Integration of Environmental Management System in Monitoring of Environmental and Social Aspects Associated with Operation of Olkaria II Geothermal Power Plant in Naivasha Sub-county, Nakuru County, Kenya.

Philip J. Barasa
P.O Box 785 -20117 Naivasha, Kenya
pbaraza@kengen.co.ke.

Keywords: KenGen, Olkaria, Geothermal, Environmental Management System, monitoring.

ABSTRACT
Environmental Impact Assessment (EIA) is a legal requirement in Kenya as provided for by Environmental Management and Coordination Act (EMCA) 1999. Besides ensuring compliance with the law, Kenya Electricity Generating Company (KenGen) Ltd treats EIA as a tool to anticipate, manage and respond to environmental, social and health risks. The management actions arising from EIAs are usually defined and translated into an Environmental Management Plan (EMP) for the design, construction, operation and/or decommissioning phases of a project. To ensure a better understanding of cause effect relationships between the project and its environment and to improve EIA predictions and mitigation methods, environmental monitoring is necessary.

KenGen has integrated the International Standards Organization (ISO 14001:2004) Environmental Management System (EMS) in the management and monitoring of environmental and social aspects associated with its operations. This has positioned the company as an environmentally responsible corporate citizen thus enhancing its corporate image as well as building trust with the local community.

KenGen currently generates 430MWe of geothermal energy from four conventional power plants namely: Olkaria I, Olkaria I additional units, Olkaria II and Olkaria IV. Olkaria II power plant has a total installed capacity of 105MWe from three generator units each rated at 35 MWe. This paper seeks to highlight how monitoring of environmental and social aspects associated with the operation of Olkaria II power plant is undertaken by KenGen. Emphasis has been placed on how integration of ISO 14001:2004 into environmental monitoring has been achieved.

1. INTRODUCTION
Environmental Impact Assessment (EIA) and Environmental Management System (EMS) are both well known and well used environmental management tools all over the world. In Kenya, EIA is a legislated tool used to assess the positive and negative environmental impacts of a proposed project and its alternative options; and to propose measures to mitigate its potential negative impacts and enhance the positive impacts. The EMS, on the other hand, is a voluntary international standard used to manage environmental impacts on a continuous basis. In theory the information generated through the EIA enables the formulation of the EMS through which the impacts during implementation are to be managed. In practice, however, EIAs and EMSs are often used in isolation and the benefits of integrating the two are lost for many organizations (DEAT, 2004).

The EMS concept represents a fundamental change from the traditional reactive, compliance based environmental management programs to a proactive, impact-predicting management system that is focused on the mission and embedded in everyday business processes and mission activities (Office of the Federal Environmental Executive, 2004). In the case where a formal EMS is in place, an Environmental Management Plan (EMP) arising from EIA study can be used as the means to take the findings and recommendations of the EIA into the system, structure and procedures of the EMS (DEAT, 2004) like for the case of Olkaria II Power Plant.

An EMS provides a clearly defined and structured approach to managing environmental performance by following a “plan-do-check-act” continuous improvement process. Although many models and structures are used for an EMS, they all essentially address the following items (National Mining Association, 2012):

• Identifying applicable legal requirements, impacts, and risks;
• Implementing controls to manage those requirements, impacts, and risks;
• Monitoring the implementation of the controls and resulting performance over time; and
• Setting goals and taking action to ensure continuous improvement.

Figure 1 below provides a conceptual framework for integrating EIA with EMS.
Figure 1: Conceptual Framework for Integrating EIA with EMS (DEAT, 2004)

EIA process defines the relevant likely effects of development activity but an important strand, post-development, is the requirement for post-authorization monitoring (Telfer et al, 2009 and Tomas et al, 2004). Environmental monitoring can be defined as “the repetitive and continued observation, measurement and evaluation of environmental data to follow changes over a period of time to assess the efficiency of control measures” (Department of Water Affairs and Forestry, 2005a). It equally covers activities undertaken to ensure that environmental components are not altered by human activity beyond a specific standard or regulation level i.e compliance monitoring. Monitoring is undertaken on a continuous basis for the duration of the project, programme or activity – usually before, during, and after implementation of each project or programme (Tomas et al, 2004).

In order for the monitoring process to be effective, there is need to develop a monitoring program that is as specific as possible. This will ensure generation of measureable and comparable data that would help illustrate trends and allow decision makers to take any further action for mitigating adverse impacts (World Bank, 2012). The monitoring programme should identify objectives and specify the type of monitoring required. It should also describe environmental performance indicators which provide linkages between impacts and mitigation measures identified in the EIA report, parameters to be measured, methods to be used, sampling location and frequency of measurements, detection limits and definition of thresholds to signal the need for corrective actions (Southern African Power Pool, 2007). In the project context, environmental performance indicators are used as a management tool to help the project manager predict environmental change, mitigate or promote those changes, and follow the development in order to be able to manage the project in an optimal way from an environmental perspective (Swedish International Development Cooperation Agency, 2002).

The purpose of environmental monitoring is to detect change that takes place in the environment over time and involves the measuring and recording of physical, social and economic variables associated with development impacts (Department of Water Affairs and Forestry, February 2005b). The primary aim of monitoring is to provide information that will aid impact management; to help achieve a better understanding of cause-effect relationships and to improve EIA impact prediction and mitigation methods. Environmental monitoring is used to (Telfer et al, 2009):

• establish baseline conditions (a critical reference point);
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- measure the impacts that occur during project construction and operation;
- check compliance with agreed conditions and standards;
- verify the accuracy of impact predictions and determine the effectiveness of mitigation measures.

Environmental audits help in assuring the accuracy and relevance of environmental monitoring, and the identification of issues via the audit process may also lead to environmental standards that exceed regulatory requirements (Department of Water Affairs and Forestry, 2005a). EMS certification auditing involves both an internal and external component which creates a higher degree of confidence in the information by reducing potential risks and errors (DEAT, 2004). This is because a formal audit plan is usually developed to ensure that all areas of the site and EMS standard are audited with special emphasis on the areas with higher risk (National Mining Association, 2012). Audits are conducted less frequently than monitoring, often annually or biannually. Figure 2 below shows a flow diagram for post-decision monitoring after obtaining EIA license.

**Figure 2: Environmental Post-Decision Monitoring Programme (Tomas et al, 2004)**

The following section provides an overview on how monitoring of environmental and social aspects associated with the operation of Olkaria II power plant is undertaken by KenGen.

**2. DESCRIPTION OF OLKARIA II POWER PLANT**

KenGen currently generates 430MWe of geothermal energy from four conventional power plants namely: Olkaria I, Olkaria I additional units, Olkaria II and Olkaria IV. Olkaria II power plant has a total installed capacity of 105MWe from three generator units each rated at 35 MWe. Unit 1 and 2 were commissioned in September 2003 whereas Unit 3 was commissioned in June 2010. Unit 3 has been registered as a Clean Development Mechanism (CDM) project. The plant works on a single flash cycle with a steam consumption of 7.5 t/h/MW and has a total of twenty six interconnected production wells, four hot reinjection wells and two cold reinjection wells. The
turbines are single flow six stage condensing with direct contact spray jet condenser. The power generated is transmitted to the national grid via 220 KV double circuit line. Figure 3 below provides the flow diagram of Olkaria II Power Plant.

Figure 3: Flow Diagram Showing Design of Olkaria II Power Plant (KenGen Internal Report)

Plate 1: Photo of Olkaria II Power Station

3. LOCATION OF THE POWER PLANT
The power plant is located at Olkaria geothermal field in Hells’ Gate National Park on land leased from Kenya Wildlife Service (KWS). Figure 4 below shows the location of Olkaria II Power Station within Hells’ Gate National park.
4. ENVIRONMENTAL IMPACT ASSESSMENT FOR OLKARIA II POWER PLANT

Environmental assessment for Olkaria II unit 1 and 2 was carried out in 1994 (Sinclair Knight, 1994) as best practice as well as to ensure compliance with the project financier’s requirements. This is because National Environment Management Authority (NEMA) was established in 2000 following the enactment of the Environmental Management and Coordination Act (EMCA) 1999. However, a detailed Environmental and Social Impact Assessment (ESIA) for Olkaria II 3rd unit was carried out and a license issued by NEMA in 2006. The resultant Environmental Management Plan has been integrated into the EMS for Olkaria Geothermal Project hence ensuring commitment towards implementation of the recommended mitigation measures.

5. ENVIRONMENTAL PERFORMANCE MONITORING

Environmental aspects that were identified during EIA study have been evaluated, based on the criteria developed under EMS, to determine their significance. Following this, an environmental performance monitoring programme has been developed for significant environmental aspects as shown in table 1 below:

Table 1: Environmental Performance Monitoring Programme for Olkaria II Power Plant

<table>
<thead>
<tr>
<th>Environmental Aspect</th>
<th>Performance Indicator</th>
<th>Monitoring Frequency</th>
<th>Target</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hydrogen sulphide (H₂S) gas emission</td>
<td>Levels measured by a hand held hydrogen sulphide meter</td>
<td>Five times in a week</td>
<td>100% compliance with World Health Organization (WHO) standard for occupational level of 10ppm for an eight hour shift</td>
</tr>
<tr>
<td></td>
<td>Medical examination of some sampled staff</td>
<td>Quarterly</td>
<td>No adverse health to staff nor loss of life as a result of H₂S poisoning</td>
</tr>
<tr>
<td>Noise emission</td>
<td>Levels measured by a hand held noise meter</td>
<td>Five times in a week</td>
<td>100% compliance with the Factories and Other Places of Work (Noise Prevention</td>
</tr>
</tbody>
</table>
5.1 Description of the Monitoring Process

5.1.1 Noise Level Monitoring

During the operation phase of a geothermal power plant, the majority of noise is generated from the cooling tower and the turbine-generator building (Kagel et al, 2007). Noise levels are measured at the following points within and outside Olkaria II power station: compressor room, workshop, office within the workshop, hot well for unit 1, 2 and 3, cooling tower for units 1,2 and 3, administration office block, administration open office, turbine 1, vacuum pump, main oil pump, ejector, control room and at the KWS rangers’ residential quarters next to the gate. Measurements are taken by a hand held noise meter and recorded on a standard form. The values are then transferred into the computer, analysed and a detailed report disseminated to the management representatives on a daily basis. Trending of the data is undertaken on a monthly basis. At the same time, the noise meters are calibrated on an annual basis to ensure validity of the data. Noise measurements are done in order to comply with the provisions of Factories and Other Places of Work (Noise Prevention and Control) Rules, 2005. All noise hazardous areas have been identified and staff working in such areas undergo annual audiometric tests to determine the possible impacts of noise on their hearing ability.
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5.1.2 Hydrogen Sulphide Gas Level Monitoring

Hydrogen sulfide remains the pollutant generally considered to be of greatest concern for the geothermal community (Kagel et al, 2007). In confined spaces, human acute poisonings continue to occur. Single inhalation exposures to high concentrations of hydrogen sulfide cause health effects in many systems. Health effects that have been observed in humans following exposure to hydrogen sulfide include death and respiratory, ocular, neurological, cardiovascular, metabolic, and reproductive effects (World Health Organization, 2003).

Hydrogen sulfide gas emissions at Olkaria II power station are measured at the same points where noise levels are taken as indicated above. Measurements are taken by a hand held hydrogen sulfide gas meter and recorded on a standard form. The values are then transferred into the computer, analysed and a detailed report disseminated to management representatives on a daily basis. However, where the level is found to exceed the maximum recommended level of 10ppm for an eight hour shift, an alarm is raised based on the documented emergency response and evacuation procedure. Trending of the data is undertaken on a monthly basis and the hydrogen sulfide gas meters are calibrated on an annual basis to ensure validity of the data.

5.1.3 Coexistence With Wildlife in the National Park

Identification of components of biological diversity and monitoring their conservation status is an important step in the establishment of measures for their conservation and sustainable use (UNEP,2006). There exists an MoU between KWS and KenGen. The purpose of the MoU is to ensure harmonious co-existence of wildlife conservation and geothermal related activities. The MoU came into being on 8th February 2008 after Olkaria II unit 2 and 3 had been commissioned. A joint committee has been established to ensure proper implementation of the MoU. The committee meets at least once every quarter of the year. The MoU also provides dispute resolution mechanism. KWS organizes for animal censurs on quarterly basis and involves KenGen staff in the studies. The census reports are shared with KenGen to aid in decision making.

5.1.4 Monitoring of Accidents and Incidents

Accidents at Olkaria Geothermal Project have been categorised into three broad categories namely: motor vehicle, industrial and on the job personal accidents. All accidents and incidents including near misses are reported to the safety officer immediately they occur for the purposes of recording in the general register and conducting a detailed investigation as per the documented procedure. Investigation entails determination of root causes, recommendation of measures to prevent recurrence of similar incidents and improvement of safety performance at the site. These measures are communicated to the rest of the staff for compliance purposes. Investigation reports for fatal accidents are supposed to be forwarded to the Energy Regulatory Commission (ERC) within seven days from the date of occurrence.

5.1.5 Abstraction of Fresh Water from Lake Naivasha

KenGen has been issued a permit to abstract water for industrial and domestic uses from Lake Naivasha. Water is required for cooling towers after overhaul, emergency fire water tanks and in the washrooms and kitchens. The permit stipulates the quantity of water to be abstracted from the lake on a daily basis. To avoid conflicts with other water resource users, there is need to ensure adherence to the approved limit of abstraction. For this reason, flow meters have been installed at the abstraction points and consumption points. Readings are recorded on a daily basis on a standard form and trending done on a monthly basis to determine deviations and recommend appropriate corrective measures. The company also monitors lake levels on a monthly basis. The data assists the company to plan ahead following the gazettlement of Lake Naivasha Water Abstraction and Reserve Water (Gazette Notice No.809 of 25th January 2013) which restricts the volume of water abstracted when the levels drop below 1885.3 meters above sea level.

5.1.6 Geothermal Fluid Quality

Natural geothermal fluids contain varying concentrations of potentially toxic minerals and other elements and are extremely hot when they reach the surface of the earth. For these reasons, geothermal waters can be dangerous to humans and surrounding ecosystems (Kagel et al, 2007). Geothermal fluid generated from Olkaria II Power Plant comprise of brine and steam condensate. The two are disposed of by reinjecting into the reservoir through cold and hot reinjection wells.

Grab samples of a mixture of brine and steam condensate, separated from steam at some selected production wells, are collected on a quarterly basis and analysed in KenGen’s geochemistry and environmental laboratories located at Olkaria Geothermal Project. The samples are collected from separator stations connected to production wells. The physical and chemical parameters analysed include: pH, total dissolved solids, electrical conductivity, sulphates, chlorides, fluorides and trace elements comprising of mercury, arsenic lead, copper, lithium, barium, boron, zinc and cadmium. The test results are compared with the standards for discharge of effluent into the environment provided for by the Environmental Management and Coordination (Water Quality) Regulations, 2006.

Samples of soil and harbaceous vegetation are also collected, next to the conditioning ponds for the production wells, and analysed for elements of environmental significance (chemical parameters). Some control stations have been established in low use zone of Hells’ Gate National Park where there is no any geothermal activities taking place. The quality of samples of soil and harbaceous vegetation taken next to the conditioning ponds is compared with that of samples taken from the control stations in order to determine if pollution has taken place as a result of brine overflow. The analysis results are contained in the quarterly monitoring reports for geothermal fluid quality which is distributed out to the responsible persons for decision making.

Since the most appropriate way of disposing brine is via reinjection and not treatment, monitoring of brine quality is done to comply with the requirement of Geothermal Resources Regulation, 1990 which states that all licensees, which includes KenGen, shall maintain,
at the site of works, a record of the physical and chemical characteristics of fluids emitted from past and current bores/wells (Regulation No.18). On the other hand monitoring of the quality of soil and herbaceous vegetation is done to gauge the effectiveness of mitigation measures put in place to prevent environmental pollution.

5.1.7 Monitoring of Stakeholders’ Concerns

Concerns of stakeholders residing in the neighborhood of Olkaria Geothermal Project as a whole revolve around Corporate Social Responsibility (CSR). As a result, KenGen recognizes the role of CSR in creating a conducive environment for business sustainability. The Company has a written policy on CSR which provides guidelines for implementing in a systematic manner, activities that bring about meaningful improvements in the society. The core CSR programmes supported by the company include education scholarships at Primary and secondary school up to university level and environmental protection and improvement. Olkaria Operational Area has a CSR committee whose role is to:

i) Work with local communities, identify and propose CSR activities in the area

ii) Coordinate the implementation of local activities

iii) Act as a liaison point for addressing community/stakeholder issues and

iv) Propose to Central CSR Committee (at KenGen headquarters) activities that are beyond the area level mandate.

The committee is chaired by the operations manager and the secretary is one of the liaison officers attached at Olkaria Geothermal Project. Meetings are held on a monthly basis to discuss requests submitted by stakeholders and provide written feedback on the status of their approval as per the CSR policy. Continuous monitoring of performance of the CSR activities is undertaken with a view to using lessons learnt to improve future programs. Community concerns not related to CSR activities are handled by the Olkaria liaison section upon receipt of complaints. The approach entails one on one or focus group meetings with the concerned parties.

5.2 Standard Operating Procedures

In line with ISO 14001, KenGen has documented standard operating procedures for the identified significant environmental aspects to facilitate putting in place operational controls. The procedures clearly state what needs to be done and the person responsible for implementation. The procedures are reviewed on a regular basis and the current version uploaded on the KenGens’ intranet system for ease of accessibility.

5.3 KenGens’ Environmental Management Policy

KenGen has written corporate policies on environmental management and Occupational Health and Safety. These policies confirm the company’s commitment towards ensuring health and safety of employees and protection of the environment in which it operates as encapsulated in its vision and mission statements. The environmental management policy underwent the last review on 10th May 2012 whereas the one for OHS came into effect on 24th June 2013.

The environmental management policy reads as follows: “Kenya Electricity Generating Company Limited (KenGen) is fully committed to long term environmentally sustainable development that is consistent with National and International Standards that is consistent with generation of reliable safe, quality and competitively priced electric energy in the Eastern Africa region.

To achieve this commitment, KenGen shall:

• Maintain and continually improve its Environmental Management System (EMS) based on the ISO 14001 standard, prevent environmental pollution and mitigate environmental impacts resulting from its operations and related activities

• Comply with or exceed the requirements of all applicable laws, regulations, permit conditions and other requirements to which the organization subscribes to which related to its environmental aspects

• Conserve energy generation resources such as water, fuel, oil, coal, steam and biomass through application of the state of the art and methods

• Set and continually evaluate environmental objectives, performance metrics and targets

• Ensure its employees receive trainings on the EMS, key environmental impacts and responsibilities associated with their individual jobs

• Participate and promote projects and programs that contribute to cleaner production, for example clean development mechanism, green energy production, and others and therefore contribute to earths sustainability

• Communicate its environmental policy and performance to its employees and other stakeholders”.

5.4 Performance Audits

Six categories of performance audits are carried out at Olkaria II Power Station. The audits are summarised in table 2 shown below:
Table 2: Categories of Performance Audits Carried out at Olkaria II Power Plant

<table>
<thead>
<tr>
<th>Type of Audit</th>
<th>Frequency</th>
<th>Auditors</th>
<th>Regulatory/Certification Body</th>
</tr>
</thead>
<tbody>
<tr>
<td>Internal and external EMS certification audits based on ISO 14001:2004 standard</td>
<td>Semi annually</td>
<td>Internal and external auditors well versed with the standard</td>
<td>Bureau Veritas</td>
</tr>
<tr>
<td>Statutory environmental audits</td>
<td>Annually</td>
<td>Internal EIA/Audit experts registered with NEMA</td>
<td>NEMA</td>
</tr>
<tr>
<td>Statutory Occupational Health and Safety (OHS) audits</td>
<td>Annually</td>
<td>OHS Advisers registered with Directorate of Occupational Health and Safety Services (DOHSS)</td>
<td>DOHSS</td>
</tr>
<tr>
<td>Statutory fire audits</td>
<td>Annually</td>
<td>Fire Auditors registered with Directorate of Occupational Health and Safety Services (DOHSS)</td>
<td>DOHSS</td>
</tr>
<tr>
<td>Environment Health and Safety compliance audit</td>
<td>Annually</td>
<td>Compliance Officers from Energy Regulatory Commission (ERC)</td>
<td>ERC</td>
</tr>
<tr>
<td>Verification Audit for Olkaria II 3rd Unit registered as a Clean Development Mechanism (CDM) project</td>
<td>Annually</td>
<td>Designated Operational Entity i.e a third-party certifier</td>
<td>CDM Executive Board</td>
</tr>
</tbody>
</table>

Upon receipt of the audit reports, the safety and quality officer prepares a corrective action plan which ensures that the audit observations and Corrective Action Requests (CARs) are adequately addressed by responsible management representatives within a stipulated time frame.

Comments from stakeholders including the local community are gathered when conducting the annual self environmental audit for Olkaria II Power Station as provided for by the Environmental (Impact Assessment and Audit) Regulations, 2003. The approach entails face-to-face interviews and use of structured questionnaires.

6. MANAGEMENT REVIEW COMMITTEES

KenGen has established management review committees namely: Area Management Review Committees (ARMC) and a Corporate Management Review Committee (CMRC). The committees have the overall responsibility and authority of ensuring development, implementation, maintenance and monitoring of the EMS system. Olkaria II Power Plant falls under the Olkaria Geothermal Operation Area Management Review Committee. The committee comprise of all functional heads or their appointees and is chaired by the operations manager. The CMRC on the other hand is chaired by KenGens’ Managing Director and Chief Executive Officer and comprise of Divisional Directors, Area Managers and Quality and Safety Officers who are the secretaries to the AMRC. The analysed performance and environmental monitoring data and results of EMS certification audits forms part of the agenda of the meetings held at least twice in a year by the two committees. This provides an opportunity for continuous improvement brought about by the top managements’ commitment.

7. CONCLUSIONS AND RECOMMENDATIONS FOR IMPROVEMENT

Environmental monitoring ensures that progress towards the set targets is followed, that any necessary changes are made to the Environmental Management Plan (EMP) developed during EIA study and that achievement is celebrated and replicated in future geothermal projects. Integration of EMP into EMS ensures that environmental monitoring becomes a collective responsibility and an ongoing process within an organization hence realizing the benefits of integrating the two. Performance audits and management reviews contribute greatly towards ensuring continuous improvement of the monitoring process.

The following recommendations can contribute to the improvement of environmental monitoring at Olkaria II Power Station:

i. Contracting external parties to measure noise and hydrogen sulphide gas levels as well as carry out laboratory test results for the quality of brine, soil and herbaceous vegetation from the designated sampling points. This will help to validate the data and build confidence with the regulators and stakeholders.

ii. Installation of data loggers, in confined spaces, for continuous measurement of hydrogen sulphide gas emissions. The continuous data can be used to make meaningful decisions especially when faced with liability.

iii. All designated monitoring points should be geo-referenced and mapped to ensure consistency in data acquisition.
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iv. There is need to benchmark the performance monitoring process with other areas outside Kenya having intense geothermal activities e.g Iceland and United States of America.

v. Targets for reduction of fresh water consumed should be set in order for the monitoring data on the quantities of water consumed to be meaningful and

vi. The monitoring data collected should be trended on a regular basis so as to identify significant deviations from the acceptable values or set targets and carry out root cause analysis that will inform appropriate corrective actions.

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