



## PROJECTS MANAGEMENT AT KENGEN, KENYA

**Paul K. Ngugi**

Kenya Electricity Generating Company Ltd. (KenGen)  
P.O. Box 785, Naivasha  
KENYA  
*pngugi@kengen.co.ke*

### ABSTRACT

Geothermal in Kenya is a national resource and has been developed predominantly for electric power generation. The Minister of Energy provides permits for exploration and licenses for exploitation of the resources. The Government through its main agents, the Ministry of Energy and KenGen identifies geothermal projects for funding and shapes the policy framework for geothermal development. Geothermal development in Kenya has been spearheaded by the geothermal unit within KenGen. The generated power is sold to the only power utility in Kenya, the Kenya Power and Lighting Company Ltd. Due to the highly capital intensive nature of geothermal projects, donor community have provided most of the capital requirements in this sector. Kenya has adopted a project cycle comprising of four phases and nine steps for geothermal projects implementation. The phases are resource exploration, resource assessment, plant construction and operation phases. The exploration phase is further subdivided to three development steps: review of existing information, detailed surface exploration and exploration drilling. The resource assessment phase is divided into two steps: appraisal drilling and feasibility study. The construction phase comprise two steps; production drilling and construction of the steam gathering pipe network, power plant and transmission line construction. The geothermal unit within KenGen has a well equipped and experienced staff for all the geotechnical disciplines and a well trained drilling human resource capability. Together they manage the geothermal projects at all the steps. However, KenGen hires consultants for peer review, feasibility study and supervision of the power plant construction. The project implementation environmental is increasing becoming regularized by various legislations that has strained the project management human resource capacity in addition to increasing the project costs and implementation time. The main challenges have been the perceived risks related to resource exploration and assessment, long development periods, high upfront capital requirements and inability to secure long-term and sustainable development funds. This is in addition to social economic, land access issues and environmental conservation as a limitation to operation requirements.

## 1. INSTITUTIONAL FRAMEWORK

### 1.1 The government

Geothermal in Kenya is a national resource and has been utilized predominantly for the generation of electricity. The Government through its agents has dominated the geothermal development from its

inception to date. The rights for utilization of geothermal resources are vested with the Minister for Energy. The Minister provides permits for exploration and licenses for exploitation of the resources. The Government is the major shareholder with 48% shareholding in the national power utility company, the Kenya Power and Lighting Company Limited. It is also the major shareholder in the major power generating company, Kenya Electricity Generating Company (KenGen) with a shareholding of 70%. KenGen has a market share of about 80%.

The Government has therefore identified geothermal projects through its key agents, the Ministry of Energy (MoE) and KenGen, sponsored them for funding through the donors' conference and facilitated their funding. In this way the Government has shaped the policy regulating the sector and dictated the rate of the development.

## **1.2 Geothermal development**

The geothermal development from its inception has remained within the energy sector. It is predominantly electricity generation oriented. Direct utilization has found limited application and is confined currently to traditional applications and greenhouse heating. The very first activities were carried out by a consortium including the East African power and Lighting Company, the predecessor of the Kenya Power and Lighting Company Ltd (KPLC). In 1977, the functions of geothermal development were transferred to the Kenya Power Company (KPC) which is the predecessor of the Kenya Electricity Generation Company (KenGen). KPC was a paper company wholly owned by the Government and managed by KPLC under a management contract whose main purpose was to attract cheap capital for development of power generation projects including geothermal. KPLC from about 1978 invested in the formation of the geothermal development unit through staff trainings and acquisition of the necessary infrastructure. This is the unit that spearheads geothermal development in Kenya to date. As a result of the power sector reorganization of 1997, KenGen was formed whose core function was generation of electricity. In this arrangement, the function for geothermal resources assessment reverted to the Government under the Ministry of Energy (MoE). However, the geothermal development unit remained within KenGen. The MoE has continued this mandate through a management contract with KenGen. Currently the MoE is carrying out development of a new geothermal field (Olkaria Domes) at Olkaria. The Energy Act of 2006 further reorganized the sector and forestalled the creation of Geothermal Development Company (GDC) wholly owned by the Government whose function will be the development of geothermal resources and sales of steam to power generators. GDC is to be formed in the next few months.

## **1.3 Power supply and distribution**

The Kenya Power and Lighting Company Limited is the sole power utility firm in Kenya whose role is to distribute and supply electric power. Bulk power suppliers enter into power purchase agreements (PPA) with the firm. The PPAs are subject to approval by the Energy Regulatory Commission (ERC).

## **1.4 Regulatory**

The energy sector is highly regulated. The regulatory function is vested with the ERC whose main objectives in relation to geothermal projects are to (i) regulate importation, exportation, generation, transmission, distribution, supply and use of electrical energy (ii) production, distribution, supply and use of renewable and other forms of energy.

The Commission's powers include to (a) issue, renew, modify, suspend or revoke licenses and permits for all undertakings and activities in the energy sector, (b) formulate, enforce and review environmental, health, safety and quality standards for the energy sector, in coordination with other statutory authorities, (c) approve electric power purchase and network service contracts for all persons engaging in electric power undertakings.

## 1.5 Donor Community

Geothermal projects are capital intensive. From the very onset of the geothermal development, Kenya enlisted the support of the donor community in funding and shaping the sector. In 1969, the Government of Kenya approached United Nations Development Program (UNDP) for an enhanced resource survey between Lake Bogoria and Olkaria. This led to the discharge of well X-2 previously drilled and the drilling of six additional wells by 1976. The success of this program had a defining moment in the development of geothermal in Kenya. This program was followed by the development and commissioning of the first geothermal Project in Kenya, the Olkaria I power plant. Since then, the donor community in particular World Bank through International Development Agency (IDA), European Investment Bank (EIB) and KfW of Germany has continued supporting the geothermal development by availing cheaper capital required for the development and training.

## 2. GEO-TECHNICAL PROCESS MANAGEMENT

### 2.1 Geothermal plans

Geothermal activities in Kenya are concentrated in the East African Rift System. The East African Rift is associated with the worldwide rift system. It is a divergence zone which is still active. The East African Rift system has been associated with intense volcanism and faulting which have resulted in development of geothermal systems. About fourteen (14) geothermal prospects have been identified in Kenya (Figure 1). In the recent past, KenGen jointly with the MoE have been carrying out detailed surface reconnaissance in at least one field per year starting from Olkaria, Suswa Eburru region which were explored in the past moving northwards. Surface exploration has now been done in Menengai, Arus-Bogoria, Baringo, Korosi, Silasi and Paka.

### 2.2 Ranking of geothermal prospects

KenGen has developed a criterion for ranking prospects which are at the same level of information, aimed at prioritizing fields for development purposes. The criteria evaluates the size, inferred resources potential in particular favour high temperature resources, social economic and environmental constraints and proximity to transmission lines.

### 2.3 Project cycle

The entire geothermal project cycle is summarized as shown in Figure 2 (Price Waterhouse Coopers, 2007). This cycle is utilized worldwide with minor alterations. There are four major phases and nine key steps in the development of geothermal project.

### 2.4 Data Review

The objective of this first step is to collate available data gathered overtime by various agencies involved in studies and research with the aim of identifying gaps on the information base and strategizing on further works. The scope of works entails a desktop review and analysis of existing data by various disciplines of earth sciences (geology, geophysics and geochemistry) and engineering



FIGURE 1: Geothermal prospects in Kenya

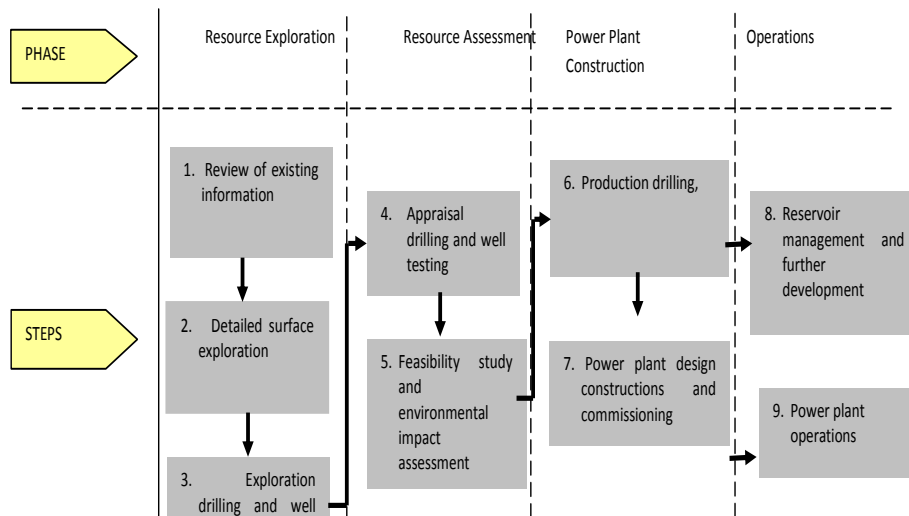


FIGURE 2: Geothermal development phases

(surface heat measurement). It has become increasingly very important that environmental considerations are brought in at this stage because in some cases it might stop future development. Some areas may not be developable because of being in traditionally prohibitive areas even though the resource itself is very attractive. The outcome of this step is an inception report recommending detailed surface work. This report would have technical reviews of all the available information and a detailed proposal for carrying out the work based on the desktop review. The report details the work program, duration, staff requirement, transport and the budget. KenGen has assigned this responsibility to its senior personnel and depending on the amount of information available, the work is completed in about one month.

## 2.5 Detailed surface exploration

The objective of this step is to define the resource by its key system characteristic namely: existence of a heat source in the form of hot magmatic body near earth surface, existence of hydrological system, its characteristics (i.e. flow direction) and geological structures controlling it and area extent of the prospect. Using the results obtained, three discovery (exploration) wells are sited. The scope of work entails field measurements, sample collections, laboratory tests, studies and analysis by various disciplines of earth sciences (geology, geophysics and geochemistry) and engineering (surface heat measurement). In addition, baseline environmental studies are undertaken. The main output from this step is a conceptual model of the geothermal system and the recommended sites for the exploration wells. KenGen through its staff has undertaken these studies in a period of about three months. An additional one to two months are taken in the office to carry out laboratory tests, data compilation and interpretation and writing of reports. KenGen often reviews the findings with Consultants who provide peer review services.

## 2.6 Exploration drilling

The main objective is to prove the resource inferred by the geoscientific studies by drilling a discovery well at the most probable location identified through the conceptual model and confirm the results with one or two additional wells. This step marks the beginning of the physical development on any prospects. The key activities in this step include: main access road and drill pad construction, establishment of drilling water and pumping installations. The pumping may be powered by diesel driven generators or electricity where economically accessible. Acquisition of land entry rights through negotiation for compensation or purchase is also carried out at this point. Other logistical requirements e.g. accommodation, storage, security, offices etc are addressed. Drilling and testing of

three discovery wells are the primary activities. Application of environmental permit is carried out as required by the Law.

For short distances of access roads, KenGen has used its internal capacity to carry out the civil works. For long stretches of access road, KenGen contracts out the earth works. The water installation works are also contracted out except operating and maintenance of the plants, which is done in-house. The drilling works can either be contracted or carried out internally depending on rig availability. The application for environmental clearance is done in-house.

The main output from these activities is the resource discovery through steam discharging wells and most importantly a go or no go decision for further development. KenGen consultants for peer review are also engaged in this step.

KenGen's experience and planning is that one year is allowed to undertake the initial logistical requirements. These include opening the area up by construction of roads, establish water supply system from surface sources or drilling of borehole and the related pipeline, pumping system and power sources. The period allows acquisition of land access rights and the compensation processes. Construction and installation of the required drilling storage facilities and security systems e.g. fencing, store house or containerized storage. Within the same period, initiate procurement of overseas materials and contracts for provision of local materials is undertaken. The material may require some advance preparation e.g. slotting.

## **2.7 Appraisal drilling and well testing**

Appraisal drilling follows a successful drilling exploration program. It is aimed at sizing the resource in terms of possible output necessary for power plant sizing, determining well productivity characteristics (average fluid output per well and steam fraction) necessary for determining cost of investments and drilling requirements, determining the reservoir fluids characteristics in particular, pressure at the surface (wellhead), dissolved solids that may lead to deposition and dissolved gas content which impact power plant performance and proving a certain fraction of required steam for a plant as a precondition for funding of production drilling and power plant construction. All the above data is obtained in preparation for feasibility study

The standard practice for KenGen is to drill and test six to nine appraisal wells. The main output is weaning of 30% steam requirement for a size of power plant necessary for soliciting for funding. In addition, data on the reservoir characteristics, steam quality and drilling issues

The drilling is carried out in-house if KenGen has an available rig. However, KenGen may contract a rig. In this case KenGen design the drilling plan and program and supervises the drilling process. KenGen has in recent past contracted drilling consultancy and supervision to beef up its capacity. The additional civil works are carried out in-house. This includes access roads, drilling pads, drilling fluids pits and well discharge ponds. Where earth moving equipment shortages are encountered, these are hired on short contracts.

The total duration takes about 15 months. Drilling takes about 12 months while testing of the last well is allowed 3months to heat up and be flow tested. The wells are estimated to cost about US\$ 4.3 per well including the civil works. Testing is estimated at US\$ 40, 000 per well

## **2.8 Feasibility study**

The main objectives of the feasibility studies are matching existing power plant technology to resource characteristics and establish a preliminary design, carrying out a financial and economic analysis to establish project viability. These include power pricing and project timelines. In addition, resource

management issues are identified that will arise during exploitation and how to mitigate them. Environmental scoping is also done at this point.

Feasibility study is mainly a desktop study. It essentially collates all the data so far accumulated and relates it to the proposed power project. One key aspect taken to consideration is simulation studies to establish sustainable resource exploitation.

The main output is a bankable document which KenGen and funding institutions have used for funding purpose. In addition the feasibility study proposes the appropriate technology to be used to optimize the resource.

This step has been contracted to consultants especially because of the comfort of the lending institutions. However, both KenGen's Board of Consultants and KenGen staff would review the reports. The feasibility study takes about six months and costs about US 2 million depending on the scope of the project.

## **2.9 Production drilling**

At this stage of development, a decision to construct a plant is already made. The drilling is therefore to provide sufficient steam to run the plant. Additional wells are drilled for reinjection purpose. One reinjection well is required for every 4 to 5 production wells.

There would be additional civil works at this stage to provide access roads to each well site, drilling fluid pits, construction of drilling pads and ponds for well effluent disposal during well testing. Wells would be drilled to provide sufficient steam plus about 10% excess at start-up and they would be tested.

All civil works would be carried out in-house. Drilling would be carried out both in-house and contracted depending on rigs availability. Well testing would be carried out in-house. A drilling consultancy and supervision may be considered to offer support to the existing drilling management staff.

The duration is subject to the number of wells to be drilled and each well is drilled in a period of about 60 days. Production drilling at Olkaria II power plant (70 MW) took about 4 year from 1988 to 1991. Currently, KenGen is using two rigs which would reduce the time by half. The wells are estimated to cost about US\$ 4.3 per well including the civil works. Testing is estimated at US\$ 40, 000 per well.

## **2.10 Power plant design, construction and commissioning**

The main objective is detailed design, procure and construct of the steam gathering system, power plant, sub-station and transmission lines. The scope work entails carrying out of detailed design for all the systems. A full environmental impact study is carried out at this stage. Using the designs, components, equipment and items are procured, manufactured installed and commissioned. Due to difficulties in managing the various contracts' interfaces, it is become more desirable to enter into engineer, procure and construct (EPC) contracts.

As soon as this stage commences, KenGen appoints a project team from within its staff. The project team contracts a consultant to supervise the contractor. KenGen and the consultants tender, shortlist and contract a contractor(s). The contractor designs, procures and install (EPC) the plants and its accessories.

It takes about 2 ½ to 3 years to design construct the power house, manufacture and ship the turbine and their accessories and to install all the equipment. The steam field and the transmission lines are constructed in parallel.

The power plant including the power house and all that goes into the power plant are estimated at US\$ 2.5 million per MW for plants less than 50 MW, US\$2.3 million those between 50 and 100 MW and US\$1.8 Million for plants size larger than 100 MW. The steam pipeline cost is estimated at US\$ 25 million for a 70 MW plant.

**2.11 Reservoir management**

After commissioning of the power plant, exploitation of the resource with time results to changes in terms of the reservoir pressures, well outputs and the chemistry of the well effluents. Monitoring is programmed to ensure steam availability to the plant, manage pressure drawdown and forestall scaling problems. The work entails regular measurement of well productivity, wellhead pressure and chemical composition of the well effluent. It may involve tracer injection and cold re-injection activities. KenGen has carried out these requirements internally. The programs continue for the entire generation life of the plant.

**2.12 Operations**

This stage entails the operations and maintenances of the power plant to ensure continuous generation. At an opportune time during the construction phase of the plant, KenGen engages operation and maintenance staff who are then trained during the construction and commissioning of the plants.

**3. ORGANIZATION**

**3.1 Management Function**

Figure 3 shows the functional organization chart used in geothermal development in KenGen.

The management function cut across many levels within the organization right from Board of Directors, Executive Directors to the local management headed by the Geothermal Execution Manager. The local management takes responsibility of all the technical and implementation aspects of all geothermal projects while higher management levels provide policy and directions.

**3.2 Training**

Geothermal development requires highly skilled labor not generally found within the Country. Until 1990, geothermal development in Kenya totally depended on expatriates on a fulltime basis (Mwangi, 2006). From 1981 to today, Kenya has keenly trained its local staff who now oversee the geothermal development. The first three Kenyans were trained in Iceland in 1982 and by 2004, 35 Kenyans had been trained in Iceland alone. Other institutions that have offered training are Pisa (Italy), Auckland University (New Zealand) and Kyushu University (Japan). Kenya has also developed a geothermal training institute which in particular has been used to train drilling operations staff. Currently Kenya

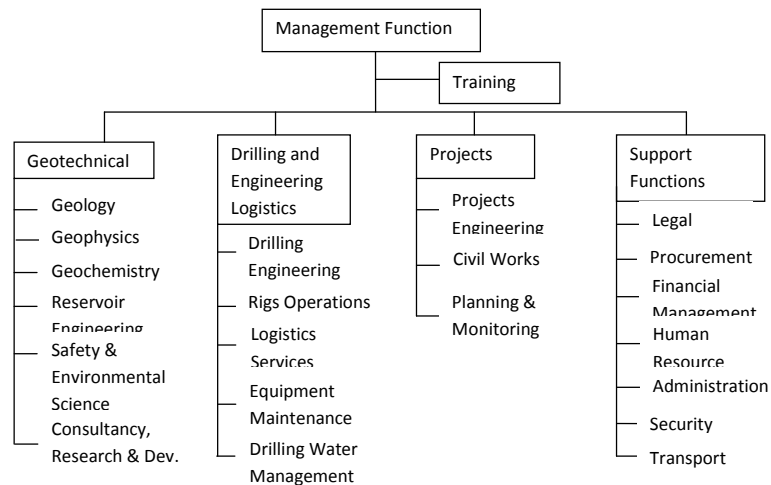


FIGURE 3: KenGen geothermal development functional organization chart

in conjunction with United Nations University, Geothermal Training Program (UNU-GTP) have in the last few years provided short courses to its own staff including others from the region.

### **3.3 Geotechnical function**

This function is undertaken by KenGen's scientific teams comprising of senior scientists and engineers. Their role spans from the very first steps of project identification right to operations and monitoring of the resources during its entire exploitation life. Together with their support staffs they carry out all the field work necessary for prospect exploration, assessment and definition, data processing and interpretation.

### **3.4 Drilling operations and engineering logistics**

This team comprising of drilling engineers and their supports staff. They carry out the well design, drilling rigs operations and management, supervision of drilling contractors under their jurisdiction and procurement functions related to rig and water supply operations and maintenance.

### **3.5 Projects**

The team dealing with projects offers supervisory and coordination roles during the power station constructions. In addition, the team provides civil works services to all the projects and geothermal planning and monitoring function. In addition, many funding institutions have required various management tools in particular regular project progress reports which this team compiles.

### **3.6 Support sections**

The teams under the support teams compliment the main geotechnical teams. In particular the legal and procurement have increasing becomes important as KenGen progresses and undertake complicated functions previously handled by expatriates. The legal and regulatory framework has increasing becomes complicated and litigations that may arise from projects implementation contracts. Legal further facilitates in the negotiation for and acquisition of land rights.

## **4. INFRASTRUCTURE**

### **4.1 Geology**

Kenya has invested in various requirements to facilitate its capability in this area (Arnason, 2007). This includes; topographic and geological maps, hand-held GPS, thermometers, thin section laboratory, microscopes (binocular and polarized), X-ray laboratory (clay analysis, XRD).

### **4.2 Geochemistry**

KenGen has further invested in the following geochemistry resources; thermometers, chemical sampling equipment (water, gas), field laboratory (pH, conductivity, CO<sub>2</sub>, H<sub>2</sub>S) and chemical laboratory (water, gas).

### **4.3 Geophysics**

In addition to the above, KenGen has in its possession geodetic (differential) GPS, gravimeter, magnetometers, shallow resistivity equipment (TEM, DC), deep resistivity equipment (MT), portable seismic stations and meteorological station.



#### **4.5 Reservoir engineering**

KenGen has further surface and downhole temperature and pressure measurement tools in addition to silencers and various sizes of lip pipes.

#### **4.6 Earth moving equipment**

KenGen undertakes its own civil works. It has in its inventory bulldozers, graders, water bowzers, compactors, theodolites and heavy duty tippers trucks

#### **4.7 Drilling equipment and accessories**

KenGen possesses a rig with a drilling capacity of 2200m (vertical). In addition to this, there are cranes, forklifts, lowbed and flat bed trailers and several prime movers to support the drilling rig. In addition, KenGen has invested in high pressure water reticulation systems in both Eburru and Olkaria that provide drilling water.

#### **4.8 Tree nursery**

Environmental management is an integral part of KenGen's operations. KenGen has established a tree nursery for growing of tree for rehabilitations of disturbed land patches and also for planting trees for distribution to third parties on a social responsibility programme.

#### **4.9 Others**

KenGen has also invested in offices and office equipments in particular computers and software that enable its staff perform their various duties

### **5. LEGAL FRAMEWORK**

The geothermal sector is increasing becoming regulated by various legislation. The key one being the Energy Act, 2006. The others are Geothermal Act, 1982, Environmental Management And Co-Ordination Act, 1999, the Public Procurement And Disposal Act, 2005, Water Abstraction Act. This is addition to the conditionality imposed by the funding institutions.

### **6. FUNDING**

Funding is the single most critical barrier to geothermal development in Kenya. Traditionally donor funding has dominated development while national contribution has been limited to about 30% of the required development capital. The credit agreements were entered between the donor and the Government. The Government after receiving the credit would on lent the same to KenGen at a slightly higher interest. KenGen after investing the capital would service the loans.

In the recent past, KenGen has received credits directly from the donor community for the construction of geothermal power plants but obtained sovereign guarantees from treasury as security. KenGen has further approached the donor community for funding at commercial basis where it has had to provide collateral. KenGen is in the process of floating infrastructure bonds to raise capital for development of its expansion program that is geothermal focused.

Currently, from the exchequer, the MoE is developing the Olkaria Domes at magnitudes not previously experienced.

## **7. INTEGRATION OF PROJECTS WITH SOCIAL PROGRAMS**

As part of social corporate responsibility (SCR), KenGen has built a nursery and primary schools at Olkaria which it maintains and accepts children from staff and local community. The primary school has 450 pupils half of which are girls. In addition, transport to school is provided for the local community. KenGen has further granted school bursaries for bright and needy students from around the Olkaria Project. Four secondary and two university pupils benefit from the scheme every year.

KenGen has further build a Clinic facility for its staff and locals and organizes health camps, inoculation and transport for local villagers. KenGen further spends US\$ 55,000 annually to supplying water to the local community.

KenGen has invested in a tree nursery for internal environmental rehabilitation purpose. However, 100,000 seedlings per year are given free on a social afforestation programme.

## **8. KEY CHALLENGES**

### **8.1 Perceived resource development risk**

Geothermal prospects while are known to exist, proper quantification and definition of the resource potential cannot be established until a substantial investment has been expended. In the Kenyan case, nine (9) to twelve (12) wells are drilled before a conclusive feasibility study can be undertaken. This part of the investment cannot be guaranteed and is perceived high risk. Commercial financiers are unwilling to commit funds when at this stage of development.

### **8.2 High initial capital requirements**

Unlike in the case of thermal plants where fuel costs are distributed over the plant life, geothermal requires that all the fuel (steam) for the entire plant life (25 yrs) be expended before commencement of generation. This make geothermal projects initial capital requirements comparatively high.

### **8.3 Long development period**

Geothermal projects follow a stepped out execution plan with limited flexibility. The project execution duration spans between 4 to 7 yrs. Coupled with resource assessment uncertainties, this duration is considered fairly long unlike the thermal plants which can be commissioned within 1 year of project conception.

### **8.4 Difficulties in obtaining long-term sustainable development financial resources**

The above factors results in difficulties to obtain long-term development financing. In most countries, governments undertake resource assessment and therefore bear the highly risky part of the geothermal investment

### **8.5 Long credit closure periods**

The traditional funding institution, predominantly the donor community, are increasing perceived as an expensive source of funding due to the long closure periods required in securing funds from these sources.

### **8.6 Environmental and land issues**

Obtaining land access rights have increasingly become complex and obtaining way leaves for transmission lines take long and expensive endeavours. New environmental legislation while is a good thing has resulted to costly operations and limited operation flexibility.

### **8.7 Inhibiting legal framework**

The geothermal development is increasingly become regulated by various national laws and funding institution administrative conditions. Besides the great effort in meeting the various legislations, projects costs and delays are increasing becoming inhibitive.

### **8.8 Human resource capacity challenges**

While KenGen has made great strides in development of the human resource capacity in the geotechnical area, project management to meet emerging technological, financial, administrative and legal project requirements are increasing becoming an urgent need.

## **REFERENCES**

Arnason, K., 2007: ArGeo - status report and discussion. *Papers and Presentations at "Short Course II on Surface Exploration for Geothermal Resources"*, organized by UNU-GTP and KenGen, Naivasha Kenya, November 2007, CD.

Mwangi, M.N., 2007: Planning of geothermal projects: A case study on Kenya. *Papers and Presentations at "Short Course II on Surface Exploration for Geothermal Resources"*, organized by UNU-GTP and KenGen, Naivasha Kenya, November 2007, CD.

Price Waterhouse Coopers Ltd., 2007: *Establishment of a geothermal development company, draft master and business plan*. Price Waterhouse Coopers Ltd, Nairobi, Kenya, July 2006.