. The study recommended that more work is required thorough understanding of the geothermal system.

GEOTHERM Phase I (2006-09) carried a study in the Mbeya region and concluded that Rungwe and Ngozi are two different systems. Based on that conclusion, GEOTHERM Phase II (2009-13) concentrated on Ngozi and concluded that Ngozi and songwe are part of one geothermal system, where the heat source is underneath Ngozi volcano with outflows at Songwe. The geological set up of the area is shown in Figure 3.

TGDC with technical support from UNEP/ARGEO and MFA (ICEIDA) has carried out additional studies in the area with the intention of establishing the geothermal system model and selecting drilling targets for confirming the existence commercial geothermal resource. The study was completed in September 2016, concluding that Ngozi and Songwe are two distinct systems. For Ngozi prospects, the geothermal reservoir is beneath Ngozi with estimated temperature of 232 ± 13 °C, TDS of 15,800 ± 2300 mg/kg (Na-Cl composition), and a PCO2 of 15 ± 4 bar. On the other hand at Songwe, geothermometry of the hot springs estimate the temperature to be 112 ±16 °C.

The study has recommended slim holes near Ngozi caldera and thermal gradient wells in Songwe area. The next step for TGDC is to submit application to GRMF for co-financing drilling of test wells. The strategy is to start with slim holes to test the resources before embarking on full size wells.

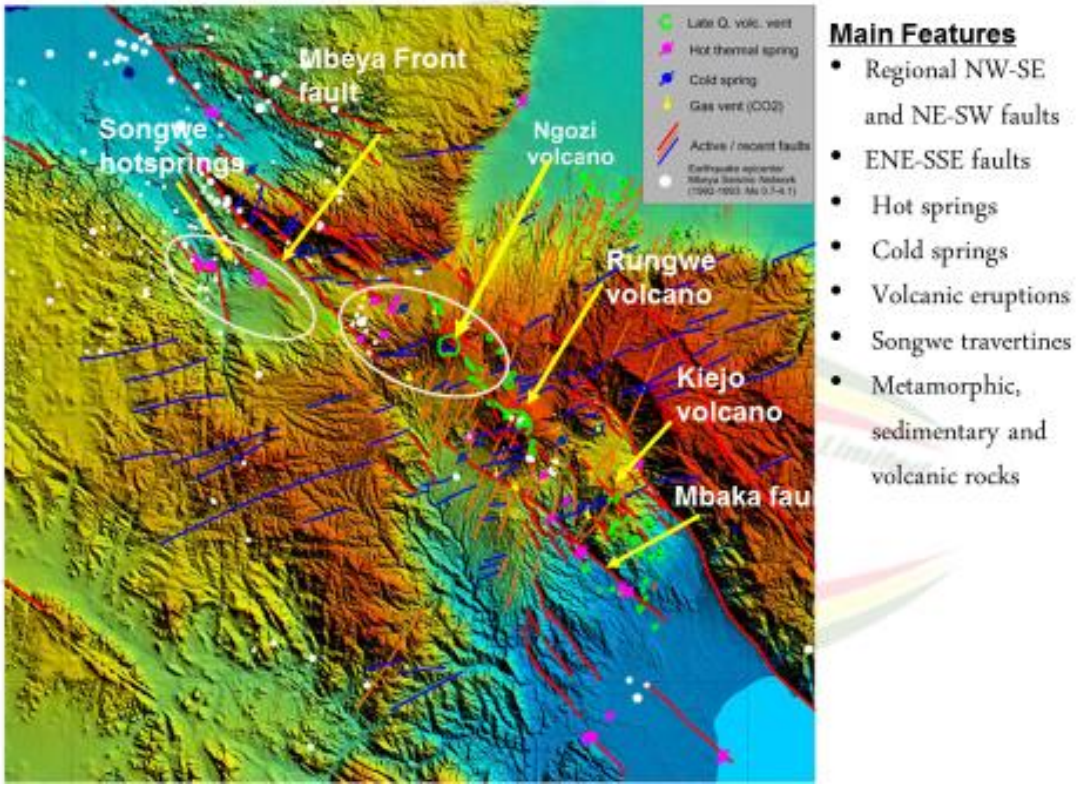

Figure 3: Location of Ngozi and Songwe Geothermal prospects

5. GEOTHERMAL ENERGY APPLICATION IN TANZANIA

Though hot springs are widely spread in the country, there is no formal commercial geothermal uesen in Tanzania. The traditional local uses include sinters for feeding animals, washing, skin bathing and cultural attachments. Lately, hot springs in Manyara national park and Songwe are used for tourism. TGDC is discussing with Tanzania National Pack Authority (TANAPA) the possibility of improving hot spring sites in the national parks geo-tourism.

In general, direct use viability depends on the temperature of the available geothermal fluid. Most agricultural, commercial and industrial processes that require heat can use geothermal energy directly. In Tanzania, hot spring clusters are widely distributed in the country. Considering their occurrences in relation to weather, land use pattern and economic growth, Tanzania has a huge potential for direct utilization in aquiculture, agro-processing, geo-tourism, and industrial and domestic heating.

In many places were geothermal exists such as Mbeya, Arusha, Dodoma and Singida, there is ample fertile land and agriculture is the main economic activity. Therefore market potential for drying of crops and also growing, flowers, fish and fruits is there. On the other hand, the hot springs in the animal marks provide a potential for introducing geo-tourism where tourists not only enjoy games but also refresh in warm water and enjoy geothermal scenery.

In Arusha and Mbeya where the infrastructure is well developed, horticulture is another possibility. In these areas there is extensive farming of coffee and tea which can be dried using geothermal heat. Recent survey indicate that there are a number of industries and hotels in Arusha and Mbeya which consumes heat in their daily production processes. Some processes for Soft drinks producers such as Coca Cola Kwanza limited, Pepsi - SBC Tanzania Ltd and water bolters - Afri Bottlers Ltd and Mbeya Spring Water may use the direct heat in their processes.

6. DISCUSSION

Recognising potential contribution of renewable energy to the country's future energy mix, the Government of the United Republic of Tanzania is determined to support geothermal development. Geothermal is environmentally benign, can improve access to sustainable, modern and cleaner energy services with the potential for contributing to job creation, income generation, and improved livelihoods.

The main challenges facing geothermal development in the country are limited awareness, high upstream costs and resource risk. Different countries have taken various approaches to scale-up geothermal development through public support including public sector taking on the full resource risk, government-led exploration and rights are transferred to the private sector to complete and install power plants, geothermal resource risk insurance and fiscal incentives. Which is the best approach is another challenge because different countries have taken different approaches depending on local situation.

Tanzania is progressively developing strategic local capacity in terms of specific knowledge and skills relevant to exploration, development and utilization for supporting the geothermal development. At the same time, steps are being taken to streamline institution and establish favourable legal and regulatory framework as well as enabling environment conducive for geothermal development. The establishment of TGDC as a government vehicle has increased the pace toward making geothermal a reality in Tanzania. Within two years of existence, TGDC has completed detailed surface studies of two projects (Ngozi and Songwe) and submitted two full application to GRMF for financing. Presently, the government is soliciting finance for test drilling at Ngozi and Songwe to confirm the availably of commercial geothermal resource for power generation and direct use.

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