9. COSTS AND FINANCIAL RISKS OF GEOTHERMAL PROJECTS

9.1. INTRODUCTION

This chapter presents the influence of the geothermal development costs and risks during the project planning and efforts to be financed, without their quantification.

There are many factors that cause geothermal development costs to vary substantially from place to place and from project to project. It therefore makes little sense to try to characterize costs or risks for a "typical" project. Cost components analyzed in this chapter can illustrate the conceptual view during the development of the investment geothermal project. Here following aspects are presented:

- the origin of costs during geothermal development,
- the factors that influence costs,
- the variation of global costs through various stages of a project
- the different types of financial risk that need to be recognized and dealt with.

9.1.1. What factors influence the costs of a geothermal power plant?

There are many factors that influence the cost of a geothermal power plant. In general, geothermal plants are affected by the cost of steel, other metals and labour, which are universal to the power industry. However, drilling costs may vary as well. Geothermal projects are site-specific, thus the costs to connect to the electric grid vary from project to project. Also, whether the project is the first in a particular area or reservoir impacts both risks and costs. The acquisition and leasing of land also varies, because to fully explore a geothermal resource a developer is required to lease the rights to area, according to country legislation. Challenges to leasing and permitting vary from project to project and from country to country. These factors include:

- Size of the plant
- Power plant technology
- Knowledge of the resource
- Temperature of the resource
- Chemistry of the geothermal water
- Resource depth and permeability
- Environmental policies
- Tax incentives
- Markets
- Financing options and costs
- Time delays

9.2. CATEGORIES OF GEOTHERMAL DEVELOPMENT COSTS

There are many different ways of dividing the geothermal development costs into categories. One model, for illustration where the costs in a project come from, is to divide them in the following categories:

1) Costs associated with acquiring and preparing the site or establishment costs
2) Costs for exploring, confirming and assessing the geothermal resource
3) Costs for deep drilling for production and injection wells
4) Costs for the production and injection system
5) Acquiring and installing the power plant
6) Connecting the power plant to the transmission grid
7) General costs for administration and management of the project.

9.2.1. Establishment costs

The issues included in this category of the preparation phase, are:

- Concession or lease acquisition
- Permitting
- Environmental studies
- Civil works (preparation of the roads, drilling pads, plant site and infrastructure, water supply)
- Support facilities.

9.2.2. Costs for resource exploration and confirmation

This category is consisted of the following components:

- Surface exploring
- Shallow drilling
- Assessment through pre-feasibility and feasibility studies.

9.2.3 Costs for production and injection wells

This category includes costs for:

- Mobilization
- Drilling
- Logging
- Testing

9.2.4. Costs for the production and injection system

In this category the costs for production equipment parts are included:

- Production piping
- Separators
- Injection piping
- Production pumps
- Injection pumps
- Corrosion inhibition systems

9.2.5. Costs for acquiring and installing the power plant

In this category, the included costs are:

- Power plant design and engineering
- Procurement procedures and complete phase of construction
- Testing and controlling.

9.2.6. Costs for connecting the power plant to the transmission grid

In this category, the included costs cover the following aspects:

- Grid connection
- Switch yards
- Transmission.

9.2.7. General costs for administration and management of the project

This category covers the following aspects of the costs:

- Project management
- Project and company administration
- Insurance costs
- Different financing fees

9.3. PRESENTATION OF POSSIBLE COST BREAKDOWN

Each of the categories in total costs of geothermal project has different contribution, depending by the project. In order to illustrate percentages values of the costs categories, here hypothetical example is given for development of a 20 MW geothermal project with approximately asumed expected costs by categories.

The structure of the approximate costs breakdown for analyzed example, development of the 20 MW geothermal project, is shown in table 9.1 and graphic in figure 9.1.

Table 1. Costs breakdown by categories

Cost categories	Costs (USD mil)	USD/KW	% of total
Establishment costs	$4,00	$200,00	4%
Costs for exploring, confirming and assessing the geothermal resource	$2,00	$100,00	2%
Costs for deep drilling for production and injection wells	$30,00	$1.500,00	30%
Costs for the production and injection system	$11,00	$550,00	11%
Costs for acquiring and installing the power plant	$38,00	$1.900,00	38%
Costs for connecting the power plant to the transmission grid	$10,00	$500,00	10%
Costs for administration and management of the project	$5,00	$250,00	5%
Total	**$100,00**	**$5.000,00**	**100%**

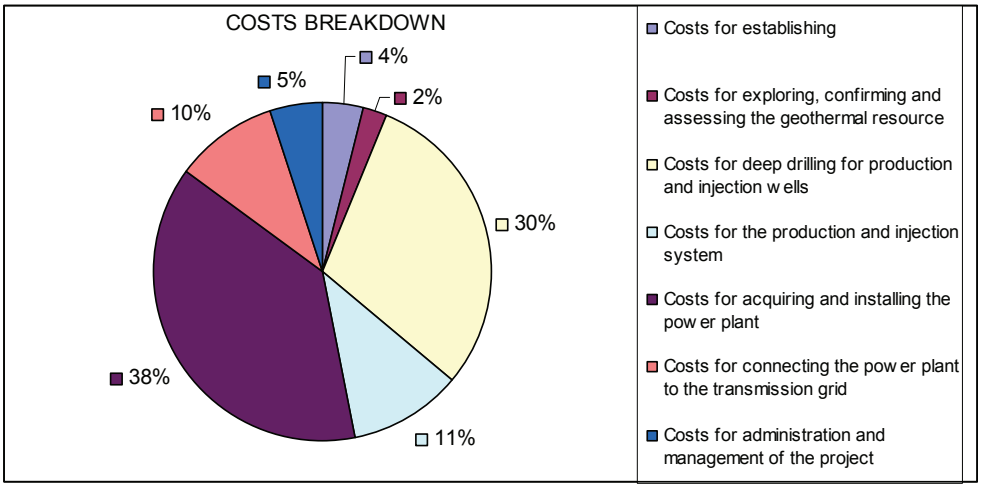

Figure 9.1. Graphic of costs breakdown

The large part of total costs is accounted for drilling and well field development and for power plant and connection costs that cover for about 90% of total costs. Other costs are relatively minor. But however, their impact is significant through properly done phases in planning, preparation and management of the project. If those phases are missed to be properly done, they might impact to higher risk and costs of drilling and field development.

9.4. GLOBAL COSTS OF GEOTHERMAL PROJECT DEVELOPMENT

Different studies have been done that address the overall costs of geothermal project development. There are differences about what overall costs are typical because of many variations between the projects and the country of implementation.

In general, according to analyzed studies, the most geothermal projects fall into the range of 3.000 USD to 6.000 USD per MW with included all costs categories above presented.

9.5. IMPACT OF DIFFERENT FACTORS ON COSTS

Different factors in different ways have impact to the various cost components related to development of the geothermal project, as given in the table 9.2.

Table 9.2. Factors with impact to the various cost components

	Project location	Local costs	Local infrastructure	Regulatory environment	Resource Characteristics	Time
Costs for establishing	Intermediate	Intermediate	Intermediate	High	Intermediate	Intermediate
Costs for exploring, confirming and assessing the geothermal resource	Intermediate	Intermediate	Intermediate	Low	High	Low
Costs for deep drilling for production and injection wells	High	High	Intermediate	Intermediate	High	High
Costs for the production and injection system	Low	Intermediate	Intermediate	Intermediate	Intermediate	Intermediate
Costs for acquiring and installing the power plant	Low	Low	Intermediate	Low	Intermediate	Intermediate
Costs for connecting the power plant to the transmission grid	High	Low	Intermediate	Intermediate	Low	Intermediate
Costs for administration and management of the project	Low	High	Low	Intermediate	Low	High

Low Intermediate High

The location of the project could have a strong impact on drilling costs because of the need to mobilize equipment and materials to a remote location. Delays to a project schedule measured in the time could have a big impact on the management costs, because these costs are incurred continuously once a project team is put in place. Resource characteristics can also have a strong impact on the costs of exploration and resource development and also on the power plant and pipelines costs categories because they will determine many of specifications of the installations needed. Some of the costs categories are significantly impacted by several factors, as are costs for production/injection wells strongly impacted by resources characteristics, project location, local costs and adherence to the realization time schedule.

9.6. COSTS BY STAGES

Analyzing the progress of development in terms of the stages of a project, fig.9.2 and fig.9.3 present different view of the costs and risks distribution.

Using the numbers from example given above, hypothetical 20 MW project, there are expected to spend about $100,000 getting the project started. Surface exploration, including some shallow drilling to measure temperature gradients, is likely to cost on the order of $1,000,000.

When drilling deep wells is started, to confirm the resource and demonstrate the feasibility of the project, it is expected to spend several millions (up to tens of millions for a large project).

Finally, the construction of the project will cost an order of magnitude more, taking into account the development drilling, the power plant and connection to the grid.

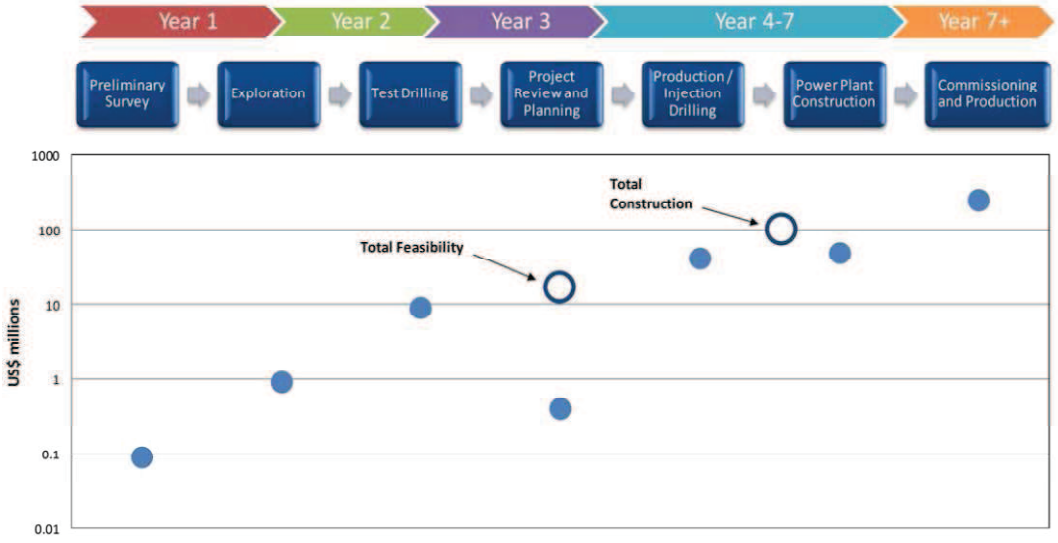

Figure 9.2. Costs distribution by stages

9.7. FINANCIAL RISK BY STAGES

Figure 9.3, presents qualitative curve that indicate risk changes by costs stages. The risk decreases from stage to stage because in order to cover the risk exponentially more budget is planned for that purpose in each successive stage.

But in this sector, most projects face a point where the cost and the risk are both high. This comes where the investment of $10 million is needed to drill resource confirmation wells.

At this point, a project can't be fully funded by debt financing because the risk remains too high. At the same time, the expenditure needed is high enough that it is not easy to find investors willing to take on all of the risk.

This is the point where different mechanisms can be used to manage the risk, such as direct assistance from governments, or insurance programs, or real value in promoting more geothermal development.

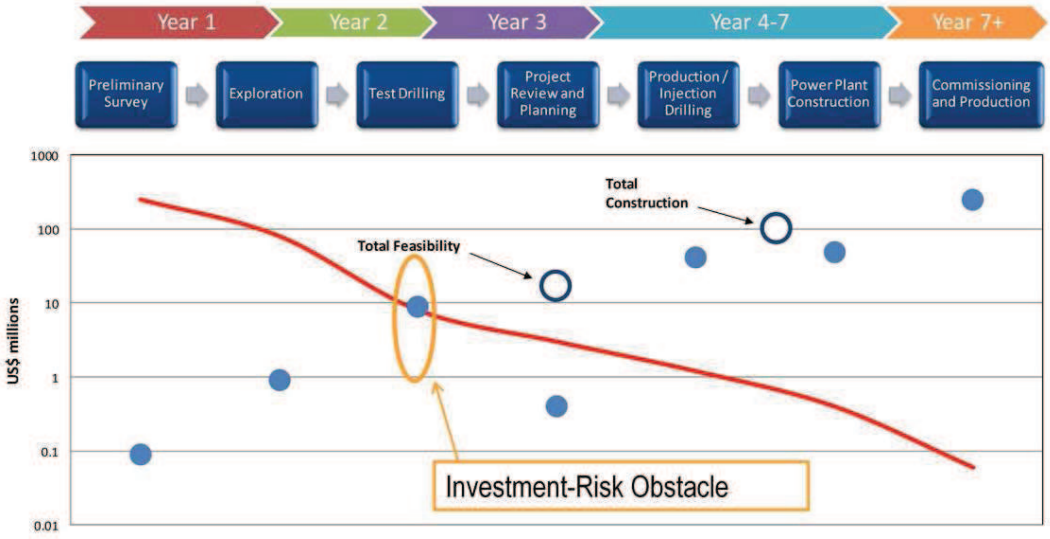

Figure 9.3. Risk by costs stages

It is difficult to separate financial risks from the technical risks in a geothermal project, or even to define exactly what it means by financial risks.

This analysis is focused on the risk that arises when the financing arrangements of the project are not well matched, or synchronized, with the technical plans and schedule for development that happens frequently during development of the geothermal projects.

Few examples on reasons for financial risks:

- One case that can easily occur is that the time-sensitive requirements for maintaining a concession or license, imposed by regulatory authorities, are not compatible with the time it takes to raise the investment capital that is needed to fund the required activities.
- Other case with requirements in a power-purchase agreement, if it happens that will minimize the risk, but possible delays in financing could put the power-purchase agreement and project at risk.
- Other case of a financial risk is a mismatch between the terms of an investment agreement or a loan agreement. If the terms are not flexible, then unexpected results could lead to a breach of the terms, which could create a loss of time and costs on both sides.

During the development of the geothermal project, the following aspects can help to mitigate financial risks:

- To make realistic plans for the development, it is necessary to thinking simultaneously about the technical needs, the administrative needs and the financial needs of the project.
- To allow for contingencies in time and budget in areas where there is uncertainty in order to be prepared for unexpected results in some aspects of the development, because they are almost certain to occur.
- It is important to understand the risk tolerance of investors and lenders in order to ensure that the project doesn't have more built-in risk than they are going to be comfortable with.
- Be realistic about the risks when agreeing to terms of the investment or loan. This could create some additional cost up front, or even delay the financing, but it will pay off in fewer financial problems in the development process.
- To think in advance about what might change as development proceeds, and build in some flexibility to deal with those changes within the terms of the financing. As an example: make sure that, if there is a need to drill one or two more wells than expected, the change in schedule and budget can be accommodated under the terms of the financing agreement. Otherwise, time and

money may be lost in meetings, conference calls and re-writing of loan terms just to take care of something that in fact occurs quite frequently.

Once there is a commitment to the financing, the financiers are partners in the project, and they are as interested in its success as the developer is, even though their specific objectives may be somewhat different. Therefore, if there are changes or problems in the development, the best thing is to keep financiers informed about what is happening, and to be included in the process to find a solution within the financing agreement.