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Clean Development Mechanism through Geothermal: Ethiopian Scenario

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ABSTRACT

Over 80 % of population in Ethiopia lives in rural area with a meager per capita electricity consumption of 23 kWh. Wood and agricultural waste is the main source of energy in the rural areas that generates black carbon to the tune of 625 Gg. This is detrimental to human health as well as glaciers over Asia and Eastern Africa. By developing available geothermal resources in the Rift Valley, Ethiopia can enhance its current electricity generation to 39 x 10^9 kWh thereby improving the country's GDP and per capita electricity consumption. Savings from carbon emissions will aid in infrastructure development of the country.

1. ENERGY DEMAND

Ethiopia is located within the East African rift system, which is very dynamic and active tectonic regime in the world. Ethiopia is one of the countries with the lowest per capita electricity consumption of 45 kWh with a population of 84 million (as on 2000, World Bank, 1996, 2001, 2010). The country's energy sources include biomass, hydropower, geothermal and oil. Since > 80 % of the population lives in rural areas, consumption of biomass as source of energy is very high. In fact the urban community heavily depends on the rural community for energy source, as the later supply wood from the forest to sustain the urban energy demand (Gebreegziabher et al., 2012). A small percentage of the population (~4.7%) has access to modern electricity (Chandrasekharam and Bundschuh, 2008).

Agriculture is the main source of income for the majority of the population. A survey on the household energy consumption pattern in Ethiopia conducted by the Addis Ababa University (Gamtessa, 2002) reports that even in Addis Ababa, the capital of Ethiopia, compared to other 8 important rural towns in Ethiopia (like Awassa, Dessie, Dire Dawa and Mekele) 59 % household use fire wood, kerosene and charcoal as their main energy source. This amounts 3 million people without electricity in Ethiopia. The electrification rate is about 4.7 % that is far below the world average (East Asia and China average is 86.9 %, South Asia 40.8 %, WEO, 2007). Currently 8000 Gwh electric power is being generated in the country; 97 % of electricity is supplied by hydropower, 0.6 % is by geothermal and the rest is from fossil fuels (Chandrasekharam and Bundschuh, 2008, EEPC, 2011). The low percentage of modern electricity usage in Ethiopia is due to the purchasing capacity by the rural population. Since the demand for modern electricity is low, generation of modern electricity is also low. This triggers a chain of other problems related to poor infrastructure development, high cost of materials being imported etc. (Kebede et al., 2002)

2. PROBLEMS IN THE CURRENT ENERGY SOURCES

Rural Ethiopians rely heavily on wood, agricultural waste, bagasse, dung and charcoal, in this order of priority, as primary energy sources for power as well as fuel for domestic chores (Wolde-Ghiorgis, 2002). The amount of electricity generated from these sources is minimal. However, these energy sources are capable of generating electricity as shown in table 1.

These sources have traditionally been in use for decades and this practice will continue due to non availability of cost effective, pollution free energy source and poor purchasing power of the rural population. These energy sources emit large amount of black carbon (BC) that is detrimental to human health as well as to the climate. The BC emission of wood, dung and agricultural waste is 1.1, 4.4 and 1.3 g/kg in that order (Streets et al., 2004, Baron et al., 2004, Ramanathan and Carmichael, 2008, Shekar Reddy, and Venkataraman, 2002). BC in the atmosphere while returning a third of the absorbed heat back in to space, keeps the earth's surface warm. Thus BC causes change in the heat input at the top of the atmosphere. According to the Intergovernmental Panel on Climate Change (IPCC) 2007 report, 'Radiative Forcing' (RF) of BC is of the order of + 0.34 W/m^2 while forcing of CO_2 is of the order of + 1.66 W/m^2.

The BC emitted in to the atmosphere is short-lived, unlike CO_2 and deposits along with snow over the Alps, Himalayas and Kilimanjaro, the regions where glaciers occur. The BC that settles over ice caps and deposits along with the snow absorbs more heat from the sun and enhances the melting process of the glaciers. BC content in ice cores recovered from ERG glacier is about 20 μg/kg while global average BC content in snow is about 5 μg/kg. 15 μg/kg of BC in snow reduces about 1% of its albedo resulting in enhanced melting of the glaciers (JingMing, et al., 2009) from the Sun and enhances the melting process of the glaciers.

Table 1: Energy source and electricity generation

Fuel	10^{12} kWh
Wood	155
Agricultural waste	16
Bagasse	1
Dung	17
Charcoal	2

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3. PRESENT OPTIONS: GEOTHERMAL

The East African Rift System is one of the active tectonic and magmatic rift systems in the world. This region exhibits ongoing continental break-up process associated with a large scale volcanism. The Ethiopian Rift, that forms a part of the East African Rift System, developed due to the formation of the triple junction i.e. Red Sea, Aden and Ethiopian Rift System. The initial Ethiopian Rift started at about 18 to 15 Ma, with the development of NE directional seafloor spreading (extension of the Gulf of Aden sea floor spreading) (Wolfenden et al., 2004). This tectono-magmatic activity resulted in geothermal manifestation at several areas along the rift floor. The most significant geothermal sites within the rift floor are Dallol, Tendaho (Dubti), Aluto Langano, Corbetti and Abaya (Fig. 1). The geothermal gradient of these sites varies from 150 to 250 °C.

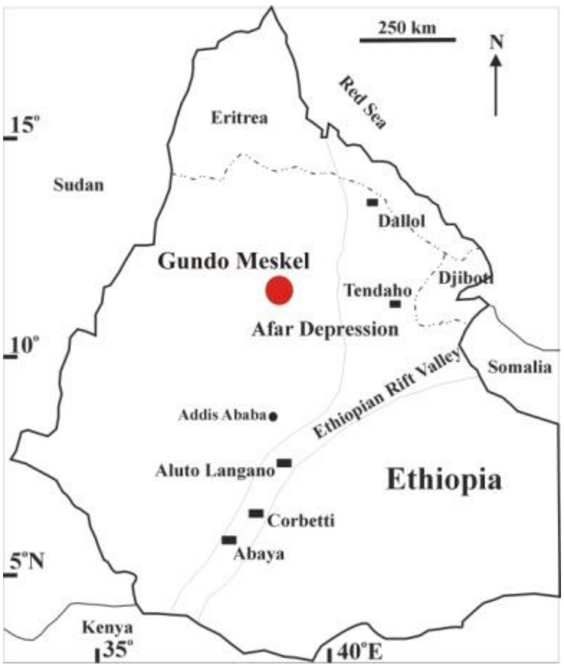

Figure 44: Map of Ethiopia showing the rift valley and geothermal sites.

The Aluto Langano geothermal field is currently generating 7.3 MWe. Similarly the Tendaho geothermal site has a generating capacity of 5 MWe and has the potential of generating 20 MWe (Chandrasekharam and Bundschuh, 2008, Teklemariam, and Kebede, 2010). It is estimated that these field will be developed by 2020 to generate 50 MWe. The total electricity generated from geothermal source currently amounts to 97 x 10^6 kWh. At present Ethiopia is generating 4 x 10^9 kWh from hydropower, 7 x 10^6 kWh from geothermal and the rest is generated from diesel and traditional sources like wood, bagasse etc, and the total electricity generated is about 5 x 10^9 kWh (Teklemariam, and Kebede, 2010). Due to uncertainties in monsoon and lack of sufficient water to fill the hydro power reservoirs, there is no guarantee that hydro power can meet the current electricity demand of Ethiopia. Since the potential geothermal energy is estimated at 5000 MWe (Teklemariam , 2011) there is fair chance that Ethiopia can completely replace hydropower by 2020, generating 39 x 10^9 kWh from all the geothermal sites within the rift valley.

4. CLEAN DEVELOPMENT MECHANISM

As shown in table 1, Ethiopia has exploitable wood and agricultural waste in the order of 1120 and 20 million tons respectively out which only 560 million tons of wood and 7 million tons of agricultural waste is currently being utilized (Wolde-Ghiorgis, 2002). These energy sources are mainly used for non-electrical purposes and a small percentage is being utilized for generation of electrical power even though these sources have large generation potential (Table 1). These two sources alone emit 616 Gg and 9 Gg of BC respectively. Thus the current BC emission from Ethiopia alone has increased several time from that reported for the year 1999 for Eastern Africa (242 Gg; Streets et al., 2004). Ethiopia has the potential to enhance its geothermal power production to 39 x 10^9 kWh by developing all its geothermal sites. By adopting this mitigation strategy both for BC and CO_2 reduction, the country can contribute in containing melting of the glaciers over the Himalayas as well as in Kilimanjaro. Electricity provided through local grids to all the villages will enhance the socio-economic status of the rural Ethiopia and help in improving the country's GDP and per-capita electricity consumption. Savings from carbon emissions can be utilized for the infrastructure development of the rural Ethiopia.

Those who belong to upper income group and afford to buy electricity generated through fossil fuels (diesel, petrol, kerosene) use this source of energy. But the ever escalating cost of imparted fuels has forced the rural elite to demand subsidy from the government. A case study in this regard was conducted on GundoMeskel town (Fig. 1) that has a population of 4000 and is located 200 km north of Addis Ababa and west of Tendaho Geothermal Site. Electricity is supplied to this town by EEPCO (Ethiopian Electricity Power Corporation) under rural electrification scheme, from fossil fuel based sources (Diesel, kerosene, gasoline and light fuel oil; Teferra, 2002). The population in this town was provided with electricity (provided through an NGO from a 220 KV diesel generator) from the above sources for three hours a day at the rate of 12 US cents/ kWh. The community could afford to buy the power when the diesel cost was 0.24 US$/L.

With an increase in diesel cost to 0.35 US$/L, the community could not buy electricity due to escalation of unit cost of power and requested for subsidy from the NGO that granted subsidy. There several such communities in Ethiopia who get electric power through such schemes

(Teferra, 2002). Several workers advocated energy policy changes to provide electricity to rural communities at affordable cost, but the easiest solution to solve such problem is to use the geothermal sources that is located at hand's distance and a local grid from the source can provide electricity at half the cost to several such rural communities in Ethiopia. The amount earned from carbon savings (about € 10/tCO_2, Chandrasekhar and Chandrasekharam, 2010) by generating 40 x 10^6 kWh from the Tendaho Geothermal Site can be utilized for the infrastructure development of towns like GundoMeskel. This will avoid several bureaucratic procedures involved in advocating energy policy shift, subsidies and make such rural towns energy independent and free them from the escalating cost of imported fossil fuels.

5. CONCLUSION

Ethiopia, located within the Afar rift domain is bestowed with large geothermal resources. Pilot power plants at couple of geothermal sites have proved the viability of electricity generated through such sources. Per-capita electricity consumption, GDP of rural population and socio-economic status of Ethiopians can be elevated by developing all the geothermal sites within the Rift Valley. A strong effort to implement CDM through such energy sources there by reducing the BC emissions and CO_2 emissions will benefit the population in terms of clean air and power. Even though several international organizations funded geothermal projects, it is not clear why this cost effective source is not developed yet. No doubt there will be pressure from the fossil fuel communities to hamper the clean growth mechanism through geothermal, the government and the scientific communities should prevail over such pressures and draft a clean energy policy for the development of this natural resources rich country.

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