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PROJECT MANAGEMENT FOR GEOTHERMAL ENERGY DEVELOPMENT

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ABSTRACT

Geothermal resource development entails five phases namely resource exploration, resource assessment, power plant construction, operations and decommissioning. Each of this phase has several steps ranging from desktop studies, appraisal drilling, well testing, production drilling, plant operations and decommissioning. The challenge is to complement all project activities without exceeding tolerance limits of time, cost, quality and scope. Project management is one of the most important issues during design and operationalization of geothermal systems for energy generation. It comprises planning, organization, motivation and the engagement of controlling resources; without these, the risk of technical failure of a project is high.

1. INTRODUCTION

Project management involves applying knowledge, skills, tools and techniques to project activities in order to meet or exceed stakeholder expectations. It is the art of directing and coordinating human and material resources throughout the life of a project to achieve project objectives within specified constraints (PMI, 2013). Over the years, and more importantly, in the recent past, project management has been used as a delivery mechanism to do business and accomplish objectives. Implementing project management conscientiously has significant results such as cost and time reductions, proper resource allocation and increased quality.

Project management recognises the triple constraints which are time, cost and scope (Figure 1). These constraints should be reduced or eliminated in order to minimise waste and deliver a quality project. Practically, in most cases, the constraints limiting impact can be reduced or eliminated.

Any attempt to deviate from, or supplement the three criteria that make up the constraints is often considered a problem that must be corrected or prevented in the first place. What is important is for the team to prioritise the constraints so that the project professional knows where to put more emphasis or focus.

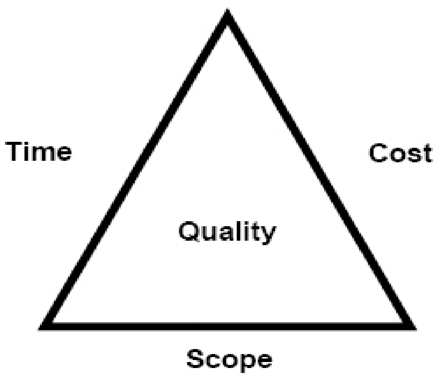

FIGURE 1: Project constraints

1.1 Time

Time is the only project constraint over which project professionals hold no control. Unlike costs, which can be constrained, or scope, which can be adjusted, time always flows at a steady pace. Without the luxury of slowing the project pace, project management professionals must resort to tracking their teams' progress against a series of milestones. Handling unexpected challenges under tight deadlines is what sets expert project professionals apart from their competition.

1.2 Cost

Cost constraints frequently cause project management professionals to revisit task lists and deadlines. The reason behind this is to prevent cost overruns which mean that the project is spiralling out of control. It also prevents lack of initiative and accountability by a team and its leaders if presented with a blank check.

1.3 Scope

In every project, it is typical to experience additional information after the first few stages of implementation. This is experienced when stakeholders call project professionals to squeeze in more tasks after the commencement of the project. This is known as scope change and a change in it can cause damage to a teams end result. To maintain controls, project professionals must watch over creep, changing agendas and lack of clarity.

2. PROJECT MANAGEMENT PROCESS GROUPS

The Project Management Institute (PMI) recognises five process groups of project management namely initiating, planning, executing, monitoring and control and closing. These process groups interact with each other and overlap as shown in Figure 2.

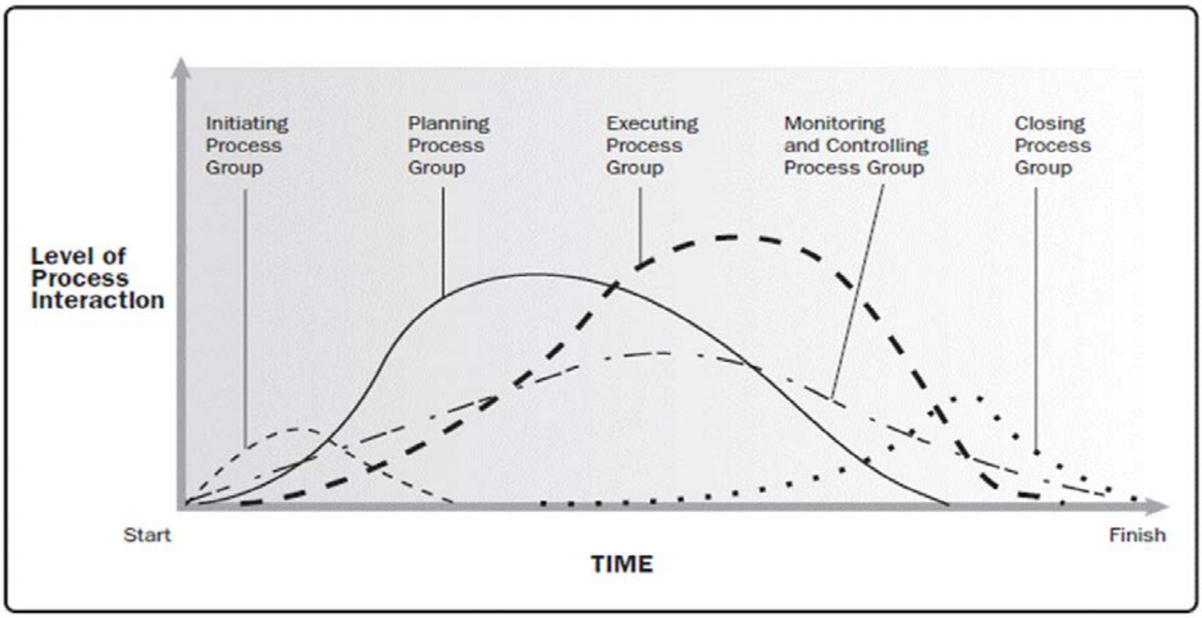

FIGURE 2: Process group interactions (PMI, 2013)

Authorization to start the project is granted in the initiating phase. The main objectives are to define the initial scope, commit initial financial resources and identification of internal and external stakeholders. Initiating process clarifies the business need to all stakeholders indicating that all necessary factors were considered when picking a particular project. In the planning stage, the primary focus is coming up with a project management plan. The plan acts as a guide throughout the project and is considered a critical parameter in the successful completion of a project.

After completion of the plan, the project activities are executed so as to satisfy the project specifications. The biggest apportion of the project budget is given to this process since this is where most of the deliverables are met.

3. GEOTHERMAL ENERGY DEVELOPMENT PROJECT PHASES

Geothermal energy development is a highly capital intensive technology that requires about 5-7 years to become operational. It has the capacity to replace the thermal-based electricity generation coupled with the minimal environmental impacts associated to its exploitation. However, it requires keen management to ensure appropriate dispensation of resources and efficient management of time for the intended results to be attained. A geothermal energy development project can be divided into five phases namely resource exploration, resource assessment, power plant construction, operations and decommissioning (Modified from Ngugi, 2008).

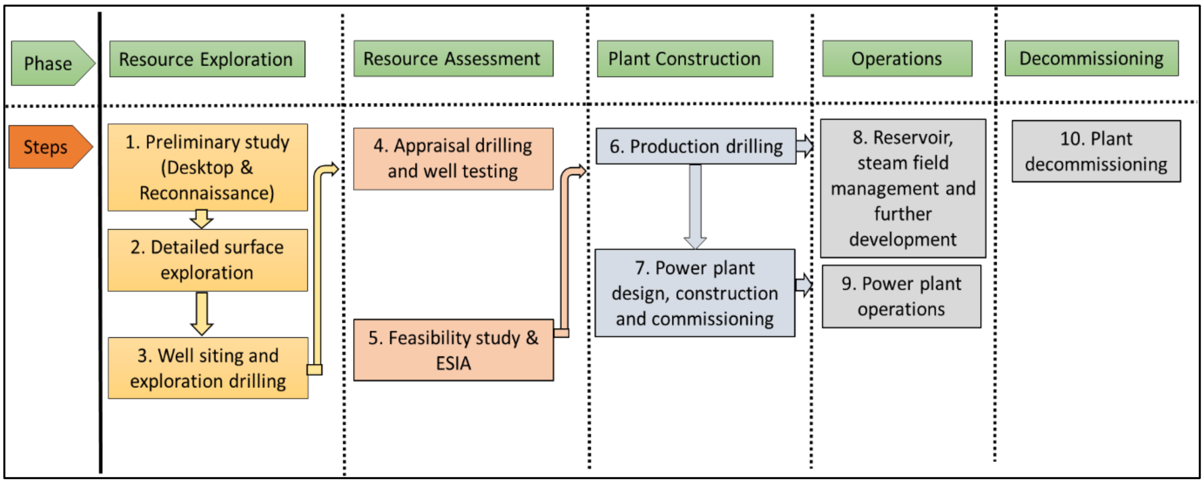

FIGURE 3: Geothermal development project phases (Modified from Ngugi, 2008)

3.1 Resource exploration

Resource exploration entails conducting a preliminary study, detailed surface exploration and exploratory drilling. Available data is collated overtime with a view of identifying gaps. A desktop study and further analysis is undertaken with an aim of developing an inception report recommending detailed surface work. This report acts as a guide to providing all information such as work program and resource requirements.

A detailed surface exploration is then carried out with the scope of work being field measurements, sample testing, environmental study and analysis. The output is a conceptual model with recommended exploration well sites. After identification of well locations, exploration wells are drilled. Drilling these wells primarily mark the beginning of physical development of geothermal prospects.

3.2 Resource assessment

Resource assessment entails appraisal drilling, well testing and environmental and social impact assessment. Appraisal drilling aims at sizing the resource in terms of possible output that is necessary for plant sizing and obtaining drilling requirements, wellhead pressures and reservoir fluid characteristics. This data is obtained in preparation of the feasibility study which is a desktop study.

3.3 Power plant construction

This phase involves production drilling, power plant design, construction and commissioning. Production drilling is carried out to provide sufficient steam to run the power plant. The objective in this phase is carrying out detailed design for all systems such as steam systems, power plant, sub-station and transmission lines.

3.4 Operations

In this stage, monitoring of the reservoir is carried out where regular measurements of well productivity and wellhead pressures are taken. It also involves operation and maintenance of the power plants to ensure continuous power generation.

3.5 Decommissioning

This stage involves geothermal project abandonment after its useful life. Following decommissioning, the site is restored to approximate its original condition or to some standard that results in stable environmental conditions. Decommissioning involves closure of all plant facilities, wells, removal of all above ground components such as steam lines, recontouring the ground surface and revegetation.

4. MONITORING AND EVALUATING GEOTHERMAL ENERGY DEVELOPMENT PROJECTS

Monitoring and evaluating projects provides the basis for decision making and links all elements inherent in geothermal energy utilisation and weighs project risks. Monitoring and evaluation ensures that the project intended goals and objectives are met, while ensuring at the same time learning opportunity, traceability and that decision making is done with good and reliable information (Njoroge, 2016). It focuses primarily on scope, time and cost management.

4.1 Scope management

Scope management includes processes required to ensure that the project includes all the work required to complete it successfully (PMI, 2013). It aims at developing a work breakdown structure (WBS). The work breakdown structure visually defines the scope into manageable chunks that a project team can understand.

4.2 Time management

Project time management includes the processes required to ensure timely completion of the project. Developing time estimates is key in ensuring proper project status reporting and planning. There are various estimations that are applied in project management and include analogous estimation, parametric estimation and 3-point estimation (PMI, 2013).

4.2.1 Analogous estimations

Analogous estimating refers to using the actual duration of a previous, similar schedule activity as the basis for estimating the duration of a future schedule activity. This method is used when there is limited information about a particular project. The estimates are made by comparing the current activity to that of a smaller activity that took place previously and drawing comparisons in proportion to that. It is frequently used to estimate the size of a particular parameter when information as to that particular parameter within the current project is limited or unavailable until a later date.

4.2.2 Parametric estimations

Parametric estimating uses the relationship between variables to calculate the cost or duration. Essentially, a parametric estimate is determined by identifying the unit cost or duration and the number of units required for the project or activity. It is a more accurate technique for estimating cost and duration as it uses statistical relationships between historical data and other variables.

4.2.3 3-point estimations

In 3-point estimations, expected value of a task is determined by calculating the mean of three different values. These three values are optimistic (t_o), pessimistic (t_p), and most likely (t_m) estimates. The two methods that are used to arrive at the expected value or mean are simple average and Project Evaluation and Review Technique (PERT).

Simple average is based on a triangular distribution. The mean is determined by the formula:

$$ts = (to + tp + tm)/3 \tag{1}$$

where to = Optimistic time;
tp = Pessimistic time; and
tm = Most likely time.

PERT is calculated using a weighted average. It is based on Beta distribution and the mean is determined by:

$$te = (to + 4tm + tp)/6 \tag{2}$$

4.3 Cost management

This is primarily concerned with the cost of the resources needed to complete project activities. Cost management varies within the project with regard to stage of development and the ability to influence these costs is greatest at the early stages of the project.

4.3.1 Earned Value Management (EVM)

This is a methodology of combining scope, schedule, and resource cost measurements to assess project performance and progress. It is a project management technique that requires the formation of an integrated baseline against which performance can be measured for the project duration (PMI, 2013).

EVM establishes three dimensions of performance measure established which are:

a) Planned value (PV); this is the authorised budget assigned to scheduled work for an activity. It is also known as budget at completion (BAC).

b) Earned value (EV); this is a measure of work performed expressed in terms of the budget authorised for that work. The EV is often used to calculate the percent complete of a project.

c) Actual cost (AC); it is the cost incurred for the work performed.

Apart from the three dimensions above, cost variances from the approved project baseline are monitored which are:

d) Schedule variance (SV); it is the amount by which the project is ahead or behind the planned delivery date, at a given point in time. It is best used in conjunction with critical path method scheduling and risk management (PMI, 2013). It is expressed using the formula

$$SV = EV - PV \tag{3}$$

where SV = Schedule variance;
EV = Earned value; and
PV = Planned value.

e) Cost variance (CV); this is the amount of budget deficit or surplus at a given point in time. It is expressed using the formula

$$CV = EV - AC \tag{4}$$

where CV = Cost variance;
EV = Earned value; and
AC = Actual cost.

These variances can be converted into efficiency indicators which are:

f) Schedule performance index (SPI); this is a measure of schedule efficiency and measures how efficiently a project team is using its time. It is a ratio of earned value to planned value expressed by the formula

$$SPI = \frac{EV}{PV} \tag{5}$$

where SPI = Schedule performance index.

SPI < 1.0 implies that less work was completed than was planned while SPI > 1.0 indicates that more work was completed than was planned.

g) Cost performance index (CPI); this is a measure of cost efficiency of budgeted resources and it is considered the most critical EVM metric for work completed (PMI, 2013). It is a ratio of earned value to actual cost expressed by the formula

$$CPI = \frac{EV}{AC} \tag{6}$$

where CPI = Cost performance index.

CPI < 1.0 implies a cost overrun while CPI > 1.0 indicates a cost underrun.

5. CONCLUSIONS

Geothermal energy development projects are increasing in size as necessitated by the increasing power demand. These projects are large scale, capital intensive and therefore dynamic in nature due to evolving technology. It is therefore imperative to employ project management at all stages of planning and development with a view of maximising power output in the geothermal energy sector. Project management is recognised globally as an effective strategy for directing and controlling a project from conception to completion. In summary, project management for geothermal energy development will enhance efficient management of resources, time, risks and costs toward a successful project.

REFERENCES

Ngugi, P.K., 2008: Planning of geothermal projects in Kenya. Paper presented at "*Short Course III on Exploration for Geothermal Resources", organized by UNU-GTP and KenGen*, Lake Naivasha, Kenya, 20 pp.

Njoroge, D., 2016: Monitoring and evaluation framework for geothermal projects: Olkaria I Unit 6, Kenya. Report 28 in: *Geothermal training in Iceland 2016.* United Nations University Geothermal Training Programme, Reykjavík, Iceland, 557-574.

PMI, 2013: *A guide to the project management body of knowledge. (PMBOK® Guide) (5th ed.).* Project Management Institute, Newtown Square, Pennsylvania, United States, 616 pp.