Environmental management at Olkaria geothermal project, Kenya

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Abstract

Geothermal development can have numerous impacts, which if not mitigated can make geothermal resource not environmentally viable. Geothermal utilization can cause surface disturbances, physical effects due to fluid withdrawal, noise and emissions of chemicals. It can also affect the neighbouring communities either socially or economically. The environmental impacts can be mitigated by using several mitigating measures like reducing the drill pad sizes, rehabilitating the opened areas by planting grass and trees, and putting in place monitoring programs. The emissions of greenhouse gases to the atmosphere are far less than with most other energy resources. With the new Environmental Management and Co-ordination Act 1999, KenGen requires to put in place an effective Environmental Management System (EMS) and possibly seek ISO 14000 certification so as to be compliant with all national and international environmental standards.

Keywords: *Olkaria, Hellsgate, environment, impacts, monitoring, geothermal.*

1 Introduction

There is a general shift of concern by industrialists from economic viability of a project to greater emphasis on environmental viability (Armannsson, 1997). Compared to other usable energy sources in Kenya geothermal energy is favorably placed and has been dubbed, " clean energy source" by Environmentalists. Although a clean source it has some environmental impacts but the beauty of geothermal compared to others is that the impacts associated with its development could be mostly mitigated.

The most important environmental impacts brought about by geothermal development include surface disturbance during drilling whereby alot of civil works take place such as access roads for drilling, pipeline routes and well pads. These can lead to serious degradation of the landscape. Particular care must be taken in unstable terrain such as the North-East Olkaria area. Rehabilitation of these areas is carried out in-order to restore the integrity and aesthetic character of the surroundings. Others are physical effects due to fluid withdrawal, noise, chemical emissions and socio-economic effects.

The aim of this paper is to update the reader on the geothermal environmental impacts and the mitigation options practiced at Olkaria, which has led to the co-existence between Kenya Electricity Generating Company (KenGen) and Kenya Wildlife (KWS), as this project is located in Hells-Gate National Park. KWS is legally entrusted with the management of this Park and the conservation of all types of fauna and flora found therein. KenGen on the other hand is involved in the exploration and production of geothermal power within the environs of Hells Gate National Park by virtue of Gazette Notice No. 585 dated 2nd March 1973.

This led to the signing of a memorandum of understanding between these two corporate bodies on 20th September1994 (Agreement on Geothermal Development in

Hells Gate and Longonot National Parks, 1994). KenGen is a member of the Hells Gate and Longonot Management Committee. KWS and KenGen hold joint quarterly meetings on Memorandum of Understanding (MoU).

2 Surface disturbances

Geothermal power development begins with surface exploration studies once a geothermal prospect area has been identified. These studies may include surface geological mapping, geophysical studies and geochemical sampling. Surface exploration has the least environmental effects. There are no major environmental impacts for instance when carrying out surface geological mapping as it only involve walking over the exploration area. There could be slight environmental impact due to the construction of access tracks for geochemical and geophysical measurements.

Land is required for drill pads, access roads, steam lines, power plant and transmission lines. At Olkaria a big chunk of this land is in Hells Gate National Park that is why the scenery and fauna conservation needs attention as the Park attracts many tourists. In this area removal of vegetation is minimised unless it is absolutely necessary like when constructing drilling pads and roads. A drill pad at Olkaria about 3200 m^2 before the pads used to be larger and could be as large as 5000 m^2. The exposure of such an area of 3200 m^2 or 5000 m^2 at each well site creates erosion hazard. This leads to removal of alot of the natural vegetation, which is not desirable as vegetation in Hells Gate National Park is food for the wild animals. The vegetation also helps in soil erosion control.

KWS and KenGen hold joint quarterly meetings to discuss and agree on plans for expansion of exploration and development. All the drill pads together with the ponds are rehabilitated after drilling and well testing by planting *Tarchonanthus camphoratus* (Mleleshwa), *Acacia drepanolobium* and the indigenous grasses like star grass (Figure 1).

Figure 1: Picture showing well OW-708 site rehabilitated with star grass and Acacia.

The tree seedlings are raised in the project tree nursery. The problem of tree growing in this project is that the survival percentage is very low because the wild animals feed on them.

So well rehabilitated sites with star grass without trees is a common feature at Olkaria North East area.

Drill rig seen from a far may be a prominent feature during drilling and this can cause visual impact, but disappear after the start of production. Some people on the other hand find drill rigs magnificently beautiful, like the school and college groups, who visit the project.

Road construction in steep areas like North East Olkaria normally involves extensive intrusion into the landscape and can cause serious erosion hazard with consequent loss of vegetation cover. Provided the road surface itself is stabilised with murram or is tarmaced as most of them are in Olkaria, the runoff is diverted at regular intervals before it accumulates to problem levels, and the situation can be kept under control. Clearing land for roads before determining the best alignment can cause serious problems. In the MoU meetings KenGen and KWS do discuss on plans for expansion of exploration areas development, in this regard they discuss and agree on road designs and construction for the purpose of harmonizing the transport network within Hells Gate National Park. At Olkaria today a team comprising of the Surveyor, Environmental Scientist and Civil Superintendent has to peg the area for the road before actual road construction works commences. Olkaria I and Olkaria II power plant that is nearing completion are located on a fairly flat area. These locations therefore do not have a severe impact on the landscape. Once again re-vegetation or some other sort of slope stabilisation and appropriate drainage is a priority. Pipeline corridors are typically 3-5 m wide during construction depending on the pipe size. Access roads may be needed for construction and maintenance. After construction of the pipes, planting star grass, “Mleleshwa” and Acacia Sp, rehabilitates the corridors. The steam pipelines are often painted to blend into the landscape. The pipelines for Olkaria I plant were not painted and visual impact is evident but that for Olkaria II are painted to blend with the Olkaria Environment.

Transmission lines require a corridor about 40m free from overlying vegetation for a 220kV line, like the one which will be constructed from Nairobi to Olkaria II plant. Access roads will be required for the construction of large steel pylons. The ones for Olkaria II line will be between 35-40m high. There exists a 132kV line as well for Olkaria I plant. In smaller power developments, wooden poles placed adjacent to the roads provide satisfactory electricity transmission like the current 8MW from Olkaria III plant are using the 33kV Narok line. The 220kV line will pose several environmental challenges, as it will have 15 towers for the 220kV line and 8 for the 132kV line. Access roads will be required; this means substantial interference with Hells Gate National Park but this will not be permanent, as it will stop when the project is completed. All possible surface disturbances should be incorporated in an environmental impact report prior to exploitation and optimum solutions devised in co-operation with all concerned.

Untidiness in the vicinity of drilled wells and other constructions can cause unacceptable eyesores. Inspection of sites is one of the monitoring programs conducted by the environmental team in the project. Biannual internal audits are also carried out to correct the same.

3 Noise

Noise is one of the most irritating disturbances to the environment from geothermal development, particularly during the construction and operation phases. Noise can be considered as "unwanted sound" and any development should aim at minimising this impact (Brown, 1995). Noise intensity is measured in decibels denoted dB (A). At Olkaria the levels are measured by use of a hand held integrating-averaging sound level meter. Noise that is specific to geothermal is drilling noise, which rarely exceeds 90dB, and the noise from a discharging well mostly under flow test, which may exceed 120dB. Using silencers this noise can be brought down to about 85dB, the noise acceptable to occupational safety authorities for people working for eight hours. So even with good designs for noise reduction workers must use ear protectors both during drilling and discharge tests.

The number and locations of the stations for noise monitoring were selected after carrying out an extensive survey to determine the potential noise sources in the project area. Thirteen (13) sites were designated as noise monitoring sites or stations. The noise level measurements are taken twice a week in all the monitoring sites or stations.

Table 1. Mean Environmental Noise level in dB (A) from 1996-1999.

Station	1995	1996	1997	1998
Power station	90.8	90.2	89.7	86.6
Offices	68.4	68.6	67.8	71.4
W/Shops	56.2	53.7	50.5	52.4
KWS Olkaria G	49.5	48.2	44.5	45.5
L/View estate	46.0	43.8	44.0	41.6
L/Side estate	44.7	42.7	42.9	40.3
Geology lab.	63.4	nd	nd	69.5
N370	67.9	86.4	nd	nd
X-2 Camp	59.4	54.6	nd	Nd
OW-10	nd	nd	63.5	62.5
Seal Pit 1	nd	nd	64.5	67.5
Seal Pit 2	nd	nd	69.3	68.8
Stores	nd	nd	66	59.3

NOTE: nd: Not determined; OW: Olkaria Well

The occupational health and Safety criteria in Kenya, regardless of hearing protection is 85dB (A) average noise level in a work place for an employee working 8-hour day. Other than the power station and the N370 rig, which have levels above Occupational exposure, limit the rest have levels far below.

4 Thermal effluents

Wasteheat is contained in the wastewaters and some in the steam. The heat contained in the steam is the principal heat used to generate electricity. Olkaria I plant uses a cooling tower to vent out the heat to the atmosphere contained in the condenser outflow and the main impact resulting from this is on the local climate. Localised slight heating of the atmosphere and an increased incidence of humidity lead to fogging a common feature at Olkaria I power station area from June to August. The foggy conditions occur during the early hours of the morning and clears by 9.00 a.m. The hot wastewater when disposed off on the surface like during well testing can have

some effect on the surrounding vegetation by scorching the plants dry. Carry-over from wells under discharge have negative effects on local vegetation with shrubs and trees being scalded by escaping steam, this was evident when well OW-714 was under test (Were, 1997). This effect is not permanent as the vegetation heals after the rains. To mitigate this impact at Olkaria of hot waste water on vegetation deep reinjection will be the solution. Like waste water from OW-27, OW-31 and OW-33 are reinjected to well OW-03. Most of the geothermal wastewater is disposed off by deep reinjection.

5 Water usage

Water is required for drilling as drilling fluid, it is used during the construction phases for compaction, and it is required for reinjection well testing and is needed for cooling water in the power station. A small amount is required for domestic use at the staff housing estates and at the offices. There will obviously be an impact on the Lake Naivasha, which is the source of this supply. A typical production well at Olkaria drilled to a depth of 2200 m can utilise up to 100,000 m^3 of water some or all of which may be lost to the formation. Negligible amounts of water are required for cementing. Completion testing and injection testing can use up to 10,000 tonnes of water per day. The amount of water used during construction is relatively small, and for Olkaria I plant which utilises a cooling tower system water is required only at startup after which recycling and re-use is practiced. The Ministry of water has granted Olkaria project permission to pump water from Lake Naivasha by issuing the Company with an abstraction license. The reason why the Olkaria Geothermal project is implementing the Eco cycle in most of its activities is because the water it uses is from Lake Naivasha, which is a highly significant national freshwater resource in a semi-arid area. Apart from the invaluable fresh water it provides, it also supports large and important economic activities – mainly flower growing and geothermal power generation. The Lake is thus a major contributor to Kenya's GDP and to the socio-economic development of the country as a whole. It is a Ramsar Site of international significance. KenGen is a member of Lake Naivasha Riparian Association. (LNRA) whose membership are all stakeholders who own riparian land, and a community based management plan (The Lake Naivasha Management Plan) for sustainable use of the Lake. Lake Naivasha Management Implementation Committee has been formed to implement the management plan. Representation of the committee is from KenGen, Municipal Council, Local administration, Kenya Wildlife Service, International Union for Conservation of Nature (IUCN) and Lake Naivasha Growers Group. In the management plan various stakeholders have developed codes of conduct to govern their activities with respect to the Lake. For the energy sector, KenGen has developed a comprehensive code of conduct and all power producers including the IPPs operating in the vicinity of the Lake are expected to adhere to it. The efforts of LNRA have been recognized by winning the Ramser wetland Conservation Award at the 7th Meeting of the Contracting Parties that was held in San Jose, Costa Rica, in May 1999. There is a continuous monitoring programme to monitor the physical and the chemical properties of the water. During drilling water is recycled from the sumps, which assists to stop drilling effluent from flooding and polluting the environment.

6 Solid wastes

Geothermal development produces significant amounts of solid waste, therefore suitable disposal methods need to be found. Because of the heavy metals particularly arsenic, which are contained in geothermal waters, these solid wastes are often

classified as hazardous waste. During drilling, wastes are produced in the form of drilling muds, petroleum products from lubricants, fuels and cement wastes. Drilling muds are either lost through circulation in the well or end up in the drilling sumps as solid waste for disposal. Since a lot of fuel and lubricants are used when drilling a single well, (approx. 300,0000 liters of diesel) storage and transport of these products should follow sound environmental practice as stipulated in the new KenGen Environmental Policy. Cements are not normally considered hazardous, although some constituents like silica may be hazardous on their own. During operation of the power plant, as for Olkaria I plant, there is special provision for safe storage of lubricants and fuels. The principal solid wastes are cooling tower sludges, which may contain mercury. The waste brine from the power station that contains traces of solid wastes (heavy metals) is safely disposed to the infiltration pond avoiding any spills, but the plan is to reinject all this wastewater into one of the wells. The other major solid waste is construction debris and normal maintenance debris. All these are transported safely avoiding any spills along the way to a designated disposal site or landfill near well OW-3, which is periodically monitored and audited, to see that it is environmentally safe.

7 Chemical discharge

Chemicals are discharged to the atmosphere via stem steam and into ground water systems via the liquid portion. Hydrogen Sulphide gas emission is the major gas that causes the greatest concern due to its unpleasant smell and toxicity at moderate concentrations. At the Olkaria Geothermal Power plant measurements done in November-December 1991 recorded maximum 1-minute concentration of 1.25 ppm (Sinclair Knight & Partners, 1994). Measurements in the steam plume from 0W-709 recorded concentrations of around 0.15 ppm. Hydrogen Sulphide gas is measured at Olkaria by using a Sambre PM 200 series of personal gas monitors, which is designed to continuously monitor one gas. Monitoring is done three times in a week for most locations around the power station and at least once in a week for those sites further away. There are a total of ten main monitoring sites for H_2S (Table 2). These are distributed to cover residential areas (the Lakeside and Lakeview estates), occupational workplace areas (Power station, Seal Pit 1 and 2), workshop, stores, administration block (Adm) areas of predominant wind direction (well OW-10) and entry points to Hells Gate National Park through Olkaria (KWS Olkaria gate and Gate near well 22).

The occupational exposure limit (O.E.L) of H_2S in work places is 10ppm for an averaged 8-hour day. It is important to note that H_2S levels at Olkaria are far below the occupational exposure limit, maximum figure recorded was at the power station 4.40 ppm (Table 2).

Table 2. H_2S concentrations (ppm) at various locations around Olkaria I Power plant (Environmental BOC report 1999).

	W/S	P/S	Admin	SP1	SP2	W-10	W-22	KWS	LV
AV	0.02	0.5	0.05	0.16	0.2	0.09	0.06	0.02	0
MAX	0.8	4.4	1.3	2.8	3.4	1.3	1	0.2	0.1
MIN	0	0	0	0	0	0	0	0	0
MED	0	0.2	0	0	0	0	0	0	0

NOTE:

KWS: Kenya Wildlife Service
LV: LakeView Estate
W/S: Workshop
P/S: Power station
Adm: Administration
SP: Seal Pit
W: Well Site

Carbon dioxide, which is usually the major constituent of geothermal gas, and methane have been causing concern because of their role as greenhouse gases. However the carbon dioxide emission from geothermal plants is small compared to that of fossil fuel plant (Table 3) and therefore any energy production by fossil fuels that can be replaced by geothermal energy is environmentally desirable. Carbon dioxide and methane from geothermal is a negligible source. Minor gases that cause concern, i.e. Hg, NH_3 and B have not been found in dangerous concentrations in most of the geothermal plants in the world. At Olkaria these gases are not monitored in the emissions but are analysed in the geothermal wastewaters.

Separators (silencers) are often inefficient and large quantities of water may be ejected from them over large areas as spray containing substances as boron that are harmful to plant life at high concentrations and arsenic. Also high concentration of silica is deposited on the ground. The main potential pollutants in the liquid effluents and which are monitored on quarterly basis at Olkaria include, arsenic, boron, mercury, lithium, zink, lead and cadmium (Table 4). The concentration levels at Olkaria have been found to be below the optimum limits, above which these environmental components are considered contaminated or polluted. Surface disposal of such water may be quite hazardous and can cause damage to flora and fauna as substances like As and Hg have been known to accumulate in plants and animals. This will not be desirable considering that our developments are taking place in Hells Gate National Park. The most effective method of solving the pollution by geothermal wastewater (liquid effluent) is the reinjection of the spent fluids.

Table 3. Emissions of carbon dioxide and sulphur from some types of power plant (Armannsson, 1998)

Plant type	Specific	CO2 g/kWh	S g/kWh
Fossil fuel	Coal	1000	11
	Oil	850	11
	Gas	550	0.005
Geothermal	Steam	96	6
	HDR	0	0
Solar	SEGS	140	0
	Battery	0	0
Nuclear		<1	0
Hydropower		0	0

Table 4. Some chemical contaminants monitored at Olkaria.

	Li	Cu	Zn	As	Cd	Ba	Hg	Pb	B
Sludge	-	1.6	0.47	0.017	<1	0.167	0.001	0.6	-
Soil	0.4	1.63	13.5	-	0.123	5.1	-	3.05	-
Vegetation	0.7	0.54	10.3	-	0.03	1.2	-	1.25	-
Waste Water	1.28	<dl	<dl	-	<dl	<dl	-	0.1	5.1
Lake Water	<dl	<dl	0.02	0.001	0.001	0.001	0.001	0	0.11

8 Socio-economic effects

Olkaria geothermal project is located within Hells Gate National Park. Oserian Development Company, which grows cut flowers for export, is approximately 1.2 km to the north-northeast of the Olkaria II power plant whose construction begins in August. Lake Naivasha is approximately 5.3 km to the north. This shows clearly that

the project is surrounded by very sensitive Landuse systems. It is interesting to note however that Olkaria project has more positive impacts to the neighbours than many people think. Some of the positive impacts associated with this project include, the tarmacking of the Moi South Lake road, which has "opened up" the area. It has made Hells Gate National Park more attractive to tourists and the maintenance cost of vehicles has reduced drastically for all the road users attracting public transportation in this area, which was a problem before. It has been observed that most of the visitors who visit this Park are attracted more by the power plant than the animals. Olkaria project has provided free piped water to the local community (The Maasai), allows their children to go to the project school, incase of an emergency they can get health services from the dispensary. The project assists the community with transport from the station, as there are no public vehicles.. The observed negative impact is a temporary increase in employment and the importation of an outside labourforce during construction. This calls for various services, and it has been observed that this puts a strain on the traditional way of life and "leave a scar" when the construction work is completed. It is the wish of Olkaria project management not to have contractors staying in the residential areas together with company employees.

9 Monitoring programs

The following monitoring programs are carried out at Olkaria Geothermal project.

1. Monitoring of noise emissions at sensitive receptor sites
2. Hydrogen Sulphide gas monitoring
3. Meteorological weather monitoring
4. Precipitation chemistry monitoring
5. Chemical elements of environmental significance in wastewater, soil and vegetation
6. Monitoring of vegetation patterns
7. Potable water quality monitoring

10 The environmental management and co-ordination act, 1999

This act is operational. It is an act of parliament to provide for the establishment of an appropriate legal and institutional framework for the management of the environment and for matters connected therewith. The functions will be carried out by an Authority to be known as National Environment Management Authority (NEMA). This act may affect our operations by delaying our projects because of the many licenses, which will be required to be obtained unlike before this act. For example the following licenses will be required for geothermal development.

1. Environmental impact assessment license.
2. Effluent discharge license
3. Excess noise permit
4. Effluent discharge permit
5. Emission license
6. Disposal site permit

Another thing, which will affect geothermal development, is the penalties for polluters as the authority, which will be, formed will be entering any premise or land

and auditing their activities. This calls for the project to immediately put in place an effective Environmental Management System (EMS) and probably have the company seek ISO-14000 certification.

11 Conclusion

Geothermal energy is relatively clean energy source. The possible environmental impacts from its exploitation include surface disturbance, physical effects due to heat effects, emission of chemicals and socio-economic effects. All these impacts can be minimized. Putting in place monitoring programmes can check the unforeseen impacts, which only appear during operational phase of geothermal development. Olkaria geothermal project has not degraded the quality of the environment of Hells Gate National Park. To avoid problems with the new Environmental Management and Co-ordination Act KenGen requires to put in place an effective Environmental Management System (EMS) and seek ISO 14000 certification.

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