DIRECT USE OF GEOTHERMAL ENERGY: MENENGAI DIRECT USE PILOT PROJECTS IN KENYA

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ABSTRACT

Direct application of geothermal energy has continuously gained popularity due to its economic, environmental and energy efficiency benefits. Its applications vary widely from agricultural applications, crop drying, space heating and industrial processes. While geothermal direct use application systems are expensive to install, the running costs are very low, hence making the technology viable and more reliable. Kenya looks forward to achieving its Vision 2030 in about a decade. This envisaged industrialization will demand clean, reliable, sufficient and affordable energy. Over the years, Kenya has utilized geothermal energy for electricity generation with little effort in direct applications. However, a few direct use applications exist with a health spa in Olkaria and Bogoria, crop dryers at Eburru, green house heating at Oserian and water harvesting both at Eburru and Suswa. Menengai is one of the Kenyan geothermal prospects. In 2015, a Direct Use Demonstration Project was launched and is being used to showcase modern direct applications of geothermal energy. In this paper we review some of the experiences of the Geothermal Development Company of Kenya in its efforts to tap and develop the geothermal resource in the country.

1. INTRODUCTION

Geothermal energy is heat derived from the earth. Kenya boasts of a great wealth in geothermal resources along its rift valley with a potential of over 10,000MW. The direct utilization of geothermal energy at the end of 2014 was 70,329MWt in a total of 82 countries, almost a 45% increase compared to the 2010 data in 72 countries. Among them Kenya's installed thermal capacity was 22.4 MWt (Lund, 2015). Worldwide, major applications of direct use include bathing and swimming (including balneology), space heating, green house and open heating, aquaculture pond and race heating, industrial process heating, snow melting and cooling and agricultural drying among others. This amounts to energy savings of about 52.5 million tonnes of equivalent oil annually preventing 46 million tonnes of carbon and 148 million tonnes of carbon dioxide that would have otherwise been released into the atmosphere (Lund, 2015). Direct application of geothermal energy can be summarized as shown in the Lindal diagram in Figure 1.

From the Lindal diagram, it is evident that it is possible to enhance the feasibility of geothermal projects with cascading and combined uses. The possible application depends on the resource temperatures, available flow rate, the chemistry of the geothermal fluid and the distance to the resource.

In Kenya, Olkaria geothermal field, managed by the Kenya Electricity Generating Company (KenGen) so far remains the most developed field, though Menengai geothermal field is also coming up. Recently, in 2015, the Geothermal Development Company (GDC) set up four direct uses pilot projects to showcase the applicability of direct use of geothermal energy in various sectors. The four projects include a milk pasteurizer, a heated green house, heated aquaculture ponds and a laundry unit. Cascading has been demonstrated by re-directing the water already used for milk pasteurization

and from the geothermal heated dryer to the fish ponds. Water exits at around 65°C and is therefore re-useable in the fish ponds since they require temperatures of about 29°C.

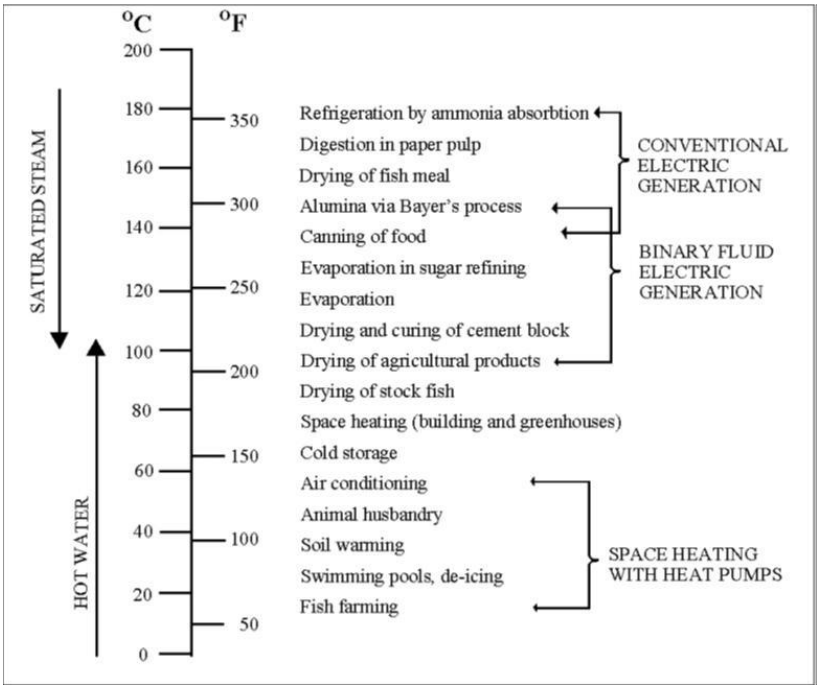

Figure 1: Lindal diagram with approximate temperature requirements of geothermal fluids for various applications (Armstead, 1983)

2. GDC'S DIRECT USE DEMONSTRATION UNITS

Geothermal Development Company has set up a Demonstration Unit in Menengai comprising of four projects; a mini greenhouse and aquaculture utilizing geothermal energy so as to maximize production and quality of the crops and fish, alongside a Containerized Laundry and Dairy Unit. The main purpose for these units is to showcase to the investors and educate local communities, schools and universities on how Geothermal energy can be used directly, how cascading of energy can be achieved and what actual economic and environmental benefits can be achieved. Currently, data is being collected from the units, after whose compilation actual results shall be produced, which shall be used as reference during the expansion of the projects and the setting up of an industrial heat Park around the geothermal prospects in future.

2.1 The Demonstration Unit's Geothermal heating Concept

A low pressure, low temperature geothermal well that produces a mixture of steam and hot brine is used as the source of energy. A water bath was constructed and a stainless steel heat exchanger used to heat cold water from an average temperature of 25°C to 85°C in a counter flow movement (Figure 2). This hot water can then be used in other parts of the project.

Figure 2: Water bath heat exchanger

2.2 The Demonstration Unit's Containerized Dairy

A milk processing unit (figure 3) with a 150 litre capacity to pasteurize milk at a time has been installed. It takes about four hours to pasteurize one batch; hence this plant can effectively be used to pasteurize bigger quantities of milk if the raw milk is available. Since this plant is located in an agriculturally rich environment, it can be utilized for milk processing for majority of the dairy farmers in the region. GDC is currently seeking the possibility of procuring milk from the local dairy co-operatives to ensure continuous processing of milk using this geothermal heated pasteuriser.

Figure 3: Inside the milk processing unit

2.3 The Demonstration Unit's Heated Aquatic Ponds

Geothermal heated water flows into two aquatic ponds (figure 4) to maintain a pond temperature of 29°C in a flow through water system. These ponds are housed in tunnels to keep predators away and to also conserve heat lost through evaporation. A single, small regenerative blower is used to aerate the ponds by pushing compressed air through diffuser tubing placed along the bottom of each fish pond. This temperature is optimal for metabolism of the tilapia species of fish, leading to enhanced growth Fish are fed using high quality fish food containing 36% crude protein by hand twice per day. The first batch of fish was harvested with an improved maturity period of six and a half months on average compared to the conventional eight month maturity age for the tilapia species of fish. The second batch has hence been introduced also.

Figure 4: Geothermal heated Aquatic Ponds.

2.4 The Demonstration Unit's Heated Greenhouse

Over the years, greenhouse heating has been the most common use of geothermal energy in agriculture around the world with the Oserian 50 hectare flower farm in Naivasha leading in Kenya and in the world. According to Mangi, 2013, the use of geothermal energy has proven the following benefits:

- Low cost energy through direct cost heating using the geothermal brine;
- Enrichment of carbon dioxide (CO_2) levels in the greenhouses
- Sterilisation of soils which is good for plant growth.

In many countries, geothermal heat is used to produce vegetables, fruits and flowers on a commercial scale all year round (FAO, 2015; Popovski and Vasilevska, 2003).

In Menengai, two crops; tomatoes (Figure 5) and capsicum have been grown on media in the greenhouse. Waste water from the fish ponds is filtered, additional nutrients added in fertigation tanks and fed to the crops through drip irrigation. During the night, early morning and wet seasons, geothermal heated water at a temperature range of 50°C - 55°C is circulated in galvanised pipes to raise the temperature and lower the relative humidity inside the green house. Temperatures are maintained at 28°C -30°C and relative humidity less than 85%. This in return ensures less fungal infections and consequently realization of a bigger produce with less use of agricultural chemicals.

Figure 5: Geothermal heated tomato Greenhouse.

2.5 The Demonstration Unit's Geothermal Operated Laundromat

A geothermal heated laundry unit that consists of a washing machines and adryer has been installed (Figure 6). Geothermal heated water is directed to the washers and mixed with cold water to temperatures dependent on the type of clothes to be washed, while the dryer has a specially designed fan coil unit that uses hot water to dry the clothes.

Figure 6: Geothermal Heated Laundromat.

3. DISCUSSION

The project has had both successes and challenges. Demonstrations to investors, students, farmers and other groups in the Menengai Direct Use projects have been successful in proving that geothermal energy can be directly used in Menengai and other areas, and that direct use of geothermal energy enhances metabolism of fish and growth of crops. It can also be used to carry out processes that require the use of hot water like laundry and milk pasteurization, among other projects. Some of the challenges include the need to have not only geothermal experts in the direct use projects but also other professionals, who would include agricultural, milk processing officers and persons with knowledge on fish farming. These experts would provide the much needed advice so as to enhance yields.

Data collection is on-going for the projects. Data collected includes:

- Tonnage of brine used to run the projects
- The aquatic pond temperatures
- Amount of water used in the fish ponds
- Temperature and humidity inside the greenhouse

- Weight of crops harvested from the green house
- Weight of fish crops harvested from the aquatic ponds
- Amount of food fed to the fish crop nutrients added

Analysis of this data will form a base reference during expansion and setting up of industries in the industrial park.

4. CONCLUSIONS

One of Geothermal Development Company (GDC)'s mandates is to promote alternative uses of geothermal resources in Kenya. The direct use pilot projects in Menengai have indicated that geothermal energy can be used directly in processes that require heat. Further, heating of aquaculture ponds enhances maturity of fish and enhances growth of crops in a heated greenhouse alongside revenue generation. As a result, GDC is planning to expand the existing projects in order to increase on the revenue generated from the existing projects. GDC also intends to collaborate with private investors in constructing an industrial park near the Menengai geothermal field where industries will be built. Thermal energy will then be availed to the industries, either directly from dedicated wells or from separated brine from the power plants. In this way, the industries will experience great savings from the cost of heating using electricity which will be replaced with the hot brine. Heat exchangers will be used to heat fresh water due to the chemical composition of brine. This will also contribute greatly in reduction of global warming resulting from carbon dioxide that would otherwise be released to the atmosphere.

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