



## **GEOHERMAL PROJECT MANAGEMENT**

**Peketsa Mwaro Mangi**

Kenya Electricity Generating Company Ltd

P.O. Box 785-20117, Naivasha

KENYA

*pmangi@kengen.co.ke*

### **ABSTRACT**

Geothermal projects are capital intensive business, where upfront costs of projects, from the early exploration stage to the operation of a geothermal power plant may take years to develop, and the initial capital requirements is comparatively high. One of the most important issues in design of geothermal projects is the management of the project, which comprises planning, organization, motivation and the engagement of controlling resources. Planning plays an important role for the development of geothermal resources and must be carefully performed from the beginning and through the entire period of the project. The initial exploration of a geothermal resource to an operational geothermal power plant is complex and quite expensive, and its success depends heavily on a sound project management strategy, based on experienced Geoscientists and Engineers.

### **1. INTRODUCTION**

What is a project?

A project is a time and cost constrained operation to realise a set of defined deliverables (the scope to fulfil the project's objectives) up to quality standards and requirements (PMI, 2013). Project management typically involves personnel from project management associates up to senior project managers (IPMA Level D to B). However, an organisation may decide to appoint a projects director (IPMA Level A) to manage a crucial project or programme.

The Project Management Institute (PMI, 2013) indicates that a project is a temporary endeavour undertaken to create a unique product, service, or result. The temporary nature of projects indicates that a project has a definite beginning and end. Temporary does not necessarily mean the duration of the project is short. It refers to the project's engagement and its longevity. Temporary does not typically apply to the product, service, or result created by the project; most projects are undertaken to create a lasting outcome.

A task that is unique and which creates a unique product, service, or result can be considered as a project. The outcome of the project may be tangible or intangible. Although repetitive elements may be present in some project deliverables and activities, this repetition does not change the fundamental, unique characteristics of the project work.

## 2. PROJECT MANAGEMENT

According to the Project Management Institute (PMI, 2013), project management is the application of knowledge, skills, tools, and techniques to project activities to meet the project requirements. Reiss, 2007, on the other hand defines project management as a collection of loosely connected techniques, some of which are useful in bringing projects to a successful conclusion.

According to the Project Management Institute (PMI), project management is a carefully planned and organized effort to accomplish a specific (and usually) one time objective, for example, to construct a building or implement a new major computer system. It includes developing a project plan, which involves defining and confirming the project goals and objectives, identifying tasks and how goals will be achieved, quantifying the resources needed, and determining budgets and timelines for completion.

Project management is accomplished through project management processes which are categorized into the following five process groups:

- Initiating;
- Planning;
- Executing;
- Monitoring and Controlling; and
- Closing.

The organization's processes and procedures for conducting project work include, but are not limited to:

### 2.1 Initiating and planning

Project initiation involves starting up a new project. You can start a new project by defining its objectives, scope, purpose and deliverables to be produced. You'll also hire your project team, setup the Project Office and review the project, to gain approval to begin the next phase.

Project planning is crucial in all the projects. Key activities must be defined to achieve the goals and for each of them, time and cost components have to be defined as well as the quality that has to be achieved. It involves creating of a set of plans to help guide your team through the execution and closure phases of the project. The plans created during this phase will help you to manage time, cost, quality, change, risk and issues. They will also help you manage staff and external suppliers, to ensure that you deliver the project on time and within budget.

### 2.2 Implementation

In this phase, you will build the physical project deliverables and present them to your customer for signoff. The Project Execution Phase is usually the longest phase in the project life cycle and it typically consumes the most energy and the most resources.

To enable you to monitor and control the project during this phase, you will need to implement a range of management processes. These processes help you to manage time, cost, quality, change, risks and issues. They also help you to manage procurement, customer acceptance and communications.

### 2.3 Organizing

Organizing projects depends on the owner of the project. In many projectized or matrix organisations, project management is undertaken by the project office (PMO-project management office), which operates according to certain rules. Depending on the position in the hierarchy of the organization or local community there are three levels of PMO mentioned:

- Administrative control office for one project;
- Project office, that primarily coordinates work of people (common sources) in a large number of projects; and
- Strategic project office, which is close to the top management as an advisory body for organizing, managing, monitoring projects and also for enforcement of project work in the organization.

## 2.4 Leadership of the people

Leadership involves providing direction and motivating others in their role or task to fulfil the project's objectives. It is a vital competence for a project manager. Leadership is required throughout the life of a project. It is particularly important when a project encounters problems, when change is required or where there is uncertainty about a course of action. Leadership is needed to exert all of a project managers competences in a way that they can be seen and embraced by the team. Project team for implementing geothermal projects should have members with different knowledge or where possible outsourcing of activities connected with some of the fields be undertaken (ICB-IPMA Competence Baseline version 3.0).

## 2.5 Monitoring and controlling

The Organization of European Co-operation for Development (OECD) defines Monitoring as follows:

**“Monitoring** is a continuous function that uses the systematic collection of data on specified indicators to provide management and the main stakeholders of an ongoing development intervention with indications of the extent of progress and achievement of objectives and progress in the use of allocated funds”.

The process of controlling includes monitoring of performance (scope, time, quality, costs, risks, and supply), comparison with the plan, identifying anomalies and planning and implementation of corrective actions / measures to ensure that the project will be carried out in the framework of set goals. The process of controlling means permanent comparison between planned and actual situation (costs achieved, implemented activities in time schedule). The sooner deviations are detected, smaller are they and easier to solve. It is very important that the team members are involved in control and that they provide the right information and not to conceal problems and deviations.

## 2.6 Examples of Project Evaluation Methods

### 2.6.1 Planned Value Calculation

As per the PMBOK Guide (PMI, 2013), Planned Value (PV) is the authorized budget assigned to work to be accomplished for an activity or WBS component. Planned Value is calculated before actually doing the work, which also serves as a baseline. Total Planned Value for the project is known as Budget at Completion (BAC) or Budgeted Cost of Work Scheduled (BCWS).

**Budget at Completion (BAC)** — also known as the project/work budget, that is the total amount of money originally planned to spend on the project/work

### Example 1

**Planned Value** = BAC or BCWS = Total planned value at Completion

Planned value is derived by applying the following formula:

*Planned % complete x BAC or BCWS*

After 7 months, 60% should be completed. Total Budget is 100m USD  
Planned Value= 60% x 100m USD= 60m USD

### 2.6.2 Earned Value Calculation

PMBOK Guide states that “Earned value (EV) is a measure of work performed expressed in terms of the budget authorized for that work. It is the budget associated with the authorized work that has been completed. The EV being measured needs to be related to the PMB, and the EV measured cannot be greater than the authorized PV budget for a component”.

#### Example 2

**Earned Value** = Budgeted Cost of Work Performed (BCWP)

Earned value is derived by applying the following formula:

*% Work completed x BAC or BCWS*

Project duration: 12 months

7 months: 50% completed

BAC or BCWS= 100m USD

Earned Value: 50% x 100m USD= 50m USD

### 2.6.3 Cost Performance Index (CPI)

As per the PMBOK Guide, “The Cost Performance Index (CPI) is a measure of the cost efficiency of budgeted resources, expressed as a ratio of earned value to actual cost.”

The Cost Performance Index specifies how much you are earning for each dollar spent on the project.

The Cost Performance Index is an indication of how well the project is remaining on budget.

The Cost Performance Index helps you analyze the efficiency of the cost utilized by the project. It measures the value of the work completed compared to the actual cost spent on the project.

#### Formula for the Cost Performance Index (CPI)

The Cost Performance Index can be determined by dividing earned value by actual cost.

Cost Performance Index = (Earned Value)/(Actual Cost)

CPI = EV/AC

#### Example of the Cost Performance Index (CPI)

You have a project to be completed in 12 months and the cost of the project is 100,000 USD. Six months have passed and 60,000 USD has been spent, but on closer review, you find that only 40% of the work has been completed so far. Find the Cost Performance Index for this project and deduce whether you are under budget or over budget.

Given in the question:

Actual Cost (AC) = 60,000 USD

Planned Value (PV) = 50% of 100,000 USD  
= 50,000 USD

Earned Value (EV) = 40% of 100,000 USD  
= 40,000 USD

Now,

$$\begin{aligned}\text{Cost Performance Index (CPI)} &= \text{EV} / \text{AC} \\ &= 40,000 / 60,000 \\ &= 0.67\end{aligned}$$

Hence, the Cost Performance Index is 0.67

#### 2.6.4 The Schedule Performance Index (SPI)

The Schedule Performance Index can be determined by dividing earned value by planned value.

$$\text{Schedule Performance Index} = (\text{Earned Value}) / (\text{Planned Value})$$

$$\text{SPI} = \text{EV} / \text{PV}$$

#### Example of the Schedule Performance Index (SPI)

You have a project to be completed in 12 months and the cost of the project is 100,000 USD. Six months have passed and 60,000 USD has been spent, but on closer review, you find that only 40% of the work has been completed so far.

Find the Schedule Performance Index and deduce whether the project is behind or ahead of schedule.

Given in the question:

$$\text{Actual Cost (AC)} = 60,000 \text{ USD}$$

$$\begin{aligned}\text{Planned Value (PV)} &= 50\% \text{ of } 100,000 \text{ USD} \\ &= 50,000 \text{ USD}\end{aligned}$$

$$\begin{aligned}\text{Earned Value (EV)} &= 40\% \text{ of } 100,000 \text{ USD} \\ &= 40,000 \text{ USD}\end{aligned}$$

Now,

$$\begin{aligned}\text{Schedule Performance Index (SPI)} &= \text{EV} / \text{PV} \\ &= 40,000 / 50,000 \\ &= 0.8\end{aligned}$$

Hence, the Schedule Performance Index is 0.8

#### 2.6.5 What kind of projects suit earned value methods?

Allan Webb (2003) points out that any project with a structured plan of work, a cost structure and data gathering system can make use of earned value methods but it would be unreasonable to suggest that the approach is equally applicable to all types of projects.

In general these are those which have most or all of the following characteristics:

- A clearly defined objective;
- A clearly perceived route to the goal;
- Work taking place over a long period;
- Tasks of creative nature;
- A formalized management structure; and
- Cost and time limitations.

#### 2.7 Closure

In this phase, you will formally close your project and then report its overall level of success to your sponsor.

Project Closure involves handing over the deliverables to your customer, passing the documentation to the business, cancelling supplier contracts, releasing staff and equipment, and informing stakeholders of the closure of the project.

### **3. PROJECT KNOWLEDGE AREAS**

#### **3.1 The ten knowledge areas**

The ten knowledge areas include integration management, scope management, time management, cost management, quality management, human resource management, communication management, risk management, procurement management, and stakeholder management. ICB reinforces the importance of the ten knowledge areas in its description of forty six competence elements that are crucial for a project manager to be able to effectively apply the knowledge, skills, tools and techniques as advocated by PMBOK. These elements are grouped into three namely, technical, contextual and behavioural competences. Technical competences relate to the project manager's technical skills and techniques and cover project management success, interested parties, project requirements and objectives, risk and opportunity, quality, project organisation, teamwork, problem resolution, project structures, scope and deliverables, time and project phases, resources, cost and finance, procurement and contract, changes, control and reports, information and documentation, communication, start and close out.

Technical competences, however, are no longer viewed as the only competences required for effective project management. This is because project management involves dealing with and managing people so as to achieve results. The project manager must demonstrate competence in managing himself as well as managing relationship between himself, project teams, sponsor, the client, and other stakeholders. These personal skills and techniques are grouped under behavioural competences and include leadership, engagement and motivation, self-control, assertiveness, relaxation, openness, creativity, results orientation, efficiency, consultation, negotiation, conflict and crisis, reliability, values appreciation and ethics. On the other hand, contextual competences scope the project manager's ability to function within a project oriented organisation and relate to the management and line management within the organisation. These competences include project, programme, and portfolio orientation; project, programme and portfolio implementation; permanent organisation; business; systems, products and technology; personnel management; health, security, safety and environment; finance and legal.

The project life cycle and the ten knowledge areas are summarized in Figure 1.

### **4. GENERIC PHASES OF GEOTHERMAL DEVELOPMENT**

Development of geothermal projects can be phased as follows, depending on the resources available and or the need to determine resource sustainability before full development (Figure 2). Such phasing of geothermal projects create certainty in their eventual success.

#### **4.1 Preliminary study (geoscientific study to exploration drilling)**

The preliminary study starts with collection and critical review of existing geological, geophysical and geochemical data available for the area. On the basis of these a detailed multidisciplinary exploration program is defined and executed. The program usually includes various surface exploration methods, i.e. mapping of the geothermal manifestations and measurements of temperature and flow rate to compare with previous information, if available.

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 also undertaken.



FIGURE 1: The project cycle and the ten knowledge areas (PMI, 2013)

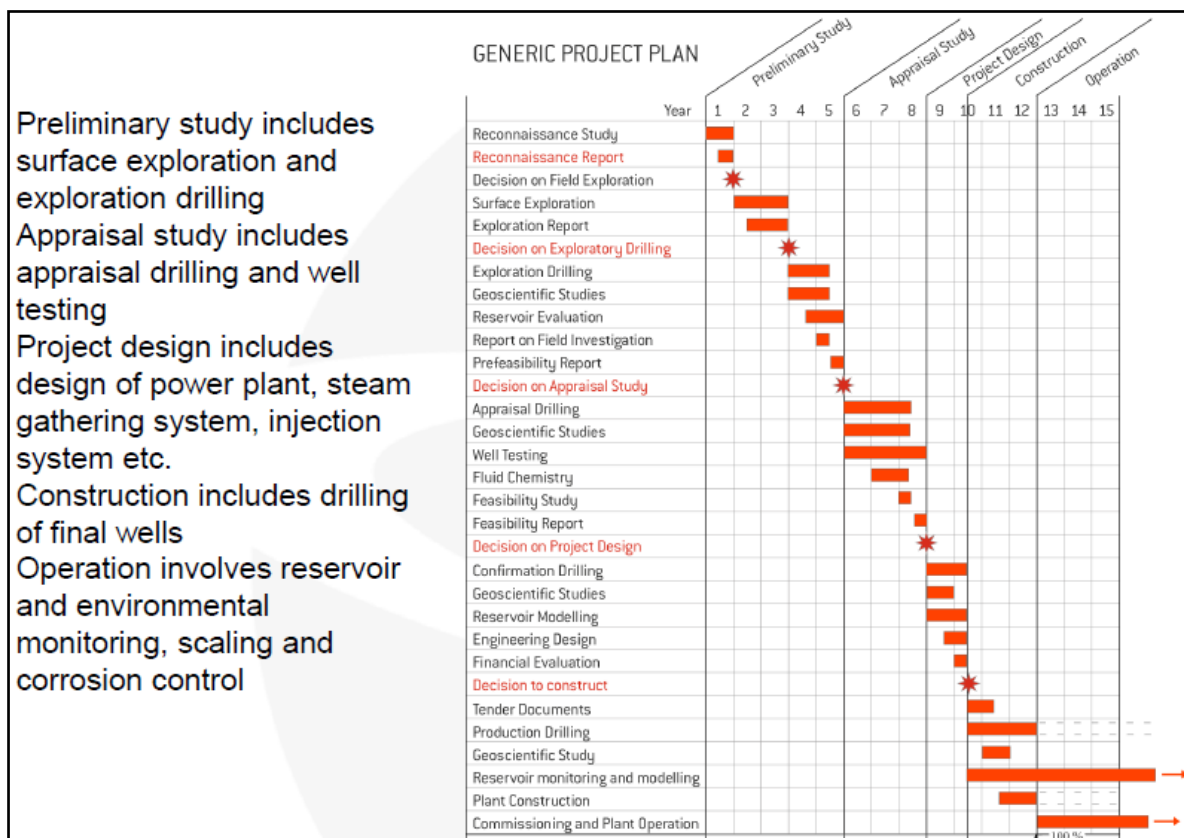


FIGURE 2: Generic diagram showing geothermal development phases

## **4.2 Exploration drilling**

This step is done to prove the resource inferred by the geoscientific studies by drilling an exploratory 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 prospect.

## **4.3 Appraisal drilling**

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.

## **4.4 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.

Based on the feasibility studies the production drilling proceeds most of the time without problems as the locations, depths and direction are already decided from the results of the exploration and appraisal drilling. Very few cores would be obtained during this phase; the ones taken would be to fill in the information gaps missed during appraisal drilling.

Additional wells are drilled for reinjection purpose.

## **4.5 Project design: Power plant, steam gathering system etc.**

This entails design, procurement and construction of the steam gathering system, power plant and 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.

## **4.6 Construction and field development**

After the exploration and drilling phase, the project site is prepared for production. The construction phase involves the construction of the geothermal field(s), infrastructure, power plants, and transmission lines. Activities in this phase of development would include:

- Clearing, grading, and constructing access roads;
- Clearing, grading, and constructing electrical generation facilities;
- Building facility structures;
- Drilling and developing well fields;
- Installing pipeline systems; and
- Installing meters, substations, and transmission lines.

The construction phase of the development process would result in the greatest area of land disturbance at the geothermal energy project site, although some of the disturbed land would be reclaimed once construction activities end.

## **4.7 Operation and maintenance**

The operations and maintenance phase involves the operation and maintenance of the geothermal field(s) and the generation of electricity. The types of operations and maintenance activities depend on the size and temperature of the geothermal reservoir. Typically, only high-temperature reservoirs are suitable for the utility-scale production of electricity, although new technologies are proving that lower-



temperature water can also be used for commercial purposes. The operations and maintenance phase can last from 10 to 50 years.

**4.8 Shut-down and abandonment**

Once geothermal production ceases, the production wells are abandoned, facility structures and infrastructure are removed, and all the disturbed areas at the project site are reclaimed. Well abandonment involves plugging, capping, and reclaiming the well site. Reclamation includes removing the power plant and all surface equipment and structures, regrading the site and access roads to preproduction contours, and replanting vegetation to facilitate natural restoration.

**5. PHASES OF 50 MW POWER PLANT**

The phases of a 50 MW power plant at shown in Figure 3.

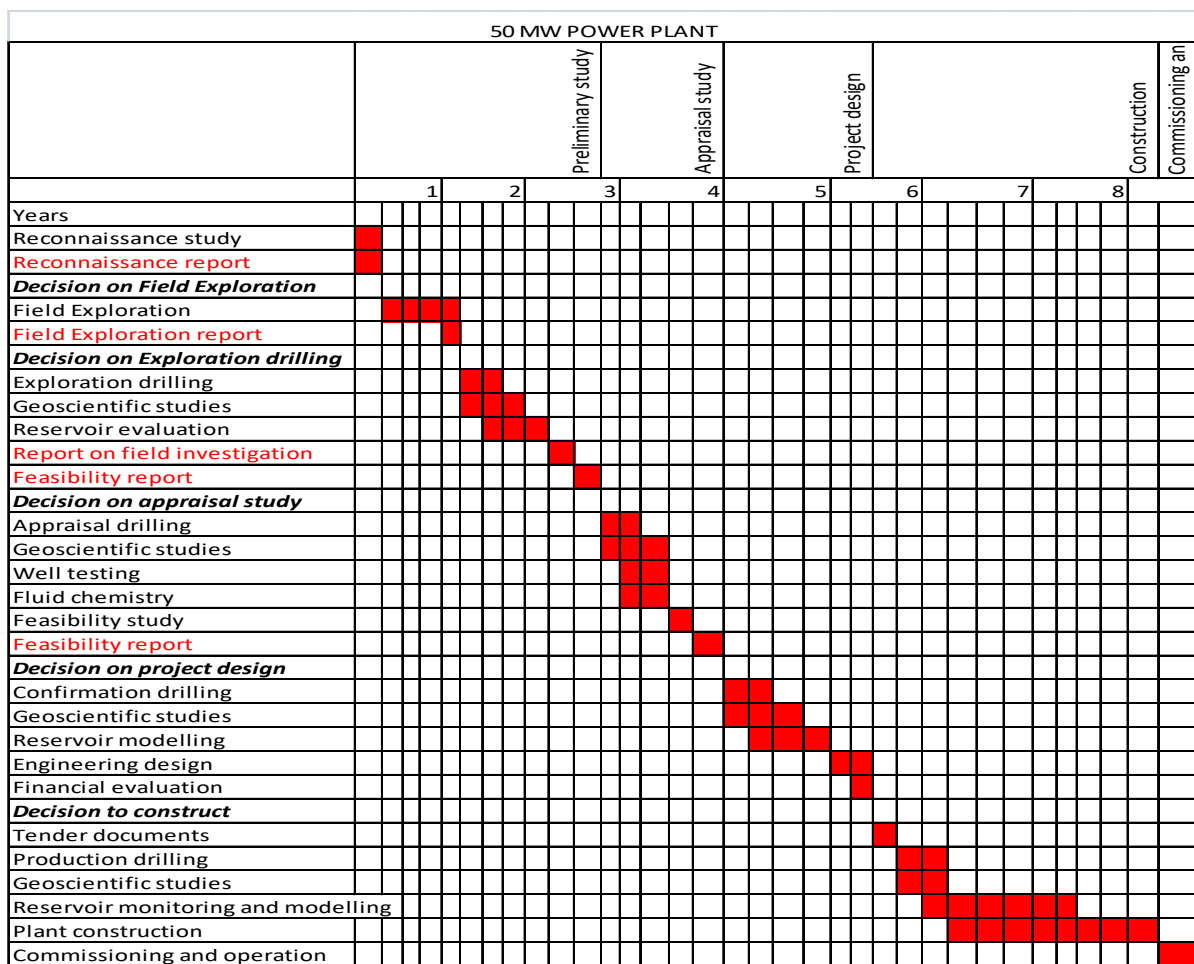


FIGURE 3: Phases of 50 MW power plant

**6. CONCLUSION**

- Project or programme orientation is critical in organizations especially for geothermal projects.
- Geothermal projects are capital intensive; A geothermal project from the early exploration stage to the operation of a geothermal power plant may take years to develop, and requires a large specialized expertise e.g geoscientists and the initial capital requirements is comparatively high.

- Geothermal projects are increasing in size.
- Multiple geothermal projects.
- Complexity of discipline.
- Project management enhances chances of project success through:
  - Efficient management of resources.
  - Effective management of time.
  - Integration and control of projects.
  - Stakeholder engagement.
  - Appropriate choice of phases.
  - Phased development.

### REFERENCES

PMI, 2013: *Project management body of knowledge (PMBOK guide), 5<sup>th</sup> ed.* Project Management Institute, Pennsylvania, United States, 589 pp.

Webb, A., 2003: *Using earned value.* Routledge, New York, New York, United States, 152 pp.