

Olkaria (Kenya) Geothermal Project Case Study

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ABSTRACT

Based on the theme of this year's meeting, it is critical to discuss the road gone through to develop the world's largest single unit Geothermal Power Plant. Olkaria IV/IAU 140MW Geothermal Power Project. The two power plants are located in Naivasha Kenya in a volcanic region of Olkaria near the Mt. Longonot. Either of these two plants form the largest geothermal power plants in Africa producing 150MWe each. The two among others, inject power to the national grid whose power composition is about 38% hydro, 29% geothermal, 1% wind, less than 0.1% solar and 32% thermal. The plants were commissioned between late 2014 and early 2015 with the defects liability period for the last unit ending in January 2016. The paper is expected to give a roadmap of the project right from researches, exploration & drilling, project execution and now the current- Operations. The paper will reflect on the three major aspects that have made the project come to operation being steam field exploration & Development, power Plants Projects-Construction and commissioning, transmission Line Construction.

During this project, the author of this paper was very much involved and well engaged to have gathered enough experiences in the way to run a Geothermal Power Project, challenges in running a Geothermal Power Project, Solutions to challenges faced, Lessons learnt only to mention but a few. The paper is entirely an original work of the author with reference to the experience, knowledge and skills gathered during the project execution period.

Introduction

The Olkaria Geothermal Projects are located in the Republic of Kenya, in the Great Rift Valley region in the rich fields of Ol Karia which fall within the Hells Gate National Park. Olkaria is located 120 km east of Nairobi. It neighbors horticultural farms that produce some of the finest flowers in the world. The project is also adjacent to Lake Naivasha a freshwater lake in the Kenya Rift and a Ramsar site.



Figure 1. The Olkaria Geothermal Project

Geothermal Power as Clean Energy

I can clearly say that geothermal energy is a clean form energy. It is in the sense that, at the point of usage, the power is very clean as it produces not any poisonous fumes. In Kenya, the power grid is connected and is therefore not differentiable from the power from the hydro and other plants. Electricity is generally clean energy.

Geothermal energy has been made available to most Kenyan households as the GOK has offered subsidies for connection of power through the Kenya Power Company. It is therefore affordable and readily available.

Geothermal Development in Kenya

Geothermal exploration in Kenya started in the 1950s and gained momentum in the 1960s when two wells were drilled at Ol Karia. From 1967, the UNDP in collaboration with then East African Power and lighting Company Limited, conducted a geological and geophysical surveys in the area between Ol Karia and Bogoria. The studies identified Ol Karia as the most prospective area leading to the construction of the first geothermal power station between 1981 and 1984.

Power for the Future

Since geothermal energy is indigenous, renewable and environmentally benign, and is not prone to effects of 'bad weather', Kenya under the Ministry of Energy and Petroleum has fast tracked the expansion of electricity generation from Geothermal Resources. Feasibility studies by the Kenya Electricity Generating Company, indicate that a large potential of geothermal energy approximately 7000MWe exist within the Kenyan Rift. The high potential areas are yet to be fully explored and include Suswa, Olongonot, Ebburu, Menengai, Silali, Emuraungogolak, Paka, Korosi and Barrier Volcanoes. It's estimated that these regions can produce over 4000MWe of power. Kenya Electricity Generating Company, mandated by the Government of the Republic of Kenya is expected to develop and produce 1260MWe of power from the geothermal sources by the year 2018.

Olkaria Geothermal Systems

The heat source of the geothermal system at Olkaria is due to intrusion of hot magma bodies to depths of less than 6 km to form numerous hills and dome that dot the Olkaria Landscape. The Ololbutot lava erupted about 200 years ago attesting the youthfulness of the volcanic activity at Olkaria.

The geothermal systems at Olkaria consists of a two - phase reservoir that is hosted within 0.9-1.65 million year old fracture trachyte and rhyolite rocks at the depths of between 600 m and 3000 m. At the Olkaria east and Olkaria North East Geothermal Fields, wells with a nominal diameter of 8 inches (200 mm) diameter are drilled into the reservoir and the upper 700 m are cased off to avoid cold fluid inflow into the bore. Into the Olkaria Domes the upper 1200 m is cased off. The wells produce 75% water and 25% of steam. Separation of steam is done using cyclone separators where dry steam is piped to the powerhouse and separated water injected back to the reservoir.

Olkaria IV and I Units IV and V

In 1999, KenGen drilled exploratory wells for Olkaria IV geothermal field. In 2006 the Government of Kenya funded appraisal drilling for this field. Production drilling commenced in 2007 by signing of six - well contract. The company signed a total of six contracts for the drilling of the geothermal wells for this project.

In any good geothermal system there is need for both production and reinjection wells. This gives the Olkaria field the capacity to support its plants as the reinjection wells ensures replenishing of the field. This project has a total of 52 production wells and 19 reinjection wells.

Drilling was contracted to a Chinese firm which has seen the Olkaria IV steam field come into place. In the rugged terrain of the Olkaria region, KenGen through its committed infrastructure team made the sites for well drilling accessible. They cleared the sites, constructed access routes and leveled the grounds to form the well pads. Olkaria IV power station alone, has two units each generating 70 megawatts. It has two turbines rated at 78 megawatts. Olkaria I addition is a replica of Olkaria IV and the two plants generate a gross power of 300 MWe. Each plant therefore exports to the national grid 140MWe. The excess generation over the rated turbine generation is used parasitically by the plant. ie to run the utility services of the plant like lighting, running of the pumps, compressors and other facilities.

The plant is founded on frictional piles in volcanic soils.



Figure 2. Civil excavations works.

The power plant project was implemented through an Engineer Procure and Construct (EPC) contract entered into by the employer-Government of Kenya through the Kenya Electricity Generating Company, and a Korean firm-Hyundai Engineering Company under the stewardship of the then Sinclair Knight Mertz currently Jacobs.

The project implementation ran through a hard time with challenges ranging from natural occurrences to human created challenges. The project however came to actual completion and operation in December 2014 and February 2015 for the two stations.

The plant uses a direct steam technology that according to the users have their advantages unlike the binary and the combined flash and double flash cycle technology. The power plant is operated remotely from the power plant control room by use of a DCS control system. It requires only one operator and two assistants to keep the 150MWe into the grid. The maintenance team is also a small group and they do little works on daily basis. The turbines run at 3000 revolutions per minute when the plant is fully loaded (Exporting 140MWe). The steam inlet pressure at this time is usually 5.5 bar absolute and the steam field pressure is usually 10.0 bar before exiting the pressure let down station. The station has been introduced to elevate the pressures to prevent deposition of silica in the steam lines.

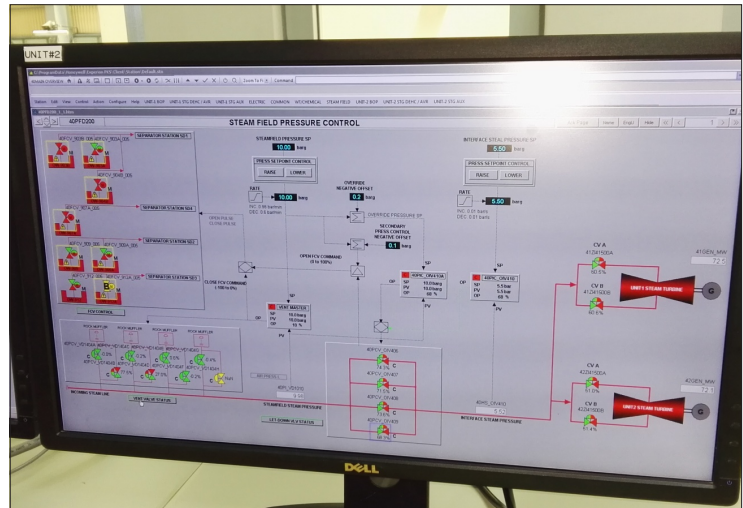


Figure 3. A screenshot of the power plant control center showing the steam field parameters.



Figure 4. Construction in Progress. Glass Reinforced Plastics pipe installations.



Figure 5. GRP pipe at the connection of the hot well area.

The Steam Field

From the interface where the steam enters the power station, backwards to the well is what we consider to be the steam field. It's composed of the separator stations, the wells, steam scrubber, sump pits and brine re-injection system. The steam field for Olkaria IV and Olkaria I unit IV & V was developed by a Chinese piping firm Sinopec International Company under a re-measure contract as the work was extensive and unpredictable of the actual cost. The consultant for the project Sinclair Knight Mertz did the design which was reviewed from time to time with the engagement of the client. The original contract sum was estimated to be USD 38, 526,972.81. The project pipe length installed was 66 km. Installation involved connection of pipes from the wells to the power station, installation of separator stations, and construction of sump pits, construction of piled foundations for the pipeline and site rehabilitation.

The Transmission Line

Electrical energy is not storable. With this in mind, the engineers in the development of the Olkaria 300 MWe project had to devise a method to evacuate the power to the off taker. We were therefore to come up with a high - voltage line running from the substation to the national grid. In the rugged terrain, towers were erected to carry the HVT line from Olkaria to Suswa. The work was very demanding work and required one to have adequate skills, experience and equipment for a smooth sailing. The work was carried out by an Indian company KEC International.

Geothermal Direct Use

In the rich Olkaria, brine is used for replenishing the dead cells of the human skin as it contains Sulphur which has medicinal values. It acts as a re-creational facility in its making and it serves many people from different and many nations. It is the only one of its kind in the south of the Sahara and North of Limpopo.



Figure 6. The spa during construction...Landscaping.

Project Challenges

The project during its time of implementation faced several challenges ranging from natural to artificial challenges. The challenges affected highly on the aspect of cost, delivery time and loss of lives.

Olkaria region often experience flash floods from different directions and from time to time..During construction, wasn't an exception. It was the time of glass reinforced plastic pipes installations and they had been well laid in their trenches awaiting to be buried. Some of them were still undergoing jointwork and the pipework was still massive. It happened that at this time, a neighbouring area had heavy downpour and through the gorges the flash flood waters accessed the unprotected site. The uncovered trenches carrying the GRP pipes got filled with water and due to buoyancy, all the pipework were demolished. Many foundations were also comprised and had to be re done.

During the dry season, The region experiences high temperatures, and the soil becomes very loose. The area is also windy. During its construction the project experienced a lot of dust and the contractor had to keep mitigating the dust by use of water bowsers running all day long. The cost of keeping water bowsers on site hiked the price of the project.

The dust around the site, due to disturbed ground and negligence of the projects stakeholders to mitigate the dust, posed a health hazard to many. It ran from the employees to the equipment which are very sensitive and malfunction on tamperage by dust. Dust also compromised visibility and the workers could cause accidents every now and then.

The community around the Olkaria region, is a hostile community. The maasai community due to its dependence of life in the parks and their large herds of cattle, their nomadic pastoralism characteristic, makes them semi - illiterate. It becomes very hard to convince them not to interfere with their land in the name of a project. To them, we destroyed their grazing grounds and they had to do all they could to prevent the project from being implemented.

Site conditions also posed another challenge whereby the soil around the project are loose pulverised volcanic ashes that hardly bind. Erosion therefore was inherent and also posed a big challenge. It affected site accessibility as one day you would go through a road and as you come in the next morning, the road is impassable.

Poor knowledge by the client. The client lacks the expertise to carry out design and installation of the power plant and have to rely on the consultant and the EPC contractor. Knowledge transfer was inadequate and this therefore means that the client is still inadequately staffed.

Conflicts between the authorities guarding the park and the people carrying out the project.
Language barrier. The contractor employed some staff who could not understand English or any of the local languages.

Research Areas of Concern In Geothermal Today

- Assessment of suitability of bentonite deposits in Meru and Isiolo as geothermal well drilling mud.
- Use of brine for geothermal cementing.
- Conversion of power station blowdown into potable water.
- Use of geothermal brine for rehabilitation
- Use of geothermal energy for fish farming
- Use of brine fro horticulture
- Use of geothermal steam for cooling.
- Wellhead optimization
- Sustainability of lake Naivasha and improvement of the environment to maintain a good human nature integration.
- Improvement of cooling towers.
- Real time relaying of geothermal information and data directly from the field to the computer server using GSM and GPRS technologies of mobile mapping and GIS.
- Increasing the efficiency in the utilization of brine to run a binary power plant.



Figure 7. Initial stages of project construction.-Site clearance and earthworks.



Figure 8. The plant during construction.



Figure 9. Turbine during installation.



Figure 10. Steamfield.



Figure 11. Old house.



Figure 12. New house.

Community service responsibility in improving the livelihood of community living within the project area. Construction of new improved houses for the Maasai.

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