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COST AND REVENUES OF DIRECT USE APPLICATIONS

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ABSTRACT

Geothermal projects in general are riskier than conventional projects, not only because of the uncertainty regarding the geothermal resource but also because of the high investment costs involved in reaching the resource underground. It is legitimate for a project developer to wonder whether or not to undertake the long and risky process of developing a geothermal resource for direct use, with high upfront costs and long payback period, when one can use a standard technology with a standard source of energy that may prove more expensive in the mid to long term but is considered less risky.

The purpose of the paper is to discuss specific issues to be taken into account when determining feasibility of a geothermal direct use project or having an impact on its bankability. It also provides an overview of the components included in capital and operational cost of geothermal direct use applications and the types of revenues related to geothermal direct use. As direct use of geothermal resources may encompass a wide range of final products, the paper discusses when a project may become economically competitive.

1. INTRODUCTION

Direct use of geothermal resources has been implemented in various parts of the world in a successful manner, for instance in geothermal district heating systems in Reykjavik (Iceland), Izmir (Turkey) or Xinayang (China) or the Oserian greenhouse in Kenya. They also have been used successfully in bathing, industrial and fish farming facilities all around the world. When managed in a sustainable manner, geothermal energy can be a very interesting alternative source of energy.

Direct use of geothermal applications are rather unconventional although they may proceed from conventional processes. Their feasibility highly depends on the geothermal resource characteristics and whether its use can be achieved in an economically competitive manner or not. Investment costs may be much higher than in conventional projects whereas their operation costs are generally significantly lower. For instance in space heating applications, the heat is expected to be extracted from the geothermal resource at minor cost.

Parameters impacting the business case of geothermal direct use application include features uncommon in other conventional projects that are highlighted in the paper.

2. FEASIBILITY AND BANKABILITY OF GEOTHERMAL APPLICATIONS

2.1 Project development phases

Geothermal projects are rather unconventional projects. They always depend on the geothermal resource itself and on the nature of the application being considered. Although conventional equipment may be used, one cannot duplicate a solution and the project concept always has to be adapted and engineered to some extent to fit the specific geothermal resource characteristics.

The development process is furthermore lengthy and cannot be handled in a conventional manner for various reasons, e.g.:

- Lack of reliable resource information during the initial phases;
- High upfront costs and risks; and
- Availability of experienced professional.

Figure 1 below, although coming from an electricity production application, is still valid in principle for a direct use application. It describes how the project costs and risk profile are expected to evolve along with the project development stages.

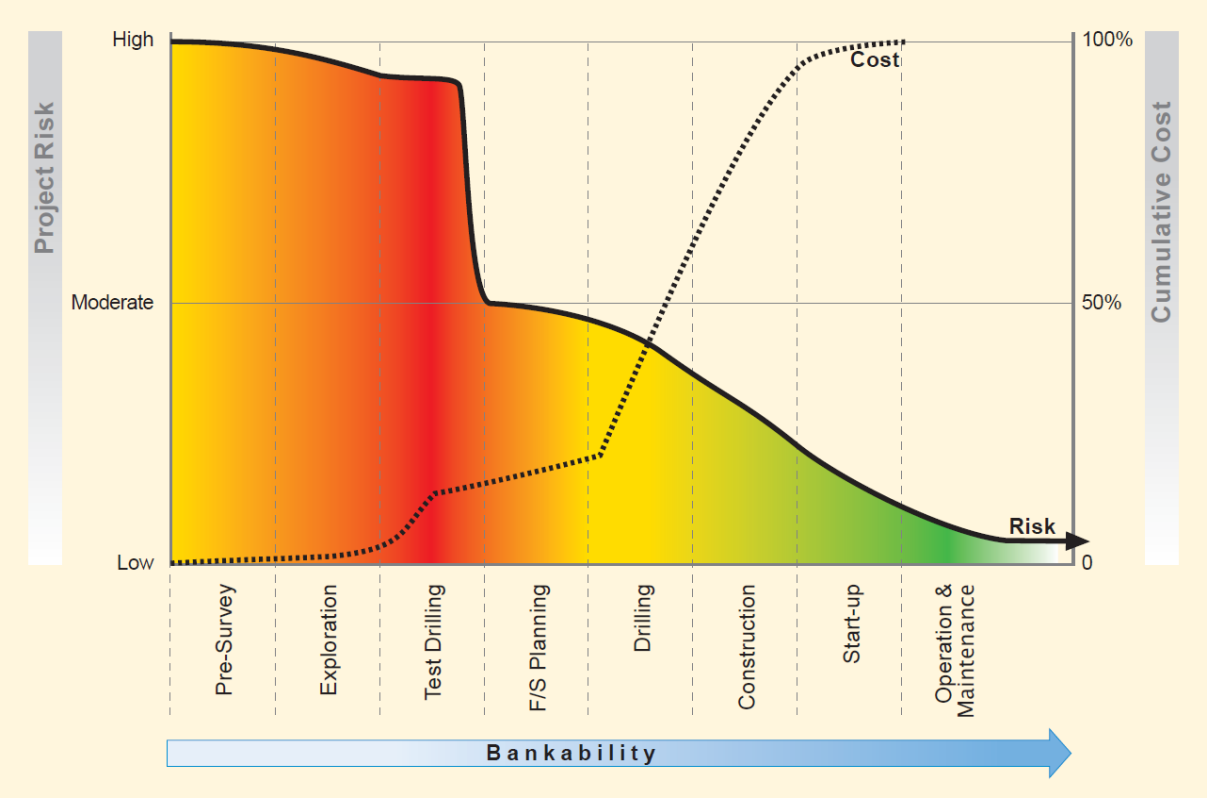

FIGURE 1: Project cost and risk profile at various stages of development – Electricity project (Gehringer and Loksha, 2012)

Geothermal projects imply high upfront costs with assessment of the geothermal resource and above all drilling of the first successful well(s). Whenever drilling is required, significant investment, and therefore financial risk, is required prior to establishing whether the resource is viable for the application considered or not.

Independent of the type of application, geothermal projects should always be developed in successive phases at the end of which the project developer decides to carry on with the project or not. This is a

simple way to manage upfront risks, although it is to be noted that the approach alone will not eliminate the risks and that the project developer might have to investigate other tools or actions for further mitigation. Carefully planning the development activities and conducting a project in incremental steps will contribute to enhancing credibility of a project towards potential financiers and lenders.

The development stages can be divided into 4 major phases: 1) identification, 2) Exploration, 3) Design and construction, 4) Operation and maintenance. Figure 2 presents these phases and the main activities that may be undertaken during the development of a geothermal project.

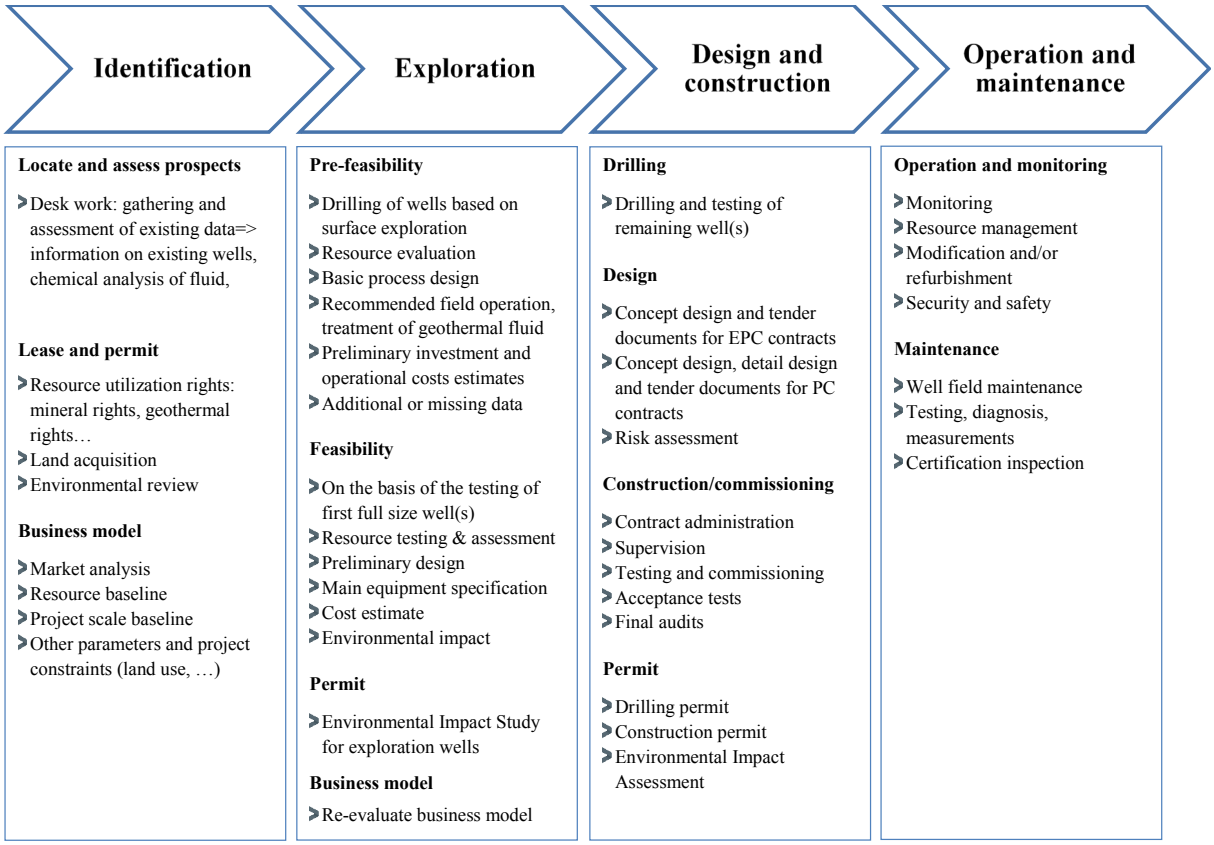

FIGURE 2: Typical activities that may be undertaken during development of a geothermal project

Experience has shown that it typically takes a few years to complete a full-size geothermal project. Various factors will impact the project duration. For instance, a green-field project with little information at hand regarding the resource might take longer time in its identification and exploration phases than a field which has previously been identified.

2.2 Bankability of a project and feasibility

A project is deemed bankable if lenders are willing to finance it. The feasibility study is a thorough study conducted once enough information on the geothermal resource is available. It is aimed at confirming or infirming the feasibility of a project by investigating various components of a project, i.a.:

- Resource assessment.
- Preliminary design for the use of the geothermal resource.
- Investment, operational and maintenance cost estimate.
- Development plan.

The operational and maintenance costs constitute, together with the expected revenues, essential input in the business model. Combined with a financial analysis aimed at validating the business model, the results of the feasibility may be gathered in a bankable feasibility study to undertake and complete the financing of a project.

3. TYPICAL CAPITAL EXPENDITURES - DESCRIPTION

The capital expenditures involved in the development of a geothermal direct use project can be viewed as separate components:

1. Exploration – early development.
2. Geothermal field development.
3. Downstream installation.

These components correspond more or less to the project stages described above. The key features and order of magnitude of these components may vary greatly from one project to the other, depending on the geothermal resource itself and on the nature of the application being considered. It is also what makes geothermal projects unconventional as one cannot fully duplicate a solution and it always has to be adapted and engineered to some extent to fit the specific geothermal resource characteristics.

3.1 Exploration – Early development

The early development phase concerns identification of the geothermal resource and its exploration.

The resource identification phase includes the collection and review of geothermal and other available information, including data regarding geology, geophysics and geochemistry of the presumed resource. Once the resource has been properly identified, the project developer decides whether to carry on with the project or not.

During the exploration phase, a pre-feasibility study is generally undertaken. The prefeasibility report is based on the surface exploration. If the outcome of the prefeasibility report is that the project is viable, the next phase will be drilling of exploration wells. Usually the exploration wells are full size wells that will become production wells if the drilling is successful. The location of the first exploration well is based on the surface exploration and locations of latter wells on the surface exploration, in addition to the outcome of testing of preceding wells. When exploration has proven that the capacity of the geothermal field is sufficient for a minimum size of economical viable power plant or other application, a feasibility report is made. On basis of that the project developer will decide if he continues with the project.

The phase may also include early environmental review and various activities related to leasing and permitting.

Direct investment costs involved at theses stage mainly concern the exploration well(s). It is to be noted that the well(s) may be used afterwards during operation.

Indirect costs may be accounted for separately, see section 3.4, and comprise:

- The activities and studies aimed at confirming the resource potential.
- Costs related to leasing and permitting.

3.2 Geothermal field development

The geothermal field is understood in the context of the paper to include all the underground elements and well heads.

Field development might begin during the exploration phase and generally continues in parallel with the activities related to the downstream installation. It consists of drilling production and reinjection wells as well as testing and preparing them for connection to the downstream components. Field development is conducted in accordance with the strategy established in earlier phases and is regularly revisited in light of current testing results as reservoir simulations will over time provide a more and more accurate picture of the geothermal resource and its capacity in the long term.

Field development is extremely important for the project as it allows verification of the preliminary resource assessment. It is also, as previously mentioned, the riskiest part of the project in terms of the investment involved and uncertainty regarding the outcome.

It is to be noted that the time and investment required to fully develop a geothermal field may vary considerably from one geothermal field to the other depending on parameters such as the wells depth, the resource geology and the availability and capacity of the drilling rig.

For projects requiring drilling, the bankable feasibility study is generally conducted simultaneously with the first exploration well and takes into account the testing results.

Direct investment costs involved at theses stage mainly concern:

- Infrastructure: roads, well pads…
- Drilling and well testing.
- Equipment required for the wells and their connection to the downstream components.

3.3 Downstream installation

The downstream installation encompasses the design, construction/installation and commissioning of all equipment, utilities and facilities required for the exploitation of the geothermal resource to the purpose of the project. The downstream components are above ground components starting from the geothermal field.

The components required for a direct use application will vary greatly depending on the application considered and may encompass:

- Gathering and re-injection pipelines along with mechanical and control equipment to handle and control the geothermal fluid: valves, de-aerators, filters, pumps etc.
- Mechanical and control equipment directly involved in the heat handling:
    - Heat exchangers, tanks, peak load boiler, transportation- and distribution pipes and end-users connection.
- Mechanical and control equipment directly involved in the application:
    - Heat exchangers, pump, temperature control.

Conceptual design is often being carried as the wells are being drilled and tested. The tender procedures can vary from one project to the other depending on their specificities. The utilities are generally tendered either as PC (Procurement and Construction) or EPC (Engineering, Procurement and Construction) contracts.

Direct Investment costs involved at theses stage mainly concern procurement and construction/installation of:

- Gathering and re-injection pipelines.
- Mechanical and control equipment to handle and control the geothermal fluid.
- Mechanical and control equipment directly involved in the application.
- Utilities and facilities.

3.4 Indirect costs

Indirect costs should also be accounted for. They may include:

- Engineering, supervision and commissioning.
- Project contingencies.
- Spare parts.
- Concessions, land costs.
- Official permits.
- Insurance…

4. TYPICAL OPERATION AND MAINTENANCE COST – DESCRIPTION

It is to be noted that the specific operation and maintenance costs of a geothermal direct use application are highly dependent on the type of application, its size and features. The components presented below only provide a general indication of operation and maintenance costs.

4.1 Personnel

Specific personnel may be required to operate and the costs associated should be taken into account.

4.2 Spare parts and consumables

Spare parts, as recommended by the manufacturer, should be accounted for here. In addition consumables may be required for e.g. lubrication oil replacement or to handle the geothermal fluid. Spare parts and consumables are usually accounted for on a yearly basis as a given percentage of investment cost of the downstream components.

4.3 Maintenance

Usually, the yearly maintenance costs may be estimated to the percentage of the installation cost, for wells, pumps, well heads and the collection pipes or as a percentage of the total installation cost. Scheduled maintenance may be required yearly, eventually resulting in production stops and impacting the revenue stream to some extent.

4.4 Overhead, licences, taxes and insurances

Administration costs or the costs associated to running and operating an office should be included here together with various insurances, taxes and licenses required to operate.

4.5 Well replacement

Depending on the project and geothermal field characteristics, well flow rate may decrease over time and well replacement may be accounted for.

5. REVENUES

The revenues will highly depend on the type of application and product(s) resulting from the direct use of the geothermal resource. The geothermal resource may provide:

- Energy or heat at a given level of enthalpy.
- Water or geothermal fluid at a given rate.
- Chemicals, gases and minerals at given concentration.

The part played by the geothermal resources in the revenues varies greatly depending on the nature of the direct use application. In some cases, energy or water is directly sold to the end-users whereas in other cases, the geothermal resources contribute to part of the process for production of a completely different end-product. Cascaded use may also be an option under consideration, complicating somehow the picture to determine the costs.

The end products, or the product sold by the project developer after using the geothermal resources in its process, may be (list non exhaustive):

- Energy for space heating, snow melting or industrial applications.
- Hot water or geothermal fluid for swimming-pools, aquaculture, agriculture, industrial applications and also for space heating depending on the metering and tariff methods.
- Agricultural products: vegetables, fruits, potted plants and dried food or goods.
- Products from fish farming.
- Salt, minerals.
- End products from various industries in which geothermal resources may play a given part.

Revenues of the geothermal direct use application owner will directly be linked to the end product delivered by the application.

6. GEOTHERMAL RESOURCES: ECONOMICALLY COMPETITIVE?

In a general manner, geothermal direct use applications are associated with consequent investment costs. On the other hand, operation and maintenance costs are usually significantly much lower than in conventional projects. The geothermal fluid mainly needs to be pumped from the field whereas in projects using fossil fuels, the energy cost is much higher.

A break-even analysis may be conducted for each specific application to determine how high the investment cost of the geothermal system may be before the project stops becoming economically competitive.

Although geothermal resources may be considered economically competitive for the direct use application being considered during the development of a geothermal field, the chances of success of such projects are highly dependent on how the project developer manages to guarantee its revenues to make-up for the high investment costs. A plant or a user using today or planning on using the geothermal resource may cease its activities before the infrastructure developed around the geothermal resource has been paid-off. Conventional source can eventually be removed and sold to be used somewhere else whereas the components of a geothermal system are more difficult to move and use in other contexts.

It is probably one of the most common obstacles to the development of geothermal projects and project developers may ask themselves: Why go through the long and risky process of developing a geothermal resource for direct use, with high upfront costs and long payback period when one can use

a standard technology with a standard source of energy that may prove more expensive in the mid to long term but is considered less risky?

The answer lies among others in careful planning, expert advice and local and national schemes that aim at mitigating the risks and encourage the sustainable development of this alternative source of energy.

7. CONCLUSION

Geothermal resources are an attractive option for various direct uses, i.a. space heating, industrial uses, agriculture, fish farming, etc. Geothermal energy is, when managed in a sustainable manner, a very interesting alternative source of energy. Such resources may be developed with the help of geothermal experts in a successful manner as has been proved in various cases around the world.

Project developers may overcome challenges associated with the high investment costs by, among other things, placing emphasis on the early development phases aimed at confirming the geothermal field characteristics and capacity. Following extensive exploration activities, a bankable feasibility report is considered to provide indication on the economic feasibility of a project with sufficient level of certainty. This approach is very similar to the front-end loading approach well known in various industrial sectors and contributes to mitigation of the high upfront risks.

After that, uncertainty related to the high investment costs and the guarantee to have a client for the products delivered by the geothermal system is probably one of the major drawbacks when it comes to have financiers deciding upon the financing of a project. The challenges in this regards may require a lot of effort to solve.

Finally, there is undeniably a lot of promotion work to be done with the consumers, financiers and project developers to contribute to using geothermal resources in direct applications on a larger scale.

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