



## **DIRECT UTILISATION IN KENYA: A CASE OF A GEOTHERMAL SPA AND DEMONSTRATION CENTRE AT OLKARIA**

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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 cooling, fruits or crops drying, and skin healing. Direct Uses of geothermal energy has been applied to a small extent in flower farms for heating green houses and carbon dioxide enrichment. Over the years, the Kenya Electricity Generating Company Ltd has utilised geothermal resources mainly for electricity generation. 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 three cascading blue lagoons, sauna and massage, steambath, restaurant, reception, Manager's office, geothermal museum and changing rooms. The museum will host artifacts, models, posters, and brochures to showcase the history of geothermal development in the country and other current developments in the technology worldwide Additional facilities that will be added include conference facility that can hold 200 people, cottages and ski lifts. After completion, 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, massage, 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 health 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 direct uses of geothermal energy, the establishment of the geothermal health spa and Demonstration Centre, challenges and gives recommendations.

### **1. INTRODUCTION**

Geothermal energy is used in electricity generation and other direct uses like greenhouse heating, carbon dioxide enrichment in greenhouses, hot bathing, sauna and massage, 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<sup>0</sup> C to over 149<sup>0</sup>C coming 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. At the Lake Bogoria resort, 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, mentions 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, 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.

The Kenya Electricity Generating Company Ltd has identified and is implementing direct use applications of geothermal energy through constructing a Geothermal Health Spa and Demonstration Centre. Additional facilities as part of the Geothermal Health Spa and Demonstration Centre include conference facility, cottages, Fish farms and vegetable farms.

The Centre is located in the Greater Olkaria Geothermal Area (GOGA) which is within the Hell's Gate National Park. It consists of three cascading blue lagoons, sauna and massage parlour, geothermal museum, restaurant, reception, changing rooms, steambath 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. After completion, 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 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.

**3. LOCATION**

The Olkaria Geothermal field is located in the Rift Valley about 120km from Nairobi and within the Hell’s Gate National Park (Figure 1). The proposed Geothermal Health Spa and Demonstration Centre will occupy an area of about 4.5 Ha and will be located in the Greater Olkaria Geothermal Area where the Kenya Electricity Generating Company Limited (KenGen) operates two geothermal power stations, Olkaria I and Olkaria II, generating 45 MWe and 105 MWe respectively.

**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, 3, 4 and 5 show KenGen’s geothermal power plants.

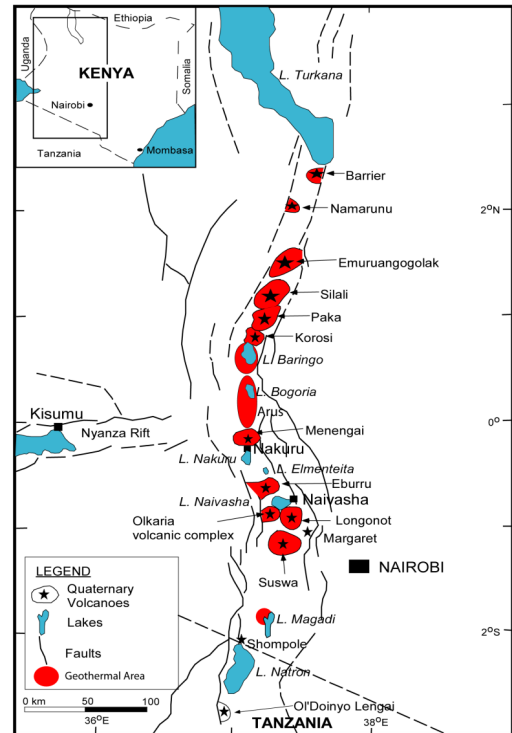


FIGURE 1: Location of Olkaria Geothermal field



FIGURE 2: Olkaria I power station (45 MW)



FIGURE 3: Olkaria II power station (105 MW)



FIGURE 4: Eburru wellhead plant (2.5 MW)



FIGURE 5: Olkaria wellhead plant (5 MW)

Most wells in Olkaria produce 75% water and 25% steam. The separated hot water from the wells is used at the Geothermal Health Spa and Demonstration Centre for sauna and massage, Spa and steambath.

#### 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, fewer 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 are compared to traditional energy sources (Duffield and Sass, 2003). Figure 6 shows greenhouse heating



FIGURE 6: Green house heating at Oserian Development Company, Naivasha, Kenya

by geothermal hot water through the white pipes at Oserian Development Company's greenhouses.

Oserian Development Company has championed greenhouse heating in Kenya. They have realized the benefits of low cost energy through direct cost heating using the geothermal brine; 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 and cereals 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. KenGen has designed a water harvesting and a drying unit on a commercial scale that is meant to benefit the community at Eburru. Figure 7 shows pyrethrum drying at using geothermal steam at Eburru.



FIGURE 7: Geothermal energy being used by the local community at Eburru for pyrethrum drying

### 5.1 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, washing clothes, cleaning of floors and general cleanliness. At Olkaria, water from the steam is being harvested for use by the wild animals within the Hell's Gate National Park. Figure 8 shows water being harvested from fumaroles at Suswa.



FIGURE 8: Water harvesting by local a community at Suswa

## 5.2 Balneological and antibacterial uses

Balneology is a medical practice of soothing aching muscles practiced in hot springs and health spas. Health spas are good for recreation and for provision of health treatment. 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. Since the construction of the blue lagoons at Olkaria, many tourists now visit the park to enjoy the therapeutic brine waters



FIGURE 9: Panoramic view of the Geothermal Health Spa at Olkaria, KenGen, Kenya



FIGURE 10: Spa pool at Lake Bogoria Resort

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 10 shows the Lake Bogoria resort spa.

### 5.3 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 GEOTHERMAL HEALTH SPA AND DEMONSTRATION CENTRE

### 6.1 Conceptual Design of the Geothermal Health Spa and Demonstration Centre

#### 6.1.1 The Centre 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 20 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 30°C. The centre utilizes part of the brine from a hot reinjection brine pipe to establish the blue lagoons, sauna and a spa.



FIGURE 11: Swimming at the Olkaria Geothermal Health Spa at KenGen, Olkaria

### 6.1.2 Source of Brine

Brine is tapped from the main reinjection line to well OW-708. To tap the brine, a tee off on the brine line was prepared and an isolation valve installed.

At full flow, the three blue lagoons, assuming that they were empty at the start fills up in 23 hours. The brine flows at 300 tons/hr. on full flow rate.

### 6.1.3 Lagoon layout

The brine is flashed into the first lagoon through a pipe designed and constructed to collect the brine as it bubbles out. A silencer was designed that muffles the noise during the flashing out of the brine. The hot water pipe to the Geothermal Health Spa and Demonstration Centre has two valves for safety reasons. These valves are also used to control the flow of the brine. The brine flows into the first lagoon at about 91°C. When the first pond fills up, the brine overflows into the second lagoon at about 85°C. The brine in the second lagoon, which is slightly bigger, cools to about 84°C before exiting into the third and largest lagoon at about 69°C. The outlet temperature in the third and largest lagoon is 46°C. The valves on the pipe bringing brine from the reinjection lines are used to control the flow of the brine and therefore the temperatures. With this management, the inlet temperature at the third and largest lagoon is 35°C and outlet temperature is 30°C.

TABLE 1: Inlet and outlet temperatures (at full flow rate)

Pond	Inlet Temp., °C	Outlet Temp., °C
1	91	85
2	84	69
3	66	46

#### 6.1.4 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. The design of the sauna is complete and construction has started.

#### 6.1.5 Steam bath

A steam bath is now being installed in the Geothermal Health Spa and Demonstration Centre. The brine will run through a heat exchanger that will vaporize steam into the steam room.

#### 6.1.6 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 12 is a schematic diagram of the flow system for the Geothermal Health Spa and Demonstration Centre.

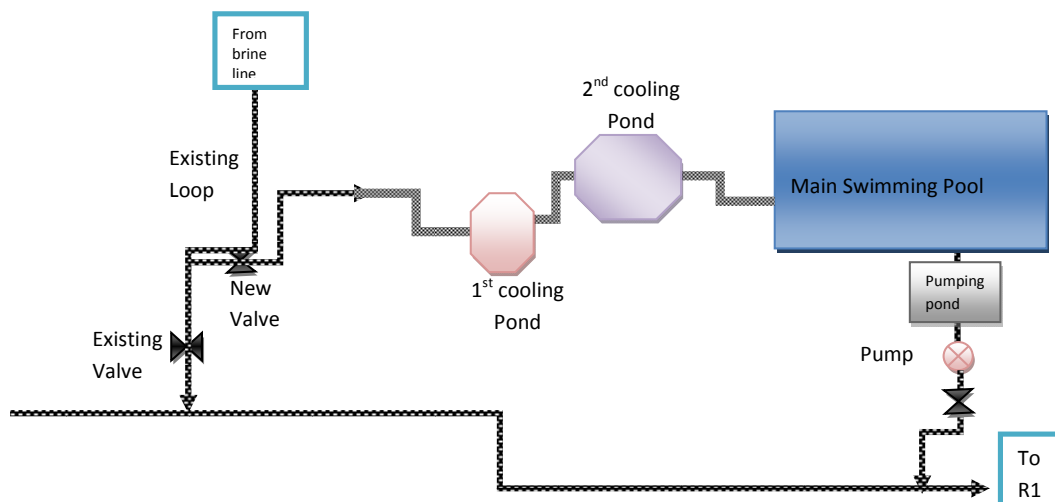


FIGURE 12: Schematic Diagram of the Flow System

## 6.2 Why centre was established

### 6.2.1 Tourist attraction

No such a centre exists in Africa. The centre acts as a tourist attraction as more tourists and visitors are now patronizing the Centre. The Geothermal Health Spa and Demonstration Centre has branded 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 lagoon. In addition to the tourists, the number of students and Kenyans visiting the Park has now increased. In Iceland, for example, the Blue Lagoon is one of the most visited attractions in Iceland, Newsweek (2008).

### **6.2.2 Geothermal spa**

A spa using geothermal waters (a hot spring) is currently operating at Lake Baringo hotel. Hotels within the vicinity of Olkaria may also adopt this concept and establish similar spas. The Company can assist these establishment to establishment similar facilities. This will improve attractions to their hotels and improve business performance. Individuals may also install spas in their homes for life enrichment.

### **6.2.3 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.

### **6.2.4 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.

We will establish a prototype greenhouse at the Geothermal Health Spa and Demonstration Centre that will showcase the use of geothermal energy in greenhouses. 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 for consideration by the company

### **6.2.5 Steam bath**

Steam bathing is believed to 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.

### **6.2.6 Sauna**

The sauna that will be established will use brine running in naked pipes at 1500C. 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 levels, remove toxins and waste and thus reduce ageing.

### **6.2.7 Cooling**

Hot water can be used to heat a cooling agent which can then be used for space cooling when temperatures are high. Designing of a functioning system, akin to the refrigeration system is now underway.

### **6.2.8 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 like psoriasis. The brine contains sulphur either as a residue or as a compound in hydrogen sulphide gas or diluted sulphuric acid. The sulphur is otherwise referred to as the body's beautifying mineral. It is available in Keratin- chemical component of the body that keeps hair, skin, fingernails, skin, strong and healthy. It also enhances production of collagen that enhances skin elasticity. Sulphur also enhances cellular respiration and therefore promotes efficient utilization of oxygen in the body (Wikianswers; Newsweek, 2008).

### **6.2.9 Posterity**

The Geothermal Health Spa and Demonstration Centre has geothermal museum and a conference facility. The museum will host murals, artefacts and models to show the history of geothermal development in the country and other current developments in technology in the industry worldwide. The Geothermal Health Spa and Demonstration Centre will thus act as a marketing centre for direct uses of geothermal energy in the region. Similar ventures will be replicated where geothermal resources exist.

### **6.2.10 Employment creation**

The establishment of the centre will create employment to the citizens of the country. People will be employed to manage the centre and with additional facilities like cottages being included, more staff will be required. The cereals or crops drying facility will also employ several people. With the concept of fish farming and irrigation being adopted by farms/ firms in the vicinity, this will create additional employment to the population.

## **7. ADDITIONAL FACILITIES**

Additional facilities are planned as part of the centre. These include ski lifts that will carry patrons from the centre up to the view point (Figure 13).

Other facilities planned for development include cottages. We will also establish prototype fish farms, green houses, and irrigation farms to showcase direct uses of geothermal energy (Figures 14-16).

## **8. 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 Health 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 has already become a major attraction to both tourists and visitors to the Park. This has increased revenue to the Kenya Wildlife Service. KenGen will establish such centres in all new geothermal fields. This will not only optimize utilization of the geothermal resources but will also enhance a good working relationship between the Company and immediate stakeholders.



FIGURE 13: Example of ski lift



FIGURE 14: Sample cottage



FIGURE 15: Fish farm



FIGURE 16: Vegetable farm

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