UNITED NATIONS UNIVERSITY

GEOTHERMAL TRAINING PROGRAMME
Orkustofnun, Grensasvegur 9,
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Reports 2012
Number 27

IMPLEMENTING ISO 14001:2004 IN THE MENENGAI GEOTHERMAL PROJECT – A BENCHMARK FOR GEOTHERMAL PROJECTS IN KENYA, WITH EXAMPLES FROM ICELAND

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ABSTRACT

Sustainable development has become a critical component in the feasibility and implementation of projects today. Fostering a good environmental management system for geothermal projects in Kenya is aimed at ensuring that the delicate balance between resource utilization and environmental sustainability is achieved. Although geothermal energy is considered a 'green energy source', its exploration and utilization will cause land disturbances, noise and thermal pollution and the release of geothermal gases among other impacts. By careful environmental management during planning, design, construction and the operation of geothermal power plants and related facilities, negative impacts on the environment can be minimized and mitigated.

GDC has identified the ISO 14001:2004 system as a tool to aid in the management of environmental and social aspects of its operations. A road map for the implementation of the ISO 14001 Environmental Management System for geothermal projects in Kenya, managed by the Geothermal Development Company Ltd (GDC), is presented in this study report. A suggestion of the revision of the environmental policy of GDC is given. The report presents an analysis and the results of the initial environmental review as well as the legal framework for geothermal resource development in Kenya. The environmental aspects and mitigating measures of operations during various stages of project development are also discussed. The study further outlines the ISO 14001 planning and implementation processes and how the operations of GDC can be aligned with the requirements of the standard. The possibilities of cross-referencing with the existing ISO 9001 Quality Management System are also discussed. A cost-benefit analysis is also presented. It is important to note that a sound environmental management system is a requirement when soliciting project development funds from funding institutions.

1. INTRODUCTION

Prospecting for geothermal resources in Kenya began in the Mid 1950s with exploration data favouring the Olkaria area. This led to the drilling of two exploration wells, X-1 and X-2, which were not promising. In 1960, prospecting stopped and only started again in 1970 with funding from the United Nations Development Program (UNDP). Then well X-2 was tested. This marked the re-start of exploration drilling in 1973. A breakthrough occurred in 1975 with well OW-2 producing 3 MWe. More wells were drilled between 1975 and 1981 with surface exploration being sponsored by UNDP, British Geological Survey (BGS), Japan International Cooperation Agency (JICA), Ministry of Energy (MoE) and KenGen **(**Omenda, 2010).

Currently, Kenya´s installed capacity from geothermal power is about 209 MWe, with KenGen and Independent Power Producers (IPPs) generating 159 and 50 MWe, respectively (Cornel Ofwona, pers. comm.).

The development of geothermal resources has taken a new turn in Kenya with the Government‘s Vision 2030, which envisions the country as a mid-income economy in the next 20 years. This has seen the formation of, amongst other institutions, the Geothermal Development Company (GDC), which is a special purpose Kenyan government corporation that has concessions to develop some 14 geothermal fields in the country.

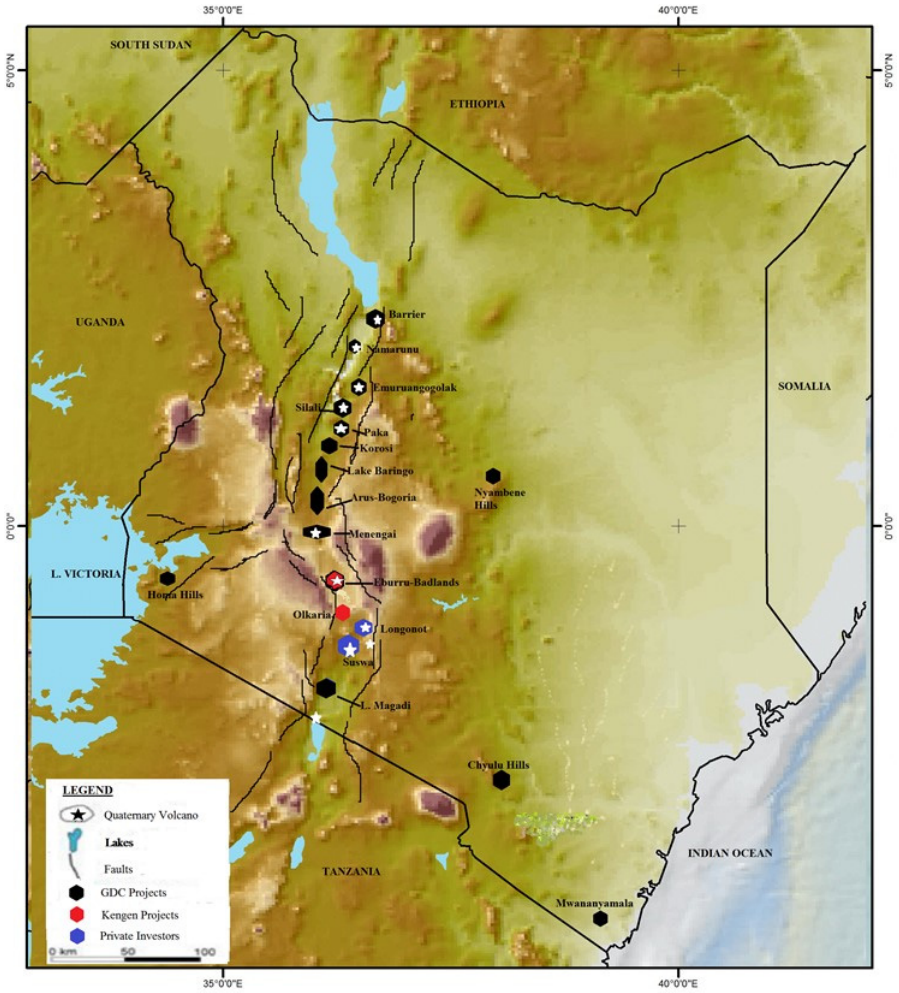

FIGURE 1: Geothermal prospects in Kenya

The various geothermal prospects in Kenya can be seen in Figure 1. The concessions of projects and prospects has been given to various companies, as illustrated in Figure 2. GDC has the concession for about 80% of the geothermal prospects in Kenya, KenGen has 10% and AGIL and WalAm Geopower have 5% each. The country plans to achieve over 5,000 MWe of electricity and additional energy for direct utilization in line with Vision 2030 (Kenya Government, 2012a).

GDC is mandated to promote rapid development of geothermal resources in Kenya through surface exploration, drilling for steam and delivering it to power plant developers for electricity generation, manage geothermal reservoirs; and to promote alternative uses of geothermal resources (GDC, 2007). The Menengai Geothermal Project (henceforth, Menengai) is GDC´s pilot

project. The project which is currently in the exploration drilling phase, has already seen the construction of a 32 km access road within the project area, drilling of 8 wells, four of which are discharging steam and a couple of other infrastructure activities.

The purpose of this report is to outline the process of ISO 14001 implementation for Menengai and other geothermal projects in Kenya that are managed by GDC. A preliminary review of the current environmental management practises at GDC is carried out to assess the compliance to the ISO standard. The project takes the GDC system through the modules and clauses of the ISO 14001:2004 standard. In each module, an analysis is given of what should be included in order to meet the ISO requirements. Possibilities of cross-referencing with the ISO 9001 system, which is already in place, are evaluated. The cost and other implications of obtaining an ISO certification for environmental management are also given.

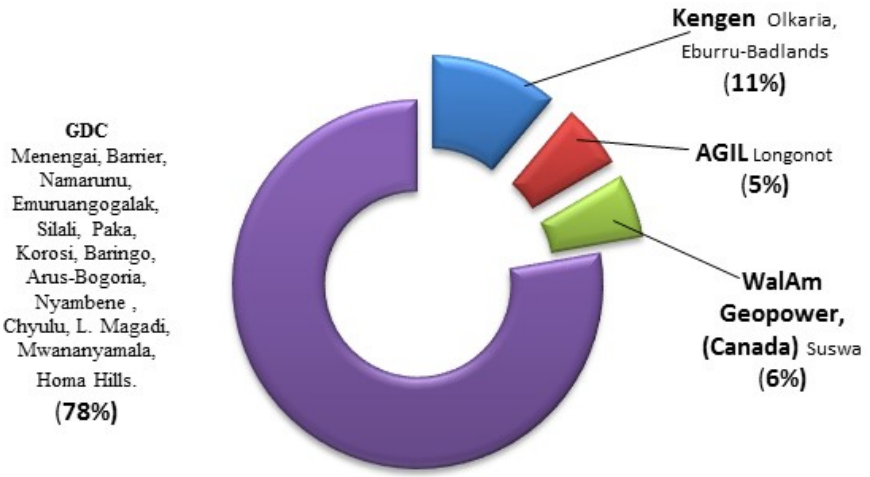

FIGURE 2: Concessions of geothermal projects in Kenya

2. HISTORY OF THE ISO 14000 ENVIRONMENTAL MANAGEMENT SYSTEM

The ISO 14000 series of environmental management systems came about due to the General Agreement on Tariffs and Trade (GATT) negotiations and the Rio Summit on Environment held in 1992. GATT was mainly concerned with the reduction of non-tariff barriers to trade, while the Rio Summit steered a commitment to worldwide protection of the environment. Environmental standards were already in existence in some developed countries. The British Standards Institution had BS 7750, the Canadian Standards Association had Environmental Management, Auditing, Eco-labelling and other standards, the European Union (EU) had all of these plus the Eco-management and Audit regulations, and many other countries (e.g. USA, Germany and Japan) had introduced eco-labelling programmes (Quality Network, 2012).

The ISO 9000 Quality Management System (QMS) was rapidly accepted over the world. The International Organisation for Standardization (ISO) assessed the need for intervention in international environmental management standards. Promoting a common approach to environmental management similar to the quality management system was the driving force behind the Environmental Management System (EMS). This would enhance an organization's ability to attain and measure improvements in environmental performance as well as facilitate trade and remove trade barriers. Therefore, the Strategic Advisory Group on the Environment (SAGE), which created a technical committee for international environmental standards, was formed in 1991.

The ISO 14000 series of standards which was first published in 1996 covered: Environmental Management Systems (ISO 14001), Environmental Auditing (ISO 19011), Environmental Performance Evaluation (ISO 14031), Eco-Labelling (ISO 14020), Product Life-cycle Assessment (ISO 14040) and environmental aspects in product standards (ISO 14062).

In 2004, revised ISO 14001:2004 and ISO 14004:2004 standards were published. These revisions improved the 1996 version, making it easy to understand, clearer in intention with an emphasis on compliance and compatibility with ISO 9001:2000. The ISO 14001:2004 revision includes a clarification of the requirements, alignment with ISO 9001:2000, more emphasis on certain requirements and the cross referencing of any additional requirements. This alignment was implemented to enable companies that wish to combine the QMS and the EMS, an ease of transition with the revision. The current revised version of the standard is ISO 14001:2004 integrates with the ISO 9000 series.

2.1 Why ISO 14001 for GDC?

Projects of such magnitude as those planned by GDC may have negative and unforeseen impacts on the environment if proper legislation and monitoring programmes are not put in place. Many companies are under pressure to do something for the environment and may embark on some form of environmental activity with many isolated procedures but no clear direction (Sturm, 1998). It is important to note that the formulation of policies and clear priorities is the most important step in environmental management. For this reason GDC has chosen the ISO 14001:2004 system of management to ensure that its goals of sustainable development are met.

ISO 14001 is not a standard that measures the environmental impact of the companies that implement it, but rather establishes the manner of systematizing and formalizing procedures related to the company's environmental impact processes. Consequently, ISO 14001 does not deal with objectives or results, but with procedures and work instructions. For most developing countries, this is a good enough step because EMAS (Eco-Management and Audit Scheme) and BS 7750 have very stringent requirements that would result in inflated project costs. From the point of view of management systems, it could be affirmed that one of the main differences between ISO 14001 and the other two standards (i.e. BS 7750 and EMAS) is the fact that ISO 14001 does indeed establish – however ambiguously – a reference to the compliance of certain environmental objectives, since it requires that companies must commit themselves to compliance with the basic environmental standards and regulations that they subscribe to (Marimon et al., 2009).

ISO 14001 has also gained more international recognition than EMAS which is widely used in the EU and the BS 7750 used in Britain. Whitelaw (1997) points out that EMAS is only an EU regulation and is unfamiliar to or not accepted by non-EU countries. In developing countries and especially Africa, ISO 14001 has been more widely acceptable than the other standards. In Kenya, ISO 14001:2004 has been introduced into the government performance contracts to enable organizations such as the GDC to obtain external confirmation of the adequacy of their environmental management systems and recognition that they are operating such systems (Ogola, 2008).

Chen (2004), in his comparison of EMAS and ISO 14001 for businesses in the United Kingdom, illustrated that the implementation of ISO 14001 is relatively cheaper and is less demanding on time and human resources, making it more affordable.

Evaluation of environmental performance at GDC has been based on a comparison of results for indicators on a temporal and site specific basis as well as comparison of results of different audits, and with results for other firms. The ISO 14031 standard on Environmental Performance Evaluation (EPE) will help provide the management of GDC with reliable and verifiable information on an ongoing basis, to assess the status of its environmental performance and identify areas for improvement as needed (Jasch, 2000).

3. LEGAL FRAMEWORK FOR GEOTHERMAL DEVELOPMENT IN KENYA

The development of geothermal resources requires compliance with relevant local, national, and international regulations to ensure sustainability. In Kenya, several Acts of Parliament have worked together to ensure that the geothermal resource is developed and used in a sustainable manner. These include the Geothermal Resources Act of 1982 and its supplementary legislation of 1990 and the Environmental Management and Coordination Act (EMCA) of 1999 with its associated regulations which are directly concerned with geothermal development. As discussed by Mwangi-Gachau (2011), other legislation may not be directly applicable to geothermal energy, but its implications affect geothermal development in one way or another.

In August 2010, Kenya promulgated a new constitution. In the constitution, all the Energy Acts, including the Geothermal Resource Assessment Act, have been consolidated into the Energy Bill 2012 and Energy Policy 2012. These new bills reflect the backbone of the new constitution which is vested in the devolution of power and natural resources. According to the bills, which are yet to be adopted as an Act by the Kenyan Parliament, the proposed net-benefit (profit)sharing from projects at county level is 80% for the investing company, 15% go to the county government, and 5% to the local community (Kenya Law Reports, 2012).

3.1 The Geothermal Resource Act of 1982

According to this Act, all unextracted geothermal resources are vested in the government subject to any rights which, by or under any written law, have been or are granted or recognised as being vested in any other person. No one is allowed to drill or carry out exploration in a gazetted geothermal area without the written authority or licence from the Minister of Energy and may be subject to certain conditions.

The regulatory aspect of the Geothermal Policy is provided for in the Geothermal Resources Regulations of 1990. It focuses on the drilling and licensing of geothermal wells. The Act was written to control the exploitation and use of geothermal resources, to vest the resources in the Government of Kenya, and to provide for related purposes. The Act defines terms commonly used in the exploitation of geothermal resources. This regulation stipulates the procedures to be followed by those who wish to explore, drill, extract and utilize geothermal resources.

For purposes of carrying out surveys, investigations, tests and measurements in search of geothermal resources, the Minister gives those involved a written one year authority subject to certain terms and conditions. The authority is not transferable but is, however, renewable. A geothermal resource licence may be granted for a period not exceeding 30 years, subject to certain set terms and conditions, and can hold for the whole or a part of a geothermal resource area. It may be renewed for a period not exceeding 5 years. The licence confers upon the licensee the right to explore, drill, extract and use and carry out anything reasonably necessary for conducting all those operations.

This Act further provides for a reasonable compensation to owners or occupiers of land in case of any disturbance, nuisance or damage to land, crops, trees, buildings, stock or works in the course of exploration or development of geothermal resources by the licensee (Kenya Law Reports, 2012; Mwawughanga, 2005).

3.2 The Environmental Management and Coordination Act of 1999 (EMCA) and associated regulations

The EMCA of 1999 provides for the establishment of an appropriate legal and institutional framework for the management of the environment in Kenya and for matters connected therewith and incidental hereto. Prior to its enactment, there was no framework for environmental legislation. Environmental management adopted a sort of piecemeal legislation with components being formulated largely in line

with other natural resource sectors i.e. Water Act Cap 372, Irrigation Act Cap 374, Kenya Power and Lighting Act Cap 48, Fisheries Act No 5 of 1989, Public Health Act Cap 242, Lakes and Rivers Act Cap 409, Land Planning Act Cap 303, River Authorities Act Cap 443, Local Government Act, Way Leaves Act Cap 292, Forest Act Cap 385, Antiquities and Monuments Act Cap 215 (Ogola, 2004).

Due to the emergence of some extreme instances of environmental degradation, other components such as environmental conservation were later grafted upon the structure of allocation and exploitation. EMCA 1999 enunciates in Section 3 that every person is entitled to a clean and healthy environment and has the duty to safeguard and enhance the environment. The Act's fundamental principles which essentially re-affirmed the environmental framework law in Kenya today include: sustainable development of the environment and natural resources, integration of environmental considerations into development and planning, precautionary measures to mitigate environmental degradation, promotion of public participation in environmental decision making and enforcement.

3.3 Environmental Management and Coordination regulations

Sections 92 and 147 of the EMCA give the Minister for Environment and Mineral Resources (with the recommendation of the National Environment Management Authority (NEMA) and in consultation with other relevant lead agencies) the authority to make regulations prescribing for matters that are required or permitted by this Act (Kenya Government, 2012b). The Regulations prepared and gazetted so far are briefly discussed in Table 1.

3.4 International legislation/conventions

Besides the national legislation, certain international guidelines govern the development of geothermal resources, especially with regard to project funding. Organizations such as the World Bank have categorized projects in their operational directive OP-4, depending on the adversity of their impacts on the environment (World Bank, 2007). Most projects in high temperature geothermal fields fall within World Bank Category A for projects that require environmental impact assessment studies. Other projects, such as those for direct utilization of geothermal resources, fall into category B due to their size, and may not require a full EIA. Other international funding organizations include the International Finance Corporation (IFC) which is a member of the World Bank Group, and The Equator Principles.

Kenya is also a signatory to several international treaties and conventions. Those deemed to have major implications on geothermal development include among others:

- The United Nations Framework Convention on Climate Change (UNFCCC): Its ultimate objective is to stabilize greenhouse gas (GHG) emissions at a level that would prevent anthropogenic interference with the global climate. UNFCC drew the Kyoto Protocol 1997 according to which the developed nations agreed to reduce their GHG emissions to an average of five percent against 1990 levels. A carbon trading system was introduced to compensate those countries that are initiating 'green' projects. Geothermal energy projects are prospective Clean Development Mechanism (CDM) projects, if implemented in place of non-renewable energy sources which are a significant source of GHG emissions (Ogola, 2010);
- The 1994 Convention for Biological Diversity, whose objective is the conservation of biological diversity, the sustainable use of its components and fair and equitable distribution of the benefits arising from the utilization of genetic resources. The convention seeks to protect biodiversity such as flora, fauna and avifauna which are common in geothermal areas;
- The Ramsar Convention on Wetlands of International Importance: Ramsar is mainly concerned with the conservation and management of wetlands and their resources. Geothermal resources in Kenya are located in areas with natural features such as lakes, calderas, hot springs etc. In Kenya, most projects are located within the Rift Valley where various Ramsar Sites exist such as Lakes Naivasha, Nakuru, Bogoria, Baringo, and Elementaita.

TABLE 1: EMCA regulations in Kenya (modified from Mwangi-Gachau, 2011)

Regulations	Highlights
EIA/EA Regulations, 2003 (Legal Notice No. 121)	It ensures that decisions on proposed projects and activities are environmentally sustainable. An EIA is conducted in order to identify impacts of a project on the environment, predict likely changes to the environment due to development, evaluate the impacts of the various alternatives on the project and propose mitigation measures for the significant negative environmental impacts. The EMCA 1999 requires that during the EIA process a proponent shall, in consultation with the Authority, seek views of persons who may be affected by the project or its activity. The goal of EA is to establish if proponents are complying with environmental requirements and enforcing legislation. The purpose of EA is to determine the extent to which the activities and programmes conform to the approved environmental management plan.
Water Quality Regulations, 2006 (Legal notice No. 120)	These regulations provide for the protection of lakes, rivers, streams, springs, wells and other water sources. The objective of the regulations is to protect human health and the environment. The regulations also provide guidelines and standards for the discharge of poisons, toxins, noxious, radioactive waste or other pollutants into the aquatic environment in line with the 3rd schedule of the regulations. Everyone is required to refrain from any actions, which may cause water pollution, whether or not the water resource was polluted before the enactment of the EMCA in 1999.
Waste Management Regulations, 2006. (Legal notice No. 121)	Waste Management Regulations are meant to streamline the handling, transportation and disposal of various types of waste. The aim of the Waste Management Regulations is to protect human health and the environment.
Conservation of Biological Resources, Access and Benefit Sharing Regulations, 2006	Kenya has a large biological diversity of ecological zones and habitats including 467 lakes and wetlands. This regulation seeks to increase the coverage of protected areas and establish new special status sites.
Controlled Substances Regulations, 2007. (Legal Notice No. 73)	This regulation defines controlled substances and provides guidance on how to handle them including licensing, materials safety data sheets, labelling, specifications, permits, declarations and penalties on contravention of these regulation.
Wetlands, River banks, Lake Shores and Sea Shore Management Regulations, 2009. (Legal Notice No. 19)	This regulation seeks to provide for the conservation and sustainable use of wetlands and their resources in Kenya; to promote the integration of sustainable use of resources in wetlands into the local and national management of natural resources for socio-economic development.
Noise and Excessive Vibration Pollution Regulation of 2008	The general provision of this regulation is that 'Except as otherwise provided in these Regulations, no person shall make or cause to be made any loud, unreasonable, unnecessary or unusual noise which annoys, disturbs, injures or endangers the comfort, repose, health or safety of others and the environment.
Air Quality Regulation; 2008	The objective is to provide for prevention, control and abatement of air pollution to ensure clean and healthy ambient air. It provides for the establishment of emission standards for various mobile and stationary sources as outlined in the EMCA, 1999. Emission limits for various areas and facilities have been set. The regulations provide the procedure for designating controlled areas, and the objectives of air quality management plans for these areas.
Forest Act; 2005	This act was ratified to establish the Kenya Forest Service (KFS). It contains many innovative means of forest management, including a strong emphasis on partnerships, the engagement of local communities, and promotion of private investment aimed at correcting previous short comings. Menengai is located in a forest reserve and a Memorandum of Understanding has been signed between GDC and KFS on the management of the resource.
Regulations waiting to be gazetted.	• Fossil Fuels Regulations, 2006. • Economic Instruments.

3.5 Local regulations

Most geothermal projects in Kenya are located within national parks or in areas of indigenous communities such as the Maasai, Turkana and Pokot. The development of resources in such areas requires adherence to certain local regulations which are not gazetted nationally. Even though the local demands may vary from one community to the next, they are generally based on the issues discussed below:

Stakeholder consultation requirements: Project stakeholders, who mainly constitute communities living in project areas, sometimes have issues relating to compensation or relocation. These have to be addressed before the projects can commence. A part of the human resource of the project will be from the local community;

Social amenities and other requirements: As most of these communities are generally poor, they usually demand that a part of the project funds will be used for constructing schools, hospitals, water boreholes and access roads.

The Energy Bill 2012 and Energy Policy 2012, if ratified by the Kenyan parliament, will give clear guidelines on the sharing of project funds. The bill proposes that project profit funds be shared among the project stakeholders in the following ratio: 80% for the investing company, 15% go to the county government, 5 % to the local community. This bill will bring an end to some of the problems usually experienced with communities in terms of project benefits and profit sharing.

4. THE ISO 14001 IMPLEMENTATION PROCESS

The process of implementing an EMS that is in line with other current standards like ISO 14001, BS 7750 or EMAS consists of seven modules, shown in Figure 3. The international standard is based on the methodology of the Plan-Do-Check-Act Cycle (PDCA), also widely known as the Deming Cycle. The modules and their interactions are given in Figure 3.

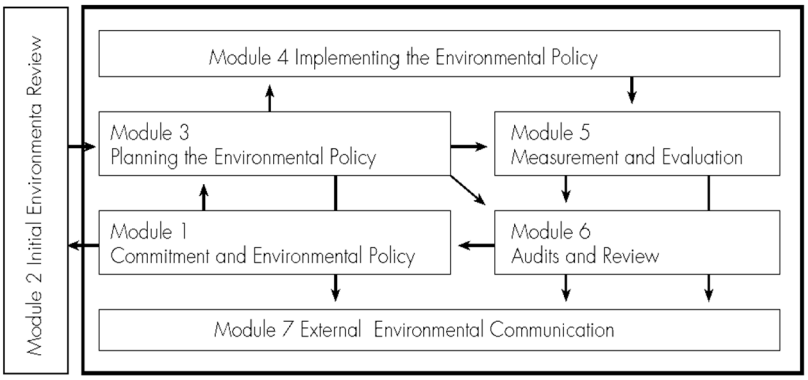

FIGURE 3: Modules of an Environmental Management System (Sturm, 1998)

The Deming Cycle, which is illustrated in Figure 4, can be described as follows:

Plan: Outlines an organization's environmental policy with its objectives and processes in order to achieve its results.

Do: The implementation of the processes.

Check: Continuous monitoring and measurement of an organization's process against environmental policy, objectives, targets, legal and other requirements.

Act: Outlines the actions taken to reverse negative impacts and continually improve the system.

The process of ISO implementation at GDC began in the year 2010 with the organization seeking certification of ISO 9001:2008 Quality Management System (QMS) from the Kenya Bureau of Standards. This initiated the training of personnel on ISO awareness and the recruitment and training of lead auditors. The documentation process followed soon after. A set of internal and external audits have been carried out to ensure that all processes are in line with ISO 9001:2008. GDC hopes to gain the quality management certification in 2012.

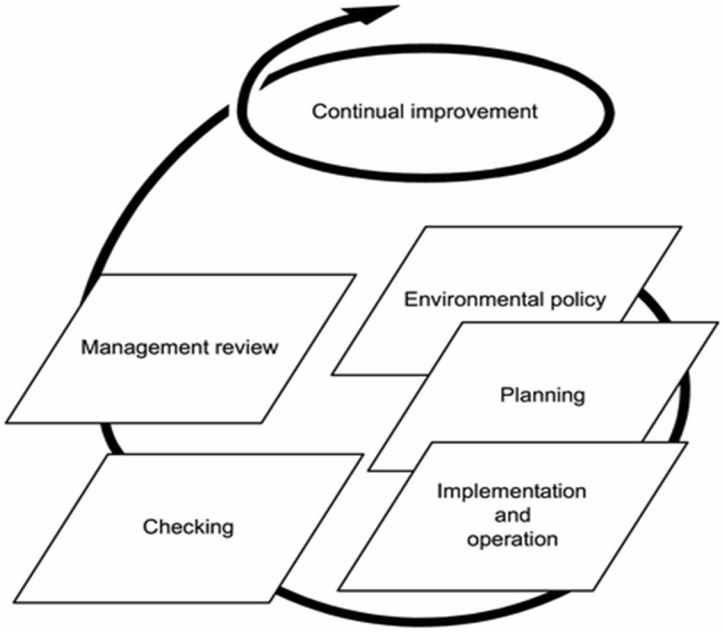

FIGURE 4: The PDCA cycle
(International Organization for Standardization, 2012)

Chapter 4 of the ISO 14001:2004 implementation manual introduces the requirements of the EMS in different sub-sections. In this report, clause 4 and its sub-clauses are discussed in a sequence as close as possible to their appearance in the standard.

4.1 Commitment and environmental policy

According to Sturm (1998), the commitment from the highest level of management should be argued on the basis of costs and benefit and on their impacts on shareholder value. He further quantifies a good policy statement as one that includes: continuous improvement in environmental performance; compliance with environmental regulations; and the maintenance of public relations regarding environmental issues of the organization, its activities, products and services.

In 2009, the management of GDC established an environmental policy for the organization. The GDC environmental policy is as follows: "*GDC shall conduct all its activities taking foremost account of the health and safety of its employees, contractors and the local community while paying proper regard to the environment."*

According to Chapter 4.2 and parts b) and c) of the ISO 14001:2004 standard, this statement does not meet the general requirements of a good policy statement. This policy statement does not include a commitment to continual improvement and prevention of pollution as well as a commitment to comply with applicable legal regulations that relate to the organization's activities.

This report suggests the review of the policy statement to read as follows:

GDC is committed to establish, implement and maintain an Environmental Management System whose focus for geothermal exploration, drilling and steam generation activities is on service improvement, prevention of environmental degradation and is in line with the stipulated national and local legislation.

GDC shall:

- *Maintain an EMS appropriate to the nature, scale and environmental impacts of its exploration and drilling operation and other related activities;*
- *Continually improve and prevent adverse impacts on the environment arising from its activities;*

- *Comply with relevant local and international environmental legislation;*
- *Set and review environmental objectives and targets as necessary;*
- *Document, implement and maintain its environmental management system;*
- *Communicate its EMS to employees, contractors, suppliers and other stakeholders;*
- *Present its environmental policy to the public.*

4.2 Initial environmental review

This step comprises the evaluation of the current system in order to determine the necessary changes to comply with the ISO 14001 demands. Based on this information, the organization knows its strengths and weaknesses, risks and opportunities and, thus, the initial EMS planning is established.

For the purposes of this study, an initial environmental review on the current status of environmental management at GDC was carried out using a set of questions adopted from Sturm (1998). The questionnaire is shown in Appendix 1. The objective of this survey was to assess the existing environmental management practices at GDC, the current situation and to forge a way forward in readiness for the ISO 14001 certification process.

The methodology adopted involved administering a set of questions to employees, suppliers and communities in the Menengai area. The questions in each sub-section are related to the relevant ISO 14001 clause and sub-clauses. A total of 25 answers were collected. 15 were from employees in the Environment and Quality Assurance departments, 5 from suppliers and 5 from project community members. The results of the initial review are presented in Figure 5.

From the 25 answers collected, those from the employees of the Environment Department scored rather positively for most modules. The samples from the Quality assurance department scored averagely. The samples from the suppliers and the community scored rather poorly for most modules. This can be attributed to inadequate communication of GDC policy and environmental objectives to other external stakeholders who are indirectly involved with GDC's operations. The ISO EMS requires that an organization avail its environmental policy to the public. Effective communication can be achieved through online postings, local events, and journals among others.

More than two thirds (2/3) of the answers collected, acknowledge a commitment by GDC's management to address environmentally related issues. They seem to be aware of the existence of an environmental policy, too. This can be attributed to posters, usually erected at all GDC operation areas, which project the company's policy and commitment. The Planning module performed rather averagely under all its clauses. The Environmental Monitoring Programs clause scored highest in this category, probably due to the occasional company and community-wide environmental campaigns carried out by the organization. Under the Implementation clause, Documents Control scored lowest, while Structure and Responsibility scored highest. Similarly, Measurement and Evaluation, Audits and Review and External Communication achieved average scores for all the various clauses. The lowest performing clauses were those for Environmental Systems Audit and Environmental Report, both with a below average score, 48 and 49%, respectively. This could be due to lack of publishing of annual environmental and audit reports, either online or through other media such as journals.

From this review, it is evident that there is some form of environmental activity in progress. According to Sturm (1998), such activity often involves numerous isolated actions but no clear direction. Most modules suggest an average performance. This can be attributed to the existence of the ISO 9001:2008 Quality Management System already adopted by the company. For an organization whose vision is to be a world leader in the development of geothermal resources, an average performance is not sufficient. Adopting a clear and internationally accepted management system for the environment will enhance GDC's competitiveness on the global platform.

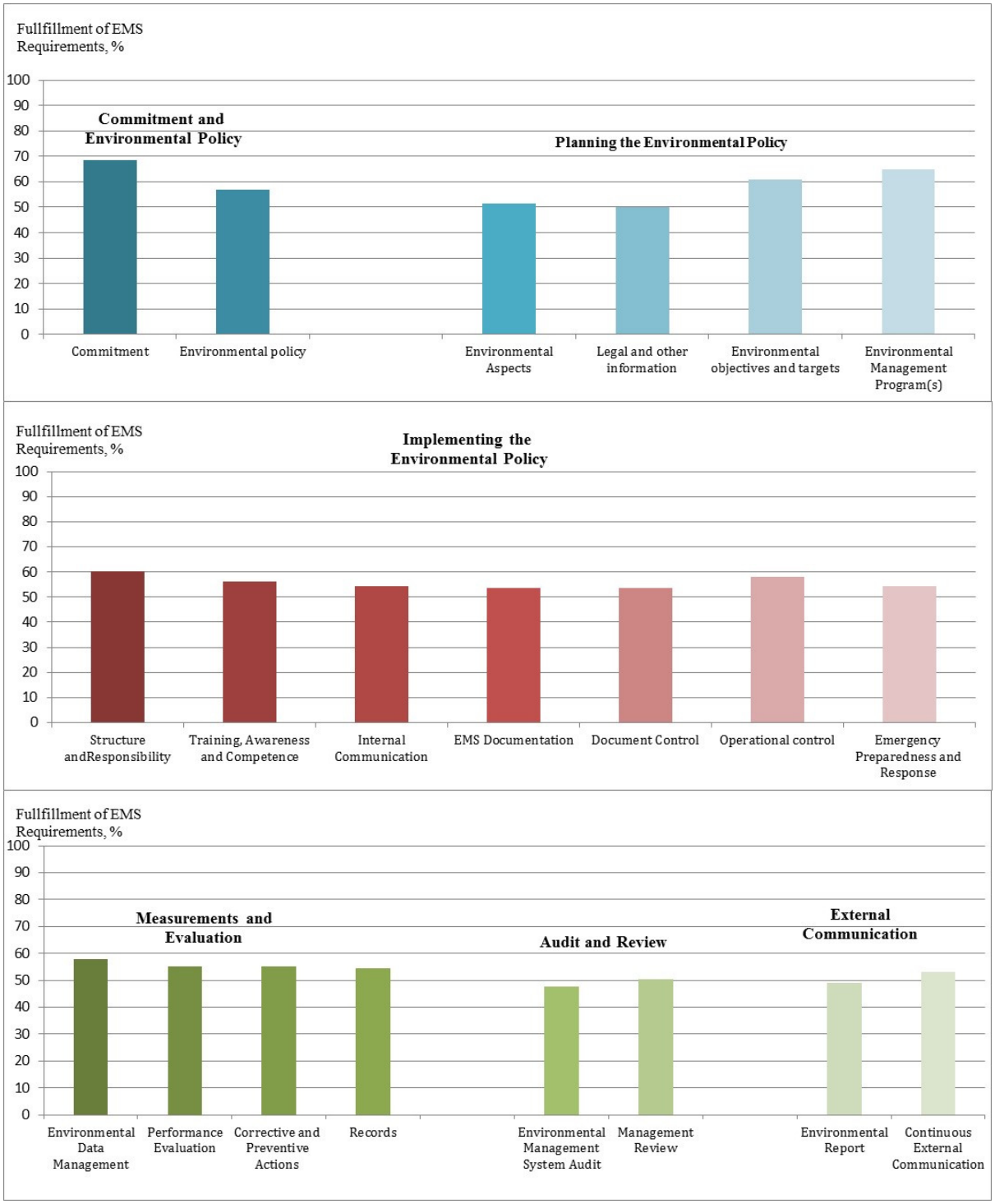

FIGURE 5: Average results of the initial environmental review

4.3 Planning the environmental policy

In accordance with the ISO 14001:2004, an environmental management plan with system elements under ISO 14004 should be formulated. The planning elements include: identification of environmental aspects, evaluation of associated impacts, legal requirements, objectives and targets as well as environmental management programs.

4.3.1 Environmental aspects of geothermal development

Numerous significant environmental effects have to be dealt with at each stage of the development of geothermal resources. The project cycle for the geothermal projects, as presented by Ngugi (2010), comprises four phases and nine steps. The phases are resource exploration, resource assessment, plant construction and operation phases. Figure 6 gives a brief overview of the stages and the environmental effects that can be encountered at each stage. GDC's mandate, however, does not cover power plant construction and operation and, therefore, significant effects at these stages are not discussed in this report. Identification of the environmental effects of a project at each stage is useful in setting the objectives and targets of an EMS. Some of the significant environmental impacts that may be experienced by GDC while exercising its mandated activities are discussed below:

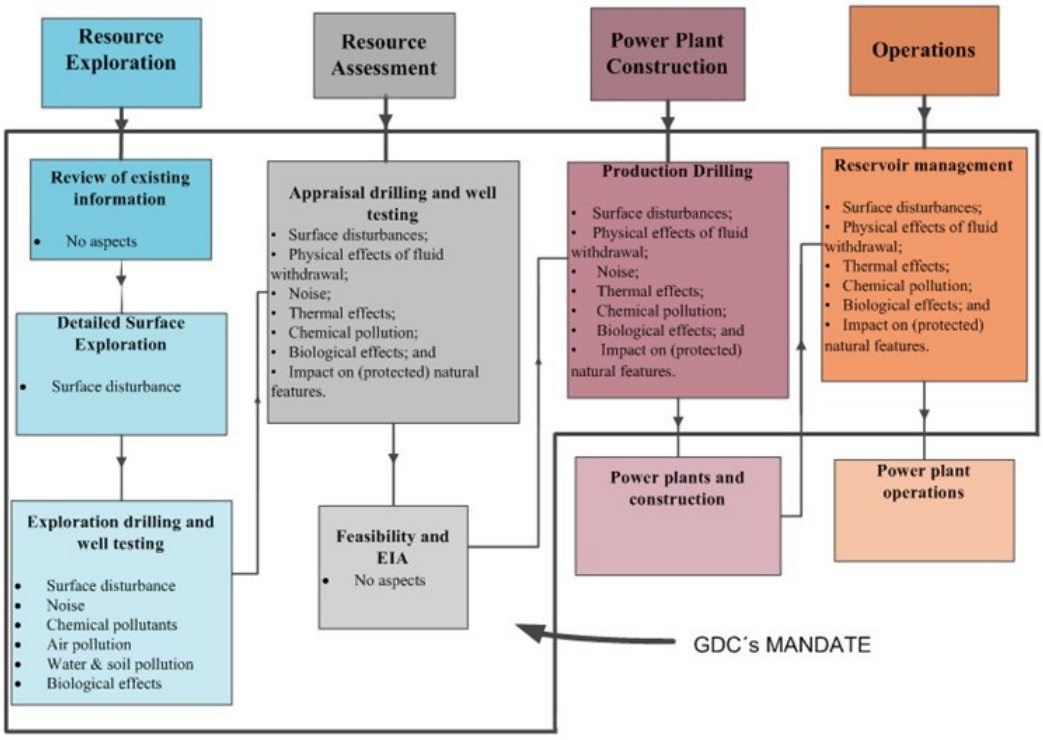

FIGURE 6: Environmental aspects of geothermal development

Emissions: The white plumes normally seen rising from geothermal wells and power plants usually consist of water vapour. The vapour normally contains gases such as hydrogen sulphide (H_2S), nitrogen (N_2) carbon dioxide (CO_2), methane (CH_4) and other non-condensable gases. In Menengai, H_2S gas from discharging wells, whose levels sometimes exceed permissible limits, is a menace to the surrounding communities, not just because of the pungent smell but also due to other effects. Table 2 shows the recommended threshold limits values, according to the Occupational Safety and Health Administration (OSHA), and the physiological effects on human health as well as the mitigating measures usually provided by GDC.

Vehicular movements and earth works during the construction and development of power plants, steam fields and transmission lines normally produce dust. This increases the particulate matter in the air which may lead to toxic inflammation of the lungs (Harrison and Yin, 2000).

As an organization that is seeking ISO 14001 certification, procedures must be put in place to communicate EMS compliance to other stakeholders including contractors. For EMS compliance, it is advisable to contract EMS certified companies to undertake earthworks and to design power plants.

TABLE 2: Threshold limit values for H_2S and possible effects on human health

Limit range (ppm)	Physiological effects	Mitigation measures
0.13	Odour threshold. Odour is unpleasant and causes sore eyes.	Normal
4.6	Strong intense odour, but tolerable. Prolonged exposure may destroy the sense of smell.	Normal
10-20	Causes painful eye, nose and throat irritation, headaches, fatigue, irritability, insomnia, gastrointestinal disturbance, loss of appetite, dizziness. Prolonged exposure may cause bronchitis and pneumonia.	Eye goggles recommended. Prolonged exposure discouraged.
50	May cause muscle fatigue, inflammation and dryness of nose, throat and bronchial. Exposure for one hour or more at levels above 50 ppm can cause severe eye tissue damage. Long-term exposure can cause lung disease.	Eye goggles and minimal exposure recommended. Use self-contained breathing apparatus.
100-150	Loss of smell, stinging pain in eyes and throat. Fatal after 8 to 48 hours of continuous exposure.	Evacuation
200-250	Nervous system depression (headache, dizziness and nausea are symptoms). Prolonged exposure may cause fluid accumulation in the lungs. Fatal after 4 to 8 hours of continuous exposure.	Evacuation
250-600	Pulmonary oedema (lungs fill with fluid, foaming in mouth, chemical damage to lungs).	Evacuation
300	May cause muscle cramps, low blood pressure and unconsciousness after 20 minutes.	Evacuation
300 to 500	May be fatal after 1 to 4 hours of continuous exposure.	Evacuation
500	Paralyzes the respiratory system and overcomes victim almost instantaneously. Death after exposure of 30 to 60 minutes.	Evacuation
700	Paralysis of the nervous system.	Evacuation
1000	Immediately fatal.	Evacuation

Noise: Noise is usually generated during earthwork construction, air drilling and well testing operations. The levels usually go beyond the ambient noise levels and, therefore, protective gear is recommended. The OSHA permissible daily exposure limits are shown in Table 3, above which protective gear is recommended. A standardised system of noise monitoring will ensure that equipment is adequately calibrated and levels are within occupational limits. Typical noise levels (in an approximate order of intensity) are:

TABLE 3: OSHA daily permissible noise exposure levels

Hours/day	Sound level (dBa)
8	90
6	92
4	95
3	97
2	100
1.5	102
1	105
0.5	110
≤0.25	115

- *Air drilling* – 120 dBa (85 dBa with suitable muffling);
- *Discharging wells after drilling* – up to 120 dBa (85 dBa with suitable muffling);
- *Well testing* – 70-110 dBa if silencers used (<60 dBa with suitable muffling);
- *Heavy machinery* (moving earth during construction) – up to 90 dBa;
- *Well bleeding* – 85 dBa (65 dBa if a muffler is used);
- *Mud drilling* – 80 dBa;
- *Diesel engines* (to operate compressors) – 45-55 dBa if suitable muffling is used (Aráuz T., 2011).

Solid waste generation and disposal: Geothermal projects usually generate a lot of solid waste, especially during construction of roads, well pads and other related infrastructure. Without clear

instructions on disposal, such wastes would form huge imposing piles. By developing clear procedures and work instructions on waste management, it is possible to control waste generation and safe disposal.

Water quality (chemical pollutants): The chemical pollutants usually found in geothermal steam and brine include hydrogen sulphide (H_2S), arsenic (As), boron (B), mercury (Hg) and other heavy metals such as lead (Pb), cadmium (Cd), iron (Fe), zinc (Zn and manganese (Mn), lithium (Li), ammonia (NH_3) as well as aluminium (Al) (Kristmannsdóttir and Ármannsson, 2003). The dissolved chemicals in spent geothermal fluids may find their way into streams, rivers and lakes if they are improperly disposed of, especially in project areas such as Menengai, where the surface rocks are highly permeable (Omondi, 2011). The contaminated water may percolate into streams and find its way to domestic water collection points. The excessive salting in these fluids may cause damage to the environment and can be harmful to human health.

The EMP adopted by GDC ensures that spent brine is pumped back into injection wells during production drilling so as to improve reservoir resilience and reduce surface water pollution. During exploration drilling when the wells are tested for a short period of time, the brine can be collected in large impermeable ponds, then tested before it can be released into local streams or rivers.

Water usage: Drilling operations require a continuous flow rate of 3600 litres of water per minute for drilling a 12 ¼" hole and 1800 litres per minute for an 8 ½" hole (Chemwotei, 2011). This amounts to approximately 2600 m^3 of water a day (24 hours) per well. By any standard, this is a large volume of water. At Menengai, numerous shallow water boreholes are drilled to provide water for this purpose. Care must be taken not to deplete the ground water because the local communities normally living around the project areas also obtain water from shallow boreholes for their livelihoods.

It is advisable that during the project design phase, engineers must monitor, test, and calculate the amount of ground-water in wells for sustainability in an area before drilling can commence. It is also possible to drill boreholes in areas further away from the drilling area and then pump it through a pipeline system to the geothermal field.

Fluid withdrawal/Injection effects: Reservoir operations normally require the withdrawal of large amounts of fluid from the reservoir in terms of steam and water. Unbalanced withdrawal of fluids may lead to land subsidence and consequently ponding, as experienced in the Wairakei geothermal field in New Zealand (Allis, 2000).

Induced seismicity, which is an important reservoir management tool, is also perceived as a problem, especially to communities that live near geothermal fields. Micro earthquakes, which are sometimes triggered by the brine injection, can be a nuisance to surrounding communities especially if they occur frequently. This was the experience with injection in Húsmúli area, west of the Hellisheidi production field in Iceland where injection triggered micro earthquakes of up to 6 on the Richter scale (Gunnarsson, 2011). This caused a lot of uproar with the neighbouring Hveragerdi community. A good EMS, if adopted by GDC, will see the installation of micro seismic monitoring stations around Menengai and other related projects, to warn of possible earthquakes.

Impacts on vegetation: Before geothermal construction can begin, an environmental review, usually carried out in the EIA phase, is required to categorize potential effects upon plants**.** Endangered species are identified and protected during the project development stages. Management should ensure that the best techniques available are used during power plant and steam field development stages to minimize the potential effects on the vegetation.

Impacts on protected natural features and wildlife: Geothermal prospects in Kenya are mostly located in places with protected natural features, and gazetted areas. Menengai is located in a forest reserve and is a habitat to many wild animals, Arus-Bogoria is home to the geysers of Kenya while Barrier which

extends into Lake Turkana is one of the most magnificent calderas in the world. Such features must be adequately protected during project development and production phases.

Surface disturbances: The effects of geothermal development on the surface usually take place during drilling, but will mostly disappear once drilling is completed and the drill rigs have been removed. At this point, the brine collection ponds are usually drained and the landscape reshaped. Surface disturbances caused by excavation, construction and the creation of new roads will accompany most new activities, but the area involved is relatively small. A typical drill site usually extends over 200–2500 m^2 (Kristmannsdóttir and Ármannsson, 1995). The area covered by drill sites can be kept at a minimum through new techniques like directional drilling of several wells from one drill pad. The power plants should be constructed strategically near the drill sites to minimize the use of steam pipes as well as visual impacts.

Stakeholder relations: Project stakeholders in geothermal development include resident communities, donors/investors as well as the project proponents. Communities that reside near geothermal projects have a significant say in project continuation. The involvement of these stakeholders at every developmental stage is important in gaining significant information on land owners and intervention areas. Maintaining a good proponent-financier-community relationship is mandatory for project continuity.

BS 7750 describes an Environmental Management Program (EMP) as a means of achieving environmental objectives and targets. It details what must be done, by whom, how and when, for each of the defined objectives and targets of high priority, by designating responsibility for achieving the objectives and targets, providing the means for fulfilment and by designating a time frame within which they will be achieved. As part of fulfilment of the EIA/EA for Menengai, an elaborate EMP must be drawn. The EMP for Menengai as proposed in the EIA document is shown in Appendix II.

4.4 Implementing the environmental policy and operation

Implementation and operation of an EMS is expected to be the most time consuming part of its establishment. Effective implementation calls for the development of necessary capabilities and support mechanisms to achieve its policy, objectives and targets.

4.4.1 Resources, roles, responsibility and authority

The management must ensure that all personnel in the organization are aware of the environmental policy, available management programs and the actual/potential impacts of their activities on the environment. GDC's strategic objective SO-4 clearly states that the organization shall recruit, develop and retain a highly skilled and motivated workforce (GDC, 2007). For this, GDC has employed specialised human resources for environmental studies. The organizational infrastructure continuously supports and maintains the resources available through budgetary allocations and scheduled training programs for such personnel.

The roles and responsibilities are defined and documented according to the ISO requirement. Authority is also communicated appropriately to all personnel in order to facilitate effective management.

Top management has appointed a specific management representative, the Manager of the Environment, whose role includes, among others, establishing, implementing and maintaining this international standard. This management representative reports to top management on the environmental performance for review, and includes recommendations for improvement.

4.4.2 Competence, training and awareness

Management must ensure that everyone in the organization is aware of the environmental policy, the EMPs and the actual or potential impacts of their activities on the environment. The initial environmental review carried out for the purpose of this study in Section 4.2 of this report shows that only about 55% of the people interviewed are aware of the policy and monitoring plans.

GDC should, therefore, embark on carrying out a training needs assessment with regard to the EMS and in depth training and awareness campaigns in order to equip all personnel with the competence to deal with their responsibilities.

4.4.3 Internal communication

ISO 14001 requires an organization to establish and maintain procedures for internal communication between various levels and operations of the organization. According to the initial environmental review, internal communication is scored at 55%. This indicates some lapses in the company's communication scenario. Possible communication strategies include: bulletin board postings, internal newspapers and brochures, meetings, electronic mail message, internal memos among others. It is important to note that at all levels, communication should be a two way process and the information conveyed should be understandable and adequately explained (GDC, 2010).

Communication also acts as a tool to demonstrate management commitment, raise awareness, deal with concerns and questions about the organization's activities, products or services, and informs interested parties about the organization's EMS and performance. Results from audits, management reviews and EMS monitoring should be communicated to those within the organization who are responsible for performance.

4.4.4 EMS documentation

According to the current EMS standards, an organization is required to document the management system for external auditing. This documentation includes a description of the basic elements of the system and their interaction. It also points to related documents which may include: process information; organization charts; internal standards and operational procedures; site emergency plans.

As explained earlier in this report, GDC is in the process of acquiring ISO 9001:2008 certification. This process has led to the streamlining of various procedures according to the standard including the documentation of environmental procedures and work instructions which are available for external auditing. ISO allows for cross referencing of documentation from one standard to another. This makes it easy to implement a subsequent ISO standard.

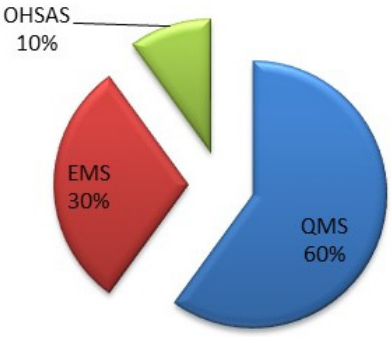

FIGURE 7: Inputs for the implementation of QMS, EMS and OHSAS

At Landsvirkjun - National Power Company of Iceland, the input required (in terms of cost, time, awareness, human resource etc.) to implement different ISO standards across all areas of operations declines with each implementation process (Ragnheidur Ólafsdóttir, pers. comm.). This relationship is illustrated in Figure 7. Implementing a QMS will require relatively large resources, but EMS and OHSAS (Occupational Health and Safety Assessment Series) less, due to sharing of core documentation, i.e. cross-referencing. This relationship can enable organizations such as GDC to estimate expected costs of future standards.

For GDC, cross referencing can be applied through EMS implementation with regard to the existing QMS documentation. In Table 4, therefore, the documented procedures currently in use by GDC under

TABLE 4: Relationship between the environmental management at GDC and the ISO 14001:2004 (based on Landsvirkjun, 2011)

ISO 14001:2004 requirements. *Documents that meet the needs*	4.1: Commitment and Environmental Policy	4.2: Initial environmental review	**4.3: Planning**	4.3.1: Environmental Aspects	4.3.2: legal and other requirements	4.3.3: Objectives and targets	**4.4: Implementing the environmental policy**	4.4.1: Structure and responsibility	4.4.2: Training, awareness and competence	4.4.3: Internal communication	4.4.4: EMS documentation	4.4.5: Document control	4.4.6: Operational control	4.4.7: Emergency preparedness and response	**4.5: Checking**	4.5.1: Monitoring and Measurement	4.5.2: Evaluation of compliance	4.5.3: Nonconformity, corrective/preventive action	4.5.4: Control of records	4.5.5: Internal audit	**4.6: Management review**
The environmental policy of GDC	x	o																			
GDC's goals		o				x					x										
Management responsibility								x													
Environmental Management System	x										x									x	
Procurement policy of GDC													x								
Division of responsibility								x													
Management of environmental aspects	x	o		x				x	x	x											
Analysis of environmental aspects		o		x	x	o										x				x	
External data and information					x														o		
Contract negotiations (Legal aspects)					x																
Budget plans	x							x	x					o		x					
Training of personnel					o				x		o			x						o	
Employment and retirement								x	o												
Archiving of the quality system												x									
Oversight and management planning of environmental aspects		o											x			x					
Steam production plans													x								
Project management								x					x								
Maintenance/calibration of equipment													x			x					
Response to human accidents, environmental accidents and dangerous conditions														x							
Response to emergencies and aspects that can have a negative impact on the environment														x							
Emergency management														x							
The management of measuring equipm.																x					
Complaints, pointers and improvements										x								x			
Preventive actions																		x			
Quality reports																			x		
Internal reports on quality and environmental management																				x	
Management review meetings								o								x		o			x

the QMS and their relationship with the ISO 14001:2004 standard requirements are presented. The symbol 'X' indicates an existing document in the environmental management under the QMS that meets the demands of the ISO 14001:2004. The symbol 'O' denotes a lapse in the documentation and the need

for the preparation of such documents. The general principle in Table 4 is that the EMS can adopt the use of existing documentation, e.g. clause 4.4.2 on training, awareness and competence, and can adopt the human resource documentation on the same that involves assessing the training needs of employees and then coming up with training programs. Clause 4.2 is rated 'O' in line with most other documentation because GDC has not carried out an initial review of all its processes. There is a need to prepare an initial review and incorporate it into the new documentation.

4.4.5 Control of documents

As vested in its principle of continuous improvement, ISO 14001 requires that EMS related documents be reviewed, revised and approved on a regular basis so that up-to-date information is available for the tasks being performed. The EMS stipulates that the organization establish, implement and maintain the following procedures:

- Approve, review, update documents as necessary for adequacy prior to issuance;
- Ensure that changes and the current revision status of documents are identified;
- Ensure that relevant versions of applicable documents are available at point of use;
- Ensure that documents remain legible and readily identifiable;
- Ensure that external documents are identified and their distribution controlled;
- Prevent the unintended use of obsolete documents.

Document control is a requirement under the QMS. As this is already taken care of under ISO 9001, further modification is not necessary.

4.4.6 Operational control

ISO procedures and work instructions are intended to systematize an organization's operations. Operations that have significant impacts on the environment must be standardized and monitored to ensure compliance. Table 5 shows the significant environmental aspects of GDC´s operations and the relevant work instructions and procedures as well as the equipment/instruments that are used in the monitoring processes.

TABLE 5: Procedures and work instructions for significant environmental aspects and the necessary monitoring tools

Environmental aspect	Procedure	Work instruction scope	Monitoring instrument/tools
Emission	Air quality monitoring (GDC/ESL/EHS/OP/009)	Monitoring H_2S and SO_2 gases.	Personal gas monitors such as PM200, GasAlert Extreme.
	Monitoring non-condensable gas (NCG) emissions in an operational geothermal plant. (GDC/ESL/EHS/OP/013)	Monitoring NCG such as CO_2, CH_4, NH_3 and Cl_2 emitted from an operational plant.	Personal gas monitors such as PM200, GasAlert Extreme.
Noise pollution	Occupational noise monitoring. (GDC/SM/QAS/OP/001)	Covers field and in-door monitoring of noise in the precincts of geothermal projects.	Hand held integrating-averaging sound level meters.
	Ambient noise monitoring. (GDC/ESL/EHS/OP/001)	Covers field monitor-ing of noise in the surroundings of geothermal projects.	Hand held integrating-averaging sound level meters.
Solid waste generation/disposal	Solid waste management (GDC/ESL/EHS/OP/010)	Management of wastes generated during site preparations, drilling and steam field devel-opment.	Waste segregation apparatus, centralised waste collection points, incinerators etc.

Environmental aspect	Procedure	Work instruction scope	Monitoring instrument/tools
	Disposal of polythene bags and bottles. (GDC/ESL/EHS/OP/011)	Waste sorting and segregation.	Solid waste segregating containers and collection points.
	Hazardous waste management (GDC/ESL/EHS/OP/005)	Covers the sampling, treat-ment and analysis of drilling mud, dam-aged chemicals, brine, silica sludge, cooling tower sludge and laboratory waste for pH (Acidity), Al, As, Cd, Cr (tot), Cu, Fe, Ni, Pb, Hg, Zn, oil and grease	Laboratory instruments. Perkin Elmer Spectrophotometer for B, As, Pb, Li, Hg, Cd, Cr (tot), Cu, Fe, Mg, Mn, K, Na, and Zn.
Water quality	Effluents quality monitoring (GDC/ESL/EHS/OP/002)	Covers the sampling of wastewater and brine (pH/20°C, Temp (°C), EC, TDS, Cl, F, B, H_2S, DO, Turbidity (NTU), TSS, As, Pb, Li, Hg, CO_3^{2-} and HCO_3^-, Cd, Cr (tot), Cu, Fe, Mg, Mn, K, Na, SO_4^{2-}, Zn) from the infiltration lagoons and temporary brine holding ponds around the operating geother-mal power stations in the geothermal fields.	Laboratory instruments: gravimetric tools for TSS, portable turbidity meters for turbidity, EC/TDS/DO/pH/ Temperature meter, Titration for Cl, Perkin Elmer Spectrophoto-meter for B,As, Pb, Li, Hg, Cd, Cr (tot), Cu, Fe, Mg, Mn, K, Na, and Zn, Selective ion electrode for F, titration with barium perchlorate for SO_4^{2-}, titration with dithizone solution for H_2S, titration with 0.1 N HCl for CO_3^{2-} and HCO_3,
	Precipitation chemistry monitoring (GDC/ESL/EHS/OP/007)	Covers collection and analysis of rain water for its chemical composition.	Laboratory instruments: Perkin Elmer atomic absorption spectrophotometer for B, As, Pb, Li, Hg, Cd, Cr (tot), Cu, Fe, Mg, Mn, K, Na, and Zn.
	Monitoring elements of environmental signifi-cance (sampling of water, soil and vegetation) (GDC/ESL/EHS/OP/003)	Analysis of pH/20°C, Temp (°C), As, Ba, B, Cd, Cu, F, Hg, Pb, Li, and Zn.	pH meters, thermometers, Perkin Elmer Atomic Ab-sorption Spectrophotometer.
Impacts on vegetation	Site rehabilitation (GDC/ESL/EHS/OP/009)	Covers site restoration from levelling, plan-ting grass, shrubs, and trees to building gabions.	Motor graders, shovels, gabion boxes, water bowsers, seedlings etc.
	Raising tree seedlings (GDC/ESL/EHS/OP/008)	Covers the manage-ment of medium- to large-scale tree nursery.	Nursery tools such as spades, rakes, pruners, watering cans etc.
Stakeholder relations	Involvement of stakeholders (GDC/ESL/EHS/OP/015)	Covers public participation of affected communities.	Public *barazas,* i.e. meetings.
	Community liaison (GDC/ESL/EHS/OP/016)	Continuous communication with affected communities and other stakeholders.	Stakeholder meetings, brochures and hand-outs, surveys etc.
	Identification of land owners (GDC/ESL/EHS/OP/017)	Negotiations of land that may be required for project development	Official land searches at the Ministry of land, land surveys, land valuations, land title deeds.
	Information on intervention areas. (GDC/ESL/EHS/OP/014)	How information is obtained and dissemi-nated to affected communities and other stakeholder	Early establishment of good rapport with local communities, administrative bodies, security personnel.

4.4.7 Emergency preparedness and response

Accidents and emergency situations are inevitable in any organization. This standard therefore requires that potential for accidents and emergencies be identified and appropriate procedures for response, developed. Such procedures must include the prevention and mitigation of the impacts on the environment and must be communicated internally and tested to make sure that the response is effective and efficient.

The GDC quality manual includes procedures for various accident and emergency situations that are related to geothermal development. They include: disaster response and evacuation, well blow-outs, oil spills and fires. Typical examples of emergencies in Menengai are the wild fires which usually occur during the dry seasons between December and March every year. GDC has responded adequately by having water boozers on site and training its technical staff in fire fighting skills.

A separate document on the Emergency Response Plan (ERP) has been developed and circulated to all personnel to equip them with action plans in case of an emergency. The plan details possible accidents, action plans, key personnel responsible for handling emergencies, contact information of response agencies such as medical personnel, police, fire department among others (GDC, 2011).

4.5 Checking

To ensure effective implementation, the EMS must be periodically checked and corrective/preventive action taken when needed. This can be effectively done through monitoring and measuring key operational characteristics, handling non-conformance by investigating the root cause, identifying and maintaining environmental records and by periodically conducting audits of the EMS for compliance.

4.5.1 Monitoring and measurement

All environmental interventions and their impacts on the environment have a variety of characteristics. In geothermal practices, these characteristics can be related to the results of monitoring and determination of chemical discharges, gaseous emissions, noise levels and others. According to ISO 14001, these properties must be measurable. This is implemented by building up an environmental inventory which includes all equipment used for monitoring and measuring. This equipment must be accurate and calibrated on a regular basis for data accuracy. A typical environmental equipment inventory for monitoring of geothermal projects would look like the one proposed in Table 6.

According to Hunt (2000), environmental monitoring in geothermal projects is necessary for:

- Data acquisition, which is a rationale for informed decisions by management, developers and regulatory authorities;
- Verification of the outcome of management decisions;
- Gaining public confidence in the environmental management process;
- Creating awareness of geothermal systems and how to develop them in an environmentally responsible manner.

4.5.2 Evaluation of compliance

Environmental performance is assessed based on the existing laws and regulations in three categories:

- *Assessment of environmental effects*: The effects of geothermal operations on the environment must be within acceptable limits;
- *Assessment of legal compliance*: Continuous assessment to ascertain that all operations are in compliance with the legal obligations set;
- *Assessment of eco-efficiency*: The environmental standards set by the company, must be economically viable for all stakeholders.

TABLE 6: Environmental equipment inventory list

	Equipment	Parameters monitored	Calibration/ maintenance schedule	Date of last calibration	Next calibration date
1	Hand held integrating - averaging sound level meter	Noise levels (dBa)	Annual	12/12/2011	12/12/2012
2	Personal gas monitor	H_2S (ppm)	Annual	12/12/2011	12/12/2012
3	Wind meter	Wind speed, wind direction	Semi-annuall	12/12/2011	12/06/2012
4	Gas monitor	NCG (CO_2, CH_4, NH_3, Cl_2, and SO_2)	Annual	12/12/2011	12/12/2012
5	Thermal imaging kit	Moisture content (ppm)	Annual	12/12/2011	12/12/2012
6	GPS receiver	GPS coordinates	Bi-annual	12/12/2011	12/12/2013
7	Relative humidity meter	Relative humidity (%)	Semi-annual	12/12/2011	12/06/2012
8	Temperature meter	Temperature (°C)	Annual	12/12/2011	12/12/2012
9	Refractometer		Annual	12/12/2011	12/12/2012
10	Confined space blower	Air quality	Bi-annual	12/12/2011	12/12/2013
11	pH meter	Alkalinity/acidity	Bi-annual	12/12/2011	12/12/2013
12	Radon test kit	Radon (pCi)	Bi-annual	12/12/2011	12/12/2013

4.5.3 Non-conformity, corrective action and preventive action

The ISO 14001 standard requires that when non-conformance occurs, the organization must be prepared to correct it and prevent re-occurrence. Focus must be on the root cause of the problem so as not just to identify it, but to understand why it happened. In order to do this, the findings, conclusions, and recommendations reached from monitoring, audits and other reviews of the EMS, should be documented and the necessary corrective and preventive actions identified. The flow chart in Figure 8 shows the process of correcting and preventing non-conformance. The process begins when non-conformity is detected in the system. It is detailed and the necessary corrective action determined. If the corrective action cannot be determined immediately, advice is

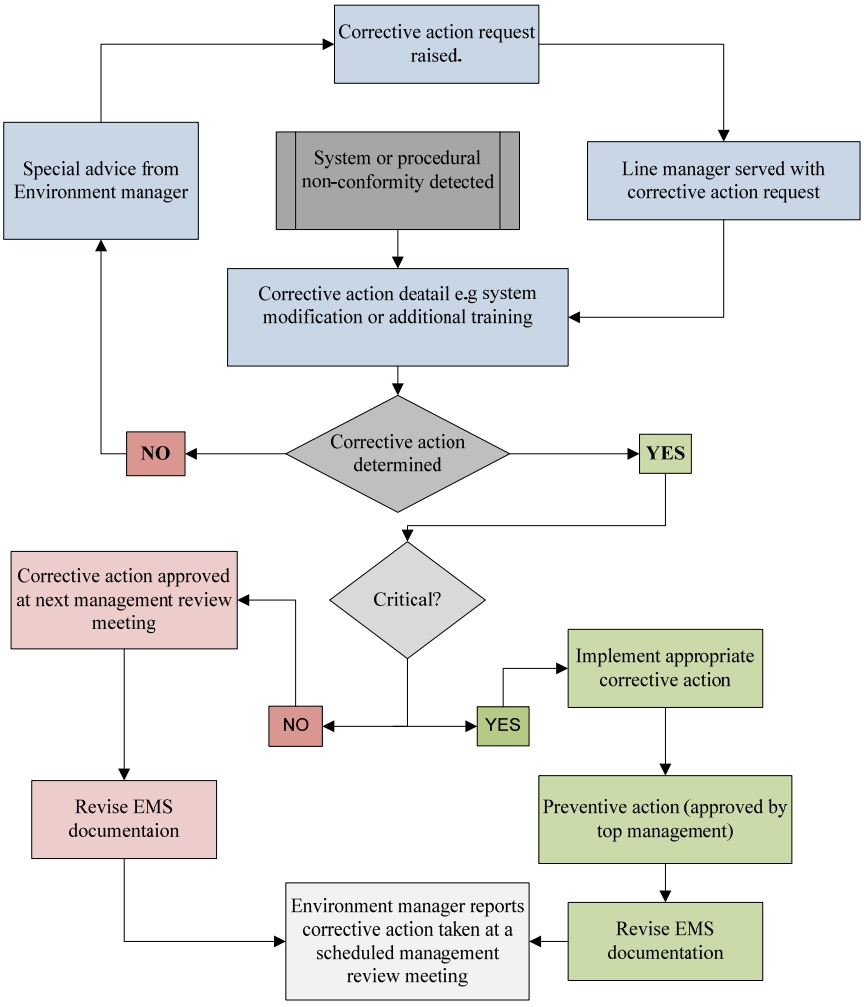

FIGURE 8: Corrective action/preventive action process (Modified from Tinsley, 2001)

sought from the management, who raises a request for the corrective action to the line manager. Once the corrective action is decided on, it is treated as either critical or non-critical. A critical non-conformance calls for immediate implementation of corrective and preventive action as well as the revision of the EMS documentation. A non-critical non-conformance can be decided on at the next management review meeting.

At GDC, experience with non-conformance to QMS involves the frequency of monitoring practices. Its environmental monitoring programs require round the clock data collection. This is mostly impossible due to a lack of automated monitoring systems and other logistics such as transport to site and human resources for monitoring practises. It is necessary to have automated monitoring systems, in which data is recorded remotely and then relayed to a system for processing.

4.5.4 Control of records

Records demonstrate conformance to the requirements of the standard. A procedure for identifying, maintaining and disposing of environmental records should be established. Environmental records include but are not limited to training records, results of audits and reviews, monitoring records (International Organization for Standardization, 2012).

Records are evidence for on-going operations of an EMS and should also cover: a register of environmental regulations, environmental effects, inspections, maintenance and calibrations, incident reports, product identification (MSDS), contractor and supplier information and emergency response records.

4.5.5 Internal audit

An audit, according to EMAS, assists management to control the work practices that have an effect on the environment, and to assess compliance. It is a systematic, documented, periodic and objective evaluation of the performance of an organization, management system and processes designed to protect the environment.

According to the initial environmental review carried out in this study, less than 50% of those interviewed were aware that periodic internal and external environmental audits are carried out by GDC. This could be a result of poor communication about audits or lack of integration of activities. ISO 14011 establishes audit procedures that provide for the planning and conducting of an audit of an EMS (International Organization for Standardization, 2012). With a good communication strategy like the one proposed by the EMS, information channels are established to ensure that each project group is well informed.

In Kenya, environmental responsibility is demonstrated through the EMCA 1999 and its associated regulations. The Environmental Audit (EA) Regulations of 2003 ensure that projects comply with recommendations of EIA after the planning stage. Funding institutions like the World Bank have developed guidelines for environmental audits in industrial projects, as documented in the Pollution Prevention and Abatement Handbook (World Bank, 1998). To accomplish this, the book recommends a collection of incentives and pressures to achieve sustainable improvements such as setting clear goals and objectives, agreeing on priorities, cooperating on approaches, sharing information, and setting realistic standards.

4.6 Management review

The ISO 14001:2004 standard requires that an organization's top management review the EMS, based on audit findings, at planned intervals, to ensure its continuing suitability, adequacy and effectiveness. It is desirable that top management carry out a review after each audit (both internal and external) so as to implement the audit recommendations.

5. COST-BENEFIT ANALYSIS

This report discusses the cost analysis and accrued benefits of implementing an EMS in an organization. The analysis was carried out at Landsvirkjun (National Power Company of Iceland) and Reykjavik Energy. Landsvirkjun is the largest electricity producer in Iceland and a majority owner of the national grid. Landsvirkjun's power generation is entirely based on production from hydropower and geothermal energy with a small backup systems based on fossil fuel. Landsvirkjun obtained ISO 9001, ISO 14001 and ISO 18001 certifications in 2003, 2006 and 2008, respectively. Reykjavik Energy, on the other hand, is a public utility company that provides electricity, geothermal water for heating and cold water for consumption to about 67% of Iceland's population. Reykjavik Energy acquired ISO 14001 certification in 2005.

5.1 Cost analysis

According to Landsvirkjun and Reykjavik Energy, the key costs incurred while introducing ISO 14001 into a company can be summarized as follows:

- *Registration fee:* This fee covers administration and paper work. It is usually non-refundable in case the organization decides not to progress or change the accreditation body;
- *Assessment fees*: There are at least three (3) assessment stages to final certification. The more enthusiastic the assessee is, the fewer the stages that are required to the final accreditation of the organization;
- *Annual audit costs*: These are mandatory under ISO 14001 guidelines. The audits are carried out semi-annually for the first two (2) years but annually thereafter;
- *Indirect costs*: These are usually associated with human resource training, technological changes, and support mechanisms for external consultancies and operational licenses.

ISO requires that an organization renew its annual subscription for the license in order to maintain the certificate. The dues paid by each certified member are in proportion to the country's Gross National Income (GNI) per capita and trade figures (International Organization for Standardization, 2012). According to the Kenya National Bureau of Statistics (2011) and Index Mundi (2012), the GDP for Kenya was estimated at 32 Billion USD. If all these factors are considered, then companies in Kenya would pay any amount between 2500 and 10,000 USD per year.

It is evident that the costs will vary from one organization to another depending on the number of employees, magnitude of operations, the level of enthusiasm, financial capability and compliance to set regulations. As depicted in Figure 9, the overall costs of ISO implementation will decline with time. The relationship can be described in the equations below:

$$Cost_1 = F_{REG} + F_{ASS} + 2F_{AUD} + F_{IND}^5 \quad (1)$$

$$Cost_2 = S_{ANN} + 2F_{AUD} + F_{IND}^4 \quad (2)$$

$$Cost_3 = S_{ANN} + F_{AUD} + F_{IND}^3 \quad (3)$$

$$Cost_4 = S_{ANN} + F_{AUD} + F_{IND}^2 \quad (4)$$

$$Cost_5 = S_{ANN} + F_{AUD} + F_{IND} \quad (5)$$

where $Cost_1$ = Annual cost for year 1, (2, 3, 4 and 5 for subsequent years);
F_{REG} = Registration fees;
F_{ASS} =Assessment fees;
F_{AUD} =Audit fees;
F_{IND} = Indirect costs;
S_{ANN} =Annual subscription.

5.2 Accrued benefits

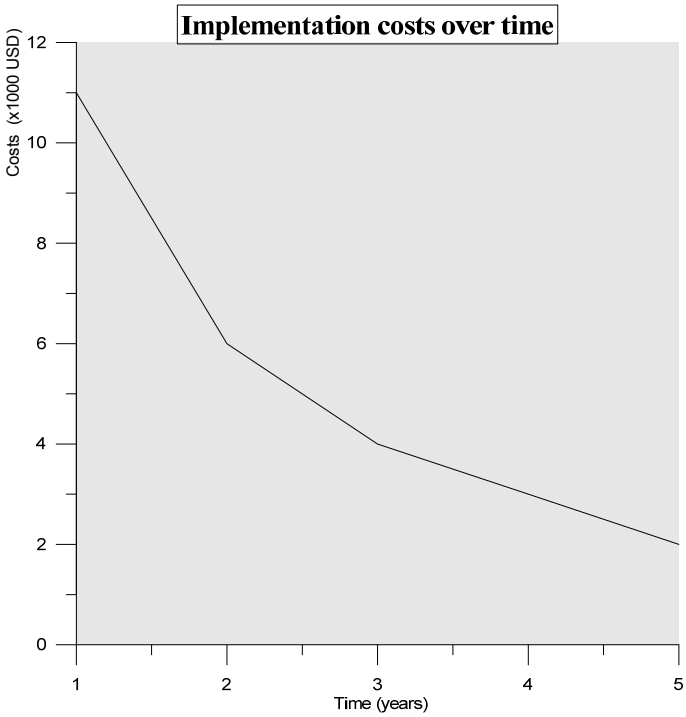

FIGURE 9: Costs of ISO implementation over time

Landsvirkjun and Reykjavik Energy enjoy a number of benefits since attaining ISO certification (Ragnheidur Ólafsdóttir and Hólmfrídur Sigurdardóttir**,** pers. comm.). According to these organizations, some of the benefits accrued include:

- *Streamlining operations*: This has led to the realization of monetary savings as a result of greater operational efficiency, reduction in the use of hazardous materials and minimized the generation of hazardous wastes;
- *Increased awareness and participation:* It has enhanced communication about environmental issues inside and outside the organization. ISO 14001 has given employees an avenue to raise environmental issues and makes it clear that environmental performance is an integral part of the corporate culture. Through ISO, the organization has documented, communicated and retained vital information;
- *A global communication platform*: ISO certification gives proof of environmental efficiency in the operation of the organization to foreign markets, investors, financiers and customers. This has enhanced competitiveness while giving stakeholders an assurance that the company will meet its EMS objectives and corporate policy requirements;
- *Improved relationships with regulators*: Both Landsvirkjun and Reykjavik Energy have reported improved relations with government regulatory agencies such as the Environmental Agency of Iceland. It is notable that regulators are quicker to provide technical support and much more supportive in general while, at the same time, a reduction in surveillance visits is noted;
- *Cost reductions*: Overall project running costs are reduced due to potentially lower insurance rates, reduced environmental liability, process improvement and energy conservation;
- *Safety benefits*: With regular reviews of procedures for controlling significant operations such as emergency preparedness and response procedures, the organizations have been able to identify and implement significant safety improvements.

5.3 Disadvantages

The implementation and accreditation process of ISO has some disadvantages. According to Reykjavik Energy and Landsvirkjun, these disadvantages mainly involve costs and time:

- *Costs:* ISO requires that an organization instils the importance of quality in all of its employees and processes to provide services which are of the highest quality possible. This can involve additional costs for training employees, purchasing new equipment and changing general processes. This can damage a company's profit margin, especially for smaller organizations.
- *Time consumption:* ISO accreditation requires the creating and filling of a lot of documentation and some changes in the work procedures. Saving time for such tasks can be a challenge, especially if the focus is shifted from creation of high quality products to paperwork.

6. DISCUSSION

GDC intends to explore and develop 14 geothermal sites in Kenya. To ensure that these resources are utilised sustainably, GDC must use tools such as the ISO 14001 to systematize the management of environmental and social issues in its project areas.

The process of implementing an environmental management system such as ISO 14001 requires the outlining of procedures and work instructions for the intended tasks. ISO does not endeavour to measure the environmental impacts of the activities of the companies that implement it, but rather, establishes the manner of systematizing and formalizing the impacts related to the organizations' environmental impact processes. The ISO 14001 implementation process involves the establishment of a commitment and a policy statement from an organization's top management. Planning the policy follows, and involves the identification of environmental aspects, legal requirements as well as the project's environmental objectives and targets. The implementation of the policy involves outlining the structures and responsibilities, creating awareness, internal communication, documentation, control of operations and documents as well as emergency preparedness. To ensure that the system is working adequately, checking must be carried out routinely through audits, monitoring programs, corrective/preventive actions and through the evaluation of compliance. The standard requires management to review the system every so often to ensure its suitability.

The legal framework for the development and exploitation of geothermal resources in Kenya involves the Geothermal Resource Act of 1982. The act bestows the authority over the resource on the government of Kenya whereby the government can issue exploitation licenses to developers for a period not exceeding 30 years. The EMCA and its associated regulations which were enacted in 1999 provided a framework for environmental legislation. The Energy Bill 2012 and the Energy Regulations 2012, if ratified by the Kenyan parliament, will give a holistic approach to the legislation that governs the exploitation and utilization of geothermal resources in Kenya. As Kenya is a signatory to various international legislations such as UNFCC, World Bank and Ramsar Convention on wetlands, government organizations such as GDC must be guided by such international regulations.

The environmental review carried out in this study indicates that little is known about the environmental policy of GDC by various stakeholders and that the outcome of environmental activity currently being carried out is not felt at all levels of the project's development. By improving the management system standard, GDC can raise awareness on environmental issues within all stakeholder groups.

GDC has already done a lot in terms of ISO implementation due to the QMS certification in progress. The documentation of procedures and work instructions that are related to environmental management can be cross-referenced. This will greatly reduce the input required for the EMS in terms of documentation, cost, awareness, and human resource among others.

The implementation of a standard such as ISO has pros and cons. It can be affirmed that the ISO certification gives a company a global communication platform for its customers, funding organizations, insurance companies and regulatory bodies among others. ISO leads to increased awareness of environmental issues as well as streamlining operations in an organization. Through ISO certification, an organization can experience a reduction in project costs due to lower insurance fees, reduced environmental liability, process improvement and energy conservation.

Some of the negative impacts that have been pointed out are high initial cost, especially for smaller organizations. The initial documentation and changing of work processes according to the stated work instructions can be time consuming.

7. CONCLUSIONS

- ISO 14001 is a flexible tool that gives an organization a holistic guide to the management of its environmental aspects. By setting its own targets and objectives, the organization can streamline operations through system sequencing;
- GDC must affirm its environmental responsibility in the management of about 80% of geothermal sites in Kenya to ensure project feasibility and sustainable development;
- The management of GDC should revise its environmental policy to meet the requirements of the ISO 14001 standard;
- The review indicates that environmental management at GDC is mainly felt within the organization. The dissemination of information to other project stakeholders needs considerable improvement;
- Environmental aspects of geothermal development and utilization at each stage should be analysed comprehensively and better monitoring plans adopted;
- Existing relevant documentation from the QMS can be cross-referenced with the needs of the EMS. Additional documentation is, however, needed to meet the demands of the ISO 14001;
- A comprehensive environmental equipment inventory list should be developed;
- Internal audits should be carried out as often as necessary and the results communicated to the relevant groups;
- It is desirable that top management carry out a review of the process after each audit;
- The initial costs of ISO certification are high, but the long term benefits accrued from the standard exceed the costs.

ACKNOWLEDGEMENTS

I wish to extend my gratitude to the Government of Iceland and the United Nations University Geothermal Training Programme, for the opportunity to participate in this training programme. My sincere gratitude goes to the Director, Dr Ingvar B. Fridleifsson and the Deputy Director, Mr Lúdvík S. Georgsson for their undivided dedication to this training. I am grateful to Ms. Thórhildur Ísberg, Mr Ingimar G. Haraldsson, Ms Málfríður Ómarsdóttir and Mr Markús A.G. Wilde, and all of UNU staff for their coordination of the training activities and for guidance whenever I needed it. I am grateful to the staff of ISOR and the Environmental Agency of Iceland for their unreserved information over the training period.

Special thanks to my company Geothermal Development Company, Ltd. of Kenya for giving me the opportunity to participate in this programme. My sincere gratitude goes to Mr Benjamin Kubo, the Environmental Manager at GDC for believing in my capabilities. To my colleagues at the Environment and Quality Assurance Sections, I am grateful for your support in terms of data collection.

To my dedicated supervisors, Dr Halldór Ármannsson and Mr Dadi Thorbjörnsson, this research could not have been completed without your guidance and input. Much appreciation goes to Ms Ragnheidur Ólafsdóttir of Landsvirkjun and Ms Hólmfrídur Sigurdardóttir of Reykjavík Energy for their generous information.

Finally, I would like to thank my family for their unwavering support and encouragement. And to my daughter Mich, who endured many days without mama, this report is dedicated to you.

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APPENDIX I: INITIAL ENVIRONMENTAL REVIEW QUESTIONNAIRE
(adapted from Sturm, 1998)

Environmental Management System aspect	**Document issue**	**Assessment** (0=very poor, 1=average, 2=good and 3=excellent)			
		0	**1**	**2**	**3**
Commitment	Top management has made a commitment to address environmental issues related to GDC's activities, products and services.				
Environmental policy	Top management has defined an environmental policy.				
	The environmental policy is appropriate to the nature, scale and environmental impacts of its activities, products and services.				
	The environmental policy includes a commitment to: a) Prevent pollution. b) Continuous improvement. c) Comply with environmental regulations and other requirements to which the organization subscribes.				
	The environmental policy provides a framework for setting and reviewing environmental objectives and targets.				
	The environmental policy is documented and communicated to all employees.				
	The environmental policy is available to the public.				
Planning the environmental policy					
Environmental aspects	GDC has established and maintained a procedure to identify the environmental aspects of its activities, products and services, in order to determine those which can have significant impacts on the environment.				
	The company has ensured that the aspects related to these significant impacts are considered in setting environmental objectives.				
	The information about significant impacts and related aspects is up-to-date.				
Legal and other information	The company has established and maintained a procedure to identify and have access to legal requirements directly applicable to the environmental aspects of its activities, products and services.				
	The company has established and maintained a procedure to identify and have access to other requirements to which the organization subscribes, directly applicable to the environmental aspects of its activities, products and services.				
Environmental objectives and targets	GDC has established and maintained documented environmental objectives.				
	The company has established and maintained documented and, whenever possible, quantified environmental targets.				
	The environmental objectives and targets are set for each relevant function and level within the organization.				

	When establishing its objectives, the organization has considered legal and other requirements, its significant environmental aspects, its technological options and its financial, operational and business requirements and the views of interested parties.				
	The environmental objectives and targets are consistent with the environmental policy and the required commitments.				
Environmental management programme(s)	GDC has established and maintained environmental management programme(s) for achieving its environmental objectives and targets.				
	The environmental management programme(s) includes responsibilities at each relevant function and organizational level.				
	The environmental management programme(s) includes the means and timeframe by which it is to be achieved				
	The organization has established a procedure to ensure that environmental aspects are included in projects relating to new developments of activities and projects.				
Implementing the environmental policy					
Structure and responsibility	GDC has defined, documented and communicated roles, responsibilities and authority.				
	The company has provided human and financial resources to implement and control the EMS.				
	The company has appointed a specific management representative who ensures that the EMS is in line with the EMS requirements and reports the performance to top management.				
Training, awareness and competence	The company has defined training needs for those personnel whose work may create a significant environmental impact.				
	Personnel at each relevant function and level are aware of a) The importance of meeting the requirements of the EMS. b) The environmental impact of their work activities and the benefits to improve performance. c) Their roles and responsibilities within the EMS. d) The potential consequences of departure from specific operating procedures.				
Internal communication	The organization has established and maintained a procedure for communicating between various levels and functions within the organization.				
EMS documentation	The organization has established and maintained information to describe the core elements of the EMS and their interaction.				
	The organization has established and maintained information to provide direction to related documentation.				
Document control	The company has established and maintained a procedure for controlling all EMS documents (properly filed, reviewed, up-to-date).				
	Procedures and responsibility are established and maintained to create and modify documents.				

Operational control	The organization has identified those operations and activities that are associated with the identified significant environmental aspects.				
	The organization has planned these activities (including maintenance) to ensure that they are carried out under specified conditions.				
Emergency preparedness and response	The organization has established and maintained procedures to identify the potential for and response to accidents and emergency situations.				
	The organization has tested these procedures and revised them after accidents.				
Measures and evaluation					
Environmental data management	The organization has established and maintained documented procedures to monitor and measure on a regular basis the key factors that can have a significant environmental impact. Monitoring equipment is calibrated and maintained.				
	The organization has established and maintained information about relevant environmental regulations.				
Performance evaluation	The organization evaluates and documents performance related to its environmental objectives and targets.				
	The organization evaluates and documents compliance with environmental regulations.				
Corrective and preventive actions	The organization has established and maintained procedures for defining responsibility and authority for handling and investigating non- conformance and for initiating and completing corrective and preventive actions.				
	The organization has established a procedure to implement and record any changes in the documented procedures resulting from corrective and preventive actions.				
Records	The organization has established and maintained procedures for the identification, maintenance and disposition of environmental records, including training records and the results of audits and reviews.				
	The environmental records are legible, identifiable and traceable to the activities, products and services involved.				
	The environmental records are stored and maintained in such a way that they are readily retrievable and protected against damage, deterioration or loss.				
Audits and reviews					
Environmental Management System audit	The company has established and maintained procedures for periodic EMS audits to be carried out, in order to determine whether or not the EMS: a) Conforms to planned arrangements for environmental management, incl. requirements of the EMS standard.				
	b) Is properly implemented and maintained.				
	The organization has established and maintained procedures for periodic EMS audits to be carried out, in order to provide information on the results of audits to management (including top management).				
	The audit procedures cover the audit scope, frequency and methodologies as well as responsibilities and requirements for conducting the audit and reporting the results.				

Management review	The organization's top management reviews the EMS periodically to evaluate the suitability, adequacy and effectiveness of the EMS.				
	The organization's top management reviews the EMS periodically to determine the necessity to implement changes to the EMS.				
	The review is documented.				
External environmental communication					
Environmental report	The organization publishes an external environmental report which covers the company's environmental policy, the objectives and targets, the environmental performance, the environmental management programmes and the structure of the EMS.				
	The environmental report is validated by external experts.				
Continuous external communication	The company communicates to stakeholders (communi-ties) about its significant environmental aspects, and records its decision.				
	GDC has established and maintained procedures to identify significant environmental aspects of company activities and has communicated relevant procedures and requirements to suppliers and contractors.				
	The organization has established and maintained procedures to identify significant environmental aspects of its activities and communicates the relevant procedures and requirements to stakeholders.				
	The organization has established and maintained procedures for receiving, documenting and responding to relevant communication from external stakeholders.				

APPENDIX II: EMP FOR MENENGAI

(African Development Bank (AfDB), 2012)

Environmental and social impacts	Proposed mitigation and aspects for monitoring	Responsibility for mitigation and monitoring		Monitoring mechanism	Frequency of monitoring
		During civil works, drilling and well discharge tests	After completion of drilling and well discharge tests		
Land acquisition and change in land use	• Draft and implement land lease with counties and purchase agreements with private land owners	Project proponent		Liaison with land owners and counties	continuous
Soils	• Control earthworks. • Control vegetation clearing and re-vegetate as required • Manage excavation activities • Undertake earthworks during dry season	Contractor	Project proponent	Inspections/ observations	continuous
	• Avoid disposal of effluents and chemicals onto soil surface	Project proponent	Project proponent	Inspection and sampling	Monthly inspec-tions and quarterly for sampling and analysis
Surface and ground water use and quality	• Avoid discharge of effluents or chemical into surface and water sources • Monitor surface and ground water quality	Project proponent	Project proponent	Sampling	Continuous
Air quality	• Maintain equipment • Sensitize equipment/machinery operators and drivers	Contractor and project proponent	Project proponent	Inspection and observation	Daily / random
	• Monitor non-condensable gases emissions • Monitor dust emissions • Monitor precipitation chemistry	Contractor and project proponent	Project proponent	Monitoring using H_2S logging equipment and personal toxic gas monitors	3 times a week
Noise	• Maintain construction and plant equipment • Control movement of vehicles after dark	Contractor and project proponent	Project proponent	Monitoring using sound level meters	Continuous
	• Provide and enforce use of PPEs	Contractor and project proponent	Project proponent	Monitoring using sound level meters	Continuous
	• Monitor noise levels	Contractor and project proponent	Project proponent	Monitoring using sound level meters	Continuous
Waste water	• Contain effluents and waste brine either in concrete or high density polythene lined ponds • Re-inject all brine discharges	Project proponent, Chief drilling and reservoir engineers and	Project proponent, Chief drilling and reservoir engineers and	Inspection and sampling	Inspection and weekly sampling of all waste brine

	• Monitor waste brine and other discharges quality	environmental technicians	environmental technicians		
Oil pollution	• Maintain plant and equipment • Prepare plans and procedures for proper handling of oil	Contractor and project proponent	Proponent and chief drilling engineer	Inspection	Continuous
	• Install interceptors in drainages • Bund oil tanks	Contractor and project proponent	Proponent and chief drilling engineer	Inspection	Continuous
	• Maintain oil interceptors	Contractor Proponent Drilling engineers	Proponent Drilling engineers	Routine maintenance	Follow maintenance procedure
Drilling chemicals	• Provide and enforce strict use of procedures and safety handling processes	Proponent Safety engineer	Proponent Safety engineer	Inspection	Continuous
	• Establish emergency response plans and response for chemicals spills	Proponent Safety engineer	Proponent Safety engineer	Plan available	Continuous
Solid waste	• Specify proper disposal of wastes • Monitor, segregate, collect, store and dispose all solid waste generated outside the site	Contractor and proponent environmental section	Contractor and proponent environmental section	Inspection and certification of completed work	Weekly and on completion of work
Flora	• Re-inject all effluents and brine • Control clearing of vegetation • Rehabilitate and re-vegetate all disturbed area	Contractor and proponent environmental section	Proponent environmental section	Inspection	Continuous
Fauna	• Control construction activities to limit habitat loss	Contractor and proponent environmental section	Proponent environmental section	Inspection	Continuous
Employment opportunities	• Consider local people for employment during construction. • Distribute opportunities to include women	Contractor and proponent	Project proponent	Appointment letters	Quarterly
Public nuisance	• Minimize air pollution • Notify public of disturbance through local leaders	Contractor and proponent	Contractor and proponent	Inspection	Daily
	• Erect danger warning signs	Contractor and proponent	Contractor and proponent	Inspection	When signs are erected
Visual intru-sions and aesthetics	• Use colours that camouflage the surrounding for pipelines, drilling and well discharge equipment • Restore/rehabilitate/re-vegetate all work areas to acceptable standards	Contractor and proponent environmental section	Proponent environmental section	Inspection	Daily/random