The Geothermal Exploration and Development Process: Graphical Representation Path to Optimal Decision Making

Catherine Hickson[1] and Ron Yehia[2]

[1]Consultant, Burnaby, B.C., Canada
[2]MYAR Consulting, Vancouver, B.C., Canada
chickson@telus.net • myar@telus.net

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ABSTRACT

Putting geothermal exploration into the development context is a critical element of business development. Without the resource there is no development; without the financing there is no project. Managing these two aspects of development and the interplay between the geoscience side of the equation and finance side is a critical part of a successful project. Helping the finance side understand the geoscience side and vice versa plays a vital role in ensuring that the project is "right sized". Thoughtful analysis of the critical decisions to be made by both sides of the equation along the development path is what will result in a successful project. A successful project is one that comes in with the required megawatts to be profitable in a time frame that there is an adequate return on investment. This paper presents two graphical tools to assist development teams in understanding their role in the development process from greenfield to electrons down a wire.

Introduction

Geothermal energy exploration and development is an arduous and expensive enterprise. As in any large undertaking, documenting and streamlining procedures can significantly reduce uncertainty and cost, and help to achieve complex objectives.

Many organizations use flowcharts to facilitate internal and external procedures, and communications. Clearly conveying knowledge through a flowchart demonstrates an expert understanding of subject matter and an ability to follow any project or task to completion. Further, using organized documented flowcharts provides a clear vision for staff, management and financing partners.

In this case, two flowcharts are showcased. The first is an exploration work flowchart that provides a comprehensive overview of various disciplines and stages of exploration. The second is a flowchart covering business and resource requirements from greenfield to long term reservoir and power plant management.

Phased Geothermal Exploration Flowchart

The original work flowchart was conceived by Yehia in early 2008 when he was a member of the Exploration Group at Ormat Technologies Inc. under the leadership of Don A. Campbell, Exploration Manager. Inspired by Walker et al. (2005), the work flowchart was developed as a self-learning tool by Yehia, with significant content contributed by Gene Suemnicht, then Exploration Group Chief Geologist at Ormat. The flowchart was later incorporated into Ormat management presentations concerning geothermal exploration. In the development of the flowchart, Yehia relied on his Enterprise IT experience where working in highly complex environments required the preparation of detailed workflow procedures and supporting documentation to improve team work performance.

The new chart (Figure 1) was created based on professional flowcharting principles. Proper symbols were used for each step highlighting such elements as decisions, processes, documents, and start/end boxes. Disciplines were colour coded (Geology; blue; Geochemistry; green; Geophysics; yellow: Geothermics; orange; Reservoir evaluation; brown) and more attention was paid to process flow. Disciplines were also rearranged on the left according to cost, with geology on top as lowest, and reservoir evaluation at the bottom with the highest associated cost. The importance of the development of a robust conceptual model was included and highlighted by red boxes.

A timeline bar was added at the top of the updated chart, to show overall direction. This contributed to emphasizing the overall flow from top left to bottom right. Originally, it was considered that each of the three vertical columns (target identification; prospect evaluation; and project appraisal) could be accomplished in one year; however, as is well documented in the industry, the time line is often significantly protracted (Figure 2).

At Alterra Power Corp., the general concept of the chart was adopted and updated (Figure 1). Elements such as the importance

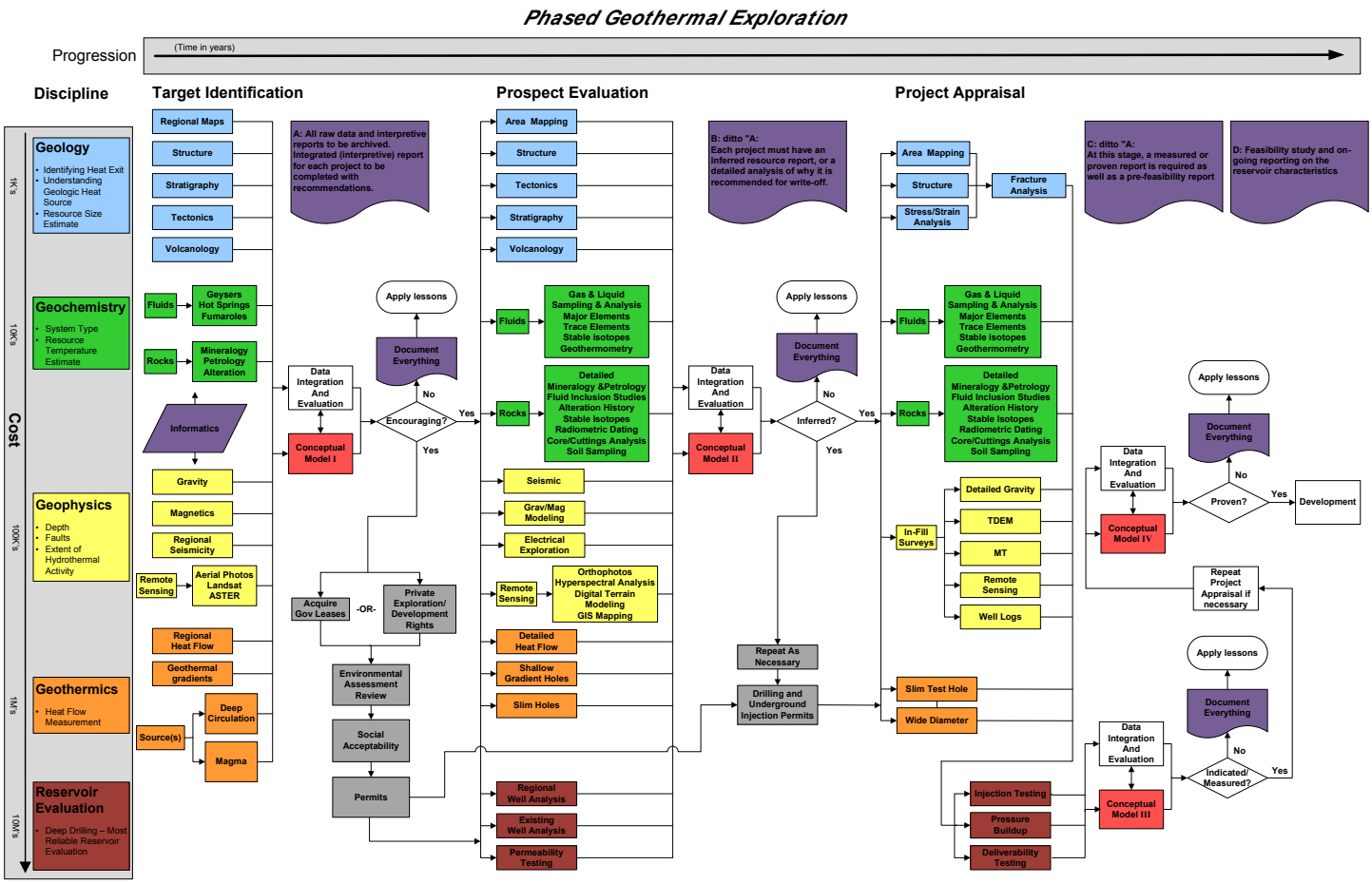

Figure 1. Flow chart showing the elements of a phased exploration program adapted from Yehia and Suemnicht (unpublished).

of informatics and documentation were added (Informatics; purple). This is particularly relevant when development takes a significant period of time and key personnel may no longer be available for continuity or consultation. Additionally, after field development, resource issues often make the original data sets even more valuable. An ability to call on the original data to better understand the evolution of the chemistry, pressure and temperature of the field (and how those parameters and others associated with them) have changed with production, can be extremely helpful to determine the best course of action.

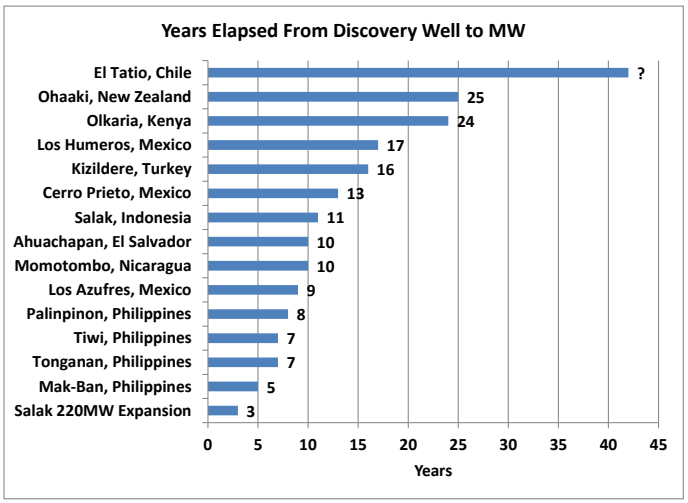

Figure 2. Compilation of exploration and development time lines (revised from Sussman and Tucker 2009).

In order to better appreciate some of the gating aspects of the process that are not directly considered to be exploration, boxes and their related relationships were added for land, environment, permits and social responsibility (Munoz et al. 2013; Hickson et al. 2007). Adding these aspects to the Exploration flowchart resulted in a better appreciation and recognized need for a flowchart - dubbed the Geothermal Development flowchart - to visualize all steps in the process (Figure 3).

Another aspect that was added to the Exploration flowchart was to make the decision boxes align with the terminology of the Canadian Geothermal Code (and the Australian Code); this terminology change further aligned this chart with the Geothermal Development chart (Figure 3).

Although at first the Geothermal Exploration chart (Figure 1) may seem overly complex, it graphically portrays the process to non-specialists in a fairly simple way; tasks need to be done (the vertical columns), decisions made (diamonds); planning and execution undertaken (horizontal colour bands). Whether a geoscience professional uses only certain aspects or the entire chart, it is a tool that provides a clear project path for all parties involved. Subject matter experts could develop additional process boxes

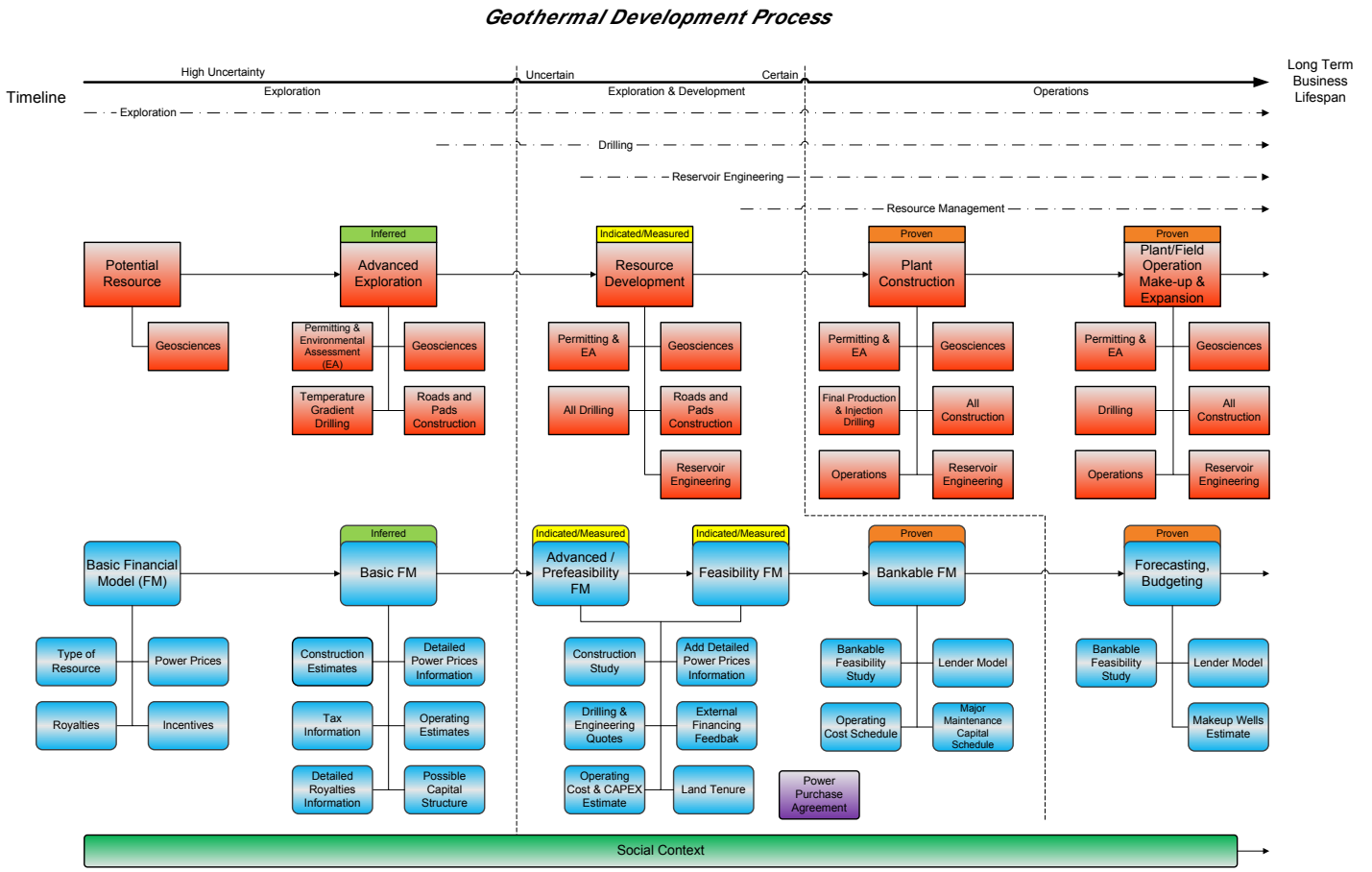

Figure 3. Integrated development flowchart.

in more detailed flowcharts. Accompanying documentation or references could also be included.

Geothermal Development Flowchart

To put the geoscience aspects of the development process into context the Geothermal Development flowchart (Figure 3) was created. Here the concept was to show the variety of work that needs to be accomplished in any development process. It highlights the importance of the technical aspects working in parallel with the financial aspects. There is no development without a resource, and conversely no development can proceed without financing. That these two aspects do not get out of sync is important for the overall success of the project.

Across the top of the flowchart, the major technical activities are indicated; exploration, drilling, reservoir engineering and resource management. These activities move the project from high uncertainty to operations over a period of time that is moderated by many factors. As pointed out by Sussman and Tucker (2009) there are many factors that can influence the development schedule. No attempt was made to attach a specific timeframe to flowchart.

The stages of the Geothermal Code are shown as reference to indicate how the development moves from left to right. Once a resource is at the inferred level, certain work must be done to take it to the indicated/measured point, and further work still to have a proven resource. Each of these steps is moderated by the financing aspects as well as the very important social context. Without a resource there is no development; without money there is no development; without social acceptance there is no development – to be successful a project must bring these three components together in a harmonious fashion in order to achieve fruition.

The all-important Power Purchase Agreement (PPA) is usually obtained when there is a measured resource, but it could be earlier or later in the process dependent on the company's risk tolerance. What is important in making the PPA decision is a good understanding of just how much power the resource will be able to deliver and what the delivery time frame will be; thus understanding the resource is critical. Putting the chicken (finance) before the egg (resource) usually ends with multiple losers.

Financing in general is not usually available until there is a proven resource and a bankable financial plan, but how much "steam-behind-pipe" is needed in order to obtain financing is dependent on the financial institution and their risk tolerance. Again a clear understanding of the resource is important to understand the level of financing risk. Resource risk is basically dependent on the level of exploration (number of drilled holes for example coupled with reservoir testing) and is a crucial element in making the right financial decisions. A good adjunct to the flowcharts (which simply graphically display the elements of the process) would be a risk assessment matrix, but in general the project is de-risked as you go from left to right.

Usually by the time there is a proven resource the social context should be well known and understood; either the community is with the developer or not. Many companies have failed to understand the complex sociology of community relations and underestimate the ability of rural and remote communities to garner support both from within and without (Hickson 2007). Careful management of communities is a critical element for project success and though it appears to be a small component of the both flowcharts, it could very easily be a game changer.

Summary

The flowcharts presented here are intended to provide graphical clarity for complex processes. The flowcharts could be made interactive in a web type or standalone application; interacting with the chart, creating follow-up charts and making other information easily accessible in an intuitive drill-down fashion. The flow charts help team members visualize and better understand their role in the overall development process. For those outside the process, they help convey the complexity of the undertaking, assist them identify critical elements, potential pitfalls and how problems in one constituent impact others – the domino effect.

Applying professional documentation principles and standards, such as the ones used in IT or engineering, can advance and improve overall company communications, training and particularly any type of process-related work such as projects or operations - including recovery of critical information after a quiescent period in the project development process.

Keeping the resource and financial sides of the equation in-step is critical for successful projects. The charts provide visual clues to enhance understanding on the financial side of the assumptions and uncertainties made on the exploration side in providing relevant information for financing; an essential element to long lived successful projects.

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