Drilling of Shallow Production and Re-injection Wells at Tendaho (Dubti) Geothermal Field (Project), Afar Region, Ethiopia

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ABSTRACT

There is a need for shallow wells drilling in Dubti for the immediate exploitation of the proven resource pertaining to the shallow reservoir, through a power plant of installed capacity of up to 12 MWe because of the current energy shortage in Ethiopia. In Dubti most of the depressions with depth of greater than 600 m, are correlated with alluvial sediment and geothermal fluids or zeolite smectite clay mineral zone as cap rock, Hence, the inferred presence of a fractured zone and shallow partial melt magma reservoir suggest that there is exploitable potential at Tendaho-Dubti for conventional hydrothermal energy development at shallow depth. The technical, economic and financial viability for the development and exploitation of that resource has been analyzed. As to the drilling of production wells for the development of a 10/12 MWe project. The procurement process of the power plant and of the steam gathering system of production wells is on progress. The technical applicability of the project has also been investigated and the relevant conclusions have been presented. Evaluation of the possible impacts of drilling and installing the 10/12 MWe power plant in Dubti- Afar area on the sugar cane plantation irrigated by the Awash system has been done. This paper gives an overall update on project process and culminating in building of a 10-12 MWe power plant.

1. Introduction

1.1. Project Location

The Tendaho geothermal field is located in Dubti Woreda (district), Afar Regional State, some 630 kilometers from the capital city, Addis Ababa, northeastern part of Ethiopia, (see Figure 1-1).
This area is one of the most promising areas for geothermal development in Ethiopia. The proposed project is situated in the north-western part of Tendaho graben, a 4,000 km² structural feature with high-standing fault scarps bounding a flat plain dotted by young volcanic edifices and local structural highs. The graben hosts the world’s famous “Afar Triple Junction” where the Red Sea, Gulf of Aden and Main Ethiopian Rifts come together giving rise to a prime region of geothermal potential. Altitudes on the graben floor vary from 400 m in the northwest to 240 m at Lake Abe in the southeast.

The prospect is found in Dubti Woreda (see Figure 1-2) and is bordered by the Somali Region (S), and by the following Afar Region Woredas: Mile (SW), Chifra and Habru (W), Afdera (N), Elidar (E), Asayita and Afambo (SE).
Figure 1-2: Map of the Woredas of the Afar Region

The project is located inside the Mile-Serdo Wildlife reserve (see Figure 1-3)
Figure 1-3: Map of the Mile-Serdo Wildlife reserve with the location of the Project area
1.2. Project Description

The scope of this section is to give a project overview including a brief description of the project objectives and benefits.

1.2.1. Project objectives and benefits

The proposed project has the following objectives and benefits, as follow:

➢ Objectives
  ✓ To reduce electricity shortage in Ethiopia;
  ✓ To support the Government of Ethiopia policy in energy diversification and fossil fuel consumption reduction; and
  ✓ To optimize the use of geothermal energy that has a high economic and environmental potential.

➢ Benefits
  ✓ To increase electricity supply of up to 15 MW from geothermal energy, this is less impacting on environment than energy from fossil fuels;
  ✓ To support energy security using a domestic renewable resource;
  ✓ To limit exposure to fossil fuel market volatility by diversifying Ethiopia power generation profile and reducing reliance on fossil fuels;
  ✓ To provide multiplier effect to local economy, which is expected to be sustained;
  ✓ To create job opportunities for local communities, according to Company’s requirements and conditions;
  ✓ Support the Ethiopian Government’s Energy Vision in decreasing the share of non-renewable energy sources and differentiates the energy generation mix, using a low carbon, highly reliable renewable resource for base load power.
  ✓ Promote least-cost generation.

1.2.2. Project components

The project consists in the definition of the extension of the shallow reservoir by drilling of up to 6 development wells and in the exploration of the deep reservoir by the initial drilling of two deep directional wells till a depth of 2,500 m.

On the basis of the conceptual model of the shallow reservoir elaborated by the geo-scientific team, a drilling program has been established (Figure 1-4). The program foresees drilling of four production wells (TD-7 to TD-10) spaced some 500 m apart and located about 1 km SE of the cluster of wells drilled in the nineties, around the south-eastern extension of the Dubti fault. In 2013 reinjection was proposed to be carried out in wells TD-R1 and TD-R2 located about 1 km north and NNW of the cluster of existing wells, that is 2-2.5 km NNW of the production wells. Some adjustments were made in their location to take into account the agricultural activities of the Dubti Plantation (Figure 1-4).
2. Total activities

2.1 Project phases

Drilling activities are to be undertaken by contractors. Following initial piling, a rotating bit drills down to a maximum depth of about 600 m for production and reinjection wells and 2,500 m for exploratory wells. “Muds”, a mixture of water, bentonite and emulsifiers, are to be injected through the pipes to the drill-bit to cool it and remove cuttings. A clean water pond lined with geo-textile membrane (synthetic liner) is to be provided at each well-pad with water supplied from water pumping stations.
2.1.1 Fluid Circulation

The fluid circulation system pumps drilling fluids down the hole through the centre of the drill pipe or rod, past the cutting surface of the bit, and returns the fluids and entrained cuttings to the surface. The purpose is to cool and lubricate the bit, remove cuttings and stabilize the hole. Recent technology developments include centrifuge systems that effectively clean mud for recirculation. This decreases mud cost and may be advantageous in many parts of the world (like in Tendaho), because it also decreases the consumption of water.

For what concerns the water demand for drilling operations, considering the most critical working conditions, the following quantities have been calculated: shallow wells: 4,500 m$^3$ each; deep wells: 30,000 m$^3$ each. Therefore, considering 6 shallow wells (27,000 m$^3$) and 2 deep exploratory wells (60,000 m$^3$), the total amount will result 87,000 m$^3$.

The pond utilized to draw water has a surface of 75,500 m$^2$ and an average depth of at least 2 m with an available water volume of about 150,000 m$^3$. It is therefore enough to meet the drilling needs without any water restoration. However, according to the development plan, the pond will be supplied with a certain supply of water from the existing canalizations. At the same time, drilling operations will take place over a period of more than one year so that the volume of water would be progressively restored.

2.1.2 Well test

Once the drilling of the development wells is completed, well testing may take place and may consist in measurements of several parameters. The main phases of conventional completion program are:

- Temperature and pressure logging to evaluate location and relative importance of feed zones as well as temperature conditions prior to later phases of the completion test;
- Geophysical logging and fracture imaging of the production part of the well;
- Step-rate well-testing, through injection in high-temperature wells or production in low temperature wells. The purpose of the step-rate well-testing, which is the main reservoir physics research conducted at the end of drilling a well, is to obtain a first estimate of the possible production capacity of a well and to estimate its production characteristics. Step-rate well-testing usually lasts from several hours to a few days.
- If the hole is not discharging, injection tests are used to determine the infectivity index, which closely reflects the value of the productivity index.
- If the hole can be stimulated to production, classical production tests, requiring the presence of a pond for accommodating the discharge fluids.

Well testing may cause local environmental and social disturbance, due to steam and gases discharged in the atmosphere, storage of polluting separated brines and noise during the discharge.

2.2 Project Status

- In the year 2015 the Ethiopian Electric Power (EEP) applied for financing from the Agence Française de Development (AFD) which had already financed the Tendaho Geothermal Resources Development Feasibility Study. Such project shall be carried out in two distinct phases, namely:
  - Phase 1:
Definition of the extension of the shallow reservoir by drilling of up to 6 development wells;
- Exploration of the deep reservoir by the initial drilling of two deep directional wells till a depth of 2,500 m;
- Strengthening of the EEP and GSE capacities for implementation of geothermal drilling activities.

- Phase 2:
  - Construction of a power plant with an approximate capacity of 7 to 15 MW;
  - Additional drilling activities to develop the deep reservoir.

✓ In the year 2016 ELC Electro-consult was awarded the contract for the supply of the consulting services relevant to Phase 1 and to the initial stage of Phase 2.
✓ The contract for civil Contractor, for the construction of Roads, Dwelling Houses and Water supply work, is under EEP’s Evaluation team.
✓ The Full Service Drilling Contract /FSDC/ tender is cancelled because of inflated financial offer.

3. Conclusion
✓ The Tendaho Graben has a huge potential for geothermal resource as studied by different parties and organizations. The outcome of studies indicated Recent to Pliocene-Pleistocene volcano-tectonic activities characterize the area.
✓ The majority of the country’s generation capacity depends on hydropower and this leads to challenges on drought times. So this project is one of the strategies of the government to have a mix of generations like solar, wind and thermal.
✓ Currently the council of ministers and house of people’s representatives of the Federal Democratic Republic of Ethiopia has approved the passing of legislation in the form of geothermal proclamation amendment, and this will have a big advantage to the exploitation of geothermal resources in the country.
✓ Recently, international financial institutions, bilateral donors and development agencies highly assist geothermal development projects in developing countries like Ethiopia.

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