



## **GEOHERMAL DIRECT USE APPLICATION: A CASE OF GEOHERMAL SPA AND DEMONSTRATION CENTRE AT OLKARIA GEOHERMAL PROJECT, KENYA**

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### **ABSTRACT**

Geothermal energy is used in electricity generation and other direct uses like greenhouse heating, carbon dioxide enrichment in greenhouses, hot bathing, sauna or steam bathing, space heating and space cooling, fruits or crops drying, and skin healing. In Kenya direct use application of geothermal energy has been applied to in flower farms for heating green houses and carbon dioxide enrichment. A huge potential market exists for direct use applications especially among homes, hotels, and flower farms. Over the years, the Company has used geothermal resources mainly for electricity generation. KenGen can tap into this market and sell hot water and steam (for space cooling and heating) to potential customers and generate revenue. There is need to market direct use applications of geothermal energy in Kenya and in the region. To this end, KenGen has constructed a Geothermal Health Spa and Demonstration Centre, the only one of its kind in Africa, to market and promote geothermal direct uses, The Centre is located in the Greater Olkaria Geothermal Area (GOGA) which is within the Hell's Gate National Park. It consists of a blue lagoon, sauna, spa, geothermal museum and a conference facility. The museum will host artefacts, models, posters, and brochures to showcase the history of geothermal development in the country and other current developments in the technology worldwide. The Centre is expected to attract both domestic and foreign tourists because of its unique nature and more so because of the benefits that will be derived from patronizing the steam bath, sauna, and the hot swimming pools or blue lagoons. There is sufficient evidence that the brine with its sulphur and silica content has balneological (healing and smoothening effects on the skin). In addition, as a result of the centre being established, the Hell's Gate National Park will be branded as the only park with a geothermal spa in the world. This will in effect promote Hell's Gate National Park the world over and thus the number of tourists visiting the park is anticipated to increase spontaneously. This paper discusses the benefits of direct use of geothermal energy and how its application in KenGen's Geothermal Spa and Demonstration Centre may generate interest in direct uses of geothermal energy in the region.

## 1. INTRODUCTION

Geothermal energy is used in electricity generation and other direct uses like greenhouse heating, carbon dioxide enrichment in greenhouses, hot bathing, sauna or steam bathing, space heating and space cooling, fruits or crops drying, and skin healing.

## 2. DIRECT USES OF GEOTHERMAL ENERGY

Kenya is naturally endowed with enormous potential of geothermal energy that is a clean indigenous environmentally benign source of renewable energy used for electric and non-electric uses. Duffield and Sass (2003) attest that geothermal resources were limited to non-electrical applications before the development of high-temperature drilling and well completion technology. The non-electric uses of geothermal energy are also known as direct uses. Non-electric uses of geothermal resources exploit geothermal waters of temperatures ranging from 38 °C to over 1490C loaded directly from the earth.

By the year 2000, global statistics on non-electric uses of geothermal energy showed Kenya has a capacity of 1.3 MWt with a capacity factor of 0.25. The annual heat produced then was 10 TJ/yr with 3 GWh/yr of utilization mainly from well OW-101 in the Olkaria field leased to Oserian Development Company Ltd (ODC) by the Kenya Electricity Generating Company Ltd (KenGen). Lagat (2003) has documented non-electric uses of hot water from well OW-101 at Olkaria Central field in green house heating, soil fumigation and addition of carbon dioxide to green houseplants at ODC. Steam from the well is used to heat fresh water through heat exchangers and the water is then circulated to heat the greenhouses. At the Lake Bogoria resort hotel water from a natural hot spring is used in the swimming pool. Duffield and Sass (2003) cite lack of awareness of the direct uses of geothermal energy as the greatest impediment to the growth of enterprises in geothermal utilization. They further argue that extensive capital ventures in development of the warm water systems, most commonly found in volcanic areas but also in a few non-volcanic areas, would significantly improve the energy balance of the nation.

Direct uses of geothermal energy have been applied in the world where geothermal resources exist. The direct uses take the form of rudimentary traditional systems where communities living in the area have used geothermal energy for various uses like bathing, drying of crops, condensation of the steam to harvest portable water and boiling of eggs, to complex systems like district heating, greenhouse heating and refrigeration. In Kenya, traditional systems are evidenced at Eburru where the local community has been tapping the steam and condensing it for domestic uses and running hot pipes through pyrethrum driers. In Iceland, the “blue lagoon” located at Svartsengi power plant in Grindavik is an international tourist attraction facility where visitors and tourists patronage the sauna and hot water bathing. Gunnlaugsson et al (2001) mention that in Iceland, use of geothermal energy gained further momentum in the twentieth century when it was used to heat greenhouses and homes. 63% of geothermal energy is used for space heating but a significant 4% is used in swimming pools. (Lundi, and Freeston, 2000) indicate that 55 countries reported direct uses of geothermal energy in 2000 compared to 28 in 1995 and 24 in 1985. They add that worldwide use of geothermal energy for bathing stood at 22.15 in 2000.

In Kenya direct use application of geothermal energy has been applied to a small extent in flower farms for heating green houses and carbon dioxide enrichment. A huge potential market exists for direct use applications especially among homes, hotels, and flower farms. Over the years, KenGen has used geothermal resources mainly for electricity generation. The Company can tap into this market and sell hot water and steam (for space cooling and heating) to potential customers and generate a lot of revenue. There is need to market direct use applications of geothermal energy in Kenya and in the region. To this end, KenGen is constructing a Geothermal Health Spa and Demonstration Centre to market and promote geothermal direct uses, the only one of its kind in Africa.

The Centre is located in the Greater Olkaria Geothermal Area (GOGA) which is within the Hell's Gate National Park. It consists of a blue lagoon, sauna, spa, geothermal museum and a conference facility. The museum will host artefacts, models, posters, and brochures to showcase the history of geothermal development in the country and other current developments in technology worldwide. By developing the Geothermal Spa and Demonstration Centre, KenGen will earn revenue through fees paid by visitors to the centre. The Centre will attract both domestic and foreign tourists because of its unique nature and more so because of the benefits that will be derived from patronizing the steam bath, sauna, and the hot swimming pools or blue lagoons. There is sufficient evidence that the brine with its sulphur and silica content has balneological (healing and smoothening effects on the skin. In addition, as a result of the centre being established, the Hell's Gate National Park will be branded as the only park with a geothermal direct use centre in the world. This will in effect promote Hell's Gate National Park the world over and thus the number of tourists visiting the park is anticipated to increase spontaneously.

### 3. LOCATION

The Olkaria Geothermal field is located in the Rift Valley about 120 km from Nairobi and within the Hell's Gate National Park (Figure 1). The Geothermal Spa and Demonstration Centre occupies an area of about 4.5 Ha and is located in the Greater Olkaria Geothermal Area where the Kenya Electricity Generating Company Limited (KenGen) operates four large geothermal power stations, Olkaria I (45 MW), Olkaria II (105 mw, Olk I AU 4 & 5 (140 MW), Olkaria IV (140 MW) and wellheads units.

### 4. USE OF GEOTHERMAL ENERGY

#### 4.1 Geothermal Use in Kenya

To date, geothermal resources in Kenya have mainly been used for indirect uses, i.e., like generation of electricity with little application in direct uses. Figure 2 and 3 shows KenGen's Olkaria I and Olkaria II power plants respectively.

Most wells in Olkaria produce 75% water and 25% steam. The separated hot water from the wells is used partly in the geothermal Geothermal Spa and Demonstration Centre for sauna and Spa.

#### 4.2 Greenhouse heating

Green house applications use hot water from geothermal wells found in the relatively rural location, where most geothermal resources are located. Such locations offer advantages that include clean air, few diseases, clean water, a stable workforce, and often, low taxes. Savings of about 80% of fuel costs and 5% to 8% of total operating costs are realized when geothermal resources

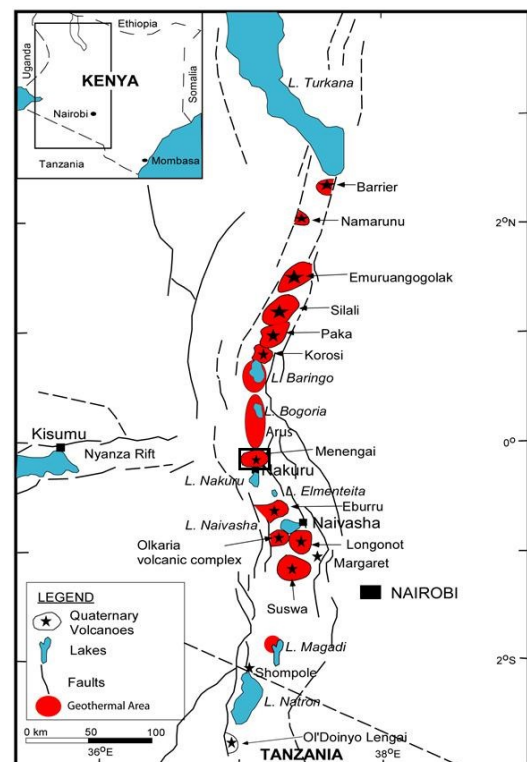


FIGURE 1: Location of Olkaria Geothermal field



FIGURE 2: Olkaria I (45 MW)

are compared to traditional energy sources (Duffield and Sass, 2003). Figure 4 shows greenhouse heating by geothermal hot water through the white pipes at Oserian Development Company's greenhouses.



FIGURE 3: Olkaria II Power Station (105 MW)



FIGURE 4: Greenhouse heating at Oserian Development Company, Naivasha, Kenya

The company has championed greenhouse heating. They have realized the benefits of low cost energy enrichment of carbon dioxide (CO<sub>2</sub>) levels in the greenhouses and sterilisation of soils which is good for plant growth. More use of geothermal energy for greenhouse heating is evident in Mauritius.

## 5. AGRO- INDUSTRIAL APPLICATIONS

Agricultural - Industrial applications like Timber drying, food dehydration, laundries, spas, milk pasteurizing can be done using heat from geothermal energy. The hot steam can be used to sterilize equipment and rooms without using drugs or chemicals. Geothermal energy can find use drying plants, making powders and concentrates that are used in food processing. At times, these substances can be used to add flavours or preserve foods without any unnatural additives. The food processing industry



in Naivasha and in the other areas where geothermal energy abundantly exists can use geothermal steam to sterilize foods at an affordable cost. At Eburru, the local community uses geothermal heat to dry pyrethrum. With proper harnessing of the geothermal steam, the local community can greatly benefit from the drying of other plants like tobacco and maize. Figure 5 shows pyrethrum drying at using geothermal steam at Eburru.



FIGURE 5: Geothermal energy being used by the local community at Eburru for pyrethrum drying  
Water harvesting

In water deficit areas where we have occurrences of fumaroles and hot grounds some communities harvest water from geothermal steam. This water is used for irrigation, watering of animals and for domestic use like drinking water, washing clothes, cleaning of floors and general cleanliness. If the chemistry of the water from the steam is suitable and within the range of drinking water and cooking. The local community within the geothermal areas, e.g., at Eburru and Suswa harvests this water and puts it to various uses. At Olkaria, water from the steam is being harvested for use by the wild animals within the Hell's Gate National Park. Figure 6 shows water being harvested from fumaroles at Suswa.



FIGURE 6: Water harvesting by local a community at Suswa

### 5.1 Balneological and antibacterial uses

Balneology is a medical practice of soothing aching muscles practiced in hot springs and health spas. The hot water from geothermal power stations is similar in chemistry to what is obtained from hot springs. It can therefore be used in treatment of skin diseases as well as aching muscles. This would offer semi medical treatment facilities for skin diseases. Health spas are good for recreation. In Iceland, for example, the Blue Lagoon at Svartsengi power plant is one of the most visited attractions in Iceland. The steamy waters are part of a lava formation, just like the geothermal waters at Olkaria. Drawing from the example of the Blue Lagoon at Svartsengi, many visitors and tourists are expected to visit the Geothermal Spa and Demonstration Centre for hot bathing, sauna, and swimming.

Lake Bogoria hotel located close to Marigat in the north rift has a spa pool which is good to take a dip in. Many locations in Kenya have potential for direct use application, e.g., Olkaria, Eburru, Homa hills, Nakuru Banita area, Lake Magadi, Kureshwa, Lake Bogoria, and Lake Baringo. Figure 7 shows the spa pool at Lake Bogoria Resort.



FIGURE 7: Spa pool at Lake Bogoria Hotel

### 5.2 District and Space Heating and cooling

District and space heating is the dominant use of low-temperature geothermal resources in countries like Iceland where temperatures are low most of the time. Hydrothermal water is distributed from one or more geothermal wells through a series of pipes to several individual houses and buildings, or blocks of buildings in district systems. During hot weather, geothermal energy can be used to cool rooms and space by heating a refrigeration fluid that vaporizes to cool the rooms or space.

In Reno Nevada, USA, district heating is practiced in the south of the area. Industrial processes continue to grow and industrial geothermal heat pumps are an emerging market. A 1996 survey found that these applications were using nearly 5.8 billion megajoules of geothermal energy each year. Its energy equivalent is nearly 1.6 million barrels of oil. It has been estimated that geothermal district heating systems can save consumers 30 to 50% of the cost of natural gas heating (US Department of Energy, 2010).

## **6. THE KENGEN'S GEOTHERMAL SPA AND DEMONSTRATION CENTRE**

### **6.1 Project Components**

The Geothermal Health Spa and Demonstration Centre consists of four interconnected “blue lagoons”, a reception area, a lobby and a parking area for about 50 vehicles, six changing rooms, an exhibition hall, a sauna, steam bath, a cafeteria and kitchen, a store, all constructed on a 45.000 m<sup>2</sup> piece of land on the west of Olkaria II power plant. The first, second and third lagoons have diameters of 30 m, 40 m and 70 metres respectively. The fourth lagoon, the children’s pond has a diameter of 10 metres. The first and second lagoons have a maximum depth of 1.5 m while the third and largest lagoon has a deeper end of 1.5 m and shallow end of 1m depth. Temperatures in the largest lagoon designated for public use is between 35 and 3°C. The centre utilizes part of the brine from a hot reinjection brine pipe to establish the blue lagoons, sauna and a spa.

#### **6.1.1 Source of Brine**

Brine is tapped from the main reinjection line to wells OW-R2/OW-708. To tap the brine, a tee off on the brine line was prepared and an isolation valve installed. This will ensure that connection of the Geothermal Spa and Demonstration Centre brine feeding system will be undertaken without necessitating a plant shut down. Temperature sensing devices with alarms will be installed along the brine line.

The brine to the centre flows by gravity because the centre is at a lower elevation than the source of the brine. The end of the pipe where the brine exits is fitted with a silencer to muffle the noise because the brine is flowing at pressure. The brine thus bubbles out in scenic style that forms part of the attraction to the centre. As the brine steams and bubbles out, the noise is muffled and temperatures also drastically reduced to almost 90°C.

#### **6.1.2 Lagoon layout**

The brine is flashed into the first lagoon through a pipe. The hot water pipe to the Geothermal Spa and Demonstration Centre has two valves for safety reasons. These valves are also used to control the flow of the brine. Tests have already been carried out on this. The brine flows into the first lagoon at about 90°C. When the first pond fills up, the brine overflows into the second lagoon at about 81°C. The brine in the second lagoon, which is slightly bigger, cools to about 66°C before exiting into the third and largest lagoon at about 30°C and 35°C. The flow rate is regulated so as to achieve desirable temperatures in each of the lagoons.

#### **6.1.3 Sauna**

Hot naked pipes carrying brine at 150°C will run in a room designated as the sauna. The heat radiated from the hot pipes will heat the room. Patrons will thus enjoy this overheat.

#### **6.1.4 Steam bath**

A heat exchanger will constitute the system that generates the steam for the steambath. The brine will run through the heat exchanger that will vaporize steam (from fresh water circulating in the ducts inside the heat exchanger) into the steam room.

#### **6.1.5 Reinjection system**

The water from the third and largest lagoon is reinjected into the subsurface at well OW-R1 by gravity through a Victaulic pipe, running on the surface. Figure 8 is a schematic diagram of the flow system for the Geothermal Spa and Demonstration Centre

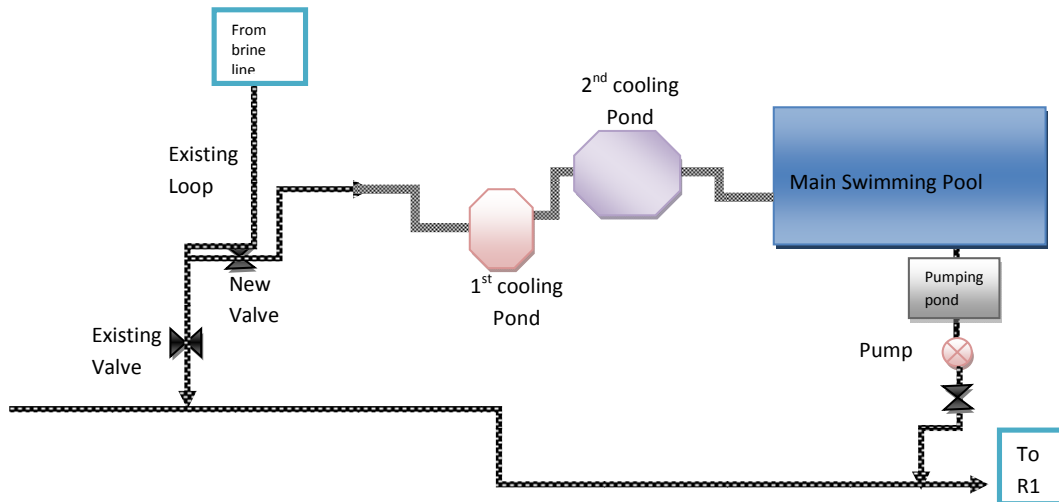


FIGURE 8: Schematic Diagram of the Flow System

## 6.2 Why centre was established

### 6.2.1 Tourist attraction

The centre acts as a tourist attraction as more tourists and visitors are expected to patronize the Centre and Hell's Gate National Park. No such a centre exists in Africa. The Geothermal Spa and Demonstration Centre will brand the Hell's Gate National Park as the only national park in Africa where hot bathing for balneological effects can be obtained. This is thus expected to raise revenue to the Kenya Wildlife Service as more tourists come to see and also make use of the sauna and blue lagoons. In addition to the tourists, the number of students and Kenyans visiting the Park is expected to double. In Iceland, for example, the Blue Lagoon is one of the most visited attractions in Iceland (Newsweek, 2008).

### 6.2.2 Branding of the Hell's Gate National Park

Branding of the Hell's Gate National Park as the only National Park in the World that hosts a Geothermal Spa and Demonstration Centre is expected to increase the number of tourists visiting the park and power plants resulting in additional revenue to KWS and new income to KenGen.

### 6.2.3 Geothermal spa

A spa using geothermal waters (a hot spring) is currently operating at Lake Baringo hotel. The Spa at Olkaria will showcase direct use application that can be adopted by hotels nearby for their guests. This will improve attractions to their hotels and improve business performance. Individuals may also install spas in their homes for life enrichment.

### 6.2.4 Hot water heating in hotels and other entertainment joints for guests

Most of the hotels within the vicinity of Olkaria Geothermal Project use electricity to heat rooms and provide warm water for bathing at high power costs. Use of hot water from the wells would reduce electricity costs because the cost of the hot water is far much less. This will be demonstrated at the centre.



### **6.2.5 Greenhouse heating**

Oserian Development Company in 2003 installed a green house heating system providing energy which amounts to 79.1TJ/yr from a well leased from KenGen. In addition to the heat from the geothermal water, carbon dioxide from separated steam is also used to provide carbon dioxide and hydrogen sulphide to improve the productivity of flowers.

Part of the direct use showcasing include establishment of a greenhouse prototype at the Geothermal Spa and Demonstration Centre. It is expected that more flower farms neighbouring Olkaria will start using geothermal water to heat their green houses. KenGen will sell separated hot water to these farms at a cost to be determined.

### **6.2.6 Steam bath**

Steam bathing is believed to heal certain skin infections and rashes, soften skin and reduce aging. Visitors will use steam bath from the hot brine that will be vented into the steam bath enclosure. In addition, this showcasing will market the use of hot brine among homes and hotels. This is expected to reduce dependence on electricity to heat water and thus reduce electricity costs. This saving in electricity will avail electricity to other industrial concerns that are located far from geothermal sources.

### **6.2.7 Sauna**

The sauna that will be established will use brine running in naked pipes at 150°C. The heat from the naked pipes will raise temperature in the room which will then serve as the sauna. Patrons will use the sauna to heat their bodies which in turn is believed to soften skin, reduce cholesterol and waste and thus reduce ageing.

### **6.2.8 Cooling**

Hot water can be used to heat a cooling agent which can then be used for space cooling when temperatures are high.

### **6.2.9 Antibacterial and balneological effects**

It is believed that due to the chemical content of the hot brine, the brine contains antibacterial chemicals that heal skin diseases and rashes. Many people will visit to bath in the blue lagoon so as to treat or keep their skins healthy. For example, in Iceland, the warm waters, just like at Olkaria Geothermal Project, contain minerals like silica and sulphur and bathing in the Blue Lagoon is reputed to help some people suffering from skin diseases such as psoriasis (Iceland's Energy lessons, 2008). The water temperature in the bathing and swimming area of the lagoon averages 40°C.

### **6.2.10 Posterity**

The Geothermal Spa and Demonstration Centre will also have a geological and geothermal museum and a conference facility. The museum will host pictorial elements to show the history of geothermal development in the country and other current developments in technology in the industry worldwide. The Geothermal Spa and Demonstration Centre will thus act as a marketing centre for direct uses of geothermal energy in the region. Similar ventures can be replicated where geothermal resources exist.

### **6.2.11 Planned projects at the Spa**

Plans are underway to implement a number of projects to compliment the direct use applications. Some of these projects include the following:

- i. A conference facility that can accommodate 200 people with partitions to allow for hosting of different groups at the same time
- ii. Construction of cottages to offer 40 single standard accommodation rooms (Figure 9)
- iii. Water condensing units (Figure 10-11)
- iv. Ski Lift (Figure 12)

Steam condensing units have been fabricated and installed both at Olkaria and Eburru (Figure 10-11). The water from this condensation is used for domestic purpose. Within the Olkaria Geothermal fields, a condensing unit was installed at the Hell's gate and condenses steam for wild animals.

Ski lifts will be installed to lift patrons from the Spa to the hill just overlying the Spa area. The ski lifts will be enhanced to cover a large area where revellers will be moved from one part of the project to the other. This project will be a complimentary to the Spa facility.



FIGURE 9: A sample cottage



FIGURE 10: Steam condensing unit at the Olkaria Hell's Gate



FIGURE 11: Fabrication of steam condensing unit for installation at Eburru



FIGURE 12: A ski lift installed to enable patrons to cover a large area

## 7. CONCLUSIONS & RECOMMENDATIONS

KenGen is the premier organization in harnessing of geothermal energy and therefore it has a social and corporate responsibility to promote geothermal energy in the region, for posterity.

The Geothermal Spa and Demonstration Centre will showcase direct uses of geothermal energy. In addition to promotion of geothermal energy as a renewable and cost saving source of energy, the centre will be a major attraction to both tourists and visitors to the Park. This will increase revenue to the Kenya Wildlife Service. The positive impacts that will be realized from the proposed development far outweigh the adverse impacts which can be mitigated. To mitigate this environmental impact arising from the development of the Geothermal Spa and Demonstration Centre, an Environmental scoping study was carried out. It is recommended that for any future development in new areas, the Company undertakes to establish Geothermal Spa and Demonstration Centres. This will not only optimize utilization of the geothermal resources but will also enhance a good working relationship between the Company and immediate stakeholders.

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