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GEOTHERMAL DEVELOPMENT IN PROTECTED AREAS: KENYAN EXPERIENCE

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ABSTRACT

Electricity generation from geothermal in Kenya started in 1981 with construction of Olkaria I (45 MW) geothermal station. The current output in Kenya is 130 MW, which is about 11% of the country's effective capacity. However, there is a plan to increase generation from geothermal by an additional 576 MW by 2026.

The current geothermal capacity is located in Olkaria Geothermal field, a large part of which is within Hell's Gate National Park. Kenya has over the last 26 years gained experience in managing the environmental issues associated with geothermal development in Olkaria. This has proved that geothermal energy development activities can harmoniously coexist with wildlife conservation with maximum benefit from both resources. Kenya plans to rely on these experiences in the other geothermal sites in Kenyan Rift, some of which are located in either National Parks or Game Reserves.

1. INTRODUCTION

Currently Kenya generates about 130 MW of power, which accounts for about 11% of the effective installed capacity. There is a plan to increase the generation from geothermal by additional 576 MW by 2026 (KPLC, 2005). All the geothermal power is exploited from Olkaria geothermal field on which Kenya's geothermal experience is based. Kenya Electricity Generating Company (KenGen) has two power stations (Olkaria I and II) with a total capacity of 115 MW. Orpower 4 Inc (Olkaria III) and Oserian Development Company have 13 MW and 2 MW binary power stations, respectively. KenGen, which is a public-private company, generates 80% of Kenya's power. Orpower4 Inc is an Independent Power Producer (IPP) while Oserian is a farming company that generates power for its farm use.

Other than producing power for farm use, Oserian Development Company is a leader in the region for growing of cut flowers. Currently Oserian is using geothermal heat and CO_2 in 50 hectares of green houses for production of cut flowers for export to the European market.

Outside of Olkaria Geothermal field, exploration drilling has been undertaken in Eburru geothermal field, which is located some 50 km north of Olkaria. Part of this field is in a gazetted government forest land. A prefeasibility study for multiple uses of geothermal for electricity generation and water production for agriculture and domestic use has been carried out for Eburru geothermal field (WestJec 2003). The first phase of this project, which is the construction of a 2.5 MW binary plant, is in the bidding stage and is planned to be commissioned at the end of 2007. Detailed surface exploration works at Suswa, Longonot, Lake Bogoria, Lake Baringo, Korosi-Chepkuk and Paka have been completed and deep exploration wells sited. Surface exploration is about to commence in Silali. Exploration drilling is planned to be done in Longonot in 2008 and Menengai in 2009.

Geothermal development at Olkaria most of which are located in Hell'sGate National Park, has created environmental challenges and also inspired vibrant economic activities in the region particularly from KenGen's corporate social responsibility initiatives. The experiences gained in Olkaria are the subject matter of this paper.

2. ENVIRONMENTAL ASPECTS OF GEOTHERMAL DEVELOPMENT IN OLKARIA

The Greater Olkaria geothermal area, which is about 80 km^2, is located about 120km from Nairobi. The field has seven sectors namely Olkaria East, Olkaria West, Olkaria Northwest, Olkaria Northeast, Olkaria Central, Olkaria Domes and Olkaria Southwest. The Olkaria I which has an installed capacity of 45 MW was commissioned in 1981 and 1982 and has been operating in the Olkaria East field for over 26 years. In the Olkaria Northeast field, 70 MW Olkaria II geothermal power station was commissioned in 2003. Three exploration wells were drilled in Olkaria Domes field between 1998 and 1999 and are targeted for Olkaria IV power station. Appraisal drilling is currently in progress in Olkaria Domes.

2.1 Hells' Gate National Park: background and features

2.1.1 Background

The Olkaria I, II and III power stations are in Hell's Gate National Park. A government institution known as Kenya Wildlife Service (KWS) manages the Park. When Units 1 and 2 of Olkaria I power station were commissioned in 1981 and 1982 geothermal development had been concentrated in Government land. Some wells had been drilled in two parcels of privately owned land. KenGen then bought a total of 340 acres from the two landowners. The government allocated the rest of the land. A temporary camp called X2 had been established 5 km away from Olkaria I station and within the park since the exploration started in 1970. However, another permanent housing estate was established about 13 km away near Lake Naivasha when Olkaria I was commissioned.

In 1984, the land belonging to the Government including the one allocated to Olkaria I development was declared a National Park known as Hell's Gate National Park. A farmer donated a portion of his land to the park to form its current size of 68 km^2. The understanding was that KenGen was interested in steam, which is underground while the park would utilize the surface resource for the wildlife conservation. KenGen realised that for it to operate within the park, it needed to establish an environmental management system. In 1985, it established an environmental section in its geothermal establishment structure and employed Environmental Scientists. Initially the staff worked under a consultant. Currently, there are three Environmental Scientists specialised in management of flora and fauna, weather and air pollution monitoring, and waste management. The office of the projects Chief Manager handles social issues.

Between 1992 and 1994, KenGen carried a comprehensive Environmental Impact Assessment (EIA) for Olkaria II development, which covered the entire Olkaria area and its environs particularly Lake

Naivasha (Sinclair Knight and Partners, 1992). Based on the EIA, a Memorandum of Understanding (MoU) was signed in September 1994 between KenGen and KWS covering KenGen's operations in Hell's Gate and Longonot National Parks (KenGen and KWS, 1994). Guided by the MoU, KenGen agreed to:

- Re-inject all waste brine;
- Remove all opportunistic plant species that may have been introduced during earth works;
- Rehabilitate disturbed areas with locally available grass and tree species;
- Remove fences that obstruct animal movement;
- Provide bridges and pipe loops for free animal movement;
- Control speed on park roads and avoid night vehicular movement unless for operations;
- Ban introduction of exotic animals;
- Educate staff and contractors on park rules and regulations and interaction with wildlife;
- Avoid cutting on slopes to reduce erosion and rehabilitate for erosion control;
- Tarmac roads serving the stations and wells;
- KenGen to continuously monitor noise and air emissions and to jointly monitor abundance of flora, fauna and birds and share the data;
- Hold joint meetings to discuss and agree on expansion plans;
- Agree on road designs and harmonise road networks within the Hell's Gate and Longonot National Parks;
- Plant suitable trees to obscure the view of power stations;
- Remove any staff camps from the park;
- KWS and KenGen to enhance security and safety in the parks for visitors and staff; and
- Construct future steam gathering systems with materials that blend with environment.

In 2000, KWS entered into a similar but separate agreement with Orpower4 Inc because of its operations of Olkaria III power station. Both agreements are operational but are currently going through some reviews.

2.1.2 Features

The area of the park is generally dry most of the time and the vegetation comprises grassland with shrubs dominated by *Leleshwa* bushes and several varieties of acacia thorn trees. The acacias are very widely spread.

Wildlife consists of species of Eland, Buffalo, Lion, Giraffe, Zebra, Leopard, Impala, Grant's and Thomson Gazele, Klipspringer, Rock hyraxes and Reedbuck. There are about 100 avifauna species some of which are raptors. One bird hide is available for bird watching.

The Park has varied landscapes with rock cliffs and plugs very popular with both amateur and professional climbers. There is a scenic Ol'Njorowa Gorge that was formed by erosion of Lake Naivasha, when it breached on the southern side. It is the only park open for walking and cycling. The park is popular with backpackers. There is one popular route where you enter the park through one (Elsa) gate and pass through open grassland full of animals then pass through Olkaria I and II power stations and naturally occurring steam jets and come out through the second (Olkaria) gate. The route is about 35 km long.

There are several camp sites spread through out the park and provide scenic sundowners to the campers and views of Mount Longonot and Aberdare mountain ranges.

Neighbouring the park is a Maasai Cultural Centre with a community of about 50 people leaving in a typical Maasai homestead, *Boma*. At the Center, one can buy Maasai curios and also enjoy cultural dances.

2.2 Economic activities profile

In the immediate vicinity of the Olkaria power stations are private wildlife sanctuaries, tourist hotels and campsites, commercial livestock ranches and horticultural and flower farms. These economic activities are vital sources of employment opportunities and foreign exchange earnings. Most of the flowers and vegetables are grown for export to European markets.

2.3 Lake Naivasha

The water used for both domestic and geothermal development comes from Lake Naivasha, which is also a Ramsar site of international significance. There is a high demand for lake water for the ever expanding flower growing business, human settlement in Naivasha town and other upcoming shopping centres, tourism and pastoralists. Geothermal development uses fairly small amounts of water for power station start-up, drilling and domestic purposes. Drilling operation has practised recycling to minimize this use.

Lake Naivasha Riparian Association involved all the stakeholders of Lake Naivasha to develop a management plan with various codes of conduct for the self-regulation in the abstraction of fresh water from the lake. The association also self regulates use of riparian land which have potential for polluting the lake.

2.4 Demographic profile

The Olkaria geothermal development project and other industries around Olkaria have attracted large populations of immigrant workers from other regions of Kenya. The population inhabiting the surrounding areas is estimate to be about 300,000 people and comprises of people of diverse ethnic and social classes, ranging from the affluent floricultural farmers of European decent to the local Maasai community, who are pastoralists. The rising population has led to increased demand on social amenities e.g. Schools and Health facilities.

3. ENVIRONMENTAL IMPACT MITIGATIONS ADOPTED

Due to the sensitive settings of Olkaria and other geothermal areas within the Kenyan rift system, KenGen has always taken environmental and social issues into account in its power development plans. The aim is to ensure sustainable development of the geothermal resources. This has been achieved with great success through the application of impact assessment tools, which form part of the early project planning and decision-making process.

The project´s Environmental staff conducts Environmental Baseline Studies during surface exploration of geothermal prospects. The existing baseline information ranging from biophysical, social and economic aspects are gathered. The findings of the initial environmental studies have bee used to guide siting of exploration geothermal wells to minimize adverse environmental impacts; provide baseline information for future EIA studies; and as benchmarks against which impacts of future developments are compared.

Comprehensive EIA studies are undertaken and lisences obtained from the National Environmental Management Authority (NEMA) before drilling of geothermal wells, construction, operation, and maintenance of geothermal power stations.

During the construction of Olkaria I power station, there were no national and international environmental regulatory guidelines to be fulfilled. Since then there have been a lot of sectoral

legislations enacted in Kenya and international policies that regulate funding of development of geothermal resources. Increased public awareness of environmental issues have also been realised in the recent past. Therefore, prior to construction of Olkaria II a comprehensive EIA study was done between 1992 and 1994 by EIA consultants (Sinclair Knight and Partners, 1994) contracted by the World Bank. The EIA process, which was the first of its kind in Kenya, was based on the World Bank operational directives (OP 4.01). Other sectoral laws of Kenya that affect energy developments also guided geothermal development in Olkaria. These included among others, the Geothermal Resources Act (1982) and supplementary legislation of 1990, Water Act, Public Health Act, which preceded the Environmental Management and Coordination Act of 1999.

KenGen's Environmental Scientists and members of the local community constituted part of the EIA team for Olkaria II development. This ensured early involvement and participation of the public in the project planning and decision-making process and transfer of local and EIA expertise knowledge.

The potential environmental aspects associated with geothermal power development in Olkaria included:

- Discharge of separated geothermal brine
- Discharge of excess geothermal steam condensate
- Emission of Non Condensable Gases (NCGs) such as hydrogen sulphide (H_2S), carbon dioxide (CO_2), and other minor gases
- Thermal emissions from geothermal steam and brine
- Noise
- Visual or aesthetic effects
- Loss of vegetation and soil erosion due to land surface disturbance
- Interference with animal habitats and migration routes
- High level of poverty and lack of adequate social services

These impacts can be broadly classified into 4 main categories: physical, biological, chemical, and social-economic impacts. Various impact mitigation options were identified through the EIA process and adopted as illustrated in the subsequent discussions.

3.1 Incorporation of environmental engineering in infrastructure design

To prevent or minimize negative environmental impacts, environmental engineering concepts were incorporated in the final design of the power infrastructure for Olkaria II (Figure 3). For Olkaria II, the design is such that there is no surface discharge of geothermal brine. All waste brine and condensate are re-injected back into the reservoir using hot brine re-injection systems. Only a few separator systems are used. The result is a quite field with less emissions of steam. The Non-condensable Gases (NCGs) are discharged into the atmosphere through the cooling tower unlike in Olkaria I, where emissions are discharged through the gas ejector systems. This has effective gas dispersal and lowers the concentrations of H_2S emissions into the surrounding areas.

3.2 Mitigation of physical impacts

The main physical impact of geothermal power development is land surface disturbance during civil works. Soils of Olkaria area are of volcanic origin, which are loose and vulnerable to erosion on exposure to wind and rainfall events. To prevent soil erosion, clearance of vegetation was minimized. All the disturbed areas (well pads, steam and brine pipeline routes, and the power house) were revegetated with indigenous plants. The rehabilitation of the disturbed areas within the park, has maintained the integrity and viability of the park ecological system.

Other minor physical impacts (visual effects, thermal, and noise emissions) were minimized through insulation and painting of power infrastructure with camouflaging colours and use of Best Available Technology (BAT) such as silencers, respectively.

3.3 Mitigation of biological impacts

As previously mentioned, the large part of Olkaria geothermal field is located within Hell'sGate National Park. The Park was gazetted in 1994 after commencement of geothermal exploration way back in 1950s. To ensure co-existence of the Park activities and geothermal power development, KenGen and KWS, a state corporation mandated with management of wildlife, signed a Memorandum of Understanding in 1994. The MoU has guidelines and procedures on management of environmental issues within Hell's Gate National Park, which KenGen agreed to adopt. The park is rich in biodiversity and destruction of micro flora and fauna, wildlife habitats and migration routes, are the main potential impacts.

Through the EIA process, sensitive animal habitats and routes were identified with guidance of the local Maasai community and Park rangers. These routes were avoided during construction of infrastructure for power development. Vertical loops were provided along the geothermal steam and brine transmission pipelines, to allow free movement of wildlife, and separated geothermal fluids isolated in securely fenced high density polyethylene (HDPE) lined sump ponds, prior to disposal through re-injection back into the reservoir.

KenGen also supplies potable water to the animals at various points so that they are not tempted to drink geothermal wastewater particularly during dry weather conditions. The waste brine conditioning ponds are fenced off from the animals.

3.4 Mitigation of chemical impacts

Operation of geothermal power stations results in gaseous emissions (75%) and effluents (25%). The emissions comprise of 1% NCGs (H_2S**,** CO_2) and other minor gases (methane, ethane, ammonia). The effluents are mainly brine and excess condensates, which contain trace elements (Arsenic, Boron, Lithium, and Mercury) in varying concentrations. To minimize contamination of ambient air, terrestrial, and aquatic environmental components, the mitigation options adopted in Olkaria included the following:

- Discharge of NCGs through cooling towers to scrap off soluble gaseous emissions
- Re-injection of brine and excess condensate back into the reservoir through dedicated steel casing lined re-injection geothermal wells;
- Monitoring of brine composition and H_2S concentrations in ambient air; and
- Collaborative research on emissions with the private commercial flower farms.

Flower trial plots were set-up close to the geothermal power stations to study potential effects of emissions on flower quality. No negative impacts were observed and KenGen and the flower farms jointly published the results (Kubo and Kollikho, 2001). This has ensured harmony and good neighbourliness with Oserian Development Company.

3.5 Management of social issues

The inhabitant populations around Olkaria are of diverse ethnic and social classes ranging from the affluent commercial farmers of European origin, immigrant tribes from other parts of Kenya in search of employment opportunities in the farms, and the native Maasai community, who are pastoralists. Several key stakeholders were identified during the EIA process: Local communities inhabiting the area, Kenya Wildlife Service, Naivasha Municipal Council, Lake Naivasha Riparian Association, and

government departments concerned with land, water, and public health issues. KenGen's management holds regular consultations with all the stakeholders for mutual identification and prioritisation of their concerns.

In addition to the KWS and KenGen meeting provided for in the MoU, KenGen is a member of the Hell'sGate and Longonot Parks Management Committee. This committee comprises the two KWS Staff in charge of Hell'sGate and Longonot National Parks, KenGen, Hotel owners, farmers around the park and other interested parties who are friends of the park including representatives of the local communities. The committee meets quarterly and discusses all issues relevant to the management of the two parks. They have a special account to which well-wishers can donate funds to improve the park management. The committee organises some activities that can earn the parks some money for their improvement. Money for several movies shot in the park also go towards the park improvement. In this meeting KenGen briefs the committee members on current geothermal activities and future capacity expansion plans.

The tarmacing of the road by KenGen from Naivasha town to Olkaria power stations improved communication for tourists visiting Hells'Gate National Park. KenGen also assists KWS in maintenance of some of the earth roads within the park whenever they are not in a position to do so. There is a marked increase in tourists visiting the Hells'Gate National Park, some of whom are more interested in visiting the Olkaria I and II power stations rather than seeing the animals. The power stations have recorded about 2000 visitors a month on average. There are others that want to see both the animals and the power stations and even choose to camp near by. In our view, the presence of the stations is a major attraction to the tourists and consequently benefits the park in terms of revenue collected.

In 1989, KenGen established a tree nursery for raising tree seedlings primarily for rehabilitation of disturbed areas within the Park. However, the activities of the nursery have been expanded to include social afforestation programmes, which is part of KenGen's corporate contribution to the countrywide conservation initiative. Since 1990, about 750,000 tree seedlings have been issued to institutions (Schools, Churches) and individuals including staff. Technical training on establishment of tree nurseries is also offered to organized groups and communities around the project.

4. CONCLUSION

Kenya strongly believes that it requires both its geothermal energy and wildlife conservation for its economic growth. In this regard, when Hell's Gate National Park was established it was envisaged that both these two resources could co-exist. To achieve this harmonious co-existence, memorandum of understanding were signed between KWS, KenGen and Orpower4 giving guidelines of mitigation measures to be undertaken in order to conserve wildlife and take care of the flora and fauna in the park. A code of conduct for power generators was also prepared under Lake Naivasha Management Plan to conserve Lake Naivasha, which is a Ramsar site.

Based on this success, Kenya is confident that geothermal can be exploited in National Parks, game reserves and other protected areas and enhance tourism.

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