Opportunties and Challenges in Geothermal Development in Ethiopia

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ABSTRACT

Ethiopia is endowed with large geothermal potential resources. So far 24 prospect areas of high temperature sources are identified with an estimated electrical potential of over 10,000 MW. These resources are located in the Ethiopian Rift Valley which is part of the East African Rift System. Despite huge geothermal resources, only a fraction of the available resources have so far been developed. The main reason for the slow pace of geothermal development in the country has been priority that has been given to hydro resources development of cheaper generation cost. As a result, about 90 % of the current total installed electrical capacity (4300 MW) is from hydro. However, as the rainfall in Ethiopia varies considerably from year to year, the need to diversify the country's energy sources to ensure a stable supply is desired.

Since recent years, new opportunities for geothermal development are being created in the country. In the master plan for energy development of the country, it has been planned to develop over 25,000 MW by 2037, to satisfy a rapidly rising local and regional demand. Of this demand, 5,000 MW is planned to be developed from geothermal resources. The new policy of the government, to generate electricity as much as possible from clean and renewable sources of hydropower, geothermal, wind, solar and other renewable energy resources, using public and private sector investments has also created opportunities for geothermal development.

Despite good progress, in emplacement of policies and master plan for geothermal development, luck of sufficient capacity to quickly negotiate with private sectors and inadequate enabling environments for private sector investments still remain as challenges in advancing development of the resource.

1. Introduction

Ethiopia is located in the horn of Africa between 3.5° and 14° N and 33° and 48° E. The country has an area of 1.14 million km^2 and a population of over 90 million, CSA (2016). The Ethiopian economy, which is a non- oil-driven economy, has grown on average rate of 10.2 % for the last 10 consecutive years. The continuous economic growth has influenced the growth of energy demand, including electricity. The electricity demand has increased over 20 % since last 10

years. The economy is agricultural led with major exports of coffee, oil seeds, animal skin and horticultural products.

The energy sector in Ethiopia can be generally categorized into two major components: (i) traditional (biomass), and (ii) modern (such as electricity and petroleum). As more than 80 % of the country's population is engaged in small-scale agricultural sector and live in rural areas, traditional energy sources represent the principal sources of energy in Ethiopia, Abayneh (2013).

Ethiopia is endowed with large geothermal potential, but the dominant electricity generation source is so far hydro. The overdependence on hydropower makes energy supply unstable, resulting in heavy strains on the pace of growth in every sector and thus more stable geothermal power is considered essential. This paper mainly highlights: (i) the status of electricity production, (ii) the status of geothermal developement and (iii) opportunities and challenges in geothermal development in Ethiopia.

2. Status of Electricity Production

The current total generation capacity (installed) has reached about 4,300 MW (Table 1), of which about 90 % is generated from hydro and the dependable capacity is 3,824 MW. However, as the rainfall in Ethiopia varies considerably from year to year, the need to diversify the country's energy sources to ensure a stable electric supply is desired. It also implies that overdependence on hydropower makes energy supply unstable, resulting in heavy strains on the pace of growth in every sector and thus more stable geothermal power is considered essential.

Table 1: Sources of generation in Ethiopia and corresponding installed capacity

No	Source of generation	Installed capacity (MW)	%
1	Hydropower	3823	89.5
2	Wind	324	7.5
3	Geothermal	7. 3	0.2
4	Thermal	89	2.1
5	Cogeneration in sugar industries	26	0.6
	Total	**4269.3**	

3. Status of Geothermal Development in the Ccountry

3.1 Surface Exploration

Ethiopia is endowed with large geothermal potential. The geothermal resources are located in the Ethiopian Rift Valley which is part of the East African Rift System. The Ethiopian Rift Valley is a region of high heat flow anomaly due to upper mantle intrusion beneath a thinned crust. Recent central volcanoes are abundant in the central-southern parts of the Rift while fissure volcanic terrains dominate to the north. The geothermal sites are close to volcanic activities and are geographically distributed from the south western part of the Rift up to the north eastern part, following the Rift axis (Figure 1).

Ethiopia has started geothermal exploration in 1969, within the Ethiopian sector of the East African Rift system. The initial level of exploration had been reconnaissance, covering the whole rift system. Under this survey, about 120 localities within the rift system were believed to have independent heating and circulation geothermal systems and from these, about two dozen were judged to have potential for high enthalpy resource development, including for electricity generation. A much larger number have been considered as low enthalpy, suitable for direct utilizations, UNDP (1973).

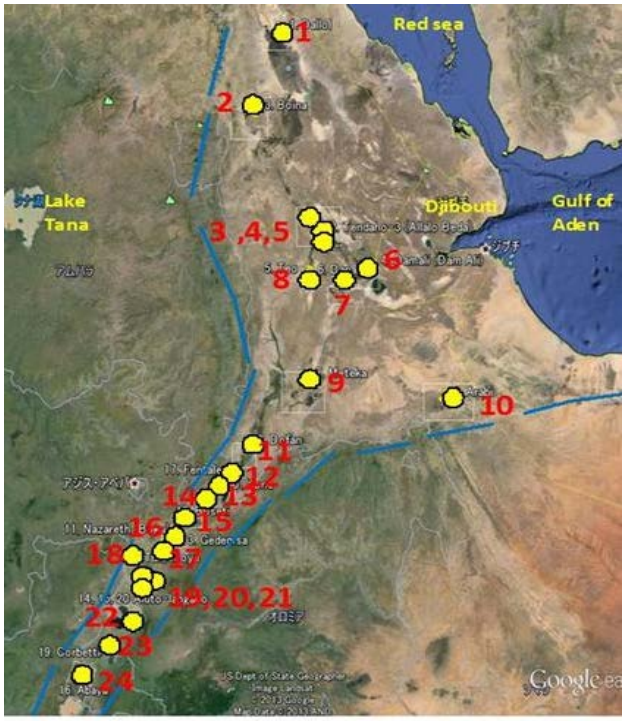

Figure 1: Location map of geothermal prospects in Ethiopia

Since the late 1970's, geo scientific surveys mostly comprising geology, geochemistry, and geophysics, were carried out at the southern-central part of the Ethiopian Rift and Tendaho

prospect in Afar to the North. In addition, a semi detailed surface exploration of ten sites in the central and southern Afar has been carried out by the Geological Survey of Ethiopia in 1986 with Italian assistance. Since then, detailed surface explorations for well sites selection have been conducted by both the public and the private sector in 14 of the 24 prospects.

3.2 Geothermal Resource Potential in Ethiopia

Ethiopia has a large geothermal potential. A geothermal master plan study has been implemented in 2013 with technical assistance from Japan. The study included, geo scientific and social and economic surveys. The results of the study have indicated, a minimum geothermal potential of 4,200 MWe and a maximum of 10,800 MWe, GSE and JICA (2015).

3.3 Deep Drilling and Geothermal Utilization

The two prospects where deep drilling and testing have been carried out in Ethiopia are Tendaho-Doubti prospect and Aluto Langano prospect.

The drilling at Aluto has been conducted in two phases: (i) early to mid 1980's, when eight deep exploratory wells were drilled and in 2013-2014 when two appraisal wells have been drilled. From the earlier eight exploratory wells four wells have been productive with an average capacity of about 2 MW, each. The drillings of the two appraisal wells, LA-9D and LA-10-D, have been planned to 2,500 m depth but due to rig technical problems LA-9D and LA-10-D have been completed prematurely to depths of 1,920 m and 1,951 m respectively. Both wells are productive with bottom hole temperatures of over 300º C; however, permeability is not sufficient enough for maximized production. Testing and reservoir engineering have indicated that the two wells together may sustain about 5 MW electricity. Installation of a well head turbine on the two wells is under consideration for early power generation. Reservoir simulation has been conducted using data from the newly drilled wells at Aluto, including data from previous wells. The results have indicated that a total of 70 MW could be sustained from the two identified target areas at Aluto Langano prospect, West Jec (2015).

The other better explored area including by drilling is the Tendaho-Doubti area. Between 1993 and 1998, three deep (about 2,100 m) and three shallow exploratory wells (about 500 m) have been drilled, financed by Italian and Ethiopian governments. The shallow wells were productive and yielded a temperature of over 250º C. In 2014, a feasibility study on the shallow resource development has been conducted with French Development Agency assistance. The feasibility study recommended, the immediate exploitation of the proven resource pertaining to the shallow reservoir by drilling of additional six wells and deployment of a power plant with capacity of tens of MW's, ElC (2014). Currently preparatory works to commence the drilling are being conducted, including hiring of a drilling service company.

Regarding resource utilization for power production, the only geothermal power plant in Ethiopia so far is a 7.3 MW Aluto Langano pilot plant, which had been installed in 1998. The power plant is a binary plant utilizing two of the hottest wells for steam turbine generation and other two of the lower temperature wells for heating of a working fluid for driving another turbine. The pilot plant had some mechanical problems to be rectified and currently is not in operation.

Direct utilization of geothermal resources in Ethiopia has been limited in hot spas, balneology and for bathing and swimming in resort areas.

4. Opportunities for Geothermal Development

4.1 Recent development plans

To fulfill the high growth rate of electricity demand, it has been planned to increase the generation capacity to over 25,000 MW by 2037. The aim is to address both domestic demands while exporting surplus power to neighboring countries and beyond. The need to expand the transmission and distribution system is also emphasized in order to deliver the energy generated to the consumer in an efficient and reliable manner. The growth plan further envisages, increasing the customer base of the power utility from the current level of 2 million to 4 million and the universal electricity access rate from 45% to 75%, Lemma (2014).

According to the country's energy development plan, a medium term and long term geothermal development goal has also been established. According to the medium-term plan, a total of 687 MWe is to be developed from six selected prospects by 2025 and in the long-term plan, a total of 5,000 MWe by 2037. The planned geothermal development is expected to be achieved with the participation of both the public and the private sector.

The Aluto Langano and Alalobad geothermal fields are priority areas in current public-sector projects and preparations are being conducted for drilling of deep wells to be followed by power plants construction.

Corbetti and Tulu Moye prospects are on the way for development by the private sector with drilling activities to commence soon. From the 687 MW's of geothermal power planned in the medium term, major contributions are expected from private sector development.

4.2 Private sector Opportunities in Geothermal Development

The Ethiopian government policy direction is to generate virtually all of the country's electricity from clean and renewable sources of hydropower, geothermal, wind, solar and other renewable energy resources, Abayneh (2013). It aims to facilitate the development of energy resources for economical supply to consumers. It also seeks to achieve the accelerated development of indigenous energy resources and the promotion of private investment in the production and supply of energy. Electricity supply, as an element of the development infrastructure is being advanced in two fronts: (i) the building up of the grid-based supply system to reach all administrative and market towns, and (ii) rural electrification based on independent, privately owned supply systems in areas where the grid has not reached.

An independent power producer (IPP) may engage in power development for selling the generated electricity to the public utility, Ethiopian Electric Power, known as the single buyer model. The single buyer model does not exclude captive geothermal power generation, i.e.

generation for own use in primary economic production or service industries owned by the developer.

A new geothermal law for operation of geothermal activities in both the public and private sector has been approved. Accordingly, a proclamation cited as the "Geothermal Resources Development Proclamation" has been put into force since September, 2016. The objectives of this proclamation are to: (i) ensure that the country's geothermal resources are developed in an orderly, sustainable and environmentally responsible manner; (ii) support the generation and delivery of electricity from geothermal energy, for local consumption and export; (iii) promote the use of low enthalpy geothermal resources for direct uses, (iv) ensure security of tenure for all investors in respect of geothermal resources development operations, and (v) encourage a sustainable, carbon-neutral economy in Ethiopia, Federal Negarit Gazette (September, 2016) .

Private developers could apply to a licensing authority that may grant the following geothermal operation licenses: (i) reconnaissance license; (ii) exploration license; and (iii) geothermal well field development and use license. Incentives such as import tax exemptions and tax holidays during production are some of the main items in private sector promotions.

Currently about four private companies have concessions in various geothermal prospects of the country. Most of them have completed surface exploration for locating wells and will commence drilling soon. Power purchase agreements for Corbetti and Tulu Moye geothermal development have been signed with the government. The agreements consider development of the Corbetti and Tulu Moye prospects to a total of 1,040 MWe (520 MWe for each prospect), with an estimated investment cost of 4 billion US$. Currently additional negotiations with the government are being conducted and mobilization works to commence test well drilling are expected.

5. Challenges in Geothermal Development and Way forward

Despite the current favorable conditions for geothermal development in Ethiopia, there are also challenges. These includes: (i) limitations in institutional and human resources capacity, (ii) enabling environments for investments may not be sufficient enough, and (iii) risks associated at the early stage of geothermal development.

To ensure that future geothermal activities could be advanced to the resource development phase much more rapidly than before, the way forward has to include: (i) strengthening of the participation of international financial institutions, bilateral donors and development agencies, to assist geothermal development projects, (ii) creation of more enabling environments for the private sector, and (iii) build up of better human, institutional and infrastructural capacity for the sector.

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