Proceedings 5th African Rift geothermal Conference
Arusha, Tanzania, 29-31 October 2014

Status of Geothermal Exploration and Development in Ethiopia

Kebede, S.

Geological Survey of Ethiopia

P.O.B 40069

Solo450354@yahoo.com

Keywords: Ethiopian Rift System, High Enthalpy

ABSTRACT

Surface explorations for geothermal resources in Ethiopia have begun over three decades ago. These explorations have been initially conducted at reconnaissance level in the Ethiopian rift valley which has an area of 150,000 sq Km. The Ethiopian Rift Valley is part of the East African rift system, with young volcanism, adequate recharge and reservoir rocks for the formation of economically viable geothermal systems.

The early stages of geothermal explorations have identified over sixteen areas to have geothermal resources suitable for electricity generation with a total potential of 5000 MW. Currently the number of prospects suitable for power generation has reached twenty two and the potential is estimated to be over 10,000 MW.

Despite the countries long term geothermal exploration, the progress of development of geothermal resources has been slow. Deep drilling have been conducted only in two prospects. A pilot plant of 7.3 MW installed in 1998 at Aluto Langano is the only geothermal plant. However, since recent years the country has adopted, a renewable energy mix policy, geared towards the advancement of geothermal resources development, including other renewable energy resources. Accordingly both public sector and private sector geothermal projects are being implemented at larger scale than before.

The public sector has focused in progressing to development, the two most explored prospects in the country, the Auto Langano and Tendaho geothermal fields. Under the public sector, geothermal power plants planned for commissioning by 2020 include: (i) 70 MW plant at Aluto Langano and 100 MW plant at Tendaho. For the purpose of achieving the public sector plan, the following geothermal investments in MUS$ are being carried out or under pipeline: ARGeo (1), ICEIDA/NDF (3.3), WB/GoJ/GoE (30), GRMF (1.3), WB (150), SREP (26), GoJ (55), AFD (20), and JICA (3). Additional geothermal power plants are expected to be commissioned at Corbetti geothermal field by private sector involvement, with a total capacity of 1000 MW, to be developed under various phases.

Despite the recent efforts to advance geothermal development in Ethiopia, there are also challenges, including: (i) high upfront capital costs required and availability of sufficient finance, (ii) risks associated with the exploration phase, and (iii) Limitations in local technological and human resource capacity.

1. INTRODUCTION

Ethiopia is located in the Horn of Africa between 3.5° and 14° N and 33° and 48° E. It stretches over more than 1.1 million square kilometers. The country is landlocked with sea-access primarily via its neighbor Djibouti. With more than 80 million inhabitants in 2010, Ethiopia is the most populous nation in Eastern Africa and the second most populous in Africa.

Access to energy is among the key elements for the economic and social developments of Ethiopia. The energy sector in Ethiopia can be generally categorized in to 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 the small-scale agricultural sector and live in rural areas, traditional energy sources represent the principal sources of energy in Ethiopia.

Domestic energy requirements in rural and urban areas are mostly met from wood, animal dung and agricultural residues. At the national level, it is estimated that biomass fuels meet 88 % of total energy consumed in the country. In urban areas access to petroleum fuels and electricity has enabled a significant proportion of the population there to employ these for cooking and other domestic energy requirements.

The annual per-capita consumption of electricity stands at 100 kWh. The same figure for the Sub-Saharan Africa is 510 kWh. This reveals that most of the energy usage is still from traditional energy sources such as wood and animal waste. Moreover it also informs the fact that with the country’s economic development and improvement of the per-capita income, there will be huge potential for consumption of electricity within the country.

The total installed electrical capacity in Ethiopia commissioned by the end of 2011 is about 2100 MW and from this a total of about 5000 GWH has been generated in 2011, Lemma (2012).

Although Ethiopia is endowed with a variety of energy resources, many of these resources have not yet been exploited. Currently about 95% of the electricity generation is from hydro and the remaining 4.4 % and 0.4% are from thermal and geothermal respectively. Development of alternative energies from renewable sources such as hydro, wind, geothermal and biomass will be a key part of Ethiopia's energy mix.

2. GEOTHERMAL RESOURCES OF ETHIOPIA

High enthalpy geothermal areas in Ethiopia are located within the Ethiopian Rift System (ERS). Tectonic and magmatic features show that the ERS to be a zone of particularly active continental crust thinning and opening. Due to a high volume of partial melts in an upwelling asthenosphere, the generation of primary and secondary magma is conducive to the occurrence of high enthalpy geothermal fluid circulation systems at economically accessible depth. The geothermal resources in Ethiopia are economically viable, due to the following main reasons:

- The resources have high reservoir temperatures ranging from over 200 to 335ºC;
- The depth to the reservoirs are economical, ranging from 500 to 2500m;
- The resources have low non condensable gas content and low scaling potential; and
- The geographical location of the resources is very close to existing infrastructures (roads, transmission lines etc).

Ethiopia started long-term geothermal exploration in 1969. Over the years, an inventory has been built up of the possible resource areas within the Ethiopian sector of the East African Rift system, as reflected in surface hydrothermal manifestations. The inventory work in the highland regions of the country is not complete but the rift system has been well covered. Of the about 120 localities within the rift system that are believed to have independent heating and circulation systems, about two dozen are judged to have potential for high enthalpy resources, for electricity generation (Figure 1). A much larger number are capable of being developed for non-electricity generation applications such as horticulture, animal breeding, aquaculture, agro-industry, health and recreation, mineral water bottling, mineral extraction, space cooling and heating, etc. (UNDP, 1973).

The early stages of geothermal explorations have identified over sixteen areas to have geothermal resources suitable for electricity generation with a total potential of 5000 MW. Currently the number of prospects suitable for power generation has reached twenty two and the potential is estimated to be over 10,000 MW.

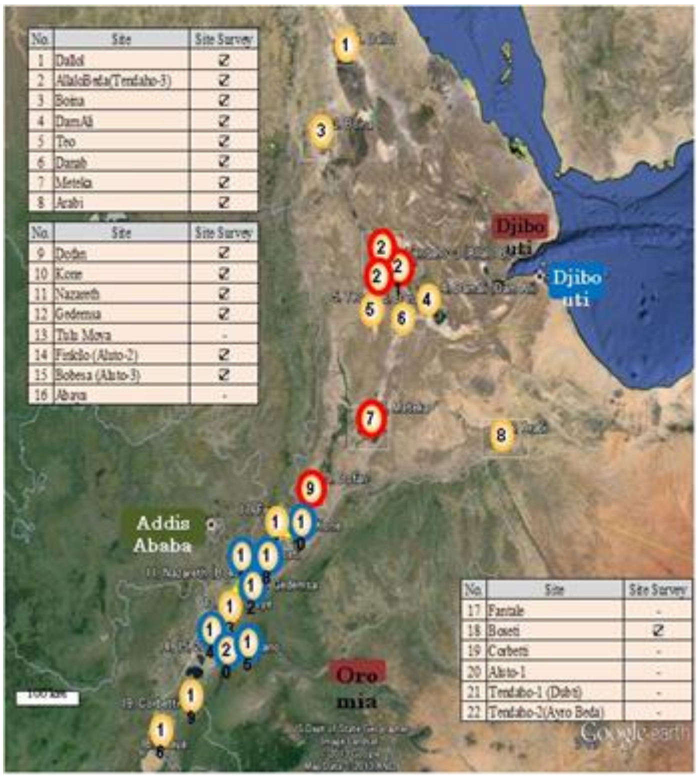

Figure 1: Location map of geothermal prospects in Ethiopia

3. CURRENT ACTIVITIES

In recent years, the country has shifted its policy of relying in a single source of electric power (hydro) to secure energy in the country and thus geothermal sector development is receiving support. As a result a long term geothermal development plan has been established. According to this plan, a total of 2500 MW geothermal power is to be developed by 2030 (Abayneh, 2013).

Inorder to achieve the long term goal, currently the following geothermal activities are being conducted in Ethiopia:

- A five year project entitled Strategic Geothermal Resource Assessment in the Ethiopian Rift Valley was started in 2009. The target areas of the assessment are Tendaho, Aluto Langano, Gedemsa, Dofan, Fentale, Meteka, Bosetti and Arabi, Geoscientific studies including: (i) geological, (ii) geochemical, (iii) geophysical (MT, TEM, Gravity and Magnetics) and (iv) Reservoir engineering studies are being conducted in these areas. The objectives of the project are to locate and identify areas (sites) for deep drilling by acquiring data that can supplement the already available studies, and upgrade and synthesize all existing information in order to establish a geothermal exploration conceptual model for future feasibility studies.

- Ethiopia and Japan conducted a feasibility study for the expansion development of the Aluto Langano Geothermal Field in 2010 which proved the expansion plan to be feasible. A project for resource evaluation by drilling of three appraisal deep wells and one reinjection well has been designed (West Jec, 2012) with investment cost of about 30 MUS$) . The project is financed by the government of Ethiopia, Japanese government and the World Bank. In this project, so far the following activities have being carried out: (i) Pre drilling preparation including well pad preparations, maintenance, testing and erection of an existing rig at the project site, and (ii) purchase of drilling consumables from overseas and capacity building required for the project. The drilling of four wells has commenced in October 2013. Additional work to be conducted in parallel with the drilling has commenced, with the assistance of Icelandic international development agency (ICEIDA) and the World Bank, which includes, production wells drilling, site selection and purchase of rigs and additional consumables.

- At Tendaho, a project proposal has been prepared to develop the geothermal resource to 100 MW at various phases. Additional surface studies indicated that, the previously drilled deep wells were not deep enough to encounter the main reservoir. In order to study the feasibility of utilizing the discovered shallow reservoir and further deep drilling, preparatory work has commenced. Currently early stage of work has commenced with assistance of African Rift Geothermal facility (ARGeo), French development agency (AFD), and ICEIDA.

- Japan international cooperation agency (JICA) and Geological Survey of Ethiopia (GSE) have signed an agreement on June 2013, for geothermal mater plan studies in Ethiopia. The project has started by conducting, geoscientific, social and economic surveys in 22 prospects inorder to prioritize them, with an estimated cost of about 3MUS$.

- Regarding the private sector participation, hot power purchase agreement (PPA) for Corbetti geothermal development has been signed in October, 2013 between the Ethiopian electric power corporation (EEPCo) and Reykavik Geothermal (RG) for the development of Corbetti geothermal field. The agreement considers development of the Corbeti (including Abaya and Tulu Moye) prospects to 1000 MW with estimated investment cost of 4 billion US$. (Lemma, 2012, RG, 2012).

:

4. CONCLUSIONS

For grid connected areas, with most of the countries generation capacity being in hydropower, Ethiopia may face challenging times during droughts. The majority of power plants in Ethiopia depend on water from different rivers and tributaries. Maintaining the appropriate mix of generation from various renewable sources including geothermal will mitigate this problem.

To this end currently geothermal: (i) is integrated in the national energy development plan, (ii) has growing participation of international financial institutions, bilateral donors and development agencies to assist geothermal development projects, and (iii) has increased private sector participation in development projects.

Despite these efforts, high upfront capital costs of geothermal projects, risks associated with the exploration phase; and limitations in local technological and human resource capacity, remain challenging to speed up the development as required.

REFERENCES

Abayneh, G**:** Short remarks on Ethiopian energy sector development program, exchange training program at the Geothermal Energy Association, Geothermal Energy Expo and the Geothermal Resource Council Annual Meeting. Las Vegas, Nevada, from September 26 through October 6, 2013.

Lemma, M.: Along the development of renewable power in Ethiopia, Workshop on the findings of surface explorations at Corbetti geothermal prospect, organized by Reykjavik Geothermal Company, power point presentation, sheraton hotel, Addis Ababa, 2012.

Ministry of Water and Energy: Scaling-Up Renewable Energy Program, Investment Plan for Ethiopia, submitted to Climate Investment Funds, Ministry of Water and Energy, Addis Ababa, 2012..

Reykjavik Geothermal (RG): Results of surface exploration at Corbetti Geothermal Prospect, Workshop on the findings of surface explorations at Corbetti geothermal prospect, organized by Reykjavik Geothermal Company, power point presentation, Sheraton hotel, Addis Ababa, 2012.

United Nations Development Programme (UNDP): Investigation of geothermal resources for power development, Geology, Geochemistry and Hydrogeology of hot springs of the east African Rift System within Ethiopia, DP/SF/UN 116-technical report, United Nations, New York, 275 PP, 1973..

West Jec: Study on Geothermal Power Development Project in the Aluto Langano Field, Ethiopia, report prepared for the ministry of economy, trade and industry of Japan,2012..